A Level

Article No. 231

Chemistry 9701

Paper-1

Classified/Topical MCQ's
(2008-2020)

- Classified to subtopics
- All variants
- Mark schemes
- Unsolved
- Questions order from new to old
- All questions included

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A Level

Unit 1
ATOMS, MOLECULES AND STOICHIOMETRY

A Level
Chemistry Paper 1
Classified/Topical MCQ's
Article Number: 231

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Syllabus

1.1 Relative masses of atoms and molecules
1.2 The mole and the Avogadro constant
1.3 The determination of relative atoms masses
1.4 The calculation of empirical and molecular formulae
1.5 Reaching masses and volumes (of solution and gases)
1.6 Multiple topics

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Unit 1: Atoms, molecules and stoichiometry

1.1: Relative masses of atoms and molecules

1. M/J 20/P13/Q7

The element sulfur produces a mass spectrum with the following peaks.

m/e value of peak	relative abundance
32	95.02
33	0.76
34	4.20
36	0.02

Which relative atomic mass of sulfur can be calculated from these data, given to four significant figures?

A 32.07 **B** 32.08 **C** 32.09 **D** 32.10

2. O/N 17/P12/Q3

The airbags in cars contain sodium azide, NaN_3, and an excess of potassium nitrate, KNO_3.
In a car accident, the reactions shown occur, producing nitrogen. This causes the airbag to inflate rapidly.

$$2NaN_3 \rightarrow 2Na + 3N_2$$
$$10Na + 2KNO_3 \rightarrow K_2O + 5Na_2O + N_2$$

How many moles of nitrogen gas are produced in **total** when 1 mol of sodium azide, NaN_3, decomposes in an airbag?

A 1.5 **B** 1.6 **C** 3.2 **D** 4.0

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1.2: The mole and the Avogadro constant

1. **M/J 19/P11/Q12, O/N 16/P13/Q12, O/N 16/P11/Q12**
1.15 g of a metallic element needs 300 cm^3 of oxygen for complete reaction, at 298 K and 1 atm pressure, to form an oxide which contains O^{2-} ions.
What could be the identity of this metallic element?
A calcium **B** magnesium **C** potassium **D** sodium

2. **MAR 19/P12/Q10**
Acidified potassium manganate(VII) reacts with iron(II) ethanedioate, FeC_2O_4.
The reactions taking place are shown.
$$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$$
$$Fe^{2+} \rightarrow Fe^{3+} + e^-$$
$$C_2O_4^{2-} \rightarrow 2CO_2 + 2e^-$$
How many moles of iron(II) ethanedioate react with one mole of potassium manganate(VII)?
A 0.60 **B** 1.67 **C** 2.50 **D** 5.00

3. **O/N 17/P12/Q16, M/J 14/P12/Q19**
In an experiment, 0.125 mol of chlorine gas, Cl_2, is reacted with an excess of cold aqueous sodium hydroxide. One of the products is a compound of sodium, oxygen, and chlorine.
Which mass of this product is formed?
A 9.31 g **B** 13.3 g **C** 18.6 g **D** 26.6 g

4. **M/J 17/P12/Q2**
Which would contain 9.03×10^{23} oxygen atoms?
A 0.25 mol aluminium oxide **C** 1.5 mol sulfur trioxide
B 0.75 mol sulfur dioxide **D** 3.0 mol water

5. **M/J 17/P11/Q3, O/N 07/P1/Q1**
When a sports medal with a total surface area of 150 cm^2 was evenly coated with silver, using electrolysis, its mass increased by 0.216 g.
How many atoms of silver were deposited per cm^2 on the surface of the medal?
A 8.0×10^{18} **B** 1.8×10^{19} **C** 1.2×10^{21} **D** 4.1×10^{22}

6. **M/J 16/P12/Q18**
An excess of chlorine gas, Cl_2, is passed through 60 cm^3 of cold aqueous 0.1 mol dm^{-3} sodium hydroxide. In a separate experiment an excess of chlorine gas is passed through 60 cm^3 of hot aqueous 0.1 mol dm^{-3} sodium hydroxide until no further reaction takes place.
How much more sodium chloride will be produced by the reaction with hot NaOH than with cold NaOH?
A 0.002 moles **B** 0.003 moles **C** 0.005 moles **D** 0.006 moles

7. **M/J 16/P13/Q26**
Which volume of oxygen, at room temperature and pressure, is needed for complete combustion of 1.0 mol of methylpropan-1-ol?
A 108 dm^3 **B** 144 dm^3 **C** 156 dm^3 **D** 288 dm^3

8. **O/N 13/P12/Q10**
Which sodium compound contains 74.2% by mass of sodium?
A sodium carbonate **B** sodium chloride **C** sodium hydroxide **D** sodium oxide

9. **M/J 15/P12/Q26**
2.40 g of propan-2-ol were mixed with excess acidified potassium dichromate(VI). The reaction mixture was then boiled under reflux for twenty minutes. The organic product was then collected by distillation. The yield of product was 75.0%.
What mass of product was collected?
A 1.74 g **B** 1.80 g **C** 2.22 g **D** 2.32 g

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10. O/N 13/P13/Q11
Which calcium compound contains 54.1% by mass of calcium?
A calcium hydroxide **B** calcium nitrate **C** calcium oxide **D** calcium sulfate

11. M/J 13/P11/Q26
2.30 g of ethanol were mixed with an excess of aqueous acidified potassium dichromate(VI). The reaction mixture was then boiled under reflux for one hour. The desired organic product was then collected by distillation. The yield of product was 60.0 %.
What mass of product was collected?
A 1.32 g **B** 1.38 g **C** 1.80 g **D** 3.20 g

12. M/J 13/P13/Q27
Which volume of oxygen, at room temperature and pressure, is needed for complete combustion of 0.1 mol of ethanol?
A 7.2 dm^3 **B** 8.4 dm^3 **C** 14.4 dm^3 **D** 16.8 dm^3

13. O/N 12/P13/Q9, M/J 08/P1/Q1
In the Basic Oxygen steel-making process the P_4O_{10} impurity is removed by reacting it with calcium oxide. The only product of this reaction is the salt calcium phosphate, $Ca_3(PO_4)_2$.
In this reaction, how many moles of calcium oxide react with one mole of P_4O_{10}?
A 1 **B** 1.5 **C** 3 **D** 6

14. O/N 11/P12/Q26
2.30 g of ethanol were mixed with aqueous acidified potassium dichromate(VI). The desired product was collected by immediate distillation under gentle warming.
The yield of product was 70.0 %.
What mass of product was collected?
A 1.54 g **B** 1.61 g **C** 2.10 g **D** 3.14 g

15. O/N 10/P11/Q15
Ammonium sulfate in nitrogenous fertilisers in the soil can be slowly oxidised by air producing sulfuric acid, nitric acid and water.
How many moles of oxygen gas are needed to oxidise completely one mole of ammonium sulfate?
A 1 **B** 2 **C** 3 **D** 4

16. O/N 10/P11/Q5, O/N 10/P13/Q5
Nickel makes up 20 % of the total mass of a coin. The coin has a mass of 10.0 g.
How many nickel atoms are in the coin?
A 2.05×10^{22} **B** 4.30×10^{22} **C** 1.03×10^{23} **D** 1.20×10^{24}

17. O/N 10/P11/Q15, O/N 10/P13/Q15
Ammonium sulfate in nitrogenous fertilisers in the soil can be slowly oxidised by air producing sulfuric acid, nitric acid and water.
How many moles of oxygen gas are needed to oxidise completely one mole of ammonium sulfate?
A 1 **B** 2 **C** 3 **D** 4

18. M/J 10/P12/Q16, M/J 10/P11/Q18, M/J 10/P13/Q19
Which element of the third period requires the least number of moles of oxygen for the complete combustion of 1 mol of the element?
A aluminium **B** magnesium **C** phosphorus **D** sodium

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Valid till October/November 2021 Exams

19. M/J 19/P12/Q39, M/J 14/P11/Q40, O/N 10/P12/Q39

In an organic synthesis, a 62% yield of product is achieved.
Which conversions are consistent with this information?

1 74.00 g of butan-2-ol → 44.64 g of butanone
2 74.00 g of butan-1-ol → 54.56 g of butanoic acid
3 74.00 g of 2-methylpropan-1-ol → 54.56 g of 2-methylpropanoic acid

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

20. O/N 12/P13/Q34

An element X and compound YZ react separately with acid as shown.

$$X(s) + 2H^+(aq) \longrightarrow X^{2+}(aq) + H_2(g)$$

$$YZ(s) + 2H^+(aq) \longrightarrow Y^{2+}(aq) + H_2Z(g)$$

When 1.0 g of either X or YZ is reacted with an excess of acid, the total volume of gas formed is the same.
Which statements are correct?

1 $A_r(X) = M_r(YZ)$
2 X and Y are metals.
3 X and Y must both be in the same Group of the Periodic Table.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

21. M/J 12/P13/Q37, M/J 12/P11/Q38

A number of alcohols with the formula $C_4H_{10}O$ are separately oxidised. Using 70 g of the alcohols a 62 % yield of organic product is achieved.
What mass of product could be obtained?

1 42.2 g of butanone
2 51.6 g of butanoic acid
3 51.6 g of 2-methyl propanoic acid

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

22. O/N 09/P12/Q40

A monomer undergoes addition polymerisation. A 1 mol sample of the monomer is completely polymerised.
How many moles of polymer might, theoretically, be formed?

1 1 2 10^{-6} 3 $\frac{0\ \ 1\ \ 0}{6.\ 2 \times 1^{\ 23}}$

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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23. O/N 11/P12/Q36

In a car engine, non-metallic element **X** forms a pollutant oxide **Y**.
Further oxidation of **Y** to **Z** occurs spontaneously in the atmosphere. In this further oxidation, 1 mol of **Y** reacts with 0.5 mol of gaseous oxygen.
Which statements about **X**, **Y** and **Z** are correct?

1 The oxidation number of **X** increases by 2 from **Y** to **Z**.
2 The molecule of **Y** has no unpaired electrons.
3 The molecule of **Z** contains three oxygen atoms.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

24. M/J 11/P12/Q36

In a car engine pollutant oxide **Y**, which contains non-metallic element **X**, is formed.
Further oxidation of **Y** to **Z** occurs in the atmosphere. In this further oxidation, 1 mol of **Y** reacts with 0.5 mol of gaseous oxygen.
X could be either nitrogen or sulfur.
Which statements about **X**, **Y** and **Z** can be correct?

1 The oxidation number of **X** increases by two from **Y** to **Z**.
2 **Y** may have an unpaired electron in its molecule.
3 **Y** is a polar molecule.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

25. O/N 10/P12/Q34

A student puts 10 cm^3 of 0.100 mol dm^{-3} sulfuric acid into one test-tube and 10 cm^3 of 0.100 mol dm^{-3} ethanoic acid into another test-tube. He then adds 1.0 g (an excess) of magnesium ribbon to each test-tube and takes suitable measurements. Both acids have the same starting temperature.
Neither reaction is complete after 2 minutes, but both are complete after 20 minutes.
Which statements are correct?

1 After 2 minutes, the sulfuric acid is at a higher temperature than the ethanoic acid.
2 After 2 minutes, the sulfuric acid has produced more gas than the ethanoic acid.
3 After 20 minutes, the sulfuric acid has produced more gas than the ethanoic acid.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

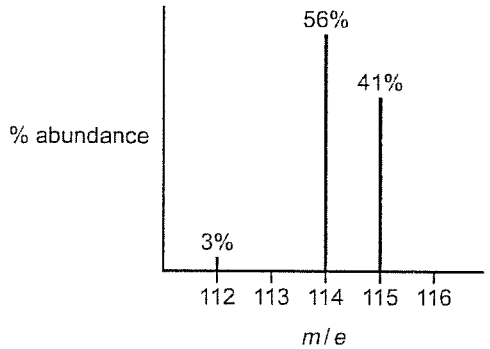
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1.3: The determination of relative atomic masses

1. M/J 19/P11/Q2

A sample of element X is analysed using mass spectrometry. The mass spectrum obtained is shown.

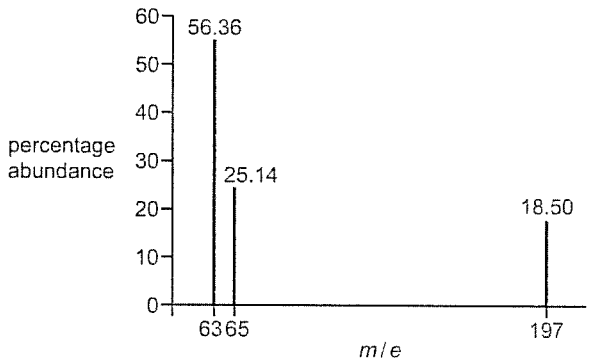


What is the relative atomic mass of this sample of element X?

A 113.7 **B** 114.0 **C** 114.2 **D** 114.4

2. M/J 19/P13/Q2

The mass spectrum of an alloy of copper and gold is shown.



Which expression can be used to calculate the relative atomic mass, A_r, of copper present in this sample?

A $\frac{(56.36 \times 63) + (25.14 \times 65)}{(56.36 + 25.14 + 18.50)}$

B $\frac{(56.36 \times 63) + (25.14 \times 65) + (18.50 \times 197)}{(56.36 + 25.14 + 18.50)}$

C $\frac{(56.36 \times 63) + (25.14 \times 65)}{(56.36 + 25.14)}$

D $\frac{(56.36 \times 63) + (25.14 \times 65)}{(63 + 65)}$

3. M/J 17/P11/Q2

The mass spectrum of a sample of lithium shows that it contains two isotopes, ^6Li and ^7Li.
The isotopic abundances are shown in the table.

isotope	isotopic abundance
^6Li	7.42%
^7Li	92.58%

What is the relative atomic mass of this sample of lithium, given to three significant figures?

A 6.07 **B** 6.50 **C** 6.90 **D** 6.93

4. MAR 17/P12/Q17

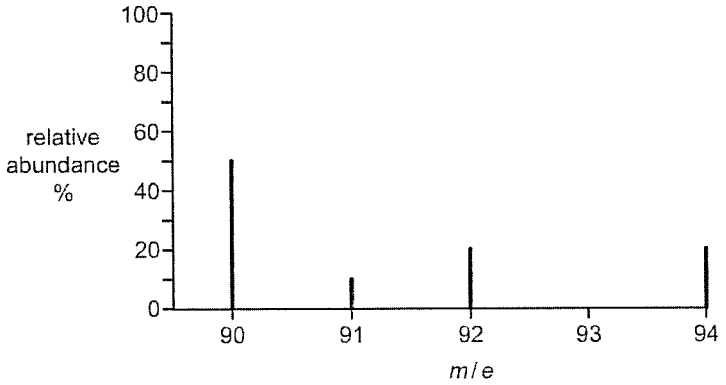
In an experiment, 0.600 mol of chlorine gas, Cl_2, is reacted with an excess of hot aqueous sodium hydroxide.
One of the products is $NaClO_3$.
Which mass of $NaClO_3$ is formed?

A 21.3 g **B** 44.7 g **C** 63.9 g **D** 128 g

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5. O/N 09/P12/Q30, O/N 09/P11/Q1

An element **X** consists of four isotopes. The mass spectrum of X is shown in the diagram.



What is the relative atomic mass of **X**?

A 91.00 **B** 91.30 **C** 91.75 **D** 92.00

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1.4: The calculation of empirical and molecular formulae

1. MAR 20/P12/Q2

For which hydrocarbon are the molecular and empirical formulae the same?

A butane **B** ethane **C** pent-1-ene **D** propane

2. O/N 19/P12/Q9

When lead(II) sulfide, PbS, is heated in air, sulfur dioxide and lead(II) oxide are formed.
What is the equation for the reaction between PbS and oxygen?

A $PbS + 2O_2 \rightarrow SO_2 + PbO_2$

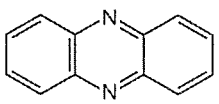
B $PbS + 2\frac{1}{2}O_2 \rightarrow SO_3 + PbO_2$

C $PbS + 1\frac{1}{2}O_2 \rightarrow SO_2 + PbO$

D $PbS + 2O_2 \rightarrow SO_3 + PbO$

3. O/N 19/P12/Q21, M/J 14/P12/Q20

The diagram shows the skeletal formula of phenazine.



phenazine

What is the empirical formula of phenazine?

A C_6H_4N **B** C_6H_6N **C** $C_{12}H_8N_2$ **D** $C_{12}H_{12}N_2$

4. M/J 19/P12/Q9

X is either chlorine or an oxide of chlorine.
X reacts with water, under suitable conditions, to form the two acids HCl and $HClO_3$ in the mole ratio of 1 (HCl) : 5 ($HClO_3$).
What could be X?

A Cl_2 **B** Cl_2O **C** ClO_2 **D** Cl_2O_7

5. MAR 19/P12/Q13

A solid Period 3 element, Q, is reacted with oxygen gas. Compound R is formed.
When R is added to water the pH decreases.
What could be the empirical formula of R?

A Q_2O_4 **B** Q_2O_5 **C** Q_4O_{10} **D** Q_5O_2

6. M/J 18/P12/Q4

Compound J burns in excess oxygen to give carbon dioxide and water only. When a 3.00 g sample of compound J is burnt in excess oxygen, 4.40 g of carbon dioxide and 1.80 g of water are formed.
What is the empirical formula of J?

A CH **B** CHO **C** CH_2 **D** CH_2O

7. O/N 17/P12/Q2

Two hydrocarbons have the formulae C_WH_X and C_YH_Z. W, X, Y and Z represent different whole numbers.

$$\frac{W}{X} = \frac{Y}{Z}$$

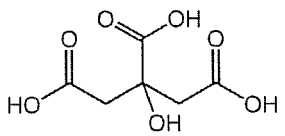
Which row is correct when comparing the two hydrocarbons?

	empirical formula	molecular formula	relative molecular mass
A	different	same	different
B	different	same	same
C	same	different	different
D	same	different	same

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8. O/N 17/P12/Q21

The diagram shows the skeletal formula of citric acid.



citric acid

What is the molecular formula of citric acid?

A $C_6H_8O_7$ **B** $C_6H_4O_7$ **C** $C_8H_8O_7$ **D** $C_{10}H_8O_7$

9. O/N 17/P11/Q1, O/N 17/P13/Q1

Which formula represents the empirical formula of a compound?

A C_2H_4O **B** $C_2H_4O_2$ **C** C_6H_{12} **D** H_2O_2

10. M/J 17/P11/Q6

The complete combustion of 2 moles of a straight chain alkane produces 400 dm^3 of carbon dioxide measured at 301 K and 1×10^5 Pa. Carbon dioxide can be assumed to behave as an ideal gas under these conditions.
What is the formula of the straight chain alkane?

A C_8H_{18} **B** $C_{16}H_{34}$ **C** $C_{20}H_{42}$ **D** $C_{40}H_{82}$

11. M/J 17/P13/Q2

A 0.216 g sample of an aluminium compound X reacts with an excess of water to produce a single hydrocarbon gas. This gas burns completely in O_2 to form H_2O and CO_2 only. The volume of CO_2 at room temperature and pressure is 108 cm^3.
What is the formula of X?

A Al_2C_3 **B** Al_3C_2 **C** Al_3C_4 **D** Al_4C_3

12. MAR 17/P12/Q2

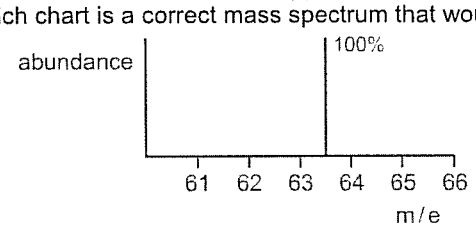
Compounds J and K each contain 40% carbon by mass.
What could J and K be?

	J	K
A	a hexose, $C_6H_{12}O_6$	starch, $(C_6H_{10}O_5)_n$
B	a pentose, $C_5H_{10}O_5$	a hexose, $C_6H_{12}O_6$
C	a pentose, $C_5H_{10}O_5$	sucrose, $C_{12}H_{22}O_{11}$
D	starch, $(C_6H_{10}O_5)_n$	sucrose, $C_{12}H_{22}O_{11}$

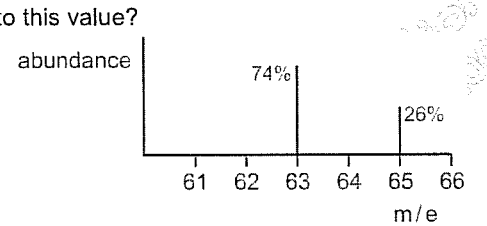
13. M/J 16/P13/Q4

The relative atomic mass of copper is 63.5.
Which chart is a correct mass spectrum that would lead to this value?

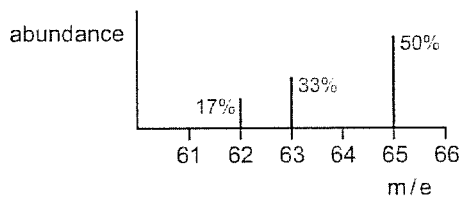
A



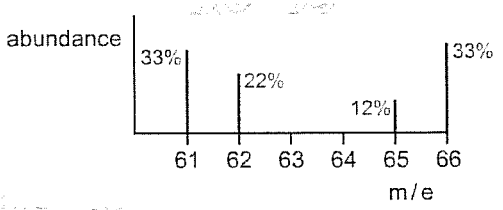
C



B



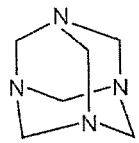
D



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14. O/N 15/P13/Q9, O/N 15/P11/Q9

Hexamine is a crystalline solid used as a fuel in portable stoves.
The diagram shows its skeletal structure.



What is the empirical formula of hexamine?

A CH_2N **B** $C_3H_6N_2$ **C** $C_4H_8N_4$ **D** $C_6H_{12}N_4$

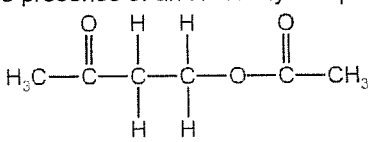
15. O/N 14/P12/Q6, O/N 14/P11/Q6

Aluminium carbide, Al_4C_3, reacts readily with aqueous sodium hydroxide. The two products of the reaction are $NaAlO_2$ and a hydrocarbon. Water molecules are also involved as reactants.
What is the formula of the hydrocarbon?

A CH_4 **B** C_2H_6 **C** C_3H_8 **D** C_6H_{12}

16. O/N 13/P13/Q28, O/N 10/P11/Q21, O/N 10/P13/Q22

Compound X reacts with ethanoic acid in the presence of an H^+ catalyst to produce the compound below.



What is the molecular formula of compound X?

A $C_2H_6O_2$ **B** $C_2H_6O_3$ **C** C_4H_8O **D** $C_4H_8O_2$

17. M/J 13/P11/Q2, O/N 02/P1/Q1

A mixture of 10 cm^3 of methane and 10 cm^3 of ethane was sparked with an excess of oxygen. After cooling to room temperature, the residual gas was passed through aqueous potassium hydroxide.
All gas volumes were measured at the same temperature and pressure.
What volume of gas was absorbed by the alkali?

A 15 cm^3 **B** 20 cm^3 **C** 30 cm^3 **D** 40 cm^3

18. M/J 13/P13/Q9

Which formula represents the empirical formula of a compound?

A CH_4O **B** C_2H_4 **C** C_6H_{12} **D** H_2O_2

19. M/J 13/P13/Q18, O/N 09/P12/Q18, O/N 09/P11/Q19, M/J 05/P1/Q18

In an historically famous experiment Wöhler heated 'inorganic' ammonium cyanate in the absence of air. The only product of the reaction was 'organic' urea, $CO(NH_2)_2$. No other products were formed in the reaction.
What is the formula of the cyanate ion present in ammonium cyanate?

A CNO^- **B** CNO^{2-} **C** CO^- **D** NO^-

20. O/N 10/P11/Q12, O/N 10/P13/Q14

Camphor is a white solid which was used to make the early plastic celluloid. Camphor contains the same percentage by mass of hydrogen and oxygen.
What is the molecular formula of camphor?

A $C_{10}H_6O_6$ **B** $C_{10}H_8O$ **C** $C_{10}H_{16}O$ **D** $C_{10}H_{10}O_2$

21. O/N 09/P12/Q1, O/N 09/P11/Q2

0.200 mol of a hydrocarbon undergo complete combustion to give 35.2 g of carbon dioxide and 14.4 g of water as the only products.
What is the molecular formula of the hydrocarbon?

A C_2H_4 **B** C_2H_6 **C** C_4H_4 **D** C_4H_8

22. M/J 09/P1/Q1

In leaded petrol there is an additive composed of lead, carbon and hydrogen only. This compound contains 29.7% carbon and 6.19% hydrogen by mass.
What is the value of **x** in the empirical formula PbC_8H_X?

A 5 **B** 6 **C** 16 **D** 20

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1.5: Reacting masses and volumes (of solutions and gases)

1. M/J 20/P12/Q6
In this question you should assume air contains 21% oxygen.
What is the minimum volume of air required to ensure complete combustion of 10 cm^3 of butane gas, under room conditions?
A 14 cm^3 **B** 27 cm^3 **C** 65 cm^3 **D** 310 cm^3

2. M/J 20/P12/Q9
The complete combustion of 2 moles of an alkane produces 400 dm^3 of carbon dioxide measured at 301 K and 1×10^5 Pa. Carbon dioxide can be assumed to behave as an ideal gas under these conditions.
What is the formula of the alkane?
A C_8H_{18} **B** $C_{16}H_{34}$ **C** $C_{20}H_{42}$ **D** $C_{40}H_{82}$

3. M/J 20/P11/Q4
10 cm^3 of ethane is burned in 45 cm^3 of oxygen at a pressure of 101 kPa and a temperature of 200 °C. Complete combustion takes place.
What is the total volume of gas present when the reaction is complete, measured under the same conditions?
A 30 cm^3 **B** 50 cm^3 **C** 55 cm^3 **D** 60 cm^3

4. M/J 20/P11/Q13
6.90 g of an ammonium salt is heated with an excess of aqueous sodium hydroxide. The volume of ammonia produced, measured under room conditions, is 2.51 dm^3.
Which ammonium salt is used?
A ammonium carbonate (M_r = 96.0) **C** ammonium nitrate (M_r = 80.0)
B ammonium chloride (M_r = 53.5) **D** ammonium sulfate (M_r = 132.1)

5. M/J 20/P11/Q17
0.25 g of anhydrous magnesium nitrate is heated strongly until it completely decomposes.
What is the total volume of gas produced, measured under room conditions?
A 40 cm^3 **B** 81 cm^3 **C** 101 cm^3 **D** 202 cm^3

6. MAR 20/P12/Q7
Sodium azide, NaN_3, decomposes as shown.

$$2NaN_3 \rightarrow 2Na + 3N_2$$

Which volume of nitrogen, measured at room temperature and pressure, will be produced by the decomposition of 150 g of sodium azide?
A 166 dm^3 **B** 83 dm^3 **C** 55 dm^3 **D** 37 dm^3

7. MAR 20/P12/Q9
1.8 g of water, heated to 227 °C in a sealed container, turns to steam with a pressure of 200 kPa.
What is the approximate volume of the container?
A 9×10^{-4} m^3 **B** 2×10^{-3} m^3 **C** 2 m^3 **D** 8×10^7 m^3

8. M/J 20/P12/Q13, O/N 16/P11/Q16, O/N 16/P13/Q16, M/J 13/P11/Q16
Magnesium nitrate, $Mg(NO_3)_2$, will decompose when heated to give a white solid and a mixture of gases. One of the gases released is an oxide of nitrogen, X.
7.4 g of anhydrous magnesium nitrate is heated until no further reaction takes place.
What mass of X is produced?
A 1.5 g **B** 2.3 g **C** 3.0 g **D** 4.6 g

9. O/N 19/P12/Q2
In this question it should be assumed that $(NH_4)_2CO_3.H_2O(s)$ dissolves in water without causing an increase in volume.
Which mass of $(NH_4)_2CO_3.H_2O(s)$ should be added to 800 cm^3 of water to form a 0.100 mol dm^{-3} solution of NH_4^+ ions?
A 4.56 g **B** 7.13 g **C** 9.12 g **D** 14.3 g

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10. M/J 19/P11/Q3, M/J 13/P13/Q10

A washing powder contains sodium hydrogencarbonate, $NaHCO_3$, as one of the ingredients. In a titration, a solution containing 1.00 g of washing powder requires 7.15 cm^3 of 0.100 mol dm^{-3} sulfuric acid for complete reaction. The sodium hydrogencarbonate is the only ingredient that reacts with the acid.
What is the percentage by mass of sodium hydrogencarbonate in the washing powder?

A 3.0 **B** 6.0 **C** 12.0 **D** 24.0

11. MAR 19/P12/Q2

A 3.7 g sample of copper(II) carbonate is added to 25 cm^3 of 2.0 mol dm^{-3} hydrochloric acid.
Which volume of gas is produced under room conditions?

A 0.60 dm^3 **B** 0.72 dm^3 **C** 1.20 dm^3 **D** 2.40 dm^3

12. M/J 18/P13/Q5

Aspirin, $C_9H_8O_4$, M_r = 180.0, can be made by a reaction between 2-hydroxybenzoic acid, $C_7H_6O_3$, M_r = 138.0, and ethanoic anhydride, $C_4H_6O_3$, M_r = 102.0. The balanced equation for the reaction is shown.

$$C_7H_6O_3 + C_4H_6O_3 \rightarrow C_9H_8O_4 + C_2H_4O_2$$

If a reaction mixture consists of 10.0 g of each of the two reactants, what is the maximum mass of aspirin that can be produced?

A 5.7 g **B** 10.0 g **C** 13.0 g **D** 17.6 g

13. O/N 17/P12/Q15

Exactly 3.705 kg of substance Y are needed to neutralise 100 moles of HCl (aq).
What could be substance Y?

A Ca **B** CaO **C** $Ca(OH)_2$ **D** $CaCO_3$

14. M/J 17/P11/Q28

A sample of 2.30 g of ethanol was mixed with an excess of aqueous acidified potassium dichromate(VI). The reaction mixture was then boiled under reflux for one hour. The required organic product was then collected by distillation. The yield of product was 60.0%.
Which mass of product was collected?

A 1.32 g **B** 1.38 g **C** 1.80 g **D** 3.00 g

15. M/J 16/P12/Q14

A 0.005 mol sample of anhydrous calcium carbonate was completely thermally decomposed to give 100 cm^3 of gas measured at a certain temperature and pressure.
In a separate experiment carried out at the same temperature and pressure, a 0.005 mol sample of anhydrous calcium nitrate was completely thermally decomposed. The volume of gaseous products was measured.
What total volume of gaseous products was produced from the calcium nitrate?

A 50 cm^3 **B** 100 cm^3 **C** 200 cm^3 **D** 250 cm^3

16. M/J 16/P11/Q3

Tetraethyl lead, $Pb(C_2H_5)_4$, has been used as a petrol additive.
What is the percentage by mass of carbon in tetraethyl lead?

A 10.2 **B** 14.9 **C** 29.7 **D** 32.0

17. M/J 16/P13/Q3

Which mass of urea, $CO(NH_2)_2$, contains the same mass of nitrogen as 101.1g of potassium nitrate?

A 22g **B** 30g **C** 44g **D** 60g

18. O/N 15/P12/Q13, M/J 12/P11/Q14, M/J 12/P13/Q15

The reaction between aluminium powder and anhydrous barium nitrate is used as the propellant in some fireworks. The metal oxides and nitrogen are the only products.
Which volume of nitrogen, measured under room conditions, is produced when 0.783 g of anhydrous barium nitrate reacts with an excess of aluminium?

A 46.8 cm^3 **B** 72.0 cm^3 **C** 93.6 cm^3 **D** 144 cm^3

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19. O/N 15/P12/Q16, M/J 04/P1/Q18

Brine is concentrated aqueous sodium chloride.
In the commercial electrolysis of brine, the products are chlorine, hydrogen and sodium hydroxide.
What is the maximum yield of each of these products when 58.5 kg of sodium chloride are electrolysed as brine?

	yield of chlorine / kg	yield of hydrogen / kg	yield of sodium hydroxide / kg
A	35.5	1	40
B	35.5	2	40
C	71	1	40
D	71	2	80

20. O/N 15/P12/Q19

4.70 g of an ammonium salt is heated with excess aqueous sodium hydroxide. The volume of ammonia gas given off, measured at room temperature and pressure, is 1.41 dm^3.
Which ammonium salt was used?

A ammonium bromide (M_r = 97.9)
B ammonium carbonate (M_r = 96)
C ammonium nitrate (M_r = 80)
D ammonium sulfate (M_r = 132.1)

21. M/J 15/P11/Q3

1.00 g of carbon is combusted in a limited supply of pure oxygen. 0.50 g of the carbon combusts to form CO_2 and 0.50 g of the carbon combusts to form CO.
The resultant mixture of CO_2 and CO is passed through excess NaOH(aq) and the remaining gas is then dried and collected.
What is the volume of the remaining gas? (All gas volumes are measured at 25 °C and 1 atmosphere pressure.)

A 1 dm^3 **B** 1.5 dm^3 **C** 2 dm^3 **D** 3 dm^3

22. M/J 15/P11/Q19

Which mass of solid residue will be obtained from the thermal decomposition of 4.10 g of anhydrous calcium nitrate?

A 0.70 g **B** 1.00 g **C** 1.40 g **D** 2.25 g

23. O/N 14/P12/Q15, O/N 14/P11/Q15

A sample of potassium oxide, K_2O, is dissolved in 250 cm^3 of distilled water. 25.0 cm^3 of this solution is titrated against sulfuric acid of concentration 2.00 mol dm^{-3}. 15.0 cm^3 of this sulfuric acid is needed for complete neutralisation.
Which mass of potassium oxide was originally dissolved in 250 cm^3 of distilled water?

A 2.83 g **B** 28.3 g **C** 47.1 g **D** 56.6 g

24. O/N 14/P13/Q8

Ferrochrome is an alloy of iron and chromium. Ferrochrome can be dissolved in dilute sulfuric acid to produce a mixture of $FeSO_4$ and $Cr_2(SO_4)_3$. The $FeSO_4$ reacts with $K_2Cr_2O_7$ in acid solution according to the following equation.

$$14H^+ + 6Fe^{2+} + Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$$

When 1.00 g of ferrochrome is dissolved in dilute sulfuric acid, and the resulting solution titrated, 13.1 cm^3 of 0.100 mol dm^{-3} $K_2Cr_2O_7$ is required for complete reaction.
What is the percentage by mass of Fe in the sample of ferrochrome?

A 1.22 **B** 4.39 **C** 12.2 **D** 43.9

25. O/N 14/P13/Q12

What is the ionic equation for the reaction between aqueous sodium carbonate and dilute nitric acid?

A $2HNO_3(aq) + CO_3^{2-}(aq) \rightarrow H_2O(l) + CO_2(g) + 2NO_3^-(aq)$
B $2H^+(aq) + CO_3^{2-}(aq) \rightarrow CO_2(g) + H_2O(l)$
C $2HNO_3(aq) + Na_2CO_3(aq) \rightarrow 2NaNO_3(aq) + CO_2(g) + H_2O(l)$
D $2HNO_2(aq) + CO_3^{2-}(aq) \rightarrow H_2O(l) + CO_2(g) + 2NO_2^-(aq)$

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26. M/J 14/P12/Q9
In an experiment, 12.0 dm^3 of oxygen, measured under room conditions, is used to burn completely 0.10 mol of propan-1-ol.
What is the final volume of gas, measured under room conditions?
A 7.20 dm^3 **B** 8.40 dm^3 **C** 16.8 dm^3 **D** 18.00 dm^3

27. M/J 14/P13/Q17
In an experiment, 0.6 mol of chlorine gas, Cl_2, is reacted with an excess of hot aqueous sodium hydroxide. One of the products is a compound of sodium, oxygen and chlorine.
Which mass of this product is formed?
A 21.3 g **B** 44.7 g **C** 63.9 g **D** 128 g

28. M/J 14/P12/Q14
Ammonium sulfate in the soil is slowly oxidised by air, producing sulfuric acid, nitric acid and water as the only products. How many moles of oxygen gas are needed for the complete oxidation of one mole of ammonium sulfate?
A 1 **B** 2 **C** 3 **D** 4

29. O/N 13/P11/Q10
Which sodium compound contains 74.2 % by mass of sodium?
A sodium carbonate **B** sodium chloride **C** sodium hydroxide **D** sodium oxide

30. O/N 13/P13/Q12
The reaction between aluminium powder and anhydrous barium nitrate is used as the propellant in some fireworks. The reaction produces the metal oxides and nitrogen.

$$10Al + 3Ba(NO_3)_2 \rightarrow 5Al_2O_3 + 3BaO + 3N_2$$

Which mass of barium oxide is produced when 5.40 g of aluminium powder reacts with an excess of anhydrous barium nitrate?
A 1.62 g **B** 3.06 g **C** 9.18 g **D** 10.2 g

31. M/J 13/P12/Q13
Magnesium nitrate, $Mg(NO_3)_2$, will decompose when heated to give a white solid and a mixture of gases. One of the gases released is oxygen.
29.7 g of anhydrous magnesium nitrate is heated until no further reaction takes place.
What mass of oxygen is produced?
A 3.2 g **B** 6.4 g **C** 12.8 g **D** 19.2 g

32. M/J 13/P11/Q11
A solution of Sn^{2+} ions will reduce an acidified solution of MnO_4^- ions to Mn^{2+} ions. The Sn^{2+} ions are oxidised to Sn^{4+} ions in this reaction.
How many moles of Mn^{2+} ions are formed when a solution containing 9.5 g of $SnCl_2$ (M_r : 190) is added to an excess of acidified $KMnO_4$ solution?
A 0.010 **B** 0.020 **C** 0.050 **D** 0.125

33. O/N 11/P11/Q2, O/N 11/P13/Q1
Lead(IV) chloride will oxidise bromide ions to bromine. The Pb^{4+} ions are reduced to Pb^{2+} ions in this reaction.
If 6.980 g of lead(IV) chloride is added to an excess of sodium bromide solution, what mass of bromine would be produced?
A 0.799 g **B** 1.598 g **C** 3.196 g **D** 6.392 g

34. O/N 11/P11/Q9, O/N 11/P13/Q12
An aqueous solution was prepared containing 1.0 mol of $AgNO_3$ and 1.0 mol of $FeSO_4$ in 1.00 dm^3 of water. When equilibrium was established, there was 0.44 mol of $Ag^+(aq)$ in the mixture.

$$Ag^+(aq) + Fe^{2+}(aq) \rightleftharpoons Ag(s) + Fe^{3+}(aq)$$

What is the numerical value of K_c?
A 0.35 **B** 0.62 **C** 1.62 **D** 2.89

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35. O/N 11/P11/Q14, O/N 11/P13/Q15

A significant contribution to atmospheric carbon dioxide levels comes from the thermal decomposition of limestone, in the manufacture of cement and of lime for agricultural purposes.
Cement works roast 1000 million tonnes of limestone per year and a further 200 million tonnes is roasted in kilns to make lime.
What is the total annual mass output of carbon dioxide (in million tonnes) from these two processes?

A 440 **B** 527 **C** 660 **D** 880

36. M/J 11/P12/Q11

0.144 g of an aluminium compound **X** react with an excess of water, to produce a gas. This gas burns completely in O_2 to form H_2O and 72 cm^3 of CO_2 only. The volume of CO_2 was measured at room temperature and pressure.
What could be the formula of **X**?
[C = 12.0, Al = 27.0; 1 mole of any gas occupies 24 dm^3 at room temperature and pressure]

A Al_2C_3 **B** Al_3C_4 **C** Al_4C_3 **D** Al_5C_3

37. M/J 11/P12/Q10

Tanzanite is used as a gemstone for jewellery. It is a hydrated calcium aluminium silicate mineral with a chemical formula $Ca_2Al_xSi_yO_{12}(OH).6\frac{1}{2}H_2O$. Tanzanite has M_r of 571.5.

Its chemical composition is 14.04% calcium, 14.17% aluminium, 14.75% silicon, 54.59% oxygen and 2.45% hydrogen.
(A_r values: H = 1.0, O = 16.0, Al = 27.0, Si = 28.1, Ca = 40.1)
What are the values of x and y?

	x	y
A	1	1
B	2	3
C	3	3
D	6	1

38. M/J 11/P13/Q12, M/J 11/P11/Q13

0.02 mol of aluminium is burned in oxygen and the product is reacted with 2.00 mol dm^{-3} hydrochloric acid.
What minimum volume of acid will be required for complete reaction?

A 15 cm^3 **B** 20 cm^3 **C** 30 cm^3 **D** 60 cm^3

39. O/N 10/P12/Q14

Which mass of solid residue can be obtained from the thermal decomposition of 4.10 g of anhydrous calcium nitrate?

A 0.70 g **B** 1.00 g **C** 1.40 g **D** 2.25 g

40. M/J 10/P12/Q8, M/J 10/P11/Q8, M/J 10/P13/Q9

2.920 g of a Group II metal, **X**, reacts with an excess of chlorine to form 5.287 g of a compound with formula XCl_2.
What is metal **X**?

A barium **B** calcium **C** magnesium **D** strontium

41. O/N 08/P1/Q1

Titanium(IV) oxide, TiO_2, is brilliantly white and much of the oxide produced is used in the manufacture of paint.
What is the maximum amount of TiO_2 obtainable from 19.0 tonnes of the ore ilmenite, $FeTiO_3$?

A 10.0 tonnes **B** 12.7 tonnes **C** 14.0 tonnes **D** 17.7 tonnes

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42. M/J 18/P13/Q36

Under room conditions, 600 cm^3 of a gas, X, has a mass of 0.700 g.
What could X be?

1 carbon monoxide
2 ethene
3 nitrogen

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

43. O/N 17/P11/Q32, O/N 17/P13/Q32

A student makes sodium chloride by reacting together 0.025 mol of sodium carbonate with an excess of 0.2 mol dm^{-3} hydrochloric acid.

$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$$

Which statements about the quantities of substance are correct?

1 600 cm^3 of carbon dioxide are produced at room temperature and pressure.
2 250 cm^3 of the hydrochloric acid are needed to exactly neutralise the sodium carbonate.
3 1.46 g of sodium chloride are produced.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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1.6: Multiple Topics

1. M/J 20/P12/Q2

A copper ore contains 3.00% of copper carbonate, $CuCO_3$, by mass.
Which mass of copper would be obtained from 1 tonne of the ore?

A 1.91 kg **B** 3.71 kg **C** 15.4 kg **D** 58.4 kg

2. M/J 20/P12/Q5

In this question you should use changes in oxidation numbers to balance a chemical equation.
The following reaction occurs when MnO_2 is warmed with dilute H_2SO_4.

$$a\ MnO_2 + b\ H^+ \rightarrow c\ Mn^{2+} + d\ MnO_4^- + e\ H_2O$$

What is the ratio of c : *d* in the correctly balanced equation?

A 1 : 1 **B** 1 : 2 **C** 2 : 3 **D** 3 : 2

3. M/J 20/P12/Q12

The fifth to eighth ionisation energies of four elements in Period 3 of the Periodic Table are shown.
Which row refers to chlorine?

	ionisation energies / kJ mol^{-1}			
	fifth	sixth	seventh	eighth
A	6280	21 200	25 900	30 500
B	6990	8 490	27 100	31 700
C	6540	9 330	11 000	33 600
D	7240	8 790	12 000	13 800

4. M/J 20/P11/Q8

In this question you should use changes in oxidation numbers to balance a chemical equation. Acidified potassium dichromate(VI) solution can oxidise a solution of V^{2+} ions. The equation for this reaction is shown.

$$a\ Cr_2O_7^{2-} + b\ V^{2+} + c\ H^+ \rightarrow d\ Cr^{3+} + e\ VO_3^- + f\ H_2O$$

What is the ratio a : b in the correctly balanced equation?

A 1 : 1 **B** 1 : 2 **C** 2 : 1 **D** 4 : 1

5. M/J 20/P11/Q11

A sample of solid ammonium chloride decomposes on heating.

solid ammonium chloride → ammonia gas + hydrogen chloride gas

A total of 2.4×10^{21} molecules of gas is formed.
How many hydrogen atoms are present in the gaseous products?

A 1.2×10^{21} **B** 2.4×10^{21} **C** 4.8×10^{21} **D** 9.6×10^{21}

6. MAR 20/P12/Q10

When the equation is correctly balanced, what is the value of *c*?

$$aC_2H_4 + bH_2O + cH^+ + 2MnO_4^- \rightarrow dC_2H_6O_2 + eMn^{2+}$$

A 3 **B** 4 **C** 5 **D** 6

7. O/N 19/P11/Q2, O/N 19/P13/Q2

Diamond is a pure form of carbon. The mass of a diamond can be measured in carats. One carat is 0.200 g of carbon.
Which expression gives the number of carats that contain 6.02×10^{23} carbon atoms?

A 0.200×12.0

B $\frac{0.200}{12.0}$

C $\frac{12.0}{0.1200}$

D $\frac{0.200}{6.02 \times 10^{23}} \times 12.0$

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8. O/N 19/P11/Q9, O/N 19/P13/Q9

In the chemical equation, w, x, y and z are all whole numbers.

$$wClO_3^- + xMnO_4^- + yH^+ \rightarrow wClO_4^- + xMnO_2 + zH_2O$$

When the equation is balanced, what are w, x and y?

	w	x	y
A	1	1	2
B	2	2	2
C	2	3	8
D	3	2	2

9. M/J 19/P11/Q9

Ethanedioic acid, HO_2CCO_2H, can be oxidised by $KMnO_4$ in dilute sulfuric acid. The products of this reaction are carbon dioxide, water, potassium sulfate and manganese(II) sulfate.

In this reaction each ethanedioic acid molecule loses two electrons as it is oxidised. A half-equation for this process is shown.

$$HO_2CCO_2H \rightarrow 2CO_2 + 2H^+ + 2e^-$$

How many water molecules are produced when five ethanedioic acid molecules are oxidised by $KMnO_4$ in dilute sulfuric acid?

A 5 **B** 8 **C** 10 **D** 16

10. M/J 19/P13/Q19

In a catalytic converter 5.6 g of carbon monoxide reacts with an excess of nitrogen monoxide.

What is produced in this reaction?

A 2.4 g of C and 6.0 g of NO_2
B 2.4 g of C and 9.2 g of NO_2
C 8.8 g of CO_2 and 1.4 g of N_2
D 8.8 g of CO_2 and 2.8 g of N_2

11. MAR 19/P12/Q15

When calcium nitrate thermally decomposes, oxygen is one of the products.

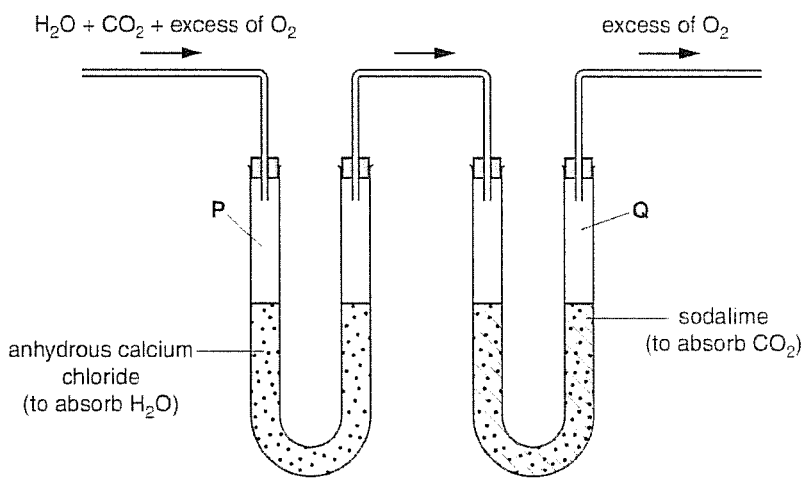
Which volume of oxygen is produced under room conditions when 0.50 mol of calcium nitrate thermally decomposes?

A 6.0 dm^3 **B** 12.0 dm^3 **C** 18.0 dm^3 **D** 30.0 dm^3

12. O/N 18/P11/Q3, O/N 18/P13/Q3, O/N 03/P1/Q3

A sample of the hydrocarbon C_6H_{12} is completely burned in dry oxygen and the product gases are collected as shown.

[A_r : H, 1 ; C, 12 ; O, 16.]



The increases in mass of the collecting vessels **P** and **Q** of the apparatus are M_P and M_Q, respectively. What is the ratio M_P / M_Q?

A 0.41 **B** 0.82 **C** 1.2 **D** 2.4

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13. M/J 17/P12/Q3

In some fireworks there is a reaction between powdered aluminium and powdered barium nitrate.
Heat is evolved, an unreactive gas is produced, and all nitrogen atoms are reduced.
What is the equation for this reaction?

A $2Al + Ba(NO_3)_2 \rightarrow Al_2O_3 + BaO + 2NO$

B $4Al + 4Ba(NO_3)_2 \rightarrow 2Al_2O_3 + 4Ba(NO_2)_2 + O_2$

C $10Al + 3Ba(NO_3)_2 \rightarrow 5Al_2O_3 + 3BaO + 3N_2$

D $10Al + 18Ba(NO_3)_2 \rightarrow 10Al(NO_3)_3 + 18BaO + 3N_2$

14. O/N 16/P12/Q3

People are advised to eat less than 6.00 g of salt (sodium chloride) per day for health reasons.
Which mass of sodium is present in 6.00 g of sodium chloride?

A 0.261 g **B** 2.36 g **C** 3.64 g **D** 3.88 g

15. O/N 16/P11/Q7, O/N 16/P13/Q7

The approximate percentage composition of the atmospheres on four different planets is given in the table below.
Which mixture of gases has the greatest density?

	planet	major gases / % by number of molecules		
		H_2	He	CH_4
A	Jupiter	89.8	10.2	0.0
B	Neptune	80.0	19.0	1.0
C	Saturn	96.3	3.3	0.4
D	Uranus	82.5	15.2	2.3

16. M/J 16/P12/Q4

In China, the concentration of blood glucose, $C_6H_{12}O_6$, is measured in mmol/*l*. In Pakistan, the concentration of blood glucose is measured in mg/d*l*.
The unit *l* is a litre (1 dm^3). The unit d*l* is a decilitre (0.1 dm^3).
A blood glucose concentration of 18.5 mmol/*l* indicates a health problem.
What is 18.5 mmol/*l* converted to mg/d*l*?

A 33.3 mg/d*l* **B** 178 mg/d*l* **C** 333 mg/d*l* **D** 3330 mg/d*l*

17. M/J 16/P11/Q4

When nuclear reactions take place, the elements produced are different from the elements that reacted. Nuclear equations, such as the one below, are used to represent the changes that occur.

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{144}_{56}Ba + {}^{89}_{36}Kr + 3{}^{1}_{0}n$$

The nucleon (mass) number total is constant at 236 and the proton number total is constant at 92.
In another nuclear reaction, uranium-238 is reacted with deuterium atoms, $^{2}_{1}H$. An isotope of a new element, J, is formed as well as two neutrons.

$$^{238}_{92}U + {}^{2}_{1}H \rightarrow J + 2{}^{1}_{0}n$$

What is isotope J?

A ^{238}Np **B** ^{238}Pu **C** ^{240}Np **D** ^{240}Pu

18. M/J 16/P11/Q17

A piece of rock has a mass of 2.00 g. It contains calcium carbonate, but no other basic substances. It neutralises exactly 36.0 cm^3 of 0.500 mol dm^{-3} hydrochloric acid.
What is the percentage of calcium carbonate in the 2.00 g piece of rock?

A 22.5% **B** 45.0% **C** 72.0% **D** 90.1%

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19. M/J 16/P11/Q6

A white powder is known to be a mixture of magnesium oxide and aluminium oxide.

100 cm^3 of 2 $moldm^{-3}$ NaOH(aq) is just sufficient to cause the aluminium oxide in x grams of the mixture to dissolve.

The reaction occurring is $Al_2O_3 + 2OH^- + 3H_2O \rightarrow 2Al(OH)_4^-$.

800 cm^3 of 2 mol dm^{-3} HCl (aq) is just sufficient to cause all of the oxide in x grams of the mixture to dissolve.

The reactions occurring are $Al_2O_3 + 6H^+ \rightarrow 2Al_3^+ + 3H_2O$ and $MgO + 2H^+ \rightarrow Mg^{2+} + H_2O$.

How many moles of each oxide are present in x grams of the mixture?

	aluminium oxide	magnesium oxide
A	0.05	0.25
B	0.05	0.50
C	0.10	0.25
D	0.10	0.50

20. M/J 16/P13/Q15, M/J 13/P13/Q12

Anhydrous magnesium nitrate, $Mg(NO_3)_2$, will decompose when heated, giving a white solid and a mixture of two gases X and Y.

Y is oxygen.

What is the ratio $\frac{\text{mass of X released}}{\text{mass of Y released}}$?

A $\frac{1}{0.174}$ **B** $\frac{1}{0.267}$ **C** $\frac{1}{0.348}$ **D** $\frac{1}{3.43}$

21. O/N 15/P13/Q3, O/N 15/P11/Q3

The compound S_2O_7 is hydrolysed by water to produce sulfuric acid and oxygen only.

Which volume of oxygen, measured at room temperature and pressure, is evolved when 0.352g of S_2O_7 is hydrolysed?

A 12 cm^3 **B** 24 cm^3 **C** 48 cm^3 **D** 96 cm^3

22. M/J 15/P12/Q2

The shell of a chicken's egg makes up 5% of the mass of an average egg. An average egg has a mass of 50 g. Assume the egg shell is pure calcium carbonate.

How many complete chicken's egg shells would be needed to neutralise 50 cm^3 of 2.0 mol dm^{-3} ethanoic acid?

A 1 **B** 2 **C** 3 **D** 4

23. O/N 14/P13/Q6

In some countries, anhydrous calcium chloride is used as a drying agent to reduce dampness in houses. The anhydrous salt absorbs enough water to form the dihydrate $CaCl_2.2H_2O$.

What is the percentage increase in mass?

A 14% **B** 24% **C** 32% **D** 36%

24. O/N 12/P12/Q15, O/N 12/P11/Q15

The nitrates of beryllium, calcium, magnesium, and strontium all decompose in the same way when heated. When 2.00 g of one of these anhydrous nitrates is decomposed, 1.32 g of gas is produced.

What is the nitrate?

A beryllium nitrate **B** calcium nitrate **C** magnesium nitrate **D** strontium nitrate

25. M/J 14/P11/Q26

How many moles of oxygen molecules are needed for the complete combustion of one mole of 3-methylpent-2-ene?

A 9 **B** $9\frac{1}{2}$ **C** 18 **D** 19

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26. M/J 14/P13/Q24

A student investigates four different fuels. Each fuel is used separately to raise the temperature of 1 dm^3 of water from 20 °C to 100 °C. Each fuel undergoes complete combustion. All other conditions are the same in each experiment.

Which fuel would produce the smallest amount of carbon dioxide in these experiments?

	fuel	energy released per mole of fuel
A	ethanol	1367 kJ mol^{-1}
B	methane	890 kJ mol^{-1}
C	methanol	715 kJ mol^{-1}
D	propane	2220 kJ mol^{-1}

27. M/J 12/P12/Q20, M/J 12/P11/Q22, M/J 12/P13/Q24

A sample of ethyl propanoate is hydrolysed by heating under reflux with aqueous sodium hydroxide. The two organic products of the hydrolysis are separated, purified and weighed.

Out of the total mass of products obtained, what is the percentage by mass of each product?

A 32.4 % and 67.6 % **B** 38.3 % and 61.7 % **C** 42.3 % and 57.7 % **D** 50.0 % and 50.0 %

28. O/N 11/P12/Q2

The following equations the letters **W**, **X**, **Y** and **Z** all represent whole numbers.

When correctly balanced, which equation requires one of letters **W**, **X**, **Y** or **Z** to be 5?

A $WC_3H_7COOH + XO_2 \rightarrow YCO_2 + ZH_2O$

B $WC_4H_8 + XO_2 \rightarrow YCO_2 + ZH_2O$

C $WH_3PO_4 + XNaOH \rightarrow YNa_2HPO_4 + ZH_2O$

D $WNH_3 + XO_2 \rightarrow YN_2 + ZH_2O$

29. O/N 11/P12/Q4

560 kg of nitrogen and 120 kg of hydrogen are pressurised, heated and passed over an iron catalyst. When the mixture of gases reaches equilibrium, it contains 96 kg of hydrogen.

Which mass of ammonia does it contain?

A 24 kg **B** 68 kg **C** 136 kg **D** 680 kg

30. O/N 11/P12/Q13

Methyl mercaptan, CH_3SH, has a foul smell and is often used to impart a smell to natural gas.

What will be formed when CH_3SH is burned in an excess of air?

A CO H_2O SO_2

B CO_2 H_2O H_2S

C CO_2 H_2O SO_2

D CO_2 H_2O SO_3

31. O/N 11/P11/Q25, O/N 11/P13/Q25

2.76 g of ethanol were mixed with an excess of aqueous acidified potassium dichromate(VI). The reaction mixture was then boiled under reflux for one hour. The organic product was then collected by distillation.

The yield of product was 75.0%.

What mass of product was collected?

A 1.98 g **B** 2.07 g **C** 2.70 g **D** 4.80 g

32. M/J 09/P1/Q2

A household bleach contains sodium chlorate(I), NaC*l*O, as its active ingredient. The concentration of NaC*l*O in the bleach can be determined by reacting a known amount with aqueous hydrogen peroxide, H_2O_2.

$$NaClO(aq) + H_2O_2(aq) \rightarrow NaCl(aq) + O_2(g) + H_2O(l)$$

When 25.0 cm^3 of bleach is treated with an excess of aqueous H_2O_2, 0.0350 mol of oxygen gas is given off.

What is the concentration of NaC*l*O in the bleach?

A 8.75×10^{-4} mol dm^{-3}

B 0.700 mol dm^{-3}

C 0.875 mol dm^{-3}

D 1.40 mol dm^{-3}

33. O/N 11/P13/Q1

Lead(IV) chloride will oxidise bromide ions to bromine. The Pb^{4+} ions are reduced to Pb^{2+} ions in this reaction.

If 6.980 g of lead(IV) chloride is added to an excess of sodium bromide solution, what mass of bromine would be produced?

A 0.799 g **B** 1.598 g **C** 3.196 g **D** 6.392 g

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34. O/N 08/P1/Q2

Carbon disulphide vapour burns in oxygen according to the following equation.

$$CS_2(g) + 3O_2(g) \rightarrow CO_2(g) + 2SO_2(g)$$

A sample of 10 cm^3 of carbon disulphide was burned in 50 cm^3 of oxygen. After measuring the volume of gas remaining, the product was treated with an excess of aqueous sodium hydroxide and the volume of gas measured again. All measurements were made at the same temperature and pressure, under such conditions that carbon disulphide was gaseous.

What were the measured volumes?

	volume of gas after burning / cm^3	volume of gas after adding NaOH(aq) / cm^3
A	30	0
B	30	20
C	50	20
D	50	40

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35. M/J 20/P13/Q31

Which contain one mole of the underlined substance under room conditions?

1 a balloon containing 24.0 dm^3 of helium
2 a block of calcium carbonate weighing 100.1 g
3 4000 cm^3 of a 0.250 mol dm^{-3} solution of sulfuric acid

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

36. MAR 19/P12/Q31, M/J 16/P12/Q31

In an experiment, 10 cm^3 of an organic compound, J, in the gaseous state was sparked with an excess of oxygen. 20 cm^3 of carbon dioxide and 5 cm^3 of nitrogen were obtained among the products. All gas volumes were measured at the same temperature and pressure.

What could be the identity of J?

1 $C_2H_6N_2$
2 C_2H_3N
3 C_2H_7N

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

37. O/N 19/P12/Q39

Which reagents, when used in excess, can convert Y into Z?

$$\underset{Y}{CH_3CH(OH)CO_2H} \rightarrow \underset{Z}{CH_3CH(OH)CO_2Na}$$

1 Na
2 Na_2CO_3
3 NaOH

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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Answers Sections

1.1	1.2	1.3	1.4	1.5	1.6
1. C	1. D	1. D	1. D	1. D	1. C
2. B	2. B	2. C	2. C	2. A	2. D
	3. A	3. D	3. A	3. D	3. C
	4. B	4. A	4. C	4. D	4. B
	5. A	5. B	5. B	5. C	5. C
	6. A		6. D	6. B	6. D
	7. B		7. C	7. B	7. C
	8. D		8. A	8. D	8. D
	9. A		9. A	9. A	9. B
	10. A		10. A	10. C	10. D
	11. C		11. D	11. A	11. A
	12. A		12. B	12. C	12. A
	13. D		13. C	13. C	13. C
	14. A		14. B	14. C	14. B
	15. D		15. A	15. D	15. D
	16. A		16. D	16. C	16. C
	17. D		17. C	17. B	17. A
	18. D		18. A	18. B	18. B
	19. A		19. A	19. A	19. D
	20. B		20. C	20. C	20. A
	21. A		21. D	21. A	21. B
	22. C		22. D	22. C	22. B
	23. D			23. B	23. C
	24. A			24. D	24. B
	25. A			25. B	25. A
				26. B	26. B
				27. A	27. C
				28. D	28. A
				29. D	29. C
				30. C	30. C
				31. A	31. C
				32. B	32. D
				33. C	33. C
				34. D	34. C
				35. B	35. A
				36. C	36. C
				37. C	37. C
				38. C	
				39. C	
				40. D	
				41. A	
				42. A	
				43. B	

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Unit 2

ATOMIC STRUCTURE

A Level
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Syllabus

2.1 Particles in the atom
2.2 The nucleus of the atom
2.3 Electrons: energy levels, atomic orbitals, ionisation energy, electron affinity
2.4 Multiple topics

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Unit 2: Atomic structure

2.1: Particles in the atom

1. **M/J 20/P11/Q10**
In which pair does each species have the same number of unpaired electrons?
A Al and Cu^{2+} **B** Ca and Cr^{3+} **C** Ca and Ni^{2+} **D** Fe^{3+} and O^{2-}

2. **M/J 20/P13/Q2**
Which molecule contains six bonding electrons?
A NCl_3 **B** H_2S **C** C_2H_4 **D** SF_6

3. **MAR 20/P12/Q1**
What number of protons, neutrons and electrons are present in the ion $^{54}Fe^{3+}$?

	protons	neutrons	electrons
A	26	28	23
B	26	28	29
C	29	25	23
D	29	25	26

4. **M/J 19/P11/Q5**
In which species is there a lone pair of electrons?
A CH_3 **B** CH_3^+ **C** CH_3^- **D** CH_4

5. **O/N 18/P12/Q2**
Beams of charged particles are deflected by an electrical field. The angle of deflection of a particle is proportional to its charge / mass ratio.
In an experiment protons are deflected by an angle of +15°. In another experiment under identical conditions $^2H^-$ ions are deflected by an angle of Y°.
What is the value of Y?
A –30.0 **B** –7.5 **C** +7.5 **D** +30.0

6. **M/J 18/P13/Q2**
Neutrons are passed through an electric field. The mass of one neutron relative to $\frac{1}{12}$ the mass of a ^{12}C atom and any deflection in the electric field is recorded.
Which row is correct?

	mass of neutron	behaviour of beam of neutrons in an electric field
A	0	deflected
B	1	deflected
C	0	not deflected
D	1	not deflected

7. **O/N 17/P12/Q1**
In which pair do the atoms contain the same number of neutrons?
A ^{11}B and ^{12}C **B** ^{7}Li and ^{9}Be **C** ^{24}Mg and ^{28}Si **D** ^{14}N and ^{16}O

8. **M/J 17/P12/Q1, M/J 13/P13/Q2**
In which species are the numbers of protons, neutrons and electrons **all** different?
A $^{19}_{9}F^-$ **B** $^{23}_{11}Na^+$ **C** $^{31}_{15}P$ **D** $^{32}_{16}S^{2-}$

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9. M/J 17/P13/Q1

The ion Y^{3-} contains 18 electrons and has a mass number of 31.
How many protons and neutrons does Y^{3-} contain?

	protons	neutrons
A	15	16
B	15	18
C	18	13
D	21	10

10. O/N 16/P11/Q5, O/N 16/P13/Q5

The ^{68}Ge isotope is medically useful because it undergoes a natural radioactive process to give an isotope of a different element, ^{68}X, which can be used to detect tumours. This transformation of ^{68}Ge occurs when an electron enters the nucleus and changes a proton into a neutron.
Which statement about the composition of an atom of ^{68}X is correct?

A It has 4 electrons in its outer p orbitals.
B It has 13 electrons in its outer shell.
C It has 37 neutrons.
D Its proton number is 32.

11. MAR 16/P12/Q3, M/J 13/P12/Q3, O/N 10/P11/Q6, O/N 10/P13/Q3, O/N 05/P1/Q2

Which ion has both more electrons than protons and more protons than neutrons?
[H = $^{1}_{1}H$; D = $^{2}_{1}H$; O = $^{16}_{8}O$]

A D^- **B** H_3O^+ **C** OD^- **D** OH^-

12. MAR 16/P12/Q4

Which species contains the smallest number of electrons?

A B^{3+} **B** Be^{2+} **C** H^- **D** He^+

13. M/J 13/P11/Q5

In which species are the numbers of protons, neutrons and electrons all different?

A $^{27}_{13}Al$ **B** $^{35}_{17}Cl^-$ **C** $^{32}_{16}S^{2-}$ **D** $^{39}_{19}K^+$

14. M/J 11/P12/Q1

Helium, He, is the second element in the Periodic Table.
Tritium is the isotope of hydrogen ^3H.
What is the same in an atom of ^4He and an atom of ^3H?

A the number of electrons
B the number of neutrons
C the number of protons
D the relative atomic mass

15. M/J 10/P12/Q2, M/J 10/P11/Q1, M/J 10/P13/Q3

What could be the proton number of an element that has three unpaired electrons in each of its atoms?

A 5 **B** 13 **C** 15 **D** 21

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16. M/J 19/P12/Q32, M/J 15/P13/Q31

The technetium-99 isotope, ^{99}Tc, is radioactive and has been found in lobsters and seaweed near to nuclear fuel reprocessing plants.
Which statements about an atom of ^{99}Tc are correct?

1 It has 13 fewer protons than neutrons.
2 It forms $^{99}Tc^{2+}$ which has 45 electrons.
3 It has 56 nucleons.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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17. O/N 19/P11/Q31, O/N 19/P13/Q31

A particular atom of germanium, Ge, has a nucleon number of 70.

Which statements about a $^{70}_{32}Ge$ atom are correct?

1 It has the same number of electrons as a $^{79}_{34}Se^{2+}$ ion.

2 It has the same number of neutrons as an atom of $^{68}_{30}Zn$.

3 It has half as many protons as an atom of $^{160}_{64}Gd$.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

18. M/J 19/P11/Q31

An atom of calcium-48 can form a 2+ ion.

Which statements about this ion are correct?

1 It has 20 protons.
2 It has 28 neutrons.
3 It has 22 electrons.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

19. M/J 19/P13/Q31

Which deductions about the $^{209}_{83}Bi$ atom are correct?

1 It has 83 electrons.
2 It has 126 nucleons.
3 It has 83 neutrons.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

20. O/N 18/P11/Q31, O/N 18/P13/Q31, O/N 14/P12/Q31, O/N 14/P11/Q31

Which ions contain one or more unpaired electrons?

1 Cu^{2+} 2 Mn^{3+} 3 V^{3+}

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

21. M/J 18/P12/Q32

In which pairs do both species have the same number of electrons?

1 ^{35}Cl and ^{37}Cl 2 $^{35}Cl^-$ and ^{40}Ar 3 ^{40}Ar and $^{40}K^+$

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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22. O/N 17/P12/Q31

In 2011 an international group of scientists agreed to add two new elements to the Periodic Table. Both elements had been made artificially and are called flerovium, Fl, and livermorium, Lv.

	Fl	Lv
proton number	114	116
nucleon number	289	292

From the information about atoms in the table, which statements are correct?

1 One atom of Lv has one more neutron than one atom of Fl.
2 One Fl^{2-} ion has the same number of electrons as one atom of Lv.
3 One Lv^{+} ion has the same number of electrons as one Fl^{-} ion.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

23. M/J 17/P11/Q31

Beams of charged particles are deflected by an electric field. In identical conditions the angle of deflection of a particle is proportional to its charge / mass ratio.

In an experiment, protons are deflected by an angle of +15°. In another experiment under identical conditions, particle Y is deflected by an angle of –5°.

What could be the composition of particle Y?

	protons	neutrons	electrons
1	1	2	2
2	3	3	5
3	4	5	1

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

24. M/J 16/P11/Q31, O/N 13/P12/Q31, O/N 13/P11/Q31

X is a particle with 18 electrons and 20 neutrons.

What could be the symbol of X?

1 $^{38}_{18}Ar$ 2 $^{40}_{20}Ca^{2+}$ 3 $^{39}_{19}K^{+}$

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

25. M/J 15/P12/Q31

Which statements about the phosphide ion, $^{31}P^{3-}$, and the chloride ion, $^{35}Cl^{-}$, are correct?

1 They have the same number of electrons.
2 They have the same number of neutrons.
3 They have the same number of protons.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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26. M/J 15/P11/Q31, O/N 12/P12/Q32, O/N 12/P11/Q32

The isotope ^{99}Tc is radioactive and has been found in lobsters and seaweed adjacent to nuclear fuel reprocessing plants.

Which statements are correct about an atom of ^{99}Tc?

1 It has 13 more neutrons than protons.
2 It has 43 protons.
3 It has 99 nucleons.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

27. M/J 14/P13/Q31

In 2011 an international group of scientists agreed to add two new elements to the Periodic Table. Both elements had been made artificially and were called ununquadium (Uuq) and ununhexium (Uuh).

	Uuq	Uuh
proton number	114	116
nucleon number	289	292

Which statements about these elements are correct?

1 One atom of Uuh has one more neutron than one atom of Uuq.
2 One Uuq^{2-} ion has the same number of electrons as one atom of Uuh.
3 One Uuh^{+} ion has the same number of electrons as one Uuq^{-} ion.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

28. O/N 13/P13/Q31

The $^{1}H_3^{+}$ ion was first characterised by J. J. Thomson over a century ago. ^{6}Li is a rare isotope of lithium which forms the $^{6}Li^{+}$ ion.

Which statements are correct?

1 Both ions contain the same number of protons.
2 Both ions contain the same number of electrons.
3 Both ions contain the same number of neutrons.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

29. M/J 13/P12/Q31

In which pairs do both species have the same number of unpaired p electrons?

1 Al^{2-} and O^{+} 2 N and Cl^{2+} 3 C and Cl^{+}

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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30. O/N 12/P13/Q32

The phosphide ion $^{31}_{15}P^{3-}$ and sulfide ion $^{32}_{16}S^{2-}$ have the same number of which sub-atomic particles?

1 neutrons
2 electrons
3 protons

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

31. M/J 12/P11/Q40, M/J 12/P13/Q39

How can a good yield of ethylamine be made using bromoethane as starting material?

1 by heating bromoethane with an excess of ammonia gas in a sealed tube
2 by adding dilute aqueous ammonia to bromoethane at room temperature
3 by heating bromoethane under reflux with aqueous ammonium chloride

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

32. M/J 09/P1/Q31

On a scale in which the mass of a ^{12}C atom is 12 the relative molecular mass of a particular sample of chlorine is 72.

Which properties of the atoms in this sample are always the same?

1 radius
2 nucleon number
3 isotopic mass

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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2.2: The nucleus of the atom

1. **O/N 18/P12/Q3**
Rubidium and bromine form ions that are isoelectronic. Each ion has 36 electrons.
Which row is correct?

	rubidium radii	bromine /bromide radii
A	atomic < ionic	atomic < ionic
B	atomic < ionic	atomic > ionic
C	atomic > ionic	atomic < ionic
D	atomic > ionic	atomic > ionic

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2. **M/J 19/P13/Q32**
Which statements are correct when referring to the two common isotopes of chlorine?
1 The isotopes have different masses.
2 The isotopes have different numbers of nucleons.
3 The isotopes have the same chemical reactions.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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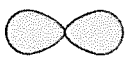
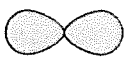
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2.3: Electrons: energy levels, atomic orbitals, ionisation energy, electron affiity

1. **M/J 20/P13/Q1**
Which particle has equal numbers of protons and neutrons and an electronic structure of $1s^2 2s^2 2p^6 3s^2 3p^6$?
A $^{39}_{18}Ar$ **B** $^{40}_{20}Ca^{2+}$ **C** $^{16}_{8}O^{2-}$ **D** $^{32}_{16}S$

2. **M/J 20/P13/Q8, O/N 16/P12/Q5**
What is the electronic configuration of an isolated Ni^{2+} ion?
A $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$
B $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 4s^2$
C $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2$
D $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8$

3. **M/J 19/P11/Q4**
The outermost electron in an atom of neon occupies a particular orbital.
Which row shows the relative energy and shape of this orbital?

	energy of orbital relative to other occupied orbitals	shape of orbital
A	higher or equal	
B	higher or equal	
C	lower or equal	
D	lower or equal	

4. **M/J 19/P13/Q3**
Which atom has exactly three unpaired electrons?
A an isolated gaseous aluminium atom
B an isolated gaseous carbon atom
C an isolated gaseous chromium atom
D an isolated gaseous phosphorus atom

5. **O/N 18/P11/Q1, O/N 18/P13/Q1**
The first four ionisation energies for element X are shown in the table.

ionisation energy	1st	2nd	3rd	4th
value / kJ mol^{-1}	577	1980	2960	6190

Which ion of X is produced by removing an electron from a filled shell?
A X^+ **B** X^{2+} **C** X^{3+} **D** X^{4+}

6. **M/J 18/P12/Q2**
The electronic configuration of an atom of sulfur is $1s^2 2s^2 2p6^3 s^2 3p^4$.
How many valence shell and unpaired electrons are present in one sulfur atom?

	valence shell electrons	unpaired electrons
A	2	1
B	4	2
C	6	0
D	6	2

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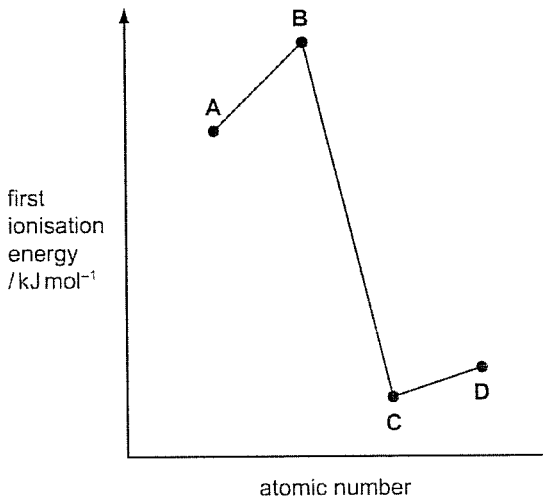
7. M/J 18/P11/Q1

This question refers to isolated gaseous atoms.
In which atom are all electrons paired?

A Ba **B** Br **C** S **D** Si

8. O/N 17/P11/Q2, O/N 17/P13/Q2, M/J 14/P12/Q10

Shown on the graph are the relative values of the first ionisation energies of four elements that have consecutive atomic numbers.
One of the elements reacts with hydrogen to form a covalent compound with formula HX.
Which element could be X?



9. M/J 17/P11/Q12

Why is the second ionisation energy of sodium larger than the second ionisation energy of magnesium?

A The attraction between the nucleus and the outer electron is greater in Na^+ than in Mg^+.
B The nuclear charge of Na^+ is greater than that of Mg^+.
C The outer electron of Na^+ is more shielded than the outer electron of Mg^+.
D The outer electron of Na is in the same orbital as the outer electron of Mg.

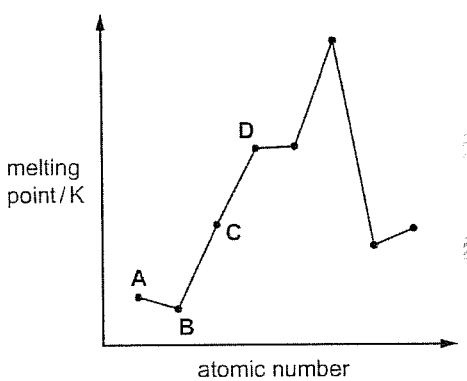
10. MAR 17/P12/Q1

Which ion has the same electronic configuration as Cl^-?

A F^- **B** P^+ **C** Sc^{3+} **D** Si^{4+}

11. O/N 16/P11/Q13, O/N 16/P13/Q13

The diagram shows the melting points of eight elements with consecutive atomic numbers.
Which element could be sodium?



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12. M/J 16/P12/Q2

Four electronic configurations are shown below. Three of these configurations belong to atoms of the elements chlorine, sodium and vanadium.
Which electronic configuration belongs to an atom of another element?

A $1s^2 2s^2 2p^6 3s^1$
B $1s^2 2s^2 2p^6 3s^2 3p^5$
C $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3 4s^2$
D $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$

13. M/J 16/P12/Q3

Elements X and Y are in the same group of the Periodic Table.
The table shows the first six ionisation energies of X and Y in $kJmol^{-1}$.

	1st	2nd	3rd	4th	5th	6th
X	800	1600	2400	4300	5400	10400
Y	1000	1800	2700	4800	6000	12300

What could be the identities of X and Y?

	X	Y
A	antimony, Sb	arsenic, As
B	arsenic, As	antimony, Sb
C	selenium, Se	tellurium, Te
D	tellurium, Te	selenium, Se

14. M/J 16/P13/Q5

Which isolated gaseous atom has a total of five electrons occupying spherically shaped orbitals?

A boron **B** fluorine **C** sodium **D** potassium

15. MAR 16/P12/Q2

For the element sulfur, which pair of ionisation energies has the largest difference between them?

A third and fourth ionisation energies
B fourth and fifth ionisation energies
C fifth and sixth ionisation energies
D sixth and seventh ionisation energies

16. O/N 15/P11/Q1, O/N 15/P13/Q1, O/N 12/P13/Q7, O/N 03/P1/Q5

The table gives the successive ionisation energies for an element X.

	1st	2nd	3rd	4th	5th	6th
ionisation energy / $kJ\,mol^{-1}$	950	1800	2700	4800	6000	12300

What could be the formula of a chloride of X?

A XCl **B** XCl_2 **C** XCl_3 **D** XCl_4

17. M/J 15/P11/Q2

Which quantity gives the best indication of the relative strengths of the hydrogen bonds between the molecules in liquid hydrogen halides?

A bond dissociation energies
B enthalpy changes of formation
C enthalpy changes of solution
D enthalpy changes of vaporisation

18. M/J 14/P11/Q1

Atoms of element X have six unpaired electrons.
What could be element X?

A carbon **B** chromium **C** iron **D** selenium

19. O/N 13/P12/Q4, O/N 13/P11/Q4

In which set do all species contain the same number of electrons?

A Co^{2+}, Co^{3+}, Co^{4+}
B F^-, Br^-, Cl^-
C Na^+, Mg^{2+}, Al^{3+}
D K_2SO_4, K_2SeO_4, K_2TeO_4

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20. M/J 14/P13/Q4

The most common ion-molecule reaction in gas clouds of the Universe is as shown.

$$H_2(g) + H_2^+(g) \rightarrow H(g) + H_3^+(g)$$

What could be the composition of an H_3^+ ion?

	protons	neutrons	electrons
A	2	1	1
B	2	1	2
C	3	0	1
D	3	0	2

21. O/N 13/P12/Q19, O/N 13/P11/Q19

Consecutive elements **X**, **Y** and **Z** are in the third period of the Periodic Table. Element **Y** has the highest first ionisation energy and the lowest melting point of these three elements.

What could be the identities of **X**, **Y** and **Z**?

A sodium, magnesium, aluminium
B magnesium, aluminium, silicon
C aluminium, silicon, phosphorus
D silicon, phosphorus, sulfur

22. O/N 13/P13/Q4

Element X forms X^- ions that can be oxidised to element X by acidified potassium manganate(VII).

What could be the values of the first four ionisation energies of X?

	1st	2nd	3rd	4th
A	418	3070	4600	5860
B	577	1820	2740	11 600
C	590	1150	4940	6480
D	1010	1840	2040	4030

23. M/J 13/P13/Q3

The first six ionisation energies of four elements are given.

Which element is most likely to be in Group IV of the Periodic Table?

	ionisation energy / kJ mol^{-1}					
	1st	2nd	3rd	4th	5th	6th
A	494	4 560	6 940	9 540	13 400	16 600
B	736	1 450	7 740	10 500	13 600	18 000
C	1 090	2 350	4 610	6 220	37 800	47 000
D	1 400	2 860	4 590	7 480	9 400	53 200

24. M/J 12/P11/Q1, M/J 12/P13/Q2

In which species does the underlined atom have an incomplete outer shell?

A $\underline{B}F_3$ **B** $\underline{C}H_3^-$ **C** $F_2\underline{O}$ **D** $H_3\underline{O}^+$

25. O/N 11/P12/Q3

From which particle is the removal of an electron the most difficult?

A $Cl^-(g)$ **B** $F^-(g)$ **C** $K^+(g)$ **D** $Na^+(g)$

26. O/N 11/P11/Q3, O/N 11/P13/Q2

Which element has an equal number of electron pairs and of unpaired electrons within orbitals of principal quantum number 2?

A beryllium **B** carbon **C** nitrogen **D** oxygen

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27. M/J 11/P11/Q1, M/J 11/P13/Q1
Which equation represents the second ionisation energy of an element X?

A $X(g) \rightarrow X^{2+}(g) + 2e^-$ **C** $X(g) + 2e^- \rightarrow X^{2-}(g)$

B $X^+(g) \rightarrow X^{2+}(g) + e^-$ **D** $X^-(g) + e^- \rightarrow X^{2-}(g)$

28. M/J 11/P11/Q5, M/J 11/P13/Q2
Which factor helps to explain why the first ionisation energies of the Group I elements decrease from lithium to sodium to potassium to rubidium?

A The nuclear charge of the elements increases.

B The outer electron is in an 's' subshell.

C The repulsion between spin-paired electrons increases.

D The shielding effect of the inner shells increases.

29. O/N 10/P11/Q2, O/N 10/P13/Q1
A simple ion X^+ contains eight protons.
What is the electronic configuration of X^+?

A $1s^2\ 2s^1\ 2p^6$ **B** $1s^2\ 2s^2\ 2p^3$ **C** $1s^2\ 2s^2\ 2p^5$ **D** $1s^2\ 2s^2\ 2p^7$

30. O/N 10/P11/Q13, O/N 10/P13/Q16
Why is the first ionisation energy of phosphorus greater than the first ionisation energy of silicon?

A A phosphorus atom has one more proton in its nucleus.

B The atomic radius of a phosphorus atom is greater.

C The outer electron in a phosphorus atom is more shielded.

D The outer electron in a phosphorus atom is paired.

31. M/J 10/P12/Q3, M/J 10/P11/Q2, M/J 10/P13/Q2
The elements radon (Rn), francium (Fr) and radium (Ra) have consecutive proton numbers in the Periodic Table.
What is the order of their first ionisation energies?

	least endothermic →		most endothermic
A	Fr	Ra	Rn
B	Fr	Rn	Ra
C	Ra	Fr	Rn
D	Rn	Ra	Fr

32. M/J 09/P1/Q3
The first seven ionisation energies of an element between lithium and neon in the Periodic Table are as follows.

1310 3390 5320 7450 11 000 13 300 71 000 kJ mol^{-1}

What is the outer electronic configuration of the element?

A $2s^2$ **B** $2s^22p^1$ **C** $2s^22p^4$ **D** $2s^22p^6$

33. O/N 08/P1/Q3
In which pair do both atoms have one electron only in an s orbital in their ground states?

A Ca, Sc **B** Cu, Be **C** H, He **D** Li, Cr

34. O/N 08/P1/Q4
Hard water contains calcium ions and hydrogencarbonate ions arising from dissolved calcium hydrogencarbonate, $Ca(HCO_3)_2$.
How many electrons are present in the hydrogencarbonate anion?

A 30 **B** 31 **C** 32 **D** 33

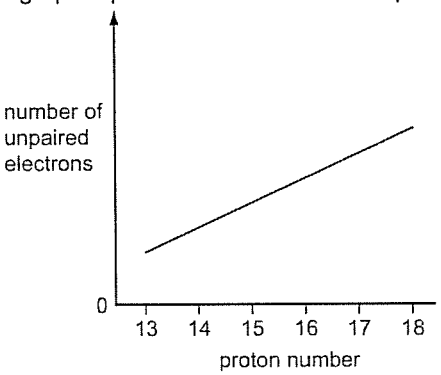
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35. M/J 09/P1/Q4

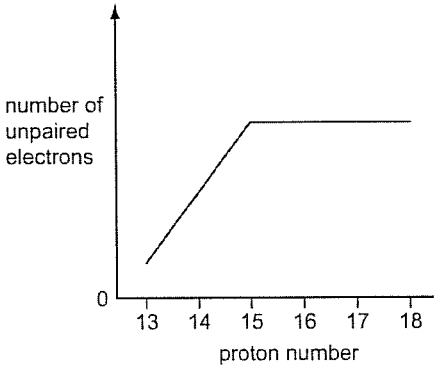
Use of the Data Booklet is relevant to this question.

Which graph represents the number of unpaired p orbital electrons for atoms with proton numbers 13 to 18?

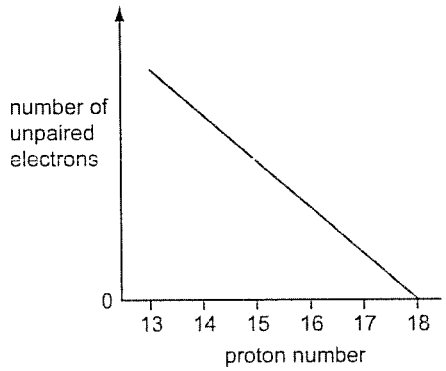
A



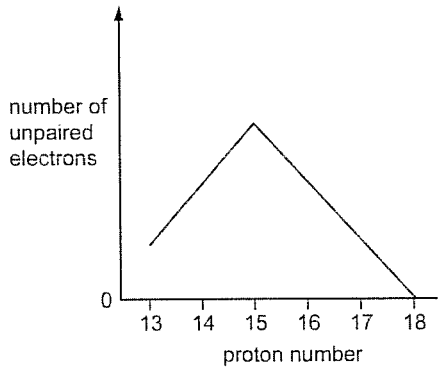
C



B



D



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36. MAR 20/P12/Q31, O/N 13/P12/Q32, O/N 13/P11/Q32

Carbon and nitrogen are adjacent in the Periodic Table.

Which properties do they both have?

1 There is an empty 2p orbital in one atom of the element.
2 The principal quantum number of the highest occupied orbital is 2.
3 They form compounds in which their atoms form bonds with four other atoms.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

37. M/J 17/P12/Q31

An isolated gaseous atom of element X has paired electrons in at least one of its 3d orbitals and has a filled 4s subshell.

What could be the identity of element X?

1 iron
2 gallium
3 copper

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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38. M/J 20/P12/Q34

Sodium and fluorine are both reactive elements. Two atoms are described.

	F	Na
atomic number	9	11
nucleon number	19	23

Which statements about these two atoms, and the ions they can form, are correct?

1 One Na atom has two more protons than one F^- ion.
2 One Na atom has two more neutrons than one F atom.
3 One Na^+ ion has the same number of electrons as one F^- ion.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

39. M/J 19/P11/Q32

Four elements, W, X, Y and Z, have electronic configurations as shown.

W	X	Y	Z
2,4	2,6	2,8,2	2,8,8,1

Which formulae represent compounds that have boiling points below room temperature?

1 WX_2 2 YX 3 Z_2X

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

40. M/J 17/P13/Q31

Which statements about the atoms ^{23}Na and ^{24}Mg are correct?

1 They have the same number of filled electron orbitals.
2 They have the same number of neutrons.
3 They are both reducing agents.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

41. M/J 16/P13/Q31

Compound X is made from two elements. One element has the second highest value of first ionisation energy in its group and the other element has the third highest value of first ionisation energy in its group.
Which compounds could be compound X?

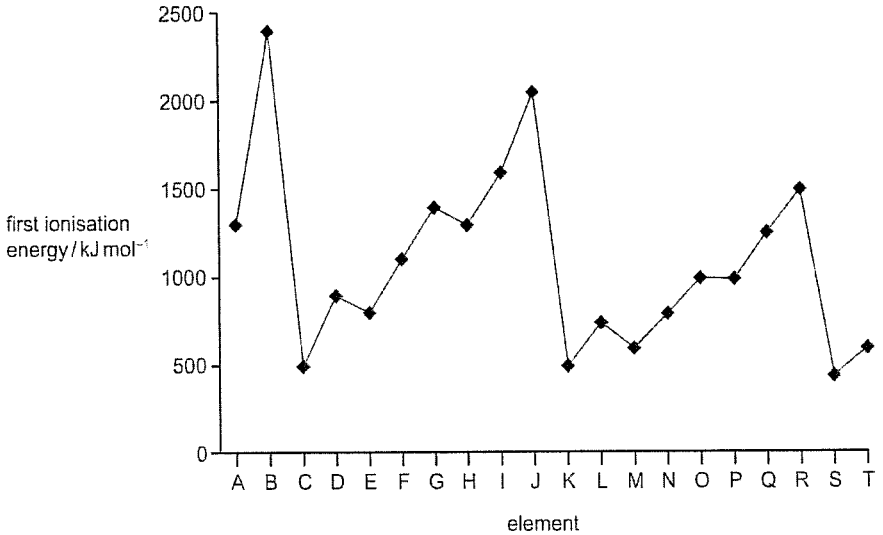
1 calcium chloride
2 magnesium bromide
3 potassium sulfide

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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42. M/J 16/P12/Q35, M/J 13/P11/Q34

The first ionisation energies of twenty successive elements in the Periodic Table are represented in the graph. The letters given are not the normal symbols for these elements.



Which statements about this graph are correct?

1 Elements B, J and R are in Group 0 of the Periodic Table.
2 Atoms of elements D and L contain two electrons in their outer shells.
3 Atoms of elements G and O contain a half-filled p subshell.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

43. O/N 15/P12/Q32

Which of the following influence the size of the ionisation energy of an atom?

1 the amount of shielding by the inner electrons
2 the charge on the nucleus
3 the distance between the outer electrons and the nucleus

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

44. O/N 15/P11/Q31, O/N 15/P13/Q31

Which statements about orbitals in a krypton atom are correct?

1 The 1s and 2s orbitals have the same energy as each other but different sizes.
2 The third energy level (n=3) has three subshells and nine orbitals.
3 The 3d subshell has five orbitals that have the same energy as each other in an isolated atom.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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45. M/J 12/P11/Q32, M/J 12/P13/Q32

In which pairs do both species have the same number of unpaired p electrons?

1 O and Cl^+
2 F^+ and Ga^-
3 P and Ne^+

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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2.4: Multiple Topics

1. M/J 19/P12/Q2

Oxygen has three stable isotopes, ^{16}O, ^{17}O and ^{18}O. All three isotopes are present in a sample of oxygen gas, O_2, which was analysed using a mass spectrometer.

How many peaks associated with the O_2^+ ion would be expected?

A 3 **B** 5 **C** 6 **D** 9

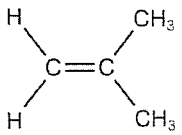
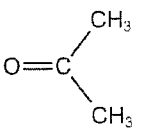
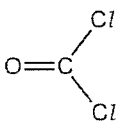
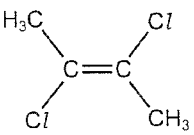
2. M/J 17/P11/Q4

Which property of an atom does **not** affect its first ionisation energy?

A the atomic radius
B the number of electron shells
C the number of neutrons
D the number of protons

3. M/J 17/P11/Q5, M/J 12/P12/Q10

Which molecule has the largest overall dipole?

A 
B 
C 
D 

4. M/J 17/P11/Q9

When K_2MnO_4 is dissolved in water, the following reaction occurs.

$$a MnO_4^{2-}(aq) + b H_2O(l) \rightarrow c MnO_4^-(aq) + d MnO_2(s) + e OH^-(aq)$$

What are the values of *a* and *c* in the balanced chemical equation?

	a	*c*
A	2	1
B	3	2
C	4	3
D	5	4

5. M/J 16/P13/Q6

Carbon and silicon have the same outer electronic structure.

Why is a Si–Si bond weaker than a C–C bond?

A Silicon atoms have a larger atomic radius than carbon atoms.
B Silicon has a greater nuclear charge than carbon.
C Silicon has a smaller first ionisation energy than carbon.
D Silicon is more metallic than carbon.

6. M/J 15/P13/Q17

This question refers to isolated gaseous species.

The species F^-, Ne and Na^+ are isoelectronic. This means they have the same number of electrons.

In which order do their radii increase?

	smallest →		largest
A	Na^+	F^-	Ne
B	F^-	Ne	Na^+
C	Na^+	Ne	F^-
D	Ne	F^-	Na^+

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7. M/J 15/P12/Q1

In which option do all three particles have the same electronic configuration **and** the same number of neutrons?

A $^{15}N^{3-}$ $^{16}O^{2-}$ $^{19}F^{-}$ **B** $^{18}O^{2-}$ $^{19}F^{-}$ ^{20}Ne **C** $^{19}F^{-}$ ^{20}Ne $^{23}Na^{+}$ **D** ^{22}Ne ^{23}Na $^{24}Mg^{2+}$

8. M/J 14/P13/Q16

The species Ne, Na^+ and Mg^{2+} are isoelectronic. This means that they have the same number of electrons. In which order do their radii increase?

	smallest ⟶		largest
A	Ne	Na^+	Mg^{2+}
B	Ne	Mg^{2+}	Na^+
C	Mg^{2+}	Ne	Na^+
D	Mg^{2+}	Na^+	Ne

9. M/J 13/P12/Q2

Equations involving four enthalpy changes are shown.

$Na(g) \rightarrow Na^+(g) + e^-$ $\Delta H = W$

$Na(g) \rightarrow Na^{2+}(g) + 2e^-$ $\Delta H = X$

$Na(s) \rightarrow Na(g)$ $\Delta H = Y$

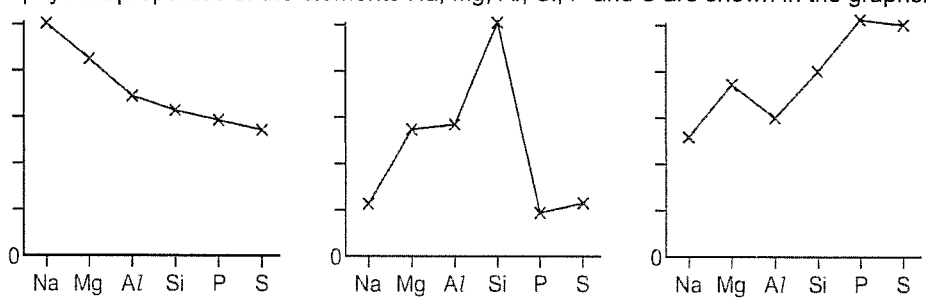
$Na(s) \rightarrow Na^{2+}(g) + 2e^-$ $\Delta H = Z$

What is the second ionisation energy of sodium?

A X **B** X – W **C** Y – W **D** Z – Y

10. M/J 13/P12/Q16

The trends in three physical properties of the elements Na, Mg, Al, Si, P and S are shown in the graphs.



Which physical property is **not** illustrated?

A atomic radius

B electrical conductivity

C first ionisation energy

D melting point

11. M/J 13/P11/Q4

The elements radon (Rn), francium (Fr) and radium (Ra) have proton numbers 86, 87 and 88 respectively. What is the order of their first ionisation energies?

	least endothermic ⟶		most endothermic
A	Fr	Ra	Rn
B	Fr	Rn	Ra
C	Ra	Fr	Rn
D	Rn	Ra	Fr

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12. O/N 12/P12/Q2, O/N 12/P11/Q2

The ^{68}Ge isotope is medically useful because it undergoes a natural radioactive process to give a gallium isotope, ^{68}Ga, which can be used to detect tumours. This transformation of ^{68}Ge occurs when an electron enters the nucleus, changing a proton into a neutron.

Which statement about the composition of an atom of the ^{68}Ga isotope is correct?

A It has 4 electrons in its outer p subshell.
B It has 13 electrons in its outer shell.
C It has 37 neutrons.
D Its proton number is 32.

13. O/N 12/P12/Q9, O/N 12/P11/Q9, M/J 07/P1/Q3

John Dalton's atomic theory, published in 1808, contained four predictions about atoms.

Which of his predictions is still considered to be correct?

A All atoms are very small in size.
B All the atoms of a particular element have the same mass.
C All the atoms of one element are different in mass from all the atoms of other elements.
D No atom can be split into simpler parts.

14. M/J 12/P12/Q2

In which species are the numbers of protons, neutrons and electrons all different?

A $^{11}_{5}B$ **B** $^{19}_{9}F^-$ **C** $^{23}_{11}Na^+$ **D** $^{24}_{12}Mg^{2+}$

15. M/J 12/P12/Q8

The value of the third ionisation energy of aluminium is 2740 kJ mol^{-1}.

Which correctly represents this statement?

A $Al(g) \rightarrow Al^{3+}(g) + 3e^-$ $\Delta H^{\ominus} = -2740$ kJ mol^{-1}
B $Al^{2+}(g) \rightarrow Al^{3+}(g) + e^-$ $\Delta H^{\ominus} = -2740$ kJ mol^{-1}
C $Al(g) \rightarrow Al^{3+}(g) + 3e^-$ $\Delta H^{\ominus} = +2740$ kJ mol^{-1}
D $Al^{2+}(g) \rightarrow Al^{3+}(g) + e^-$ $\Delta H^{\ominus} = +2740$ kJ mol^{-1}

16. M/J 12/P11/Q4, M/J 12/P13/Q3

The value of the second ionisation energy of calcium is 1150 kJ mol^{-1}.

Which equation correctly represents this statement?

A $Ca(g) \rightarrow Ca^{2+}(g) + 2e^-$; $\Delta H^{\ominus} = +1150$ kJ mol^{-1}
B $Ca^+(g) \rightarrow Ca^{2+}(g) + e^-$; $\Delta H^{\ominus} = +1150$ kJ mol^{-1}
C $Ca^+(g) \rightarrow Ca^{2+}(g) + e^-$; $\Delta H^{\ominus} = -1150$ kJ mol^{-1}
D $Ca(g) \rightarrow Ca^{2+}(g) + 2e^-$; $\Delta H^{\ominus} = -1150$ kJ mol^{-1}

17. M/J 12/P11/Q5, M/J 12/P13/Q6

Two conversions are outlined below.

$NH_4^+ \rightarrow NH_3$
$C_2H_4 \rightarrow C_2H_6$

What similar feature do these two conversions have?

A a lone pair of electrons in the product
B change in oxidation state of an element
C decrease in bond angle of the species involved
D disappearance of a π bond

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18. M/J 20/P12/Q31

Scientists are trying to synthesise a new element with proton number 119. The element is predicted to be a Group 1 element in Period 8 of the Periodic Table.

Which predictions are likely to be correct about this element?

1 The outermost occupied orbital of one atom of this element will be an s orbital.
2 The atomic radius will be the largest of the seven elements in Group 1.
3 It will have a greater first ionisation energy than element 118.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

19. O/N 19/P12/Q31

Which gaseous molecules are polar?

1 ammonia
2 hydrogen sulfide
3 boron trifluoride

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

20. O/N 19/P11/Q32, O/N 19/P13/Q32

The first ionisation energy of chlorine is greater than that of sulfur.

Which factors contribute to this?

1 Chlorine has more protons in its nucleus than sulfur does.
2 Chlorine has greater electron shielding than sulfur does.
3 The covalent bonds in chlorine molecules are stronger than those in sulfur molecules.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

21. M/J 19/P12/Q31

When O_2 reacts with H_2S the products are SO_2 and H_2O.

Mixture Y contains an equal number of the two molecules shown, and **no other molecules.**

$$^{16}_{8}O = {}^{18}_{8}O \qquad {}^{1}_{1}H - {}^{32}_{16}S - {}^{1}_{1}H$$

Which statements about Y are correct?

1 The average M_r in Y is 34.
2 If some oxygen molecules are removed from Y, the average M_r of the mixture remains the same.
3 When mixture Y is ignited, some H_2S remains unreacted.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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22. MAR 19/P12/Q32

In which pairs do both species have the same number of unpaired electrons in p orbitals?

1 O and Cl^+ 2 F^+ and Ga^- 3 N and Kr^{3+}

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

23. O/N 17/P11/Q31, O/N 17/P13/Q31

The definitions of many chemical terms can be illustrated by chemical equations.

Which terms can be illustrated by an equation that includes the formation of a positive ion?

1 first ionisation energy
2 heterolytic fission of a covalent bond
3 enthalpy change of atomisation

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

24. O/N 15/P12/Q31

The relative molecular mass, M_r, of a particular sample of chlorine is 72.0.

Which properties of the atoms in this sample will be the same for all of the atoms?

1 radius 2 nucleon number 3 isotopic mass

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

25. O/N 14/P13/Q32

Which statements are correct when referring to the isotopes of a single element?

1 The isotopes have different masses.
2 The isotopes have different numbers of nucleons.
3 The isotopes have different chemical reactions.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

26. M/J 13/P13/Q32

Which statements are correct when referring to the atoms ^{23}Na and ^{24}Mg?

1 They have the same number of full electron orbitals.
2 They have the same number of neutrons.
3 They are both reducing agents.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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27. M/J 12/P11/Q33, M/J 12/P13/Q31

Nitrogen and phosphorus are both in Group V of the Periodic Table. Phosphorus forms a chloride with the formula PCl_5.

Why is it **not** possible for nitrogen to form NCl_5?

1 Nitrogen's outer shell can only contain eight electrons.
2 Nitrogen cannot have oxidation state +5.
3 Nitrogen is almost inert.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

28. M/J 10/P12/Q31, M/J 10/P11/Q33, M/J 10/P13/Q32

Sodium hydrogensulfide, NaSH, is used to remove hair from animal hides.

Which statements about the SH^- ion are correct?

1 It contains 18 electrons.
2 Three lone pairs of electrons surround the sulfur atom.
3 Sulfur has an oxidation state of +2.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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Answers Sections

2.1		2.2		2.3				2.4	
1.	A	1.	C	1.	B	41.	A	1.	B
2.	A	2.	A	2.	D	42.	A	2.	C
3.	A			3.	A	43.	A	3.	B
4.	C			4.	D	44.	C	4.	B
5.	B			5.	D	45.	B	5.	A
6.	D			6.	D			6.	C
7.	A			7.	A			7.	B
8.	B			8.	A			8.	D
9.	A			9.	A			9.	B
10.	C			10.	C			10.	B
11.	D			11.	C			11.	A
12.	D			12.	D			12.	C
13.	D			13.	A			13.	A
14.	B			14.	C			14.	C
15.	C			15.	D			15.	D
16.	D			16.	C			16.	B
17.	A			17.	D			17.	C
18.	B			18.	B			18.	B
19.	D			19.	C			19.	B
20.	A			20.	D			20.	D
21.	A			21.	D			21.	A
22.	A			22.	D			22.	A
23.	B			23.	C			23.	B
24.	A			24.	A			24.	D
25.	D			25.	D			25.	B
26.	A			26.	D			26.	C
27.	A			27.	B			27.	D
28.	B			28.	D			28.	B
29.	A			29.	B				
30.	B			30.	A				
31.	D			31.	A				
32.	D			32.	C				
				33.	D				
				34.	C				
				35.	D				
				36.	C				
				37.	B				
				38.	A				
				39.	D				
				40.	C				

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A Level

Unit 3

CHEMICAL BONDING

A Level
Chemistry Paper 1
Classified/Topical MCQ's
Article Number: 231

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Syllabus

- 3.1 Ionic bonding
- 3.2 Covalent bonding and co-ordinate (dative covalent bonding including shapes of simple molecules)
- 3.3 Intermolecular forces, electronegativity and bond properties
- 3.4 Metallic bonding
- 3.5 Bonding and physical properties
- 3.6 Multiple topics

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Unit 3: Chemical bonding

3.1: Ionic bonding

1. **M/J 19/P12/Q5**
The table shows some properties of four substances.
Which substance could be potassium iodide?

	melting point of solid / °C	electrical conductivity when molten
A	–66	poor
B	–39	good
C	680	good
D	1600	poor

2. **M/J 18/P13/Q12**
Which description of the bonding and acid / base nature of aluminium oxide is correct?

	bonding	acid / base nature
A	simple covalent	amphoteric
B	giant covalent	basic only
C	ionic	amphoteric
D	ionic	basic only

3. **O/N 17/P11/Q4, O/N 17/P13/Q4**
In the sodium chloride lattice the number of chloride ions that surround each sodium ion is called the *co-ordination number* of the sodium ions.
What are the co-ordination numbers of the sodium ions and the chloride ions in the sodium chloride lattice?

	sodium ions	chloride ions
A	4	6
B	6	4
C	6	6
D	8	6

4. **O/N 15/P12/Q1**
Which type of bonding is never found in elements?
A covalent
B ionic
C metallic
D van der Waals' forces

5. **M/J 16/P11/Q12, O/N 12/P12/Q13, O/N 12/P11/Q13**
Why is the ionic radius of a chloride ion larger than the ionic radius of a sodium ion?
A A chloride ion has one more occupied electron shell than a sodium ion.
B Chlorine has a higher proton number than sodium.
C Ionic radius increases regularly across the third period.
D Sodium is a metal, chlorine is a non-metal.

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6. M/J 14/P13/Q8

Four substances have the physical properties shown.
Which substance is an ionic solid?

	melting point /°C	boiling point /°C	electrical conductivity of solid	electrical conductivity of molten substance	electrical conductivity of aqueous solution
A	–115	–85	poor	poor	good
B	660	2470	good	good	insoluble
C	993	1695	poor	good	good
D	1610	2230	poor	poor	insoluble

7. O/N 12/P13/Q11, M/J 04/P1/Q20

Which molecule is planar?

A C_2Cl_4 **B** C_3H_6 **C** C_3H_8 **D** NF_3

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3.2: Covalent bonding and co-ordinate (dative covalent) bonding including shapes of simple molecules

1. M/J 20/P12/Q1

In which carbon allotrope are all electrons localised?

A buckminsterfullerene **C** graphite

B diamond **D** graphene

2. M/J 20/P12/Q29

PVC is used as a packaging material.

What holds the different polymer strands together in a piece of solid PVC?

A covalent bonds **C** ionic bonds

B hydrogen bonds **D** van der Waals' forces

3. M/J 20/P11/Q3

When considering one molecule of ethene, which row describes both the hybridisation of the atomic orbitals in the carbon atoms and the overall bonding?

	hybridisation	bonding
A	sp^2	4 σ bonds 1 π bond
B	sp^2	5 σ bonds 1 π bond
C	sp^3	4 σ bonds 1 π bond
D	sp^3	5 σ bonds 1 π bond

4. M/J 20/P11/Q24

Poly(propene) is an addition polymer.

What are the C–C–C bond angles along its polymer chain?

A They are all 109°. **C** Half of them are 90° and half are 180°.

B Half of them are 109° and half are 120°. **D** They are all 120°.

5. M/J 20/P13/Q9

At 200 °C aluminium chloride is a gas with $M_r = 267$.

What is the number of covalent bonds, dative covalent bonds and lone pairs of electrons in one molecule of aluminium chloride at 200 °C?

	covalent bonds	dative covalent bonds	lone pairs
A	6	2	0
B	6	2	16
C	6	2	18
D	3	0	9

6. MAR 20/P12/Q3

Which molecule does not have any 90° or 180° bond angles?

A C_2H_6 **B** CO_2 **C** PF_5 **D** SF_6

7. O/N 19/P11/Q3, O/N 19/P13/Q3

Which molecule or ion contains the smallest bond angle?

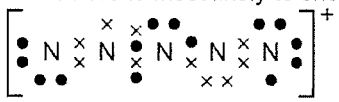
A C_2H_4 **B** CH_3COCH_3 **C** NH_4^+ **D** NH_3

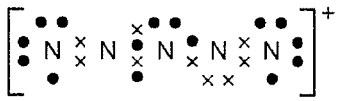
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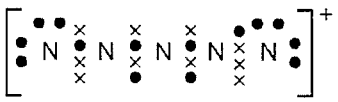
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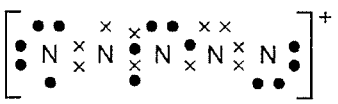
8. MAR 20/P12/Q8

A stable ion N_5^+ has been produced by research chemists.
Which structure is most likely to show the electron arrangement of this ion?

A 

B 

C 

D 

9. O/N 19/P12/Q4

Which statement about the electrons in a ground state carbon atom is correct?

A Electrons are present in four different energy levels.
B There are more electrons in p orbitals than there are in s orbitals.
C The occupied orbital of highest energy is spherical.
D The occupied orbital of lowest energy is spherical.

10. O/N 19/P11/Q4, O/N 19/P13/Q4

Four compounds are shown.

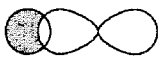
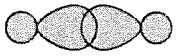
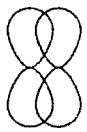
C_2H_4 C_2H_5OH CH_3CHO CH_3CO_2H

How many of these compounds have an odd number of s bonds?

A 1 **B** 2 **C** 3 **D** 4

11. M/J 19/P12/Q4

A σ bond is made between two carbon atoms in a molecule of ethene.
Which diagram shows the orbital overlap that occurs to form this bond?

A  **B**  **C**  **D** 

12. M/J 19/P11/Q19

Which statement is correct?

A Ammonia reacts with alkalis to form the ammonium ion.
B Ammonium chloride contains ionic, covalent and co-ordinate bonds.
C The ammonium ion reacts with acids to produce ammonia.
D The bond angle in the ammonium ion is approximately

13. Mar 19/P12/Q3

Which statement about a 3p orbital is correct?

A It can hold a maximum of 6 electrons.
B It has the highest energy of the orbitals with principal quantum number 3.
C It is at a higher energy level than a 3s orbital but has the same shape.
D It is occupied by one electron in an isolated phosphorus atom.

14. MAR 19/P12/Q4

The eight species that follow all have covalent bonds.
In which pair do the species have different shapes from each other?

A $BeCl_2$ and CO_2 **B** CH_4 and NH_4^+ **C** NH_3 and BF_3 **D** SCl_2 and H_2O

15. O/N 18/P12/Q4

In which set do all the molecules have all their atoms arranged in one plane?

A $AlCl_3$, BF_3, PH_3 **B** $AlCl_3$, CO_2, NH_3 **C** BF_3, C_2H_4, C_3H_6 **D** C_2H_4, CO_2, H_2O

16. M/J 18/P12/Q1

Which feature is present in both ethene and poly(ethene)?

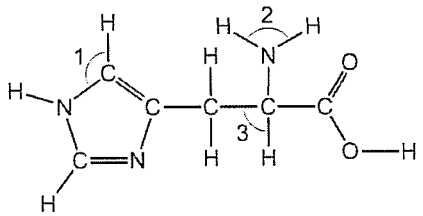
A bond angles of 109°
B π covalent bonds
C σ covalent bonds
D sp^3 orbitals

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17. MAR 19/P12/Q5

Histidine is an amino acid.

histidine



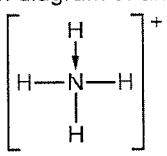
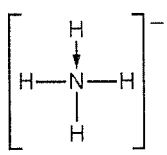
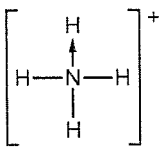
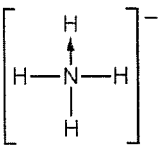
What are the approximate bond angles 1, 2, and 3?

	1	2	3
A	109.5	107	90
B	120	107	109.5
C	120	120	90
D	120	120	109.5

18. M/J 18/P12/Q18

The dative covalent bond can be represented by an arrow, →. The arrow points towards the atom receiving the lone pair.

Which diagram of an ammonium ion is correct?

A  **B**  **C**  **D** 

19. M/J 18/P11/Q5

Which molecule has no overall dipole?

A CH_3Cl **B** CH_2Cl_2 **C** $CHCl_3$ **D** CCl_4

20. M/J 18/P13/Q4

Which statement describes the bond between carbon and hydrogen in an ethene molecule?

A a π bond between an s orbital and an sp^2 orbital

B a π bond between an s orbital and an sp^3 orbital

C a σ bond between an s orbital and an sp^2 orbital

D a σ bond between an s orbital and an sp^3 orbital

21. M/J 17/P11/Q1

Which molecule contains six bonding electrons?

A C_2H_4 **B** H_2S **C** NCl_3 **D** SF_6

22. O/N 16/P12/Q6

When solid aluminium chloride is heated, Al_2Cl_6 is formed.

Which bonding is present in Al_2Cl_6?

A covalent and co-ordinate (dative covalent)

B covalent only

C ionic and co-ordinate (dative covalent)

D ionic only

23. O/N 16/P12/Q7

In which hydride is the H-X-H bond angle the smallest?

A BH_3 **B** CH_3 **C** C_2H_6 **D** NH_3

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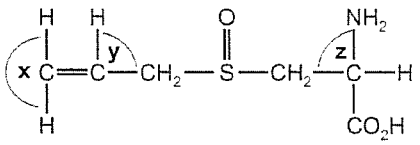
24. O/N 16/P12/Q13

Which element shows the greatest tendency to form covalent compounds?

A boron **B** magnesium **C** neon **D** potassium

25. MAR 17/P12/Q5

The characteristic smell of garlic is due to alliin.



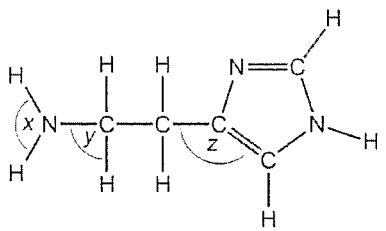
alliin

What are the approximate bond angles x, y and z in a molecule of alliin?

	x	y	z
A	90°	90°	109°
B	120°	109°	90°
C	120°	120°	109°
D	180°	109°	109°

26. O/N 16/P11/Q6, O/N 16/P13/Q6

Histamine is produced in the body to help fight infection. Its shape allows it to fit into receptors which expand blood vessels.



histamine

What are the bond angles *x*, *y* and *z* in histamine, from the smallest to the largest?

	smallest bond angle ⟶		largest bond angle
A	*x*	*y*	*z*
B	*y*	*x*	*z*
C	*y*	*z*	*x*
D	*z*	*y*	*x*

27. M/J 16/P12/Q5

Each of the four species in this question are isolated and gaseous.

Which species is not planar?

A BF_3 **B** CH_3^+ **C** C_2H_4 **D** NH_3

28. M/J 16/P11/Q5

Dicarbon monoxide, C_2O, is found in dust clouds in space. The structure of this molecule is C=C=O. The molecule contains no unpaired electrons.

How many lone pairs of electrons are present in a molecule of C_2O?

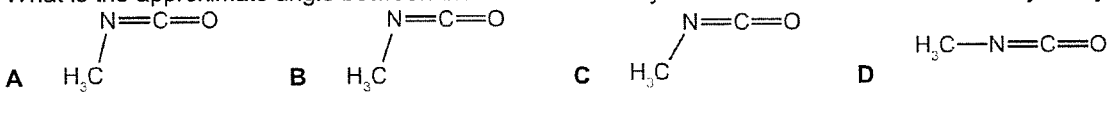
A 1 **B** 2 **C** 3 **D** 4

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29. M/J 16/P13/Q7

Methyl isocyanate, CH_3NCO, is a toxic liquid which is used in the manufacture of some pesticides.

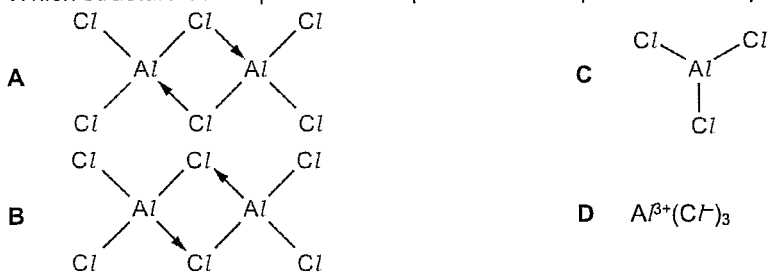
What is the approximate angle between the bonds formed by the N atom in a molecule of methyl isocyanate?



30. M/J 16/P12/Q13, M/J 06/P1/Q15

Solid aluminium chloride sublimes at 178 °C.

Which structure best represents the species in the vapour at this temperature?



31. M/J 16/P11/Q2

What is the correct number of bonds of each type in the Al_2Cl_6 molecule?

	covalent	co-ordinate (dative covalent)
A	6	1
B	6	2
C	7	0
D	7	1

32. MAR 16/P12/Q15

Which row of the table is correct?

	shape		bonds present	
	ammonia molecule	ammonium ion	ammonia molecule	ammonium ion
A	pyramidal	regular tetrahedral	σ	σ
B	pyramidal	regular tetrahedral	σ	π
C	regular tetrahedral	pyramidal	σ	σ
D	regular tetrahedral	pyramidal	π	σ

33. MAR 16/P12/Q6

Which series shows molecules in order of increasing bond angle?

A $CH_4 \rightarrow BF_3 \rightarrow NH_3$ **B** $H_2O \rightarrow CO_2 \rightarrow BF_3$ **C** $NH_3 \rightarrow CH_4 \rightarrow CO_2$ **D** $NH_3 \rightarrow CH_4 \rightarrow H_2O$

34. M/J 15/P13/Q4

Which pair has species with different shapes?

A $BeCl_2$ and CO_2 **B** CH_4 and NH_4^+ **C** NH_3 and BF_3 **D** SCl_2 and H_2O

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35. O/N 15/P11/Q4, O/N 15/P13/Q4

Nitrogen, N_2, and carbon monoxide, CO, both have $M_r = 28$.
The boiling point of N_2 is 77 K.
The boiling point of CO is 82 K.
What could be responsible for this difference in boiling points?

A CO molecules have a permanent dipole, the N_2 molecules are not polar.

B N_2 has σ and π bonding, CO has bonding only.

C N_2 has a strong N≡N bond, CO has a C=O bond.

D The CO molecule has more electrons than the N_2 molecule.

36. O/N 15/P11/Q19, O/N 15/P13/Q19

Element X forms a pollutant oxide Y. Y can be further oxidised to Z. Two students made the following statements.
Student P 'The molecule of Y contains lone pairs of electrons.'
Student Q 'The oxidation number of X increases by 1 from Y to Z.'
X could be carbon or nitrogen or sulfur.
Which student(s) made a correct statement?

A P only **B** Q only **C** both P and Q **D** neither P nor Q

37. M/J 15/P11/Q10

The double bond between the two carbon atoms in an ethene molecule consists of one σ bond and one π bond.
Which orbitals overlap to form each of these bonds?

	σ bond	π bond
A	sp^2–sp^2	p–p
B	sp^2–sp^2	sp^2–sp^2
C	sp^3–sp^3	p–p
D	sp^3–sp^3	sp^2–sp^2

38. M/J 15/P13/Q14

The compound $(CH_3)_3NAlCl_3$ has a simple molecular structure.
Which statement about $(CH_3)_3NAlCl_3$ is correct?

A $(CH_3)_3NAlCl_3$ molecules attract each other by hydrogen bonds.

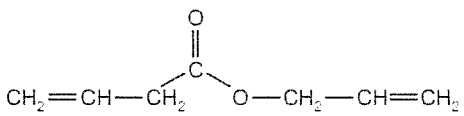
B The Al atom has an incomplete valance shell of electrons.

C The bonds around the Al atom are planar.

D The molecules contain coordinate and covalent bonding

39. M/J 15/P13/Q21, O/N 12/P13/Q21

The diagram shows a molecule that has σ bonds and π bonds.



How many σ bonds are present in this molecule?

A 15 **B** 17 **C** 18 **D** 21

40. O/N 14/P13/Q3

Which row shows properties of a ceramic material?

	melting point /K	boiling point /K	conductivity of solid
A	156	352	none
B	922	1380	good
C	2130	2943	good
D	3125	3873	none

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41. M/J 14/P11/Q6

$AlCl_3$ vapour forms molecules with formula Al_2Cl_6 as it is cooled.
What happens to the bond angles during the change from $AlCl_3$ to Al_2Cl_6?

A Some decrease, some remain the same. **C** They all decrease.
B Some increase, some remain the same. **D** They all increase.

42. M/J 14/P13/Q2

Which compound has the greatest total number of lone pairs of electrons in the valence shells of all of its atoms?

A CH_3Cl **B** CO_2 **C** N_2H_4 **D** NH_4CN

43. M/J 14/P13/Q10

X is an element in Period 2.
In which fluoride is the F–X–F angle the largest?

A BF_3 **B** CF_4 **C** NF_3 **D** OF_2

44. M/J 13/P12/Q9

Dicarbon monoxide, C_2O, is found in dust clouds in space. Analysis of it shows that the sequence of atoms in this molecule is C – C – O. All bonds are double bonds and there are no unpaired electrons.
How many lone pairs of electrons are present in a molecule of C_2O?

A 1 **B** 2 **C** 3 **D** 4

45. M/J 13/P12/Q17

Which statement about ammonia is completely correct?

A Ammonia acts as a nucleophile by accepting a pair of electrons when it reacts with bromoethane.
B Ammonia can form a co-ordinate bond with a hydrogen ion to form an ammonium ion.
C Ammonia is a base and accepts hydroxide ions.
D The shape of the ammonia molecule is pyramidal with bond angles of 109.5°.

46. O/N 12/P12/Q3, O/N 12/P11/Q3

Sodium borohydride, $NaBH_4$, and boron trifluoride, BF_3, are compounds of boron.
What are the shapes around boron in the borohydride ion and in boron trifluoride?

	borohydride ion	boron trifluoride
A	square planar	pyramidal
B	square planar	trigonal planar
C	tetrahedral	pyramidal
D	tetrahedral	trigonal planar

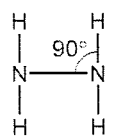
47. O/N 12/P12/Q12, O/N 12/P11/Q12

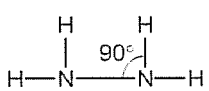
In which pair do the molecules have the same shape as each other?

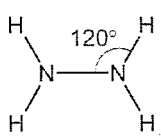
A H_2O and CO_2 **B** H_2O and SCl_2 **C** NH_3 and BH_3 **D** SCl_2 and $BeCl_2$

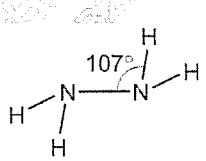
48. M/J 12/P12/Q3, O/N 02/P1/Q6

What is the **most** likely shape of a molecule of hydrazine, N_2H_4?

A


B


C


D


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49. M/J 12/P11/Q12, M/J 12/P13/Q13

Aluminium chloride catalyses certain reactions by forming carbocations with chloroalkanes as shown.

$$RCl + AlCl_3 \rightarrow R^+ + AlCl_4^-$$

Which property makes this reaction possible?

A $AlCl_3$ exists as the dimer Al_2Cl_6 in the vapour.

B $AlCl_3$ is a covalent molecule.

C The aluminium atom in $AlCl_3$ has an incomplete octet of electrons.

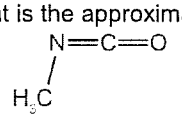
D The chlorine atom in RCl has a vacant p orbital.

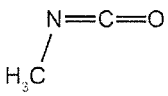
50. O/N 11/P11/Q4, O/N 11/P13/Q5

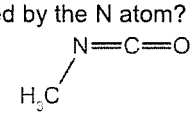
Methyl isocyanate, CH_3NCO, is a toxic liquid which is used in the manufacture of some pesticides.

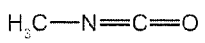
In the methyl isocyanate molecule, the sequence of atoms is $H_3C—N=C=O$.

What is the approximate angle between the bonds formed by the N atom?

A  104°

B  109°

C  120°

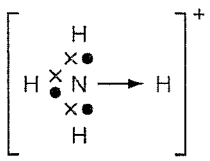
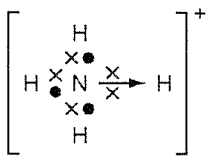
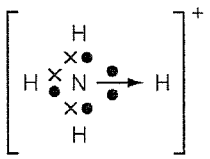
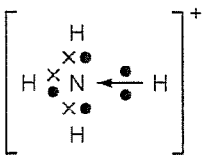
D  180°

51. M/J 11/P12/Q2

Which diagram correctly shows the bonding in the ammonium ion, NH_4^+?

key

- ● N electron
- × H electron

A  **B**  **C**  **D** 

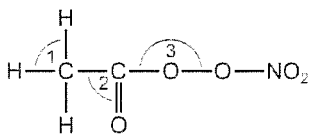
52. O/N 10/P12/Q10

Which molecule or structure does **not** contain three atoms bonded at an angle between 109° and 110°?

A ethanoic acid **B** graphite **C** propane **D** silicon(IV) oxide

53. O/N 10/P11/Q7, O/N 10/P13/Q6

Organic nitrates in photochemical smog can cause breathing difficulties.
The diagram shows an example of an organic nitrate molecule.



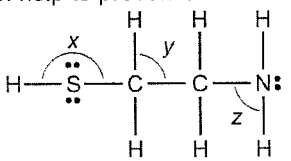
What is the correct order of the bond angles shown in ascending order (smallest first)?

A 1 → 2 → 3 **B** 2 → 1 → 3 **C** 3 → 1 → 2 **D** 3 → 2 → 1

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54. O/N 09/P12/Q3, O/N 09/P11/Q4

The antidote molecule shown can help to prevent liver damage if someone takes too many paracetamol tablets.



: represents a lone pair

What is the order of **decreasing** size of the bond angles *x*, *y* and *z*?

	largest ⟶		smallest
A	*x*	*y*	*z*
B	*x*	*z*	*y*
C	*y*	*z*	*x*
D	*z*	*y*	*x*

Valid till October/November 2021 Exams

55. M/J 20/P13/Q32

Buckminsterfullerene is a fullerene allotrope of carbon.

Which statements about buckminsterfullerene are correct?

1 Buckminsterfullerene is a giant covalent molecule.
2 Buckminsterfullerene has delocalised electrons.
3 Buckminsterfullerene has strong intramolecular bonds.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

56. O/N 19/P12/Q32

A carbon monoxide molecule, CO, has three bonds between the carbon atom and the oxygen atom.

Which features are present in one CO molecule?

1 two lone pairs of electrons
2 a co-ordinate (dative covalent) bond from oxygen to carbon
3 two π bonds

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

57. O/N 17/P12/Q32

The chlorine oxide free radical, ClO$^{\bullet}$, is produced by the reaction between chlorine atoms and ozone.

$$Cl^{\bullet} + O_3 \rightarrow ClO^{\bullet} + O_2$$

Which features are present in the chlorine oxide free radical?

1 an odd number of electrons
2 a single covalent bond
3 a dative covalent bond from oxygen to chlorine

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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58. M/J 17/P13/Q32

Which compounds contain covalent bonds?

1 aluminium chloride
2 ammonia
3 calcium fluoride

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

59. O/N 16/P11/Q32, O/N 16/P13/Q32

Which elements can form π bonds in their compounds?

1 carbon 2 oxygen 3 nitrogen

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

60. O/N 15/P12/Q36, M/J 11/P13/Q34, M/J 11/P11/Q37

Which descriptions of the ammonium ion are correct?

1 It contains ten electrons.
2 It has a bond angle of 109.5°.
3 It has only three bonding pairs of electrons.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

61. M/J 15/P12/Q32, O/N 11/P13/Q34

Why does aluminium chloride, Al_2Cl_6, sublime at the relatively low temperature of 180 °C?

1 The intermolecular forces between the Al_2Cl_6 molecules are weak.
2 The co-ordinate bonds between aluminium and chlorine are weak.
3 The covalent bonds between aluminium and chlorine are weak.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

62. M/J 15/P13/Q34, O/N 09/P12/Q31, O/N 09/P11/Q32

Which physical properties are due to hydrogen bonding between water molecules?

1 Water has a higher boiling point than H_2S.
2 Ice floats on water.
3 The H–O–H bond angle in water is approximately 104°.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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63. M/J 14/P12/Q33

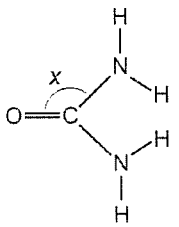
Which elements have atoms which can form π bonds with atoms of other elements?

1 oxygen
2 nitrogen
3 fluorine

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

64. M/J 15/P11/Q32

Urea is a product of animal metabolism. It can also be used as a fertiliser.



urea

The diagram shows angle *x* in this molecule.

Which statements about the structure of urea are correct?

1 Angle *x* is approximately 120°.
2 The molecule has two π bonds.
3 The molecule has only three lone pairs of electrons.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

65. M/J 13/P11/Q33

Valence shell electron pair repulsion theory should be used to answer this question.

Which species are trigonal planar?

1 BH_3 2 CH_3^+ 3 PH_3

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

66. M/J 12/P12/Q31

Which of the following molecules and ions have a regular trigonal planar shape?

1 BF_3 2 CH_3^+ 3 $AlCl_3$

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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67. M/J 12/P11/Q37, M/J 12/P13/Q38

What is **always** involved in a carbon-carbon π bond?

1 a shared pair of electrons
2 a sideways overlap of p orbitals
3 delocalised electrons

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

68. O/N 11/P12/Q31

Which statements about bond angles are correct?

1 The bond angle in SO_2 is smaller than the bond angle in CO_2.
2 The bond angle in H_2O is smaller than the bond angle in CH_4.
3 The bond angle in NH_3 is smaller than the bond angle in BF_3.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

69. O/N 11/P11/Q32

Why does aluminium chloride, Al_2Cl_6, sublime at the relatively low temperature of 180 °C?

1 The intermolecular forces between the Al_2Cl_6 molecules are weak.
2 The co-ordinate bonds between aluminium and chlorine are weak.
3 The covalent bonds between aluminium and chlorine are weak.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

70. O/N 10/P12/Q33

Which statements about covalent bonds are correct?

1 A triple bond consists of one π bond and two σ bonds.
2 The electron density in a σ bond is highest along the axis between the two bonded atoms.
3 A π bond restricts rotation about the σ bond axis.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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3.3: Intermolecular forces, electronegativity and bond properties

1. **M/J 20/P12/Q7**
When aqueous bromine is shaken with cyclohexane and allowed to stand, two layers form. The top cyclohexane layer is coloured and the bottom aqueous layer is almost colourless.
What is the most likely explanation for this observation?
A Bromine is reduced to bromide ions in the bottom layer.
B Bromine molecules are non-polar.
C Bromine reacts with water but cannot react with cyclohexane.
D The product of the reaction between bromine and cyclohexane is coloured.

2. **M/J 20/P12/Q8**
In which change are only temporary dipole-induced dipole forces overcome?
A $C_2H_5OH(l) \rightarrow C_2H_5OH(g)$
B $H_2O(s) \rightarrow H_2O(l)$
C $O_2(s) \rightarrow O_2(l)$
D $C_4H_{10}(l) \rightarrow C_4H_{10}(s)$

3. **M/J 20/P12/Q14**
Which statement explains why iodine is less volatile than chlorine?
A Chlorine is more electronegative than iodine and so has more repulsion between its molecules.
B The greater number of electrons in iodine leads to larger temporary dipole-induced dipole forces.
C The I–I bond energy is smaller than the C*l*–C*l* bond energy.
D The iodine molecules have stronger permanent dipole-permanent dipole forces.

4. **M/J 20/P13/Q3**
Solid carbon dioxide, CO_2, is similar to solid iodine, I_2, in its structure.
Which statement about solid CO_2 and solid SiO_2 is correct?
A Both solid CO_2 and solid SiO_2 exist in a lattice structure.
B Both solid CO_2 and solid SiO_2 have a simple molecular structure.
C Both solid CO_2 and solid SiO_2 have atoms joined by single covalent bonds.
D Both solid CO_2 and solid SiO_2 change spontaneously to gas at s.t.p..

5. **O/N 19/P11/Q5, O/N 19/P13/Q5**
Ethanal, CH_3CHO, ethanol, C_2H_5OH, and methoxymethane, CH_3OCH_3, are three organic compounds.
Which compound has the highest boiling point and what is the interaction that causes this boiling point to be the highest?

	highest boiling point	interaction
A	methoxymethane	permanent dipole-dipole forces
B	ethanal	hydrogen bonds
C	ethanol	hydrogen bonds
D	ethanal	permanent dipole-dipole forces

6. **M/J 18/P13/Q1**
Why is the boiling point of ammonia, NH_3, higher than the boiling point of phosphine, PH_3?
A Ammonia molecules are polar; phosphine molecules are not.
B Ammonia molecules have significant hydrogen bonding; phosphine molecules do not.
C N–H covalent bonds are stronger than P–H covalent bonds.
D There is one lone pair in each ammonia molecule but no lone pair in each phosphine molecule.

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7. M/J 19/P13/Q5

Ethane, CH_3CH_3, and fluoromethane, CH_3F, have the same number of electrons in their molecules.
Their boiling points are given.

CH_3CH_3	184.5 K
CH_3F	194.7 K

What is responsible for this difference in boiling points?

A CH_3F has a larger Mr than CH_3CH_3.
B CH_3F has a permanent dipole, CH_3CH_3 does not.
C CH_3F has a strong C–F bond, CH_3CH_3 does not.
D Hydrogen bonding occurs in CH_3F, but not in CH_3CH_3.

8. O/N 19/P11/Q16, O/N 19/P13/Q16, O/N 16/P12/Q18,

Chlorine and bromine have different volatilities.
Which row identifies the more volatile of the two elements, and gives the correct explanation?

	identity of the more volatile element	explanation for the difference in volatility
A	bromine	instantaneous dipole-induced dipole forces are greater in bromine than they are in chlorine
B	bromine	instantaneous dipole-induced dipole forces are greater in chlorine than they are in bromine
C	chlorine	instantaneous dipole-induced dipole forces are greater in bromine than they are in chlorine
D	chlorine	instantaneous dipole-induced dipole forces are greater in chlorine than they are in bromine

9. M/J 17/P12/Q4

Which organic compound has the highest boiling point?

A $C(CH_3)_4$
B $CH_3CH_2CH_2CH_2CH_3$
C $CH_3COCH_2CH_3$
D $CH_3CH(OH)CH_2CH_3$

10. MAR 17/P12/Q4

The boiling points of methane, ethane, propane and butane are given.

compound	CH_4	CH_3CH_3	$CH_3CH_2CH_3$	$CH_3CH_2CH_2CH_3$
boiling point/K	112	185	231	273

Which statement explains the increase in boiling point from methane to butane?

A Closer packing of molecules results in stronger van der Waals' forces.
B More covalent bonds are present and therefore more energy is required to break the bonds.
C More electrons in the molecules results in stronger van der Waals' forces.
D More hydrogen atoms in the molecules results in stronger hydrogen bonding.

11. M/J 16/P12/Q19

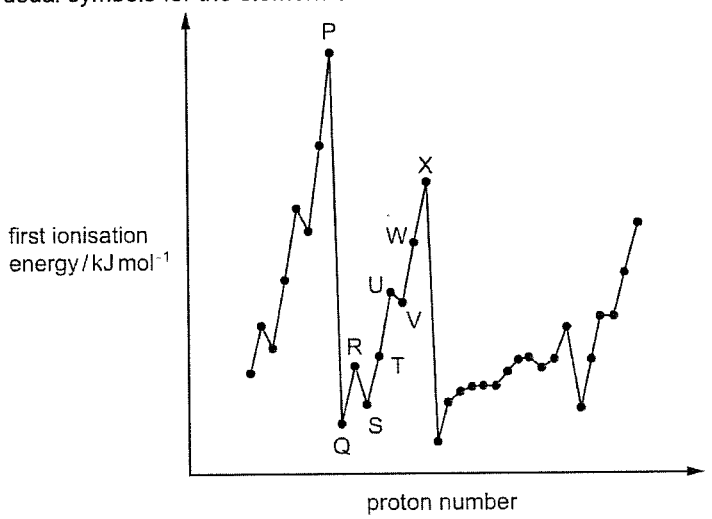
Fluorine and iodine are Group 17 elements. Their melting points are different due to differing strengths of van der Waals' forces between molecules.
Which row is correct?

	melting point	strength of van der Waals' forces between molecules
A	$F_2 > I_2$	$F_2 > I_2$
B	$F_2 > I_2$	$F_2 < I_2$
C	$F_2 < I_2$	$F_2 < I_2$
D	$F_2 < I_2$	$F_2 > I_2$

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12. O/N 16/P12/Q12

The graph below shows the variation of the first ionisation energy with proton number for some elements. The letters used are not the usual symbols for the elements.



Which statement about the elements is correct?

A P and X are in the same period in the Periodic Table.

B The general increase from Q to X is due to increasing atomic radius.

C The small decrease from R to S is due to decreased shielding.

D The small decrease from U to V is due to repulsion between paired electrons.

13. M/J 16/P11/Q7

At room temperature and pressure, H_2O is a liquid and H_2S is a gas.
What is the reason for this difference?

A O has higher first and second ionisation energies than S.

B The covalent bond between O and H is stronger than the covalent bond between S and H.

C There is significant hydrogen bonding between H_2O molecules but not between H_2S molecules.

D The instantaneous dipole-induced dipole forces between H_2O molecules are stronger than the instantaneous dipole-induced dipole forces between H_2S molecules.

14. O/N 15/P11/Q22, O/N 15/P13/Q22

Crude oil is a mixture of many hydrocarbons ranging in size from 1 to 40 carbon atoms per molecule. The alkanes in crude oil can be separated because they have different boiling points.
The table below shows the boiling points of some alkanes.

alkane	boiling point / °C	M_r
butane	0	58
pentane	36	72
hexane	69	86
2-methylbutane	28	72
dimethylpropane	10	72
2,3-dimethylbutane	58	86

What is the correct explanation for the difference in the boiling points of the three isomers with $M_r = 72$?

A Boiling point is dependent upon the length of the carbon chain only.

B Increased branching on a carbon chain increases the boiling point.

C Increased branching reduces the strength of the intermolecular hydrogen bonding.

D Increased branching reduces the strength of the intermolecular van der Waals' forces.

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15. M/J 15/P13/Q6

Which statement can be explained by intermolecular hydrogen bonding?

A Ethanol has a higher boiling point than propane.

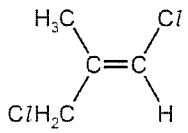
B Hydrogen chloride has a higher boiling point than silane, SiH_4.

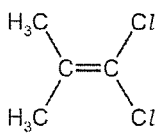
C Hydrogen iodide forms an acidic solution when dissolved in water.

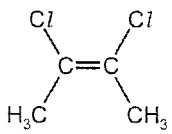
D Propanone has a higher boiling point than propane.

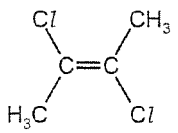
16. M/J 14/P11/Q9

Which molecular structure will have the **smallest** overall dipole?

A 

B 

C 

D 

17. O/N 12/P13/Q2

Which statement can be explained by intermolecular hydrogen bonding?

A Butane has a higher boiling point than propane.

B Hydrogen bromide forms an acidic solution when dissolved in water.

C SiH_4 has a higher boiling point than CH_4.

D Water has a higher boiling point than CH_4.

18. O/N 11/P12/Q5

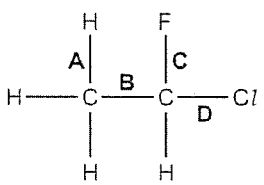
The presence of dipoles helps to explain why the element Br_2 and the compound $CHCl_3$ exist as liquids at room temperature.

Which types of dipole are involved?

	Br_2	$CHCl_3$
A	induced dipoles and permanent dipoles	induced dipoles and permanent dipoles
B	induced dipoles and permanent dipoles	induced dipoles only
C	induced dipoles only	induced dipoles and permanent dipoles
D	induced dipoles only	induced dipoles only

19. O/N 11/P12/Q22

Which bond in the structure below has the lowest bond energy?



20. M/J 11/P12/Q12, M/J 05/P1/Q13

Which element is likely to have an electronegativity similar to that of aluminium?

A barium **B** beryllium **C** magnesium **D** strontium

21. M/J 11/P11/Q11, M/J 11/P13/Q10

In which change would only van der Waals' forces have to be overcome?

A evaporation of ethanol $C_2H_5OH(l) \rightarrow C_2H_5OH(g)$

B melting of ice $H_2O(s) \rightarrow H_2O(l)$

C melting of solid carbon dioxide $CO_2(s) \rightarrow CO_2(l)$

D solidification of butane $C_4H_{10}(l) \rightarrow C_4H_{10}(s)$

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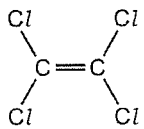
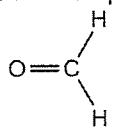
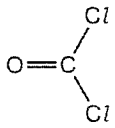
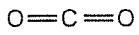
22. O/N 10/P12/Q1

The ability of an atom in a covalent bond to attract electrons to itself is called its electronegativity.
The greater the difference between the electronegativities of the two atoms in the bond, the more polar is the bond.
Which pair will form the most polar covalent bond between the atoms?

A chlorine and bromine
B chlorine and iodine
C fluorine and chlorine
D fluorine and iodine

23. O/N 09/P12/Q4, O/N 09/P11/Q5

Which molecule has the largest overall dipole?

A 
B 
C 
D 

24. M/J 09/P1/Q5

Which statement explains why the boiling point of methane is higher than that of neon?
[A_r: H, 1; C, 12; Ne, 20]

A A molecule of methane has a greater mass than a molecule of neon.
B Molecules of methane form hydrogen bonds, but those of neon do not.
C Molecules of methane have stronger intermolecular forces than those of neon.
D The molecule of methane is polar, but that of neon is not.

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25. MAR 20/P12/Q32

The strong hydrogen bonding present in liquid water causes an increase in which properties?
1 viscosity 2 boiling point 3 surface tension

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

26. O/N 19/P11/Q33, O/N 19/P13/Q33

Liquids X and Y do not react with one another. They have identical boiling points.
When a particular volume of X is shaken with a similar volume of Y, they form a liquid mixture Z.
The average intermolecular forces in liquid Z are stronger than the average of the forces in X and the forces in Y.
Which deductions from this information are correct?
1 The mixing of X and Y is exothermic.
2 The vapour pressure of liquid Z will be less than that of either liquid X or liquid Y at the same temperature.
3 The boiling point of liquid Z will be lower than that of either liquid X or liquid Y at the same pressure.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

27. M/J 17/P13/Q33

Ethylene glycol, $HOCH_2CH_2OH$, is used as a de-icer. It allows ice to melt at temperatures below 0 °C.
Which statements are correct?
1 Ethylene glycol changes the extensive network of hydrogen bonds in ice.
2 Ethylene glycol molecules form hydrogen bonds with other ethylene glycol molecules.
3 Ethylene glycol molecules will dissolve in the water formed from the ice.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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28. M/J 16/P13/Q32

Water has some unusual physical properties compared to other hydrides of Group 16 elements. Some of these properties are due to hydrogen bonds. These intermolecular forces are much stronger in water than they are in H_2S, for example.

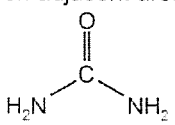
Which statements are correct?

1 Hydrogen bonds cause the melting point of ice to be higher than expected.
2 Hydrogen bonds cause the surface tension of water to be higher than expected.
3 Hydrogen bonds cause the viscosity of water to be higher than expected.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

29. O/N 14/P13/Q33, O/N 10/P13/Q31, O/N 10/P11/Q33

Which types of intermolecular forces can exist between adjacent urea molecules?



urea

1 hydrogen bonding
2 permanent dipole-dipole forces
3 instantaneous dipole-induced dipole forces

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

30. M/J 11/P12/Q34

What is involved when a hydrogen bond is formed between two molecules?

1 a hydrogen atom bonded to an atom less electronegative than itself
2 a lone pair of electrons
3 an electrostatic attraction between opposite charges

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

31. M/J 14/P12/Q31, M/J 14/P11/Q32

P and Q are two compounds with similar M_r values. Molecules of P attract each other by hydrogen bonds. Molecules of Q attract each other by van der Waals' forces only.

A sample of liquid P is compared to a sample of liquid Q.

How will their properties differ?

1 P is more soluble in water than Q.
2 P has a higher melting point than Q.
3 P is more viscous than Q.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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32. M/J 14/P13/Q36

The intermolecular forces between iodine molecules are instantaneous dipole-induced dipole forces. Which statements explain why iodine has these intermolecular forces?

1 An iodine molecule is polar and experiences an attraction from a lone pair of electrons on an adjacent molecule.
2 An iodine molecule has a fluctuating dipole because the electrons in a molecule are more mobile than the nuclei.
3 The electron charge cloud within an I_2 molecule may become unsymmetrical and may then ttract other I_2 molecules.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

33. O/N 11/P11/Q33, O/N 11/P13/Q32

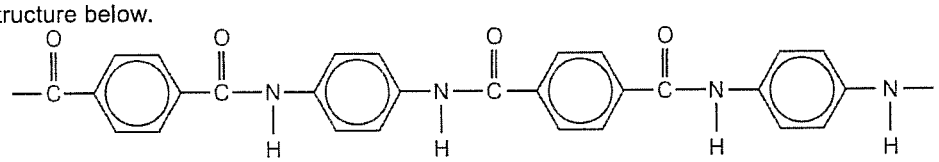
The three statements that follow are all true.
Which of these can be explained, at least in part, by reference to hydrogen bonding?

1 At 0 °C ice floats on water.
2 The boiling point of propan-2-ol is 82 °C. The boiling point of propanone is 56 °C.
3 At 20 °C propanone and propanal mix completly.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

34. O/N 08/P1/Q31

Kevlar has the structure below.



Compared to a steel rope of similar dimensions, a *Kevlar* rope is both lighter and stronger.
Which properties of *Kevlar* help to explain these facts?

1 The fibres of *Kevlar* align due to hydrogen bonding.
2 The mass per unit length is less in a *Kevlar* rope than in a steel rope.
3 The *Kevlar* molecule has no permanent dipole.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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3.4: Metallic bonding

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1. **M/J 13/P11/Q32**
   The Group II metals have higher melting points than the Group I metals.
   Which factors could contribute towards the higher melting points?
   1 There are smaller interatomic distances in the metallic lattices of the Group II metals.
   2 More electrons are available from each Group II metal atom for bonding the atom into the metallic lattice.
   3 Group II metals have a higher first ionisation energy than the corresponding Group I metal.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

2. **M/J 11/P11/Q32, M/J 11/P13/Q31**
   Which are features of the structure of metallic copper?
   1 a lattice of ions
   2 delocalised electrons
   3 ionic bonds

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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3.5: Bonding and physical properties

1. **M/J 18/P12/Q9**
Materials can be classified by their chemical structures. Four common types of structure are metallic, ionic, simple molecular and giant molecular.
Some physical properties of four substances are shown in the table.
Which substance has a simple molecular structure?

	melting point /°C	effect of adding water	electrical conductivity
A	64	reacts	good when solid
B	113	insoluble	always poor
C	767	soluble	good when solid
D	1600	insoluble	always poor

2. **M/J 18/P11/Q2**
Which compound has a boiling point that is influenced by hydrogen bonding?
A CH_3CHO **B** CH_3OCH_3 **C** HCO_2CH_3 **D** HCO_2H

3. **M/J 18/P11/Q6**
Which solid contains more than one type of bonding?
A iodine **B** silicon dioxide **C** sodium chloride **D** zinc

4. **MAR 17/P12/Q12**
The electrical conductivities of two compounds, Y and Z, are shown in the table.

	Y	Z
conductivity of the compound in the liquid state	good	does not conduct
conductivity of the mixture obtained by adding the compound to water	good	good

What could compounds Y and Z be?

	Y	Z
A	Al_2O_3	$SiCl_4$
B	NaF	Al_2O_3
C	NaF	$SiCl_4$
D	$SiCl_4$	Al_2O_3

5. **MAR 16/P12/Q9**
An article in a science magazine contains the following statement.
'It is lighter than a feather, stronger than steel, yet incredibly flexible and more conductive than copper.'
Which form of carbon is being described?
A buckminsterfullerene **C** graphene
B diamond **D** graphite

6. **O/N 13/P13/Q8**
Which solid contains more than one kind of bonding?
A copper **B** diamond **C** ice **D** magnesium oxide

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7. O/N 14/P12/Q9, O/N 14/P11/Q9

Methylpropan-1-ol and butan-1-ol are structural isomers. Methylpropan-1-ol has a lower boiling point.
Which statement explains why the boiling point of methylpropan-1-ol is lower than that of butan-1-ol?

A Methylpropan-1-ol cannot form hydrogen bonds.

B Methylpropan-1-ol has weaker covalent bonds than butan-1-ol.

C Methylpropan-1-ol has weaker van der Waals' forces than butan-1-ol.

D Methylpropan-1-ol molecules have more surface area than butan-1-ol molecules.

8. O/N 14/P13/Q7

Copper and iodine are both shiny crystalline solids.
Which forces exist between particles in solid copper and between neighbouring iodine molecules in solid iodine?

	copper	iodine
A	ionic bonds	covalent bonds
B	ionic bonds	van der Waals' forces
C	metallic bonds	covalent bonds
D	metallic bonds	van der Waals' forces

9. M/J 14/P11/Q14

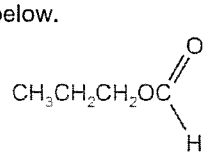
What is the order of increasing melting point of the four chlorides shown?

CCl_4 HCl $MgCl_2$ PCl_5

	lowest melting point →			highest melting point
A	CCl_4	HCl	PCl_5	$MgCl_2$
B	HCl	CCl_4	PCl_5	$MgCl_2$
C	HCl	PCl_5	CCl_4	$MgCl_2$
D	$MgCl_2$	PCl_5	CCl_4	HCl

10. M/J 13/P11/Q28

The structural formula of a compound X is shown below.



What is the name of compound X and how does its boiling point compare with that of butanoic acid?

	name of **X**	boiling point of **X**
A	methyl propanoate	higher
B	methyl propanoate	lower
C	propyl methanoate	higher
D	propyl methanoate	lower

a c

11. M/J 13/P13/Q8

Which compound is the only gas at room temperature and pressure?

A $CH_3CH_2CH_2NH_2$ $M_r = 59.0$

B $CH_3CH_2CH_2OH$ $M_r = 60.0$

C CH_2OHCH_2OH $M_r = 62.0$

D CH_3CH_2Cl $M_r = 64.5$

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12. M/J 18/P11/Q32

Which statements are correct?

1 The hydrogen bonds in ice are more regularly arranged than in water.
2 The solidification of water to form ice is exothermic.
3 Pure water is less dense than ice.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

13. M/J 16/P12/Q32

Three elements, X, Y and Z, have electronic configurations as shown.

X	Y	Z
2,6	2,8,1	2,8,7

Which formulae represent compounds that conduct electricity in the liquid state?

1 YZ
2 Y_2X
3 Z_2X

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

14. M/J 14/P13/Q32

P and Q are two liquid compounds with similar M_r values. Molecules of P attract each other by hydrogen bonds. Molecules of Q attract each other by van der Waals' forces only.

How do the properties of P and Q differ?

1 P has higher surface tension than Q.
2 P has a higher boiling point than Q.
3 P is less viscous than Q.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

15. O/N 12/P11/Q33, O/N 12/P12/Q33

Which of these substances have a giant structure?

1 silicon(IV) oxide
2 baked clay found in crockery
3 phosphorus(V) oxide

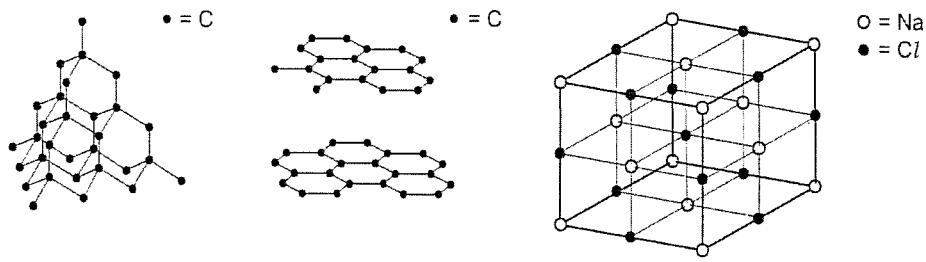
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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16. M/J 13/P13/Q34, M/J 10/P12/Q32, M/J 10/P11/Q31, M/J 10/P13/Q33

Which diagrams represent part of a giant molecular structure?

1 2 3



A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

17. M/J 12/P12/Q34

Silver chloride dissolves in aqueous ammonia.

What happens in this process?

1 A co-ordinate bond is formed.
2 The oxidation number of nitrogen is unchanged.
3 Ammonia acts as a Brønsted-Lowry base.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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3.6: Multiple Topics

1. M/J 19/P12/Q7

Which pair of substances are both simple molecular?

A C_{60} and graphene
B C_{60} and iodine
C graphene and graphite
D graphite and iodine

2. M/J 18/P12/Q3

In which pair does the second substance have a **lower** boiling point than the first substance?

A C_2H_6 and C_2H_5Cl
B CH_3OCH_3 and C_2H_5OH
C Ne and Ar
D CH_3NH_2 and C_2H_6

3. M/J 18/P13/Q3

The table refers to the electron distribution in the second shell of an atom with eight protons.
Which row is correct for this atom?

	orbital shape ∞		orbital shape ○	
	orbital type	number of electrons	orbital type	number of electrons
A	p	2	s	4
B	p	4	s	2
C	s	2	p	4
D	s	4	p	2

4. O/N 17/P12/Q4

Ethane burns in oxygen to produce carbon dioxide and water vapour.
Which bond angles are present in the molecules of ethane and its combustion products?

	ethane	combustion products
A	90°	104.5° and 180°
B	90°	109.5° and 120°
C	109.5°	104.5° and 180°
D	109.5°	109.5° and 180°

5. O/N 17/P11/Q3, O/N 17/P13/Q3

In which structure are three atoms bonded together in a straight line?

A poly(ethene), $\{CH_2CH_2\}_n$
B propane, C_3H_8
C silicon tetrachloride, $SiCl_4$
D sulfur hexafluoride, SF_6

6. M/J 16/P13/Q13

Each pair below consists of a sample of two separate elements. Each element is in its standard state at room temperature and pressure.
Which pair of elements has chemical bonds of the same type between their atoms?

A aluminium and phosphorus
B chlorine and argon
C magnesium and silicon
D sulfur and chlorine

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7. O/N 15/P11/Q5, O/N 15/P13/Q5, O/N 12/P12/Q8, O/N 12/P11/Q8

Some car paints contain small flakes of silica, SiO_2.

In the structure of solid SiO_2

- each silicon atom is bonded to **x** oxygen atoms,
- each oxygen atom is bonded to **y** silicon atoms,
- each bond is a **z** type bond.

What is the correct combination of **x**, **y** and **z** in these statements?

	x	y	z
A	2	1	covalent
B	2	1	ionic
C	4	2	covalent
D	4	2	ionic

8. M/J 15/P12/Q3

Phosphorus forms a compound with hydrogen called phosphine, PH_3. This compound can react with a hydrogen ion, H^+.

Which type of interaction occurs between PH_3 and H^+?

A dative covalent bond
B dipole-dipole forces
C hydrogen bond
D ionic bond

9. M/J 15/P12/Q17

Which statement about the ammonium ion, NH_4^+, is correct?

A All bond angles are 107°.
B Ammonium ions are formed when ammonia behaves as an acid.
C Ammonium ions are unreactive when heated with NaOH(aq).
D The bonds are all the same length.

10. M/J 14/P11/Q16

Which description of the bonding and acid/base nature of aluminium oxide is correct?

	bonding	acid / base nature
A	covalent	amphoteric
B	covalent	basic
C	ionic	amphoteric
D	ionic	basic

11. M/J 13/P13/Q16

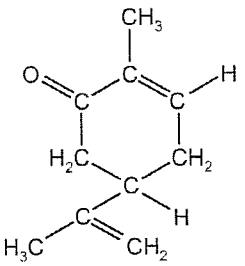
How do the strengths of the covalent bonds within molecules, and the van der Waals' forces between molecules, vary going down Group VII from chlorine to bromine to iodine?

	strength of covalent bonds	strength of van der Waals' forces
A	decrease	decrease
B	decrease	increase
C	increase	decrease
D	increase	increase

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12. O/N 12/P12/Q20, O/N 12/P11/Q20

Carvone is found in spearmint.



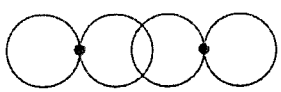
carvone

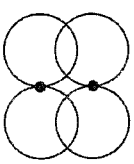
How many σ and π bonds are present in this molecule?

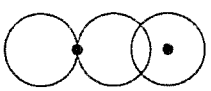
	σ	π
A	13	3
B	22	3
C	22	6
D	25	3

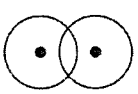
13. O/N 12/P13/Q6

Which diagram represents the overlap of two orbitals which will form a π bond?

A 

B 

C 

D 

14. M/J 12/P12/Q5

Which solid contains more than one kind of bonding?

A iodine **B** silicon dioxide **C** sodium chloride **D** zinc

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15. M/J 20/P11/Q33

Carbon exists in several different forms. Two of these forms are buckminsterfullerene and graphene. Buckminsterfullerene is a fullerene allotrope of carbon.

Which statements about buckminsterfullerene and graphene are correct?

1 Both have delocalised electrons.
2 Buckminsterfullerene has a giant molecular structure.
3 The carbon atoms in graphene form a tetrahedral lattice.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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16. M/J 20/P11/Q32

Which molecules have no overall dipole moment?

1 boron trifluoride
2 methane
3 phosphorus pentafluoride

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

17. MAR 19/P12/Q35

Which statements about ceramics are correct?

1 Ceramics are good electrical conductors.
2 Ceramics are strong materials.
3 Ceramics have high melting points.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

18. MAR 19/P12/Q36, O/N 13/P12/Q35, O/N 13/P11/Q35

Which types of bonding are present in ammonium carbonate, $(NH_4)_2CO_3$?

1 ionic
2 covalent
3 co-ordinate (dative covalent)

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

19. M/J 17/P11/Q32

Graphene, graphite and the fullerene C_{60} are allotropes of carbon.

Which statements are correct for all three of these allotropes of carbon?

1 Delocalised electrons are present in the structure.
2 All bond angles are 120°.
3 It has a giant molecular crystalline lattice structure.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

20. MAR 16/P12/Q31

No other combination of statements is used as a correct response.

Which molecules have an overall dipole moment?

1 carbon monoxide, CO
2 phosphine, PH_3
3 carbon dioxide, CO_2

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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21. O/N 15/P11/Q32, O/N 15/P13/Q32

The Group IV elements carbon, silicon and germanium can all exist in the giant molecular structure which is also found in diamond. The bond lengths in these structures are given below.

element X	C	Si	Ge
bond length X–X / nm	0.154	0.234	0.244

Why does the bond length increase down the group?

1 Orbital overlap decreases down the group.
2 Atomic radius increases down the group.
3 Nuclear charge increases down the group.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

22. M/J 15/P13/Q32

Nitrogen exists in air as covalently bonded diatomic molecules, N_2.

Which features are present in one N_2 molecule?

1 three π bonds
2 three shared pairs of electrons
3 two lone pairs of electrons

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

23. M/J 13/P12/Q33

Which substances contain delocalised electrons?

1 cyclohexene
2 graphite
3 sodium

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

24. O/N 12/P13/Q33

Which substances have a giant structure?

1 calcium oxide
2 calcium
3 baked clay found in crockery

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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Answers Sections

3.1	3.2		3.3	3.4	3.5	3.6
1. C	1. B	41. C	1. B	1. B	1. B	1. B
2. C	2. D	42. B	2. C	2. B	2. D	2. D
3. C	3. B	43. A	3. B		3. A	3. B
4. B	4. A	44. C	4. A		4. C	4. C
5. A	5. B	45. B	5. C		5. C	5. D
6. C	6. A	46. D	6. B		6. C	6. D
7. A	7. D	47. B	7. B		7. C	7. C
	8. C	48. D	8. C		8. D	8. A
	9. D	49. C	9. D		9. B	9. D
	10. B	50. C	10. C		10. D	10. C
	11. C	51. C	11. C		11. D	11. B
	12. B	52. B	12. D		12. B	12. D
	13. D	53. C	13. C		13. B	13. B
	14. C	54. C	14. D		14. B	14. A
	15. D	55. C	15. A		15. B	15. D
	16. C	56. A	16. D		16. B	16. A
	17. B	57. B	17. D		17. B	17. C
	18. C	58. B	18. C			18. A
	19. D	59. A	19. D			19. D
	20. C	60. B	20. B			20. B
	21. C	61. D	21. C			21. B
	22. A	62. B	22. D			22. C
	23. D	63. B	23. B			23. C
	24. A	64. D	24. C			24. A
	25. C	65. B	25. A			
	26. A	66. A	26. B			
	27. D	67. B	27. A			
	28. C	68. A	28. A			
	29. C	69. D	29. A			
	30. A	70. C	30. C			
	31. B		31. A			
	32. A		32. C			
	33. C		33. B			
	34. C		34. B			
	35. A					
	36. A					
	37. A					
	38. D					
	39. C					
	40. D					

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A Level

Unit 4

STATES OF MATTER

A Level
Chemistry Paper 1
Classified/Topical MCQ's
Article Number: 231

Editorial Board

Syllabus

4.1 The gaseous state: ideal and real gases and pV = nRT
4.2 The solid state: lattice structures
4.3 Multiple topics

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Unit 4: States of matter

4.1: The gaseous state: ideal and real gases and pV = nRT

1. **M/J 20/P11/Q7**
What are the units of K_p for the reaction shown?

$$H_2O(g) + C(s) \rightleftharpoons H_2(g) + CO(g)$$

A Pa^{-1} **B** Pa **C** Pa^2 **D** no units

2. **M/J 20/P11/Q9**
A sample of argon gas has a mass of 0.20 g, at a pressure of 100 000 Pa and a temperature of 12 °C.
Which volume does the gas occupy?
A 1.2×10^{-4} cm^3 **B** 5.0 cm^3 **C** 59 cm^3 **D** 119 cm^3

3. **O/N 19/P12/Q5**
In this question you should assume the vapour behaves as an ideal gas.
0.175 g of a volatile liquid produces a vapour of volume 4.50×10^{-5} m^3 at 100 °C and pressure of 1.013×10^5 Pa.
What is the M_r of the liquid?
A 31.9 **B** 87.1 **C** 119 **D** 127

4. **O/N 19/P12/Q6**
Which reaction is endothermic?
A $Ca(OH)_2(aq) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$
B $2Cl(g) \rightarrow Cl_2(g)$
C $2Ca(s) + O_2(g) \rightarrow 2CaO(s)$
D $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

5. **M/J 19/P12/Q6**
X, Y and Z are all gases that behave ideally and react according to the equation shown.

$$X(g) + 2Y(g) \rightarrow 2Z(g)$$

When 3.0 mol of X and 3.0 mol of Y are placed inside a container with a volume of 1.0 dm^3, they react to form the maximum amount of Z.
The final temperature of the reaction vessel is 120 °C.
What is the final pressure inside the reaction vessel?
A 4.49×10^6 Pa **B** 9.80×10^6 Pa **C** 1.47×10^7 Pa **D** 1.96×10^7 Pa

6. **M/J 19/P11/Q6, M/J 15/P13/Q11**
The gas laws can be summarised in the ideal gas equation below.

$$pV = nRT$$

When an evacuated tube of volume 400 cm^3 is filled with gas at 300 K and 101 kPa, the mass of the tube increases by 0.65 g.
Assume the gas behaves as an ideal gas.
What could be the identity of the gas?
A argon **B** helium **C** krypton **D** neon

7. **M/J 19/P11/Q7**
Under which conditions will nitrogen behave most like an ideal gas?

	temperature	pressure
A	low	high
B	high	low
C	low	low
D	high	high

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8. M/J 19/P13/Q7

What changes in conditions or molecular properties make it more likely that gases approach ideal behaviour?

A higher pressure
B lower temperature
C more polar molecules
D weaker intermolecular forces

9. MAR 19/P12/Q6

A sample of gas occupies 240 cm^3 at 37 °C and 100 kPa.
How many moles of gas are present in the sample?

A 9.32×10^{-6} **B** 9.32×10^{-3} **C** 0.0781 **D** 78.1

10. O/N 18/P12/Q5, O/N 15/P12/Q4, O/N 10/P12/Q7

Flask X contains 5 dm^3 of helium at 12 kPa pressure and flask Y contains 10 dm^3 of neon at 6 kPa pressure.
If the flasks are connected at constant temperature, what is the final pressure?

A 8 kPa **B** 9 kPa **C** 10 kPa **D** 11 kPa

11. O/N 18/P11/Q2, O/N 18/P13/Q2

What is a basic assumption of the kinetic theory, as applied to an ideal gas?

A Collisions between gas molecules are elastic.
B Each gas molecule occupies a finite volume.
C Gases consist of particles that experience the force of gravity.
D Gas molecules attract each other with weak intermolecular forces.

12. O/N 18/P11/Q5, O/N 18/P13/Q5, M/J 15/P12/Q5

The gas laws can be summarised in the ideal gas equation below.

$$pV = nRT$$

The volume of a sample of methane is measured at a temperature of 60 °C and a pressure of 103kPa. The volume measured is 5.37×10^{-3} m^3.
Assume the gas behaves as an ideal gas.
What is the mass of the sample of methane, given to two significant figures?

A 0.00018 g **B** 0.0032 g **C** 0.18 g **D** 3.2 g

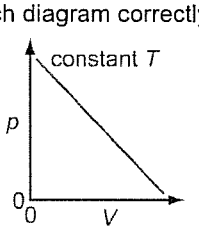
13. M/J 18/P12/Q6, O/N 05/P1/Q5

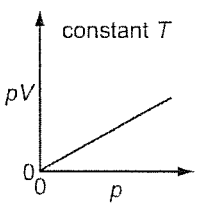
Which gas is likely to deviate most from ideal gas behaviour?

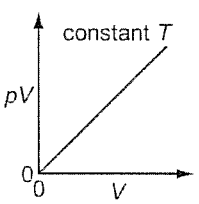
A HCl **B** He **C** CH_4 **D** N_2

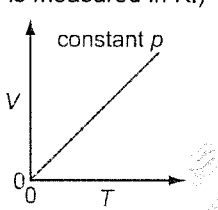
14. M/J 18/P13/Q6, M/J 08/P1/Q8

Which diagram correctly describes the behaviour of a fixed mass of an ideal gas? (T is measured in K.)

A


B


C


D


15. Mar 18/P12/Q7, M/J 12/P12/Q6

The gas laws can be summarised in the ideal gas equation.

$$pV = nRT$$

0.96 g of oxygen gas is contained in a glass vessel of volume 7000 cm^3 at a temperature of 3 °C.
What is the pressure in the vessel?

A 1.1 kPa **B** 2.1 kPa **C** 10.8 kPa **D** 21.6 kPa

16. O/N 17/P11/Q5, O/N 17/P13/Q5

A fluorescent light tube has an internal volume of 400 cm^3 and an internal pressure of 200 kPa.
It is filled with 0.03 moles of an ideal gas.
What is the temperature of the gas inside the fluorescent light tube?

A 3.21×10^{-1} K **B** 3.21×10^{2} K **C** 3.21×10^{5} K **D** 3.21×10^{8} K

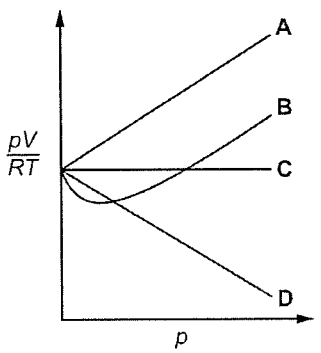
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17. O/N 17/P12/Q5

A sample of an ideal gas is contained at a constant temperature of 300 K in a gas syringe.

The pressure is increased and a graph of $\frac{pV}{RT}$ against pressure is plotted.

Which graph correctly represents the results?



18. M/J 17/P12/Q5

At a temperature of 2500 K and a pressure of 1.00×10^{-4} Pa a sample of 0.321 g of sulfur vapour has a volume of 2.08×10^{6} m^3.

What is the molecular formula of sulfur under these conditions?

A S **B** S_2 **C** S_4 **D** S_8

19. M/J 17/P13/Q5

All gases listed are at the same pressure.

Which gas will most closely approach ideal behaviour?

A ammonia at 100 K **B** ammonia at 500 K **C** neon at 100 K **D** neon at 500 K

20. MAR 17/P12/Q6

Which gas sample contains the fewest molecules?

A 1.00 dm^3 of carbon dioxide at 27 °C and 2.0 kPa

B 1.00 dm^3 of hydrogen at 100 °C and 2.0 kPa

C 1.00 dm^3 of nitrogen at 300 °C and 4.0 kPa

D 1.00 dm^3 of oxygen at 250 °C and 3.0 kPa

21. O/N 16/P12/Q8

In an experiment, a sample of a pure gas is put into a gas syringe at a temperature of 300 K and pressure of 16 kPa. The gas is compressed until the volume occupied by the gas is halved.

After compression, the temperature of the gas in the syringe is 375 K and the pressure is 40 kPa.

Which statement is correct?

A Intermolecular forces between the gas molecules are significant.

B It is possible to calculate the number of moles of gas present using these data alone.

C The gas is behaving ideally.

D The pressures used are too high for ideal gas behaviour.

22. O/N 16/P11/Q2, O/N 16/P13/Q2

In the ideal gas equation, $pV = nRT$, what are the units of n and T?

	n	T
A	no units	°C
B	no units	K
C	mol	°C
D	mol	K

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23. M/J 16/P12/Q6

Argon is a gas used to fill electric light bulbs.
Under which conditions of pressure and temperature will argon behave most like an ideal gas?

	pressure	temperature
A	high	high
B	high	low
C	low	high
D	low	low

24. M/J 16/P13/Q2

What will make it more likely that a gas will approach ideal behaviour?

A higher pressure **C** more polar molecules
B lower temperature **D** weaker intermolecular forces

25. MAR 16/P12/Q7

What is the volume of steam produced when 1.00 g of ice is heated to 323 °C at a pressure of 101 kPa?

A 0.27 dm^3 **B** 1.3 dm^3 **C** 2.7 dm^3 **D** 48 dm^3

26. M/J 15/P11/Q5

The gas laws can be summarised in the ideal gas equation below.

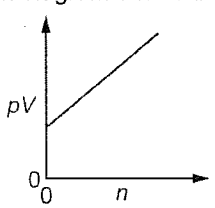
$$pV = nRT$$

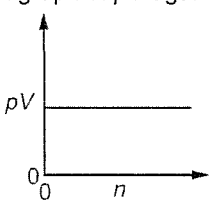
0.96 g of oxygen gas is contained in a glass vessel of volume 7.0×10^{-3} m^3 at a temperature of 30 °C.
Assume the gas behaves as an ideal gas.
What is the pressure in the vessel?

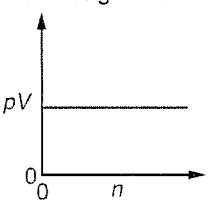
A 1.1 kPa **B** 2.1 kPa **C** 10.8 kPa **D** 21.6 kPa

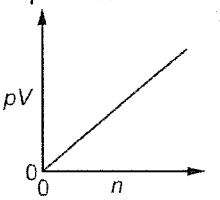
27. M/J 15/P13/Q2

Which diagram shows the correct graph of pV against n for an ideal gas at constant temperature?

A


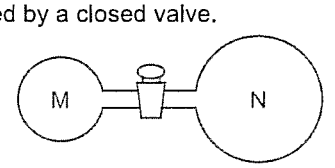
B


C


D


28. O/N 14/P12/Q4, O/N 14/P11/Q4

Two glass vessels M and N are connected by a closed valve.



M contains helium at 20 °C at a pressure of 1×10^5 Pa. N has been evacuated, and has three times the volume of M. In an experiment, the valve is opened and the temperature of the whole apparatus is raised to 100 °C.
What is the final pressure in the system?

A 3.18×10^4 Pa **B** 4.24×10^4 Pa **C** 1.25×10^5 Pa **D** 5.09×10^5 Pa

29. O/N 14/P13/Q9

When an evacuated glass tube of volume 200 cm^3 is filled with a gas at 300 K and 101 kPa, the mass of the tube increases by 1.06 g.
What is the identity of the gas?

A argon **B** krypton **C** neon **D** xenon

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30. M/J 14/P11/Q2

Iodine is a black, shiny, non-metallic solid and a member of Group VII. It sublimes easily on heating to give a purple vapour.

A sample of iodine vapour of mass 6.35 g has a volume of 1.247 dm^3 when maintained at constant temperature and a pressure of 1.00×10^5 Pa.

If iodine vapour acts as an ideal gas, what is the temperature of the iodine vapour?

A 300 K **B** 600 K **C** 300 000 K **D** 600 000 K

31. M/J 14/P13/Q7

A 10.0 cm^3 bubble of an ideal gas is formed on the sea bed where it is at a pressure of 2020 kPa. Just below the sea surface the pressure is 101 kPa and the temperature is the same as the sea bed. What is the volume of the bubble when it rises to just below the sea surface?

A 10.0 cm^3 **B** 20.2 cm^3 **C** 200 cm^3 **D** 2 020 000 cm^3

32. O/N 13/P12/Q8, O/N 13/P11/Q8

The approximate percentage composition of the atmosphere on four different planets is given in the table below.

The density of a gas may be defined as the mass of 1 dm^3 of the gas measured at s.t.p.

Which mixture of gases has the greatest density?

	planet	major gases / % by number of molecules
A	Jupiter	H_2 89.8, He 10.2
B	Neptune	H_2 80.0, He 19.0, CH_4 1.0
C	Saturn	H_2 96.3, He 3.25, CH_4 0.45
D	Uranus	H_2 82.5, He 15.2, CH_4 2.3

33. O/N 13/P13/Q7

Measured values of the pressure, volume and temperature of a known mass of a gaseous compound are to be substituted into the equation $pV = nRT$.

The measurements are used to calculate the relative molecular mass, M_r ,of a compound.

Which conditions of pressure and temperature would give the most accurate value of M_r?

	pressure	temperature
A	high	high
B	high	low
C	low	high
D	low	low

34. O/N 13/P13/Q9

When an evacuated fluorescent light tube of volume 300 cm^3 is filled with a gas at 300 K and 101 kPa, the mass of the tube increases by 1.02 g. The gas obeys the ideal gas equation $pV = nRT$.

What is the identity of the gas?

A argon **B** krypton **C** neon **D** nitrogen

35. M/J 13/P11/Q9

Which would behave the **least** like an ideal gas at room temperature?

A carbon dioxide **B** helium **C** hydrogen **D** nitrogen

36. M/J 13/P12/Q7

Ethanol has a boiling point of 78 °C. At 101 kPa and 79 °C ethanol vapour does not perfectly obey the gas equation $pV = nRT$.

What is the reason for this?

A Ethanol vapour is in equilibrium with ethanol liquid at 79 °C.

B There are intermolecular forces between the molecules of ethanol vapour.

C The vapourisation of ethanol liquid is an endothermic process.

D Vapours will not obey the gas equation perfectly at such a low pressure.

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37. M/J 13/P11/Q10

The general gas equation can be used to calculate the M_r value of a gas.
For a sample of a gas of mass mg, which expression will give the value of M_r?

A $M_r = \frac{mpV}{RT}$ **B** $M_r = \frac{pVRT}{m}$ **C** $M_r = \frac{mRT}{pV}$ **D** $M_r = \frac{pV}{mRT}$

38. M/J 13/P13/Q6

Which **least** resembles an ideal gas at room temperature and pressure?

A ammonia **B** helium **C** hydrogen **D** methane

39. M/J 13/P13/Q7

When 0.15 g of an organic compound is vaporised, it occupies a volume of 65.0 cm^3 at 405 K and 1.00×10^5 Nm^{-2}.
Using the expression $pV = nRT$, which of the following expressions should be used to calculate the relative molecular mass, M_r, of the compound?

A $\frac{0.15 \times 65 \times 10^{-6} \times 1 \times 10^5}{8.31 \times 405}$ **C** $\frac{0.15 \times 65 \times 10^{-3} \times 1 \times 10^5}{8.31 \times 405}$

B $\frac{0.15 \times 8.31 \times 405}{1 \times 10^5 \times 65 \times 10^{-3}}$ **D** $\frac{0.15 \times 8.31 \times 405}{1 \times 10^5 \times 65 \times 10^{-6}}$

40. O/N 12/P12/Q6, O/N 12/P11/Q6

The volume of a sample of ammonia is measured at a temperature of 60 °C and a pressure of 103 kPa. The volume measured is 5.37×10^{-3} m^3.
What is the mass of the sample of ammonia, given to two significant figures?

A 0.00019 g **B** 0.0034 g **C** 0.19 g **D** 3.4 g

41. O/N 12/P12/Q17, O/N 12/P11/Q17

1.15 g of a metallic element reacts with 300 cm^3 of oxygen at 298 K and 1 atm pressure, to form an oxide which contains O^{2-} ions.
What could be the identity of the metal?

A calcium **B** magnesium **C** potassium **D** sodium

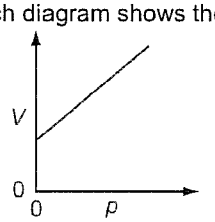
42. O/N 12/P13/Q3

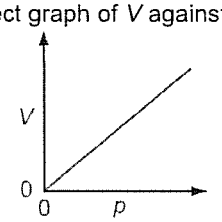
The volume of a sample of ammonia was measured at a temperature of 40 °C and a pressure of 95 kPa. The volume measured was 4.32×10^{-5} m^3.
What is the mass of the sample of ammonia?

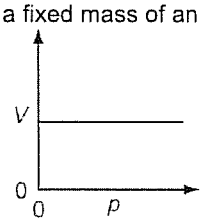
A 2.7×10^{-5} g **B** 2.1×10^{-4} g **C** 2.7×10^{-2} g **D** 2.1×10^{-1} g

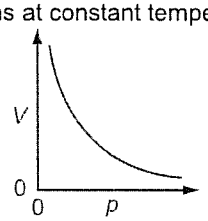
43. O/N 12/P13/Q1

Which diagram shows the correct graph of V against p for a fixed mass of an ideal gas at constant temperature?

A


B


C


D


44. M/J 12/P11/Q6, M/J 12/P13/Q7

The gas laws can be summarised in the ideal gas equation.

$$pV = nRT$$

0.56 g of ethene gas is contained in a vessel at a pressure of 102 kPa and a temperature of 30 °C.
What is the volume of the vessel?

A 49 cm^3 **B** 494 cm^3 **C** 48 900 cm^3 **D** 494 000 cm^3

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45. O/N 11/P12/Q9

The use of sucrose in food processing depends in part on osmotic pressure, symbol Π.

In dilute solution, Π varies with concentration in a similar way to gas behaviour. The equation $\Pi V = nRT$ can be used, where n is the number of moles of solute molecules contained in volume V at temperature T. The number of moles of solvent molecules should be ignored.

Under aqueous acidic conditions sucrose is hydrolysed

$$\underset{\text{sucrose}}{C_{12}H_{22}O_{11}} + H_2O \rightarrow \underset{\text{glucose}}{CH_2OH(CHOH)_4CHO} + \underset{\text{fructose}}{CH_2OH(CHOH)_3COCH_2OH}$$

What can be deduced from this hydrolysis equation?

	the osmotic pressure	glucose and fructose are
A	decreases	optical isomers
B	decreases	structural isomers
C	increases	optical isomers
D	increases	structural isomers

46. M/J 12/P11/Q8, M/J 12/P13/Q8

Under which set of conditions is a gas most likely to behave ideally?

	temperature	pressure
A	high	high
B	high	low
C	low	high
D	low	low

47. O/N 11/P11/Q5, O/N 11/P13/Q4

At room temperature and pressure chlorine does not behave as an ideal gas.

At which temperature and pressure would the behaviour of chlorine become more ideal?

	pressure /kPa	temperature /K
A	50	200
B	50	400
C	200	200
D	200	400

48. M/J 10/P12/Q1, M/J 10/P11/Q3, M/J 10/P13/Q1

Which gas closely approaches ideal behaviour at room temperature and pressure?

A ammonia **B** carbon dioxide **C** helium **D** oxygen

49. M/J 06/P1/Q6

Which of the following least resembles an ideal gas?

A ammonia **B** helium **C** hydrogen **D** trichloromethane

50. M/J 10/P12/Q7, M/J 10/P11/Q9, M/J 10/P13/Q6

Which mass of gas would occupy a volume of 3 dm^3 at 25 °C and 1 atmosphere pressure?

[1 mol of gas occupies 24 dm^3 at 25 °C and 1 atmosphere pressure.]

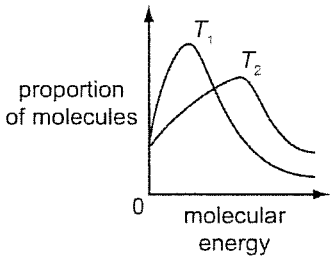
A 3.2g O_2 gas **B** 5.6g N_2 gas **C** 8.0g SO_2 gas **D** 11.0g CO_2 gas

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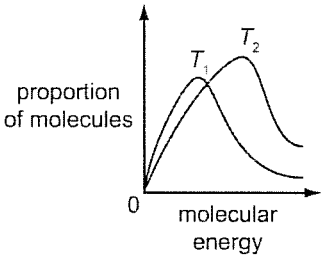
51. O/N 10/P12/Q2

Which diagram correctly represents the Boltzmann distribution of molecular energies at two temperatures T_1 and T_2, where T_1 = 300 K and T_2 = 310 K?

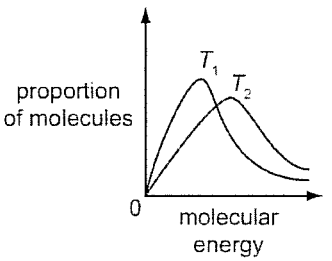
A



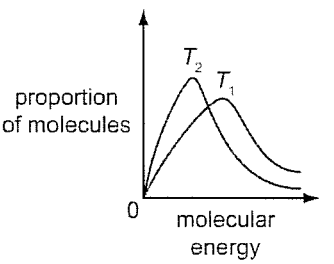
C



B



D



52. O/N 08/P1/Q7

Which of the following would behave most like an ideal gas at room temperature?

A carbon dioxide **B** helium **C** hydrogen **D** nitrogen

53. M/J 02/P1/Q6

Flask X contains 1 dm^3 of helium at 2 kPa pressure and flask Y contains 2 dm^3 of neon at 1 kPa pressure. If the flasks are connected at constant temperature, what is the final pressure?

A $1\frac{1}{3}$kPa **B** $1\frac{1}{2}$kPa **C** $1\frac{2}{3}$kPa **D** 2 kPa

Valid till October/November 2021 Exams

54. MAR 17/P12/Q32, M/J 11/P12/Q32

When a sample of a gas is compressed at constant temperature from 1500 kPa to 6000 kPa, its volume changes from 76.0 cm^3 to 20.5 cm^3.

Which statements are possible explanations for this behaviour?

1 The gas behaves non-ideally.
2 The gas partially liquefies.
3 Gas is adsorbed on to the vessel walls.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

55. M/J 16/P11/Q32

What are basic assumptions of the kinetic theory as applied to an ideal gas?

1 Gas particles are in continuous random motion.
2 Gas particles experience no intermolecular forces.
3 The volume of each gas particle is zero.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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56. O/N 15/P12/Q33, M/J 11/P12/Q33

Which equations can apply to an ideal gas?

[p = pressure, V = volume, M = molar mass, ρ = density, c = concentration, R = gas constant, T = temperature]

1 $p = \frac{\rho RT}{M}$ 2 $pV = \frac{cRT}{M}$ 3 $pV = MRT$

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

57. O/N 14/P12/Q34, O/N 14/P11/Q34

A student borrowed a friend's chemistry notes and copied out the notes in the box below.

Which statements are correct?

A gas behaves **less** like an ideal gas when the gas

1 is at low pressure.

2 is at low temperature.

3 can be easily liquefied.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

58. M/J 12/P11/Q31, M/J 12/P13/Q33

The gas laws can be summarised in the ideal gas equation.

$$pV = nRT$$

where each symbol has its usual meaning.

Which statements are correct?

1 One mole of an ideal gas occupies the same volume under the same conditions of temperature and pressure.

2 The density of an ideal gas at constant pressure is inversely proportional to the temperature, T.

3 The volume of a given mass of an ideal gas is doubled if its temperature is raised from 25 °C to 50 °C at constant pressure.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

59. O/N 11/P12/Q33, O/N 07/P1/Q31

Which are assumptions of the kinetic theory of gases and hence of the ideal gas equation, $PV = nRT$?

1 Molecules move without interacting with one another except for collisions.

2 Intermolecular forces are negligible.

3 Intermolecular distances are much greater than the molecular size.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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60. M/J 09/P1/Q32

An ideal gas obeys the gas laws under all conditions of temperature and pressure.
Which of the following are true for an ideal gas?

1 The molecules have negligible volume.
2 There are no forces of attraction between molecules.
3 The molecules have an average kinetic energy which is proportional to its absolute temperature.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

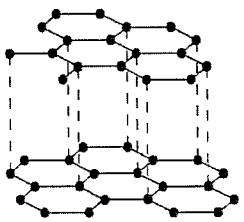
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4.2: The solid state: lattice structures

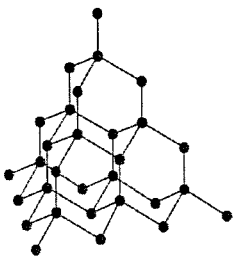
1. MAR 19/P12/Q7

P, Q and R represent three different structures of an element.

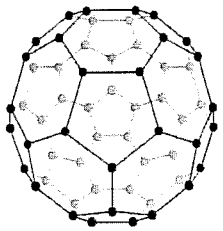
P



Q



R



Which structures are giant molecular?

A P, Q and R **B** P and Q only **C** P and R only **D** Q and R only

2. M/J 15/P12/Q4, O/N 10/P12/Q5

Which solid has a simple molecular lattice?

A calcium fluoride **B** nickel **C** silicon(IV) oxide **D** sulfur

3. M/J 11/P11/Q10, M/J 11/P13/Q13

Three substances, R, S and T, have physical properties as shown.

substance	R	S	T
mp/°C	801	2852	3550
bp/°C	1413	3600	4827
electrical conductivity of solid	poor	poor	good

What could be the identities of R, S and T ?

	R	S	T
A	MgO	NaCl	C [graphite]
B	MgO	NaCl	SiO_2
C	NaCl	MgO	C [graphite]
D	NaCl	MgO	SiO_2

4. M/J 09/P1/Q7

A crystal of iodine produces a purple vapour when gently heated.
Which pair of statements correctly describes this process?

	type of bond broken	formula of purple species
A	covalent	I
B	covalent	I_2
C	induced dipole-dipole	I_2
D	permanent dipole-dipole	I_2

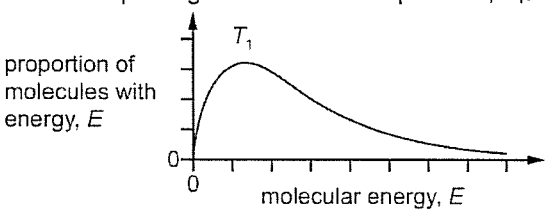
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4.3: Multiple Topics

1. MAR 19/P12/Q1

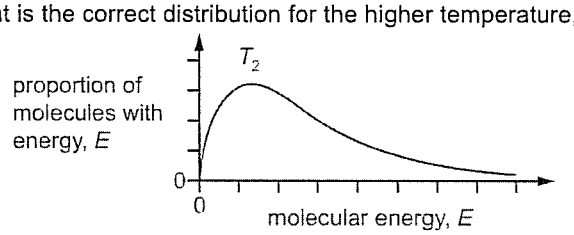
The Boltzmann distribution is shown for a sample of gas at an initial temperature, T_1.



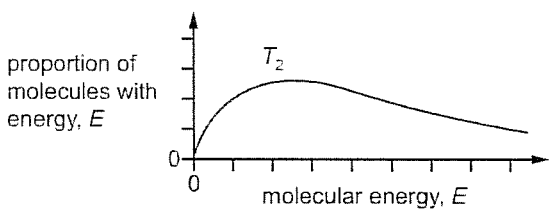
The sample of gas was heated to temperature, T_2.

What is the correct distribution for the higher temperature, T_2?

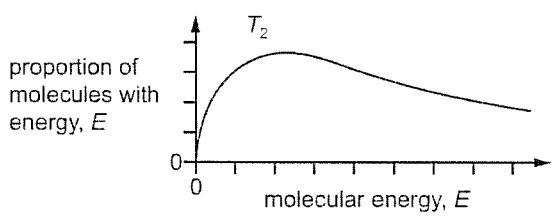
A



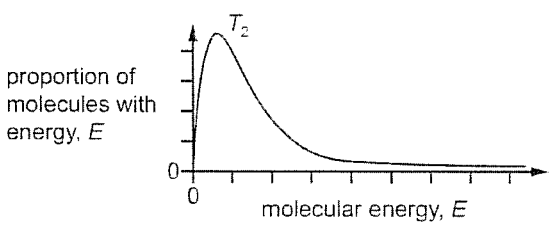
B



C



D



2. O/N 18/P12/Q10

In a chemical system the particles involved have a range of energies. This can be shown on a graph called the Boltzmann distribution.

Which statement correctly explains the effect of a catalyst on the particles in a chemical system?

A A catalyst enables particles with a lower energy to collide successfully.

B A catalyst increases the number of particles with higher energies.

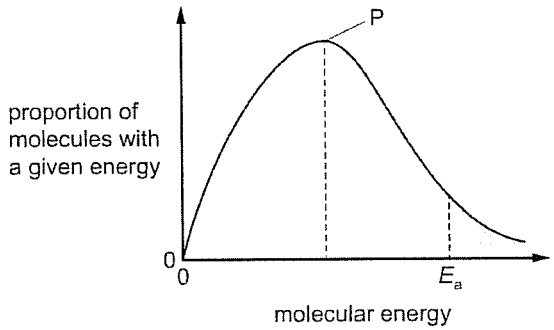
C A catalyst increases the number of particles with the most probable energy value.

D A catalyst increases the value of the most probable particle energy.

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3. M/J 18/P11/Q4

The diagram shows the Boltzmann distribution of energies in a gas. The gas can take part in a reaction with an activation energy, E_a. The gas is maintained at a constant temperature.



Which statement is correct?

A If a catalyst is added, peak P will be lower and E_a will move to the left.

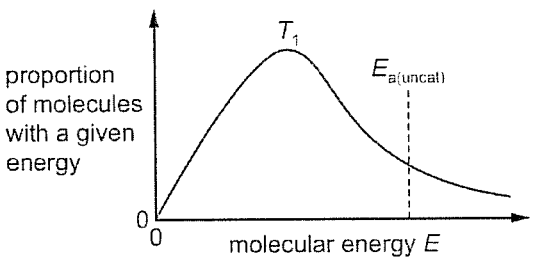
B If a catalyst is added, peak P will be lower and E_a will move to the right.

C If a catalyst is added, peak P will be the same and E_a will move to the left.

D If a catalyst is added, peak P will be the same and E_a will move to the right.

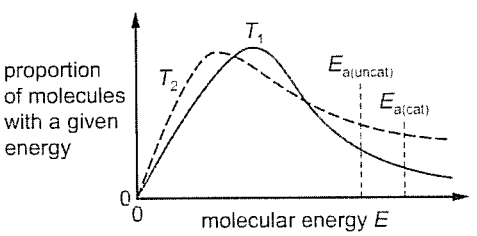
4. O/N 17/P11/Q10, O/N 17/P13/Q10

The diagram shows the distribution of molecular energies in a sample of gas at a temperature T_1.
The activation energy for an uncatalysed reaction of this gas, $E_{a(uncat)}$, is shown.

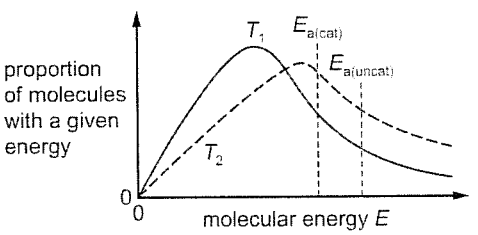


Which diagram correctly shows the new distribution and new activation energy, $E_{a(cat)}$, when the temperature is increased to T_2, and a catalyst is used that increases the rate of the reaction?

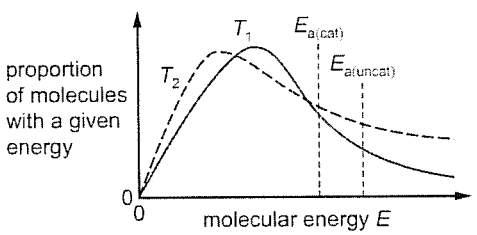
A



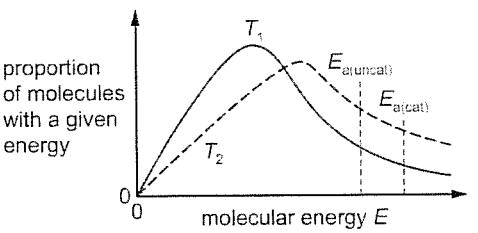
C



B



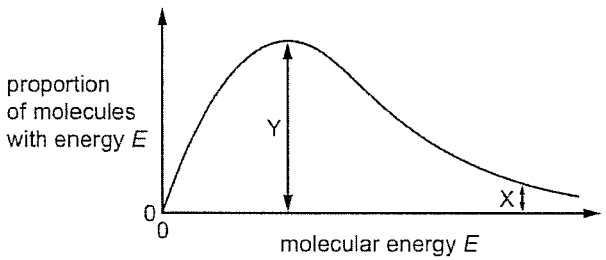
D



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5. M/J 17/P13/Q11

The diagram shows the Boltzmann distribution of the energy of gaseous molecules at a particular temperature.



Which statement is correct?

A If the temperature of the gas is raised, the height of the maximum of the curve increases.

B If the temperature of the gas is raised, the maximum of the curve moves to the right.

C The length of the line labelled X shows the activation energy for the reaction.

D The length of the line labelled Y shows the enthalpy change of the reaction.

6. O/N 11/P11/Q12, O/N 11/P13/Q11

Butanedioate ions can be dehydrogenated to form *trans*-butenedioate ions. The enzyme fumarase speeds up this reaction.

Why does fumarase speed up this reaction?

A Fumarase is a protein.

B Fumarase is effective at body temperature.

C Fumarase lowers the activation energy of the dehydrogenation reaction.

D The enzyme fumarase is specific for this dehydrogenation reaction.

7. O/N 08/P1/Q6, O/N 03/P1/Q8

A substance commonly found in the house or garden has the following properties.

- It is combustible.
- It is an electrical insulator.
- It melts over a range of temperature.

What could the substance be?

A brass **B** paper **C** poly(ethene) **D** silicon(IV) oxide

Valid till October/November 2021 Exams

8. M/J 17/P12/Q32

Which allotropes of carbon have a giant molecular structure?

1 buckminsterfullerene
2 diamond
3 graphite

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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Answers Sections

4.1				4.2		4.3	
1.	B	41.	D	1.	B	1.	B
2.	D	42.	C	2.	D	2.	A
3.	C	43.	D	3.	C	3.	C
4.	D	44.	B	4.	C	4.	C
5.	C	45.	D			5.	B
6.	A	46.	B			6.	C
7.	B	47.	B			7.	C
8.	D	48.	C			8.	C
9.	B	49.	A				
10.	A	50.	C				
11.	A	51.	B				
12.	D	52.	B				
13.	A	53.	A				
14.	D	54.	D				
15.	C	55.	A				
16.	B	56.	D				
17.	C	57.	C				
18.	A	58.	B				
19.	D	59.	A				
20.	B	60.	A				
21.	C						
22.	D						
23.	C						
24.	D						
25.	C						
26.	C						
27.	D						
28.	A						
29.	D						
30.	B						
31.	C						
32.	D						
33.	C						
34.	B						
35.	A						
36.	B						
37.	C						
38.	A						
39.	D						
40.	D						

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Unit 5
CHEMICAL ENERGETICS

A Level
Chemistry Paper 1
Classified/Topical MCQ's
Article Number: 231

Editorial Board

Syllabus

5.1 Enthalpy change
5.2 Hess' Law, including Born-Haber cycles
5.3 Multiple topics

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Unit 5: Chemical energetics

5.1: Enthalpy change

1. **M/J 20/P12/Q4**
Solid sulfur consists of S_8 molecules.
Which equation represents the standard enthalpy of atomisation of sulfur?
A $\frac{1}{8}S_8(s) \rightarrow S(g)$ **B** $\frac{1}{8}S_8(g) \rightarrow S(g)$ **C** $S_8(s) \rightarrow 8S(g)$ **D** $S_8(g) \rightarrow 8S(g)$

2. **M/J 20/P11/Q5**
Two reactions are shown.
$$H_2(g) \rightarrow 2H(g)$$
$$CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$$
If molar amounts are used, how can the two energy changes associated with these reactions be described?
A enthalpy of atomisation and enthalpy of combustion
B enthalpy of atomisation and enthalpy of formation
C bond energy and enthalpy of combustion
D bond energy and enthalpy of formation

3. **M/J 20/P13/Q4**
The enthalpy changes of two reactions are shown.
$K_2CO_3(s) + 2HCl(aq) \rightarrow 2KCl(aq) + H_2O(l) + CO_2(g)$ $\Delta H = -34.0$ kJ mol^{-1}
$KHCO3(s) + HCl(aq) \rightarrow KCl(aq) + H_2O(l) + CO_2(g)$ $\Delta H = +32.8$ kJ mol^{-1}
What is the enthalpy change for the reaction shown?
$$2KHCO_3(s) \rightarrow K_2CO_3(s) + H_2O(l) + CO_2(g)$$
A –31.6 kJ mol^{-1} **B** 1.2 kJ mol^{-1} **C** 66.8 kJ mol^{-1} **D** 99.6 kJ mol^{-1}

4. **MAR 20/P12/Q4**
The following data are needed for this question.
$NaHCO_3(s) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l) + CO_2(g)$ $\Delta H = -38.97$ kJ mol^{-1}
$Na_2CO_3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$ $\Delta H = -96.59$ kJ mol^{-1}
On heating, sodium hydrogencarbonate decomposes as shown.
$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(l) + CO_2(g)$$
What is the enthalpy change for this decomposition?
A –57.62 kJ mol^{-1} **B** –18.65 kJ mol^{-1} **C** 18.65 kJ mol^{-1} **D** 57.62 kJ mol^{-1}

5. **O/N 19/P12/Q7**
Which equation correctly represents the standard enthalpy change of atomisation of the given element?
A $\frac{1}{2}I_2(g) \rightarrow I(g)$
B $Na(s) \rightarrow Na(g)$
C $Cl_2(g) \rightarrow 2Cl(g)$
D $Na(g) \rightarrow Na^+(g) + e^-$

6. **O/N 19/P12/Q8**
$(NH_4)_2Cr_2O_7$ decomposes when heated.
$$(NH_4)_2Cr_2O_7 \rightarrow N_2 + 4H_2O + Cr_2O_3$$
Which element is oxidised and which element is reduced?

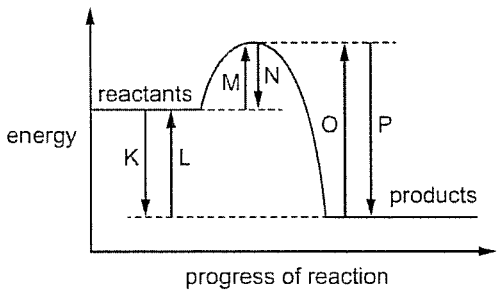
	oxidised	reduced
A	chromium	nitrogen
B	hydrogen	chromium
C	nitrogen	chromium
D	nitrogen	hydrogen

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7. M/J 19/P12/Q8

A reaction pathway diagram is shown.

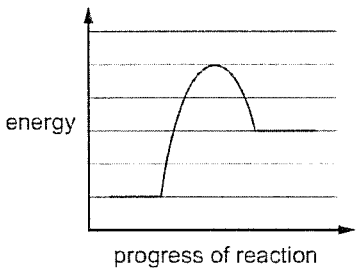


Which row is correct?

	enthalpy change of the forward reaction	activation energy of the reverse reaction
A	K	M
B	K	O
C	L	O
D	P	M

8. M/J 19/P13/Q6

The reaction pathway diagram for a chemical reaction is shown.



Which statement is correct?

A The activation energy of the forward reaction and the enthalpy change of the backward reaction have the same sign.

B The activation energy of the forward reaction is more than twice the enthalpy change of the backward reaction and opposite in sign.

C The enthalpy change of the forward reaction and the activation energy of the backward reaction have the same sign.

D The enthalpy change of the forward reaction is more than twice the activation energy of the backward reaction.

9. M/J 19/P11/Q18

At 550 °C nitrogen dioxide reacts with unburnt hydrocarbon fragments such as CH_3 in the catalytic converter of a motor vehicle.

$$4CH_3 + 7NO_2 \rightarrow 3\tfrac{1}{2}N_2 + 4CO_2 + 6H_2O$$

Which row gives the energy change for this reaction and a possible reason for it?

	energy change of reaction	reason why the reaction is endothermic or exothermic
A	endothermic	chemical energy is converted to heat energy
B	endothermic	the N≡N bond energy is very high
C	exothermic	CO_2 and H_2O have negative $\Delta H_f^{\ominus}$ values
D	exothermic	double bonds are broken in NO_2

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10. MAR 19/P12/Q8

The standard enthalpy changes of combustion of carbon, hydrogen and methanol are shown.

$$C(s) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H_c^{\ominus} = -394 \text{ kJ mol}^{-1}$$

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(l) \qquad \Delta H_c^{\ominus} = -286 \text{ kJ mol}^{-1}$$

$$CH_3OH(l) + 1\tfrac{1}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(l) \qquad \Delta H_c^{\ominus} = -726 \text{ kJ mol}^{-1}$$

Which expression gives the standard enthalpy change of formation of methanol in kJ mol^{-1}?

A $-394 + (-286) - (-726)$ **C** $-394 + (-286 \times 2) - (-726)$

B $-394 + (-286 \times 2) - 726$ **D** $-726 - (-394) - (-286 \times 2)$

11. MAR 19/P12/Q9

The equation for a chemical reaction is shown. All substances are in their standard states.

$$XeF_6 + 3H_2O \rightarrow XeO_3 + 6HF$$

Which statement describes the standard enthalpy change of reaction for this reaction?

A the enthalpy change when a total of one mole of products is produced

B the enthalpy change when a total of one mole of reactants is reacted

C the enthalpy change when one mole of water reacts

D the enthalpy change when six moles of hydrogen fluoride are produced

12. O/N 18/P12/Q1

Which statement about enthalpy changes is correct?

A Enthalpy changes of atomisation are always negative.

B Enthalpy changes of combustion are always positive.

C Enthalpy changes of formation are always positive.

D Enthalpy changes of neutralisation are always negative.

13. O/N 18/P12/Q7, O/N 14/P12/Q3, O/N 14/P11/Q3

Ethanol is increasingly being used as a fuel for cars.
The standard enthalpy change of formation of carbon dioxide is –393 kJ mol^{-1}.
The standard enthalpy change of formation of water is –286 kJ mol^{-1}.
The standard enthalpy change of formation of ethanol is –277 kJ mol^{-1}.
What is the standard enthalpy change of combustion of ethanol?

A –1921 kJ mol^{-1} **B** –1367 kJ mol^{-1} **C** –956 kJ mol^{-1} **D** –402 kJ mol^{-1}

14. O/N 18/P11/Q6, O/N 18/P13/Q6

A butane burner is used to heat water. The Mr of butane is 58.

- $\Delta H_c^{\ominus}$ of butane is –2877 kJ mol^{-1}.
- 250 g of water is heated from 12 °C to 100 °C.
- The burner transfers 47% of the heat released from the burning fuel to the water.

Assume that the butane undergoes complete combustion and none of the water evaporates.
What is the minimum mass of butane that must be burnt?

A 0.068 g **B** 1.85 g **C** 3.94 g **D** 4.48 g

15. M/J 18/P12/Q7

The enthalpy change of reaction 1 is –114 kJ mol^{-1}.

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l) \qquad \text{reaction 1}$$

By using this information, what is the most likely value for the enthalpy change of reaction 2?

$$Ba(OH)_2(aq) + 2HCl(aq) \rightarrow BaCl_2(aq) + 2H_2O(l) \qquad \text{reaction 2}$$

A –57 kJ mol^{-1} **B** –76 kJ mol^{-1} **C** –114 kJ mol^{-1} **D** –228 kJ mol^{-1}

16. M/J 17/P11/Q7

Which expression gives the standard enthalpy change of combustion of methane?

A $\Delta H_f^{\ominus}(CH_4) + \Delta H_f^{\ominus}(CO_2) - 2\Delta H_f^{\ominus}(H_2O)$ **C** $\Delta H_f^{\ominus}(CH_4) + 2\Delta H_f^{\ominus}(H_2O) - \Delta H_f^{\ominus}(CO_2)$

B $\Delta H_f^{\ominus}(CO_2) + 2\Delta H_f^{\ominus}(H_2O) + \Delta H_f^{\ominus}(CH_4)$ **D** $\Delta H_f^{\ominus}(CO_2) + 2\Delta H_f^{\ominus}(H_2O) - \Delta H_f^{\ominus}(CH_4)$

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17. M/J 18/P11/Q7, O/N 10/P11/Q8, O/N 10/P13/Q11

Enthalpy changes of combustion can be used to determine enthalpy changes of formation. The following equation represents the enthalpy change of formation of butane.

$$4C(s) + 5H_2(g) \rightarrow C_4H_{10}(g)$$

By using the following standard enthalpy of combustion data, what is the value of the standard enthalpy change of formation, $\Delta H_f^{\ominus}$, for this reaction?

compound	$\Delta H_c^{\ominus}$ / kJ mol^{-1}
carbon	–394
hydrogen	–286
butane	–2877

A –5883 kJ mol^{-1} **B** –129 kJ mol^{-1} **C** +129 kJ mol^{-1} **D** +2197 kJ mol^{-1}

18. M/J 18/P13/Q7

Anhydrous copper(II) chloride, $CuCl_2$, combines with water to form $CuCl_2.2H_2O$. The standard enthalpy changes of formation for this reaction are shown in the table.

	$\Delta H_f^{\ominus}$ / kJ mol^{-1}
H_2O	–286
$CuCl_2$	–206
$CuCl_2.2H_2O$	–808

What is the standard enthalpy change of the reaction shown?

$$CuCl_2 + 2H_2O \rightarrow CuCl_2.2H_2O$$

A –1586 kJ mol^{-1} **B** –316 kJ mol^{-1} **C** –110 kJ mol^{-1} **D** –30 kJ mol^{-1}

19. O/N 17/P12/Q6

In calculating the enthalpy change, ΔH, of an experiment involving solutions, the mass of the solution, m, specific heat capacity of the solution, c, and the temperature change, ΔT, are needed.

$$\Delta T = T_{final} - T_{initial}$$

Which expression for ΔH is correct?

A $\Delta H = \frac{mc}{\Delta T}$ **B** $\Delta H = \frac{-mc}{\Delta T}$ **C** $\Delta H = mc\Delta T$ **D** $\Delta H = -mc\Delta T$

20. O/N 17/P12/Q7

The following data are needed for this question.

$\Delta H_f^{\ominus}$ ($P_4O_{10}(s)$) = –3012 kJ mol^{-1}

$\Delta H_f^{\ominus}$ ($H_2O(l)$) = –286 kJ mol^{-1}

$\Delta H_f^{\ominus}$ ($H_3PO_4(s)$) = –1279 kJ mol^{-1}

What is $\Delta H^{\ominus}$ for the reaction shown?

$$P_4O_{10}(s) + 6H_2O(l) \rightarrow 4H_3PO_4(s)$$

A –9844 kJ mol^{-1} **B** –388 kJ mol^{-1} **C** –97 kJ mol^{-1} **D** +2019 kJ mol^{-1}

21. O/N 17/P11/Q8, O/N 17/P13/Q8

Sulfur can be oxidised in two ways.

$$S(s) + O_2(g) \rightarrow SO_2(g) \qquad \Delta H^{\ominus} = -296.5 \text{ kJ mol}^{-1}$$

$$2S(s) + 3O_2(g) \rightarrow 2SO_3(g) \qquad \Delta H^{\ominus} = -791.4 \text{ kJ mol}^{-1}$$

Sulfur trioxide can be made from sulfur dioxide and oxygen.

$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$$

What is the standard enthalpy change for this reaction?

A –1384.4 kJ mol^{-1} **B** –989.8 kJ mol^{-1} **C** –494.9 kJ mol^{-1} **D** –198.4 kJ mol^{-1}

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22. M/J 17/P12/Q7

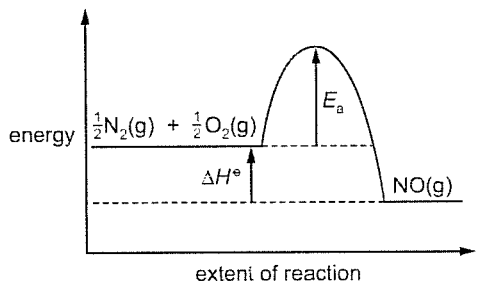
In the high temperatures of car engines, nitrogen reacts with oxygen to give nitrogen monoxide.

$$\tfrac{1}{2}N_2(g) + \tfrac{1}{2}O_2(g) \rightarrow NO(g) \qquad \Delta H^{\ominus} = +90 \text{ kJ mol}^{-1}$$

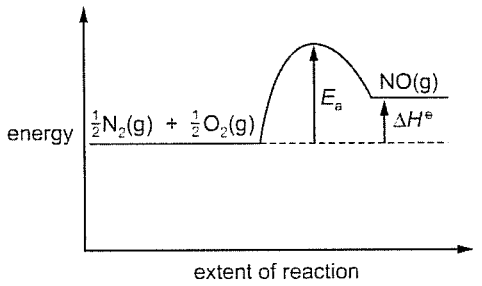
This reaction has activation energy E_a.

Which reaction pathway diagram could correctly represent this reaction?

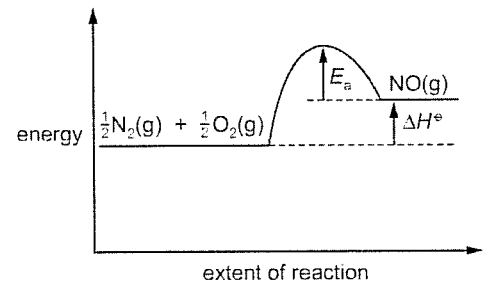
A



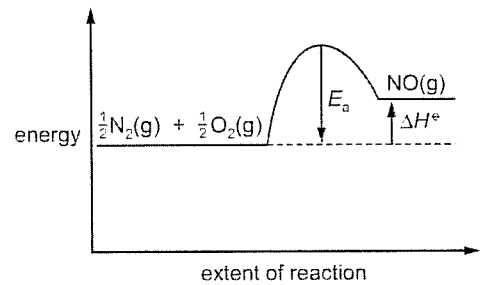
C



B



D



23. M/J 17/P13/Q6

The following data are needed for this question.

$\Delta H_f^{\ominus}(CO(g)) = -111 \text{ kJ mol}^{-1}$

$\Delta H_f^{\ominus}(CO_2(g)) = -394 \text{ kJ mol}^{-1}$

$\Delta H_f^{\ominus}(Fe_2O_3(s)) = -822 \text{ kJ mol}^{-1}$

Carbon monoxide reacts with iron(III) oxide.

$$3CO(g) + Fe_2O_3(s) \rightarrow 3CO_2(g) + 2Fe(s)$$

What is the enthalpy change when 55.8 g of iron are produced by this reaction?

A –27.0 kJ **B** –13.5 kJ **C** +13.5 kJ **D** +27.0 kJ

24. MAR 17/P12/Q7

A student mixed 25.0 cm^3 of 4.00 mol dm^{-3} hydrochloric acid with an equal volume of 4.00 mol dm^{-3} sodium hydroxide. The initial temperature of both solutions was 15.0 °C. The maximum temperature recorded was 30.0 °C.

Using these results, what is the enthalpy change of neutralisation of hydrochloric acid?

A $-62.7 \text{ kJ mol}^{-1}$ **B** $-31.4 \text{ kJ mol}^{-1}$ **C** $-15.7 \text{ kJ mol}^{-1}$ **D** $-3.14 \text{ kJ mol}^{-1}$

25. MAR 17/P12/Q9

All the reactants and products of an exothermic reaction are gaseous.

Which statement about this reaction is correct?

A The total bond energy of the products is less than the total bond energy of the reactants, and ΔH for the reaction is negative.

B The total bond energy of the products is less than the total bond energy of the reactants, and ΔH for the reaction is positive.

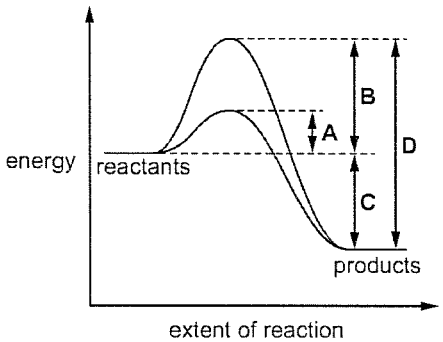
C The total bond energy of the products is more than the total bond energy of the reactants, and ΔH for the reaction is negative.

D The total bond energy of the products is more than the total bond energy of the reactants, and ΔH for the reaction is positive.

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26. O/N 16/P12/Q2

The diagram shows the pathways of a reaction, with and without a catalyst.
Which letter represents the overall energy change for the reaction?



27. O/N 16/P12/Q9

In a calorimetric experiment 1.60 g of a fuel are burnt. 45.0% of the energy released is absorbed by 200 g of water. The temperature of the water rises from 18.0 °C to 66.0 °C.
What is the total energy released per gram of fuel burnt (to 3 significant figures)?

A 25 100 J **B** 55 700 J **C** 89 200 J **D** 143 000 J

28. M/J 16/P11/Q1, O/N 07/P1/Q8

Which equation shows the reaction that occurs during the standard enthalpy change of atomisation of bromine?

A $Br_2(l) \rightarrow 2Br(g)$ **B** $Br_2(g) \rightarrow 2Br(g)$ **C** $\frac{1}{2}Br_2(l) \rightarrow Br(g)$ **D** $\frac{1}{2}Br_2(g) \rightarrow Br(g)$

29. M/J 16/P11/Q8

Gaseous phosphorus pentachloride can be decomposed into gaseous phosphorus trichloride and chlorine by heating. The table gives the bond energies.

bond	bond energy / kJ mol^{-1}
P–C*l* (in both chlorides)	330
C*l*–C*l*	242

What is the enthalpy change for the decomposition of PCl_5 to PCl_3 and Cl_2?

A –418 kJ mol^{-1} **B** –88 kJ mol^{-1} **C** +88 kJ mol^{-1} **D** +418 kJ mol^{-1}

30. M/J 16/P13/Q1

Enthalpy changes, ΔH, can be positive or negative.
Which row is correct?

	ΔH positive	ΔH negative
A	atomisation	bond breaking
B	bond breaking	neutralisation
C	bond making	combustion
D	combustion	bond making

31. MAR 16/P12/Q10

Which equation has an enthalpy change of reaction which corresponds to the standard enthalpy change of atomisation of chlorine?

A $\frac{1}{2}Cl_2(g) \rightarrow Cl(g)$ **B** $\frac{1}{2}Cl_2(l) \rightarrow Cl(g)$ **C** $Cl_2(g) \rightarrow 2Cl(g)$ **D** $Cl_2(l) \rightarrow 2Cl(g)$

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32. MAR 16/P12/Q5

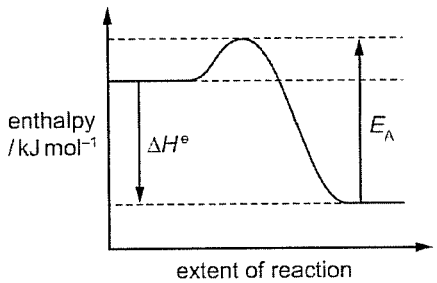
Nitric oxide, NO, and bromine vapour react together according to the following equation.

$$2NO(g) + Br_2(g) \rightarrow 2NOBr(g) \qquad \Delta H^{\ominus} = -23 kJmol^{-1}$$

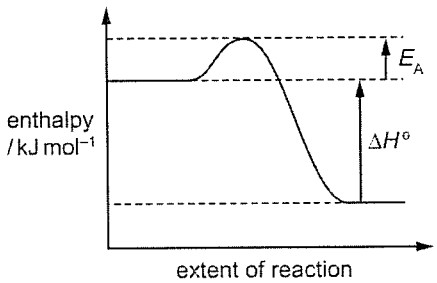
The reaction has an activation energy of +5.4 kJ mol^{-1}.

What is the correct reaction pathway diagram for this reaction?

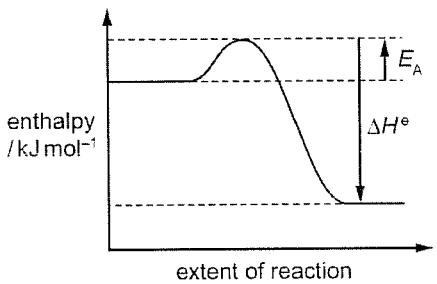
A



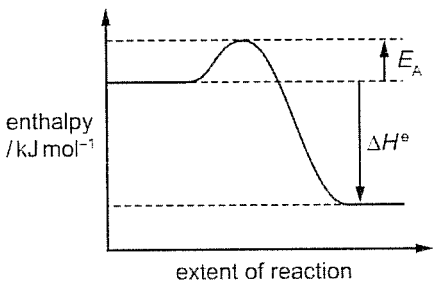
C



B



D



33. M/J 16/P13/Q8, O/N 10/P12/Q4

Methanol may be prepared by the reaction between carbon monoxide and hydrogen.

$$CO(g) + 2H_2(g) \rightarrow CH_3OH(g)$$

The relevant average bond energies are given below.

E (C ≡ O) 1077 kJ mol^{-1}
E (C – O) 360 kJ mol^{-1}
E (C – H) 410 kJ mol^{-1}
E (H – H) 436 kJ mol^{-1}
E (O – H) 460 kJ mol^{-1}

What is the enthalpy change of this reaction?

A –537 kJ mol^{-1} **B** –101 kJ mol^{-1} **C** +101 kJ mol^{-1} **D** +537 kJ mol^{-1}

34. M/J 15/P12/Q8

Nitrogen dioxide, NO_2, exists in equilibrium with dinitrogen tetroxide, N_2O_4.

$$2NO_2(g) \rightleftharpoons N_2O_4(g) \qquad \Delta H = -57 \text{ kJ mol}^{-1}$$

Which conditions give the greatest percentage of $N_2O_4(g)$ at equilibrium?

	pressure	temperature
A	high	high
B	high	low
C	low	high
D	low	low

35. O/N 14/P12/Q11, O/N 14/P11/Q11

For which equation is the enthalpy change correctly described as an enthalpy change of formation?

A $C(g) + O_2(g) \rightarrow CO_2(g)$

B $C(s) + \frac{1}{2}O_2(g) \rightarrow CO(g)$

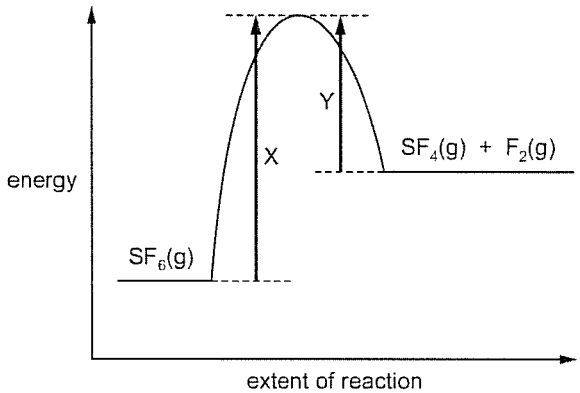
C $2N(g) + 4O(g) \rightarrow N_2O_4(g)$

D $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$

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36. O/N 15/P12/Q10

The decomposition reaction $SF_6(g) \rightarrow SF_4(g) + F_2(g)$ can be described by the reaction pathway diagram shown.



What are the values of $\Delta H^{\ominus}$ and E_a for this reaction?

	$\Delta H^{\ominus}$	E_a
A	X	X + Y
B	X	Y
C	X – Y	X
D	Y – X	X

37. O/N 15/P11/Q6

Solid sulfur consists of molecules made up of eight atoms covalently bonded together.
The bonding in sulfur dioxide is O=S=O.

enthalpy change of combustion of S_8, $\Delta H_c^{\ominus} S_8(s) = -2376 kJ\ mol^{-1}$

energy required to break 1 mole $S_8(s)$ into gaseous atoms = 2232 kJ mol^{-1}
O=O bond enthalpy = 496 kJ mol^{-1}

Using these data, what is the value of the S=O bond enthalpy?

A 239 kJ mol^{-1} **B** 257 kJ mol^{-1} **C** 319 kJ mol^{-1} **D** 536 kJ mol^{-1}

38. O/N 15/P11/Q7

In an experiment, the burning of 1.45 g (0.025 mol) of propanone was used to heat 100 g of water.
The initial temperature of the water was 20.0 °C and the final temperature of the water was 78.0 °C.
Which experimental value for the enthalpy change of combustion for propanone can be calculated from these results?

A –1304 kJ mol^{-1} **B** –970 kJ mol^{-1} **C** –352 kJ mol^{-1} **D** –24.2 kJ mol^{-1}

39. M/J 15/P11/Q7

The standard enthalpy changes of combustion of glucose and ethanol are given as –2820 and –1368 kJ mol^{-1} respectively.
Glucose, $C_6H_{12}O_6$, can be converted into ethanol.

$$C_6H_{12}O_6(s) \rightarrow 2C_2H_5OH(l) + 2CO_2(g)$$

What is the standard enthalpy change for this reaction?

A –1452 kJ mol^{-1} **B** –84 kJ mol^{-1} **C** +84 kJ mol^{-1} **D** +1452 kJ mol^{-1}

40. M/J 14/P11/Q5

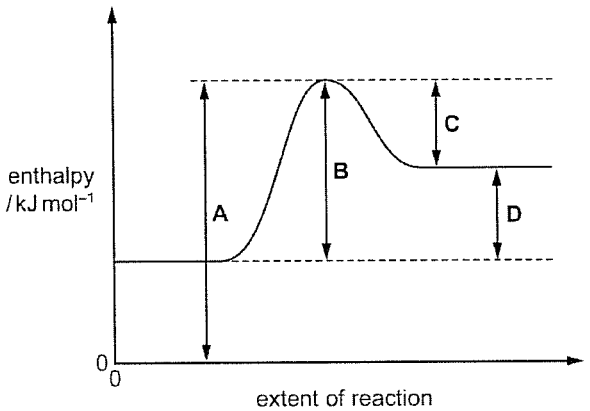
A student mixed 25.0 cm^3 of 0.350 mol dm^{-3} sodium hydroxide solution with 25.0 cm^3 of 0.350 mol dm^{-3} hydrochloric acid. The temperature rose by 2.50 °C. Assume that no heat was lost to the surroundings.
The final mixture had a specific heat capacity of 4.20 J cm^{-3} K^{-1}.
What is the molar enthalpy change for the reaction?

A –150 kJ mol^{-1} **B** –60.0 kJ mol^{-1} **C** –30.0 kJ mol^{-1} **D** –0.150 kJ mol^{-1}

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41. M/J 15/P11/Q11

The diagram shows a reaction pathway for an endothermic reaction.
Which arrow represents the activation energy for the forward reaction?



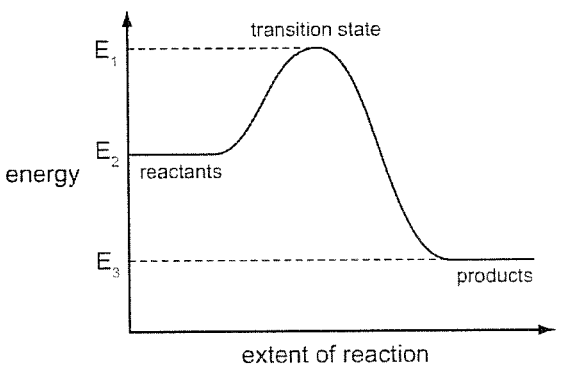
42. O/N 14/P12/Q7, O/N 14/P11/Q7

In an experiment to calculate the enthalpy change of combustion of a fuel, 1.5 g (0.0326 mol) of the fuel was used to heat 200 g of water. The temperature of the water rose from 25 °C to 55 °C. The specific heat capacity of water is 4.18 $Jg^{-1}K^{-1}$.
There is significant heat loss in this experiment. Therefore, the experimental value for the enthalpy change of combustion, ΔH_c, of the fuel will be different from the theoretical value.
Using the information above, what is the experimental value for the enthalpy change of combustion, ΔH_c, of the fuel?

A $-1410\ kJmol^{-1}$ **B** $-769\ kJmol^{-1}$ **C** $-30.7\ kJmol^{-1}$ **D** $-16.7\ kJmol^{-1}$

43. O/N 14/P12/Q8, O/N 14/P11/Q8, O/N 10/P12/Q6

The reaction pathway diagram below illustrates the energies of the reactants, the products and the transition state of a reaction.



Which expression represents the activation energy of the forward reaction?

A $E_1 - E_2$ **B** $E_2 - E_1$ **C** $E_2 - E_3$ **D** $E_3 - E_2$

44. M/J 14/P12/Q11

The diagram shows the skeletal formula of cyclopropane.



The enthalpy change of formation of cyclopropane is $+53.3\ kJ\ mol^{-1}$ and the enthalpy change of atomisation of graphite is $+717\ kJ\ mol^{-1}$.
The bond enthalpy of H–H is $436\ kJ\ mol^{-1}$ and of C–H is $410\ kJ\ mol^{-1}$.
What value for the average bond enthalpy of the C–C bond in cyclopropane can be calculated from this data?

A $187\ kJ\ mol^{-1}$ **B** $315\ kJ\ mol^{-1}$ **C** $351\ kJ\ mol^{-1}$ **D** $946\ kJ\ mol^{-1}$

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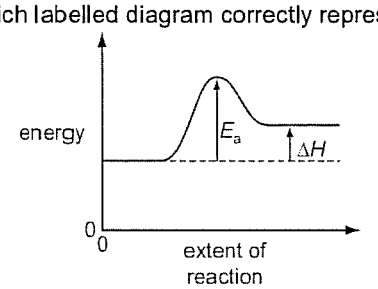
45. O/N 14/P13/Q10

Nitrogen monoxide is an atmospheric pollutant that is formed inside car engines by an endothermic reaction between nitrogen and oxygen.

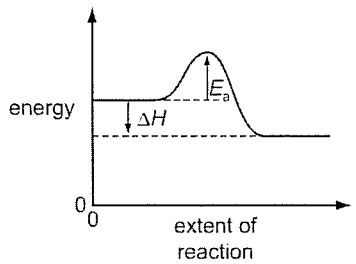
$$N_2(g) + O_2(g) \rightarrow 2NO(g) \quad \Delta H = +66 \text{ kJ mol}^{-1}$$

Which labelled diagram correctly represents the energy profile for this reaction?

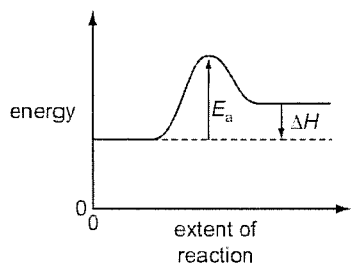
A



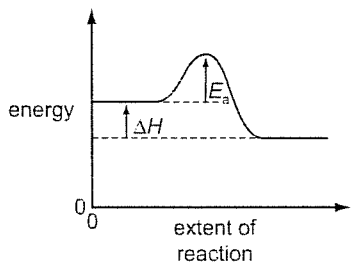
C



B



D



46. O/N 14/P13/Q11

When 0.47 g of a hydrocarbon was completely burnt in air, the energy released heated 200 g of water from 23.7 °C to 41.0 °C.

What was the amount of energy absorbed by the water?

A $0.47 \times 4.18 \times 17.3$ J

B $0.47 \times 4.18 \times (273 + 17.3)$ J

C $200 \times 4.18 \times 17.3$ J

D $200 \times 4.18 \times (273 + 17.3)$ J

47. M/J 14/P12/Q8

Which equation represents the standard enthalpy change of formation of ethanol, C_2H_5OH?

A $2C(g) + 3H_2(g) + \frac{1}{2}O_2(g) \rightarrow C_2H_5OH(l)$

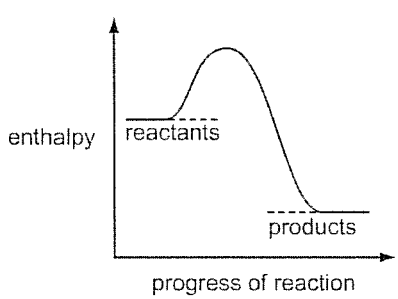
B $2C(s) + 3H_2(g) + \frac{1}{2}O_2(g) \rightarrow C2H5OH(l)$

C $2C(s) + 3H_2(g) + \frac{1}{2}O_2(g) \rightarrow C_2H_5OH(g)$

D $2C(g) + 6H(g) + O(g) \rightarrow C_2H_5OH(l)$

48. M/J 14/P13/Q3

A reaction pathway diagram is shown.



Which enthalpy change could the diagram not apply to?

A enthalpy of atomisation

B enthalpy of combustion

C enthalpy of formation

D enthalpy of neutralisation

49. M/J 14/P13/Q11, M/J 11/P12/Q8

Which reaction has an enthalpy change equal to the standard enthalpy change of formation of propane?

A $3C(g) + 4H_2(g) \rightarrow C_3H_8(g)$

B $3C(g) + 8H(g) \rightarrow C_3H_8(g)$

C $3C(s) + 4H_2(g) \rightarrow C_3H_8(g)$

D $3C(s) + 4H_2(g) \rightarrow C_3H_8(l)$

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50. M/J 14/P13/Q6

Hydrazine, N_2H_4, is used as a rocket fuel because it reacts with oxygen as shown, producing 'environmentally friendly' gases.

$$N_2H_4(l) + O_2(g) \rightarrow N_2(g) + 2H_2O(g) \qquad \Delta H = -534 \text{ kJ mol}^{-1}$$

Despite its use as a rocket fuel, hydrazine does not burn spontaneously in oxygen.
Which statement explains why hydrazine does **not** burn spontaneously?

A Hydrazine is a liquid.
B The activation energy is too high.
C The N≡N bond is very strong.
D The reaction is exothermic.

51. M/J 14/P13/Q9

The enthalpy change of formation of $Mn(NO_3)_2(s)$ is –696 kJ mol^{-1}.
The enthalpy change of formation of $MnO_2(s)$ is –520 kJ mol^{-1}.
The enthalpy change of formation of $NO_2(g)$ is +33 kJ mol^{-1}.
On heating, $Mn(NO_3)_2$ decomposes into MnO_2 and NO_2.

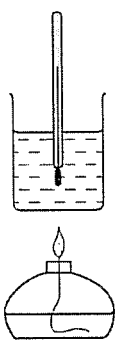
$$Mn(NO_3)_2(s) \rightarrow MnO_2(s) + 2NO_2(g)$$

What is the value of the standard enthalpy change of this reaction?

A –242 kJ mol^{-1} **B** –209 kJ mol^{-1} **C** +209 kJ mol^{-1} **D** +242 kJ mol^{-1}

52. O/N 13/P11/Q11

A student carried out an experiment to determine the enthalpy change for the combustion of methanol.
The following results were obtained by the student.



start temperature of the water	20 °C
final temperature of the water	53 °C
mass of alcohol burner before burning	259.65 g
mass of alcohol burner after burning	259.15 g
mass of glass beaker plus water	150.00 g
mass of glass beaker	50.00 g

How much of the heat energy produced by the burning of methanol went into the water?

A 209 J **B** 13 794 J **C** 20 691 J **D** 22 154 J

53. M/J 13/P12/Q4

Which factor can affect the value of the activation energy of a reaction?

A changes in concentration of the reactants
B decrease in temperature
C increase in temperature
D the presence of a catalyst

54. M/J 13/P12/Q10

A student mixed 25 cm^3 of 0.10 mol dm^{-3} sodium hydroxide solution with 25 cm^3 of 0.10 mol dm^{-3} hydrochloric acid and noted a temperature rise of 2.5 °C.
What is the enthalpy change of the reaction per mole of NaOH?

A –209 kJ mol^{-1} **B** –104.5 kJ mol^{-1} **C** –209 J mol^{-1} **D** –522.5 J mol^{-1}

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55. M/J 13/P12/Q11

Which energy change corresponds to the enthalpy change of atomisation of hydrogen at 298 K?

A the bond energy of a H – H bond
B half the bond energy of a H – H bond
C minus half the bond energy of a H – H bond
D minus the bond energy of a H – H bond

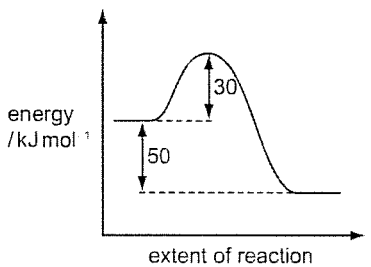
56. M/J 13/P12/Q12

Propanone has molecular formula C_3H_6O.
The enthalpy change of combustion of hydrogen is –286 kJ mol^{-1}.
The enthalpy change of combustion of carbon is –394 kJ mol^{-1}.
The enthalpy change of formation of propanone is –254 kJ mol^{-1}.
Using this information, what is the enthalpy change of combustion of propanone?

A –2644 kJ mol^{-1} **B** –2294 kJ mol^{-1} **C** –1786 kJ mol^{-1} **D** –426 kJ mol^{-1}

57. M/J 13/P11/Q7

The reaction pathway for a reversible reaction is shown below.



Which statement is correct?

A The activation energy of the reverse reaction is +80 kJ mol^{-1}.
B The enthalpy change for the forward reaction is +30 kJ mol^{-1}.
C The enthalpy change for the forward reaction is +50 kJ mol^{-1}.
D The enthalpy change for the reverse reaction is +30 kJ mol^{-1}.

58. M/J 13/P11/Q12

This question should be answered using bond enthalpy data. The equation for the complete combustion of methane is given below.

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

What is the enthalpy change of combustion of methane?

A –1530 kJ mol^{-1} **B** –1184 kJ mol^{-1} **C** –770 kJ mol^{-1} **D** –688 kJ mol^{-1}

59. M/J 13/P13/Q11

This question should be answered using bond enthalpy data. The equation for the complete combustion of methanal is given below.

$$H_2C{=}O + O_2 \rightarrow CO_2 + H_2O$$

What is the enthalpy change of combustion of methanal?

A +416 kJ mol^{-1} **B** +396 kJ mol^{-1} **C** –344 kJ mol^{-1} **D** –690 kJ mol^{-1}

60. O/N 12/P12/Q4, O/N 12/P11/Q4

A reaction which causes the presence of oxides of nitrogen in car exhausts is the formation of NO.

$$N_2 + O_2 \rightarrow 2NO \quad \Delta H = +180 \text{ kJ mol}^{-1}$$

What is the bond energy in kJ mol^{-1} of the bond between the atoms in NO?

A 655 **B** 835 **C** 1310 **D** 1670

61. O/N 12/P12/Q10, O/N 12/P11/Q10

A student calculated the standard enthalpy change of formation of ethane, C_2H_6, using a method based on standard enthalpy changes of combustion.
He used correct values for the standard enthalpy change of combustion of ethane (–1560 kJ mol^{-1}) and hydrogen (–286 kJ mol^{-1}) but he used an incorrect value for the standard enthalpy change of combustion of carbon. He then performed his calculation correctly. His final answer was –158 kJ mol^{-1}.
What did he use for the standard enthalpy change of combustion of carbon?

A –1432 kJ mol^{-1} **B** –860 kJ mol^{-1} **C** –430 kJ mol^{-1} **D** –272 kJ mol^{-1}

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62. O/N 12/P12/Q5, O/N 12/P11/Q5

In the table below,

- '+' means that this type of standard enthalpy change can **only** have positive values,
- '–' means that this type of standard enthalpy change can **only** have negative values,
- '+/–' means that **either** positive **or** negative values are possible.

Which row is correct?

	atomisation	formation	solution
A	+	+	+/–
B	+	+/–	+/–
C	–	+/–	–
D	–	–	+

63. O/N 12/P12/Q11, O/N 12/P11/Q11

Which process could be used to calculate the bond energy for the covalent bond X–Y by dividing its ΔH by n?

A $XY_n(g) \rightarrow X(g) + nY(g)$

B $2XY_n(g) \rightarrow 2XY_{n-1}(g) + Y_2(g)$

C $Y(g) + XY_{n-1}(g) \rightarrow XY_n(g)$

D $nXY(g) \rightarrow nX(g) + \frac{n}{2}Y_2(g)$

64. O/N 12/P13/Q5

Ethyne, C_2H_2, completely combusts, as shown in the equation.

$$H{-}C{\equiv}C{-}H + 2\tfrac{1}{2}O{=}O \rightarrow H_2O + 2CO_2$$

Using the average bond enthalpies in the table, what is the enthalpy change of combustion of ethyne?

bond	average bond enthalpy / kJ mol^{-1}
C—H	410
C≡C	840
O=O	496
C=O	740
O—H	460
C—O	360

A –980 kJ mol^{-1} **B** –540 kJ mol^{-1} **C** +540 kJ mol^{-1} **D** +980 kJ mol^{-1}

65. O/N 12/P13/Q10

The enthalpy change of the neutralisation given below is –114 kJ mol^{-1}.

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

By using this information, what is the most likely value for the enthalpy change of the following neutralisation?

$$Ba(OH)_2(aq) + 2HCl(aq) \rightarrow BaCl_2(aq) + 2H_2O(l)$$

A –57 kJ mol^{-1} **B** –76 kJ mol^{-1} **C** –114 kJ mol^{-1} **D** –228 kJ mol^{-1}

66. M/J 12/P12/Q14, M/J 07/P1/Q14

Slaked lime, $Ca(OH)_2$, may be made from limestone, $CaCO_3$.

On heating in a lime kiln at 1000 °C, limestone decomposes as follows.

reaction 1 $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

Water is then reacted with calcium oxide, CaO, as follows.

reaction 2 $CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(s)$

What are the enthalpy changes of these reactions?

	reaction 1	reaction 2
A	endothermic	endothermic
B	endothermic	exothermic
C	exothermic	endothermic
D	exothermic	exothermic

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67. M/J 12/P12/Q12, O/N 08/P1/Q8

Red lead oxide, Pb_3O_4, is used in metal priming paints. It can be made by heating PbO in air.

$$6PbO(s) + O_2(g) \rightarrow 2Pb_3O_4(s)$$

Which two values are needed to calculate the enthalpy change for this reaction?

A enthalpy change of atomisation of O_2 and enthalpy change of formation of Pb_3O_4

B enthalpy change of formation of O_2 and enthalpy change of formation of Pb_3O_4

C enthalpy change of formation of PbO and enthalpy change of atomisation of O_2

D enthalpy change of formation of PbO and enthalpy change of formation of Pb_3O_4

68. M/J 12/P11/Q3, M/J 12/P13/Q4

The equation for a reaction is shown.

$$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l) \; ; \; \Delta H = x \text{ kJ mol}^{-1}$$

Which pair of descriptions is fully correct for this reaction?

	type(s) of enthalpy change	value of x
A	formation only	positive
B	formation only	negative
C	combustion, formation	positive
D	combustion, formation	negative

69. M/J 12/P11/Q4, M/J 12/P13/Q3

The value of the second ionisation energy of calcium is 1150 kJ mol^{-1}.

Which equation correctly represents this statement?

A $Ca(g) \rightarrow Ca^{2+}(g) + 2e^- \; ; \quad \Delta H^{\ominus} = +1150 \text{ kJ mol}^{-1}$

B $Ca^+(g) \rightarrow Ca^{2+}(g) + e^- \; ; \quad \Delta H^{\ominus} = +1150 \text{ kJ mol}^{-1}$

C $Ca^+(g) \rightarrow Ca^{2+}(g) + e^- \; ; \quad \Delta H^{\ominus} = -1150 \text{ kJ mol}^{-1}$

D $Ca(g) \rightarrow Ca^{2+}(g) + 2e \; ; \quad \Delta H^{\ominus} = -1150 \text{ kJ mol}^{-1}$

70. M/J 12/P11/Q7, M/J 12/P13/Q5

Propanone has the molecular formula C_3H_6O.

The enthalpy change of combustion of hydrogen is –286 kJ mol^{-1}.

The enthalpy change of combustion of carbon is –394 kJ mol^{-1}.

The enthalpy change of combustion of propanone is –1786 kJ mol^{-1}.

Using this information, what is the enthalpy change of formation of propanone?

A –1106 kJ mol^{-1} **B** –540 kJ mol^{-1} **C** –254 kJ mol^{-1} **D** +1106 kJ mol^{-1}

71. O/N 11/P11/Q6, O/N 11/P13/Q7

The standard enthalpy change for the reaction

$$2NF_3(g) \rightarrow 2N(g) + 6F(g) \qquad \text{is } \Delta H^{\ominus} = +1668 \text{ kJ}$$

What is the bond energy of the N–F bond?

A –556 kJ mol^{-1} **B** –278 kJ mol^{-1} **C** +278 kJ mol^{-1} **D** +556 kJ mol^{-1}

72. O/N 11/P11/Q19, O/N 11/P13/Q19

Which reaction is endothermic?

A $2HBr \rightarrow H_2 + Br_2$

B $N_2 + 3H_2 \rightarrow 2NH_3$

C $2SO_2 + O_2 \rightarrow 2SO_3$

D $SO_3 + H_2O \rightarrow H_2SO_4$

73. M/J 11/P12/Q7, M/J 08/P1/Q10

Titanium occurs naturally as the mineral rutile, TiO_2. One possible method of extraction of titanium is to reduce the rutile by heating with carbon.

$$TiO_2(s) + 2C(s) \rightarrow Ti(s) + 2CO(g)$$

The standard enthalpy changes of formation of $TiO_2(s)$ and CO(g) are –940 kJ mol^{-1} and –110 kJ mol^{-1} respectively.

What is the standard enthalpy change of this reaction?

A –830 kJ mol^{-1} **B** –720 kJ mol^{-1} **C** +720 kJ mol^{-1} **D** +830 kJ mol^{-1}

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74. M/J 11/P12/Q9, M/J 06/P1/Q8

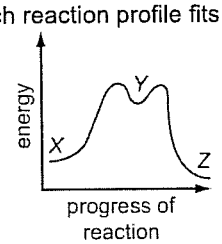
In the conversion of compound *X* into compound *Z*, it was found that the reaction proceeded by way of compound *Y*, which could be isolated. The following steps were involved.

$X \rightarrow Y$; ΔH, positive

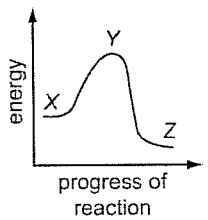
$Y \rightarrow Z$; ΔH, negative

Which reaction profile fits these data?

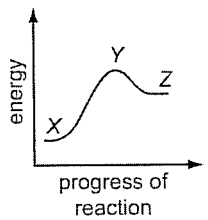
A



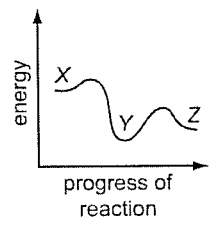
B



C



D



75. M/J 11/P11/Q8, M/J 11/P13/Q9

The equation below represents the combination of gaseous atoms of non-metal X and of hydrogen to form gaseous X_2H_6 molecules.

$$2X(g) + 6H(g) \rightarrow X_2H_6(g) \quad \Delta H = -2775 \text{ kJ mol}^{-1}$$

The bond energy of an X–H bond is 395 kJ mol^{-1}.

What is the bond energy of an X–X bond?

A –405.0 kJ mol^{-1} **B** –202.5 kJ mol^{-1} **C** +202.5 kJ mol^{-1} **D** +405.0 kJ mol^{-1}

76. M/J 11/P11/Q9, M/J 11/P13/Q8

50 cm^3 of 2.50 mol dm^{-3} hydrochloric acid was placed in a polystyrene beaker of negligible heat capacity. Its temperature was recorded and then 50 cm^3 of 2.50 mol dm^{-3} NaOH at the same temperature was quickly added, with stirring. The temperature rose by 17 °C.

The resulting solution may be considered to have a specific heat capacity of 4.2 J g^{-1} K^{-1}.

What is an approximate value for the molar enthalpy change of neutralisation of hydrochloric acid and sodium hydroxide from this experiment?

A $\frac{-(50 \times 4.2 \times 17)}{(0.050 \times 2.5)}$ J mol^{-1}

B $\frac{-(50 \times 4.2 \times 17)}{(0.10 \times 2.5)}$ J mol^{-1}

C $\frac{-(100 \times 4.2 \times 17)}{(0.050 \times 2.5)}$ J mol^{-1}

D $\frac{-(100 \times 4.2 \times 17)}{(50 \times 2.5)}$ J mol^{-1}

77. M/J 11/P11/Q12, M/J 11/P13/Q11

Hydrazine, N_2H_4, is widely used as a rocket fuel because it reacts with oxygen as shown, producing 'environmentally friendly' gases.

$$N_2H_4(l) + O_2(g) \rightarrow N_2(g) + 2H_2O(g) \qquad \Delta H = -534 \text{ kJ mol}^{-1}$$

Despite its use as a rocket fuel, hydrazine does not burn spontaneously in oxygen.

Which statement explains why hydrazine does **not** burn spontaneously?

A Hydrazine is a liquid.

B The activation energy is too high.

C The N≡N bond is very strong.

D The reaction is exothermic.

78. O/N 10/P11/Q3, O/N 10/P13/Q2

Equations involving four enthalpy changes are shown.

$Na(g) \rightarrow Na^+(g) + e^-$ $\Delta H = W$

$Na(g) \rightarrow Na^{2+}(g) + 2e^-$ $\Delta H = X$

$Na(s) \rightarrow Na(g)$ $\Delta H = Y$

$Na(s) \rightarrow Na^{2+}(g) + 2e^-$ $\Delta H = Z$

What is the second ionisation energy of sodium?

A 2W **B** X – W **C** Y – W **D** Z – Y

79. O/N 10/P11/Q11, O/N 10/P13/Q13

Which equation represents the change corresponding to the enthalpy change of atomisation of iodine?

A $\frac{1}{2} I_2(g) \rightarrow I(g)$ **B** $I_2(g) \rightarrow 2I(g)$ **C** $\frac{1}{2} I_2(s) \rightarrow I(g)$ **D** $I_2(s) \rightarrow 2I(g)$

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80. O/N 10/P11/Q9, O/N 10/P13/Q12

In a calorimetric experiment 1.60 g of a fuel is burnt. 45% of the energy released is absorbed by 200 g of water whose temperature rises from 18 °C to 66 °C. The specific heat capacity of water is 4.2 $Jg^{-1}K^{-1}$.
What is the total energy released per gram of fuel burnt?

A 25 200 J **B** 56 000 J **C** 89 600 J **D** 143 360 J

81. M/J 10/P12/Q4, M/J 10/P11/Q4, M/J 10/P13/Q5

Some bond energy values are listed below.

bond	bond energy / kJ mol^{-1}
C–H	410
C–C*l*	340
C*l*–C*l*	244
Br–Br	193

These bond energy values relate to the following four reactions.

P $Br_2 \rightarrow 2Br$
Q $2Cl \rightarrow Cl_2$
R $CH_3 + Cl \rightarrow CH_3Cl$
S $CH_4 \rightarrow CH_3 + H$

What is the order of enthalpy changes of these reactions from most negative to most positive?

A P → Q → R → S **B** Q → R → S → P **C** R → Q → P → S **D** S → P → Q → R

82. M/J 10/P12/Q5, M/J 10/P11/Q5, M/J 10/P13/Q4

Given the following enthalpy changes,

$$I_2(g) + 3Cl_2(g) \rightarrow 2ICl_3(s) \quad \Delta H^{\ominus} = -214 \text{ kJ mol}^{-1}$$

$$I_2(s) \rightarrow I_2(g) \quad \Delta H^{\ominus} = +38 \text{ kJ mol}^{-1}$$

What is the standard enthalpy change of formation of iodine trichloride, $ICl_3(s)$?

A +176 kJ mol^{-1} **B** –88 kJ mol^{-1} **C** –176 kJ mol^{-1} **D** –214 kJ mol^{-1}

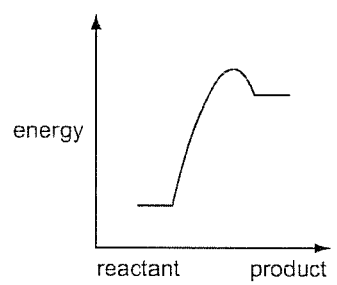
83. O/N 09/P12/Q9, O/N 09/P11/Q10, M/J 04/P1/Q12

Four reactions of the type shown are studied at the same temperature.

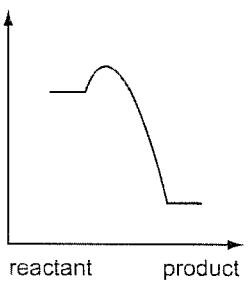
$$X(g) + Y(g) \rightarrow Z(g)$$

Which is the correct reaction pathway diagram for the reaction that would proceed **most** rapidly and with the **highest** yield?

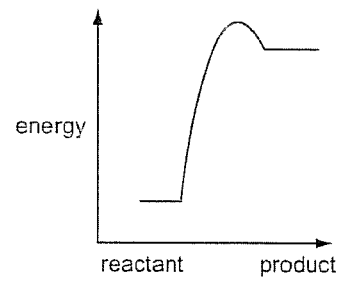
A



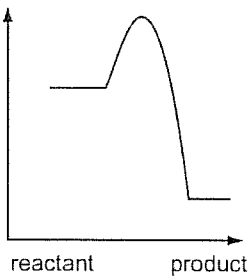
C



B



D



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84. O/N 09/P11/Q6

The first stage in the industrial production of nitric acid from ammonia can be represented by the following equation.

$$4NH_3\,(g) + 5O_2\,(g) \rightleftharpoons 4NO\,(g) + 6H_2O\,(g)$$

Using the following standard enthalpy change of formation data, what is the value of the standard enthalpy change, $\Delta H^{\ominus}$, for this reaction?

compound	$\Delta H_f^{\ominus}$ / kJ mol^{-1}
$NH_3(g)$	–46.1
$NO(g)$	+90.3
$H_2O(g)$	–241.8

A +905.2 kJ mol^{-1} **B** –105.4 kJ mol^{-1} **C** –905.2 kJ mol^{-1} **D** –1274.0 kJ mol^{-1}

85. O/N 09/P11/Q9

PCl_5 dissociates as follows.

$$PCl_5(g) \rightarrow PCl_3(g) + Cl_2(g)$$

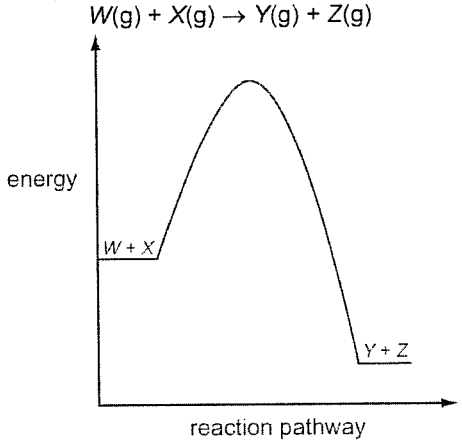
The extent of dissociation is 13% at 160 °C and 100% at 300 °C.
Which pair of statements about this formation of PCl_3 is correct?

	shape of PCl_3 molecule	the reaction is
A	pyramidal	endothermic
B	pyramidal	exothermic
C	trigonal	endothermic
D	trigonal	exothermic

86. O/N 08/P1/Q9

The diagram represents the reaction pathway for the following reaction.

$$W(g) + X(g) \rightarrow Y(g) + Z(g)$$



What statement can be made about the reverse reaction, $Y(g) + Z(g) \rightarrow W(g) + X(g)$?

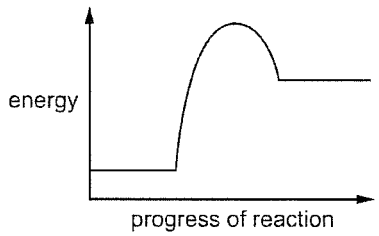
A It will have a larger activation energy and a positive ΔH.
B It will have a larger activation energy and a negative ΔH.
C It will have a smaller activation energy and a positive ΔH.
D It will have a smaller activation energy and a negative ΔH.

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87. M/J 20/P12/Q32

Which reactions would have the reaction profile shown?



1 $NaOH + HCl \rightarrow NaCl + H_2O$
2 $CaCO_3 \rightarrow CaO + CO_2$
3 $2MgO \rightarrow 2Mg + O_2$

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

88. M/J 20/P13/Q33

Gaseous sodium ions can be formed from sodium atoms.

$$Na(s) \rightarrow Na^+(g)$$

Which quantities are required to calculate the enthalpy change of formation of $Na^+(g)$?

1 first ionisation energy of sodium
2 enthalpy change of atomisation of sodium
3 enthalpy change of formation of sodium

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

89. MAR 20/P12/Q33

A reaction between carbon and oxygen is shown.

$$C(s) + \frac{1}{2} O_2(g) \rightarrow CO(g)$$

How can the standard enthalpy change of this reaction be described correctly?

1 standard enthalpy change of formation
2 standard enthalpy change of combustion
3 standard enthalpy change of atomisation

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

90. O/N 18/P11/Q32, O/N 18/P13/Q32

Which molecules and ions have a bond angle of 120°?

1 BF_3 2 CH_3^- 3 NH_3

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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91. M/J 19/P11/Q33

Which statements about enthalpy changes are correct?

1 The enthalpy change of atomisation is always positive.
2 The enthalpy change when a C–C bond is broken is positive.
3 The enthalpy change of neutralisation of a weak acid is always negative.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

92. M/J 19/P13/Q33

For which enthalpy changes is the value of ?H always negative?

1 combustion
2 hydration
3 solution

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

93. M/J 18/P12/Q33

For which reactions does the value of $\Delta H^{\ominus}$ represent both a standard enthalpy change of combustion and a standard enthalpy change of formation?

1 $C(s) + O_2(g) \rightarrow CO_2(g)$
2 $2C(s) + O_2(g) \rightarrow 2CO(g)$
3 $CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

94. M/J 18/P11/Q33

Calcium reacts with water to form calcium hydroxide and hydrogen.

$$Ca(s) + 2H_2O(l) \rightarrow Ca(OH)_2(s) + H_2(g)$$

The standard enthalpy change for this reaction is – 414 kJ mol^{-1}.

What further information is needed in order to calculate the standard enthalpy change of formation of calcium hydroxide, $\Delta H_f^{\ominus} Ca(OH)_2(s)$?

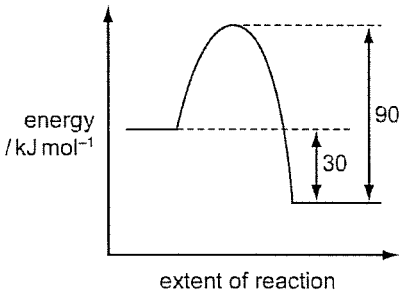
1 $\Delta H_f^{\ominus}$ for $H_2O(l)$
2 $\Delta H_f^{\ominus}$ for $H_2(g)$
3 first and second ionisation energies of Ca

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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95. M/J 18/P13/Q34, M/J 13/P12/Q32

The diagram shows the reaction pathway for a reversible reaction.



Which statements are correct?

1 The enthalpy change for the backward reaction is +90 kJ mol^{-1}.
2 The forward reaction is exothermic.
3 The enthalpy change for the forward reaction is –30 kJ mol^{-1}.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

96. M/J 17/P12/Q33

Which statements about endothermic reactions are correct?

1 On the reaction pathway diagram the products of the reaction are lower than the reactants.
2 There is a net transfer of heat energy from the surroundings to the reacting system.
3 the total bond energies of the reactants > the total bond energies of the products

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

97. M/J 17/P11/Q33

A reaction between carbon and oxygen is shown.

$$C(s) + \frac{1}{2}O_2(g) \rightarrow CO(g)$$

How can the enthalpy change of this reaction be described correctly?

1 enthalpy change of formation
2 enthalpy change of combustion
3 enthalpy change of atomisation

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

98. O/N 16/P11/Q33, O/N 16/P13/Q33

For which enthalpy changes is the value of ΔH always negative?

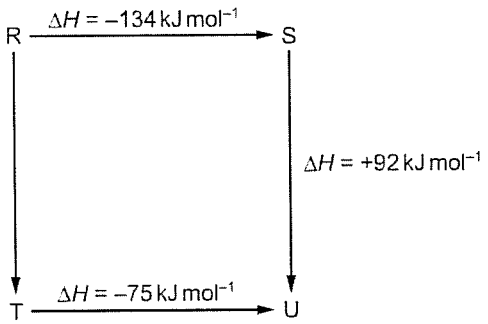
1 combustion 2 hydration 3 solution

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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99. MAR 16/P12/Q32, O/N 04/P1/Q31

The diagram illustrates the enthalpy changes of a set of reactions



Which statements are correct?

1 The enthalpy change for the transformation U → R is +42 kJ mol^{-1}.
2 The enthalpy change for the transformation T → S is endothermic.
3 The enthalpy change for the transformation R → T is –33 kJ mol^{-1}.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

100. O/N 14/P12/Q32

The bond energy of the Br–O bond is 235 kJ mol^{-1}.
Which reactions are exothermic?

1 $OH^{\bullet} + HBr \rightarrow H_2 + BrO^{\bullet}$
2 $OH^{\bullet} + HBr \rightarrow H_2O + Br^{\bullet}$
3 $H^{\bullet} + HBr \rightarrow H_2 + Br^{\bullet}$

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

101. O/N 14/P12/Q35, O/N 14/P11/Q35

On being heated, hydrogen iodide breaks down more quickly than hydrogen chloride.
Which statements explain this faster rate?

1 The HI bond is weaker than the HC*l* bond.
2 The reaction of the breakdown of HI has a smaller activation energy than that of HC*l*.
3 The breakdown of HI is more exothermic than that of HC*l*.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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102. M/J 14/P11/Q31

When the liquid N_2F_4 is heated, it decomposes into a single product, X.

Which statements are correct?

1 N – F bonds are broken during this decomposition.

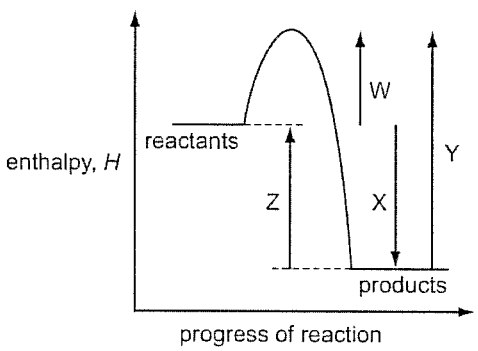
2 The enthalpy change when N_2F_4 decomposes into X is approximately +160 kJ mol^{-1}.

3 Molecules of X are non-linear.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

103. O/N 11/P12/Q32

An energy profile diagram is shown.



What do the labels on the diagram represent?

1 W = ΔH of the forward reaction, Y = E_a of the backward reaction

2 Z = ΔH of the backward reaction, Y = E_a of the backward reaction

3 X = ΔH of the forward reaction, W = E_a of the forward reaction

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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5.2: Hess' Law, including Born-Haber cycles

1. O/N 19/P11/Q7, O/N 19/P13/Q7

The following data are needed for this question.

$\Delta H_f^{\ominus}(N_2H_4(l)) = 50.6$ kJ mol^{-1}

$\Delta H_f^{\ominus}(N_2O_4(g)) = 9.2$ kJ mol^{-1}

$\Delta H_f^{\ominus}(H_2O(g)) = -241.8$ kJ mol^{-1}

Hydrazine, $N_2H_4(l)$, reacts with dinitrogen tetraoxide, $N_2O_4(g)$, to form nitrogen gas and water vapour.

$$2N_2H_4(l) + N_2O_4(g) \rightarrow 3N_2(g) + 4H_2O(g)$$

What is the enthalpy change for this reaction?

A –1077.6 kJ mol^{-1} **B** –856.8 kJ mol^{-1} **C** –301.6 kJ mol^{-1} **D** –182.0 kJ mol^{-1}

2. M/J 19/P11/Q8

Two reactions and their enthalpy changes are shown.

$2C(s) + 2H_2(g) \rightarrow C_2H_4(g)$ $\Delta H^{\ominus} = +52.2$ kJ mol^{-1}

$C_2H_2(g) + H_2(g) \rightarrow C_2H_4(g)$ $\Delta H^{\ominus} = -175.8$ kJ mol^{-1}

These data can be used to calculate the enthalpy change for the reaction shown.

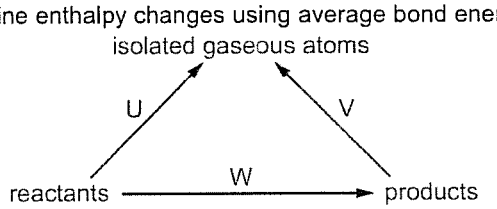
$2C(s) + H_2(g) \rightarrow C_2H_2(g)$ $\Delta H^{\ominus} = X$

What is the value of X?

A –228.0 kJ mol^{-1} **B** –123.6 kJ mol^{-1} **C** +123.6 kJ mol^{-1} **D** +228.0 kJ mol^{-1}

3. O/N 15/P12/Q6

Hess' law may be used to determine enthalpy changes using average bond energies, as shown in the diagram.



U is the sum of the average bond energies of the reactants, and V is the sum of the average bond energies of the products.

For the reaction shown below, which expression will give a value for W, the enthalpy change of combustion of methane?

$$CH_4 + 2O_2 \rightarrow CO + 2H_2O$$

A U – V **B** U + V **C** 2(U – V) **D** V – U

4. M/J 15/P12/Q6

Metaldehyde, $(CH_3CHO)_4$, is used as a solid fuel for camping stoves. The equation for the complete combustion of metaldehyde is shown.

$$(CH_3CHO)_4(s) + 10\ O_2(g) \rightarrow 8CO_2(g) + 8H_2O(l)$$

$\Delta H_c^{\ominus}$ = standard enthalpy change of combustion.

Which expression will give a correct value for the enthalpy change of formation of metaldehyde?

A $\Delta H_c^{\ominus}$ metaldehyde – ($8\Delta H_c^{\ominus}$ carbon + $8\Delta H_c^{\ominus}$ hydrogen)

B $\Delta H_c^{\ominus}$ metaldehyde – ($8\Delta H_c^{\ominus}$ carbon + $16\Delta H_c^{\ominus}$ hydrogen)

C ($8\Delta H_c^{\ominus}$ carbon + $8\Delta H_c^{\ominus}$ hydrogen) – $\Delta H_c^{\ominus}$ metaldehyde

D ($8\Delta H_c^{\ominus}$ carbon + $16\Delta H_c^{\ominus}$ hydrogen) – $\Delta H_c^{\ominus}$ metaldehyde

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5. M/J 15/P13/Q3

A student performed an experiment to measure the enthalpy change of combustion of ethane.
He used the following values for the standard enthalpy changes of combustion of carbon and hydrogen.

$\Delta H_c^{\ominus}$ carbon = –394 kJ mol^{-1}

$\Delta H_c^{\ominus}$ hydrogen = –286 kJ mol^{-1}

He calculated the enthalpy change of formation of ethane to be –140 kJ mol^{-1}.
What was his experimental value for the standard enthalpy change of combustion of ethane?

A –.2364 kJ mol^{-1} **B** –1506 kJ mol^{-1} **C** –1112 kJ mol^{-1} **D** –540 kJ mol^{-1}

6. M/J 15/P13/Q7

Carbon monoxide and methanol can react together to form ethanoic acid.

$$CO(g) + CH_3OH(l) \xrightarrow{\Delta H_r^{\ominus}} CH_3CO_2H(l)$$

CO(g) + CH3OH(l) → CH3CO2H(l)

Standard enthalpy changes of combustion are given in the table.

compound	standard enthalpy change of combustion, $\Delta H_c^{\ominus}$
CO	–283.0 kJ mol^{-1}
CH_3OH	–726.0 kJ mol^{-1}
CH_3CO_2H	–874.1 kJ mol^{-1}

A –1883.1 kJ mol^{-1} **B** –134.9 kJ mol^{-1} **C** +134.9 kJ mol^{-1} **D** +1883.1 kJ mol^{-1}

7. O/N 14/P13/Q5

Hydrogen sulfide, H_2S, is released from volcanoes. It reacts with oxygen in the air to form sulfur dioxide.

$$2H_2S(g) + 3O_2(g) \rightarrow 2H_2O(l) + 2SO_2(g)$$

$\Delta H_f^{\ominus}$ [$H_2S(g)$] = –21 kJ mol^{-1}

$\Delta H_f^{\ominus}$ [$H_2O(l)$] = –286 kJ mol^{-1}

$\Delta H_f^{\ominus}$ [$SO_2(g)$] = –297 kJ mol^{-1}

What is the standard enthalpy change of this reaction?

A –1208 kJ mol^{-1} **B** –1124 kJ mol^{-1} **C** –562 kJ mol^{-1} **D** –541 kJ mol^{-1}

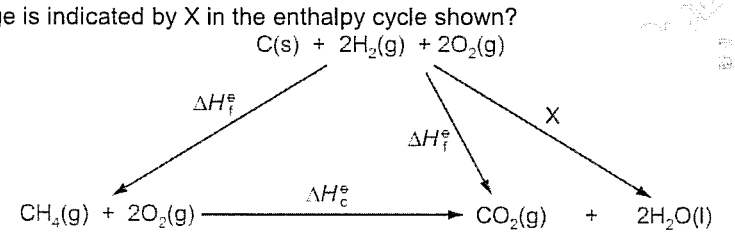
8. M/J 14/P12/Q3

The enthalpy change of formation of carbon dioxide is –394 kJ mol^{-1}.
The enthalpy change of formation of water is –286 kJ mol^{-1}.
The enthalpy change of formation of methane is –74 kJ mol^{-1}.
What is the enthalpy change of combustion of methane?

A –892 kJ mol^{-1} **B** –606 kJ mol^{-1} **C** +606 kJ mol^{-1} **D** +892 kJ mol^{-1}

9. M/J 14/P11/Q3

Enthalpy changes that are difficult to measure directly can often be determined using Hess' Law to construct an enthalpy cycle.
Which enthalpy change is indicated by X in the enthalpy cycle shown?



A –4 × the enthalpy of combustion of hydrogen **C** –2 × the enthalpy of formation of water
B +4 × the enthalpy of combustion of hydrogen **D** +2 × the enthalpy of formation of water

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10. O/N 11/P12/Q10

Hess's Law can be used to calculate the average C–H bond energy in methane

$\Delta H^{\ominus}_{at}$ = standard enthalpy change of atomisation

$\Delta H^{\ominus}_{f}$ = standard enthalpy change of formation

$\Delta H^{\ominus}_{f}$ = standard enthalpy change of combustion

Which data values are needed in order to perform the calculation?

A $\Delta H^{\ominus}_{at}$ (C), $\Delta H^{\ominus}_{at}$ (H), $\Delta H^{\ominus}_{f}$ (CH_4)

B $\Delta H^{\ominus}_{c}$ (C), $\Delta H^{\ominus}_{c}$ (H_2), $\Delta H^{\ominus}_{c}$ (CH_4)

C $\Delta H^{\ominus}_{c}$ (C), $\Delta H^{\ominus}_{c}$ (H_2), $\Delta H^{\ominus}_{f}$ (CH_4)

D $\Delta H^{\ominus}_{f}$ (CH4) only, as $\Delta H^{\ominus}_{f}$ (C), and $\Delta H^{\ominus}_{f}$ (H_2), are defined as zero

11. O/N 10/P12/Q8

The enthalpy change of formation, ΔH_f, of hydrated calcium ions is the enthalpy change of the following reaction.

$$Ca(s) + aq - 2e^- \rightarrow Ca^{2+}(aq)$$

The following enthalpy changes are **not** quoted in the Data Booklet.

$$Ca(s) \rightarrow Ca(g) \qquad \Delta H_a = 177 \text{ kJ mol}^{-1}$$

$$Ca^{2+}(g) + aq \rightarrow Ca^{2+}(aq) \qquad \Delta H_{hyd} = -1565 \text{ kJ mol}^{-1}$$

What is the enthalpy change of formation of hydrated calcium ions?

A -1388 kJ mol^{-1} **B** -798 kJ mol^{-1} **C** -238 kJ mol^{-1} **D** $+352$ kJ mol^{-1}

12. M/J 09/P1/Q8

Hydrogen peroxide slowly decomposes into water and oxygen. The enthalpy change of reaction can be calculated using standard enthalpies of formation.

$\Delta H^{\ominus}_{f}$ (hydrogen peroxide(l)) = -187.8 kJ mol^{-1}

$\Delta H^{\ominus}_{f}$ (water(l)) = -285.8 kJ mol^{-1}

Using a Hess cycle, what is the enthalpy change of reaction for this decomposition?

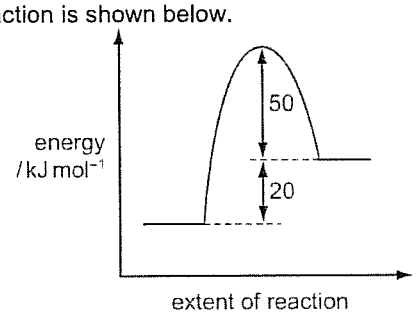
$$2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$$

A $+98$ kJ mol^{-1} **B** -98 kJ mol^{-1} **C** -196 kJ mol^{-1} **D** -947.2 kJ mol^{-1}

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13. M/J 13/P13/Q33

The reaction pathway for a reversible reaction is shown below.



Which statements are correct?

1 The enthalpy change for the backward reaction is -20 kJ mol^{-1}.
2 The forward reaction is endothermic.
3 The activation energy for the forward reaction is $+70$ kJ mol^{-1}.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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14. M/J 09/P1/Q33

For which reactions does the value of $\Delta H^{\ominus}$ represent **both** a standard enthalpy change of combustion **and** a standard enthalpy change of formation?

1 $C(s) + O_2(g) \rightarrow CO_2(g)$

2 $2C(s) + O_2(g) \rightarrow 2CO(g)$

3 $CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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5.3: Multiple Topics

1. O/N 17/P11/Q11, O/N 17/P13/Q11

200 g of water are at 25 °C.
The water is heated to 75 °C by burning 2 g of ethanol.
What is the amount of energy transferred to the water?

A 0.418 kJ **B** 10.4 kJ **C** 41.8 kJ **D** 62.7 kJ

2. O/N 16/P11/Q8, O/N 16/P13/Q8

An important reaction in the manufacture of nitric acid is the catalytic oxidation of ammonia.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$$

For every mole of O_2 that reacts in this way, 181.8 kJ of energy are released.
A factory makes 2.50×10^5 mol of NO every day.
How much energy, in kJ, is released every day?

A 3.64×10^7 **B** 4.55×10^7 **C** 5.68×10^7 **D** 2.27×10^8

3. O/N 16/P11/Q15, O/N 16/P13/Q15

At 550 °C nitrogen dioxide reacts with unburnt hydrocarbon fragments such as $CH_3^{\bullet}$ in the catalytic converter of a motor vehicle.

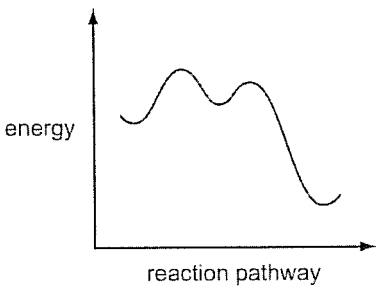
$$4CH_3^{\bullet} + 7NO_2 \rightarrow 3\tfrac{1}{2}N_2 + 4CO_2 + 6H_2O$$

The following table lists types of energy change for this reaction and possible reasons for them.
Which row gives the energy change for this reaction and the reason for it?

	energy change of reaction	reason why the reaction is endothermic or exothermic
A	endothermic	chemical energy is converted to heat energy
B	endothermic	the N≡N bond energy is very high
C	exothermic	CO_2 and H_2O have large negative $\Delta H_f^{\ominus}$ values
D	exothermic	double bonds are broken in NO_2

4. M/J 12/P11/Q28, M/J 12/P13/Q29

A reaction pathway diagram is shown.

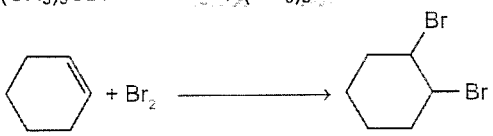


Which reaction does **not** have such a profile?

A $CH_3CHO + HCN \xrightarrow{NaCN} CH_3CH(OH)CN$

B $C_2H_5Br + NaOH \rightarrow C_2H_5OH + NaBr$

C $(CH_3)_3CBr + NaOH \rightarrow (CH_3)_3COH + NaBr$

D 

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5. M/J 16/P12/Q34

An ethanol burner can be used to heat water. If appropriate measurements are taken, a value for the enthalpy of combustion of ethanol can be calculated. The equation

$$\text{heat transferred} = -mc\Delta T$$

is used as part of the calculation.

Which symbols are correctly described?

1 ΔT is the change in temperature of the water.
2 m is the mass of water used in the experiment.
3 c is the specific heat capacity of ethanol.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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Answers Sections

5.1						5.2		5.3	
1.	A	41.	B	81.	C	1.	A	1.	C
2.	C	42.	B	82.	B	2.	D	2.	C
3.	D	43.	A	83.	C	3.	A	3.	C
4.	C	44.	B	84.	C	4.	C	4.	B
5.	B	45.	A	85.	A	5.	B	5.	B
6.	C	46.	C	86.	A	6.	B		
7.	B	47.	B	87.	C	7.	B		
8.	C	48.	A	88.	B	8.	A		
9.	C	49.	C	89.	D	9.	D		
10.	C	50.	B	90.	D	10.	A		
11.	D	51.	D	91.	A	11.	D		
12.	D	52.	B	92.	B	12.	C		
13.	B	53.	D	93.	D	13.	A		
14.	C	54.	A	94.	D	14.	D		
15.	C	55.	B	95.	C				
16.	D	56.	C	96.	C				
17.	B	57.	A	97.	D				
18.	D	58.	D	98.	B				
19.	D	59.	C	99.	D				
20.	B	'60.	A	100.	C				
21.	D	61.	C	101.	B				
22.	C	62.	B	102.	C				
23.	B	63.	A	103.	C				
24.	B	64.	A						
25.	C	65.	C						
26.	C	66.	B						
27.	B	67.	D						
28.	C	68.	D						
29.	D	69.	B						
30.	B	70.	C						
31.	A	71.	C						
32.	D	72.	A						
33.	B	73.	C						
34.	B	74.	A						
35.	B	75.	D						
36.	C	76.	C						
37.	D	77.	B						
38.	B	78.	B						
39.	B	79.	C						
40.	B	80.	B						

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Unit 6

ELECTROCHEMISTRY

A Level
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Syllabus

6.1 Redox processes: electron transfer and changes in oxidation number (oxidation state)
6.2 Multiple topics

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Unit 6: Electrochemistry

6.1: Redox processes: electron transfer and changes in oxidation number (oxidation state)

1. **M/J 20/P12/Q10**
In which reaction does an element undergo the largest change in oxidation number?
A $Cl_2 + 2OH^- \rightarrow OCl^- + Cl^- + H_2O$
B $3Cl_2 + 6OH^- \rightarrow ClO_3^- + 5Cl^- + 3H_2O$
C $Cr_2O_7^{2-} + 6Fe^{2+} + 14H^+ \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$
D $3MnO_4^{2-} + 4H^+ \rightarrow MnO_2 \rightarrow 2MnO_4^- + 2H_2O$

2. **M/J 20/P11/Q2**
Cobalt can form the positive ion $Co(NH_3)_4Cl^{2+}$.
What is the oxidation number of cobalt in this ion?
A +1 **B** +2 **C** +3 **D** +6

3. **M/J 20/P13/Q10**
When solid $KClO_3$ is heated in the absence of air, a mixture of two chlorine compounds in the mole ratio of 3 : 1 is formed. Chlorine is the only element whose oxidation number changes in this reaction.
What could be the oxidation numbers of chlorine in the two compounds that are formed?
A +3 and –1 **B** +6 and +4 **C** +7 and –1 **D** +7 and +1

4. **MAR 20/P12/Q5, M/J 13/P13/Q1**
In the redox reaction shown, how do the oxidation states of vanadium and sulfur change?
$VO_2^+ + SO_2 \rightarrow V^{3+} + SO_4^{2-}$

	vanadium		sulfur	
	from	to	from	to
A	+1	+3	0	–2
B	+1	+3	+4	+6
C	+5	+3	0	–2
D	+5	+3	+4	+6

5. **O/N 18/P12/Q8**
Ammonium metavanadate, NH_4VO_3, can be used to make a solution containing VO2Cl, which contains chloride ions.
What is the change in the oxidation number of vanadium in this reaction?
A –1 **B** 0 **C** +1 **D** +2

6. **O/N 19/P11/Q6, O/N 19/P13/Q6**
What is the oxidation number of sulfur in each species?

	H_2S	SO_2	H_2SO_3
A	–2	+4	+4
B	–2	+4	+6
C	+2	–4	+4
D	+2	–4	+6

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7. M/J 19/P13/Q1

Manganese and nitrogen can show a range of different oxidation states.
Calculate the sum of the oxidation states of Mn and N in each row of the table.
In which row is this sum the smallest?

	manganese-containing species	nitrogen-containing species
A	$MnCl_4$	N_2
B	$MnCO_3$	NO_2^-
C	K_2MnO_4	NH_4^+
D	$Mn(OH)_3$	NH_2OH

8. M/J 19/P13/Q8

Ethanol can be oxidised to ethanal by dilute acidified dichromate(VI) ions.
The oxidation reaction equation is $C_2H_5OH \rightarrow C_2H_4O + 2H^+ + 2e^-$.
The reduction reaction equation is $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$.
Which equation is correct?

A $Cr_2O_7^{2-} + 8H^+ + 3C_2H_5OH \rightarrow 2Cr^{3+} + 7H_2O + 3C_2H_4O$
B $Cr_2O_7^{2-} + 12H^+ + C_2H_5OH \rightarrow 2Cr^{3+} + 7H_2O + C_2H_4O$
C $Cr_2O_7^{2-} + 12H^+ + 3C_2H_5OH \rightarrow 2Cr^{3+} + 6H_2O + 3C2H_4O$
D $Cr_2O_7^{2-} + 14H^+ + 3C_2H_5OH \rightarrow 2Cr^{3+} + 6H_2O + 3C2H_4O$

9. O/N 18/P11/Q7, O/N 18/P13/Q7

Nitric acid is known to take part in the oxidation of atmospheric sulfur dioxide. One possible reaction is shown.

$$SO_2 + HNO_3 \rightarrow NO^+ + HSO_4^-$$

Which row shows the correct changes in oxidation numbers of nitrogen and sulfur?

	nitrogen	sulfur
A	–3	+3
B	–2	+2
C	–2	+3
D	–1	+2

10. O/N 18/P11/Q8, O/N 18/P13/Q8

A transition metal ion, M^{2+}, reacts with acidified dichromate(VI) ions to form M^{4+} ions, Cr^{3+} ions, and H_2O.
Which equation correctly represents this reaction?

A $Cr_2O_7^{2-} + 14H^+ + M^{2+} \rightarrow 2Cr^{3+} + 7H_2O + M^{4+}$
B $Cr_2O_7^{2-} + 14H^+ + 2M^{2+} \rightarrow 2Cr^{3+} + 7H_2O + 2M^{4+}$
C $Cr_2O_7^{2-} + 14H^+ + 3M^{2+} \rightarrow 2Cr^{3+} + 7H_2O + 3M^{4+}$
D $Cr_2O_7^{2-} + 14H^+ + 6M^{2+} \rightarrow 2Cr^{3+} + 7H_2O + 6M^{4+}$

11. M/J 18/P11/Q9

Oxidation numbers should be used to answer this question.
A redox reaction takes place between hydroxylammonium ions, $[NH_3OH]^+$, and acidified iron(III) ions, Fe^{3+}. The products are iron(II) ions, Fe^{2+}, H^+ ions, water and a compound of nitrogen.
The mole ratio of reacting hydroxylammonium ions to reacting iron(III) ions is 1 : 2.
Which nitrogen-containing compound could be formed in the reaction?

A NH_3 **B** N_2O **C** NO **D** NO_2

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12. M/J 18/P12/Q8

Sulfur reacts with concentrated nitric acid in a redox reaction.

$$S + 4HNO_3 \rightarrow SO_2 + 4NO_2 + 2H_2O$$

What are the changes in oxidation number of sulfur and of nitrogen in this reaction?

	sulfur	nitrogen
A	+2	−3
B	+2	−1
C	+4	−3
D	+4	−1

13. M/J 18/P11/Q8

Ethanedioate ions, $C_2O_4^{2-}$, react with a suitable reagent to form CO_2. A half-equation for this reaction is shown.

$$C_2O_4^{2-} \rightarrow 2CO_2 + 2e^-$$

Which row is correct?

	oxidation state of carbon in $C_2O_4^{2-}$	type of reaction
A	+3	oxidation
B	+3	reduction
C	+5	oxidation
D	+5	reduction

14. M/J 18/P13/Q8

Xenon hexafluoride, XeF_6, reacts with water.

$$XeF_6 + 3H_2O \rightarrow XeO_3 + 6HF$$

Which statement is correct?

A Hydrogen is reduced in this reaction.

B Hydrogen is the only element oxidised in this reaction.

C The only element oxidised in this reaction is xenon.

D This is not a redox reaction.

15. O/N 17/P12/Q8

Which statement is **always** correct for an oxidation reaction?

A It involves the gain of oxygen by an element.

B For one reactant to be oxidised a different reactant must be reduced.

C The element or ion being oxidised will gain electrons.

D The oxidation number of the element being oxidised will increase.

16. O/N 17/P11/Q6, O/N 17/P13/Q6

One of the reactions in a lead / acid cell is shown.

$$Pb(s) + PbO_2(s) + 4H^+(aq) + 2SO_4^{2-}(aq) \rightarrow 2PbSO_4(s) + 2H_2O(l)$$

Which statement about this reaction is correct?

A Lead is both oxidised and reduced.

B Lead is neither oxidised nor reduced.

C Lead is oxidised only.

D Lead is reduced only.

17. M/J 17/P13/Q7

Vanadium reacts with dilute sulfuric acid to form $V_2(SO_4)_3$ and hydrogen gas.

What happens to vanadium atoms in this reaction?

A They lose three electrons and are oxidised.

B They lose three electrons and are reduced.

C They lose two electrons and are oxidised.

D They lose two electrons and are reduced.

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18. M/J 17/P12/Q8

A reaction sequence is shown.

$$SO_2 \xrightarrow{1} SO_3 \xrightarrow{2} H_2SO_4 \xrightarrow{3} H_2S \xrightarrow{4} SO_2$$

In each stage of this sequence the sulfur is oxidised, reduced or neither oxidised nor reduced.
Which row is correct?

	1	2	3	4
A	neither	oxidised	reduced	reduced
B	oxidised	neither	reduced	reduced
C	oxidised	neither	reduced	oxidised
D	oxidised	oxidised	reduced	oxidised

19. M/J 17/P13/Q8

$Na_2S_2O_3$ reacts with HC*l* as shown.

$$Na_2S_2O_3(aq) + 2HCl\ (aq) \rightarrow 2NaCl\ (aq) + H_2O(l) + SO_2(g) + S(s)$$

When calculating the oxidation number of sulfur in $Na_2S_2O_3$, the average oxidation number of the two sulfur atoms should be found.
What is the oxidation number of sulfur in each of $Na_2S_2O_3$, SO_2, and S?

	$Na_2S_2O_3$	SO_2	S
A	+2	+2	+1
B	+2	+4	0
C	+4	+4	0
D	+5	+4	0

20. MAR 17/P12/Q8

HOC*l*(aq) is the molecule that kills bacteria when chlorine is added to water.
The following reaction produces this molecule.

$$Cl_2\ (g) + H_2O(l) \rightleftharpoons HOCl\ (aq) + H^+(aq) + Cl^-(aq)$$

Which statement about this reaction is correct?

A Chlorine is both oxidised and reduced.
B Chlorine is oxidised but not reduced.
C Hydrogen is both oxidised and reduced.
D Hydrogen is oxidised but not reduced.

21. O/N 16/P11/Q3, O/N 16/P13/Q3

The reaction between acidified dichromate(VI) ions, $Cr_2O_7^{2-}$, and aqueous Fe^{2+} ions results in the dichromate(VI) ions being reduced to Cr^{3+} ions.
What is the correct equation for this reaction?

A $Cr_2O_7^{2-} + Fe^{2+} + 14H^+ \rightarrow 2Cr^{3+} + Fe^{3+} + 7H_2O$
B $Cr_2O_7^{2-} + 2Fe^{2+} + 14H^+ \rightarrow 2Cr^{3+} + 2Fe^{3+} + 7H_2O$
C $Cr_2O_7^{2-} + 3Fe^{2+} + 14H^+ \rightarrow 2Cr^{3+} + 3Fe^{3+} + 7H_2O$
D $Cr_2O_7^{2-} + 6Fe^{2+} + 14H^+ \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$

22. M/J 15/P13/Q5

In which reaction does an element have the largest change in oxidation number?

A $Cr_2O_7^{2-} + 6Fe^{2+} + 14H^+ \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$
B $3OCl^- \rightarrow ClO_3^- + 2Cl^-$
C $5Fe^{2+} + MnO_4^- + 8H^+ \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$
D $PbO_2 + Sn^{2+} + 4H^+ \rightarrow Sn^{4+} + Pb^{2+} + 2H_2O$

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23. MAR 17/P12/Q10

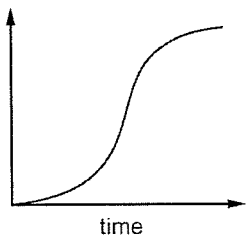
Oxidation of ethanedioate ions by acidified manganate(VII) ions is very slow at room temperature.

$$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \rightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$$

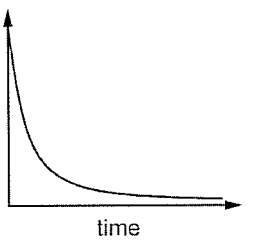
Mn^{2+} ions catalyse this reaction.

Which graph shows how the concentration of acidified manganate(VII) ions varies after ethanedioate ions are added?

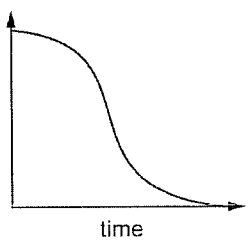
A



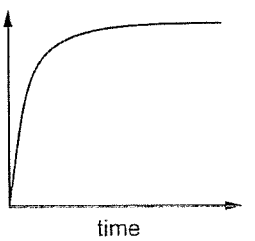
C



B



D



24. M/J 17/P11/Q8, M/J 13/P11/Q1

Solutions containing chlorate(I) ions are used as household bleaches and disinfectants. These solutions decompose on heating as shown.

$$3ClO^- \rightarrow ClO_3^- + 2Cl^-$$

Which oxidation state is shown by chlorine in each of these three ions?

	ClO^-	ClO_3^-	Cl^-
A	+1	+3	–1
B	–1	+3	+1
C	+1	+5	–1
D	–1	+5	+1

25. O/N 16/P11/Q9, O/N 16/P13/Q9

Sodium chromate(VI), Na_2CrO_4, is manufactured by heating chromite, $FeCr_2O_4$, with sodium carbonate in an oxidising atmosphere. Chromite contains $Cr_2O_4^{2-}$ ions.

$$2FeCr_2O_4 + 4Na_2CO_3 + 3\frac{1}{2}O_2 \rightarrow 4Na_2CrO_4 + Fe_2O_3 + 4CO_2$$

What happens in this reaction?

A Chromium and iron are the only elements oxidised.
B Chromium, iron and carbon are oxidised.
C Only chromium is oxidised.
D Only iron is oxidised.

26. M/J 16/P12/Q9, M/J 12/P11/Q16, M/J 12/P13/Q17, M/J 07/P1/Q15

In the treatment of domestic water supplies, chlorine is added to the water to form HClO.

$$Cl_2(aq) + H_2O(l) \rightarrow H^+(aq) + Cl^-(aq) + HClO(aq)$$

The HClO reacts further to give ClO^- ions.

$$HClO(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + ClO^-(aq)$$

Both HClO and ClO^- kill bacteria by oxidation.

What is the change in oxidation number of chlorine when forming the ClO^- ion from aqueous chlorine?

A –1 **B** 0 **C** +1 **D** +2

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27. MAR 16/P12/Q1, M/J 11/P12/Q19

Which compound contains two different elements with identical oxidation states?

A HC*l*O **B** $Mg(OH)_2$ **C** Na_2SO_4 **D** $NH_4C\mathit{l}$

28. O/N 15/P12/Q17, M/J 11/P11/Q16, M/J 11/P13/Q17, O/N 08/P1/Q17

A student observed the reactions when sodium chloride and sodium iodide were each reacted separately with concentrated sulfuric acid and with concentrated phosphoric acid. The observations are recorded in the table.

	sodium chloride	sodium iodide
conc. H_2SO_4	colourless acidic gas formed	purple vapour formed
conc. H_3PO_4	colourless acidic gas formed	colourless acidic gas formed

Which deduction can be made from these observations?

A Concentrated phosphoric acid is a stronger oxidising agent than concentrated sulfuric acid.

B Concentrated phosphoric acid is a stronger oxidising agent than iodine.

C Concentrated sulfuric acid is a stronger oxidising agent than chlorine.

D Concentrated sulfuric acid is a stronger oxidising agent than iodine.

29. M/J 15/P12/Q19

Chlorate(V) ions, $C\mathit{l}O_3^-$, are produced in the redox reaction between chlorine and hot aqueous sodium hydroxide. Oxidation numbers can be used to help balance the equation for this reaction.

What will be the values of coefficients **v**, **x** and **y** in the balanced equation?

$$\mathbf{v}C\mathit{l}_2\,(g) + \mathbf{w}OH^-\,(aq) \rightarrow \mathbf{x}C\mathit{l}^-\,(aq) + \mathbf{y}C\mathit{l}O_3^-\,(aq) + \mathbf{z}H_2O\,(l)$$

	v	x	y
A	2	3	1
B	3	4	2
C	3	5	1
D	7	12	2

30. M/J 15/P11/Q4

In oxygen difluoride, OF_2, fluorine has an oxidation number of –1. OF_2 will react with sulfur dioxide according to the following equation.

$$OF_2 + SO_2 \rightarrow SO_3 + F_2$$

What is oxidised and what is reduced in this reaction?

	fluorine	oxygen in OF_2	sulfur
A	oxidised	oxidised	reduced
B	oxidised	reduced	oxidised
C	reduced	oxidised	reduced
D	reduced	reduced	oxidised

31. O/N 14/P12/Q2, O/N 14/P11/Q2

In which reaction does hydrogen behave as an oxidising agent?

A $H_2 + C\mathit{l}_2 \rightarrow 2HC\mathit{l}$ **B** $C_2H_4 + H_2 \rightarrow C_2H_6$ **C** $N_2 + 3H_2 \rightarrow 2NH_3$ **D** $2Na + H_2 \rightarrow 2NaH$

32. O/N 13/P12/Q2, O/N 13/P11/Q2

In which reaction does a single nitrogen atom have the greatest change in oxidation number?

A $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

B $3NO_2 + H_2O \rightarrow 2HNO_3 + NO$

C $2NO + O_2 \rightarrow 2NO_2$

D $4NH_3 + 6NO \rightarrow 5N_2 + 6H_2O$

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33. M/J 14/P12/Q6

In which reaction is the species in **bold** acting as an oxidising agent?

A $\mathbf{2Ca} + O_2 \rightarrow 2CaO$

B $Cr_2O_7^{2-} + 8H^+ + \mathbf{3SO_3^{2-}} \rightarrow 2Cr^{3+} + 4H_2O + 3SO_4^{2-}$

C $Mg + \mathbf{Fe^{2+}} \rightarrow Mg^{2+} + Fe$

D $\mathbf{SO_2} + 2H_2O + 2Cu^{2+} + 2Cl^- \rightarrow H_2SO_4 + 2H^+ + 2CuCl$

34. O/N 13/P12/Q3, O/N 13/P11/Q3

The following half reactions occur when potassium iodate(V), KIO_3, in hydrochloric acid solution oxidises iodine to ICl_2^-.

$$IO_3^- + 2Cl^- + 6H^+ + 4e^- \rightarrow ICl_2^- + 3H_2O$$
$$I_2 + 4Cl^- \rightarrow 2ICl_2^- + 2e^-$$

What is the ratio of IO_3^- to I_2 in the balanced chemical equation for the overall reaction?

A 1 : 1 **B** 1 : 2 **C** 1 : 4 **D** 2 : 1

35. O/N 13/P12/Q21, O/N 13/P11/Q21

Which reaction will give the best yield of 1-chloropropane?

A chlorine gas with propene gas in the dark

B propan-1-ol with dilute NaCl(aq)

C propan-1-ol with PCl_5

D propene with dilute HCl(aq)

36. O/N 13/P13/Q1, M/J 10/P12/Q6, M/J 10/P11/Q6, M/J 10/P13/Q7

Ammonium nitrate, NH_4NO_3, can decompose explosively when heated.

$$NH_4NO_3 \rightarrow N_2O + 2H_2O$$

What are the changes in the oxidation numbers of the two nitrogen atoms in NH_4NO_3 when this reaction proceeds?

A –2, –4 **B** +2, +6 **C** +4, –6 **D** +4, –4

37. O/N 13/P13/Q3

A 10 cm^3 sample of 0.30 mol dm^{-3} $Tl^+NO_3^-$ required 20 cm^3 of 0.10 mol dm^{-3} acidified NH_4VO_3 to oxidise it to Tl^{3+} in solution. Vanadium is the only element reduced in this reaction.

What is the oxidation number of the vanadium in the reduced form?

A +1 **B** +2 **C** +3 **D** +4

38. O/N 12/P12/Q1, O/N 12/P11/Q1

In which reaction does an element undergo the largest change in oxidation state?

A $Cl_2 + 2OH^- \rightarrow OCl^- + Cl^- + H_2O$

B $3Cl_2 + 6OH^- \rightarrow ClO_3^- + 5Cl^- + 3H_2O$

C $Cr_2O_7^{2-} + 6Fe^{2+} + 14H^+ \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$

D $3MnO_4^{2-} + 4H^+ \rightarrow MnO_2 + 2MnO_4^- + 2H_2O$

39. O/N 12/P13/Q15

The reaction between KI and concentrated H_2SO_4 is a redox reaction.

$$5H_2SO_4 + 8KI \rightarrow 4K_2SO_4 + 4I_2 + H_2S + 4H_2O$$

What is the change in oxidation state of the element that is reduced?

A 1 **B** 4 **C** 6 **D** 8

40. O/N 12/P13/Q19

Deposits of ammonium sulfate have been discovered in areas of high atmospheric pollution. They are believed to arise from the following reaction.

$$SO_3 + H_2O + 2NH_3 \rightarrow (NH_4)_2SO_4$$

What does **not** occur in this reaction?

A acid / base neutralisation

B dative bond formation

C ionic bond formation

D oxidation / reduction

41. M/J 12/P12/Q11

In which substance does nitrogen exhibit the highest oxidation state?

A NO **B** N_2O **C** N_2O_4 **D** $NaNO_2$

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42. M/J 12/P11/Q10, M/J 12/P13/Q10

The oxide of titanium, TiO_2, is used as a 'whitener' in toothpaste. It is obtained from the ore iron(II) titanate, $FeTiO_3$.

What is the change, if any, in the oxidation number (oxidation state) of titanium in the reaction $FeTiO_3 \rightarrow TiO_2$?

A It is oxidised from +3 to +4.
B It is reduced from +3 to +2.
C It is reduced from +6 to +4.
D There is no change in the oxidation number.

43. O/N 11/P12/Q11

The amount of titanium dioxide in an ore can be determined by using the following reaction.

$$3TiO_2 + 4BrF_3 \rightarrow 3TiF_4 + 2Br_2 + 3O_2$$

Which element increases in oxidation number in this reaction?

A bromine **B** fluorine **C** oxygen **D** titanium

44. O/N 11/P11/Q7, O/N 11/P13/Q6

When chlorine and aqueous sodium hydroxide are heated together the following overall reaction occurs.

$$3Cl_2(aq) + 6NaOH(aq) \rightarrow 5NaCl(aq) + NaClO_3(aq) + 3H_2O(l)$$

What are the oxidation numbers for chlorine in each of the following species?

	Cl_2	$NaCl$	$NaClO_3$
A	0	+1	–5
B	+2	–1	+3
C	0	–1	+5
D	–2	+1	–3

45. M/J 11/P11/Q2, M/J 11/P13/Q4

In flooded soils, like those used for rice cultivation, the oxygen content is low. In such soils, anaerobic bacteria cause the loss of nitrogen from the soil as shown in the following sequence.

In which step is the change in oxidation number (oxidation state) of nitrogen different to the changes in the other steps?

$$NO_3^-(aq) \xrightarrow{A} NO_2^-(aq) \xrightarrow{B} NO(g) \xrightarrow{C} N_2O(g) \xrightarrow{D} N_2(g)$$

46. O/N 10/P12/Q13

In aqueous solution, the acid HIO disproportionates according to the following equation where **m**, **n**, **p** and **q** are simple whole numbers in their lowest ratios.

$$\mathbf{m}HIO \rightarrow \mathbf{n}I_2 + \mathbf{p}HIO_3 + \mathbf{q}H_2O$$

This equation can be balanced using oxidation numbers.

What are the values for **n** and **p**?

	n	**p**
A	1	2
B	2	1
C	4	1
D	4	2

47. O/N 10/P11/Q4, O/N 10/P13/Q4

Sulfur dioxide, SO_2, is added to wines to prevent oxidation of ethanol by air. To determine the amount of SO_2, a sample of wine is titrated with iodine, I_2. In this reaction, **one** mole of SO_2 is oxidised by one mole of I_2.

What is the change in oxidation number of sulfur in this reaction?

A +2 to +4 **B** +2 to +6 **C** +4 to +5 **D** +4 to +6

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48. M/J 10/P12/Q6, M/J 10/P11/Q6

Ammonium nitrate, NH_4NO_3, can decompose explosively when heated.

$$NH_4NO_3 \rightarrow N_2O + 2H_2O$$

What are the changes in the oxidation numbers of the two nitrogen atoms in NH_4NO_3 when this reaction proceeds?

A –2, –4 **B** +2, +6 **C** +4, –6 **D** +4, –4

49. O/N 09/P12/Q6, O/N 09/P11/Q7

Which conversion involves a reduction of chromium?

A $Cro_4^{2-} \rightarrow CrO_3$ **B** $Cro_4^{2-} \rightarrow Cr_2O_7^{2-}$ **C** $CrO_2Cl_2 \rightarrow Cro_4^{2-}$ **D** $CrO_2Cl_2 \rightarrow Cr_2O_3$

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50. O/N 19/P12/Q33

Carbon can exist as allotropes which include graphite, diamond and a fullerene.
Which statements are correct?

1 All three allotropes contain covalent bonds.
2 All three allotropes are giant molecular.
3 All three allotropes have delocalised electrons.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

51. M/J 19/P12/Q33

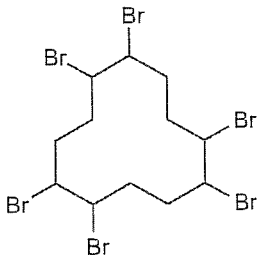
In which reactions are nitrogen atoms reduced?

1 $2NO_2 \rightarrow N_2 + 2O_2$
2 $4NO_2 \rightarrow 2N_2O + 3O_2$
3 $4NO_2 + 6H_2O \rightarrow 4NH_3 + 7O_2$

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

52. M/J 19/P12/Q37, M/J 16/P12/Q37

The diagram shows a compound used as a flame retardant.



Which statements about this structure are correct?

1 The empirical formula is C_2H_3Br.
2 The C_{12} ring is not planar.
3 There are six chiral carbon atoms.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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53. Mar 19/P12/Q33

In which reactions is the underlined element or compound reduced?

1 $NaC\underline{l}O + H_2O_2 \rightarrow O_2 + NaCl + H_2O$

2 $2\underline{N}H_3 + 2Li \rightarrow 2LiNH_2 + H_2$

3 $3CH_3\underline{C}H_2OH + K_2Cr_2O_7 + 4H_2SO_4 \rightarrow 3CH_3CHO + Cr_2(SO_4)_3 + K_2SO_4 + 7H_2O$

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

54. O/N 18/P12/Q33

Aqueous iron(II) sulfate can take part in redox reactions.

$$6FeSO_4 + 7H_2SO_4 + Na_2Cr_2O_7 \rightarrow 3Fe_2(SO_4)_3 + Cr_2(SO_4)_3 + Na_2SO_4 + 7H_2O$$

Which redox changes occur during this reaction?

1 Fe(II) is oxidised to Fe(III).

2 Cr(VI) is reduced to Cr(III).

3 Oxygen is reduced to water.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

55. M/J 18/P11/Q35

Each of the three mixtures shown can result in a chemical reaction.

Which mixtures result in a redox reaction?

1 bromine + hydrogen

2 sodium chloride + concentrated sulfuric acid

3 potassium iodide + silver nitrate

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

56. O/N 17/P12/Q33

Hydrogen sulfide can be oxidised to form sulfur dioxide.

$$2H_2S + 3O_2 \rightarrow 2SO_2 + 2H_2O$$

Which statements are correct?

1 The oxidation number of sulfur increases by 6.

2 The oxidation number of oxygen increases by 2.

3 The oxidation number of hydrogen decreases.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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57. O/N 17/P11/Q33, O/N 17/P13/Q33

One way of recovering tin from old printed circuit boards is to dissolve it in a mixture of concentrated hydrochloric acid and concentrated nitric acid. The tin dissolves because it reacts with the mixture of these concentrated acids.

$$Sn + 4HCl + 2HNO_3 \rightarrow SnCl_4 + NO_2 + NO + 3H_2O$$

Which statements about this reaction are correct?

1 Nitrogen is present in three different oxidation states in the reactants and products.
2 The oxidation state of tin increases from 0 to +4.
3 The oxidation state of chlorine remains the same.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

58. MAR 17/P12/Q33

Which of these statements are always correct?

1 The sum of the oxidation numbers of all the atoms in a compound is zero.
2 The oxidation number of sodium in a salt is positive.
3 The oxidation number of chlorine in a compound is negative.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

59. M/J 15/P13/Q33

When dilute acid is added to an aqueous solution containing nitrite ions, NO_2^-, a mixture of gases is produced.

$$2H^+(aq) + 2NO_2^-(aq) \rightarrow H_2O(l) + NO(g) + NO_2(g)$$

Which statements correctly describe the process?

1 Some nitrogen atoms are oxidised and some nitrogen atoms are reduced.
2 The $H^+(aq)$ ion is oxidised by $NO_2^-(aq)$.
3 The $H^+(aq)$ ion acts as a catalyst.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

60. O/N 13/P12/Q36, O/N 13/P11/Q36, M/J 10/P12/Q36, M/J 10/P11/Q36, M/J 10/P13/Q36

Sulfur dioxide and sulfites are used in food preservation.

Why are they used for this purpose?

1 They are reducing agents so retard the oxidation of food.
2 They inhibit the growth of aerobic bacteria.
3 They react with $NO_2(g)$ converting it to $NO(g)$.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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61. O/N 14/P13/Q31

In a solution that contains both Br_2 and Cl_2, a process takes place that produces BrO_3^- ions.
The process is represented by the following equations.

equation 1 $Br_2 + H_2O \rightarrow HBr + HBrO$

equation 2 $3HBrO + Cl_2 \rightarrow 2Cl^- + BrO_3^- + Br_2 + 3H^+$

Which statements about these reactions are correct?

1 Chlorine is reduced in equation 2.
2 Bromine is oxidised in both equation 1 and equation 2.
3 Bromine is reduced in both equation 1 and equation 2.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

62. M/J 13/P13/Q31

A space shuttle's upward thrust came from the following reaction between aluminium and ammonium perchlorate.

$$10Al + 6NH_4ClO_4 \rightarrow 4Al_2O_3 + 2AlCl_3 + 12H_2O + 3N_2$$

Which statements about this reaction are correct?

1 Aluminium is oxidised.
2 Chlorine is reduced.
3 Nitrogen is oxidised.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

63. M/J 12/P11/Q34, M/J 12/P13/Q36, M/J 06/P1/Q36, O/N 02/P1/Q36

Ammonia and chlorine react in the gas phase.

$$8NH_3 + 3Cl_2 \rightarrow N_2 + 6NH_4Cl$$

Which statements are correct?

1 Ammonia behaves as a reducing agent.
2 Ammonia behaves as a base.
3 The oxidation number of the hydrogen changes.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

64. O/N 11/P11/Q35, O/N 11/P13/Q33

Which of the halide ions, chloride, bromide or iodide, acts as a reducing agent when its sodium salt reacts with concentrated sulfuric acid?

1 at least one of Cl^-, Br^- and I^-
2 at least two of Cl^-, Br^- and I^-
3 all three of Cl^-, Br^- and I^-

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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65. O/N 10/P12/Q32

Zirconium, Zr, proton number 40, is a metal which is used in corrosion-resistant alloys.
Zirconium metal is extracted from the oxide ZrO_2 by the following sequence of reactions.

reaction 1 $ZrO_2 + 2Cl_2 + 2C \rightarrow ZrCl_4 + 2CO$

reaction 2 $ZrCl_4 + 2Mg \rightarrow Zr + 2MgCl_2$

Which statements about this extraction process are correct?

1 Carbon in reaction 1 behaves as a reducing agent.
2 Magnesium in reaction 2 behaves as a reducing agent.
3 Chlorine in reaction 1 behaves as a reducing agent.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

66. M/J 10/P12/Q33, M/J 10/P11/Q32, M/J 10/P13/Q31

Which reactions are redox reactions?

1 $CaBr_2 + 2H_2SO_4 \rightarrow CaSO_4 + Br_2 + SO_2 + 2H_2O$
2 $CaBr_2 + 2H_3PO_4 \rightarrow Ca(H_2PO_4)_2 + 2HBr$
3 $CaBr_2 + 2AgNO_3 \rightarrow Ca(NO_3)_2 + 2AgBr$

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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6.2: Multiple Topics

1. **MAR 19/P12/Q19**
Ammonia, NH_3, and hydrazine, NH_2NH_2, are two compounds of nitrogen, N_2.
Which statement is correct?
A The N–N bond in NH_2NH_2 is polar.
B NH_3 and NH_2NH_2 have lone pairs of electrons but N_2 does not.
C The oxidation number of each nitrogen in NH_2NH_2 is +2.
D The reaction of nitrogen with hydrogen has a high activation energy.

2. **O/N 16/P11/Q19, O/N 16/P13/Q19, M/J 11/P11/Q15, M/J 11/P13/Q16**
X, Y and Z represent different halogens. The table shows the results of nine experiments in which aqueous solutions of X_2, Y_2 and Z_2 were separately added to separate aqueous solutions containing X^-, Y^- and Z^- ions.

	$X^-(aq)$	$Y^-(aq)$	$Z^-(aq)$
$X_2(aq)$	no reaction	no reaction	no reaction
$Y_2(aq)$	X_2 formed	no reaction	Z_2 formed
$Z_2(aq)$	X_2 formed	no reaction	no reaction

Which row of the following table contains the ions X^-, Y^- and Z^- in order of their **decreasing** strength as reducing agents?

	strongest ⟶		weakest
A	X^-	Y^-	Z^-
B	X^-	Z^-	Y^-
C	Y^-	Z^-	X^-
D	Z^-	X^-	Y^-

Valid till October/November 2021 Exams

3. **MAR 17/P12/Q34**
Sulfur dioxide and oxygen react in the gas phase.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H = -197 \text{ kJ mol}^{-1}$$

Which statements are correct?
1 Increasing the pressure increases the equilibrium yield of SO_3.
2 Increasing the temperature lowers the value of the equilibrium constant K_p.
3 The presence of a vanadium(V) oxide catalyst increases the equilibrium yield of SO_3.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

4. **O/N 13/P13/Q34**
The following equilibrium is an exothermic reaction in the forward direction.

$$2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(l)$$

What happens when the concentration of CrO_4^{2-} ions **increases and** the temperature **decreases**?
1 The concentration of $Cr_2O_7^{2-}$ ions increases.
2 The equilibrium constant increases.
3 The activation energy decreases.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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Answers Sections

6.1				6.2	
1.	B	41.	C	1.	D
2.	C	42.	D	2.	B
3.	C	43.	C	3.	B
4.	D	44.	C	4.	B
5.	B	45.	A		
6.	A	46.	B		
7.	D	47.	D		
8.	A	48.	D		
9.	B	49.	D		
10.	C	50.	D		
11.	B	51.	A		
12.	D	52.	A		
13.	A	53.	D		
14.	D	54.	B		
15.	D	55.	D		
16.	A	56.	D		
17.	A	57.	A		
18.	C	58.	B		
19.	B	59.	D		
20.	A	60.	B		
21.	D	61.	A		
22.	C	62.	A		
23.	B	63.	B		
24.	C	64.	B		
25.	A	65.	B		
26.	C	66.	D		
27.	A				
28.	D				
29.	C				
30.	B				
31.	D				
32.	A				
33.	C				
34.	B				
35.	C				
36.	D				
37.	B				
38.	B				
39.	D				
40.	D				

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Unit 7

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Syllabus

7.1 Chemical equilibria: reversible reactions; dynamic equilibrium
7.2 Multiple topics

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Unit 7: Equilibria

7.1: Chemical equilibria: reversible reactions; dynamic equilibrium

1. M/J 20/P12/Q3

The catalysed formation of ammonia by the Haber process can be represented by the equation shown.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92 \text{ kJ mol}^{-1}$$

Which change in conditions will increase both the rate of formation and the equilibrium yield of ammonia?

A decrease in the temperature
B increase in the temperature
C increase in the pressure
D increase in the surface area of the catalyst

2. M/J 20/P12/Q11

PCl_5 decomposes as shown.

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

1.0 mol of $PCl_5(g)$, 1.0 mol of $PCl_3(g)$ and 1.0 mol of $Cl_2(g)$ are placed in a container of volume 1 dm^3 at 250 °C and allowed to reach equilibrium.
At this temperature, the equilibrium mixture contains 1.8 moles of PCl_3.
What is the value of K_c at 250 °C?

A 1 **B** 1.8 **C** 9 **D** 16.2

3. M/J 20/P11/Q1

Ethene can be oxidised to form epoxyethane, C2H4O.

$$C_2H_4(g) + \frac{1}{2}O_2(g) \rightleftharpoons C_2H_4O(g) \qquad \Delta H^{\ominus} = -107 \text{ kJ mol}^{-1}$$

Which set of conditions gives the greatest yield of epoxyethane at equilibrium?

	pressure	temperature / °C
A	high	100
B	high	200
C	low	100
D	low	200

4. M/J 20/P13/Q11

Two reactions are shown.

reaction 1 $X_2(g) + Y_2(g) \rightleftharpoons 2XY(g)$

reaction 2 $XY(g) \rightleftharpoons \frac{1}{2}X_2(g) + \frac{1}{2}Y_2(g)$

The equilibrium constant, K_p, for reaction 1 is 0.0052.
What is K_p for reaction 2?

A 2.6×10^{-3} **B** 13.9 **C** 192.3 **D** 384.6

5. MAR 20/P12/Q6

The equation for the reaction between silver chloride and aqueous ammonia is shown.

$$AgCl(s) + 2NH_3(aq) \rightleftharpoons [Ag(NH_3)_2]^+(aq) + Cl^-(aq)$$

What are the units of K_c for this reaction?

A no units **B** $mol^{-1}\ dm^3$ **C** $mol\ dm^{-3}$ **D** $mol^2\ dm^{-6}$

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6. MAR 20/P12/Q11

The main stage in the Contact process is an equilibrium reaction.

$$2SO_2 + O_2 \rightleftharpoons 2SO_3$$

Which row describes the effect of the named condition on the equilibrium yield?

	presence of catalyst	high pressure	high temperature
A	no effect on yield	decreases yield	increases yield
B	no effect on yield	increases yield	decreases yield
C	increases yield	decreases yield	increases yield
D	increases yield	increases yield	decreases yield

7. O/N 19/P12/Q10, M/J 13/P12/Q8

The reaction between sulfur dioxide and oxygen is a dynamic equilibrium.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

What happens when the pressure of the system is increased?

A The rate of reaction will decrease and the position of the equilibrium will move to the left.

B The rate of reaction will decrease and the position of the equilibrium will move to the right.

C The rate of reaction will increase and the position of the equilibrium will move to the left.

D The rate of reaction will increase and the position of the equilibrium will move to the right.

8. O/N 19/P11/Q10, O/N 19/P13/Q10

Two compounds X and Y react to produce compound Z. The reaction is reversible.

$$X + Y \rightleftharpoons Z$$

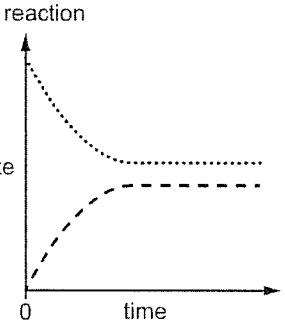
When X and Y are mixed together in a closed system a dynamic equilibrium is gradually established.
Which graph could represent the change in the rates of the forward and reverse reactions over time?

key

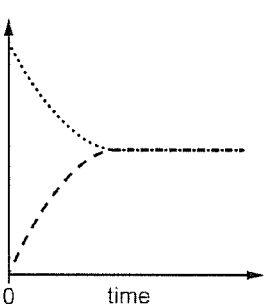
..... rate of forward reaction

- - - - rate of reverse reaction

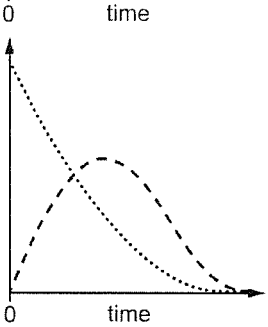
A



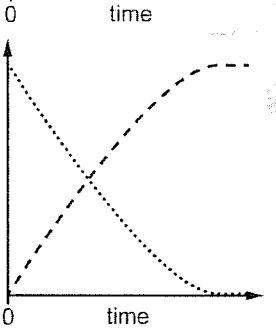
C



B



D



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9. O/N 19/P11/Q11, O/N 19/P13/Q11

The reaction between sulfur dioxide and oxygen is reversible.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad K_c = 280 \text{ mol}^{-1} \text{ dm}^3 \text{ at } 1000 \text{ K}$$

In an equilibrium mixture at 1000 K the sulfur dioxide concentration is 0.200 mol dm^{-3} and the oxygen concentration is 0.100 mol dm^{-3}.
What is the sulfur trioxide concentration?

A 1.058 mol dm^{-3} **B** 1.120 mol dm^{-3} **C** 2.366 mol dm^{-3} **D** 5.600 mol dm^{-3}

10. M/J 19/P12/Q10

Ethyl ethanoate undergoes the following reaction.

$$CH_3CO_2C_2H_5 + H_2O \rightleftharpoons C_2H_5OH + CH_3CO_2H \qquad K_c = 0.27$$

Equal amounts of ethanoic acid and ethanol were mixed together and allowed to reach equilibrium.
At equilibrium, the concentrations of both ethanoic acid and ethanol were 0.42 mol dm^{-3}.
What is the concentration of ethyl ethanoate at equilibrium?

A 0.22 mol dm^{-3} **B** 0.65 mol dm^{-3} **C** 0.81 mol dm^{-3} **D** 1.54 mol dm^{-3}

11. M/J 19/P11/Q10

Hydrogen iodide gas decomposes reversibly producing iodine vapour and hydrogen.

$$2HI(g) \rightleftharpoons I_2(g) + H_2(g) \qquad \Delta H = +12 \text{ kJ mol}^{-1}$$

The position of the equilibrium for this reaction may be altered by changing the external conditions.
Which row correctly describes the change in position of equilibrium?

	effect of increasing the pressure	effect of increasing the temperature
A	moves to the right	moves to the right
B	moves to the right	moves to the left
C	no change	moves to the right
D	no change	moves to the left

12. M/J 19/P11/Q11

The reaction between sulfur dioxide and oxygen is reversible.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad K_c = 280 \text{ mol}^{-1} \text{ dm}^3 \text{ at } 1000 \text{ K}$$

In an equilibrium mixture at 1000 K the sulfur trioxide concentration is 6.00 mol dm^{-3}.
The sulfur dioxide concentration is twice the oxygen concentration.
What is the sulfur dioxide concentration?

A 0.175 mol dm^{-3} **B** 0.254 mol dm^{-3} **C** 0.318 mol dm^{-3} **D** 0.636 mol dm^{-3}

13. M/J 19/P13/Q9

What is the correct expression for Kc for the reaction shown?

$$I_2(aq) + 2Fe^{2+}(aq) \rightleftharpoons 2I^-(aq) + 2Fe^{3+}(aq)$$

A $\dfrac{[2I^-][2Fe^{3+}]}{[I_2][2Fe^{2+}]}$ **B** $\dfrac{[I^-]^2[Fe^{3+}]^2}{[I_2][Fe^{2+}]^2}$ **C** $\dfrac{[I_2][2Fe^{2+}]}{[2I^-][2Fe^{3+}]}$ **D** $\dfrac{[I_2][Fe^{2+}]^2}{[I^-]^2[Fe^{3+}]^2}$

14. M/J 19/P13/Q10

X and Y react together to form Z in a reversible reaction.
The equilibrium yield of Z is lower at higher temperature.
The equilibrium yield of Z is lower at lower pressure.
Which equation could represent this reaction?

A $X(g) + Y(g) \rightleftharpoons Z(g)$ $\Delta H = -100$ kJ mol^{-1}

B $X(g) + Y(g) \rightleftharpoons Z(g)$ $\Delta H = +100$ kJ mol^{-1}

C $X(s) + Y(g) \rightleftharpoons 2Z(g)$ $\Delta H = -100$ kJ mol^{-1}

D $X(s) + Y(g) \rightleftharpoons 2Z(g)$ $\Delta H = +100$ kJ mol^{-1}

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15. MAR 19/P12/Q11

When copper is added to a solution of silver ions, the following equilibrium is established.

$$Cu(s) + 2Ag^+(aq) \rightleftharpoons Cu^{2+}(aq) + 2Ag(s) \qquad K_c = 1.0 \times 10^5$$

What is the concentration of silver ions at equilibrium when $[Cu^{2+}] = 0.10$ mol dm^{-3}?

A 5.0×10^{-7} mol dm^{-3} **B** 5.0×10^{-4} mol dm^{-3} **C** 1.0×10^{-3} mol dm^{-3} **D** 1.0×10^{2} mol dm^{-3}

16. O/N 18/P12/Q9

In this question, all pressures are measured in atm.

The equation represents the equilibrium between three gaseous substances X, Y and Z.

$$X + 3Y \rightleftharpoons 2Z$$

At temperature T_1, the numerical value of K_p, the equilibrium constant, is 2.

At a higher temperature T_2, the partial pressures at equilibrium are as shown.

X	Y	Z
2	3	5

Which row is correct?

	the numerical value of K_p at T_2	the forward reaction is
A	54/25	endothermic
B	54/25	exothermic
C	25/54	endothermic
D	25/54	exothermic

17. O/N 18/P12/Q11

Nitrogen and hydrogen can react together to form ammonia.

The formation of ammonia is exothermic.

The rate and yield of the reaction can be altered by changing the conditions under which the reaction is carried out.

Which row shows the effects of adding iron to the mixture and increasing the temperature?

	adding iron	increasing the temperature
A	has no effect on the equilibrium yield	reduces the equilibrium yield
B	increases the equilibrium yield	increases the equilibrium yield
C	increases the equilibrium yield	increases the rate
D	increases the rate	has no effect on the equilibrium yield

18. O/N 18/P11/Q9, O/N 18/P13/Q9

In this question you should assume that all gases behave ideally.

Hydrogen and iodine react reversibly in the following reaction. The system reaches dynamic equilibrium.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \qquad \Delta H = -9.5 \text{ kJ mol}^{-1}$$

Which statement must be true for the K_p of this equilibrium to be constant?

A The partial pressures of H_2, I_2 and HI are equal.

B The external pressure is constant.

C The forward and reverse reactions have stopped.

D The temperature is constant.

19. M/J 18/P11/Q15

In which reaction does ammonia behave as a Brønsted-Lowry base?

A $NH_3 + CH_3CH_2Br \rightarrow CH_3CH_2NH_2 + HBr$

B $NH_3 + H_2O + CO_2 \rightarrow (NH_4)HCO_3$

C $2NH_3 + 2Na \rightarrow 2NaNH_2 + H_2$

D $4NH_3 + 3O_2 \rightarrow 2N_2 + 6H_2O$

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20. O/N 18/P11/Q10, O/N 18/P13/Q10

0.200 mol of sulfur dioxide and 0.200 mol of oxygen are placed in a 1.00 dm^3 sealed container.
The gases are allowed to react until equilibrium is reached.

$$2SO_2 + O_2 \rightleftharpoons 2SO_3$$

At equilibrium there is 0.100 mol of SO_3 in the container.
What is the value of K_c?

A 0.150 mol dm^{-3} **B** 0.800 mol dm^{-3} **C** 1.25 mol^{-1} dm^3 **D** 6.67 mol^{-1} dm^3

21. O/N 18/P11/Q11, O/N 18/P13/Q11

Two reactions are shown.

reaction 1 $N_2(g) + 3H2(g) \rightleftharpoons 2NH_3(g)$

reaction 2 $2O_3(g) \rightleftharpoons 3O_2(g)$

In reaction 1, a finely powdered iron catalyst is used.
In reaction 2, a vaporised tetrachloromethane catalyst in ultraviolet light is used.
Which statement about the catalysts used is correct?

A Both reaction 1 and reaction 2 use a heterogeneous catalyst.

B Both reaction 1 and reaction 2 use a homogeneous catalyst.

C Reaction 1 uses a heterogeneous catalyst and reaction 2 uses a homogeneous catalyst.

D Reaction 1 uses a homogeneous catalyst and reaction 2 uses a heterogeneous catalyst.

22. M/J 18/P12/Q5

The gases X and Y react to form Z.

$$X(g) + Y(g) \rightleftharpoons Z(g)$$

An equilibrium mixture of these three gases is compressed at constant temperature.
What will be the changes in the mole fraction of Z and in K_p?

	mole fraction of Z	K_p
A	increase	increase
B	increase	no change
C	no change	increase
D	no change	no change

23. M/J 18/P12/Q10

In a particular reversible reaction the yield of product is increased

- if the temperature is increased;
- if the pressure is decreased.

Which equation could describe this reversible reaction?

A $CH_4(g) + H_2O(g) \rightleftharpoons 3H_2(g) + CO(g)$ $\Delta H = +206$ kJ mol^{-1}

B $4NH_3(g) + 3O_2(g) \rightleftharpoons 2N_2(g) + 6H_2O(g)$ $\Delta H = -227$ kJ mol^{-1}

C $2NO_2(g) \rightleftharpoons N_2O_4(g)$ $\Delta H = -58$ kJ mol^{-1}

D $3O_2(g) \rightleftharpoons 2O_3(g)$ $\Delta H = +143$ kJ mol^{-1}

24. M/J 18/P12/Q19

Sulfur dioxide can be catalytically oxidised by an oxide of nitrogen in the atmosphere.
Which reaction shows the regeneration of the catalyst?

A $N_2 + 2O_2 \rightleftharpoons 2NO_2$

B $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

C $N_2 + O_2 \rightarrow 2NO$

D $NO + \frac{1}{2}O_2 \rightarrow NO_2$

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25. M/J 18/P13/Q9

Hydrogen is produced industrially from methane as shown in the equation.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \qquad \Delta H^{\ominus} = +205 \text{ kJ mol}^{-1}$$

Which conditions would most favour the formation of hydrogen?

	pressure	temperature
A	high	high
B	high	low
C	low	high
D	low	low

26. M/J 18/P13/Q10

The chemical equilibrium shown is formed when ammonia is produced in the Haber process.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

The following concentrations are found to be present at equilibrium under certain conditions.

N_2	H_2	NH_3
0.200 mol dm^{-3}	0.300 mol dm^{-3}	0.600 mol dm^{-3}

What is the numerical value of K_c under these conditions?

A 0.0150 **B** 6.0 **C** 10.0 **D** 66.7

27. M/J 18/P13/Q17

Silver chloride and silver iodide form equilibria when added to water.

$$AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq) \qquad K_c = K_1$$

$$AgI(s) \rightleftharpoons Ag^+(aq) + I^-(aq) \qquad K_c = K_2$$

Each equilibrium position lies well to the left.

Silver iodide will not dissolve in aqueous ammonia. Silver chloride will dissolve in aqueous ammonia. Another equilibrium is formed.

$$Ag^+(aq) + 2NH_3(aq) \rightleftharpoons Ag(NH_3)_2^+(aq) \qquad K_c = K_3$$

The position of this equilibrium lies to the right.

What is the order of magnitude for these three equilibrium constants?

A $K_1 > K_2 > K_3$ **B** $K_2 > K_1 > K_3$ **C** $K_3 > K_1 > K_2$ **D** $K_3 > K_2 > K_1$

28. O/N 17/P12/Q9

Nitrogen dioxide, NO_2, is a brown gas.

Dinitrogen tetroxide, N_2O_4, is a colourless gas.

An equilibrium is established between NO_2 and N_2O_4 in a closed vessel.

$$2NO_2(g) \rightleftharpoons N_2O_4(g) \qquad \Delta H = -57 \text{ kJ mol}^{-1}$$

brown colourless

Which row describes the effects of changing conditions on the colour of an equilibrium mixture of NO_2 and N_2O_4?

	increasing the pressure	increasing the temperature
A	colour becomes darker	colour becomes darker
B	colour becomes darker	colour becomes lighter

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29. O/N 17/P11/Q9, O/N 17/P13/Q9, O/N 02/P1/Q11

Hydrogen iodide dissociates into hydrogen and iodine.

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$$

In an experiment, *b*mol of hydrogen iodide were put into a sealed vessel at pressure p. At equilibrium, *x*mol of the hydrogen iodide had dissociated.

Which expression for K_p is correct?

A $\dfrac{x^2}{(b-x)^2}$ **B** $\dfrac{x^2p^2}{(b-x)^2}$ **C** $\dfrac{x^2p^2}{4b(b-x)}$ **D** $\dfrac{x^2}{4(b-x)^2}$

30. M/J 17/P12/Q9

Hydrogen and carbon dioxide gases are mixed at 800 K. A reversible reaction takes place.

$$H_2(g) + CO_2(g) \rightleftharpoons H_2O(g) + CO(g)$$

At equilibrium, the partial pressures of H_2 and CO_2 are both 10.0 kPa. K_p is 0.288 at 800 K.

What is the partial pressure of CO in the equilibrium mixture?

A 5.37 kPa **B** 18.6 kPa **C** 28.8 kPa **D** 347 kPa

31. M/J 17/P12/Q10

A reaction involved in the Contact process is shown.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H^{\ominus} = -197 \text{ kJ mol}^{-1}$$

The reaction is investigated at 200 kPa and 700 K and the value of the equilibrium constant, K_p, is found to be Y. The reaction is then investigated at 1000 kPa and 700 K and the value of K_p is found to be Z.

Which statement comparing Y and Z is correct?

A Y and Z are the same.

B Y is greater than Z.

C Z is 2.2 times greater than Y.

D Z is 5.0 times greater than Y.

32. M/J 17/P11/Q10

Methanol can be produced from hydrogen and carbon monoxide.

$$2H_2(g) + CO(g) \rightleftharpoons CH_3OH(g)$$

What is the expression for K_p for this reaction?

A $K_p = \dfrac{(2p_{H2})^2 \times p_{CO}}{p_{CH_3OH}}$

B $K_p = \dfrac{(p_{H2})^2 \times p_{CO}}{p_{CH_3OH}}$

C $K_p = \dfrac{p_{CH_3OH}}{(p_{H2})^2 \times p_{CO}}$

D $K_p = \dfrac{p_{CH_3OH}}{p_{CO} \times (2p_{H2})^2}$

33. M/J 17/P13/Q10

For the reaction shown, an equilibrium is established at a temperature of 700 K.

The equilibrium constant, K_p, for the reaction is 9.80 kPa. The partial pressure of N_2O_4 at equilibrium is 80.0 kPa.

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

What is the partial pressure of NO_2 at equilibrium?

A 8.16 kPa **B** 28.0 kPa **C** 66.6 kPa **D** 784 kPa

34. MAR 17/P12/Q3, M/J 12/P12/Q7

Two moles of compound P were placed in a vessel. The vessel was heated and compound P was partly decomposed to produce Q and R. A dynamic equilibrium between chemicals P, Q and R was established. At equilibrium *x* moles of R were present and the total number of moles present was $(2 + \frac{x}{2})$.

What is the equation for this equilibrium reaction?

A $P \rightleftharpoons 2Q + R$ **B** $2P \rightleftharpoons 2Q + R$ **C** $2P \rightleftharpoons Q + R$ **D** $2P \rightleftharpoons Q + 2R$

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35. MAR 17/P12/Q11

Ammonia is manufactured from nitrogen and hydrogen using the Haber process.

$$N_2(g) + 3H_2(g)\ 2NH_3(g)$$

What is the expression for K_c for this equilibrium?

A $\frac{2[NH_3(g)]}{[N_2(g)]+3[H_2(g)]}$ **B** $\frac{2[NH_3(g)]}{[N_2(g)]\times 3[H_2(g)]}$ **C** $\frac{[NH_3(g)]^2}{[N_2(g)]+[H_2(g)]^3}$ **D** $\frac{[NH_3(g)]^2}{[N_2(g)]\times[H_2(g)]^3}$

36. O/N 16/P12/Q10

Nitrogen reacts with hydrogen to produce ammonia.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

A mixture of 2.00 mol of nitrogen, 6.00 mol of hydrogen and 2.40 mol of ammonia is allowed to reach equilibrium in a sealed vessel of volume 1 dm^3. It was found that 2.32 mol of nitrogen were present in the equilibrium mixture.

What is the value of K_c?

A $\frac{(1.76)^2}{(2.32)(6.96)^3}$ **B** $\frac{(1.76)^2}{(2.32)(6.32)^3}$ **C** $\frac{(2.08)^2}{(2.32)(6.32)^3}$ **D** $\frac{(2.40)^2}{(2.32)(6.00)^3}$

37. O/N 16/P11/Q10, O/N 16/P13/Q10

The table shows the partial pressures in an equilibrium mixture formed by the Haber process.

substance	partial pressure / kPa
nitrogen	7000
hydrogen	8000
ammonia	4000

$$3H_2(g) + N_2(g) \rightleftharpoons 2NH_3(g)$$

What is the numerical value of the equilibrium constant, K_p, for this reaction?

A 4.46×10^{-9} **B** 4.76×10^{-5} **C** 7.14×10^{-5} **D** 2.24×10^{8}

38. M/J 16/P12/Q7

0.10 g of the volatile liquid X formed 0.025 dm^3 of vapour at 100 °C and atmospheric pressure.

1 mol of vapour occupies 22.4 dm^3 at 0 °C and atmospheric pressure.

What is the relative molecular mass of X?

A $\frac{0.025 \times 273 \times 22.4}{0.10 \times 373}$

B $\frac{0.025 \times 373 \times 22.4}{0.10 \times 273}$

C $\frac{0.10 \times 273 \times 22.4}{0.025 \times 373}$

D $\frac{0.10 \times 373 \times 22.4}{0.025 \times 273}$

39. M/J 16/P12/Q10

When solid ammonium chloride dissociates at a certain temperature in a 0.500 dm^3 container, ammonia and hydrogen chloride are formed.

$$NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g)$$

The initial amount of ammonium chloride was 1.00 mol, and when the system had reached equilibrium there was 0.300 mol of ammonium chloride.

What is the numerical value of K_c for this reaction under these conditions?

A 0.490 **B** 1.63 **C** 1.96 **D** 3.27

40. M/J 16/P11/Q9

An aqueous solution was prepared containing a mixture of 1.0 mol of $AgNO_3$ and 1.0 mol of $FeSO_4$ in 1.00 dm^3 of water. When equilibrium was established, there was 0.44 mol of $Ag^+(aq)$ in the mixture.

$$Ag^+(aq) + Fe^{2+}(aq) \rightleftharpoons Ag(s) + Fe^{3+}(aq)$$

What is the numerical value of K_c?

A 0.62 **B** 1.40 **C** 1.62 **D** 2.89

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41. M/J 16/P11/Q11

Enzymes are biological catalysts. Many enzymes show specificity. An example of an enzyme which shows specificity is glucokinase. Glucokinase is involved in the metabolism of glucose.
What does specificity mean in this context?

A Glucokinase is most effective as a catalyst over a narrow pH range.

B Glucokinase is most effective as a catalyst over a narrow range of temperatures.

C Glucokinase only operates on a narrow range of substrate molecules.

D Glucokinase provides an alternative route for the reactions it catalyses.

42. M/J 16/P11/Q10

The equation for the reaction between carbon monoxide and hydrogen is shown.

$$CO(g) + 3H_2(g) \rightleftharpoons CH_4(g) + H_2O(g)$$

What are the units of K_p for this reaction?

A kPa **B** kPa^{-1} **C** kPa^{2} **D** kPa^{-2}

43. M/J 16/P13/Q9

The equilibrium constant, K_c, for the reaction shown is 2 mol^{-2} dm^6, at 600 K.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

What is the concentration of NH_3 at equilibrium, at 600 K, when the equilibrium concentrations of N_2 and H_2 are both 2 mol dm^{-3}?

A $\sqrt{8}$ mol dm^{-3} **B** $\sqrt{16}$ mol dm^{-3} **C** $\sqrt{32}$ mol dm^{-3} **D** 32 mol dm^{-3}

44. M/J 16/P13/Q10

Sulfur dioxide is used as a preservative in wine making.
The following equations describe the reactions that occur when sulfur dioxide dissolves in water.

$$H_2O + SO_2 \rightleftharpoons HSO_3^- + H^+$$

$$HSO_3^- + H^+ \rightleftharpoons SO_3^{2-} + 2H^+$$

Which statement about **these two reactions** is correct?

A HSO_3^- acts as a base.

B SO_2 acts as an oxidising agent.

C SO_3^{2-} acts as an acid.

D SO_3^{2-} acts as a reducing agent.

45. M/J 16/P13/Q11

Catalysts are an important feature of many industrial processes and biochemical reactions.
Which row correctly describes the effect of a catalyst on a reversible chemical reaction?

	position of equilibrium	effect on value of ΔH
A	moved to right	decreased
B	unaffected	decreased
C	unaffected	increased
D	unaffected	unaffected

46. MAR 16/P12/Q11

In an experiment, 2.00 mol of hydrogen and 3.00 mol of iodine were heated together in a sealed container and allowed to reach equilibrium at a fixed temperature. The container had a fixed volume of 1.00 dm^3. At equilibrium, there were 2.40 mol of iodine present in the mixture.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

What is the value of the equilibrium constant, K_c?

A 0.107 **B** 0.357 **C** 0.429 **D** 2.33

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47. O/N 15/P12/Q8

Hydrogen can be obtained by reacting methane with steam.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \qquad \Delta H^{\ominus} = +210 \text{ kJ mol}^{-1}$$

Which conditions of pressure and temperature will give the greatest equilibrium yield of hydrogen?

	pressure	temperature
A	high	high
B	high	low
C	low	high
D	low	low

48. O/N 15/P12/Q9

Nitrogen monoxide reacts with oxygen in a reversible reaction according to the equation shown below.

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$$

The partial pressures of each of the components in an equilibrium mixture are shown in the table.

partial pressure NO/kPa	partial pressure O_2/kPa	partial pressure NO_2/kPa
10	30	20

What is the numerical value of the equilibrium constant, K_p, for this equilibrium?

A 6.67×10^{-2} **B** 1.33×10^{-1} **C** 7.50 **D** 15.0

49. O/N 15/P11/Q2, O/N 15/P13/Q2

Which set of conditions gives the highest yield of ammonia at equilibrium?

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H^{\ominus} = -92 \text{ kJ mol}^{-1}$$

	catalyst	pressure	temperature
A	absent	high	low
B	absent	low	high
C	present	high	high
D	present	low	low

50. O/N 15/P11/Q10, O/N 15/P13/Q10

A mixture of nitrogen and hydrogen gases, at a temperature of 500 K, was put into an evacuated vessel of volume 6.0 dm^3. The vessel was then sealed.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

The mixture was allowed to reach equilibrium. It was found that 7.2 mol of N_2 and 12.0 mol of H_2 were present in the equilibrium mixture. The value of the equilibrium constant, K_c, for this equilibrium is 6.0×10^{-2} at 500 K.

What is the concentration of ammonia present in the equilibrium mixture at 500 K?

A 0.58 mol dm^{-3} **B** 0.76 mol dm^{-3} **C** 3.5 mol dm^{-3} **D** 27 mol dm^{-3}

51. O/N 15/P11/Q11, O/N 15/P13/Q11

Ammonia is made by the Haber process. The reactants are nitrogen and hydrogen.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H \text{ –ve}$$

What will increase the rate of the forward reaction?

A adding argon to the mixture but keeping the total volume constant

B decreasing the temperature

C increasing the total pressure by reducing the total volume at constant temperature

D removing ammonia as it is made but keeping the total volume of the mixture the same

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52. M/J 15/P12/Q9

When a sample of HI is warmed to a particular temperature the equilibrium below is established.

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$$

At this temperature, it is found that the partial pressure of HI(g) is 28 times the partial pressure of $H_2(g)$.
What is the value of K_p at this temperature?

A 1.28×10^{-3} **B** 0.035 **C** 28 **D** 784

53. M/J 15/P12/Q10, O/N 09/P12/Q10, O/N 09/P11/Q11

Photochromic glass, used for sunglasses, darkens when exposed to bright light and becomes more transparent again when the light is less bright. The darkness of the glass is related to the concentration of silver atoms.
The following reactions are involved.

reaction 1 $Ag^+ + Cl^- \rightleftharpoons Ag + Cl$

reaction 2 $Cu^+ + Cl \rightarrow Cu^{2+} + Cl^-$

reaction 3 $Cu^{2+} + Ag \rightarrow Cu^+ + Ag^+$

Which statement about these reactions is correct?

A Cu^+ and Cu^{2+} ions act as catalysts.

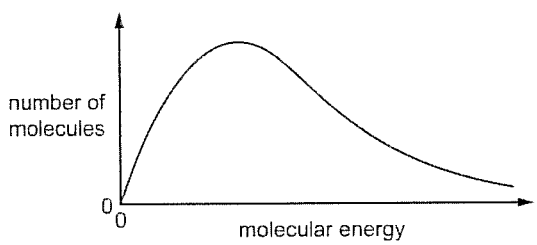
B Cu^+ ions act as an oxidising agent in reaction 2.

C Reaction 3 increases the darkness of the glass.

D Silver atoms are reduced in reaction 3.

54. M/J 15/P12/Q11

The Boltzmann distribution below shows the distribution of molecular energies in a sample of a gas at a given temperature.



Which statement correctly describes the change in such a distribution if the temperature is increased?

A Fewer molecules possess the most probable energy value and this value shifts to the left.

B Fewer molecules possess the most probable energy value and this value shifts to the right.

C More molecules possess the most probable energy value and this value shifts to the left.

D The area under the curve of the distribution increases.

55. M/J 15/P11/Q6

One mole of phosphorus(V) chloride, PCl_5, is heated to 600 K in a sealed flask of volume 1 dm^3.
Equilibrium is established and measurements are taken.

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

The experiment is repeated with one mole of phosphorus(V) chloride heated to 600 K in a sealed flask of volume 2 dm^3.
How will the measurements vary?

A The equilibrium concentrations of $PCl_3(g)$ and $Cl_2(g)$ are higher in the second experiment.

B The equilibrium concentration of $PCl_5(g)$ is lower in the second experiment.

C The equilibrium concentrations of all three gases are the same in both experiments.

D The value of the equilibrium constant is higher in the second experiment.

56. M/J 15/P11/Q8

In which reaction is the underlined substance acting as a base?

A $HNO_3 + \underline{H_2SO_4} \rightarrow H_2NO_3^+ + HSO_4^-$

B $HSiO_3^- + \underline{HCN} \rightarrow CN^- + H_2O + SiO_2$

C $HNO_2 + \underline{HCO_3^-} \rightarrow H_2O + CO_2 + NO_2^-$

D $C_6H_5O^- + \underline{CH_2C/CO_2H} \rightarrow C_6H_5OH + CH_2C/CO_2^-$

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57. M/J 15/P11/Q9

One molecule of haemoglobin, Hb, can bind with four molecules of oxygen according to the following equation.

$$Hb(aq) + 4O_2(aq) \rightleftharpoons Hb(O_2)_4(aq)$$

When the equilibrium concentration of O_2 is 7.6×10^{-6} mol dm^{-3}, the equilibrium concentrations of Hb and $Hb(O_2)_4$ are equal.

What is the value of K_c for this equilibrium?

A 3.0×10^{20} **B** 1.3×10^{5} **C** 7.6×10^{-6} **D** 3.3×10^{-21}

58. M/J 15/P13/Q8

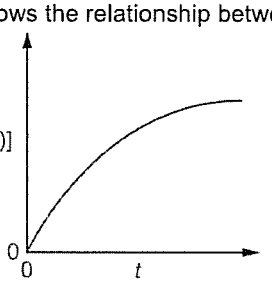
The following reaction was carried out.

$$HCO_2CH_3(aq) + NaOH(aq) \rightarrow HCO_2Na(aq) + CH_3OH(aq)$$

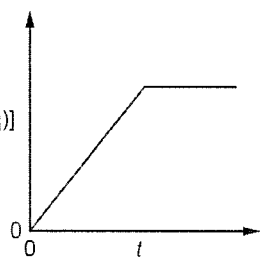
The concentration of methanol, $[CH_3OH(aq)]$, was measured with time, *t*.

Which graph shows the relationship between $[CH_3OH(aq)]$ and *t*?

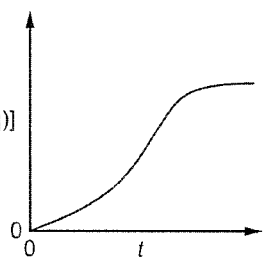
A



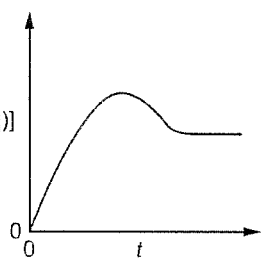
C



B



D



59. M/J 14/P12/Q4

Hydrogen and carbon dioxide gases are mixed in equal molar amounts at 800 K. A reversible reaction takes place.

$$H_2(g) + CO_2(g) \rightleftharpoons H_2O(g) + CO(g)$$

At equilibrium, the partial pressures of H_2 and CO_2 are both 10.0 kPa. K_p is 0.288 at 800 K.

What is the partial pressure of CO in the equilibrium mixture?

A 5.37 kPa **B** 18.6 kPa **C** 28.8 kPa **D** 347 kPa

60. M/J 14/P12/Q7

The formation of hydrogen and ethyne, C_2H_2, from methane reaches dynamic equilibrium.

$$2CH_4(g) \rightleftharpoons 3H_2(g) + C_2H_2(g)$$

What are the units of K_c?

A mol dm^{-3} **B** mol^2 dm^{-6} **C** mol^3 dm^{-9} **D** mol^4 dm^{-12}

61. M/J 14/P11/Q7

The Contact process is used in the manufacture of sulfuric acid. The equation for the main reaction is shown below.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H = -196 \text{ kJ mol}^{-1}$$

Which statement about this reaction is **incorrect**?

A Increased pressure gives a higher yield of SO_3.

B Increased temperature gives a higher yield of SO_3.

C In the forward reaction the oxidation state of sulfur changes from +4 to +6.

D Vanadium(V) oxide is used as a catalyst.

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62. M/J 14/P11/Q10

The equilibrium constant, K_c, for the reaction $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$, is 60 at 450 °C.

What is the number of moles of hydrogen iodide in equilibrium with 2 mol of hydrogen and 0.3 mol of iodine at 450 °C?

A $\frac{1}{100}$ **B** $\frac{1}{10}$ **C** 6 **D** 36

63. O/N 13/P12/Q9, O/N 13/P11/Q9

Nitrogen reacts with hydrogen to produce ammonia.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

A mixture of 2.00 mol of nitrogen, 6.00 mol of hydrogen, and 2.40 mol of ammonia is allowed to reach equilibrium in a sealed vessel of volume 1 dm^3 under certain conditions. It was found that 2.32 mol of nitrogen were present in the equilibrium mixture.

What is the value of K_c under these conditions?

A $\frac{(1.76)^2}{(2.32)(6.96)^3}$ **B** $\frac{(1.76)^2}{(2.32)(6.32)^3}$ **C** $\frac{(2.08)^2}{(2.32)(6.32)^3}$ **D** $\frac{(2.40)^2}{(2.32)(6.00)^3}$

64. O/N 13/P13/Q10

Nitrogen reacts with hydrogen to produce ammonia.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

A mixture of 1.00 mol of nitrogen, 3.00 mol of hydrogen and 1.98 mol of ammonia is allowed to reach equilibrium in a sealed vessel under certain conditions. It was found that 1.64 mol of nitrogen were present in the equilibrium mixture.

What is the value of K_c under these conditions?

A $\frac{(0.70)^2}{(1.64)(4.92)^3}$ **B** $\frac{(1.34)^2}{(1.64)(3.64)^3}$ **C** $\frac{(1.64)(4.92)^3}{(0.70)^2}$ **D** $\frac{(1.64)(3.64)^3}{(1.34)^2}$

65. M/J 13/P11/Q6

An experiment is set up to measure the rate of hydrolysis of ethyl ethanoate.

$$CH_3CO_2C_2H_5 + H_2O \rightleftharpoons CH_3CO_2H + C_2H_5OH$$

The hydrolysis is found to be slow in neutral aqueous solution but it proceeds at a measurable rate when the solution is acidified with hydrochloric acid.

What is the function of the hydrochloric acid?

A to dissolve the ethyl ethanoate

B to ensure that the reaction reaches equilibrium

C to increase the reaction rate by catalytic action

D to suppress ionisation of the ethanoic acid formed

66. M/J 12/P12/Q9

Methanol is manufactured by reacting carbon dioxide and hydrogen.

$$CO_2(g) + 3H_2(g) \rightleftharpoons CH_3OH(g) + H_2O(g) \qquad \Delta H = -49 \text{ kJ mol}^{-1}$$

What would increase the equilibrium yield of methanol in this process?

A adding a catalyst **C** increasing the pressure

B adding an excess of steam **D** increasing the temperature

67. M/J 12/P11/Q2, M/J 12/P13/Q1

Ammonia is manufactured by the Haber Process, in an exothermic reaction.

Assuming that the amount of catalyst remains constant, which change will **not** bring about an increase in the rate of the forward reaction?

A decreasing the size of the catalyst pieces **C** increasing the temperature

B increasing the pressure **D** removing the ammonia as it is formed

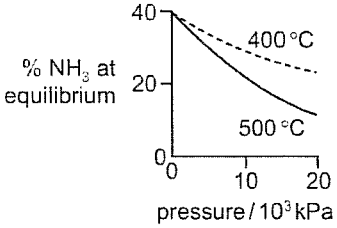
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68. M/J 13/P13/Q17, M/J 10/P12/Q11, M/J 10/P11/Q15, M/J 10/P13/Q15

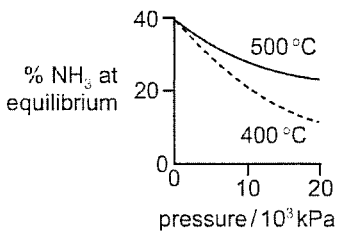
Graphs can be drawn to show the percentage of ammonia at equilibrium when nitrogen and hydrogen are mixed at different temperatures and pressures.

Which diagram correctly represents these two graphs?

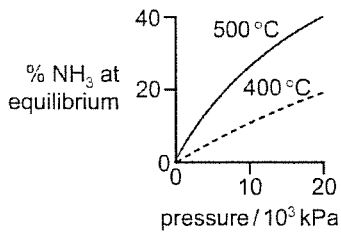
A



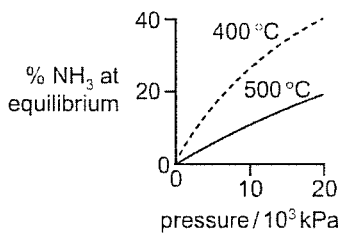
B



C



D



69. M/J 12/P11/Q9, M/J 12/P13/Q11

Two moles of compound P were placed in a vessel. The compound P was partly decomposed by heating. A dynamic equilibrium between chemicals P, Q and R was established.

At equilibrium, x mol of R were present and the total number of moles present was $(2 + x)$.

What is the equation for this equilibrium?

A $P \rightleftharpoons 2Q + R$ **B** $2P \rightleftharpoons 2Q + R$ **C** $2P \rightleftharpoons Q + R$ **D** $2P \rightleftharpoons Q + 2R$

70. O/N 11/P12/Q7

For the equilibrium $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$, what will change the value of K_p?

A adding a catalyst
B adding more O_2
C increasing the pressure
D increasing the temperature

71. O/N 11/P12/Q12, M/J 08/P1/Q11

For the reaction

$$W(aq) + 2X(aq) \rightleftharpoons 2Y(aq) + 3Z(aq)$$

what are the correct units for the equilibrium constant K_c?

A $mol\ dm^{-3}$ **B** $mol^2\ dm^{-6}$ **C** $mol^{-1}\ dm^3$ **D** $mol^{-2}\ dm^6$

72. O/N 11/P11/Q8, O/N 11/P13/Q10

Sulfur dioxide is used as a preservative in wine making.

The following equations describe how sulfur dioxide dissolves.

$$H_2O + SO_2 \rightleftharpoons HSO_3^- + H^+$$

$$HSO_3^- + H^+ \rightleftharpoons SO_3^{2-} + 2H^+$$

Which statement about these two reactions is correct?

A HSO_3^- acts as a base.
B SO_2 acts as an oxidising agent.
C SO_3^{2-} acts as an acid.
D SO_3^{2-} acts as a reducing agent.

73. O/N 11/P11/Q10, O/N 11/P13/Q8

When gaseous iodine is heated with hydrogen at 450 °C, an equilibrium is established.

$$\underset{\text{colourless}}{H_2(g)} + \underset{\text{purple}}{I_2(g)} \rightleftharpoons \underset{\text{colourless}}{2HI(g)} \qquad \Delta H = +53\ kJ\ mol^{-1}$$

Which change of conditions will cause the purple colour of the equilibrium mixture to become paler?

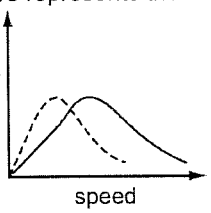
A decrease in pressure
B decrease in temperature
C increase in pressure
D increase in temperature

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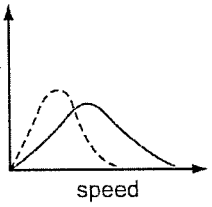
74. O/N 11/P11/Q11, O/N 11/P13/Q9, M/J 06/P1/Q12

Which solid-line curve most accurately represents the distribution of molecular speeds in a gas at 500 K if the dotted-line curve represents the corresponding distribution for the same gas at 300 K?

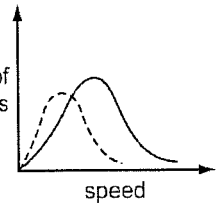
A



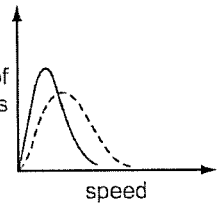
C



B



D



75. M/J 11/P12/Q4

The esterification reaction

$$\text{ethanol + ethanoic acid} \rightleftharpoons \text{ethyl ethanoate + water}$$

is an equilibrium. The forward reaction is exothermic.
How can the value of the equilibrium constant K_c be increased?

A by adding a little concentrated sulfuric acid as a catalyst
B by increasing the initial concentration of ethanol
C by lowering the temperature
D by raising the temperature

76. M/J 11/P12/Q5

Ammonia is manufactured on a large scale by the Haber process.
In a particular plant, conditions of 400 °C and 250 atm in the presence of an iron catalyst are used.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H^{\ominus} = -92 \text{ kJ mol}^{-1}$$

What could contribute most to increasing the equilibrium yield of ammonia?

A adding more catalyst
B increasing the pressure to 400 atm
C increasing the temperature to 1000 °C
D using air rather than nitrogen

77. M/J 11/P11/Q7, M/J 11/P13/Q5

In the last century the Haber process was sometimes run at pressures of 1000 atm and higher. Now it is commonly run at pressures below 100 atm.
What is the reason for this change?

A An iron catalyst is used.
B Maintaining the higher pressures is more expensive.
C The equilibrium yield of ammonia is increased at lower pressures.
D The rate of the reaction is increased at lower pressures.

78. O/N 10/P11/Q10, O/N 10/P13/Q10

The value of the equilibrium constant, K_c, for the reaction to form ethyl ethanoate from ethanol and ethanoic acid is 4.0 at 60 °C.

$$C_2H_5OH + CH_3CO_2H \rightleftharpoons CH_3CO_2C_2H_5 + H_2O$$

When 1.0 mol of ethanol and 1.0 mol of ethanoic acid are allowed to reach equilibrium at 60 °C, what is the number of moles of ethyl ethanoate formed?

A $\frac{1}{3}$ **B** $\frac{2}{3}$ **C** $\frac{1}{4}$ **D** $\frac{3}{4}$

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79. O/N 10/P12/Q11

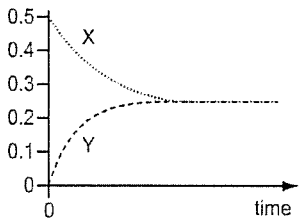
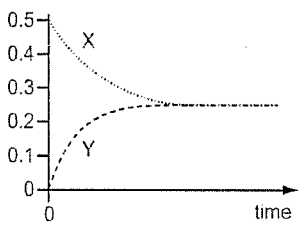
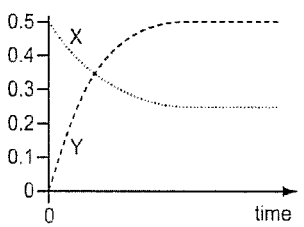
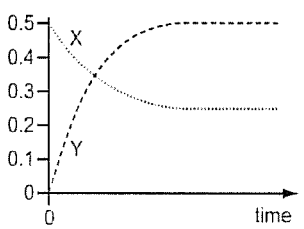
A dimer, X, is stable when solid but a dynamic equilibrium is set up in solution.

$$X(aq) \rightleftharpoons 2Y(aq)$$

A solution of X has an initial concentration of 0.50 mol dm^{-3}. When equilibrium has been reached [X(aq)] has fallen to 0.25 mol dm^{-3}.

The changes in [X(aq)] and [Y(aq)] are plotted against time until equilibrium is reached. The value of K_c is then calculated.

Which graph and value for K_c are correct?

	graph	K_c / mol dm^{-3}
A		1
B		2
C		1
D		2

80. O/N 10/P12/Q9

The following equilibrium is set up in a mixture of concentrated nitric and sulfuric acids.

$$HNO_3 + H_2SO_4 \rightleftharpoons H_2NO_3^+ + HSO_4^-$$

Which row correctly describes the behaviour of each substance in the equilibrium mixture?

	HNO_3	H_2SO_4	$H_2NO_3^+$	HSO_4^-
A	acid	acid	base	base
B	acid	base	base	acid
C	base	acid	acid	base
D	base	acid	base	acid

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81. M/J 10/P12/Q10, M/J 10/P11/Q7, M/J 10/P13/Q8

The Haber process for the manufacture of ammonia is represented by the following equation.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92 \text{ kJ mol}^{-1}$$

Which statement is correct about this reaction when the temperature is increased?

A Both forward and backward rates increase.

B The backward rate only increases.

C The forward rate only increases.

D There is no effect on the backward or forward rate.

82. M/J 10/P12/Q9, M/J 10/P11/Q10, M/J 10/P13/Q10

The table gives the concentrations and pH values of the aqueous solutions of two compounds, X and Y. Either compound could be an acid or a base.

	X	Y
concentration	2 mol dm^{-3}	2 mol dm^{-3}
pH	6	9

Student P concluded that X is a strong acid.
Student Q concluded that the extent of dissociation is lower in X(aq) than in Y(aq).
Which of the students are correct?

A both P and Q **B** neither P nor Q **C** P only **D** Q only

83. O/N 09/P12/Q16, O/N 09/P11/Q17

When sulfur trioxide is manufactured from sulfur dioxide and oxygen, using the Contact process, which condition affects the value of the equilibrium constant, K_c?

A adjusting the temperature

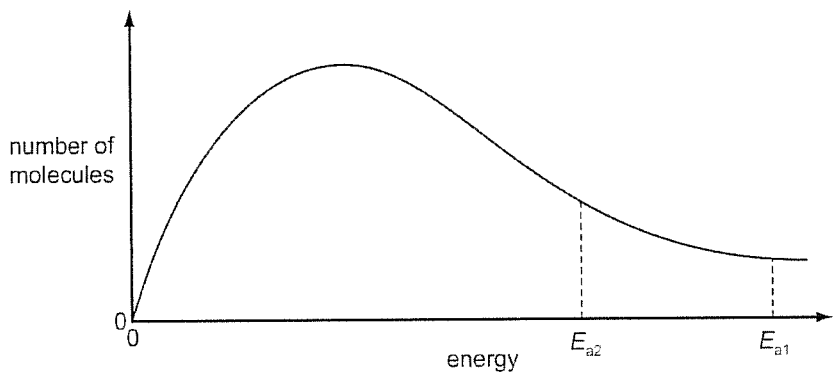
B adjusting the pressure

C using a catalyst

D removing SO_3 from the equilibrium mixture

84. M/J 09/P1/Q10

The diagram shows the Maxwell-Boltzmann energy distribution curve for molecules of a mixture of two gases at a given temperature. For a reaction to occur the molecules must collide together with sufficient energy.



E_a is the activation energy for the reaction between the gases. Of the two values shown, one is for a catalysed reaction, the other for an uncatalysed one.
Which pair of statements is correct when a catalyst is used?

A	E_{a1}	catalysed reaction fewer effective collisions	E_{a2}	uncatalysed reaction more effective collisions
B	E_{a1}	uncatalysed reaction fewer effective collisions	E_{a2}	catalysed reaction more effective collisions
C	E_{a1}	catalysed reaction more effective collisions	E_{a2}	uncatalysed reaction fewer effective collisions
D	E_{a1}	uncatalysed reaction more effective collisions	E_{a2}	catalysed reaction fewer effective collisions

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85. O/N 09/P12/Q7, O/N 09/P11/Q8

The equilibrium

$$N_2(g) + O_2(g) \rightleftharpoons 2NO(g) \quad \Delta H = +180 \text{ kJ mol}^{-1}$$

contributes to a series of reactions producing photochemical smog.
Which factors would affect the value of K_p of the above equilibrium?

	change in pressure	change in temperature	presence or absence of a catalyst
A	✓	✓	✗
B	✓	✗	✓
C	✗	✓	✓
D	✗	✓	✗

86. O/N 08/P1/Q11

Dinitrogen tetroxide dissociates into nitrogen dioxide on heating.

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

In an experiment the partial pressures of the gases at equilibrium were found to be NO_2, 0.33 atm; N_2O_4, 0.67 atm.
What is the numerical value of K_p at the temperature of the experiment?

A 0.16 **B** 0.49 **C** 0.65 **D** 2.03

87. O/N 08/P1/Q12

Crotonaldehyde, $CH_3CH=CHCHO$, can be obtained by oxidising butadiene, $CH_2=CHCH=CH_2$, using air or oxygen. One method is to pass a mixture of butadiene and oxygen through a hot aqueous solution of palladium(II) ions, $Pd^{2+}(aq)$, which catalyse the reaction.
Which statement is **not** correct about the action of the $Pd^{2+}(aq)$ ions?

A Changing the concentration of the $Pd^{2+}(aq)$ will have an effect on the rate of the reaction.
B $Pd^{2+}(aq)$ increases the energy of the reacting molecules.
C $Pd^{2+}(aq)$ lowers the activation energy for the reaction.
D When $Pd^{2+}(aq)$ is used, the reaction proceeds by a different route.

88. O/N 08/P1/Q10

For the equilibrium $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$, what will change the value of K_p?

A adding a catalyst **C** increasing the pressure
B adding more O_2 **D** increasing the temperature

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89. M/J 20/P11/Q34, O/N 07/P1/Q32

Carbon monoxide burns readily in oxygen to form carbon dioxide.
What can be deduced from this information?

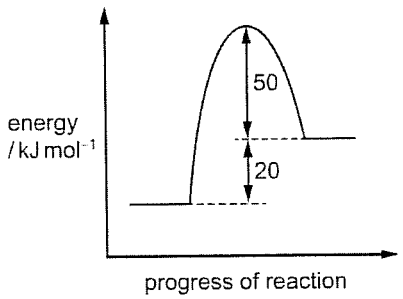
1 The +4 oxidation state of carbon is more stable than the +2 state.
2 The standard enthalpy change of formation of carbon dioxide is more negative than that of carbon monoxide.
3 The value of the equilibrium constant for the reaction, $2CO(g) + O_2(g) \rightleftharpoons 2CO_2(g)$, is likely to be high.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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90. O/N 19/P12/Q34

The reaction pathway diagram for a reversible reaction is shown.



Which statements are correct?

1 The enthalpy change for the backward reaction is –20 kJ mol^{-1}.
2 The forward reaction is endothermic.
3 The activation energy for the forward reaction is +70 kJ mol^{-1}.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

91. M/J 19/P12/Q34

The manufacture of ammonia from nitrogen and hydrogen is an important industrial process.
Which of the following would leave the equilibrium constant, K_p, for the formation of ammonia unchanged?

1 addition of an iron catalyst
2 addition of ammonia
3 an increase in pressure

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

92. O/N 18/P12/Q34

The equation represents an equilibrium.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \qquad \Delta H = -900 \text{ kJ mol}^{-1}$$

What would increase the concentration of NO at equilibrium?

1 a reduction in the reaction temperature
2 the use of a suitable catalyst
3 an increase in the total pressure

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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93. M/J 18/P12/Q34

The temperature of a reversible gas phase reaction is increased.
Which statements are always correct?

1 More product is present at equilibrium.
2 The average speed of the particles increases.
3 There are more successful collisions per unit time.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

94. M/J 18/P11/Q34

Which statements are correct when a reversible reaction is at equilibrium?

1 All species are at equal concentration.
2 The concentrations of all species remain constant.
3 The rate of the forward reaction equals the rate of the reverse reaction.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

95. M/J 16/P12/Q33

In this question, all gases can be assumed to behave ideally.
A chemist heats a mixture of nitrogen and oxygen gases in a sealed container at a constant temperature until the mixture reaches a dynamic equilibrium containing $N_2(g)$, $O_2(g)$ and NO(g).

$$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$$

The chemist repeats the experiment at the same temperature using the same initial amounts of $N_2(g)$ and $O_2(g)$, but at a much higher pressure.
Which statements about the second experiment at higher pressure are correct?

1 At higher pressure, there are more particles per unit volume.
2 The composition of the equilibrium mixture does not change.
3 There are more collisions per second so equilibrium is reached faster.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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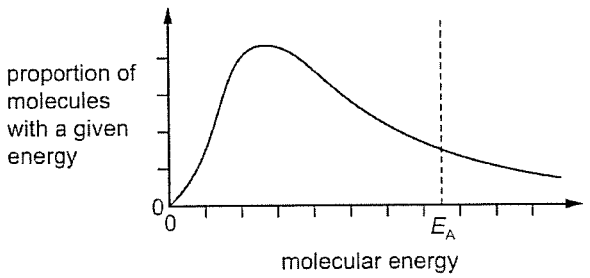
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96. M/J 16/P11/Q37

The equation shows a gas phase reaction.

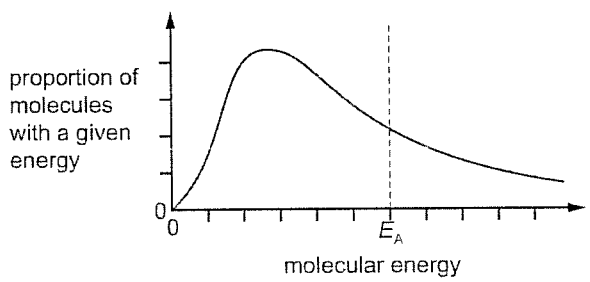
$$X(g) \rightarrow 2Y(g)$$

The diagram shows the Boltzmann distribution of a fixed mass of X(g) at temperature T in the absence of a catalyst. The line E_A indicates the activation energy.

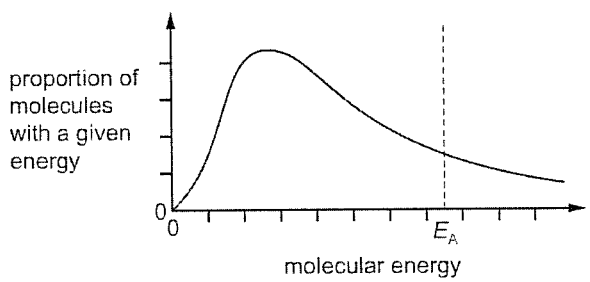


Which diagrams correctly show the effect of the following changes made separately and independently?

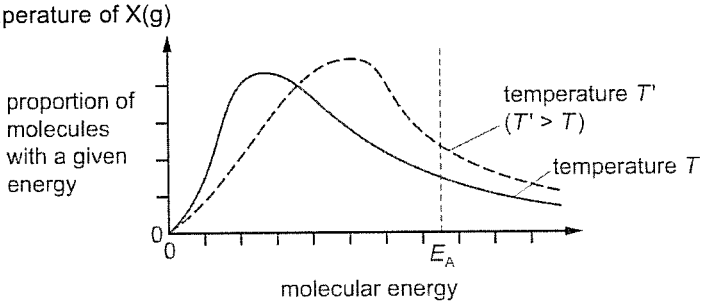
1 adding a catalyst



2 increasing the pressure of X(g)



3 increasing the temperature of X(g)



A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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97. M/J 14/P11/Q34

The Brønsted-Lowry theory describes acid and base character.
When concentrated sulfuric acid and concentrated nitric acid are mixed, the following reaction occur.

$$H_2SO_4 + HNO_3 \rightleftharpoons HSO_4^- + H_2NO_3^+$$

$$H_2NO_3^+ \rightleftharpoons H_2O + NO_2^+$$

$$H_2O + H_2SO4 \rightleftharpoons HSO_4^- + H_3O^+$$

Which species are bases in these reactions?
1 HSO_4^-
2 HNO_3
3 NO_2^+

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

98. O/N 13/P12/Q33, O/N 13/P11/Q33

What are necessary properties of a dynamic equilibrium?
1 Equal amounts of reactants and products are present.
2 Concentrations of reactants and products remain constant.
3 The rate of the forward reaction is the same as the rate of the reverse reaction.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

99. O/N 13/P12/Q34, O/N 13/P11/Q34

If N_2O_4 gas is placed in a sealed vessel the following equilibrium is established.

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

The forward reaction is endothermic.
What happens when the temperature is increased?
1 The equilibrium constant increases.
2 The partial pressure of NO_2 increases.
3 The activation energy is unchanged.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

100. M/J 11/P11/Q31, M/J 11/P13/Q33

Which statements are correct in terms of the Brønsted-Lowry theory of acids and bases?
1 Water can act as either an acid or a base.
2 Sulfuric acid, H_2SO_4, does not behave as an acid when dissolved in ethanol, C_2H_5OH.
3 The ammonium ion acts as a base when dissolved in liquid ammonia.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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101. O/N 09/P12/Q32, O/N 09/P11/Q33

Which equilibriam, in which all species are gaseous, would have equilibrium constants, K_p, with no units?

1 sulfur dioxide and oxygen in equilibrium with sulfur trioxide
2 hydrogen and iodine in equilibrium with hydrogen iodide
3 carbon monoxide and steam in equilibrium with carbon dioxide and hydrogen

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

102. O/N 10/P11/Q31, O/N 10/P13/Q32

Ethanol is manufactured by reacting ethene gas and steam in the presence of phosphoric(V) acid.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \qquad \Delta H = -45 kJ\ mol^{-1}$$

The reaction is carried out at 570 K and 60 atm.
What would be the consequences of carrying out the reaction at the same temperature but at a pressure of 200 atm?

1 The manufacturing costs would increase.
2 The maximum yield at equilibrium would be higher.
3 The reaction would proceed at a faster rate.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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7.2: Multiple Topics

1. M/J 20/P12/Q15

Ammonium carbonate is a crystalline solid. On gentle warming a reaction occurs, forming ammonia as one product.

How are the carbonate ions behaving during this reaction?

A Brønsted-Lowry acid
B Brønsted-Lowry base
C oxidising agent
D reducing agent

2. M/J 20/P13/Q5

Nitrogen reacts with oxygen to form nitrogen monoxide, NO, and nitrogen dioxide, NO_2. Nitrogen dioxide reacts with water and with hydroxide ions.

$$N_2(g) + O_2(g) \rightarrow 2NO(g)$$
$$2NO(g) + O2(g) \rightarrow 2NO_2(g)$$
$$2NO_2(g) + H2O(l) \rightarrow HNO_2(aq) + H^+(aq) + NO_3^-(aq)$$
$$2NO_2(g) + 2OH^-(aq) \rightarrow NO_2^-(aq) + NO_3^-(aq) + H_2O(l)$$

What can be deduced using only the information from these equations?

A HNO_2 is a strong acid.
B HNO_3 is a weak acid.
C NO_2 is a neutral gas.
D NO is a reducing agent.

3. M/J 20/P13/Q6

Which solution has the lowest pH value?

A 0.01 mol dm^{-3} butanoic acid
B 0.01 mol dm^{-3} ethanoic acid
C 0.01 mol dm^{-3} hydrochloric acid
D 0.01 mol dm^{-3} sualfuric acid

4. MAR 20/P12/Q15

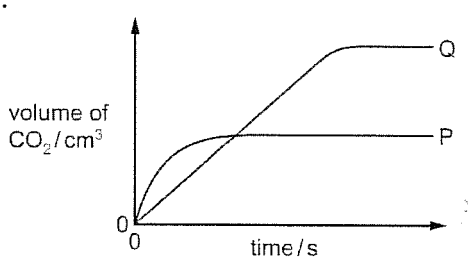
Solid ammonium nitrate is put into a test-tube and solution X is added to it. The resulting mixture is warmed and the gas given off is tested with damp red litmus paper. The litmus paper changes colour from red to blue.

What could be the identity of X and its role in the reaction?

	identity of X	role of X
A	NaOH(aq)	proton donor
B	NaOH(aq)	proton acceptor
C	HCl(aq)	proton donor
D	HCl(aq)	proton acceptor

5. M/J 19/P13/Q11

The volume of carbon dioxide collected by reacting 0.100 mol of magnesium carbonate with 50.0 cm^3 of 1.00 mol dm^{-3} sulfuric acid is measured against time. The volume produced is plotted against time and the line labelled P on the graph is obtained.



The experiment is repeated using 0.100 mol of the same magnesium carbonate, and a different sample of acid. All other conditions remain the same. Plotting these results gives the line labelled Q.

Which sample of acid could give the line labelled Q?

A 100 cm^3 of 0.500 mol dm^{-3} sulfuric acid
B 100 cm^3 of 1.00 mol dm^{-3} sulfuric acid
C 200 cm^3 of 0.500 mol dm^{-3} hydrochloric acid
D 200 cm^3 of 1.00 mol dm^{-3} hydrochloric acid

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6. O/N 18/P11/Q18, O/N 18/P13/Q18, O/N 13/P12/Q17, O/N 13/P11/Q17, O/N 08/P1/Q19, M/J 02/P1/Q17

Which statement explains the observation that magnesium hydroxide dissolves in aqueous ammonium chloride, but not in aqueous sodium chloride?

A The ionic radius of the NH_4^+ ion is similar to that of Mg^{2+} but not that of Na^+.

B NH_4Cl dissociates less fully than $NaCl$.

C The Na^+ and Mg^{2+} ions have the same number of electrons.

D The NH_4^+ ion can donate a proton.

7. O/N 16/P12/Q10

Nitrogen reacts with hydrogen to produce ammonia.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

A mixture of 2.00 mol of nitrogen, 6.00 mol of hydrogen and 2.40 mol of ammonia is allowed to reach equilibrium in a sealed vessel of volume 1 dm^3. It was found that 2.32 mol of nitrogen were present in the equilibrium mixture.

What is the value of K_c?

A $\dfrac{(1.76)^2}{(2.32)(6.69)^3}$ **B** $\dfrac{(1.76)^2}{(2.32)(6.32)^3}$ **C** $\dfrac{(2.08)^2}{(2.32)(6.32)^3}$ **D** $\dfrac{(2.40)^2}{(2.32)(6.00)^3}$

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8. O/N 17/P11/Q34, O/N 17/P13/Q34

The following reaction takes place in a suitable solvent.

$$Na^+NH_2^- + NH_4^+Cl^- \rightarrow Na^+Cl^- + 2NH_3$$

Which statements explain why this reaction should be classified as a Brønsted-Lowry acid-base reaction?

1 The ammonium ion acts as a proton donor.
2 Na^+Cl^- is a salt.
3 Ammonia is a nucleophile.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

9. MAR 17/P12/Q35

Three test-tubes, X, Y, and Z, each contain a small amount of water.

- A small amount of $NaCl$ is added to test-tube X.
- A small amount of $SiCl_4$ is added to test-tube Y.
- A small amount of $AlCl_3$ is added to test-tube Z.

After a short time, two drops of Universal Indicator solution are added to each test-tube.

Which observations are made?

1 The indicator added to test-tube X stays green.
2 The indicator added to test-tube Y turns red.
3 The indicator added to test-tube Z turns red.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

10. MAR 16/P12/Q33

Which statements about reversible reactions are correct?

1 An increase in concentration of a reactant always increases the concentration of the product.
2 An increase in temperature always increases the rate at which the equilibrium is stablished.
3 An increase in temperature always increases the concentration of the product at equilibrium.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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11. O/N 15/P12/Q34, M/J 12/P12/Q32

Ammonia and chlorine react in the gas phase.

$$8NH_3 + 3Cl_2 \rightleftharpoons N_2 + 6NH_4Cl$$

Which statements are correct?

1 Each nitrogen atom is oxidised.
2 Each chlorine atom is reduced.
3 Ammonia behaves as a base.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

12. M/J 14/P12/Q34

Sulfuric acid is a Brønsted-Lowry acid.
In which reactions is sulfuric acid behaving as an acid?

1 $H_2SO_4 + HNO_3 \rightarrow H2NO_3^+ + HSO_4^-$
2 $H_2SO_4 + CO_3^{2-} \rightarrow CO_2 + H_2O + SO_4^{2-}$
3 $H_2SO_4 + MgO \rightarrow MgSO_4 + H_2O$

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

13. M/J 12/P12/Q33

Concentrated sulfuric acid behaves as a strong acid when it reacts with water.

$$H_2SO_4(l) + aq \rightarrow H^+(aq) + HSO_4^-(aq)$$

The HSO_4^- ion formed behaves as a weak acid.

$$HSO_4^-(aq) \rightleftharpoons H^+(aq) + SO_4^{2-}(aq)$$

Which statements are true for 1.0 mol dm^{-3} sulfuric acid?

1 $[H^+(aq)]$ is high
2 $[SO_4^{2-}(aq)]$ is high
3 $[HSO_4^-(aq)] = [SO_4^{2-}(aq)]$

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

14. O/N 08/P1/Q32

Which of the following can act as a Bronsted-Lowry acid?

1 H_3O^+
2 NH_4^+
3 H_2O

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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Answers Sections

7.1						7.2	
1.	C	41.	C	81.	A	1.	B
2.	D	42.	D	82.	D	2.	D
3.	A	43.	C	83.	A	3.	D
4.	B	44.	A	84.	B	4.	B
5.	A	45.	D	85.	D	5.	D
6.	B	46.	C	86.	A	6.	D
7.	D	47.	C	87.	B	7.	A
8.	C	48.	B	88.	D	8.	D
9.	A	49.	A	89.	A	9.	A
10.	C	50.	B	90.	A	10.	B
11.	C	51.	C	91.	A	11.	C
12.	D	52.	A	92.	D	12.	A
13.	B	53.	A	93.	C	13.	D
14.	A	54.	B	94.	C	14.	A
15.	C	55.	B	95.	A		
16.	D	56.	C	96.	B		
17.	A	57.	A	97.	B		
18.	D	58.	A	98.	C		
19.	B	59.	A	99.	A		
20.	D	60.	B	100.	D		
21.	C	61.	B	101.	C		
22.	B	62.	C	102.	A		
23.	A	63.	A				
24.	D	64.	A				
25.	C	65.	C				
26.	D	66.	C				
27.	C	67.	D				
28.	C	68.	D				
29.	D	69.	B				
30.	A	70.	D				
31.	A	71.	B				
32.	C	72.	A				
33.	B	73.	D				
34.	D	74.	C				
35.	D	75.	C				
36.	A	76.	B				
37.	A	77.	B				
38.	D	78.	B				
39.	C	79.	C				
40.	D	80.	C				

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Unit 8

REACTION KINETICS

A Level
Chemistry Paper 1
Classified/Topical MCQ's
Article Number: 231

Editorial Board

Syllabus

8.1 Simple rate equations; orders of reaction; rate constants
8.2 Effect of temperature on reaction rates and rate constant; the concept of activation energy
8.3 Homogeneous and heterogeneous catalysis including enzymes
8.4 Multiple topics

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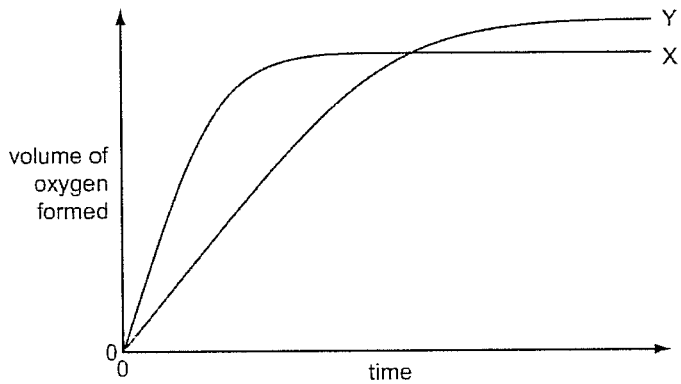
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Unit 8: Reaction kinetics

8.1: Simple rate equations; orders of reaction; rate constants

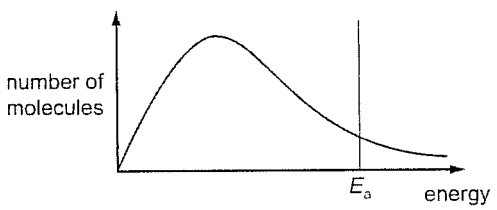
1. **M/J 14/P12/Q5, M/J 11/P11/Q6, M/J 11/P13/Q6, M/J 07/P1/Q11**
In the diagram, curve X was obtained by observing the decomposition of 100 cm^3 of 1.0 mol dm^{-3} hydrogen peroxide, catalysed by manganese(IV) oxide.



Which alteration to the original experimental conditions would produce curve Y?

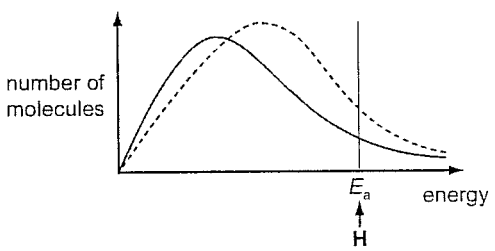
A adding more manganese(IV) oxide
B adding some 0.1 mol dm^{-3} hydrogen peroxide
C adding water
D raising the temperature

2. **M/J 13/P13/Q4**
The diagram represents, for a given temperature, the Boltzmann distribution of the kinetic energies of the molecules in a mixture of two gases that will react together. The activation energy for the reaction, E_a, is marked.

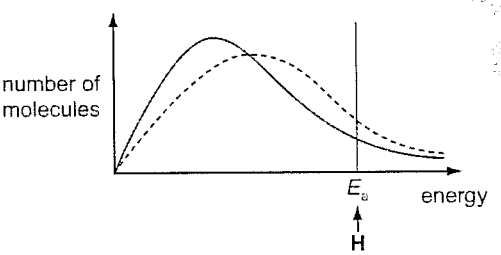


The dotted curves below show the Boltzmann distribution for the same reaction at a higher temperature. On these diagrams, **H** represents the activation energy at the higher temperature.
Which diagram is correct?

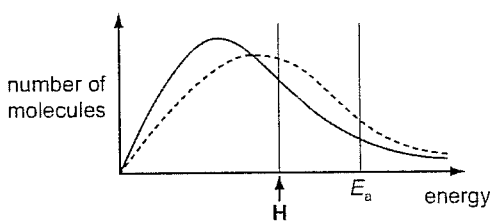
A



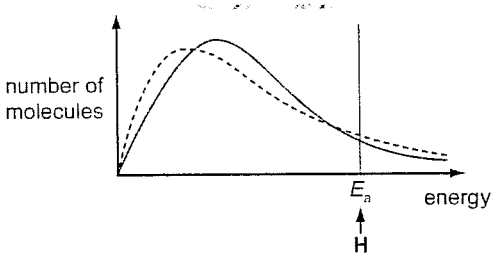
C



B



D



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3. O/N 13/P13/Q5, M/J 10/P12/Q13, M/J 10/P13/Q13, M/J 10/P11/Q12

$Na_2S_2O_3$ reacts with dilute HCl to give a pale yellow precipitate. If 1 cm^3 of 0.1 mol dm^{-3} HCl is added to 10 cm^3 of 0.02 mol dm^{-3} $Na_2S_2O_3$ the precipitate forms slowly.

If the experiment is repeated with 1 cm^3 of 0.1 mol dm^{-3} HCl and 10 cm^3 of 0.05 mol dm^{-3} $Na_2S_2O_3$ the precipitate forms more quickly.

Why is this?

A The activation energy of the reaction is lower when 0.05 mol dm^{-3} $Na_2S_2O_3$ is used.

B The reaction proceeds by a different pathway when 0.05 mol dm^{-3} $Na_2S_2O_3$ is used.

C The collisions between reactant particles are more violent when 0.05 mol dm^{-3} $Na_2S_2O_3$ is used.

D The reactant particles collide more frequently when 0.05 mol dm^{-3} $Na_2S_2O_3$ is used.

Valid till October/November 2021 Exams

4. MAR 16/P12/Q34

A chemist puts a sample of dilute aqueous hydrochloric acid into beaker 1. She adds a sample of zinc and measures the rate of production of hydrogen gas.

She then puts a different sample of dilute aqueous hydrochloric acid into beaker 2. She adds a different sample of zinc and measures the rate of production of hydrogen gas.

The rate of the reaction in beaker 2 is greater than the rate of the reaction in beaker 1.

Which factors **could** help to explain this observation?

1 The reaction in beaker 1 has a higher activation energy than the reaction in beaker 2.
2 The zinc in beaker 1 is in larger pieces than the zinc in beaker 2.
3 The acid in beaker 1 is at a lower concentration than the acid in beaker 2.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

5. O/N 15/P11/Q34, O/N 15/P13/Q34

Which statements correctly describe an effect of a rise in temperature on a gas-phase reaction?

1 More particles now have energies greater than the activation energy.
2 The energy distribution profile changes with more particles having the most probable energy.
3 The activation energy of the reaction is decreased.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

6. M/J 15/P11/Q34

Why does raising the pressure of a fixed mass of gaseous reactants at a constant temperature cause an increase in the rate of reaction?

1 More collisions occur per second when the pressure is increased.
2 More molecules have energy greater than the activation energy at the higher pressure.
3 Raising the pressure lowers the activation energy.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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7. M/J 14/P12/Q32

The reaction

$$E + F \rightleftharpoons G + H$$

is catalysed by platinum.

Which statements about the properties of the catalyst are correct?

1 The catalyst has no effect on the enthalpy change of the reaction.
2 The catalyst increases the rate of the reverse reaction.
3 The catalyst increases the average kinetic energy of the reacting particles.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

8. M/J 11/P12/Q31

Solid calcium carbonate is added to 100 cm^3 of dilute hydrochloric acid and the rate of the reaction is measured. 100 cm^3 of distilled water is then added to a second 100 cm^3 portion of the acid, and the experiment repeated under the same conditions.

Why does the addition of water decrease the rate of the reaction?

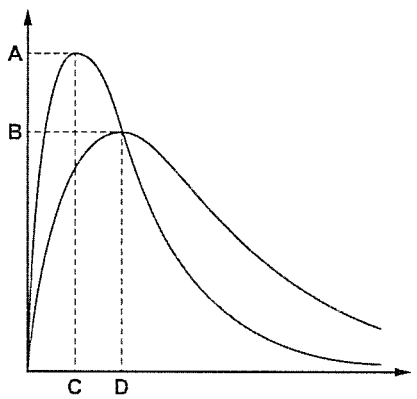
1 Adding water reduces the frequency of collisions between reactant molecules.
2 Adding water reduces the proportion of effective collisions between reactant molecules.
3 Adding water reduces the proportion of reactant molecules possessing the activation energy.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

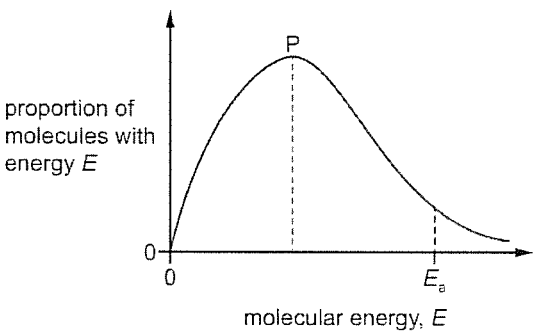
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8.2: Effect of temperature on reaction rates and rate constants; the concept of activation energy

1. **M/J 20/P11/Q6**
The diagram shows the Boltzmann energy distribution curves for molecules of a sample of a gas at two different temperatures.
Which letter on the axes represents the most probable energy for molecules of the same sample of gas at the lower temperature?



2. **O/N 19/P11/Q1, O/N 19/P13/Q1**
The diagram shows the Boltzmann distribution of energies in a gas. The gas undergoes a reaction with an activation energy, E_a. The peak of the distribution is labelled P.



If the same reaction is carried out in the presence of a catalyst, which statement is correct?
A The peak P is at a lower height and the position of E_a moves to the left.
B The peak P is at a lower height and the position of E_a moves to the right.
C The peak P remains at the same height and the position of E_a moves to the left.
D The peak P remains at the same height and the position of E_a moves to the right.

3. **M/J 19/P11/Q1**
The temperature of a sample of an inert gas is increased.
What effect does this have on the number of molecules with the most probable energy and on the number of molecules with high energy?

	number of molecules with the most probable energy	number of molecules with high energy
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

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4. O/N 18/P12/Q10

In a chemical system the particles involved have a range of energies. This can be shown on a graph called the Boltzmann distribution.

Which statement correctly explains the effect of a catalyst on the particles in a chemical system?

A A catalyst enables particles with a lower energy to collide successfully.

B A catalyst increases the number of particles with higher energies.

C A catalyst increases the number of particles with the most probable energy value.

D A catalyst increases the value of the most probable particle energy.

5. M/J 18/P12/Q11

A chemical company used a catalyst in a chemical process. The company has now decided not to use the catalyst but to increase the temperature so that the rate of the reaction is the same asit was when the catalyst was used.

Which statement about the new conditions compared to the original conditions is correct?

A The activation energy has been decreased.

B The activation energy has been increased.

C There are fewer successful collisions per unit time.

D There are more successful collisions per unit time.

6. O/N 17/P12/Q10

A large excess of marble chips was reacted with 25 cm^3 of 1.0 mol dm^{-3} hydrochloric acid at 40 °C.

How will the result be different when the reaction is repeated with 60 cm^3 of 0.5 mol dm^{-3} hydrochloric acid at 40 °C?

A The reaction is faster and less of the products are made.

B The reaction is faster and more of the products are made.

C The reaction is slower and less of the products are made.

D The reaction is slower and more of the products are made.

7. O/N 17/P12/Q11

Which change alters the activation energy of a given reaction?

A adding a suitable catalyst

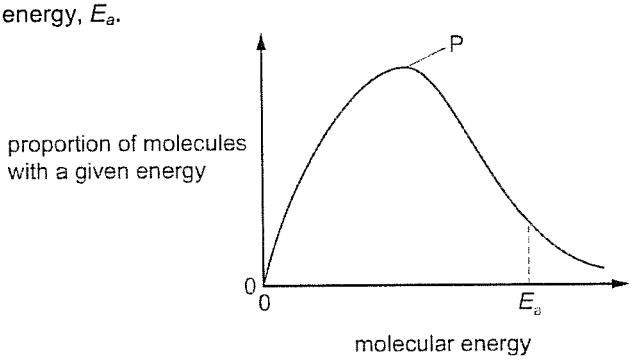
B changing the particle size of the reactants

C changing the pressure at which the reaction is carried out

D changing the temperature at which the reaction is carried out

8. M/J 16/P12/Q1

The diagram shows the Boltzmann distribution of energies in 1 mole of a gas. The gas can take part in a reaction with an activation energy, E_a.



Which statement correctly describes the effect of an increase in temperature?

A Peak P will be higher and fewer molecules will have energy > E_a.

B Peak P will be higher and more molecules will have energy > E_a.

C Peak P will be lower and fewer molecules will have energy > E_a.

D Peak P will be lower and more molecules will have energy > E_a.

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9. O/N 17/P11/Q7, O/N 17/P13/Q7

Iodine and propanone react according to the following equation.

$$I_2(aq) + CH_3COCH_3(aq) \rightarrow CH_3COCH_2I(aq) + HI(aq)$$

If the concentration of propanone is increased, keeping the total reaction volume constant, the rate of the reaction also increases.

What could be the reason for this?

A A greater proportion of collisions is successful at the higher concentration.

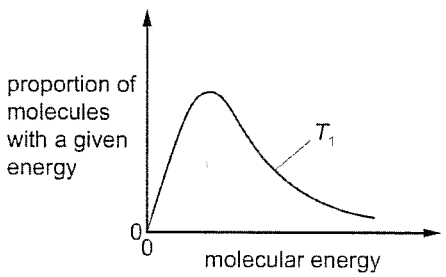
B The particles are further apart at the higher concentration.

C The particles have more energy at the higher concentration.

D There are more collisions between reactant particles per second at the higher concentration.

10. O/N 16/P12/Q1

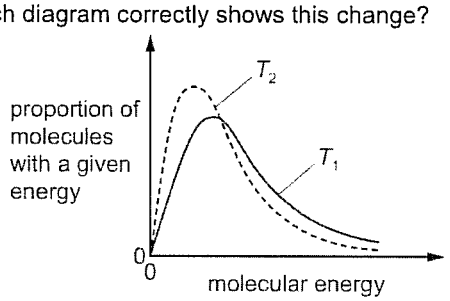
The molecules of a gas at a constant temperature, T_1, have the distribution of molecular energies shown in the diagram.



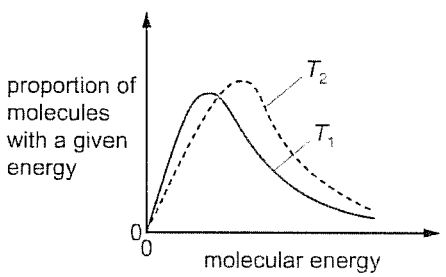
When the temperature is increased to T_2, the distribution of molecular energies changes.

Which diagram correctly shows this change?

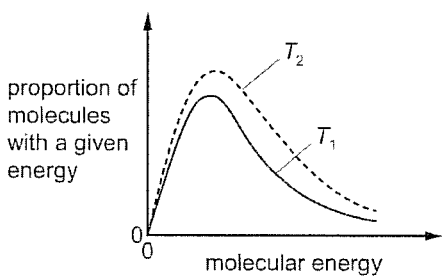
A



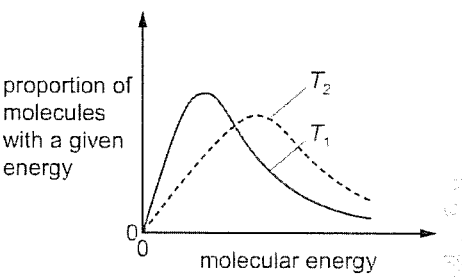
C



B



D



11. O/N 15/P12/Q11

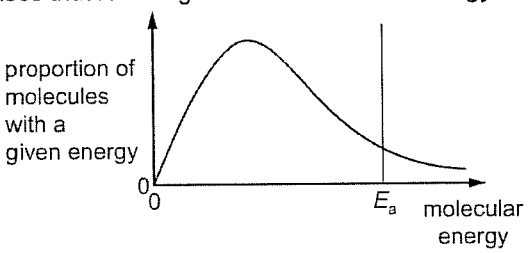
Which row correctly describes what happens when the temperature of a chemical reaction is **decreased**?

	activation energy (E_a)	number of successful collisions
A	decreases	decreases
B	decreases	increases
C	remains the same	decreases
D	remains the same	increases

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12. O/N 16/P11/Q1, O/N 16/P13/Q1

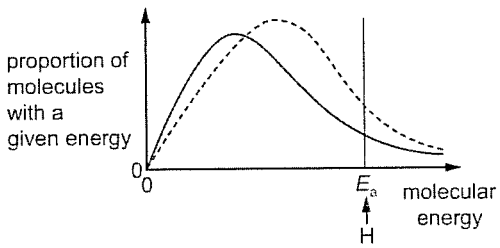
The diagram represents, for a given temperature, the Boltzmann distribution of the kinetic energies of the molecules in a mixture of two gases that react together. The activation energy for the reaction, E_a, is marked.



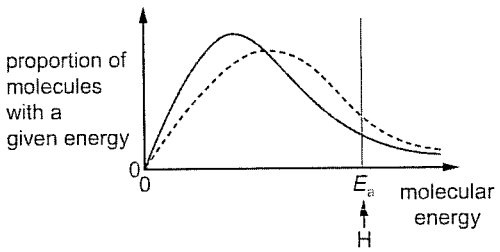
The dotted curves below show the Boltzmann distribution for the same reaction at a higher temperature. On these diagrams, H represents the activation energy at the higher temperature.

Which diagram is correct?

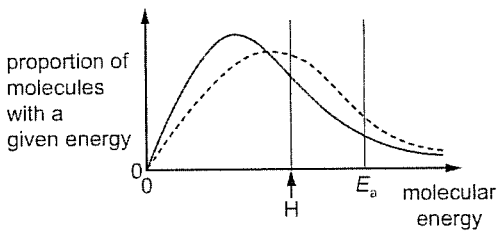
A



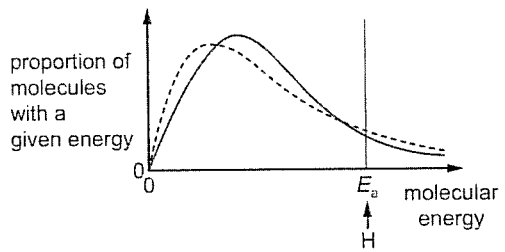
C



B

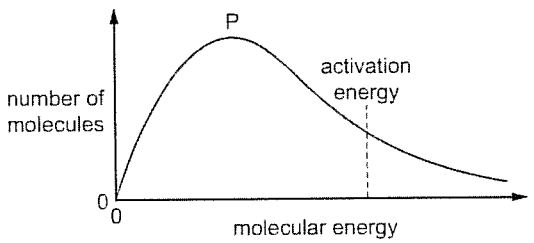


D



13. M/J 15/P11/Q1

The diagram shows a Boltzmann distribution of molecular energies for a gaseous mixture. The distribution has a peak, labelled P on the diagram.



What happens when an effective catalyst is added to the mixture?

A The height of the peak decreases and the activation energy moves to the right.

B The height of the peak decreases and the activation energy moves to the left.

C The height of the peak remains the same and the activation energy moves to the right.

D The height of the peak remains the same and the activation energy moves to the left.

14. M/J 14/P12/Q26

Compound X, C_4H_8O, produces an orange precipitate when it is reacted with 2,4-dinitrophenylhydrazine reagent. Compound X produces a carboxylic acid when heated under reflux with an acidified solution of potassium dichromate(VI).

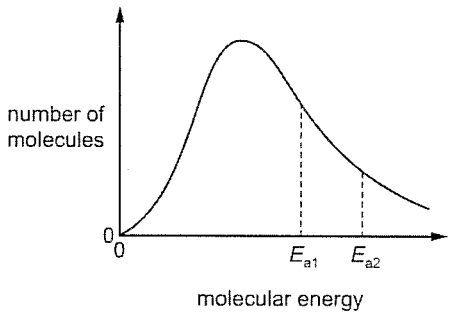
What could be compound X?

A butanal **B** butanone **C** 2-methylbutanal **D** 4-hydroxybut-1-ene

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15. M/J 15/P13/Q1

The diagram shows the Boltzmann energy distribution curve for molecules of a mixture of two gases at a given temperature. For a reaction to occur the molecules must collide together with sufficient energy.



E_a is used to represent the activation energy for the reaction between the gases. Of the two values shown, one is the activation energy for a catalysed reaction, the other for an uncatalysed reaction.
Which statement about E_{a1} is correct?

A E_{a1} corresponds to a catalysed reaction with fewer effective collisions than the uncatalysed reaction.

B E_{a1} corresponds to an uncatalysed reaction with fewer effective collisions than the catalysed reaction.

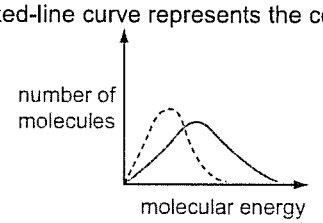
C E_{a1} corresponds to a catalysed reaction with a greater number of effective collisions than the uncatalysed reaction.

D E_{a1} corresponds to an uncatalysed reaction with a greater number of effective collisions than the catalysed reaction.

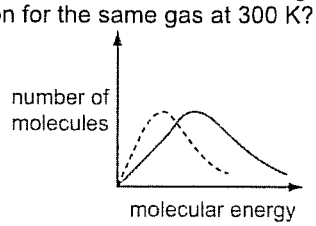
16. O/N 14/P12/Q1, O/N 14/P11/Q1

Which solid-line curve most accurately represents the distribution of molecular energies in a gas at 500 K if the dotted-line curve represents the corresponding distribution for the same gas at 300 K?

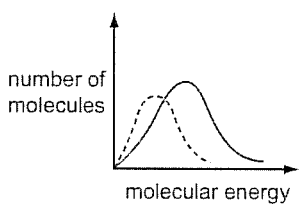
A



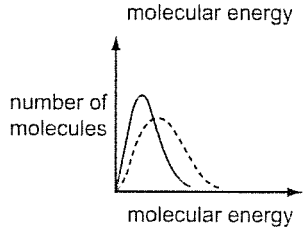
C



B

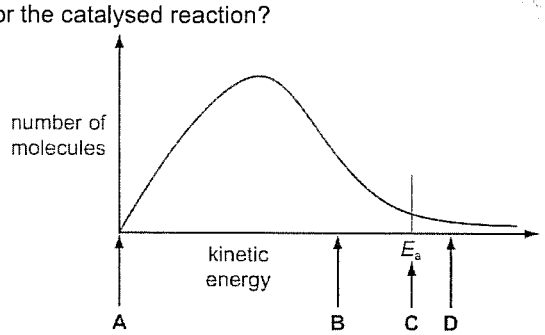


D



17. O/N 14/P13/Q1

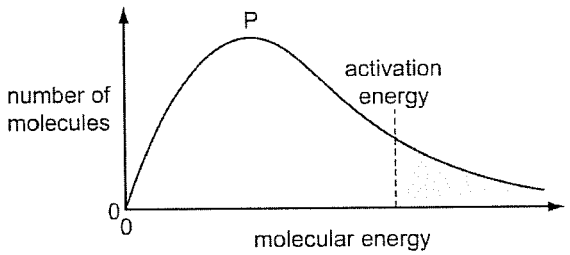
The diagram below represents, for a given temperature, the Boltzmann distribution of the kinetic energy of the molecules in a mixture of two gases that react slowly together.
The activation energy for the reaction, E_a, is marked.
When the reaction is catalysed, the rate of reaction increases a little.
What will be the position of E_a for the catalysed reaction?



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18. M/J 14/P12/Q1

The diagram shows a Boltzmann distribution of molecular energies for a gaseous mixture. The distribution has a peak, labelled P on the diagram.



What happens when the temperature of the mixture increases?

A The height of the peak, P, decreases and the activation energy moves to the left.

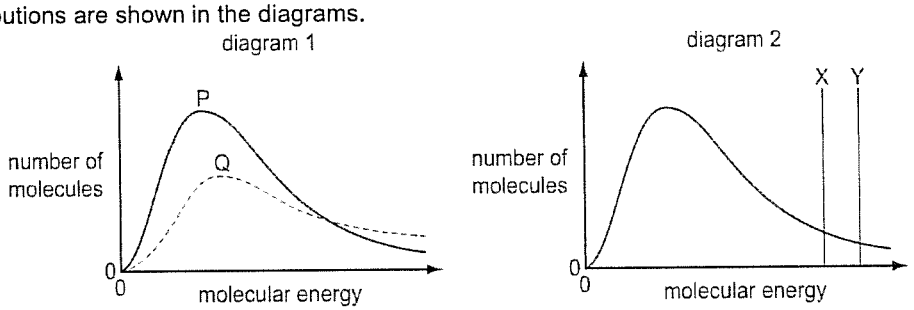
B The height of the peak, P, decreases and the activation energy moves to the right.

C The height of the peak, P, decreases and the activation energy does not change.

D The height of the peak, P, increases and the activation energy moves to the left.

19. M/J 14/P11/Q11

Boltzmann distributions are shown in the diagrams.



In diagram 1, one curve, P or Q, corresponds to a temperature higher than that of the other curve.
In diagram 2, one line, X or Y, corresponds to the activation energy in the presence of a catalyst and the other line corresponds to the activation energy of the same reaction in the absence of a catalyst.
Which combination gives the correct curve and line?

	higher temperature	presence of catalyst
A	P	X
B	P	Y
C	Q	X
D	Q	Y

20. M/J 13/P11/Q8

Why does the rate of a gaseous reaction increase when the pressure is increased at a constant temperature?

A More particles have energy that exceeds the activation energy.

B The particles have more space in which to move.

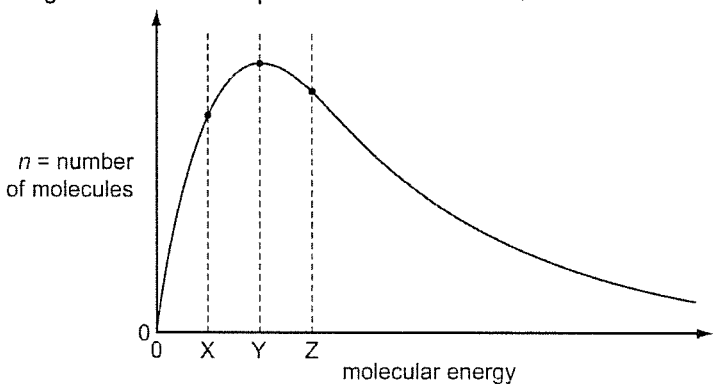
C The particles move faster.

D There are more frequent collisions between particles.

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21. M/J 14/P13/Q1

The Boltzmann distribution for a gas at constant temperature is shown below.



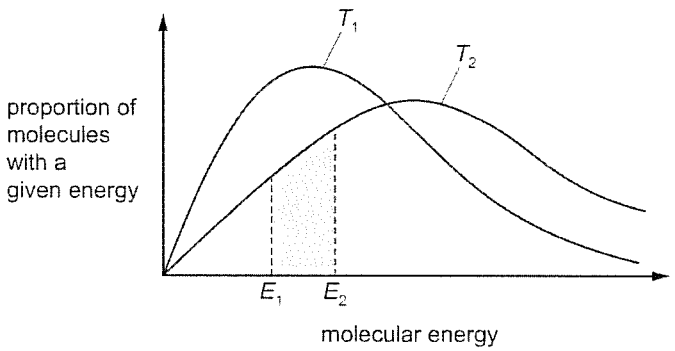
If the temperature of the gas is **reduced** by 10 °C the graph changes shape.
What happens to the values of n for the molecular energies X, Y and Z ?

	X	Y	Z
A	higher	lower	higher
B	higher	lower	lower
C	lower	higher	lower
D	lower	lower	lower

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22. M/J 19/P13/Q34, M/J 16/P13/Q33

The diagram shows the Boltzmann distribution of molecular energies in one mole of a gas at two temperatures, T_1 and T_2.



Which statements are correct?

1 The shaded area represents the proportion of molecules with energies between E_1 and E_2 at temperature T_2.
2 No particles have zero energy at either temperature.
3 T_2 is a lower temperature than T_1.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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23. M/J 20/P12/Q33

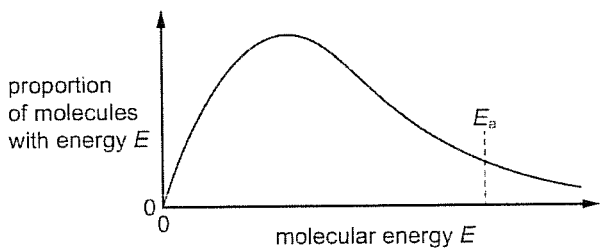
Which factors can lead to an increase in the rate of a reaction?

1 a lower activation energy
2 an increase in temperature
3 an increase in the concentration of a reactant

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

24. M/J 17/P12/Q11

The Boltzmann distribution for the hydrogenation of an alkene at a particular temperature in the absence of a catalyst is shown.



Which row correctly describes the effects of adding nickel to the reaction vessel?

	the shape of the Boltzmann distribution	activation energy, E_a
A	changes	decreases
B	changes	increases
C	does not change	decreases
D	does not change	increases

25. M/J 17/P13/Q34

A student carried out two experiments using MnO_2 as a catalyst to decompose hydrogen peroxide. The equation for this reaction is shown.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

The student's results are recorded in the table.

	mass MnO_2	conditions	vol H_2O_2	final vol O_2	time taken
experiment 1	0.25 g	room conditions	10.0 cm^3	480 cm^3	200 s
experiment 2	0.25 g	room conditions	10.0 cm^3	480 cm^3	500 s

Which statements are correct?

1 The activation energy was the same for both experiments.
2 The concentration of the hydrogen peroxide solution used was 4.0 mol dm^{-3}.
3 The MnO_2 used in experiment 1 was in larger pieces than the MnO_2 used in experiment 2.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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26. M/J 14/P11/Q33

R and S react together.

$$R + S \rightleftharpoons T$$

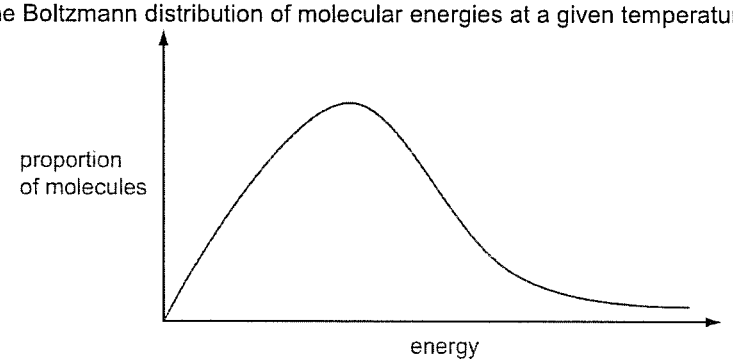
Which factors affect the rate of the forward reaction?

1 the activation energy of the reaction
2 the enthalpy change of the reaction
3 the equilibrium constant of the reaction

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

27. O/N 13/P13/Q32, O/N 10/P11/Q32, O/N 10/P13/Q33

The diagram represents the Boltzmann distribution of molecular energies at a given temperature.



Which of the factors that affect the rate of a reaction can be explained using such a Boltzmann distribution?

1 increasing the concentration of reactants
2 increasing the temperature
3 the addition of a catalyst

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

28. O/N 09/P12/Q33, O/N 09/P11/Q34

Why does a mixture of hydrogen gas and bromine gas react together faster at a temperature of 500 K than it does at a temperature of 400 K?

1 A higher proportion of effective collisions occurs at 500 K.
2 Hydrogen molecules and bromine molecules collide more frequently at 500 K.
3 The activation energy of the reaction is lower at 500 K.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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29. O/N 08/P1/Q33

Under given conditions, what governs the rate of a forward reaction?

1 the activation energy of the reaction
2 the enthalpy change of the reaction
3 the equilibrium constant of the reaction

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

30. O/N 08/P1/Q36

Which statements about the Haber process for the industrial production of ammonia are correct?

1 The equilibrium constant K_p increases with pressure.
2 As the temperature increases, the equilibrium constant for the forward reaction becomes smaller.
3 The process is usually carried out at between 450 °C and 550 °C at a pressure of at least 150 atm.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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8.3: Homogeneous and heterogeneous catalysts including enzymes

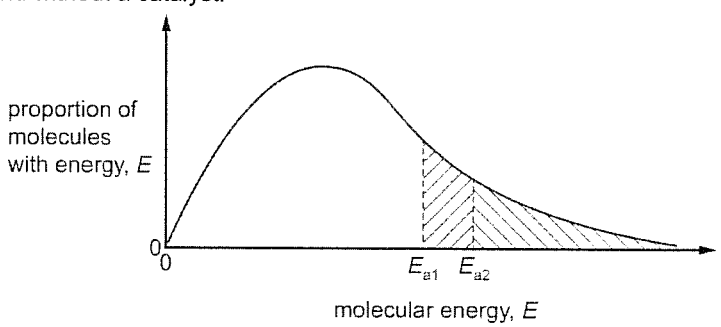
1. M/J 20/P13/Q16

Nitrogen oxides are removed from the exhaust gases of internal combustion engines by the action of acatalyst in a catalytic converter.
Which row is correct?

	change in oxidation number of nitrogen	type of catalyst
A	decrease	heterogeneous
B	decrease	homogeneous
C	increase	heterogeneous
D	increase	homogeneous

2. O/N 19/P12/Q1

The diagram shows a Boltzmann distribution of the energies of gaseous molecules and the activation energies, E_a, of a reaction with and without a catalyst.



Which statement about this distribution curve is correct?

A If the temperature of the gas is increased, the maximum of the curve becomes higher.
B If the temperature of the gas is increased, the maximum of the curve moves to the left.
C The fraction of molecules that react in the presence of a catalyst is shown by ▨.
D The fraction of molecules that react in the absence of a catalyst is shown by ▧.

3. O/N 19/P12/Q11

Hydrated aluminium ions undergo the following reaction.

$$[Al(H_2O)_6]^{3+}(aq) + H_2O(l) \rightleftharpoons [Al(H_2O)_5OH]^{2+}(aq) + H_3O+(aq)$$

Which statement about this reaction is correct?

A $H_2O(l)$ and $[Al(H_2O)_5OH]^{2+}(aq)$ are a conjugate acid-base pair.
B $H_2O(l)$ is acting as an acid as it is donating H^+ ions.
C If $OH^-(aq)$ is added, the equilibrium will move to the right.
D K_c varies as the pH is varied.

4. M/J 19/P12/Q11

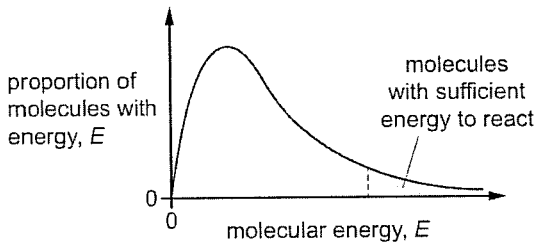
Which row is an example of heterogeneous catalysis?

	reaction	catalyst
A	esterification	sulfuric acid
B	the Contact process	divanadium pentoxide
C	destruction of the ozone layer	chlorine radicals
D	atmospheric formation of sulfur trioxide	nitrogen dioxide

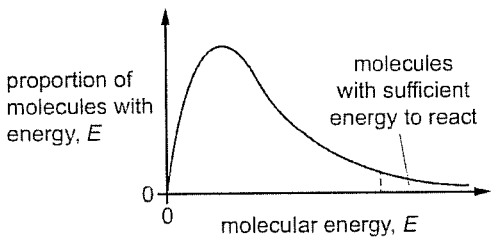
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5. M/J 19/P12/Q1

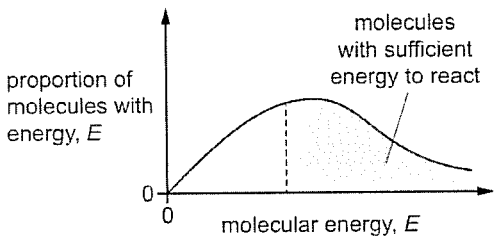
The Boltzmann distribution of molecular energies in a sample of aqueous hydrogen peroxide at room temperature is shown.



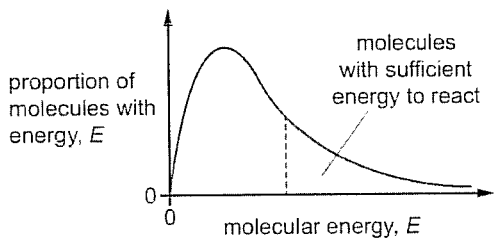
A



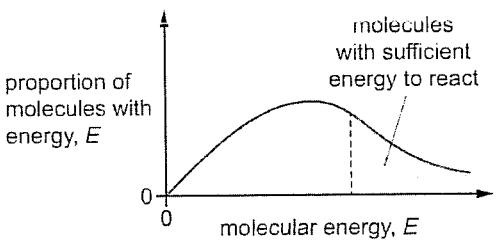
C



B



D



6. M/J 18/P13/Q11

The enzyme maltase speeds up the reaction between maltose and water.

$$\text{maltose} + \text{water} \xrightarrow{\text{maltase}} \text{glucose}$$

Maltase shows specificity.

Which statement describes the specificity of maltase?

A Maltase is a biological catalyst and it is a type of protein.

B Maltase is most effective between pH 6.1 and pH 6.8.

C Maltase lowers the activation energies of the reactions it catalyses.

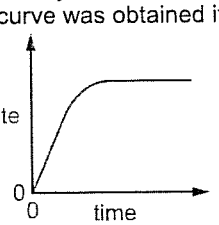
D Maltase only speeds up a small number of chemical reactions.

7. O/N 16/P11/Q11, O/N 16/P13/Q11, O/N 13/P12/Q5, O/N 13/P11/Q5

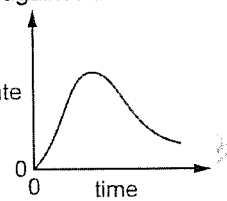
An autocatalytic reaction is a reaction in which one of the products catalyses the reaction.

Which curve was obtained if the rate of reaction was plotted against time for an autocatalytic reaction?

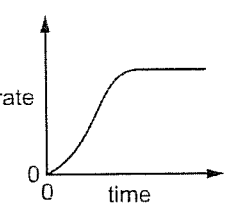
A



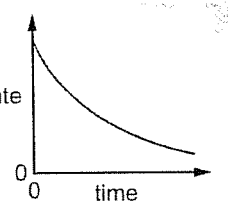
C



B



D



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8. M/J 13/P13/Q5

Crotonaldehyde, $CH_3CH=CHCHO$, can be obtained by oxidising butadiene, $CH_2=CHCH=CH_2$, using air or oxygen. One method is to pass a mixture of butadiene and oxygen through a hot aqueous solution of palladium(II) ions, $Pd^{2+}(aq)$, which catalyse the reaction.

Which statement is **not** correct about the action of the $Pd^{2+}(aq)$ ions?

A Changing the concentration of the $Pd^{2+}(aq)$ will have an effect on the rate of the reaction.

B $Pd^{2+}(aq)$ increases the energy of the reacting molecules.

C $Pd^{2+}(aq)$ lowers the activation energy for the reaction.

D $Pd^{2+}(aq)$ provides a different route for the reaction.

9. O/N 12/P12/Q25, O/N 12/P11/Q25

One of the reactions taking place in a catalytic converter in a car exhaust system is between nitrogen oxide and octane (unburned petrol). The products of this reaction are non-toxic.

Which is the correct equation for the reaction?

A $C_8H_{16} + 16NO \rightarrow 8CO + 8N_2 + 8H_2O$

B $C_8H_{16} + 24NO \rightarrow 8CO_2 + 12N_2 + 8H_2O$

C $C_8H_{18} + 17NO \rightarrow 8CO + 8\frac{1}{2}N_2 + 9H_2O$

D $C_8H_{18} + 25NO \rightarrow 8CO_2 + 12\frac{1}{2}N_2 + 9H_2O$

10. O/N 11/P12/Q1

In the Haber process for the manufacture of ammonia, why is the heterogeneous catalyst iron in a finely divided state?

A to increase its surface area

B to produce the maximum reduction in the activation energy

C to reduce its loss during the reaction

D to reduce its surface area

11. O/N 11/P11/Q12, O/N 11/P13/Q11

Butanedioate ions can be dehydrogenated to form *trans*-butenedioate ions. The enzyme fumarase speeds up this reaction.

Why does fumarase speed up this reaction?

A Fumarase is a protein.

B Fumarase is effective at body temperature.

C Fumarase lowers the activation energy of the dehydrogenation reaction.

D The enzyme fumarase is specific for this dehydrogenation reaction.

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12. M/J 19/P11/Q34

Vanadium and pepsin can both act as catalysts. Vanadium is a metal. Pepsin is an enzyme.

Which statements are correct for both vanadium and pepsin?

1 They will speed up any chemical reaction.
2 They can lower the activation energy for a reaction.
3 They are not used up when they act as catalysts.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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13. MAR 19/P12/Q38, MAR 16/P12/Q38

Chlorine atoms in the upper atmosphere cause the breakdown of ozone.

$$Cl + O_3 \rightarrow O_2 + ClO$$
$$ClO + O \rightarrow Cl + O_2$$

Which statements are correct when referring to these chlorine atoms?

1 The chlorine atoms act as catalysts.
2 The chlorine atoms are free radicals.
3 The chlorine atoms are formed by heterolytic fission of a covalent bond in chlorofluorocarbons.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

14. M/J 17/P12/Q34

The rate of chemical reactions can be increased by the addition of a suitable catalyst.
For which reactions can a heterogeneous catalyst be used?

1 $N_2 + 3H_2 \rightleftharpoons 2NH_3$

2 $2SO_2 + O_2 \rightleftharpoons 2SO_3$

3 $2NO + 2CO \rightleftharpoons N_2 + 2CO_2$

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

15. O/N 14/P12/Q33, O/N 14/P11/Q33, O/N 06/P1/Q33

A reversible reaction is catalysed.
Which statements about the effects of the catalyst on this system are correct?

1 The catalyst alters the mechanism of the reaction.
2 The catalyst reduces the activation energy for both the forward and the backward reaction.
3 The catalyst alters the composition of the equilibrium mixture.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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8.4: Multiple Topics

1. M/J 17/P11/Q11

When 4 g of powdered calcium carbonate, M_r = 100, were added to 100 cm^3 of 0.10 mol dm^{-3} hydrochloric acid the volume of carbon dioxide produced was recorded.

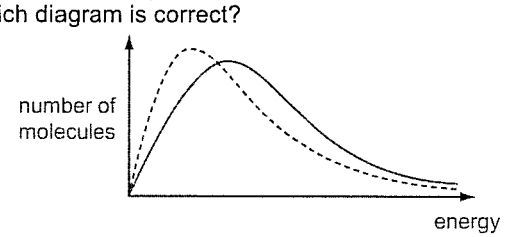
time / s	30	60	90	120	150	180	210	240
total volume of carbon dioxide given off / cm^3	40	70	88	101	110	116	120	120

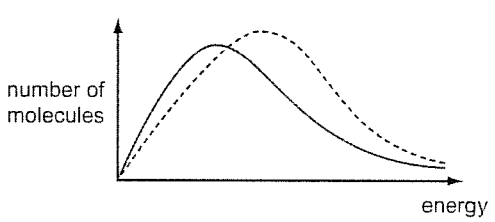
Which row gives the correct explanations about these results?

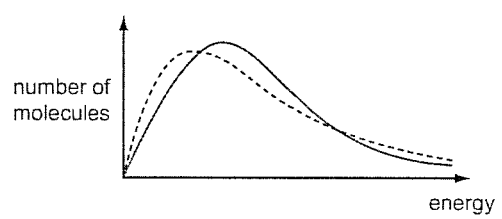
	why the rate of the reaction changes with time	why the reaction stops
A	fewer collisions between reacting molecules occur	the calcium carbonate is used up
B	fewer collisions between reacting molecules occur	the hydrochloric acid is used up
C	more collisions between reacting molecules occur	the calcium carbonate is used up
D	more collisions between reacting molecules occur	the hydrochloric acid is used up

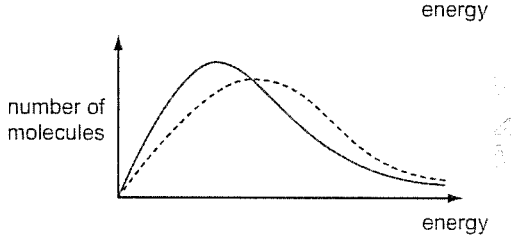
2. O/N 13/P12/Q6

The diagrams below show the Boltzmann distribution for air at two temperatures.
The solid line represents the distribution at –20 °C.
The dotted line represents the distribution at –10 °C.
Which diagram is correct?

A


C


B


D


3. M/J 13/P11/Q18

Sulfur trioxide is manufactured from sulfur dioxide and oxygen, using the Contact process.
Which condition affects the value of the equilibrium constant, K_c?

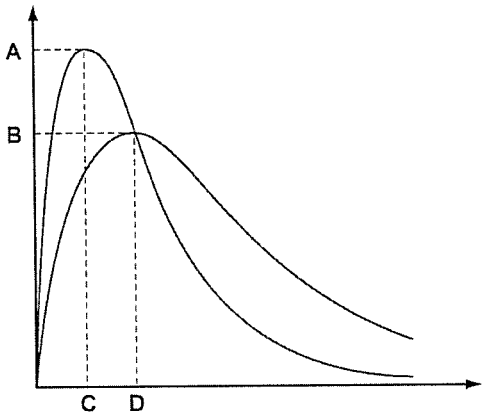
A adjusting the temperature
B increasing the pressure
C removing SO_3 from the equilibrium mixture
D using a catalyst

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4. M/J 13/P12/Q5, O/N 06/P1/Q12

The diagram shows the Maxwell-Boltzmann energy distribution curves for molecules of a sample of a gas at two different temperatures.

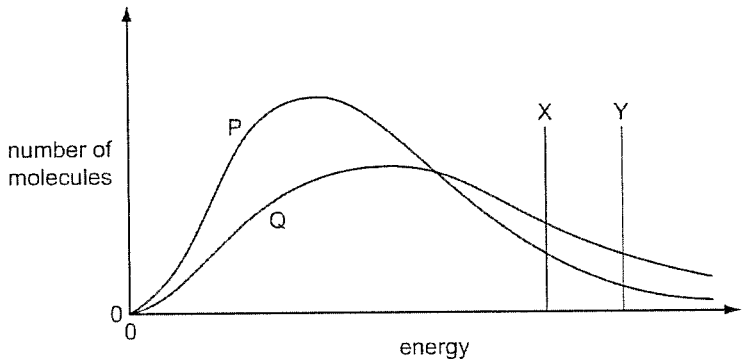
Which letter on the axes represents the most probable energy of the molecules at the **lower** temperature?



5. O/N 12/P13/Q8

The gaseous compound Z decomposes on heating.

In the diagram below, Boltzmann distributions for Z at two different temperatures P and Q are shown. The lines X and Y indicate activation energies for the decomposition of Z with and without a catalyst.



Which curve and which line describe the decomposition of Z at a higher temperature and with a catalyst present?

	higher temperature	catalyst present
A	P	X
B	P	Y
C	Q	X
D	Q	Y

6. O/N 11/P11/Q12, O/N 11/P13/Q11

Butanedioate ions can be dehydrogenated to form *trans*-butenedioate ions. The enzyme fumarase speeds up this reaction.

Why does fumarase speed up this reaction?

A Fumarase is a protein.

B Fumarase is effective at body temperature.

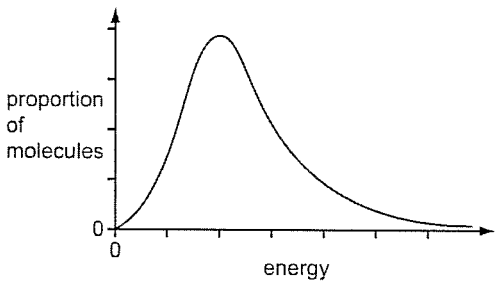
C Fumarase lowers the activation energy of the dehydrogenation reaction.

D The enzyme fumarase is specific for this dehydrogenation reaction.

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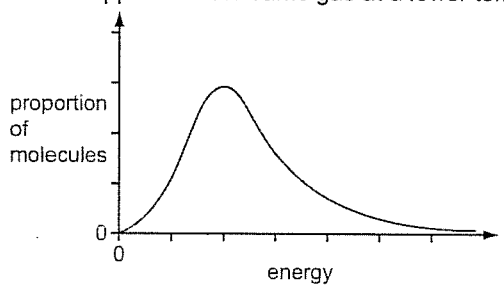
7. M/J 12/P12/Q1, M/J 08/P1/Q12

The molecular energy distribution curve represents the variation in energy of the molecules of a gas at room temperature.

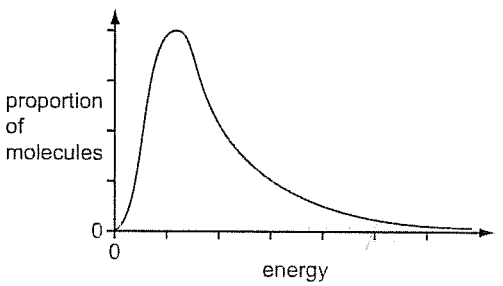


Which curve applies for the same gas at a lower temperature?

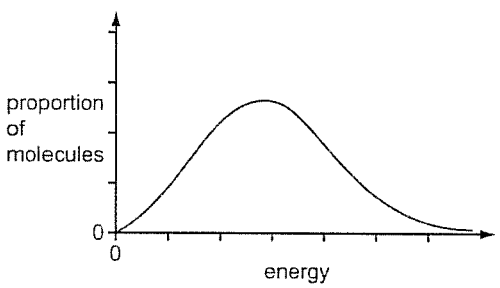
A



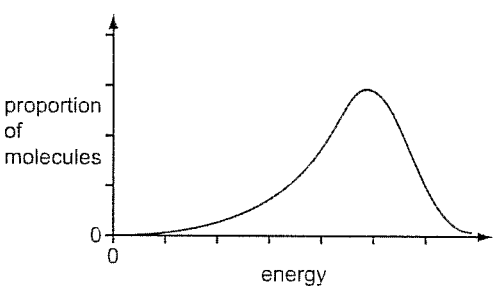
C



B

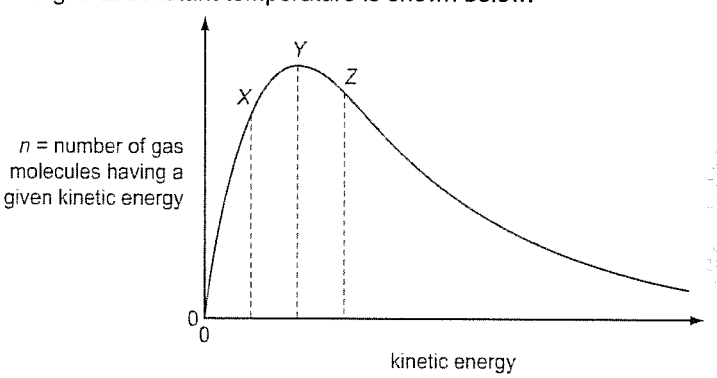


D



8. M/J 11/P12/Q6

The Boltzmann distribution for a gas at constant temperature is shown below.



If the temperature of the gas is **reduced** by 10 °C the graph changes shape.
What happens to the values of *n* for the points marked *X*, *Y* and *Z*?

	X	*Y*	*Z*
A	higher	lower	higher
B	higher	lower	lower
C	lower	higher	lower
D	lower	lower	lower

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9. M/J 11/P11/Q4, M/J 11/P13/Q7

Different Boltzmann distributions are shown in the diagrams.

diagram 1

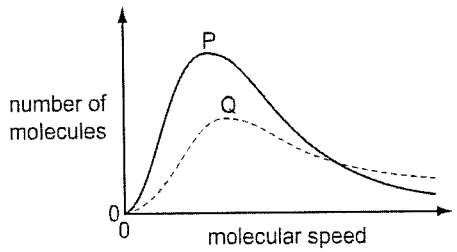
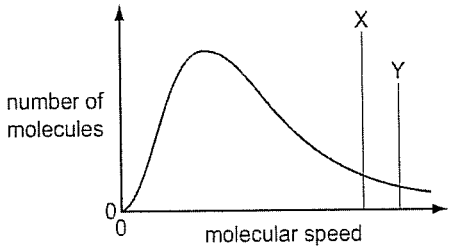


diagram 2



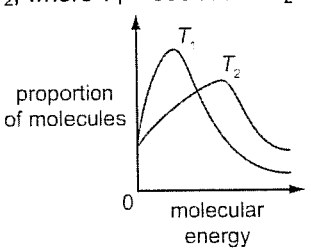
In diagram 1, one curve P or Q corresponds to a temperature higher than that of the other curve.
In diagram 2, one line X or Y corresponds to the activation energy for a catalysed reaction and the other line corresponds to the activation energy of the same reaction when uncatalysed.
Which combination gives the correct curve and line?

	higher temperature	presence of catalyst
A	P	X
B	P	Y
C	Q	X
D	Q	Y

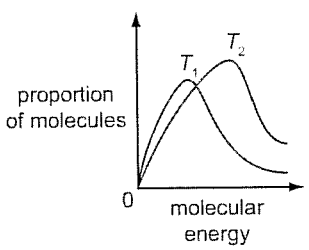
10. O/N 10/P12/Q2

Which diagram correctly represents the Boltzmann distribution of molecular energies at two temperatures T_1 and T_2, where T_1 = 300 K and T_2 = 310 K?

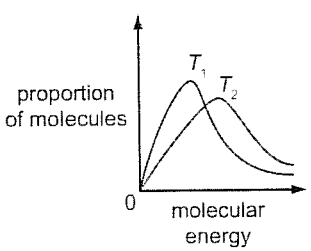
A



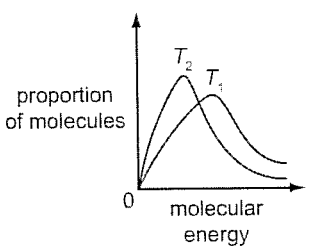
C



B



D



Valid till October/November 2021 Exams

11. M/J 17/P11/Q34

Which changes can be used to measure the rates of chemical reactions?

1 the decrease in concentration of a reactant per unit time
2 the rate of appearance of a product
3 the increase in total volume per unit time at constant pressure

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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12. MAR 20/P12/Q34

Hydrochloric acid reacts with zinc.

$$2HCl(aq) + Zn(s) \rightarrow ZnCl_2(aq) + H_2(g)$$

What will increase the rate of this reaction but will not change the Boltzmann distribution of molecular energies?

1 addition of a suitable catalyst
2 an increase in concentration of hydrochloric acid
3 an increase in temperature of hydrochloric acid

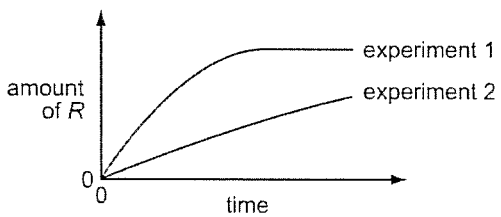
A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

13. O/N 19/P11/Q34, O/N 19/P13/Q34, M/J 14/P13/Q34, M/J 05/P1/Q34

The stoichiometry of a catalysed reaction is shown by the equation below.

$$P(g) + Q(g) \rightleftharpoons R(g) + S(l)$$

Two experiments were carried out in which the rate of production of *R* was measured. The results are shown in the diagram below.



Which changes in the conditions might explain the results shown?

1 A lower pressure was used in experiment 2.
2 A different catalyst was used in experiment 2.
3 Product S was continuously removed from the reaction vessel in experiment 2.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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Answers Sections

8.1	8.2	8.3	8.4
1. B	1. C	1. A	1. B
2. C	2. C	2. D	2. D
3. D	3. B	3. C	3. A
4. C	4. A	4. B	4. C
5. D	5. B	5. B	5. C
6. D	6. D	6. D	6. C
7. B	7. A	7. C	7. C
8. D	8. D	8. B	8. B
	9. D	9. D	9. C
	10. D	10. A	10. B
	11. C	11. C	11. A
	12. C	12. C	12. B
	13. D	13. B	13. B
	14. A	14. A	
	15. C	15. B	
	16. A		
	17. B		
	18. C		
	19. C		
	20. D		
	21. B		
	22. B		
	23. A		
	24. C		
	25. B		
	26 D		
	27. C		
	28. B		
	29. D		
	30. C		

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Unit 9
THE PERIODIC TABLE: CHEMICALPERIODICITY

A Level
Chemistry Paper 1
Classified/Topical MCQ's
Article Number: 231

Editorial Board

Syllabus

9.1 Periodicity of physical properties of the elements in the third period
9.2 Periodicity of chemical properties of the elements in the third period
9.3 Chemical periodicity of other elements
9.4 Multiple topics

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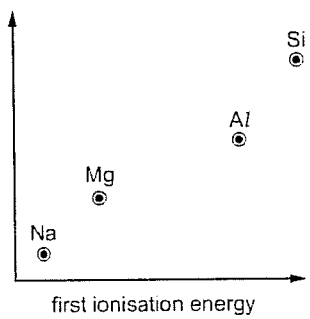
Unit 9: The Periodic Table: chemical periodicity

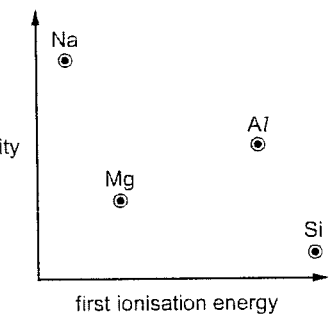
9.1: Periodicity of physical properties of the elements in the third period

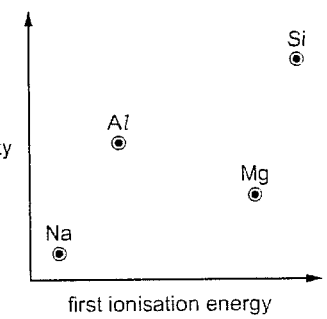
1. **MAR 20/P12/Q16**
Sodium, magnesium and aluminium are three elements in Period 3 of the Periodic Table. Each element forms an oxide.
Which row is correct?

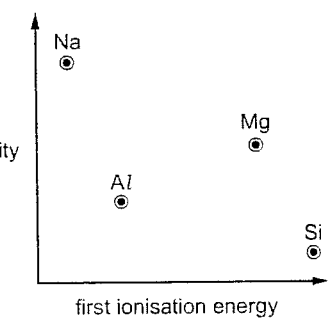
	sodium oxide	magnesium oxide	aluminium oxide
A	basic	amphoteric	amphoteric
B	giant ionic	giant ionic	simple molecular
C	high melting point	high melting point	low melting point
D	readily reacts with water	slight reaction with water	no reaction with water

2. **O/N 19/P12/Q12, M/J 15/P12/Q15**
Which diagram correctly shows the electronegativity of the elements Na, Mg, Al and Si plotted against their first ionisation energies?

A


C


B


D


3. **O/N 19/P11/Q13, O/N 19/P13/Q13**
X, Y and Z are consecutive elements in Period 3 of the Periodic Table. Element Y has the highest first ionisation energy and the lowest melting point of these three elements.
What are the identities of X, Y and Z?

	X	Y	Z
A	Na	Mg	Al
B	Mg	Al	Si
C	Al	Si	P
D	Si	P	S

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4. M/J 19/P13/Q12, M/J 16/P12/Q12, M/J 12/P12/Q18

Sodium and sulfur react together to form sodium sulfide, Na_2S.
How do the atomic radius and ionic radius of sodium compare with those of sulfur?

	atomic radius	ionic radius
A	sodium < sulfur	sodium > sulfur
B	sodium < sulfur	sodium < sulfur
C	sodium > sulfur	sodium > sulfur
D	sodium > sulfur	sodium < sulfur

5. O/N 18/P11/Q14, O/N 18/P13/Q14

Which row describes the structure and bonding of SiO_2 and $SiCl_4$?

	SiO_2		$SiCl_4$	
	bonding	structure	bonding	structure
A	covalent	giant	covalent	giant
B	covalent	giant	covalent	simple
C	ionic	giant	covalent	giant
D	ionic	giant	covalent	simple

6. M/J 18/P11/Q10

Element X has a higher first ionisation energy than element Y.
Two students state what they believe is one factor that helps to explain this.
student 1 "X has a higher first ionisation energy than Y because an atom of X has more protons in its nucleus than an atom of Y."
student 2 "X has a higher first ionisation energy than Y because X has a smaller atomic radius than Y."
Only one of the two students is correct.
What could X and Y be?

	X	Y
A	carbon	boron
B	magnesium	aluminium
C	oxygen	nitrogen
D	oxygen	sulfur

7. M/J 18/P11/Q13

Which element has the second smallest atomic radius in its group and the third lowest first ionisation energy in its period?

A boron **B** calcium **C** magnesium **D** sodium

8. O/N 17/P11/Q12, O/N 17/P13/Q12

The elements Cl, Mg, Si and S are all in Period 3.
What is the correct sequence of the melting points of these elements, from lowest to highest?

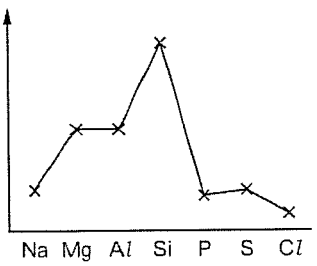
	lowest melting point →			highest melting point
A	Cl	S	Mg	Si
B	Cl	S	Si	Mg
C	Mg	Si	S	Cl
D	Si	Mg	S	Cl

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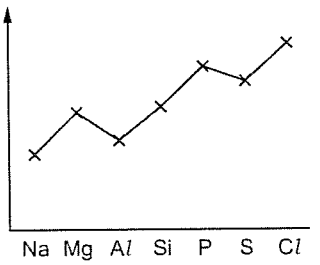
9. M/J 18/P12/Q13

The graphs show trends in four physical properties of elements in Period 3, excluding argon.
Which graph has electronegativity on the y-axis?

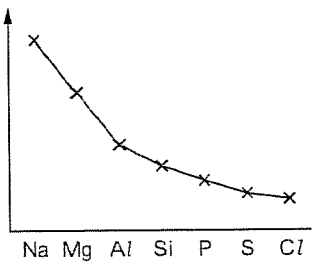
A



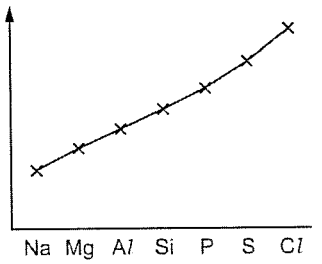
C



B



D



10. M/J 17/P12/Q12

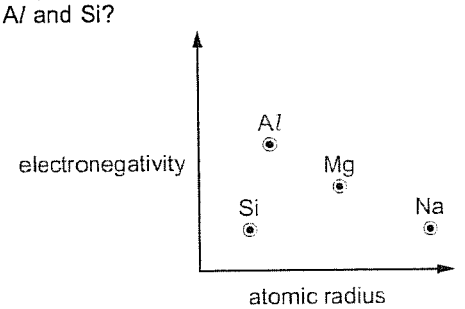
The elements magnesium and sulfur each form doubly charged ions.
How do the atomic radii and ionic radii of these elements compare?

	atomic radius		ionic radius	atomic radius		ionic radius
A	Mg	>	Mg^{2+}	S	>	S^{2-}
B	Mg	>	Mg^{2+}	S	<	S^{2-}
C	Mg	<	Mg^{2+}	S	>	S^{2-}
D	Mg	<	Mg^{2+}	S	<	S^{2-}

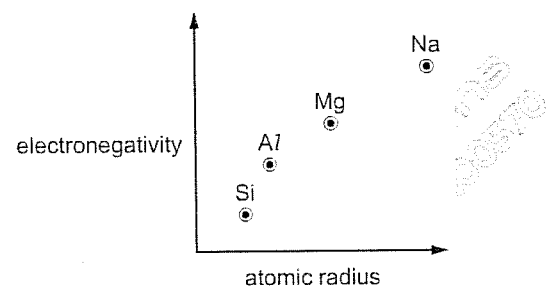
11. M/J 17/P12/Q13, M/J 14/P11/Q19

Which graph correctly shows relative electronegativity plotted against relative atomic radius for the elements Na, Mg, Al and Si?

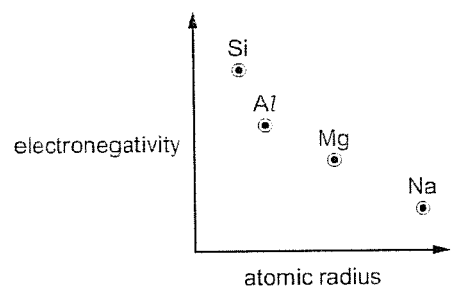
A



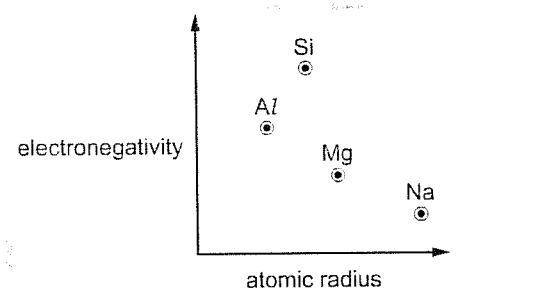
C



B



D

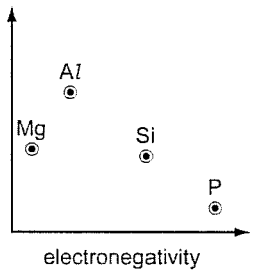


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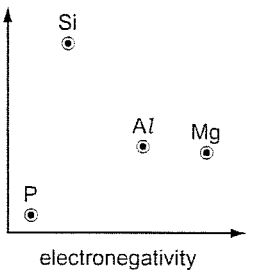
12. M/J 17/P11/Q13, M/J 14/P12/Q16

Which graph correctly shows the relative melting points of the elements Mg, Al, Si and P plotted against their relative electronegativities?

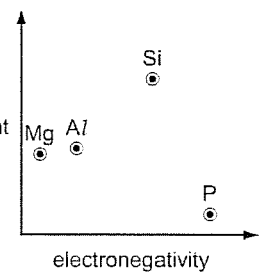
A



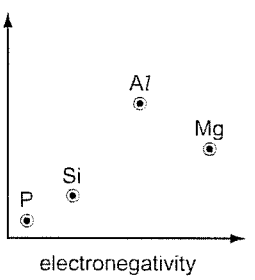
C



B



D



13. O/N 15/P12/Q15

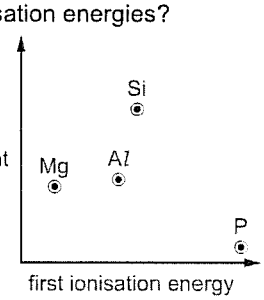
Which row correctly compares the electrical conductivity and first ionisation energy of magnesium and aluminium?

	higher electrical conductivity	higher first ionisation energy
A	aluminium	aluminium
B	aluminium	magnesium
C	magnesium	aluminium
D	magnesium	magnesium

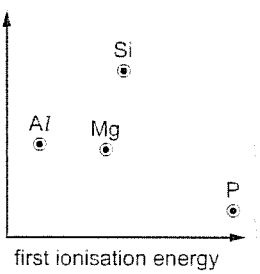
14. M/J 17/P13/Q13, M/J 14/P13/Q14

Which graph correctly shows the relative melting points of the elements Mg, Al, Si and P plotted against their relative first ionisation energies?

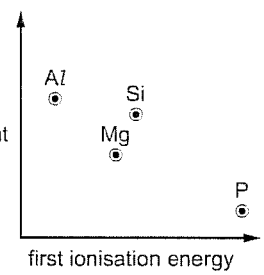
A



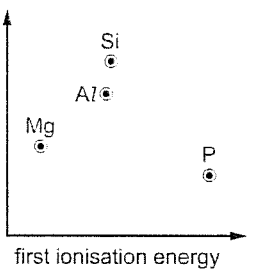
C



B



D



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15. O/N 15/P12/Q3

Three substances have the physical properties shown in the table.

substance	melting point /°C	boiling point /°C	conductivity (solid)	conductivity (liquid)	conductivity (aqueous)
U	420	907	good	good	insoluble
V	993	1695	poor	good	good
W	−70	58	poor	poor	hydrolyses, resulting solution conducts well

What could be the identities of **U**, **V** and **W**?

	U	V	W
A	Na	KCl	$SiCl_4$
B	Na	NaF	C_2H_5Br
C	Zn	KCl	HCl
D	Zn	NaF	$SiCl_4$

16. O/N 15/P11/Q14, O/N 15/P13/Q14

Which of the elements sodium, magnesium, aluminium, silicon, phosphorus, sulfur and chlorine

- has a lower first ionisation energy than the preceding element in the Periodic Table,
- conducts electricity and
- has a lower atomic radius than the preceding element in the Periodic Table?

A aluminium **B** magnesium **C** phosphorus **D** sulfur

17. O/N 15/P11/Q15, O/N 15/P13/Q15

The melting points of the Period 3 elements sodium to aluminium are shown in the table.

element	Na	Mg	Al
mp/K	371	923	932

Which factor explains the **increase** in melting points from sodium to aluminium?

A the changes in first ionisation energy from sodium to aluminium

B the increase in electronegativity from sodium to aluminium

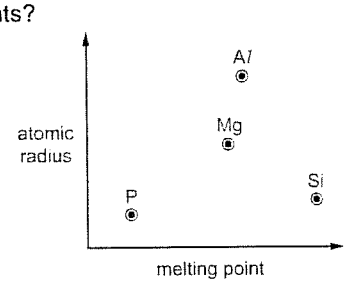
C the increase in the Ar of the elements from sodium to aluminium

D the increase in the number of outer electrons in each atom from sodium to aluminium

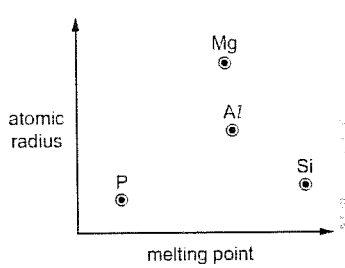
18. M/J 15/P11/Q15

Which diagram correctly shows the atomic radii of the elements Mg, Al, Si and P plotted against their melting points?

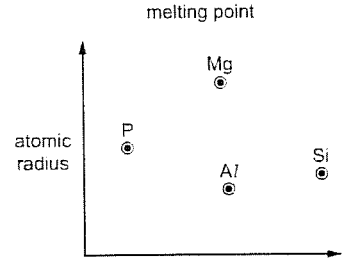
A



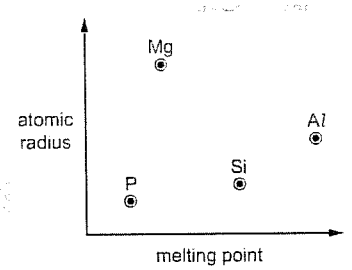
C



B



D



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19. O/N 14/P12/Q14, O/N 14/P11/Q14

Sir Humphrey Davy discovered boron, calcium, magnesium and sodium.
Which of these elements has the **second** smallest atomic radius in its group and the **third** lowest first ionisation energy in its period?

A boron **B** calcium **C** magnesium **D** sodium

20. O/N 14/P13/Q2

In some types of spectroscopy, it is important to know if ions are isoelectronic. This means that they contain equal numbers of electrons.
Which ion is **not** isoelectronic with K^+?

A Ca^{2+} **B** Cl^- **C** S^{2-} **D** Ti^{3+}

21. M/J 14/P13/Q12

A student investigated the chloride of a Period 3 element. This is what he wrote down as his record of what he did and what he saw.

> The compound was a white crystalline solid. It dissolved easily in water to give a solution of pH 12. When placed in a test-tube and heated in a roaring Bunsen flame, the compound melted after several minutes heating.

What can be deduced from this record?

A At least one of the recorded observations is incorrect.
B The compound was magnesium chloride, $MgCl_2$.
C The compound was phosphorus pentachloride, PCl_5.
D The compound was sodium chloride, $NaCl$.

22. O/N 14/P13/Q14

X, **Y** and **Z** are compounds of three elements in Period 3. Their electrical conductivities are shown in the table.

	X	Y	Z
conductivity of the compound in the molten state	good	does not conduct	does not conduct
conductivity of the mixture obtained by adding the compound to water	good	good	does not conduct

What could be compounds **X**, **Y** and **Z**?

	X	Y	Z
A	Al_2O_3	$SiCl_4$	NaF
B	NaF	Al_2O_3	$SiCl_4$
C	NaF	$SiCl_4$	SiO_2
D	$SiCl_4$	Al_2O_3	SiO_2

23. M/J 14/P11/Q4

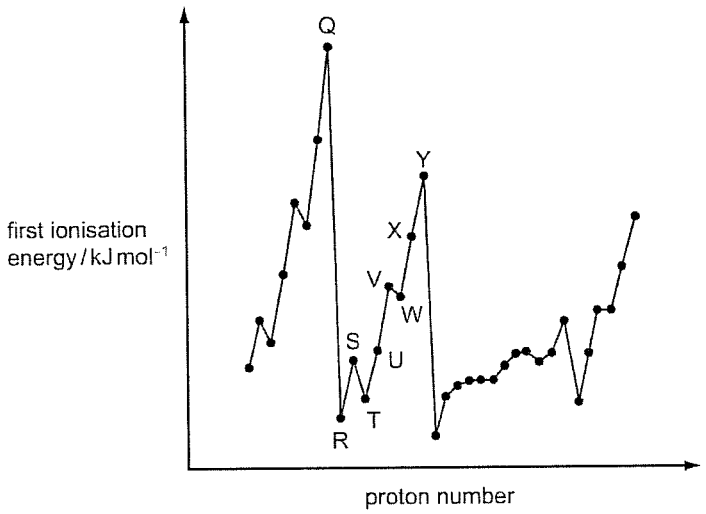
The table shows the physical properties of four substances.
Which substance has a giant covalent structure?

	melting point /°C	boiling point /°C	electrical conductivity of solid	electrical conductivity of liquid	electrical conductivity of aqueous solution
A	–119	39	poor	poor	insoluble
B	–115	–85	poor	poor	good
C	993	1695	poor	good	good
D	1610	2230	poor	poor	insoluble

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24. O/N 13/P13/Q18

The graph below shows the variation of the first ionisation energy with the number of protons for some elements.



Which statement is correct?

A Elements Q and Y are in the same period in the Periodic Table.

B The general increase from elements R to Y is due to increasing atomic radius.

C The small decrease between elements S and T is due to decreased shielding.

D The small decrease between elements V and W is due to repulsion between paired electrons.

25. M/J 13/P12/Q6

Which pair of elements has chemical bonds of the same type between their atoms in the solid state?

A aluminium and phosphorus

B chlorine and argon

C magnesium and silicon

D sulfur and chlorine

26. O/N 12/P13/Q12

Why is the ionic radius of a sulfide ion larger than the ionic radius of a potassium ion?

A Ionic radius always decreases with increasing atomic number.

B Positive ions have smaller radii than negative ions.

C The potassium ion has more protons in its nucleus than the sulfide ion.

D The sulfide ion is doubly charged; the potassium ion is singly charged.

27. O/N 11/P11/Q1, O/N 11/P13/Q3

Three elements, **X**, **Y** and **Z**, have the physical properties shown in the table.

element	melting point /°C	boiling point /°C	density /g cm^{-3}
X	–7	59	3.12
Y	98	883	0.97
Z	649	1107	1.74

What could be the identities of **X**, **Y** and **Z**?

	X	Y	Z
A	Br_2	Al	Si
B	Br_2	Na	Mg
C	I_2	Mg	Na
D	I_2	Si	K

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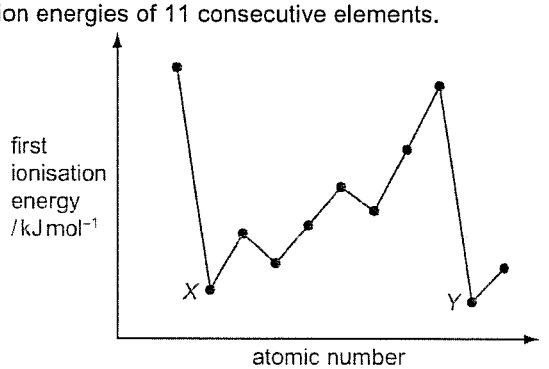
28. O/N 11/P12/Q19, M/J 05/P1/Q12

Ar, Ca^{2+} and K^+, contain the same number of electrons.
In which order do their radii increase?

	smallest radius ⟶		largest radius
A	Ar	K^+	Ca^{2+}
B	Ca^{2+}	Ar	K^+
C	Ca^{2+}	K^+	Ar
D	K^+	Ar	Ca^{2+}

29. M/J 11/P12/Q15

The diagram shows the first ionisation energies of 11 consecutive elements.



Which type of elements are labelled X and Y?

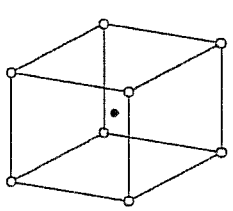
A Group I metals **B** Group II metals **C** halogens **D** noble gases

30. O/N 10/P12/Q3

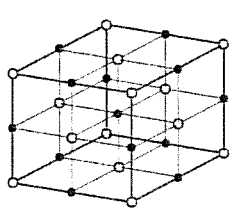
The table gives the radii, in pm, of some ions. [1 pm = 10^{-12}m]

ion	radii
Na^+	102
Mg^{2+}	72
Cs^+	167
Cl^-	181
O^{2-}	140

Caesium chloride, CsCl, has a different lattice structure from both sodium chloride, NaCl, and magnesium oxide, MgO.



CsCl lattice



NaCl and MgO lattice

Which factor appears to determine the type of lattice for these three compounds?

A the charge on the cation **C** the ratio of the ionic radii
B the ratio of the ionic charges **D** the sum of the ionic charges

31. M/J 09/P1/Q12

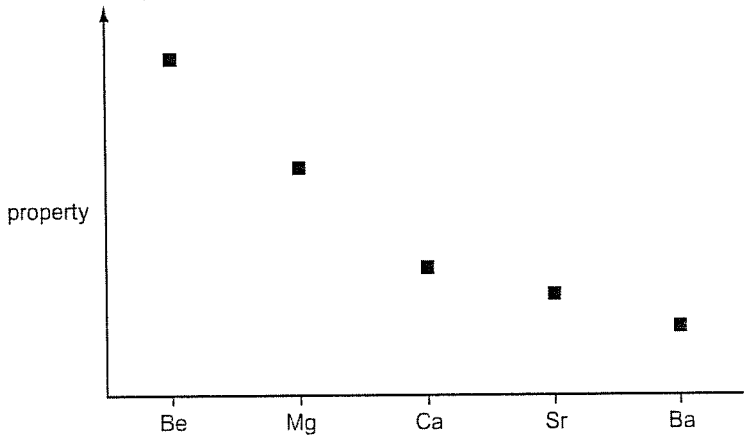
Which group of particles is in order of increasing size?

A N O F **C** Na^+ Mg^{2+} Al^{3+}
B N^{3-} O^{2-} F^- **D** Na^+ Ne F^-

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32. O/N 09/P12/Q2, O/N 09/P11/Q3

The graph represents the variation of a property of the Group II elements.

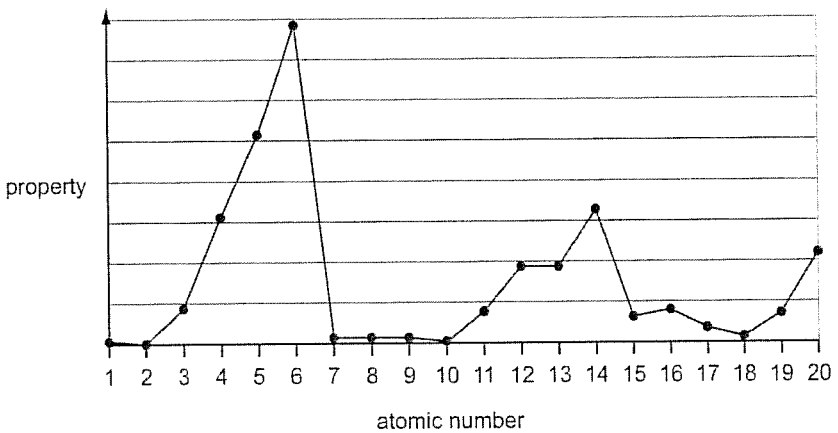


What is this property?

A ionic radius
B ionisation energy
C neutron/proton ratio
D rate of reaction with water

33. O/N 09/P12/Q11, O/N 09/P11/Q12

The following graph shows the variation of a property of the first 20 elements in the Periodic Table with the atomic number of the element.



What is the property?

A atomic radius
B first ionisation energy
C ionic radius
D melting point

Valid till October/November 2021 Exams

34. M/J 17/P11/Q35

Which statements describe a trend in Period 3 between every pair of adjacent elements from sodium to chlorine?

1 The atomic radius decreases.
2 The 1st ionisation energy decreases.
3 The melting point decreases.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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35. M/J 16/P13/Q35

Why is the first ionisation energy of aluminium less than that of magnesium?

1 The outer electron in the aluminium atom is more shielded from the nuclear charge.
2 The outer electron in the aluminium atom is in a higher energy orbital.
3 The outer electron in the aluminium atom is further from the nucleus.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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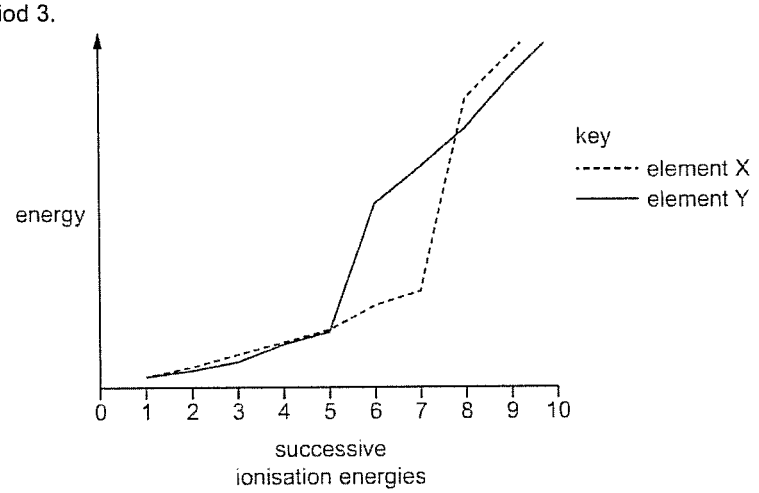
9.2: Periodicity of chemical properties of the elements in the third period

1. **M/J 20/P12/Q16**
One molecule of an oxide of element Z reacts with six molecules of water to produce an acidic compound.
What is element Z?
A aluminium **B** phosphorus **C** silicon **D** sulfur

2. **M/J 20/P11/Q16**
Sodium, aluminium and silicon are three elements in Period 3. Each element forms an oxide.
Which row has three correct properties of these oxides?

	sodium oxide	aluminium oxide	silicon dioxide
A	basic	basic	amphoteric
B	giant ionic	giant ionic	simple molecular
C	high melting point	low melting point	high melting point
D	reacts with water	no reaction with water	no reaction with water

3. **O/N 19/P12/Q3**
The graph shows the successive ionisation energies of element X and element Y.
Both elements are in Period 3.



Which statement is correct?
A An atom of element X needs one extra electron for a full outer shell; an atom of element Y needs three extra electrons for a full outer shell.
B An atom of element Y has five electrons in the 3p subshell.
C Element X has an oxidation number of +7 in most of its compounds.
D When element X combines with element Y, the bonding is ionic.

4. **M/J 20/P11/Q19**
What is the order of increasing melting point of the three chlorides shown?
CCl_4 $MgCl_2$ PCl_5

	lowest melting point →		highest melting point
A	CCl_4	PCl_5	$MgCl_2$
B	$MgCl_2$	CCl_4	PCl_5
C	$MgCl_2$	PCl_5	CCl_4
D	PCl_5	CCl_4	$MgCl_2$

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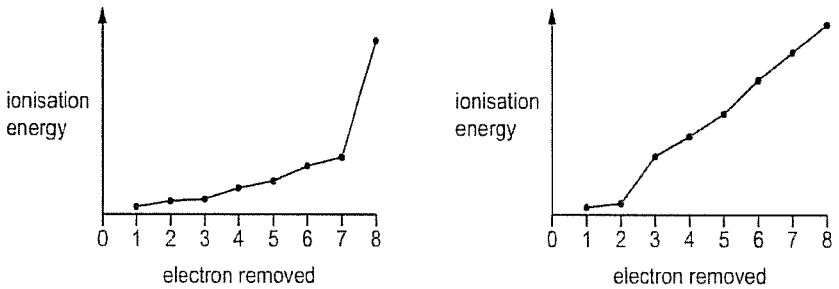
5. O/N 19/P11/Q12, O/N 19/P13/Q12

Which oxide will cause an increase in pH when added to water?

A MgO **B** Al_2O_3 **C** SiO_2 **D** SO_2

6. M/J 19/P12/Q3

The first eight successive ionisation energies for two elements of Period 3 of the Periodic Table are shown in the graphs.



What is the formula of the ionic compound formed from these elements?

A $MgCl_2$ **B** $CaBr_2$ **C** Na_2S **D** K_2Se

7. M/J 19/P13/Q4

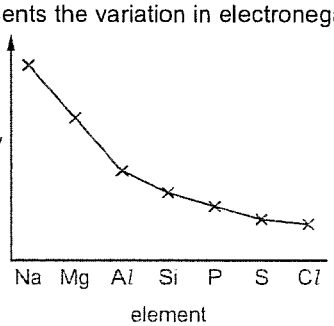
Element W is in period three of the Periodic Table and has a solid, white oxide, X. X is thermally stable and has a very high melting point.
X is slightly soluble in water.
Which row describes the structure and bonding of X?

	structure	bonding
A	giant three dimensional lattice	covalent
B	strong double bonds within small molecules	covalent
C	giant three dimensional lattice	ionic
D	strong ionic bonds within small molecules	ionic

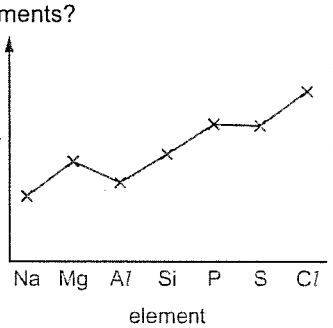
8. M/J 19/P13/Q13

Which graph represents the variation in electronegativity for Period 3 elements?

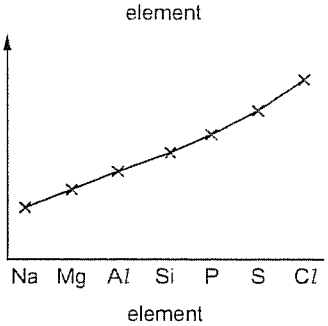
A



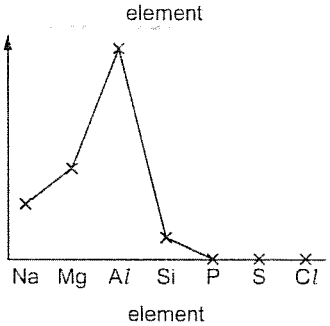
C



B



D



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9. MAR 19/P12/Q12

X, Y and Z are elements in Period 3 of the Periodic Table. The results of some experiments carried out with compounds of these elements are shown.

element	result of adding the oxide of the element to $H_2O(l)$	result of adding the chloride of the element to $H_2O(l)$	result of adding the oxide of the element to $HCl(aq)$
X	no reaction	hydrolyses	forms chloride salt
Y	forms hydroxide	dissolves	forms chloride salt
Z	forms acid	hydrolyses	hydrolyses

Which statement could be correct?

A X is Al and Y is Mg.
B X is Si and Y is Na.
C Y is Al and Z is P.
D Y is Na and Z is Al.

10. O/N 18/P12/Q12

The melting points of the Period 3 elements phosphorus to argon are shown in the table.

element	P	S	Cl	Ar
mp/K	317	392	172	84

Which factor explains the changes in melting points from phosphorus to argon?

A the changes in electronegativity from phosphorus to argon
B the changes in first ionisation energy from phosphorus to argon
C the increase in the number of electrons in each atom from phosphorus to argon
D the number of atoms in each molecule of the element from phosphorus to argon

11. O/N 18/P11/Q12, O/N 18/P13/Q12

Sodium and sulfur are burned separately in oxygen.
Each reaction has a distinctive coloured flame.
Which row is correct?

	$Na + O_2$	$S + O_2$
A	white	blue
B	white	yellow
C	yellow	blue
D	yellow	yellow

12. M/J 18/P11/Q12

Silicon is heated in an excess of chlorine, producing compound J.
Excess water is added to the sample of J produced.
Which row is correct?

	structure of J	Is HCl produced when water is added to J?
A	giant molecular	no
B	giant molecular	yes
C	simple molecular	no
D	simple molecular	yes

13. MAR 18/P12/Q13, O/N 13/P13/Q17

Which oxide is insoluble in aqueous sodium hydroxide?

A MgO **B** Al_2O_3 **C** P_4O_{10} **D** SO_2

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14. O/N 18/P11/Q13, O/N 18/P13/Q13

X and Y are elements in Period 3 of the Periodic Table.

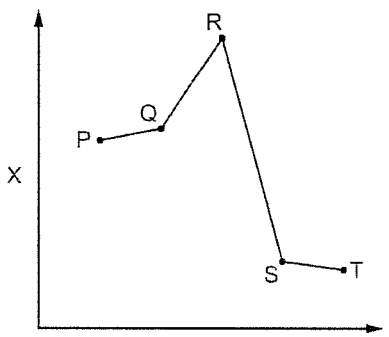
- The oxide of X is a solid at room temperature. This oxide has a giant structure.
- The chloride of X does not react with water.
- Argon is the only element in Period 3 with a lower melting point than Y.

What could be the formula of a compound formed between elements X and Y?

A Al_2S_3 **B** MgS **C** NaCl **D** PCl_5

15. O/N 17/P12/Q12

The relative magnitude of the property X of five elements is shown. P, Q, R, S and T are all in Period 3 and have consecutive atomic numbers.



Which row shows a correct pairing of property X and element R?

	property X	element R
A	electrical conductivity	Al
B	electronegativity	Si
C	melting point	Al
D	second ionisation energy	Si

16. O/N 17/P12/Q13

Element Z has a giant structure.
The chloride of Z reacts with water to give a solution with a pH less than 5.
Which row shows two elements which could be Z?

A aluminium, magnesium **C** phosphorus, magnesium
B aluminium, silicon **D** phosphorus, silicon

17. M/J 17/P13/Q12

Magnesium chloride, $MgCl_2$, and silicon tetrachloride, $SiCl_4$, are separately added to water.
What are the approximate pH values of the solutions formed?

	$MgCl_2$	$SiCl_4$
A	0–3	0–3
B	0–3	6–7
C	6–7	0–3
D	6–7	6–7

18. M/J 16/P13/Q12, O/N 09/P12/Q13, O/N 09/P11/Q14, M/J 06/P1/Q14

The oxide and chloride of an element **X** are separately mixed with water. The two resulting solutions have the same effect on litmus.
What could element **X** be?

A Al **B** Ca **C** Na **D** P

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19. MAR 16/P12/Q13
When dealing with a spillage of metallic sodium it is important that no toxic or flammable products are formed.
Which material should be used if there is a spillage of metallic sodium?

A dilute hydrochloric acid
B ethanol
C sand
D water spray

20. O/N 15/P12/Q14
Which chloride of a Period 3 element dissolves in water to form a solution with a pH of 7?

A aluminium chloride
B phosphorus(V) chloride
C silicon(IV) chloride
D sodium chloride

21. O/N 15/P11/Q16, O/N 15/P13/Q16
X is the oxide of a Period 3 element. **X** reacts with water to give an acidic solution.
A solution is prepared by reacting 0.100 g of **X** with excess water. This solution was neutralised by exactly 25.0 cm^3 of 0.100 mol dm^{-3} sodium hydroxide solution.
What could be the identity of **X**?

A Al_2O_3 **B** MgO **C** P_4O_{10} **D** SO_3

22. M/J 15/P12/Q13
What happens when a piece of magnesium ribbon is placed in cold water?

A A vigorous effervescence occurs.
B Bubbles of gas form slowly on the magnesium.
C The magnesium floats on the surface of the water and reacts quickly.
D The magnesium glows and a white solid is produced.

23. M/J 15/P11/Q14
Which observations are made when a sample of silicon chloride, $SiCl_4$, is added to a beaker of water?

A No visible changes are observed.
B Steamy fumes and a white precipitate are both observed.
C The appearance of a white precipitate is the only observation.
D The appearance of steamy fumes is the only observation.

24. M/J 15/P13/Q12
Which oxide will produce the solution with the highest pH when it is mixed with water?

A Al_2O_3 **B** CO_2 **C** Na_2O **D** SO_2

25. M/J 15/P13/Q15
The labels had become detached from four bottles in the laboratory. A student realised that the contents of one of them could easily be identified, because on addition of water it would not give fumes of hydrogen chloride.
Which did not give the HCl fumes?

A Al_2Cl_6 **B** $MgCl_2$ **C** PCl_5 **D** $SiCl_4$

26. O/N 14/P12/Q12, O/N 14/P11/Q12
Element **X**, in Period 3, has the following properties.

- Its oxide has a giant structure.
- It forms covalent bonds with chlorine.
- Its oxide will neutralise HCl (aq).

What is element **X**?

A Mg **B** Al **C** Si **D** P

27. O/N 14/P12/Q13, O/N 14/P11/Q13
Which property is **not** associated with the element sodium?

A It can react with cold water to form hydrogen.
B It forms a basic oxide.
C It forms a neutral chloride.
D It is an oxidising agent.

28. O/N 14/P12/Q19, O/N 14/P11/Q19
Which oxide does not react with cold dilute sodium hydroxide to produce a salt?

A Al_2O_3 **B** P_4O_{10} **C** SO_2 **D** SiO_2

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29. O/N 14/P13/Q18

One molecule of the oxide of element **Z** reacts with six molecules of water to produce an acidic compound.
What is element **Z**?

A aluminium **B** phosphorus **C** sodium **D** sulfur

30. M/J 14/P12/Q2

Substances X, Y and Z are all solids. Some of their physical properties are given in the table.

substance	X	Y	Z
melting point/°C	772	114	1610
boiling point/°C	1407	183	2205
electrical conductivity of the liquid state	conducts	does not conduct	does not conduct

What type of lattice could each substance have?

	X	Y	Z
A	giant molecular	simple molecular	ionic
B	ionic	giant molecular	simple molecular
C	ionic	simple molecular	giant molecular
D	simple molecular	ionic	giant molecular

31. M/J 14/P11/Q8

When making sparkler fireworks, a mixture of barium nitrate powder with aluminium powder, water and glue is coated onto wires and allowed to dry. At this stage, the following exothermic reaction may occur.

$$16Al + 3Ba(NO_3)_2 + 36H_2O \rightarrow 3Ba(OH)_2 + 16Al(OH)_3 + 6NH_3$$

Which conditions would be best to reduce the rate of this reaction during the drying process, and would also keep the aluminium and barium nitrate unchanged?

	temperature/K	pH
A	298	7
B	298	14
C	398	7
D	398	14

32. M/J 14/P13/Q18

Which properties do compounds of aluminium and silicon have in common?

A Aqueous solutions of their chlorides contain aluminium or silicon cations.
B Their chlorides have co-ordinate bonding.
C Their oxides are amphoteric.
D Their oxides are insoluble in water.

33. M/J 12/P12/Q15

The period 4 elements gallium (Ga), germanium (Ge), arsenic (As) and selenium (Se) are the elements below aluminium, silicon, phosphorus and sulfur in the Periodic Table, a portion of which is shown below.

period 3 elements	Al	Si	P	S
period 4 elements	Ga	Ge	As	Se

The properties of each period 4 element resemble those of the period 3 element directly above it. Which period 4 elements form oxides that dissolve in water to give an acid solution?

A As and Se **B** Ga and Ge **C** Ga and Se **D** Se only

34. O/N 11/P11/Q13, O/N 11/P13/Q13

Which element shows the greatest tendency to form some covalent compounds?

A aluminium **B** magnesium **C** neon **D** potassium

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35. O/N 12/P12/Q18, O/N 12/P11/Q18

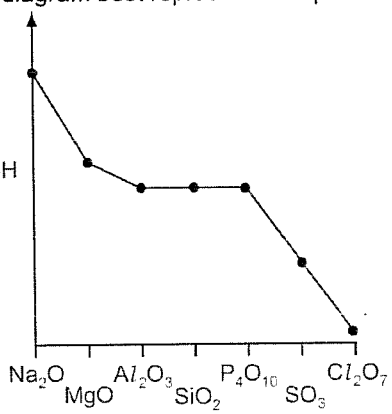
Elements **X** and **Y** are both in period three.
When the chloride of **X** is added to water, it reacts and a solution of pH_2 is produced.
When the chloride of **Y** is added to water, it dissolves and a solution of pH_7 is produced.
Which statement explains these observations?

A Both chlorides hydrolyse in water.
B **X** is phosphorus and **Y** is aluminium.
C **X** is silicon and **Y** is sodium.
D **X** is sodium and **Y** is phosphorus.

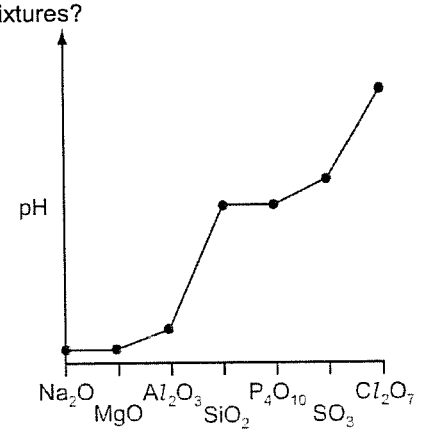
36. M/J 11/P12/Q14

The highest oxides of the elements sodium to chlorine are separately added to water.
Which diagram best represents the pH of the resulting mixtures?

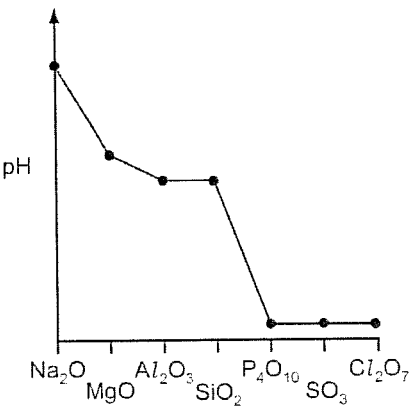
A



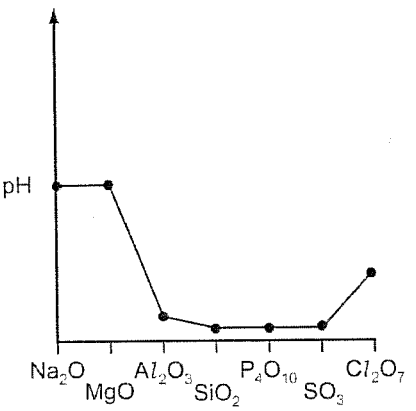
C



B



D



37. M/J 11/P12/Q16

Why does aluminium oxide dissolve in sodium hydroxide solution?

A Aluminium oxide can behave as a base.
B Aluminium oxide can behave as an acid.
C Aluminium oxide has a giant structure.
D The bonding in aluminium oxide is ionic.

38. M/J 10/P12/Q17, M/J 10/P11/Q19, M/J 10/P13/Q16

Two properties of non-metallic elements and their atoms are as follows.
property 1 has an oxide that can form a strong acid in water
property 2 has **no** paired 3p electrons
Which properties do phosphorus and sulfur have?

	phosphorus	sulfur
A	1 and 2	1 only
B	1 only	1 and 2
C	1 and 2	1 and 2
D	2 only	1 only

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39. M/J 10/P12/Q18, M/J 10/P11/Q16, M/J 10/P13/Q17
Consecutive elements X, Y, Z are in the third period of the Periodic Table. Element Y has the highest first ionisation energy and the lowest melting point.
What could be the identities of X, Y and Z?

A aluminium, silicon, phosphorus
B magnesium, aluminium, silicon
C silicon, phosphorus, sulfur
D sodium, magnesium, aluminium

40. O/N 09/P12/Q12, O/N 09/P11/Q13
Which statement correctly describes what happens when silicon tetrachloride is added to water?

A The $SiCl_4$ dissolves to give a neutral solution only.
B The $SiCl_4$ reacts to give an acidic solution only.
C The $SiCl_4$ reacts to give a precipitate and an acidic solution.
D The $SiCl_4$ reacts to give a precipitate and a neutral solution.

41. M/J 09/P1/Q11
In some fireworks there is a reaction between powdered aluminium and powdered barium nitrate in which heat is evolved and an unreactive gas is produced.
What is the equation for this reaction?

A $2Al + Ba(NO_3)_2 \rightarrow Al_2O_3 + BaO + 2NO$
B $4Al + 4Ba(NO_3)_2 \rightarrow 2Al_2O_3 + 4Ba(NO_2)_2 + O_2$
C $10Al + 3Ba(NO_3)_2 \rightarrow 5Al_2O_3 + 3BaO + 3N_2$
D $10Al + 18Ba(NO_3)_2 \rightarrow 10Al(NO_3)_3 + 18BaO + 3N_2$

42. O/N 08/P1/Q13
Which oxide, when mixed with water, will produce the most acidic solution?

A CO **B** CO_2 **C** SiO_2 **D** P_2O_5

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43. M/J 20/P13/Q36, O/N 12/P12/Q36, O/N 12/P11/Q36
When added to water, which oxides will not cause a change in pH?
1 Al_2O_3 2 SiO_2 3 P_4O_{10}

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

44. O/N 18/P12/Q35
A sample containing x mol of Al_2Cl_6 is dissolved in water to give solution W.
In order to precipitate all of the aluminium as its hydroxide, y mol of sodium hydroxide are required.
More of the alkali is added to re-dissolve the precipitate, giving solution Z.
Which statements are correct?
1 the initial pH of solution W is below 7
2 $y = 3x$
3 Z contains x mol of aluminium

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

45. M/J 17/P12/Q35
Which chlorides, when added to water, can produce a solution with a pH of less than 5?
1 $SiCl_4$ 2 $AlCl_3$ 3 $MgCl_2$

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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46. O/N 16/P11/Q35, O/N 16/P13/Q35, M/J 08/P1/Q34

Water is added to anhydrous aluminium chloride to make a 0.1 mol dm^{-3} solution.
Which observations are correct?

1 The reaction is endothermic.
2 The solution is acidic.
3 The solution contains the ion $[Al(H_2O)_6]^{3+}$.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

47. M/J 16/P11/Q34

A little water is added to each of the following compounds and the mixture warmed.
For which compounds will an acidic gas be evolved?

1 aluminium chloride
2 silicon tetrachloride
3 phosphorous pentachloride

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

48. O/N 15/P12/Q35

Which statements about calcium and strontium compounds are correct?

1 When calcium oxide and strontium oxide are added to water they both produce alkalis.
2 Calcium hydroxide is more soluble than strontium hydroxide.
3 Calcium sulfate is less soluble than strontium sulfate.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

49. M/J 15/P12/Q35

When added to water, which oxides will cause a change in the pH of the water?

1 SiO_2 2 CaO 3 SO_2

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

50. O/N 13/P13/Q36

Which chlorides of Period 3 elements will form a neutral solution when added to water?

1 NaCl 2 Al_2Cl_6 3 PCl_5

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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51. M/J 11/P11/Q34, M/J 11/P13/Q36

Which statements are correct?

1 Aluminium chloride dissolves in water to give an acidic solution.
2 Magnesium chloride dissolves in water to give a slightly acidic solution.
3 Sodium chloride dissolves in water to give an alkaline solution.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

52. M/J 11/P11/Q35, M/J 11/P13/Q38

Which oxides react with water to give a solution of pH 10 or higher?

1 CaO
2 Na_2O
3 SrO

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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9.3: Chemical periodicity of other elements

1. M/J 20/P11/Q15
Element Z has a giant structure.
The chloride of Z reacts with water to give a solution with a pH less than 5.
Which pair shows two elements which could be Z?

A aluminium, magnesium
B aluminium, silicon
C phosphorus, magnesium
D phosphorus, silicon

2. M/J 20/P13/Q19
Element X is in Period 3. It reacts rapidly with water to form an alkaline solution.
Which statement about the chloride of element X is correct?

A It conducts electricity when molten.
B It has a melting point of less than 100 °C.
C It has covalent bonding.
D It reacts rapidly with cold water.

3. O/N 19/P12/Q13
Which statement about the compounds of Group 2 elements magnesium to barium is correct?

A Carbonates of Group 2 elements produce bubbles when added to dilute nitric acid.
B Nitrates of Group 2 elements produce nitrogen and oxygen on heating.
C Oxides of Group 2 elements produce bubbles when added to dilute hydrochloric acid.
D The oxides of Group 2 elements are amphoteric.

4. M/J 19/P12/Q12
Element Q readily oxidises in air. The oxide produced reacts with water to form a solution of very low pH.
Where could element Q be found in the Periodic Table?

	period	group
A	2	1
B	2	14
C	3	14
D	3	15

5. M/J 19/P12/Q13
The eight elements sodium to argon are in the same period of the Periodic Table.
The equation corresponding to the first ionisation energy is shown.

$$X(g) \rightarrow X^{+}(g) + e^{-}$$

For which of these eight elements is the electron in this equation removed from a filled orbital?

A Mg, Al, Si, P, S, Cl and Ar
B Al, Si, P, S, Cl and Ar only
C Mg, S, Cl and Ar only
D S, Cl and Ar only

6. MAR 19/P12/Q14
Metal T reacts with water to produce a colourless solution. A white precipitate is produced when this colourless solution is mixed with aqueous sulfuric acid.
What is metal T?

A barium **B** magnesium **C** potassium **D** sodium

7. O/N 18/P12/Q6, M/J 15/P13/Q10
1.00 g of a metallic element reacts completely with 300 cm^3 of oxygen at 298 K and 1 atm pressure to form an oxide which contains O^{2-} ions.
The volume of one mole of gas at this temperature and pressure is 24.0 dm^3.
What could be the identity of the metal?

A calcium **B** magnesium **C** potassium **D** sodium

8. M/J 18/P12/Q12
Which oxide does not react with cold, dilute sodium hydroxide to produce a salt?

A Al_2O_3 **B** P_4O_{10} **C** SO_2 **D** SiO_2

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9. O/N 18/P12/Q13

Which observations are made when a sample of silicon chloride, $SiCl_4$, is added to a beaker of water?

A No visible change is observed.

B Steamy fumes and a precipitate are both observed.

C The appearance of a precipitate is the only observation.

D The appearance of steamy fumes is the only observation.

10. M/J 18/P13/Q13

X and Y are elements of the third period.
X and Y are individually heated in excess chlorine. Each product is purified and then separately added to water, producing two solutions. Both solutions have a pH of less than 5.
What could be X and Y?

A Na and P **B** Mg and Al **C** Mg and Si **D** Si and P

11. O/N 17/P12/Q14

Radium is an element below barium in Group 2 of the Periodic Table.
Which equation shows what happens when solid radium nitrate, $Ra(NO_3)_2$, is heated strongly?

A $Ra(NO_3)_2(s) \rightarrow RaO(s) + N_2O(g) + 2O_2(g)$

B $2Ra(NO_3)_2(s) \rightarrow 2RaO(s) + 2N_2(g) + 5O_2(g)$

C $2Ra(NO_3)_2(s) \rightarrow 2RaO(s) + 4NO_2(g) + O_2(g)$

D $4Ra(NO_3)_2(s) \rightarrow 2Ra_2O(s) + 8NO_2(g) + 3O_2(g)$

12. O/N 16/P12/Q14

Elements Y and Z are both in Period 3.
When the chloride of Y is added to water, it reacts and a solution of pH 2 is produced.
When the chloride of Z is added to water, it dissolves and a solution of pH 7 is produced.
Which statement explains these observations?

A Both chlorides hydrolyse in water.

B Y is magnesium and Z is sodium.

C Y is phosphorus and Z is aluminium.

D Y is silicon and Z is sodium.

13. MAR 16/P12/Q8

Solid carbon dioxide, CO_2, is similar to solid iodine, I_2, in its structure and properties. Carbon is in Group 14. Silica, SiO_2, is a Group 14 compound. Which statement about solid CO_2 and solid SiO_2 is correct?

A Both solids exist in a lattice structure.

B Both solids have a simple molecular structure.

C Both solids have atoms joined by single covalent bonds.

D Both solids change spontaneously to gas at s.t.p.

14. MAR 16/P12/Q12

Consecutive elements **X**, **Y** and **Z** are in Period 3 of the Periodic Table. Element **Y** has the highest first ionisation energy and the lowest melting point of these three elements.
What are the identities of **X**, **Y** and **Z**?

A sodium, magnesium, aluminium

B magnesium, aluminium, silicon

C aluminium, silicon, phosphorus

D silicon, phosphorus, sulfur

15. M/J 11/P12/Q13, O/N 05/P1/Q13

In 1999, researchers working in the USA believed that they had made a new element and that it had the following electronic configuration.

$$[Rn]\ 5f^{14}6d^{10}7s^27p^6$$

In which Group of the Periodic Table would you expect to find this element?

A II **B** IV **C** VI **D** 0

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16. MAR 20/P12/Q36

Which statements are correct?

1 Aluminium chloride dissolves in water to give an acidic solution.
2 Magnesium chloride dissolves in water to give a solution of pH close to 7.
3 Sodium chloride dissolves in water to give an alkaline solution.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

17. M/J 18/P13/Q35

The structure of metals is considered to be positive ions surrounded by delocalised electrons.
The melting points of the metals in Period 3 increase with increasing atomic number.
Which statements help to explain this trend from sodium to aluminium?

1 The charge on the metal ion increases.
2 There are more delocalised electrons per metal ion.
3 The radius of the metal ion decreases.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

18. O/N 12/P13/Q35

In the gas phase, aluminium chloride exists as the dimer, Al_2Cl_6.
By using this information, which of the following are structural features of the Al_2Cl_6 molecule?

1 Each aluminium atom is surrounded by four chlorine atoms.
2 There are twelve non-bonded electron pairs in the molecule.
3 Each aluminium atom contributes electrons to four covalent bonds.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

19. O/N 10/P11/Q36, O/N 10/P13/Q37

Element X is a solid. It occurs as a contaminant of carbonaceous fuels.
Its oxide Y is formed in car engines.
Further oxidation of Y to Z can occur in the atmosphere.
Which statements about Y and Z are correct?

1 Molecule Y has lone pairs of electrons.
2 The atmospheric oxidation of Y to Z is a catalysed reaction.
3 Y is a colourless gas.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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9.4: Multiple Topics

1. O/N 18/P11/Q19, O/N 18/P13/Q19, M/J 15/P13/Q16

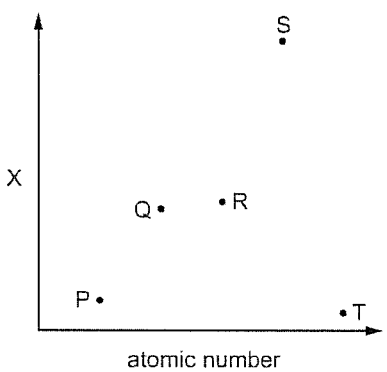
Transition elements and their compounds are widely used as catalysts.

What is the identity and what is the oxidation number of the element present in the catalyst used in the Contact process?

	element	oxidation number
A	iron	0
B	iron	+3
C	vanadium	0
D	vanadium	+5

2. MAR 17/P12/Q15

The magnitude of property X of five elements from the third period of the Periodic Table, P, Q, R, S and T is shown. P, Q, R, S and T have consecutive atomic numbers. The letters do not represent the symbols of the elements.



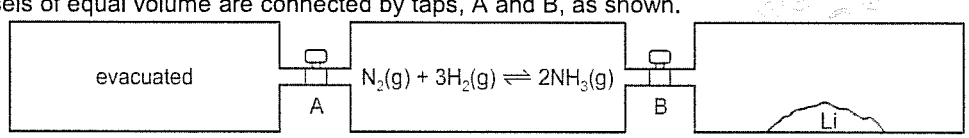
Which row correctly identifies property X and element R?

	property X	element R
A	electrical conductivity	Al
B	electronegativity	Si
C	melting point	Al
D	melting point	Si

3. O/N 16/P12/Q11

Lithium reacts with nitrogen at room temperature to form solid Li_3N.

Three vessels of equal volume are connected by taps, A and B, as shown.



At the start, A and B are closed, the left-hand vessel is evacuated, the middle vessel has the indicated reaction at equilibrium and the right-hand vessel contains lithium only.

Which action would allow the equilibrium mixture to contain the most ammonia?

A Keep both A and B closed.
B Open both A and B.
C Open A only.
D Open B only.

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4. O/N 17/P11/Q13, O/N 17/P13/Q13

An element Y reacts according to the following sequence.

$$Y \xrightarrow{\text{burns in } O_2} \text{white solid} \xrightarrow{HCl(aq)} \text{solution} \xrightarrow{NaOH(aq)} \text{white precipitate} \xrightarrow{\text{an excess of } NaOH(aq)} \text{solution}$$

What could be element Y?

A Al **B** Ca **C** Mg **D** P

5. M/J 15/P11/Q18

Mohr's salt is a pale green crystalline solid which is soluble in water. It contains two cations, one of which is Fe^{2+}, and one anion which is SO_4^{2-}.

The identity of the second cation was determined by heating Mohr's salt with aqueous sodium hydroxide. A colourless gas was evolved which readily dissolved in water giving an alkaline solution.

A green precipitate was also formed.

What are the identities of the gas and the precipitate?

	gas	precipitate
A	NH_3	$Fe(OH)_2$
B	NH_3	Na_2SO_4
C	SO_2	$Fe(OH)_2$
D	SO_2	Na_2SO_4

6. O/N 14/P12/Q19

Which oxide does not react with cold dilute sodium hydroxide to produce a salt?

A Al_2O_3 **B** P_4O_{10} **C** SO_2 **D** SiO_2

7. O/N 14/P13/Q19

A student examines two semi-precious stones; one is agate, SiO_2, and the other is calcite, $CaCO_3$.

How could they be distinguished?

A Add a fixed amount of cold aqueous sodium hydroxide to each separately and measure any temperature change.

B Heat each separately over a gentle Bunsen flame and note which one melts first.

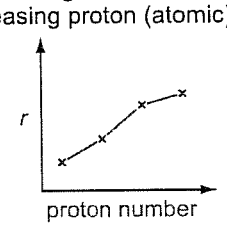
C Shake each separately with dilute hydrochloric acid and test any gas formed.

D Shake each separately with distilled water and add a few drops of Universal Indicator.

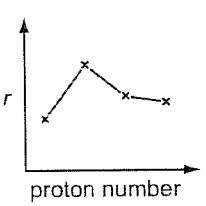
8. O/N 12/P12/Q19, O/N 12/P11/Q19

Which diagram shows the variation of the metallic radius r of the Group I elements, Li, Na, K and Rb, with increasing proton (atomic) number?

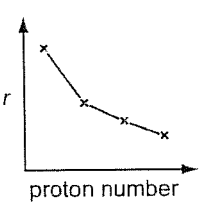
A



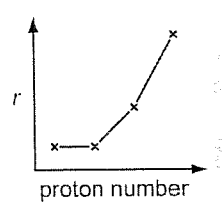
B



C



D



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9. O/N 12/P13/Q13

Mohr's salt is a pale green crystalline solid which is soluble in water. It contains two cations, one of which is Fe^{2+} and one anion which is SO_4^{2-}.
The identity of the second cation was determined by heating solid Mohr's salt with solid sodium hydroxide and a colourless gas was evolved. The gas readily dissolved in water giving an alkaline solution.
A grey-green solid residue was also formed which was insoluble in water.
What are the identities of the gas and the solid residue?

	gas	residue
A	NH_3	$Fe(OH)_2$
B	NH_3	Na_2SO_4
C	SO_2	$Fe(OH)_2$
D	SO_2	Na_2SO_4

10. O/N 11/P12/Q6

Three compounds have the physical properties shown in the table.

compound	P	Q	R
melting point/°C	2852	993	–119
boiling point/°C	3600	1695	39
conductivity (solid)	poor	poor	poor
conductivity (liquid)	good	good	poor
conductivity (aqueous)	insoluble	good	insoluble

What might be the identities of **P**, **Q** and **R**?

	P	Q	R
A	MgO	KC*l*	NH_3
B	MgO	NaF	C_2H_5Br
C	SiO_2	KC*l*	C_2H_5Br
D	SiO_2	NaF	HC*l*

11. M/J 09/P1/Q18

Mohr's salt is a pale green crystalline solid which is soluble in water. It is a 'double sulfate' which contains two cations, one of which is Fe^{2+}.
The identity of the second cation was determined by heating solid Mohr's salt with solid sodium hydroxide and a colourless gas was evolved. The gas readily dissolved in water giving an alkaline solution. A grey-green solid residue was also formed which was insoluble in water.
What are the identities of the gas and the solid residue?

	gas	residue
A	H_2	$FeSO_4$
B	NH_3	Na_2SO_4
C	NH_3	$Fe(OH)_2$
D	SO_2	$Fe(OH)_2$

12. M/J 09/P1/Q13, O/N 02/P1/Q16

River water in a chalky agricultural area may contain Ca^{2+}, Mg^{2+}, CO_3^{2-}, HCO_3^-, Cl^-, and NO_3^- ions. In a waterworks, such water is treated by adding a calculated quantity of calcium hydroxide.
What will be precipitated following the addition of calcium hydroxide?

A $CaCl_2$ **B** $CaCO_3$ **C** $MgCO_3$ **D** $Mg(NO_3)_2$

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13. O/N 16/P12/Q33

X is an element that has

- its outer electrons in the 4th principal quantum shell,
- a higher 1st ionisation energy than calcium.

What could be the identity of **X**?

1 bromine
2 krypton
3 xenon

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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Answers Sections

9.1		9.2		9.2		9.3		9.4	
1.	D	1.	B	41.	C	1.	B	1.	D
2.	B	2.	D	42.	D	2.	A	2.	C
3.	D	3.	A	43.	B	3.	A	3.	A
4.	D	4.	A	44.	D	4.	D	4.	A
5.	B	5.	A	45.	B	5.	C	5.	A
6.	D	6.	A	46.	C	6.	A	6.	D
7.	C	7.	C	47.	A	7.	A	7.	C
8.	A	8.	B	48.	D	8.	D	8.	A
9.	D	9.	A	49.	C	9.	B	9.	A
10.	B	10.	D	50.	D	10.	D	10.	B
11.	B	11.	C	51.	B	11.	C	11.	C
12.	B	12.	D	52.	A	12.	D	12.	B
13.	B	13.	A			13.	A	13.	B
14.	C	14.	C			14.	D		
15.	D	15.	A			15.	D		
16.	A	16.	B			16.	B		
17.	D	17.	C			17.	A		
18.	C	18.	D			18.	D		
19.	C	19.	C			19.	A		
20.	D	20.	D						
21.	A	21.	D						
22.	C	22.	B						
23.	D	23.	B						
24.	D	24.	C						
25.	D	25.	B						
26.	C	26.	B						
27.	B	27.	D						
28.	C	28.	D						
29.	A	29.	B						
30.	C	30.	C						
31.	D	31.	A						
32.	B	32.	D						
33.	D	33.	A						
34.	D	34.	A						
35.	A	35.	C						
		36.	B						
		37.	B						
		38.	A						
		39.	C						
		40.	C						

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Unit 10

GROUP 2

A Level
Chemistry Paper 1
Classified/Topical MCQ's
Article Number: 231

Editorial Board

Syllabus

10.1 Similarities and trends in the properties of the Group 2 metals, magnesium to barium, and their compounds
10.2 Some uses of Group 2 compounds
10.3 Multiple topics

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Unit 10: Group 2

10.1: Similarities and trends in the properties of the Group 2 metals, magnesium to barium and their compounds

1. M/J 20/P12/Q17

Which property shows an increase from magnesium to barium?

A the first ionisation energy of the elements
B the oxidising power of the metals
C the solubility of the hydroxides
D the solubility of the sulfates

2. M/J 20/P11/Q14

An excess of MgO is shaken with water. The resulting mixture is filtered into test-tube P.
An excess of BaO is shaken with water. The resulting mixture is filtered into test-tube Q.
Which oxide reacts more readily with water and which filtrate has the lower pH?

	oxide reacts more readily with water	test-tube with filtrate of **lower** pH
A	BaO	P
B	BaO	Q
C	MgO	P
D	MgO	Q

3. M/J 20/P13/Q14

The statements apply to the elements in Group 2.
Which statement is correct?

A As atomic number increases, ionic radius increases.
B As atomic number increases, reducing ability decreases.
C As atomic number increases, first ionisation energy increases.
D As atomic radius increases, first ionisation energy increases.

4. M/J 20/P13/Q18

Which property shows an increase from calcium to barium going down Group 2?

A the ease of decomposition of the carbonates
B the solubility of the hydroxides
C the solubility of the sulfates
D the volume of hydrogen given off when 1 g of the metal reacts with water

5. MAR 20/P12/Q13

Compound Z is insoluble in water but soluble at low pH.
What could be compound Z?

A barium carbonate **B** barium chloride **C** barium hydroxide **D** barium sulfate

6. M/J 19/P12/Q16

A white solid, Z, is soluble in water. A sample of Z is heated with a Bunsen burner until there is no further change. When the residue is shaken with water a solution is formed with no solid remaining.
What could Z be?

A $MgCO_3$ **B** $Mg(NO_3)_2$ **C** $BaCO_3$ **D** $Ba(NO_3)_2$

7. M/J 19/P11/Q14

Substance X reacts with water. A gas is given off and the pH of the solution increases. The solution is then reacted with sulfuric acid and a white precipitate forms.
What could be substance X?

A barium **B** barium oxide **C** magnesium **D** magnesium oxide

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8. O/N 19/P12/Q14, M/J 14/P11/Q13

When equal volumes of saturated solutions of barium hydroxide and calcium hydroxide are mixed, a white precipitate, **Y**, forms. The mixture is filtered and carbon dioxide is bubbled through the filtrate, producing a second white precipitate, **Z**.

What are **Y** and **Z**?

	Y	Z
A	$Ba(OH)_2$	$Ca(OH)_2$
B	$Ba(OH)_2$	$CaCO_3$
C	$Ca(OH)_2$	$BaCO_3$
D	$Ca(OH)_2$	$Ba(OH)_2$

9. M/J 19/P12/Q15

How many of the solutions shown, when added to separate portions of magnesium sulfate solution, produce a white precipitate?

HCl(aq) $NH_3(aq)$ $(NH_4)_2CO_3(aq)$ $Ba(NO_3)_2(aq)$

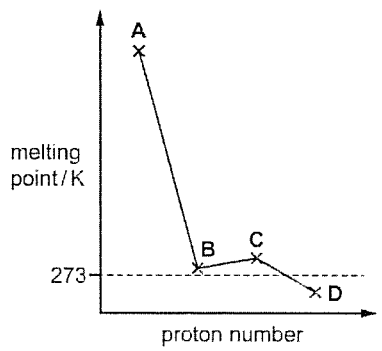
A 0 **B** 1 **C** 2 **D** 3

10. M/J 19/P11/Q13

The relative melting points of four consecutive elements in the Periodic Table are shown in the graph.

The elements all have proton numbers less than 20.

Which element is in Group 16?



11. M/J 19/P11/Q15, M/J 16/P13/Q14

Solutions of $Mg(NO_3)_2$ and $Ba(NO_3)_2$ separately undergo a series of reactions.

$Mg(NO_3)_2(aq)$ —(sodium carbonate solution)→ M —(excess HCl(aq))→ N —(excess NaOH(aq))→ P

$Ba(NO_3)_2(aq)$ —(sodium carbonate solution)→ Q —(excess HCl(aq))→ R —(excess NaOH(aq))→ S

M, N and P are magnesium compounds.

Q, R and S are barium compounds.

How many of M, N, P, Q, R and S are white precipitates?

A 2 **B** 3 **C** 4 **D** 5

12. MAR 19/P12/Q16

L, M and N are Group 2 metals. L reacts more vigorously with dilute hydrochloric acid than N does. $M(OH)_2$ is more soluble than $N(OH)_2$.

What could be the identities of L, M and N?

	L	M	N
A	Ba	Ca	Sr
B	Ba	Sr	Ca
C	Ca	Ba	Sr
D	Sr	Ca	Ba

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13. O/N 18/P12/Q14

A 4.00 g sample of an anhydrous Group 2 metal nitrate is heated strongly until there is no further change. A solid residue of mass 1.37 g is formed.

Which metal is present?

A barium **B** calcium **C** magnesium **D** strontium

14. O/N 18/P12/Q15

In which row are all statements comparing magnesium and barium correct?

	fourth ionisation energy		reaction with water	
	magnesium	barium	magnesium	barium
A	higher	lower	faster	slower
B	higher	lower	slower	faster
C	lower	higher	faster	slower
D	lower	higher	slower	faster

15. O/N 18/P11/Q15, O/N 18/P13/Q15

A sample of anhydrous calcium nitrate is placed in a test-tube and heated in a roaring Bunsen flame until it decomposes. The description of the gas in the test-tube is then noted. A glowing splint is then put into the test-tube and any changes are noted.

Which observations are correct?

	description of the gas in the test-tube	result of glowing splint test
A	brown	the splint goes out
B	brown	the splint relights
C	colourless	the splint goes out
D	colourless	the splint relights

16. O/N 18/P11/Q18, O/N 18/P13/Q18, O/N 10/P12/Q15

Which statement explains the observation that magnesium hydroxide dissolves in aqueous ammonium chloride, but not in aqueous sodium chloride?

A The ionic radius of the NH_4^+ ion is similar to that of Mg^{2+} but not that of Na^+.

B NH_4Cl dissociates less fully than NaCl.

C The Na^+ and Mg^{2+} ions are isoelectronic (have the same number of electrons).

D The NH_4^+ ion can donate a proton.

17. M/J 18/P11/Q18

When 3.00 g of an anhydrous nitrate of a Group 2 metal is decomposed, 1.53 g of gas is produced.

What is the nitrate compound?

A beryllium nitrate **B** calcium nitrate **C** magnesium nitrate **D** strontium nitrate

18. M/J 17/P12/Q14

Trends are seen in the physical and chemical properties of the elements of Group 2 and their compounds.

Which property shows a **decrease** from magnesium to barium?

A the rate of the reaction between the element and dilute hydrochloric acid

B the solubility of the hydroxides

C the solubility of the sulfates

D the temperature of decomposition of the carbonates

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19. M/J 18/P11/Q19

Which row correctly describes one property of barium and one property of barium oxide?

	observation when barium metal is added to water	pH of solution obtained when a spatula measure of BaO is added to 100 cm^3 of water
A	a few gas bubbles form on the metal surface	8
B	a few gas bubbles form on the metal surface	13
C	rapid effervescence is seen	8
D	rapid effervescence is seen	13

20. M/J 17/P11/Q14

An excess of MgO is shaken with water. The resulting mixture is filtered into test-tube X.
An excess of BaO is shaken with water. The resulting mixture is filtered into test-tube Y.
Which oxide reacts more readily with water and which filtrate has the lower pH?

	oxide reacts more readily with water	test-tube with filtrate of **lower** pH
A	barium oxide	X
B	barium oxide	Y
C	magnesium oxide	X
D	magnesium oxide	Y

21. M/J 17/P11/Q15

Samples of magnesium carbonate, $MgCO_3$, are placed in crucibles R and S. The sample in crucible R is heated until there is no further loss in mass, and then allowed to cool. The sample in crucible S is left unheated.
Dilute hydrochloric acid is then added to both crucibles.
On adding the dilute hydrochloric acid, which observations are correct?

	R	S
A	gas produced	gas produced
B	gas produced	no gas produced
C	no gas produced	gas produced
D	no gas produced	no gas produced

22. M/J 17/P13/Q15

Which row correctly describes the reactions of calcium and strontium with water?

	substance reduced	substance oxidised	more vigorous reaction
A	calcium or strontium	water	calcium + water
B	calcium or strontium	water	strontium + water
C	water	calcium or strontium	calcium + water
D	water	calcium or strontium	strontium + water

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23. M/J 17/P13/Q14

The table gives information about calcium carbonate and calcium hydroxide.
Which row is correct?

	calcium carbonate is more soluble than calcium hydroxide	calcium hydroxide can be manufactured using calcium carbonate as a starting material
A	no	no
B	no	yes
C	yes	no
D	yes	yes

24. MAR 17/P12/Q14

Why does barium react more rapidly with cold water than magnesium does?

A Barium atoms are larger and form ions more easily than magnesium atoms.
B Barium floats on the surface of the water but magnesium sinks in the water.
C Barium hydroxide is less soluble than magnesium hydroxide.
D The sum of the 1st and 2nd ionisation energies of barium is more than that for magnesium.

25. MAR 17/P12/Q18

Z is an anhydrous compound of a Group 2 element. When it is heated, **Z** undergoes thermal decomposition to produce two different gases. **Z** has relatively low thermal stability compared to other Group 2 compounds containing the same anion as **Z**.
What is compound **Z**?

A barium carbonate
B barium nitrate
C magnesium carbonate
D magnesium nitrate

26. O/N 16/P12/Q17

When heated, magnesium nitrate decomposes.
Which equation for the thermal decomposition of magnesium nitrate is correct?

A $Mg(NO_3)_2 \rightarrow MgO + NO_2 + NO + O_2$
B $2Mg(NO_3)_2 \rightarrow 2MgO + 4NO + 3O_2$
C $2Mg(NO_3)_2 \rightarrow 2MgO + 4NO_2 + O_2$
D $3Mg(NO_3)_2 \rightarrow Mg_2N_3 + MgO + 3NO + 7O_2$

27. O/N 16/P11/Q18, O/N 16/P13/Q18

Which row of the table gives correct comparisons between the solubilities of calcium and barium hydroxide and the thermal stabilities of calcium and barium carbonate?

	solubility		thermal stability	
	calcium hydroxide	barium hydroxide	calcium carbonate	barium carbonate
A	higher	lower	higher	lower
B	higher	lower	lower	higher
C	lower	higher	higher	lower
D	lower	higher	lower	higher

28. M/J 16/P13/Q16, M/J 11/P11/Q14, M/J 11/P13/Q14

Steam is passed over heated magnesium to give compound J and hydrogen.
What is not a property of compound J?

A It has an M_r of 40.3.
B It is basic.
C It is a white solid.
D It is very soluble in water.

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29. M/J 16/P11/Q14

X and Y are both Group 2 metals.
X and Y both form hydroxide compounds, but $X(OH)_2$ is more soluble in water than $Y(OH)_2$.
If a piece of metal Y is put into cold water a very slow reaction occurs, and only a very few, small hydrogen bubbles can be seen.
What could be the identities of X and Y?

	X	Y
A	barium	magnesium
B	barium	strontium
C	calcium	strontium
D	magnesium	calcium

30. M/J 16/P11/Q16

In some areas lime, $Ca(OH)_2$, is added to soil to improve crop growth.
Which statement correctly describes a reason why lime improves crop growth?

A Lime acts as a catalyst which speeds up the release of nitrates into the soil.
B Lime is an effective pesticide and protects the plants from damage.
C Lime is used to reduce the acidity of the soil.
D Lime lowers the pH of the soil.

31. O/N 15/P12/Q12

Which property decreases on descending Group II?

A radius of the cation, M^{2+}
B reactivity of the element with water
C shielding of outermost electrons
D the ease of thermal decomposition of the carbonates, MCO_3

32. O/N 15/P11/Q12, O/N 15/P13/Q12

X is a Group II metal. The carbonate of **X** decomposes when heated in a Bunsen flame to give carbon dioxide and a white solid residue as the only products. This white solid residue is
sparingly soluble in water. Even when large amounts of the solid residue are added to water the pH of the saturated solution is less than that of limewater.
What could be the identity of **X**?

A magnesium **B** calcium **C** strontium **D** barium

33. O/N 15/P11/Q13, O/N 15/P13/Q13, O/N 12/P13/Q16

Rat poison needs to be insoluble in rain water but soluble at the low pH of stomach contents.
What is a suitable barium compound to use for rat poison?

A barium carbonate **B** barium chloride **C** barium hydroxide **D** barium sulfate

34. M/J 15/P13/Q18, O/N 08/P1/Q16, M/J 04/P1/Q16

Due to their similar ionic radii, the reactions of lithium and magnesium and their corresponding compounds are very similar.
Which statement about the reactions of lithium or its compounds can be predicted from this statement?

A Lithium burns very slowly in oxygen.
B Lithium carbonate decomposes on heating in a blue Bunsen burner flame, forming lithium oxide and carbon dioxide.
C Lithium nitrate decomposes on heating, forming lithium nitrite, $LiNO_2$, and oxygen.
D Lithium reacts very violently with cold water, liberating hydrogen.

35. M/J 14/P12/Q12

When barium is burnt in oxygen, what colour is the flame?

A green **B** orange **C** red **D** white

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36. O/N 14/P13/Q13

Pieces of calcium and magnesium are reacted separately with cold water.
Pieces of calcium and magnesium are also burned separately with oxygen.
Which row correctly describes the observations from these reactions?

	calcium with cold water	magnesium with cold water	calcium with oxygen	magnesium with oxygen
A	rapid bubbling	slow bubbling	red flame	white flame
B	rapid bubbling	slow bubbling	white flame	red flame
C	slow bubbling	rapid bubbling	red flame	white flame
D	slow bubbling	rapid bubbling	white flame	red flame

37. M/J 14/P12/Q15

Which statement about the oxides and hydroxides of the Group II elements Mg, Ca, Sr and Ba is correct?

A Each of the oxides reacts readily with water to form a solution of pH 12 or above.

B Magnesium oxide is used as a furnace lining because it has a giant molecular structure and hence a high melting point.

C The hydroxides are produced directly by the thermal decomposition of the corresponding nitrates.

D The solubility of the hydroxides increases from $Mg(OH)_2$ to $Ba(OH)_2$.

38. M/J 14/P11/Q17

Group II nitrates undergo thermal decomposition according to the following equation.

$$X(NO_3)_2 \rightarrow XO + 2NO_2 + \frac{1}{2} O_2$$

Which Group II nitrate requires the highest temperature to bring about its thermal decomposition?

A barium nitrate
B calcium nitrate
C manganesium nitrate
D strontium nitrate

39. M/J 14/P13/Q13

X is an s-block element. **X** forms an insoluble carbonate with the formula XCO_3. **X** forms a hydroxide that is more soluble than strontium hydroxide.
What could be the identity of **X**?

A barium **B** calcium **C** cobalt **D** rubidium

40. M/J 14/P13/Q15

Which substance will **not** be a product of the thermal decomposition of hydrated magnesium nitrate?

A dinitrogen monoxide
B magnesium oxide
C oxygen
D steam

41. M/J 14/P13/Q19

When strontium is burnt in oxygen, what colour is the flame?

A green **B** red **C** white **D** yellow

42. O/N 13/P12/Q13, O/N 13/P11/Q13

A metal, **X**, reacts with water to produce a colourless solution which gives a white precipitate when mixed with aqueous sulfuric acid.
What is metal **X**?

A barium **B** magnesium **C** potassium **D** sodium

43. O/N 13/P12/Q14, O/N 13/P11/Q14

Which property **increases** in value going down Group II?

A electronegativity
B ionic radius
C maximum oxidation number
D second ionisation energy

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44. M/J 13/P13/Q13

In which row of the table are all statements comparing magnesium and barium correct?

	fourth ionisation energy of magnesium	fourth ionisation energy of barium	reaction of magnesium with cold water	reaction of barium with cold water
A	higher	lower	faster	slower
B	higher	lower	slower	faster
C	lower	higher	faster	slower
D	lower	higher	slower	faster

45. M/J 13/P12/Q14

In which row of the table are all statements comparing the compounds of calcium and barium correct?

	solubility of calcium hydroxide	solubility of barium hydroxide	thermal stability of calcium carbonate	thermal stability of barium carbonate
A	higher	lower	higher	lower
B	higher	lower	lower	higher
C	lower	higher	higher	lower
D	lower	higher	lower	higher

46. M/J 13/P11/Q13

In which row of the table are all statements comparing the compounds of magnesium and barium correct?

	solubility of hydroxides		solubility of sulfates	
	solubility of magnesium hydroxide	solubility of barium hydroxide	solubility of magnesium sulfate	solubility of barium sulfate
A	higher	lower	higher	lower
B	higher	lower	lower	higher
C	lower	higher	higher	lower
D	lower	higher	lower	higher

47. M/J 13/P11/Q19

Which reagent, when mixed and heated with ammonium sulfate, liberates ammonia?

A aqueous bromine
B dilute hydrochloric acid
C limewater
D potassium dichromate(VI) in acidic solution

48. M/J 12/P11/Q13, M/J 12/P13/Q12, O/N 05/P1/Q16

When a mineral was heated in a Bunsen flame to constant mass, a colourless gas that turned lime water milky was evolved. The remaining solid was cooled and then added to aqueous hydrochloric acid. Vigorous effervescence was seen.

What was the mineral?

A aragonite, $CaCO_3$
B artinite, $MgCO_3.Mg(OH)_2.3H_2O$
C barytocalcite, $BaCO_3.CaCO_3$
D dolomite, $CaCO_3.MgCO_3$

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49. O/N 12/P12/Q14, O/N 12/P11/Q14

What are the trends in the stated properties as Group II is descended from magnesium to barium?

	decomposition temperature of the carbonate	first ionisation energy
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

50. M/J 12/P11/Q15, M/J 12/P13/Q14

The oxides BaO, CaO, MgO and SrO all produce alkaline solutions when added to water.
Which oxide produces the saturated solution with the highest pH?

A BaO(aq) **B** CaO(aq) **C** MgO(aq) **D** SrO(aq)

51. O/N 11/P11/Q15, O/N 11/P13/Q14, O/N 06/P1/Q14

A 5.00 g sample of an anhydrous Group II metal nitrate loses 3.29 g in mass when heated strongly.
Which metal is present?

A magnesium **B** calcium **C** strontium **D** barium

52. O/N 10/P12/Q12

Equimolar quantities of magnesium carbonate and strontium carbonate are separately heated to bring about complete thermal decomposition. The minimum temperature for this to occur is called T_d.
The cold residues are separately added to equal volumes of water and the change in pH is measured. The change in pH is called ΔpH.
Which metal has the higher value of T_d, and the greater value of ΔpH?

	T_d	ΔpH
A	Mg	Mg
B	Mg	Sr
C	Sr	Mg
D	Sr	Sr

53. O/N 10/P13/Q17, O/N 10/P11/Q14

When magnesium nitrate, $Mg(NO_3)_2.7H_2O$, is heated, which three gases are given off?

A dinitrogen oxide, oxygen, water vapour
B hydrogen, nitrogen, oxygen
C hydrogen, nitrogen dioxide, oxygen
D nitrogen dioxide, oxygen, water vapour

54. O/N 10/P11/Q19, O/N 10/P13/Q19

Which property of beryllium and its compounds is typical of the elements below it in Group II?

A Be does not react with hot water.
B $BeCl_2$ is covalent.
C $Be(NO_3)_2$ produces BeO on thermal decomposition.
D BeO dissolves in alkalis.

55. M/J 10/P12/Q19, M/J 10/P13/Q18, M/J 10/P11/Q17

Which property of Group II elements (beryllium to barium) decreases with increasing atomic number?

A reactivity with water
B second ionisation energy
C solubility of hydroxides
D stability of the carbonates

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56. O/N 19/P12/Q35

Silicon forms a tetrachloride, $SiCl_4$.

Which statements are correct?

1 In $SiCl_4$, the Si is d+ and each Cl is $\delta-$.
2 $SiCl_4$ is a liquid at room temperature.
3 $SiCl_4$ reacts with water to give an acidic solution and a precipitate.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

57. M/J 19/P12/Q35

Which reactions involving calcium and its compounds produce two gaseous products?

1 heating solid anhydrous calcium nitrate
2 heating solid anhydrous calcium carbonate
3 adding calcium metal to water

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

58. M/J 19/P11/Q35

Which oxides, when placed in cold water for one day, will react with the water?

1 MgO 2 Al_2O_3 3 SiO_2

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

59. M/J 19/P11/Q36

A mixture of magnesium carbonate and magnesium nitrate is heated strongly in a hard-glass test-tube.

Which gases are formed?

1 carbon dioxide 2 nitrogen dioxide 3 oxygen

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

60. O/N 17/P12/Q35

Which statements correctly describe a trend on going down Group 2?

1 Reactivity of the elements increases.
2 First ionisation energy of the elements decreases.
3 The hydroxides become more soluble in water.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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61. O/N 18/P11/Q35, O/N 18/P13/Q35

Which reaction routes can be used to make a pure sample of barium sulfate?

1 Ba metal $\xrightarrow[\text{in } O_2]{\text{heat}}$ product $\xrightarrow[HCl]{\text{dilute}}$ product 2 $\xrightarrow[H_2SO_4]{\text{dilute}}$ product 3 $\xrightarrow[\text{and dry}]{\text{filter, wash}}$

2 $Ba(NO_3)_2$ $\xrightarrow[\text{heat in air}]{\text{strong}}$ solid product $\xrightarrow[\text{of water}]{\text{an excess}}$ product 2 $\xrightarrow[H_2SO_4]{\text{dilute}}$ product 3 $\xrightarrow[\text{and dry}]{\text{filter, wash}}$

3 $Ba(OH)_2$ $\xrightarrow[HNO_3]{\text{dilute}}$ product $\xrightarrow[H_2SO_4]{\text{dilute}}$ product 2 $\xrightarrow[\text{and dry}]{\text{filter, wash}}$

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

62. O/N 18/P11/Q36, O/N 18/P13/Q36

Which properties increase from magnesium to barium?

1 ionic radius of the cation M^{2+}
2 screening of outermost electrons by inner shells
3 solubility of the hydroxides, $M(OH)_2$, in water

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

63. O/N 17/P11/Q35, O/N 17/P13/Q35

Which statements about the elements barium and calcium and their compounds are correct?

1 Barium nitrate decomposes at a higher temperature than calcium nitrate.
2 Barium hydroxide is more soluble in water than is calcium hydroxide.
3 Calcium is more reactive with water than is barium.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

64. M/J 17/P13/Q35

The formula of a solid magnesium compound is $Mg(NO_3)_2.6H_2O$. When the solid compound is heated in a hard-glass test-tube, one or more changes are observed.

Which statements are correct?

1 Strong heating produces a basic residue.
2 Strong heating produces a brown gas.
3 Gentle heating produces colourless droplets of liquid on the upper parts of the test-tube.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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65. O/N 16/P12/Q35

Equal masses of barium carbonate and magnesium carbonate powders are mixed together. The mixture is then heated using a Bunsen burner flame until there is no further change. A gas is given off.
Which statements are correct?

1 The residue left after heating reacts with aqueous hydrochloric acid to produce carbon dioxide.
2 The percentage decrease in mass after heating is 26% (to 2 significant figures).
3 The gas given off during heating relights a glowing splint.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

66. O/N 15/P11/Q35, O/N 15/P13/Q35, O/N 08/P1/Q34

Which statements concerning the Group II elements magnesium, calcium and barium are correct?

1 Their reactivity increases with increasing relative atomic mass.
2 The oxidation number exhibited in their stable compounds is +2.
3 On strong heating, their nitrates give off oxygen only.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

67. M/J 15/P11/Q36

X is a Group II metal. It forms a sulfate which is more soluble than barium sulfate. It forms a hydroxide which is more soluble than calcium hydroxide.
What could be the identity of **X**?

1 strontium 2 magnesium 3 beryllium

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

68. O/N 14/P12/Q36, O/N 14/P11/Q36

Which statements about calcium oxide are correct?

1 It reacts with cold water.
2 It is produced when calcium nitrate is heated.
3 It can be reduced by heating with magnesium.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

69. O/N 11/P12/Q34

Which properties would be expected for radium, $_{88}Ra$, or its compounds?

1 Radium carbonate would not decompose at the temperature of a Bunsen flame.
2 Radium hydroxide is very insoluble.
3 Radium does not react with cold water.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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70. O/N 11/P12/Q35

When a firework is lit, a fuel and an oxidising agent react together.
In one such firework, magnesium is the fuel and barium nitrate is the oxidising agent.
Which solids are produced when the firework is lit?

1 BaO
2 MgO
3 $Mg(NO_3)_2$

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

71. O/N 11/P13/Q35, O/N 11/P11/Q34

A farmer spreads lime on land which has already been treated with an ammonium nitrate fertiliser.
Which reactions will occur in the treated soil?

1 $Ca(OH)_2 + 2NH_4^+(aq) \rightarrow Ca^{2+}(aq) + 2NH_3 + 2H_2O$
2 $Ca(OH)_2 + 2H^+(aq) \rightarrow Ca^{2+}(aq) + 2H_2O$
3 $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

72. O/N 10/P11/Q34, O/N 10/P13/Q35

Samples of calcium and barium are separately added to beakers of cold water containing a few drops of litmus solution.
Which observations will be made with **only** the calcium and **not** with the barium?

1 A white suspension appears in the water.
2 The solution turns blue.
3 A gas is evolved.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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10.2: Some uses of Group 2 compounds

1. M/J 20/P12/Q18

A test-tube of HBr(g) and a separate test-tube of HI(g) are heated to the same temperature.
Which combination of observations is possible?

	test-tube of HBr(g)	test-tube of HI(g)
A	a brown vapour appears	no change
B	a purple vapour appears	no change
C	no change	a brown vapour appears
D	no change	a purple vapour appears

2. M/J 18/P12/Q15

To manufacture cement, 1000 million tonnes of limestone are decomposed each year. To manufacture lime for agriculture, 200 million tonnes of limestone are decomposed each year.
What is the total mass of carbon dioxide in million tonnes produced from these two processes in a year?

A 440 **B** 528 **C** 660 **D** 880

3. M/J 18/P12/Q16

In Group 2 of the Periodic Table, the properties of the elements and their compounds show regular change down the group.
Which property shows a decrease from magnesium to barium?

A the decomposition temperature of the carbonates
B the decomposition temperature of the nitrates
C the solubility of the hydroxides
D the solubility of the sulfates

4. O/N 17/P11/Q14, O/N 17/P13/Q14

Which compound would most usually be added to soil to reduce its acidity?

A aluminium hydroxide **C** magnesium hydroxide
B calcium hydroxide **D** sodium hydroxide

5. MAR 16/P12/Q18, O/N 13/P13/Q14

River water in a chalky agricultural area contains Ca^{2+}, Mg^{2+}, CO_3^{2-}, HCO_3^-, Cl^- and NO_3^- ions. In a water treatment plant, such water is treated by adding a calculated quantity of calcium hydroxide.
What will be precipitated from the river water following the addition of calcium hydroxide?

A $CaCl_2$ **B** $CaCO_3$ **C** $Ca(NO_3)_2$ **D** $Mg(NO_3)_2$

6. M/J 15/P11/Q13

The three minerals below are obtained from mines around the world. Each one behaves as a mixture of two carbonate compounds. They can be used as fire retardants because they decompose in the heat, producing CO_2. This gas smothers the fire.

barytocite $BaCa(CO_3)_2$
dolomite $CaMg(CO_3)_2$
huntite $Mg_3Ca(CO_3)_4$

What is the order of effectiveness as fire retardant, from best to worst?

	best → worst		
A	dolomite	barytocite	huntite
B	dolomite	huntite	barytocite
C	huntite	barytocite	dolomite
D	huntite	dolomite	barytocite

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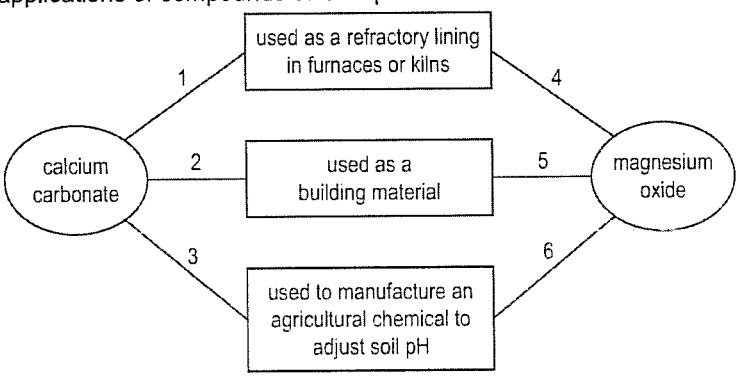
7. O/N 13/P12/Q15, O/N 13/P11/Q15

Which row correctly identifies the uses of some of the compounds of Group II metals?

	used as a refractory lining in kilns	used in agriculture to increase the pH of a soil
A	CaO	$Ca(OH)_2$
B	CaO	$Mg(OH)_2$
C	MgO	$Ca(OH)_2$
D	MgO	$Mg(OH)_2$

8. O/N 13/P13/Q13

The diagram shows some applications of compounds of Group II elements.



Which numbered links are correct?

	calcium carbonate	magnesium oxide
A	1, 2 and 3	4 and 5 only
B	1, 2 and 3	5 and 6 only
C	2 and 3 only	4 only
D	2 and 3 only	6 only

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9. O/N 18/P12/Q36

Which statements concerning calcium hydroxide are correct?

1 It is less soluble in water than strontium hydroxide.
2 When it is added to water an alkaline solution is formed.
3 It is used in agriculture to lower soil pH.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

10. M/J 18/P12/Q36

Solid barium oxide is added to some ammonium sulfate solution in a test-tube and the mixture is warmed. A piece of damp red litmus paper is held over the mouth of the test-tube.

Which observations would be made?

1 The damp litmus paper initially turns from red to blue.
2 A white precipitate forms in the test-tube.
3 A brown gas is evolved with strong heating.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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11. M/J 13/P13/Q35

Solids **W**, **X**, **Y** and Z are compounds of two different Group II metals. Some of their applications are described below.

Compound **W** is used as a refractory lining material in kilns.

Compound **X** is used as a building material. It can also be heated in a kiln to form compound **Y**.

When **Y** is hydrated, it forms compound **Z** which is used agriculturally to treat soils.

Which statements about these compounds are correct?

1 More acid is neutralised by 2.0 g of **X** than by 2.0 g of **W**.
2 The M_r of **X** is greater than the M_r of **Y** by 44.0.
3 The metallic element in **Y** reacts with cold water more quickly then the metallic element in **W**.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

12. M/J 10/P12/Q34, M/J 10/P11/Q34, M/J 10/P13/Q35

When organic refuse decomposes in water carboxylic acids are formed. The water becomes acidic and aquatic life is destroyed.

Which additives are suitable to remove this acid pollution?

1 calcium carbonate
2 calcium hydroxide
3 potassium nitrate

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

13. O/N 09/P12/Q34, O/N 09/P11/Q35

A farmer added lime to damp soil, followed by the nitrogenous fertiliser ammonium sulfate. A chemical reaction occurred in the soil.

Which substances were formed in this reaction?

1 sulfuric acid
2 calcium sulfate
3 ammonia

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

14. M/J 09/P1/Q35

The rock dolomite is a double carbonate of magnesium and calcium, $CaCO_3.MgCO_3$.

When heated strongly, a product called *calcined dolomite* is formed which is used to line some furnaces for the production of metals.

Why is calcined dolomite used for this purpose?

1 It is a refractory material.
2 It will absorb acidic impurities in metallurgical processes.
3 It will reduce metallic oxides to metals.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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10.3: Multiple Topics

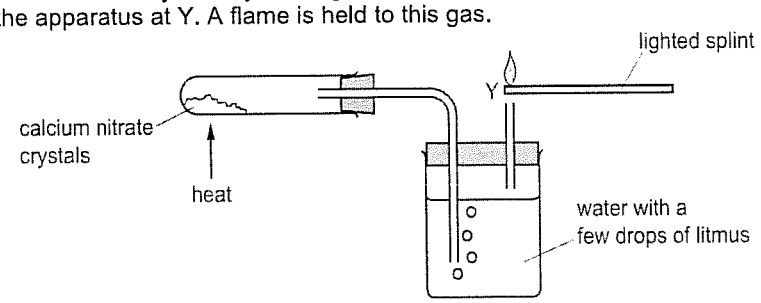
1. M/J 20/P13/Q12

Compound T is a white crystalline solid.
When a sample of compound T is mixed with aqueous sodium hydroxide and heated, a gas is produced which turns damp red litmus paper blue.
Further testing of a solution of compound T with aqueous barium chloride produces a dense white precipitate which does not dissolve when dilute hydrochloric acid is added to the mixture.
What is the identity of compound T?

A ammonium carbonate **C** sodium carbonate
B ammonium sulfate **D** sodium sulfate

2. MAR 20/P12/Q17

A student investigates calcium nitrate crystals by heating them in the apparatus shown.
A colourless gas leaves the apparatus at Y. A flame is held to this gas.



Which observations would the student make?

	litmus solution	flame at Y
A	changes to blue	flame burns more brightly
B	changes to blue	flame goes out
C	changes to red	flame burns more brightly
D	changes to red	flame goes out

3. O/N 19/P11/Q14, O/N 19/P13/Q14

A 5.00 g sample of an anhydrous Group 2 metal nitrate loses 3.29 g in mass when heated strongly.
Which metal is present?

A magnesium **B** calcium **C** strontium **D** barium

4. O/N 19/P11/Q15, O/N 19/P13/Q15

Solutions P and Q each contain a different Group 2 ion at the same concentration. One contains Mg^{2+}, the other contains Ba^{2+}. Tests are carried out on separate 5 cm^3 samples of P and Q.
test 1: add 1 cm^3 of 0.1 mol dm^{-3} $Na_2SO_4(aq)$
test 2: add 1 cm^3 of 0.1 mol dm^{-3} NaOH(aq)
What are the results of these tests?

	results in test 1	results in test 2
A	more precipitate with Ba^{2+}	more precipitate with Ba^{2+}
B	more precipitate with Ba^{2+}	more precipitate with Mg^{2+}
C	more precipitate with Mg^{2+}	more precipitate with Ba^{2+}
D	more precipitate with Mg^{2+}	more precipitate with Mg^{2+}

5. M/J 19/P13/Q15

River water in an agricultural area contains NH_4^+, CO_3^{2-}, HCO_3^-, Cl^- and NO_3^- ions. In a water treatment plant, this water is treated by adding a calculated quantity of calcium hydroxide.
What is precipitated from the river water when calcium hydroxide is added?

A CaCl **B** $CaCO_3$ **C** $Ca(NO_3)_2$ **D** NH_4OH

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6. M/J 18/P13/Q14

An ore contains magnesium carbonate and barium carbonate. A sample of the ore is dissolved in nitric acid.
How could this solution be processed into a magnesium compound and a separate barium compound?

A Add HCl (aq), filter off the solid barium chloride.

B Add HCl (aq), filter off the solid magnesium chloride.

C Add H_2SO_4(aq), filter off the solid barium sulfate.

D Add H_2SO_4(aq), filter off the solid magnesium sulfate.

7. M/J 18/P13/Q15

When calcium and calcium hydride, CaH_2, react separately with water, they each produce a white solid and a colourless gas. The white solid is the same compound in each reaction.
Which statement is correct?

A Both Ca and CaH_2 produce H_2.

B Both Ca and CaH_2 produce O_2.

C Ca produces H2 and CaH_2 produces O_2.

D Ca produces O_2 and CaH_2 produces H_2.

8. O/N 17/P12/Q19, O/N 14/P13/Q16

X is a mixture of two compounds of Group II elements.
X can undergo thermal decomposition to produce a white solid and only two gaseous products.
One of the gaseous products relights a glowing splint.
What could be the components of mixture **X**?

A $MgCl_2$ and $CaCO_3$

B $MgCO_3$ and $Ca(NO_3)_2$

C $Mg(NO_3)_2$ and $Ca(NO_3)_2$

D MgO and $CaSO_4$

9. O/N 17/P11/Q15, O/N 17/P13/Q15

The mineral dolomite is a mixture of magnesium carbonate and calcium carbonate.
An aqueous reagent, X, was added to a small sample of dolomite. Effervescence was seen and a white solid, Y, was formed.
What could be the correct identity of reagent X and solid Y?

	reagent X	solid Y
A	hydrochloric acid	calcium chloride
B	hydrochloric acid	magnesium chloride
C	sulfuric acid	calcium sulfate
D	sulfuric acid	magnesium sulfate

10. M/J 17/P12/Q15

Calcium oxide is added to water and the resulting mixture is filtered.
This filtrate is X.
When carbon dioxide is bubbled through filtrate X, a white precipitate is formed.
Which equation for this reaction of filtrate X with carbon dioxide is correct?

A $CaO + CO_2 \rightarrow CaCO_3$

B $Ca(OH)_2 + CO_2 \rightarrow CaO + H_2CO_3$

C $2CaO + H_2O + CO_2 \rightarrow CaCO_3 + Ca(OH)_2$

D $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

11. M/J 16/P12/Q16

A solid, **T**, was placed in an excess of the liquid **U**.
A colourless gas was given off and a white precipitate was seen. The precipitate was not **T**.
What could be the identities of **T** and **U**?

	T	U
A	$BaCO_3$	H_2O
B	Ca	dilute H_2SO_4
C	Mg	dilute H_2SO_4
D	$SrCO_3$	dilute HCl

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12. O/N 15/P12/Q5

Calcium forms an ionic compound with carbon, called calcium carbide. The oxidation number of carbon in calcium carbide is –1.
Calcium carbide is readily hydrolysed by water giving two products only.
What could be the formulae of calcium carbide and the two products of hydrolysis?

	calcium carbide	products
A	Ca_2C	CaO and C_2H_4
B	Ca_2C	$Ca(OH)_2$ and C_2H_2
C	CaC_2	CaO and C_2H_4
D	CaC_2	$Ca(OH)_2$ and C_2H_2

13. M/J 15/P12/Q14

Compound **X** releases carbon dioxide gas and forms a white solid, **Y**, when it is heated. Neither **X** nor **Y** are soluble in water. Compound **Y** is used as a refractory kiln lining.
What is compound **X**?

A $CaCO_3$ **B** CaO **C** $MgCO_3$ **D** MgO

14. M/J 14/P11/Q15

When calcium is burnt in oxygen, what colour is the flame?

A green **B** red **C** white **D** yellow

15. O/N 13/P13/Q19

Elements **J** and **K** react together to form compound **L**. Elements **J** and **K** are both in Period 3.
Element **J** has the smallest atomic radius in Period 3. There are only two elements in Period 3 which have a lower melting point than element **K**.
Which compound could be **L**?

A $MgCl_2$ **B** MgS **C** Na_2S **D** PCl_3

16. O/N 12/P13/Q18

Which oxide, when mixed with water, will produce the solution with the lowest pH?

A CO_2 **B** Na_2O **C** P_4O_{10} **D** SiO_2

17. M/J 12/P12/Q17

What can be seen when a piece of magnesium ribbon is placed in cold water?

A A vigorous effervescence occurs.
B Bubbles of gas form slowly on the magnesium.
C The magnesium floats on the surface of the water and reacts quickly.
D The magnesium glows and a white solid is produced.

18. O/N 11/P12/Q18

Lime mortar is made from quicklime, water and sand. Over a period of time, lime mortar changes into a much harder form. Both fresh and old lime mortar react with aqueous hydrochloric acid but only the old lime mortar effervesces during the reaction.
Which equation describes the change from fresh to old lime mortar?

A $CaO + CO_2 \rightarrow CaCO_3$
B $CaO + H_2O \rightarrow Ca(OH)_2$
C $Ca(OH)_2 \rightarrow CaO + H_2O$
D $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

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19. M/J 20/P13/Q35

Strontium nitrate is heated strongly for several minutes.
Which statements are correct?
1 A brown gas is produced.
2 A gas is produced that relights a glowing splint.
3 A white powder remains after heating.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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20. M/J 18/P13/Q32

Which statements are correct?

1 Magnesium carbonate decomposes at a lower temperature than calcium carbonate.
2 Calcium hydroxide is more soluble in water than magnesium hydroxide.
3 Calcium is a stronger reducing agent than magnesium.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

21. MAR 16/P12/Q36

A sample containing 0.40 mol of calcium nitrate was decomposed by heating in a roaring Bunsen burner flame until there was no further decomposition.

What are the products of this reaction?

1 0.40 mol of calcium oxide
2 0.40 mol of nitrogen, $N_2(g)$
3 0.40 mol of oxygen, $O_2(g)$

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

22. M/J 13/P12/Q34

Solids **W**, **X**, **Y** and **Z** are compounds of two different Group II metals. Some of their applications are described below.

Compound **W** is used as a refractory lining material in kilns.
Compound **X** is used as a building material. It can also be heated in a kiln to form compound **Y**.
When **Y** is hydrated, it forms compound **Z** which is used agriculturally to treat soils.

Which statements about these compounds are correct?

1 Adding **W** to water has less effect on pH than adding **Y**.
2 Adding **Z** to soil increases the pH of the soil.
3 The metallic element in **Y** reacts with cold water more quickly than the metallic element in **W**.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

23. M/J 13/P11/Q35

Solids **W**, **X**, **Y** and **Z** are compounds of two different Group II metals. Some of their applications are described below.

Compound **W** is used as a refractory lining material in kilns.
Compound **X** is used as a building material. It can also be heated in a kiln to form compound **Y**.
When **Y** is hydrated, it forms compound **Z** which is used agriculturally to treat soils.

Which statements about these compounds are correct?

1 More acid is neutralised by 1 g of **W** than by 1g of **X**.
2 The metallic element in **W** reacts with water more quickly than the metallic element in **Y**.
3 Adding **Z** to a soil decreases the pH of the soil.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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24. O/N 08/P1/Q34

Which statements concerning the Group II elements magnesium, calcium and barium are correct?

1 Their reactivity increases with increasing relative atomic mass.
2 The oxidation number exhibited in their stable compounds is +2.
3 On strong heating, their nitrates give off oxygen only.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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Answers Sections

10.1				10.2		10.3	
1.	C	41.	B	1.	D	1.	B
2.	A	42.	A	2.	B	2.	C
3.	A	43.	B	3.	D	3.	B
4.	B	44.	B	4.	B	4.	B
5.	A	45.	D	5.	B	5.	B
6.	D	46.	C	6.	D	6.	C
7.	A	47.	C	7.	C	7.	A
8.	C	48.	C	8.	C	8.	C
9.	D	49.	C	9.	B	9.	C
10.	C	50.	A	10.	B	10.	D
11.	B	51.	B	11.	C	11.	B
12.	B	52.	D	12.	B	12.	D
13.	B	53.	D	13.	C	13.	C
14.	B	54.	C	14.	B	14.	B
15.	B	55.	B			15.	D
16.	D	56.	A			16.	C
17.	D	57.	D			17.	B
18.	C	58.	D			18.	D
19.	D	59.	A			19.	A
20.	A	60.	A			20.	A
21.	C	61.	A			21.	D
22.	D	62.	A			22.	A
23.	B	63.	B			23.	D
24.	A	64.	A			24.	B
25.	D	65.	B				
26.	C	66.	B				
27.	D	67.	D				
28.	D	68.	B				
29.	A	69.	D				
30.	C	70.	B				
31.	D	71.	A				
32.	A	72.	D				
33.	A						
34.	B						
35.	A						
36.	A						
37.	D						
38.	A						
39.	A						
40.	A						

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Unit 11

GROUP 17

A Level
Chemistry Paper 1
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Syllabus

11.1 Physical properties of the Group 17 elements
11.2 The chemical properties of the elements and their hydrides
11.3 Some reactions of the halide ions
11.4 The reactions of chlorine with aqueous sodium hydroxide
11.5 Some important uses of the halogens and of halogen commands
11.6 Multiple topics

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Unit 11: Group 17

11.1: Physical properties of the Group 17 elements

1. **M/J 20/P13/Q13**
Which property explains the trend in volatility of the elements going down Group 17?
A decreasing covalent bond strength
B decreasing van der Waals' forces
C increasing covalent bond strength
D increasing van der Waals' forces

2. **M/J 18/P12/Q14**
In this question, X represents an atom of chlorine, bromine or iodine.
Which explanation for the variation in volatility down Group 17 is correct?
A Instantaneous dipole-induced dipole forces between molecules become stronger.
B Permanent dipole-permanent dipole forces between molecules become stronger.
C The bond energy of the X_2 molecules decreases.
D The first ionisation energy $X(g) \rightarrow X^+(g) + e^-$ decreases.

3. **O/N 17/P12/Q25**
Equal volumes of aqueous silver nitrate were added to separate small volumes of bromoethane and iodoethane in two test-tubes. The test-tubes were shaken.
Which row about the observations made for **bromoethane** is correct?

	colour of precipitate	rate of reaction
A	cream	faster than for iodoethane
B	cream	slower than for iodoethane
C	yellow	faster than for iodoethane
D	yellow	slower than for iodoethane

4. **O/N 17/P12/Q17**
Sodium bromide reacts with concentrated sulfuric acid.
Which observation will be made?
A A coloured vapour is produced.
B A purple solid is formed.
C A strong smell of H_2S is detected.
D Yellow sulfur is formed.

5. **O/N 17/P11/Q19, O/N 17/P13/Q19**
The strengths of the covalent bonds within halogen molecules, and the van der Waals' forces between halogen molecules, vary going down Group 17 from chlorine to bromine to iodine.
Which row shows these correctly?

	strength of covalent bonds	strength of van der Waals' forces
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

6. **O/N 15/P11/Q17, O/N 15/P13/Q17**
Which statement about bromine is correct?
A Bromine is insoluble in non-polar solvents.
B Bromine vapour is more dense than air.
C Bromine will not vaporise significantly under normal conditions.
D Gaseous bromine is purple.

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7. M/J 13/P12/Q19

The halogens exist as diatomic molecules, X_2.
The boiling points of the Group VII elements increase as the group is descended from chlorine to iodine.
Which statement helps to explain this increase in boiling point as Group VII is descended?

A The electronegativity of X decreases as the group is descended.

B The number of electrons in each X_2 molecule increases as the group is descended.

C The size of the permanent dipole in the X_2 molecule increases as the group is descended.

D The X – X bond strength increases as the group is descended.

8. M/J 13/P13/Q15

When iodine is heated, a vapour is produced.
Which row of the table correctly identifies the species in the vapour and its colour?

	species	colour
A	I(g)	brown
B	I(g)	purple
C	I_2(g)	brown
D	I_2(g)	purple

9. O/N 11/P11/Q17, O/N 11/P13/Q16

Why do the halogens become less volatile as Group VII is descended?

A The halogen-halogen bond energy decreases.

B The halogen-halogen bond length increases.

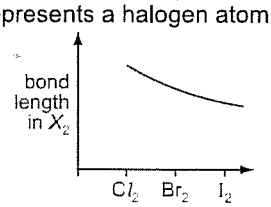
C The number of electrons in each molecule increases.

D The van der Waals' forces between molecules become weaker.

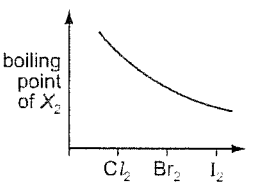
10. O/N 09/P12/Q14, O/N 09/P11/Q15, M/J 05/P1/Q16

Which graph correctly describes a trend found in the halogen group?
[X represents a halogen atom.]

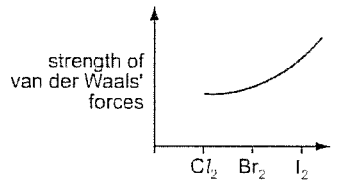
A



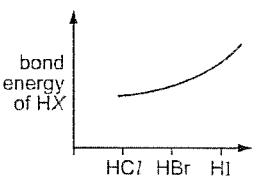
C



B



D



11. O/N 10/P12/Q18

Which statement about bromine is correct?

A Bromine is insoluble in non-polar solvents.

B Bromine vapour is more dense than air.

C Bromine will not vapourise significantly under normal conditions.

D Gaseous bromine is purple.

12. O/N 10/P11/Q17, O/N 10/P13/Q8

Which statement describes the halogens chlorine, bromine and iodine?

A Their bond energies decrease with increasing proton number.

B Their first ionisation energies increase with increasing proton number.

C They are all coloured gases at room temperature.

D They are all good reducing agents.

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13. MAR 20/P12/Q35, M/J 16/P11/Q35

The element astatine, At, is below iodine in Group 17 of the Periodic Table.
Which statements concerning At are likely to be correct?

1 It is a dark-coloured solid at room temperature.
2 It is a more powerful oxidising agent than iodine.
3 Its hydride is thermally stable.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

14. O/N 18/P12/Q32

The melting point of chlorine is lower than the melting point of iodine.
Which statements help to explain this difference?

1 Iodine has more electrons than chlorine and so has stronger van der Waals' forces.
2 An iodine molecule is more polar than a chlorine molecule.
3 The covalent bonds between iodine atoms are stronger than the covalent bonds between chlorine atoms.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

15. M/J 14/P12/Q35

Silver chloride dissolves in aqueous ammonia.
What happens in this process?

1 Ammonia forms a complex with the Ag^+ ion.
2 Ammonia acts as a Brnsted-Lowry base.
3 A redox reaction occurs.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

16. O/N 12/P11/Q34, O/N 12/P12/Q34

The element astatine, At, is below iodine in Group VII of the Periodic Table.
Which statements concerning At will be correct?

1 It is a dark-coloured solid at room temperature.
2 It is a more powerful oxidising agent than iodine.
3 Its hydride is thermally stable.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

17. O/N 08/P1/Q35

Chlorine is a greenish-yellow gas, bromine is a dark red liquid and iodine is a dark grey solid.
What causes these differences in volatility?

1 the halogen-halogen bond energy
2 the magnitude of the van der Waals' forces between the molecules
3 the number of electrons in the halogen molecule

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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11.2: The chemical properties of the elements and their hydrides

1. **M/J 20/P11/Q18**
Astatine, At, is below iodine in Group 17 of the Periodic Table.
Which statement is most likely to be correct?
A AgAt(s) reacts with an excess of dilute aqueous ammonia to form a solution of a soluble complex.
B Astatine and KCl (aq) react to form KAt(aq) and chlorine.
C KAt(aq) and dilute sulfuric acid react to form HAt(g).
D NaAt(s) and concentrated sulfuric acid react to form astatine.

2. **MAR 20/P12/Q12, M/J 14/P12/Q13**
X and Y are oxides of different Period 3 elements.
If one mole of Y is added to water, the solution formed is neutralised by exactly one mole of X. What could be the identities of X and Y?

	X	Y
A	Al_2O_3	P_4O_{10}
B	Al_2O_3	SO_3
C	Na_2O	P_4O_{10}
D	Na_2O	SO_3

3. **MAR 20/P12/Q14**
Hot aqueous sodium hydroxide reacts with chlorine.
$$6NaOH(aq) + 3Cl_2(g) \rightarrow 5NaCl(aq) + NaClO_3(aq) + 3H_2O(l)$$
Which statement is correct?
A The oxidation numbers of chlorine and hydrogen both change in the reaction.
B The oxidation numbers of chlorine in the products are –1 and +1.
C If the aqueous sodium hydroxide is cold the reaction produces NaClO instead of $NaClO_3$.
D Sodium undergoes disproportionation in this reaction.

4. **M/J 19/P11/Q16**
Concentrated sulfuric acid is added to separate solid samples of sodium chloride, sodium bromide and sodium iodide.
With which samples does sulfuric acid act as an oxidising agent?
A sodium chloride only
B sodium chloride and sodium bromide
C sodium bromide and sodium iodide
D sodium iodide only

5. **O/N 18/P12/Q16**
Which statement about the halogens is correct?
A Iodine cannot behave as an oxidising agent.
B The volatility of the elements increases from chlorine to iodine because of the increase in molecular size down the group.
C When an equimolar mixture of chlorine and hydrogen is exploded, only one product is formed.
D When concentrated sulfuric acid is added to solid sodium bromide, hydrogen sulfide is one of the products.

6. **M/J 14/P11/Q12**
Redox reactions occur very frequently in the chemistry of Group VII.
Which statement is correct?
A Chlorine will oxidise bromide ions but not iodide ions.
B Fluorine is the weakest oxidising agent out of F_2, Cl_2, Br_2 and I_2.
C Iodide ions are the weakest reducing agent out of F^-, Cl^-, Br^- and I^-.
D When chlorine reacts with water, chlorine is both oxidised and reduced.

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7. O/N 18/P11/Q16, O/N 18/P13/Q16
Which row correctly describes the properties of the halogens as Group 17 is descended from chlorine to iodine?

	volatility	strength as oxidising agent
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

8. M/J 17/P13/Q17, M/J 14/P12/Q18
A test-tube of HBr(g) and a test-tube of HI(g) are heated to the same temperature.
Which combination of observations is possible?

	tube of HBr(g)	tube of HI(g)
A	a brown vapour appears	no change is apparent
B	a purple vapour appears	no change is apparent
C	no change is apparent	a brown vapour appears
D	no change is apparent	a purple vapour appears

9. M/J 13/P11/Q14
What happens when iodine solution is added to a solution of sodium bromide?
A A reaction occurs without changes in oxidation state.
B Bromide ions are oxidised, iodine atoms are reduced.
C Bromide ions are reduced, iodine atoms are oxidised.
D No reaction occurs.

10. M/J 13/P11/Q15
Element 85, astatine, is in Group VII. Concentrated sulfuric acid is added to sodium astatide. The mixture of products includes astatine, hydrogen astatide, hydrogen sulfide, and sodium sulfate.
Which product is formed by the oxidation of one of the constituents of sodium astatide?
A astatine **B** hydrogen astatide **C** hydrogen sulfide **D** sodium sulfate

11. M/J 12/P11/Q17, M/J 12/P13/Q18
What trend is observed on descending Group VII?
A The colours of the elements become lighter.
B The elements become more volatile.
C The hydrides of the elements become more thermally stable.
D The reactions of the elements with hydrogen become less vigorous.

12. O/N 11/P12/Q17, M/J 07/P1/Q16, O/N 02/P1/Q17
The standard enthalpy changes of formation of HC*l* and HI are –92 kJ mol^{-1} and +26 kJ mol^{-1} respectively.
Which statement is **most** important in explaining this difference?
A Chlorine is more electronegative than iodine.
B The activation energy for the H_2 + Cl_2 reaction is much less than that for the H_2 + I_2 reaction.
C The bond energy of HI is smaller than the bond energy of HC*l*.
D The bond energy of I_2 is smaller than the bond energy of Cl_2.

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13. O/N 10/P12/Q19

Concentrated sulfuric acid reacts with both solid sodium chloride at room temperature and with solid sodium iodide at room temperature.

Which row correctly describes how concentrated sulfuric acid behaves in each of these reactions?

	with sodium chloride	with sodium iodide
A	as an oxidising agent only	as an oxidising agent only
B	as a strong acid and as an oxidising agent	as a strong acid only
C	as a strong acid only	as a strong acid and as an oxidising agent
D	as a strong acid only	as a strong acid only

14. M/J 09/P1/Q16, M/J 04/P1/Q17

Which statement is most likely to be true for astatine, which is below iodine in Group VII of the Periodic Table?

A Astatine and aqueous potassium chloride react to form aqueous potassium astatide and chlorine.

B Potassium astatide and hot dilute sulfuric acid react to form white fumes of only hydrogen astatide.

C Silver astatide reacts with dilute aqueous ammonia in excess to form a solution of a soluble complex.

D Sodium astatide and hot concentrated sulfuric acid react to form astatine.

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15. M/J 20/P12/Q36

The bond .....P..... of the HBr molecule is .....Q..... than that of the HI molecule.

Which pairs of words correctly complete the above sentence?

	P	Q
1	energy	greater
2	length	less
3	polarity	greater

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

16. O/N 19/P12/Q36

Which statements about ammonia are correct?

1 An ammonia molecule has three bond pairs and one lone pair of electrons.
2 When ammonia is bubbled into water the pH of the solution increases.
3 Ammonia gas can be made by warming ammonium sulfate with aqueous hydrochloric acid.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

17. M/J 19/P12/Q36

A small quantity of hot, concentrated sulfuric acid is added separately to solid samples of potassium halides, KX.

Which potassium halides react and produce a mixture of products that include a halogen, X_2?

1 potassium iodide
2 potassium bromide
3 potassium chloride

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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18. M/J 18/P12/Q35

Three samples of chlorine gas each contain 0.710 g of chlorine. Each sample is reacted with a reagent.

- In the first reaction a sample is reacted completely with hydrogen gas.
- In the second reaction a sample is reacted completely with cold NaOH(aq).
- In the third reaction a sample is reacted completely with hot NaOH(aq).

Which masses of the named products would be formed?

1 Exactly 0.730 g of HCl form in the first reaction.
2 Exactly 0.585 g of NaCl form in the second reaction.
3 Exactly 0.975 g of NaCl form in the third reaction.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

19. M/J 16/P11/Q33

Bromine reacts with water.

$$Br_2 + H_2O \rightleftharpoons HOBr + HBr$$

Which oxidation states of bromine are present in the equilibrium mixture?

1 +3 2 0 3 –1

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

20. O/N 15/P11/Q33

The salt $NaClO_3$ is used as a non-selective weedkiller.

On careful heating, this reaction occurs: $4NaClO_3 \rightarrow NaCl + 3NaClO_4$.

On strong heating this reaction occurs: $NaClO_4 \rightarrow NaCl + 2O_2$.

The overall reaction is $2NaClO_3 \rightarrow 2NaCl + 3O_2$.

What do these equations show?

1 $NaClO_3$ can behave as an oxidising agent.
2 $NaClO_3$ can behave as a reducing agent.
3 The oxidation numbers of chlorine in the three compounds shown are +6, +8 and –1.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

21. M/J 13/P12/Q35, M/J 16/P12/Q36

Which properties increase in the sequence hydrogen chloride, hydrogen bromide and hydrogen iodide?

1 thermal stability 2 bond length 3 ease of oxidation

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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22. O/N 14/P13/Q35, M/J 12/P12/Q35

Compared with the HI molecule, the bond .....P..... of the HBr molecule is .....Q.....
Which pairs of words correctly complete the above sentence?

	P	Q
1	energy	greater
2	length	less
3	polarity	greater

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

23. O/N 12/P13/Q36

The table describes some of the chemistry and thermodynamic properties of the halogens.

process	name and symbol of quantity
$2HX(g) \rightarrow H_2(g) + X_2(g)$	enthalpy change of reaction, $\Delta H^{\ominus}$
$H_2(g) + X_2(g) \rightleftharpoons 2HX(g)$	equilibrium constant, K_p
$X(g) \rightarrow X^+(g) + e^-$	ionisation energy, $\Delta H_i^{\ominus}$

Which statements about the relative values of these quantities are correct?

1 $\Delta H^{\ominus}$ for HC*l* > $\Delta H^{\ominus}$ for HBr

2 K_p for HBr > K_p for HI

3 $\Delta H_i^{\ominus}$ for I > $\Delta H_i^{\ominus}$ for C*l*

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

24. M/J 12/P11/Q35, M/J 12/P13/Q34

Which statements are correct for all three halogens, chlorine, bromine and iodine?

1 They all form hydrides that are strong acids in aqueous solution.
2 They all react with aqueous sodium hydroxide to form oxo-anions.
3 They all require one more electron to fill the p orbitals of their outer shells.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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11.3: Some reactions of the halide ions

1. **M/J 20/P11/Q12, O/N 15/P12/Q18**
A white powder is a mixture of sodium chloride and sodium iodide. It is dissolved in water in a test-tube. Excess aqueous silver nitrate is added to the test-tube. A precipitate, X, is observed.
Excess concentrated ammonia is then added to the test-tube containing X. After the test-tube has been shaken, a precipitate, Y, is observed.
Which statement about X or Y is correct?
A X is a pure white colour.
B X is pure silver iodide.
C Y is pure silver chloride.
D Y is yellow.

2. **M/J 20/P13/Q17, O/N 15/P11/Q18, O/N 15/P13/Q18**
The addition of aqueous silver nitrate to aqueous barium chloride produces a white precipitate which dissolves in excess dilute aqueous ammonia to form a colourless solution.
The addition of excess dilute nitric acid to the colourless solution produces a white precipitate, Z.
What is Z?
A $AgCl$ **B** $BaCl_2$ **C** $Ba(NO_3)_2$ **D** NH_4NO_3

3. **MAR 20/P12/Q18, M/J 10/P13/Q11, M/J 10/P11/Q13, M/J 10/P12/Q14**
How does concentrated sulfuric acid behave when it reacts with sodium chloride?
A as an acid only
B as an acid and oxidising agent
C as an oxidising agent only
D as a reducing agent only

4. **O/N 19/P12/Q15**
Chlorate(V) ions, ClO_3^-, are produced in the redox reaction between chlorine and hot aqueous sodium hydroxide. Oxidation numbers can be used to help balance the equation for this reaction.

$$vCl_2(g) + wOH^-(aq) \rightarrow xCl^-(aq) + yClO_3^-(aq) + zH_2O(l)$$

What are the values of v, x and y in the balanced equation?

	v	x	y
A	2	3	1
B	3	4	2
C	3	5	1
D	7	12	2

5. **O/N 19/P11/Q17, O/N 19/P13/Q17**
Sodium azide, NaN_3, is dissolved in water. Acidified silver nitrate is added to the solution and a white precipitate forms. Aqueous ammonia is then added to the white precipitate.
The azide ion, N_3^-, has similar chemical properties to the Cl^- ion.
Which row of the table can be predicted from this information?

	formula of white precipitate	observation on adding aqueous ammonia
A	AgN_3	colourless solution formed
B	AgN_3	precipitate remains
C	Ag_3N	colourless solution formed
D	Ag_3N	precipitate remains

6. **M/J 19/P13/Q17**
An aqueous solution of a calcium compound is treated with a mixture of dilute aqueous nitric acid and aqueous silver nitrate. The resulting white precipitate dissolves when dilute aqueous ammonia is added.
What is the relative molecular mass, M_r, of the calcium compound?
A 54.0 **B** 75.6 **C** 111.1 **D** 199.9

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7. M/J 19/P13/Q16, M/J 16/P11/Q15

The solids sodium chloride and sodium iodide both react with concentrated sulfuric acid at room temperature.
With NaCl, the products are $NaHSO_4$ and HCl.
With NaI, the products are $NaHSO_4$, HI, I_2, SO_2, H_2O, S and H_2S.
What is the best explanation for this difference in products?

A Chloride ions will displace iodine from solution.
B Hydrogen chloride is more volatile than hydrogen iodide.
C Iodide ions are better reducing agents than chloride ions.
D Sulfuric acid is able to act as a dehydrating agent with NaI.

8. MAR 19/P12/Q17

The table shows some reactions of a white compound, G.

test	observation
silver nitrate is added to a solution of G followed by aqueous ammonia	a precipitate is formed which does not dissolve when the ammonia is added
solid G is warmed with concentrated sulfuric acid	a mixture of gases is formed including hydrogen sulfide

What could be the identity of G?

A caesium chloride **B** lithium bromide **C** potassium sulfate **D** sodium iodide

9. M/J 18/P12/Q17

When concentrated sulfuric acid is added to solid sodium bromide, bromine gas is produced, along with a number of other products. However when concentrated sulfuric acid is added to solid sodium chloride only hydrogen chloride and sodium hydrogensulfate are produced.
What is the reason for this difference?

A Bromine is less volatile than chlorine.
B Hydrochloric acid is a weak acid.
C Sulfuric acid is not an oxidising agent.
D The bromide ion is a stronger reducing agent than the chloride ion.

10. M/J 18/P11/Q16

Aqueous silver nitrate is added to a solution of potassium iodide.
Aqueous ammonia is then added.
What would be observed?

A a cream precipitate that dissolves on addition of aqueous ammonia
B a cream precipitate that does not dissolve on addition of aqueous ammonia
C a yellow precipitate that dissolves on addition of aqueous ammonia
D a yellow precipitate that does not dissolve on addition of aqueous ammonia

11. M/J 18/P13/Q16

When concentrated sulfuric acid is added to solid sodium chloride, HCl is formed but not Cl_2.
When concentrated sulfuric acid is added to solid sodium iodide, I_2 is formed.
Which statement explains these observations?

A Sulfuric acid is an oxidising agent and chloride ions are more easily oxidised.
B Sulfuric acid is an oxidising agent and iodide ions are more easily oxidised.
C Sulfuric acid is a reducing agent and chloride ions are more easily reduced.
D Sulfuric acid is a reducing agent and iodide ions are more easily reduced.

12. M/J 17/P11/Q17

When concentrated sulfuric acid reacts with sodium iodide the products include sulfur, iodine, hydrogen sulfide and sulfur dioxide.
Which statement is correct?

A Hydrogen sulfide is the product of a reduction reaction.
B Iodide ions are stronger oxidising agents than sulfate ions.
C Sulfur atoms from the sulfuric acid are both oxidised and reduced.
D Sulfur atoms from the sulfuric acid are oxidised to make sulfur dioxide.

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13. M/J 17/P12/Q17, O/N 14/P13/Q15

A powder is known to be either a single sodium halide or a mixture of two sodium halides. A sample of the powder was dissolved in water. Aqueous silver nitrate was added, and a pale yellow precipitate was formed. When concentrated aqueous ammonia was added, the precipitate partly dissolved leaving a darker yellow precipitate.

What might the powder have consisted of?

A sodium bromide only

B sodium iodide only

C a mixture of sodium chloride and sodium bromide

D a mixture of sodium chloride and sodium iodide

14. O/N 16/P12/Q15

When chlorine reacts with hot aqueous sodium hydroxide, two chlorine-containing ions are formed. One of these is the chloride ion, Cl^-.

What is the other ion?

A ClO^- **B** ClO_2^- **C** ClO_3^- **D** ClO_4^-

15. M/J 16/P13/Q18

In a series of nine experiments to test the reactivity of the halogens, an aqueous solution of each halogen was added to an equal volume of an aqueous solution containing halide ions as shown in the table below.

solution	sodium chloride (aq)	sodium bromide (aq)	sodium iodide (aq)
chlorine (aq)	experiment 1	experiment 2	experiment 3
bromine (aq)	experiment 4	experiment 5	experiment 6
iodine (aq)	experiment 7	experiment 8	experiment 9

The nine resulting mixtures were then shaken with hexane. The nine tubes were corked and left to stand so that the aqueous and organic solvents could separate into layers.

How many test-tubes contained a purple upper layer?

A 1 **B** 2 **C** 3 **D** 5

16. MAR 16/P12/Q16

Hydrogen chloride gas and hydrogen iodide gas have different thermal stabilities. The difference is due to a difference in the energies of some of the covalent bonds that are involved in the decomposition.

Which row identifies the more stable of the two compounds, and gives the correct explanation?

	identity of the more thermally stable compound	explanation for the difference in stability
A	hydrogen chloride	the Cl–Cl bond is stronger than the I–I bond
B	hydrogen chloride	the H–Cl bond is stronger than the H–I bond
C	hydrogen iodide	the Cl–Cl bond is stronger than the I–I bond
D	hydrogen iodide	the H–Cl bond is stronger than the H–I bond

17. MAR 16/P12/Q19

After black and white photographic film has been developed, unreacted silver bromide is removed by reaction with sodium thiosulfate.

$$AgBr + 2Na_2S_2O_3 \rightarrow 4Na^+ + Br^- + [Ag(S_2O_3)_2]^{3-}$$

What is the function of the thiosulfate ion?

A to make the silver ions soluble **C** to reduce the bromine

B to oxidise the silver ions **D** to reduce the silver ions

18. M/J 14/P12/Q17

When solid sodium iodide reacts with concentrated sulfuric acid, the products include $NaHSO_4$, H_2S, SO_2 and S.

In the formation of which product has the oxidation state of sulfur changed by a value of 8?

A H_2S **B** $NaHSO_4$ **C** S **D** SO_2

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19. M/J 15/P11/Q17

Astatine, At, is below iodine in Group VII of the Periodic Table.
Which statement is most likely to be correct?

A AgAt(s) reacts with excess dilute aqueous ammonia to form a solution of a soluble complex.

B Astatine and KCl (aq) react to form KAt(aq) and chlorine.

C KAt(aq) and dilute sulfuric acid react to form white fumes of HAt(g).

D NaAt(s) and concentrated sulfuric acid react to form astatine.

20. M/J 15/P13/Q19

Two separate tests were carried out on an aqueous solution of a salt which contains only two ions.
In each test, the resulting mixtures were filtered and the filtrate solution was collected.

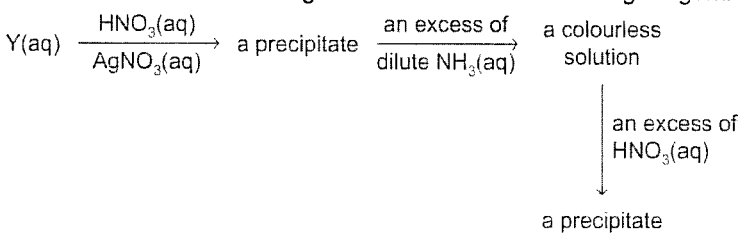
	reagent	result	filtrate collected
test 1	aqueous silver nitrate acidified with dilute nitric acid	yellow precipitate forms	solution P
test 2	dilute sulfuric acid	white precipitate forms	solution Q

Which ions are present in the filtrates?

	solution P	solution Q
A	$Ba^{2+}(aq)$	$Cl^-(aq)$
B	$Ba^{2+}(aq)$	$I^-(aq)$
C	$Mg^{2+}(aq)$	$Cl^-(aq)$
D	$Mg^{2+}(aq)$	$I^-(aq)$

21. M/J 13/P11/Q17, M/J 10/P12/Q15, M/J 10/P13/Q14, M/J 10/P11/Q14, O/N 16/P12/Q16

Y is a salt of one of the halogens chlorine, bromine, iodine, or astatine (element 85).
The reaction scheme shows a series of reactions using a solution of Y as the starting reagent.

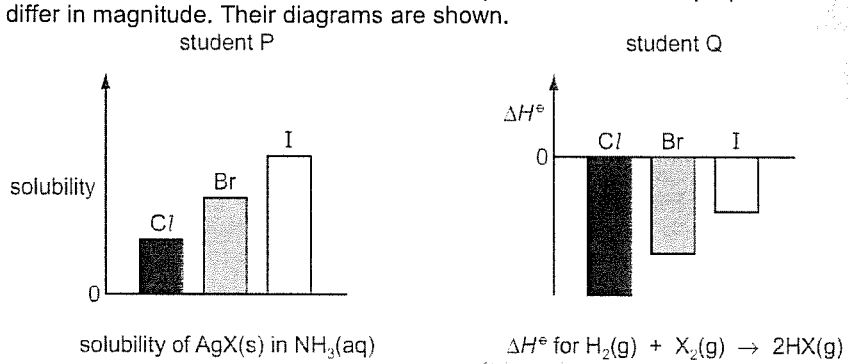


What could Y be?

A sodium chloride **B** sodium bromide **C** potassium iodide **D** potassium astatide

22. M/J 13/P13/Q14, M/J 16/P13/Q17

Two students, P and Q, were asked to draw bar charts to represent how some properties of the halogens and their compounds differ in magnitude. Their diagrams are shown.



Which of the student's diagrams are correct?

A both P and Q **B** P only **C** Q only **D** neither P nor Q

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23. M/J 12/P13/Q16

The following two experiments are carried out with anhydrous potassium chloride and observations X and Y are made at the end of each experiment.

Concentrated sulfuric acid is added to the potassium chloride and the fumes produced are bubbled into aqueous potassium iodide solution - observation X.

The potassium chloride is dissolved in aqueous ammonia and this is then added to aqueous silver nitrate - observation Y.

What are the observations X and Y?

	X	Y
A	brown solution	colourless solution
B	brown solution	white precipitate
C	colourless solution	colourless solution
D	colourless solution	white precipitate

24. O/N 11/P12/Q16

Sodium iodide reacts with concentrated sulfuric acid. The equation which represents one of the reactions that takes place is shown.

$$8NaI + 9H_2SO_4 \rightarrow 8NaHSO_4 + 4I_2 + H_2S + 4H_2O$$

Which species has been oxidised in this reaction?

A H^+ **B** I^- **C** Na^+ **D** SO_4^{2-}

25. O/N 10/P11/Q16, O/N 10/P13/Q9

Chile saltpetre, $NaNO_3$, contains sodium iodide as an impurity.

Aqueous silver nitrate is added to an aqueous solution of Chile saltpetre. Concentrated aqueous ammonia is then added.

Which observations are made?

	with acidified silver nitrate	with concentrated aqueous ammonia
A	no precipitate	no further reaction
B	no precipitate	precipitate forms
C	precipitate forms	precipitate dissolves
D	precipitate forms	precipitate remains

26. M/J 09/P1/Q15, O/N 03/P1/Q16

In black and white photographic film, light converts silver chloride into metallic silver. After the film has been developed, the unreacted silver chloride is removed by reaction with sodium thiosulfate to produce a 'fixed' negative.

$$AgCl + 2Na_2S_2O_3 \rightarrow 4Na^+ + Cl^- + [Ag(S_2O_3)_2]^{3-}$$

What is the function of the thiosulfate ion?

A to make the silver ions soluble
B to oxidise the silver ions
C to oxidise the silver metal
D to reduce the silver ions

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27. O/N 19/P11/Q35, O/N 19/P13/Q35

Which statements are correct?

1 Chloride ions are oxidised when concentrated sulfuric acid is added to NaCl(s).
2 A disproportionation reaction takes place when chlorine is added to cold NaOH(aq).
3 An acidic solution forms when chlorine is added to water.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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28. M/J 15/P13/Q36

The element astatine, At, is below iodine in Group VII of the Periodic Table.
Which statements concerning At can be predicted to be correct?

1 At_2 reacts with hydrogen more slowly than I_2 does.
2 At^- ions react with $I_2(aq)$ to form At_2 molecules.
3 At_2 is a dark coloured solid at room temperature.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

29. M/J 14/P11/Q36

A test-tube of HI gas and a test-tube of HBr gas are placed together in an environment at temperature, T.
Which combinations of observations are possible depending on the temperature, T?

1 A brown vapour appears in one of the test-tubes. No change is apparent in the other test-tube.
2 A brown vapour appears in one of the test-tubes. A purple vapour appears in the other test-tube.
3 No change is apparent in either test-tube

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

30. M/J 13/P11/Q36

When a red-hot platinum wire is plunged into a test tube of hydrogen iodide, the gas is decomposed into its elements. If the experiment is repeated with hydrogen chloride, no change occurs.
Which factors contribute to this behaviour?

1 the strength of the hydrogen-halogen bond
2 the size of the halogen atom
3 the standard enthalpy of formation, $\Delta H_f^{\ominus}$, of each of the products of decomposition

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

31. M/J 10/P12/Q35, M/J 10/P13/Q34, M/J 10/P11/Q35

In a car engine, non-metallic element X forms a pollutant oxide Y.

Further oxidation of Y to Z occurs in the atmosphere. In this further oxidation, 1 mol of Y reacts with $\frac{1}{2}$ mol of gaseous oxygen.
What can X be?

1 carbon
2 nitrogen
3 sulfur

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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32. O/N 09/P12/Q35, O/N 09/P11/Q36

Which statements about the reaction of solid sodium bromide with concentrated sulfuric acid are correct?

1 Hydrogen bromide is a product of the reaction.
2 Sulfuric acid is oxidised to sulfur dioxide.
3 Bromide ions are reduced to bromine.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

33. M/J 09/P1/Q36, O/N 04/P1/Q36

Which properties in the sequence hydrogen chloride, hydrogen bromide and hydrogen iodide steadily increase?

1 thermal stability
2 bond length
3 ease of oxidation

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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11.4: The reactions of chlorine with aqueous sodium hydroxide

1. O/N 19/P12/Q16, O/N 16/P11/Q14, O/N 16/P13/Q14
The properties of chlorine, bromine and their compounds are compared.
Which property is **smaller** for chlorine than for bromine?

A bond strength of the hydrogen-halide bond
B first ionisation energy
C solubility of the silver halide in $NH_3(aq)$
D strength of the van der Waals' forces between molecules of the element

2. O/N 19/P12/Q17
Solid sodium iodide reacts with concentrated sulfuric acid to form more than one product that contains sulfur.
What is the lowest oxidation number of sulfur in these products?

A –2 **B** 0 **C** +4 **D** +6

3. M/J 19/P12/Q17
An excess of chlorine was bubbled into 100 cm^3 of hot 6.0 mol dm^{-3} sodium hydroxide.
How many moles of sodium chloride would be produced in the reaction?

A 0.3 **B** 0.5 **C** 0.6 **D** 1.2

4. M/J 19/P11/Q17
The reaction of bromine with warm NaOH(aq) produces products with the same oxidation numbers, in the same ratios, as the reaction of chlorine with hot NaOH(aq).
In one reaction between bromine and warm NaOH(aq), 30.2 g of a product containing sodium, bromine and oxygen is produced.
Which mass of NaOH has reacted?

A 8.00 g **B** 10.2 g **C** 20.3 g **D** 48.0 g

5. MAR 19/P12/Q18, O/N 14/P11/Q17
Under standard conditions, which statement is correct?

A $Cl^-(aq)$ can oxidise $Br_2(aq)$
B $Cl^-(aq)$ can reduce $Br_2(aq)$
C $Cl_2(aq)$ can oxidise $Br^-(aq)$
D $Cl_2(aq)$ can reduce $Br^-(aq)$

6. O/N 18/P12/Q17
Chlorine reacts with both hot and cold sodium hydroxide to form products containing chlorine.
Cold sodium hydroxide forms sodium chlorate(X) and hot sodium hydroxide forms sodium chlorate(Y). X and Y are oxidation numbers.
Which equation is correct?

A Y = X – 6 **B** Y = X – 4 **C** Y = X + 4 **D** Y = X + 6

7. O/N 18/P11/Q17, O/N 18/P13/Q17
Reaction 1: chlorine reacts with cold aqueous sodium hydroxide to form solution Z.
Reaction 2: solution Z is heated and forms $ClO_3^-(aq)$ and $Cl^-(aq)$.
Which equations represent reaction 1 and reaction 2?

A reaction 1 $2Cl_2 + 4OH^- \rightarrow ClO_2^- + 3Cl^- + 2H_2O$
reaction 2 $3ClO_2^- \rightarrow 2ClO_3^- + Cl^-$

B reaction 1 $2Cl_2 + 4OH^- \rightarrow ClO_2^- + 3Cl^- + 2H_2O$
reaction 2 $3ClO^- \rightarrow ClO_3^- + 2Cl^-$

C reaction 1 $Cl_2 + 2OH^- \rightarrow ClO^- + Cl^- + H_2O$
reaction 2 $2ClO^- + 2OH^- \rightarrow ClO_3^- + Cl^- + H_2O$

D reaction 1 $Cl_2 + 2OH^- \rightarrow ClO^- + Cl^- + H_2O$
reaction 2 $3ClO^- \rightarrow ClO_3^- + 2Cl^-$

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8. M/J 18/P11/Q14

Chlorine reacts with cold aqueous sodium hydroxide to produce sodium chloride, water and compound X.
Chlorine reacts with hot aqueous sodium hydroxide to produce sodium chloride, water and compound Y.
What are the oxidation states of chlorine in compound X and compound Y?

	X	Y
A	–1	–5
B	–1	+5
C	+1	–5
D	+1	+5

9. O/N 17/P11/Q17, O/N 17/P13/Q17

71.0 g of chlorine, Cl_2, react with an excess of sodium hydroxide solution at a particular temperature. The reaction produces exactly 35.5 g of product **X**.
What is product **X**?

A H_2O **B** NaCl **C** NaClO **D** $NaClO_3$

10. M/J 17/P12/Q16

Element X reacts with cold, dilute, aqueous sodium hydroxide to form two different chlorine-containing products, Y and Z.
What are the oxidation states of chlorine in Y and Z?

	Y	Z
A	0	+1
B	0	+5
C	–1	+1
D	–1	+5

11. M/J 17/P11/Q18

A solution of sodium hydroxide reacts with 3 mol of chlorine under certain conditions. The reaction produces 5 mol of sodium chloride and 1 mol of **X**, the only other chlorine-containing product.
What is the formula of compound **X**?

A NaClO **B** $NaClO_2$ **C** $NaClO_3$ **D** $NaClO_4$

12. M/J 17/P11/Q19

Redox reactions are common in the chemistry of Group 17.
Which statement is correct?

A Br^- ions will reduce Cl2 but not I_2.
B Cl_2 will oxidise Br^- ions but not I^- ions.
C F_2 is the weakest oxidising agent out of F_2, Cl_2, Br_2 and I_2.
D I^- ions are the weakest reducing agent out of F^-, Cl^-, Br^- and I^-.

13. M/J 17/P13/Q16

Chlorine gas is added to cold, aqueous sodium hydroxide.
In a separate experiment, chlorine gas is added to hot, aqueous sodium hydroxide.
Which oxidation states of chlorine are found in the reactants and products of the two reactions that take place?

A 0, –1, +1 and +5 **B** 0, –1 and +1 only **C** 0, –1 and +5 only **D** 0, +1 and +5 only

14. MAR 16/P12/Q14

Chlorine gas is widely used to treat contaminated water.
Which species present in water when chlorine gas has been added is responsible for killing bacteria?

A ClO_2^- **B** Cl^- **C** HCl **D** OCl^-

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15. M/J 15/P11/Q16

Chlorine is widely used in water treatment plants.
Which reaction takes place when chlorine dissolves in water?

A $Cl_2 + H_2O \rightarrow HCl + HClO$
B $2Cl_2 + 2H_2O \rightarrow 3HCl + HClO_2$
C $3Cl_2 + 3H_2O \rightarrow 5HCl + HClO_3$
D $4Cl_2 + 4H_2O \rightarrow 7HCl + HClO_4$

16. O/N 14/P12/Q16, O/N 14/P11/Q16

Chlorine gas reacts with cold aqueous sodium hydroxide. It can also react with hot aqueous sodium hydroxide.
What are the oxidation numbers of chlorine in the products of these reactions?

	cold aqueous sodium hydroxide	hot aqueous sodium hydroxide
A	–1, +1	–1, +5
B	–1, +1	+1, +6
C	–1, +2	–1, +5
D	–1, +2	+1, +6

17. M/J 12/P12/Q16

Chlorine shows oxidation states ranging from –1 to +7 in its compounds.
What are the reagent(s) and conditions necessary for the oxidation of elemental chlorine into a compound containing chlorine in the +5 oxidation state?

A $AgNO_3(aq)$ followed by $NH_3(aq)$ at room temperature
B concentrated H_2SO_4 at room temperature
C cold dilute NaOH(aq)
D hot concentrated NaOH(aq)

18. O/N 10/P12/Q16, M/J 06/P1/Q17

What happens when chlorine is bubbled through aqueous potassium iodide?

A Chlorine is oxidised to chlorate(V) ions.
B Chlorine is oxidised to chloride ions.
C Iodide ions are oxidised to iodine.
D There is no observable reaction.

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19. M/J 20/P11/Q36

Chlorine reacts with sodium hydroxide in two different ways depending upon the temperature.

reaction 1 $Cl_2 + 2OH^- \rightarrow Cl^- + ClO^- + H_2O$
reaction 2 $3Cl_2 + 6OH^- \rightarrow 5Cl^- + ClO_3^- + 3H_2O$

Which statements about these reactions are correct?
1 Reaction 2 requires a higher temperature than reaction 1.
2 The products of reaction 1 show chlorine in two different oxidation states.
3 The products of reaction 2 show oxygen in two different oxidation states.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

20. M/J 11/P12/Q35

When the yellow liquid NCl_3 is stirred into aqueous sodium hydroxide, the reaction that occurs can be represented by the following equation.

$$2NCl_3(l) + 6NaOH(aq) \rightarrow N_2(g) + 3NaCl(aq) + 3NaOCl(aq) + 3H_2O(l)$$

What will be the result of this reaction?
1 The nitrogen undergoes a redox reaction.
2 A bleaching solution remains after the reaction.
3 The final solution gives a precipitate with acidified silver nitrate.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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11.5: Some important uses of the halogens and of halogen compounds

1. **MAR 17/P12/Q16**
Some uses of chlorine and bromine are given.
Which is a use of bromine?
A making bleaches for textiles and the paper industry
B making CFCs
C making flame retardants and fire extinguishers
D making the polymer PVC

2. **M/J 13/P12/Q15**
Many modern cars are fitted with halogen lamps. When such lamps are first switched on, a distinct purple colour can be seen.
Which species is responsible for this purple colour?
A $I_2(s)$ **B** $I_2(l)$ **C** $I_2(g)$ **D** $I(g)$

3. **M/J 10/P11/Q11, M/J 10/P13/Q12, M/J 10/P12/Q12, M/J 06/P1/Q11**
Swimming pool water can be kept free of harmful bacteria by adding aqueous sodium chlorate(I), NaOCl. This reacts with water to produce HOCl molecules which kill bacteria.

$$OCl^-(aq) + H_2O \rightleftharpoons OH^-(aq) + HOCl(aq)$$

In bright sunshine, the OCl^- ion is broken down by ultra-violet light.

$$OCl^-(aq) + \text{uv light} \rightarrow Cl^-(aq) + \tfrac{1}{2}O_2(g)$$

Which method would maintain the highest concentration of HOCl(aq)?
A acidify the pool water
B add a solution of chloride ions
C add a solution of hydroxide ions
D bubble air through the water

4. **M/J 09/P1/Q14**
Over half a million tonnes of bromine are manufactured annually and are mainly used for making other compounds. One important use is for agricultural chemicals.
What is another important use for bromine?
A antiseptic agents
B bleaches for textiles and the paper industry
C flame-retardants and fire extinguishers
D water purification

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5. **M/J 16/P13/Q34**
When $KClO_3$ is heated, the following reaction occurs.

$$4KClO_3 \rightarrow 3KClO_4 + KCl$$

Which statements are correct?
1 The oxidation state of Cl in $KClO_3$ is +5.
2 The oxidation state of some Cl atoms decreases by 6.
3 The reaction involves disproportionation.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

6. **M/J 15/P12/Q36**
Halogenated hydrocarbons have many uses.
What have halogenated hydrocarbons been used for?
1 solvents
2 refrigerants
3 monomers in polymer manufacture

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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11.6: Multiple Topics

1. M/J 19/P13/Q14

Dilute hydrochloric acid is added to solid barium carbonate and solid magnesium carbonate in separate test-tubes.
Dilute sodium hydroxide is added to 0.1 mol dm^{-3} barium chloride and 0.1 mol dm^{-3} magnesium chloride in separate test-tubes.
Which row is correct?

	$BaCO_3(s)$ + $HCl(aq)$	$BaCl_2(aq)$ + $NaOH(aq)$	$MgCO_3(s)$ + $HCl(aq)$	$MgCl_2(aq)$ + $NaOH(aq)$
A	no change	white ppt	no change	no change
B	effervescence	no change	effervescence	no change
C	effervescence	no change	effervescence	white ppt
D	effervescence	white ppt	effervescence	white ppt

2. O/N 17/P11/Q18, O/N 17/P13/Q18

Compound Q is a white crystalline solid which dissolves easily in water. When concentrated sulfuric acid is added to a dry sample of Q steamy white fumes are formed which, when passed through aqueous silver nitrate solution, form a white precipitate. This precipitate is soluble in dilute ammonia solution.
What could be the identity of compound Q?

A AgCl **B** NaBr **C** NaCl **D** $PbBr_2$

3. O/N 13/P12/Q16, O/N 13/P11/Q16

Solid potassium halides react with concentrated sulfuric acid, according to the following equations.

reaction 1 $2KCl + H_2SO_4 \rightarrow K_2SO_4 + 2HCl$
reaction 2 $2KBr + 2H_2SO_4 \rightarrow K_2SO_4 + SO_2 + Br_2 + 2H_2O$
reaction 3 $8KI + 5H_2SO_4 \rightarrow 4K_2SO_4 + H_2S + 4I_2 + 4H_2O$

What is the largest **change** in the oxidation number of sulfur in each of these reactions?

	reaction 1	reaction 2	reaction 3
A	0	0	4
B	0	2	4
C	0	2	8
D	0	4	8

4. M/J 13/P12/Q18

What happens when bromine solution is added to a solution of sodium iodide?

A A reaction occurs without changes in oxidation state.
B Bromine atoms are oxidised, iodide ions are reduced.
C Bromine atoms are reduced, iodide ions are oxidised.
D No reaction occurs.

5. M/J 11/P12/Q17

Concentrated sulfuric acid can behave **both** as a strong acid **and** as an oxidising agent.
With which compound does concentrated sulfuric acid react in this way?

A ethanol **C** propanenitrile
B magnesium carbonate **D** sodium bromide

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6. M/J 19/P13/Q35

Which statements about sodium chloride are correct?

1 It is a product of the reaction between chlorine and cold aqueous sodium hydroxide.
2 It is a product of the reaction between chlorine and hot aqueous sodium hydroxide.
3 It is a product of the reaction between chlorine and aqueous sodium bromide.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

7. O/N 18/P12/Q31, M/J 11/P11/Q33, M/J 11/P13/Q32

Zinc reacts with hydrochloric acid according to the following equation.

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

Which statements are correct?
[All volumes are measured at room conditions.]

1 A 3.27 g sample of zinc reacts with an excess of hydrochloric acid to give 0.050 mol of zinc chloride.
2 A 6.54 g sample of zinc reacts completely with exactly 100 cm^3 of 1.00 mol dm^{-3} hydrochloric acid.
3 A 13.08 g sample of zinc reacts with an excess of hydrochloric acid to give 9.60 dm^3 of hydrogen.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

8. MAR 17/P12/Q36

Sodium chloride and sodium iodide react with concentrated sulfuric acid.
Which statements are correct?

1 Sodium chloride is not oxidised by concentrated sulfuric acid.
2 No colour change is seen when concentrated sulfuric acid is added to sodium chloride.
3 Sodium iodide is oxidised by concentrated sulfuric acid.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

9. O/N 16/P12/Q31

Photochromic lenses in spectacles darken in sunlight because silver crystals are produced by the reaction shown.

$$Ag^+ + Cl^- \rightarrow Ag + Cl$$

Which statements are correct for this reaction?

1 Both silver and chlorine atoms have an oxidation number of zero.
2 The oxidation number of chlorine increases.
3 Electrons are transferred from Cl^- ions to Ag^+ ions.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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10. O/N 10/P11/Q35, O/N 10/P13/Q34

Disproportionation is the term used to describe a reaction in which a reactant is simultaneously both oxidised and reduced.

To which incomplete equations does the term disproportionation apply?

1 $Cl_2(g) + 2OH^-(aq) \rightarrow H_2O(l) + Cl^-(aq) + ...$

2 $3Cl_2(g) + 6OH^-(aq) \rightarrow 3H_2O(l) + ClO_3^-(aq) + ...$

3 $2NO_2(g) + H_2O(l) \rightarrow HNO_3(aq) + ...$

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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Answers Sections

11.1	11.2	11.3	11.4	11.5	11.6
1. D	1. D	1. D	1. D	1. C	1. C
2. A	2. D	2. A	2. A	2. C	2. C
3. B	3. C	3. A	3. B	3. A	3. C
4. A	4. C	4. C	4. D	4. C	4. C
5. B	5. C	5. A	5. C	5. A	5. D
6. B	6. D	6. C	6. C	6. A	6. A
7. B	7. A	7. C	7. D		7. D
8. D	8. D	8. D	8. D		8. A
9. C	9. D	9. D	9. D		9. A
10. B	10. A	10. D	10. C		10. A
11. D	11. D	11. B	11. C		
12. A	12. C	12. A	12. A		
13. D	13. C	13. D	13. A		
14. D	14. D	14. C	14. D		
15. D	15. A	15. D	15. A		
16. D	16. B	16. B	16. A		
17. C	17. B	17. A	17. D		
	18. A	18. A	18. C		
	19. C	19. D	19. B		
	20. B	20. B	20. A		
	21. C	21. A			
	22. A	22. C			
	23. B	23. C			
	24. A	24. B			
		25. D			
		26. A			
		27. C			
		28. A			
		29. C			
		30. B			
		31. C			
		32. D			
		33. C			

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Unit 12

NITROGEN AND SULFUR

A Level
Chemistry Paper 1
Classified/Topical MCQ's
Article Number: 231

Editorial Board

Syllabus

12.1 Nitrogen
12.2 Sulfur: The formation of atmospheric sulfur dioxide, its role in acid rain
12.3 Multiple topics

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Unit 12: Nitrogen and sulfur

12.1: Nitrogen

1. **M/J 20/P13/Q12, O/N 16/P11/Q17, O/N 16/P13/Q17**
Compound **T** is a white crystalline solid.
When a sample of **T** was mixed with aqueous sodium hydroxide and heated, a pungent smelling gas was produced which turned damp red litmus paper blue. This same gas produced dense white smoke with hydrogen chloride gas.
Further testing of a solution of **T** with barium chloride solution produced a dense white precipitate which did not dissolve when dilute hydrochloric acid was added to the mixture.
What is the identity of compound **T**?
A ammonium carbonate **C** sodium carbonate
B ammonium sulfate **D** sodium sulfate

2. **MAR 20/P12/Q19**
Which statement about nitrogen or its compounds is correct?
A In the Haber process the temperature is kept high to give a good equilibrium yield of ammonia.
B Nitrogen gas is unreactive because of the strong nitrogen–nitrogen double bond.
C Nitrogen monoxide will react with carbon monoxide under suitable conditions.
D The formula of ammonium sulfate is NH_4SO4.

3. **O/N 18/P12/Q19, M/J 05/P1/Q18**
In an historically famous experiment Whler heated "inorganic" ammonium cyanate in the absence of air. The only product of the reaction was "organic" urea, $CO(NH_2)_2$. No other products were formed in the reaction.
What is the formula of the cyanate ion present in ammonium cyanate?
A CNO^- **B** CNO^{2-} **C** CO^- **D** NO^-

4. **M/J 18/P11/Q17**
Oxides of nitrogen are present in the environment due to natural and man-made sources.
Which row is correct?

	natural source of nitrogen oxides	man-made source of nitrogen oxides
A	electrical discharges in the atmosphere	internal combustion engines
B	electrical discharges in the atmosphere	as a by-product of the Haber process
C	decomposition of dead plants in rivers	internal combustion engines
D	decomposition of dead plants in rivers	as a by-product of the Haber process

5. **O/N 17/P12/Q18**
The reaction of nitrogen and oxygen to produce oxides of nitrogen happens at high temperatures in car engines or lightning strikes during thunderstorms.
What is the main reason for these reactions requiring such high temperatures?
A the lack of reactivity of nitrogen, due to the half-filled 2p subshell in the nitrogen atom
B the lack of reactivity of nitrogen, due to the strength of the bond in N_2
C the lack of reactivity of oxygen, due to electron-electron repulsion in one of its 2p orbitals
D the lack of reactivity of oxygen, due to the strength of the bond in O_2

6. **O/N 17/P11/Q16, O/N 17/P13/Q16**
Which fertiliser contains the greatest percentage of nitrogen by mass?
A ammonium nitrate, NH_4NO_3
B ammonium sulfate, $(NH_4)_2SO_4$
C diammonium hydrogen phosphate, $(NH_4)_2HPO_4$
D urea, $CO(NH_2)_2$

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7. M/J 17/P12/Q18

The ammonium ion is formed by the following reaction.

$$NH_3 + H^+ \rightarrow NH_4^+$$

Which statement about the species involved in this reaction is correct?

A The ammonia molecule contains a dative covalent bond.

B The ammonium ion is a Brønsted-Lowry base as it has accepted a proton.

C The H–N–H bond angle changes from 107° in ammonia to 90° in the ammonium ion.

D The number of electrons surrounding each nitrogen atom does not change.

8. M/J 17/P11/Q16

Which statement about nitrogen or its compounds is correct?

A In the Haber process the temperature is kept high to give a good equilibrium yield of ammonia.

B Nitrogen gas is unreactive because of the strong nitrogen-nitrogen double bond.

C Nitrogen monoxide will react with carbon monoxide under suitable conditions.

D The formula of ammonium sulfate is NH_4SO_4.

9. M/J 17/P13/Q9

Ammonia is produced by the Haber process.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3 \qquad \Delta H^{\ominus} = -92 \text{ kJ mol}^{-1}$$

A fault in the temperature control during the process resulted in the temperature changing to 600 °C for two hours.

What effect did this have on the ammonia production during this time?

A Ammonia was formed faster. The equilibrium yield decreased.

B Ammonia was formed faster. The equilibrium yield increased.

C Ammonia was formed slower. The equilibrium yield decreased.

D Ammonia was formed slower. The equilibrium yield increased.

10. O/N 16/P12/Q4

When copper reacts with a 50% solution of nitric acid, nitrogen monoxide is evolved and a blue solution results. The balanced equation for this reaction is shown.

$$p\text{Cu} + q\text{HNO}_3 \rightarrow r\text{Cu(NO}_3)_2 + s\text{H}_2\text{O} + t\text{NO}$$

What are the values of the integers *p*, *q*, *r*, *s* and *t*?

	p	*q*	*r*	*s*	*t*
A	1	4	1	2	2
B	2	6	2	3	2
C	2	8	2	4	4
D	3	8	3	4	2

11. M/J 11/P13/Q15, M/J 11/P11/Q18

Nitrogen monoxide, NO, is a primary pollutant produced by petrol engines and is found in their exhaust gases. Which reaction occurs in a catalytic converter and decreases the emission of nitrogen monoxide?

A $NO(g) + CO(g) \rightarrow NO_2(g) + C(s)$

B $NO(g) + CO_2(g) \rightarrow NO_2(g) + CO(g)$

C $2NO(g) + 2CO(g) \rightarrow N_2(g) + 2CO_2(g)$

D $2NO(g) + CO_2(g) \rightarrow 2NO_2(g) + C(s)$

12. M/J 17/P13/Q18, O/N 13/P13/Q15

Ammonia exists as simple covalent molecules, NH_3. Ammonia can react with suitable reagents to form products containing ammonium ions, NH_4^+. Ammonia can also react with suitable reagents to form products containing amide ions, NH_2^-.

Which of these nitrogen-containing species are present in an aqueous solution of ammonia?

A ammonia molecules, ammonium ions and amide ions

B ammonia molecules and ammonium ions only

C ammonia molecules only

D ammonium ions only

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13. M/J 16/P11/Q18

Which statement about the ammonia molecule and/or the ammonium ion is correct?

A Ammonia molecules are basic because they can donate H^+ ions.

B Ammonium ions are basic because they can accept H^+ ions.

C If ammonium ions are heated with NaOH(aq), ammonia molecules are formed.

D The bond angle in NH_4^+ is 2.5° less than the bond angle in NH_3.

14. O/N 12/P13/Q17

In the Haber process, the reaction between the two gaseous reactants requires the use of a catalyst that contains a transition element.

What is the metal and in what mole ratio do the gases react?

	metal	mole ratio
A	Fe	1:2
B	Fe	1:3
C	V	1:2
D	V	1:3

15. O/N 11/P12/Q14

Nitrogenous fertilisers are used extensively in modern farming. If rainwater washes excess fertiliser into a nearby lake, a process called eutrophication may occur.

Three of the stages of eutrophication are described below.

P Water plants growing on the lake bed die due to lack of sunlight.

Q An excessive growth of algae occurs.

R Excessive bacterial activity causes a reduction in oxygen levels.

In which order do these three stages occur?

A $P \rightarrow Q \rightarrow R$ **B** $P \rightarrow R \rightarrow Q$ **C** $Q \rightarrow P \rightarrow R$ **D** $Q \rightarrow R \rightarrow P$

16. M/J 11/P13/Q18, M/J 11/P11/Q17

Ammonium nitrate, NH_4NO_3, is manufactured in large quantities for use in fertiliser.

Which statement about ammonium nitrate fertiliser is **not** correct?

A It can cause environmental problems.

B It consists of 35% nitrogen by mass.

C It is insoluble in water.

D Nitric acid is used in its manufacture.

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17. O/N 19/P12/Q36, M/J 16/P13/Q36

Ammonia is a colourless gas that is produced by the Haber process.

Which statements about ammonia are correct?

1 An ammonia molecule has three bond pairs and one lone pair of electrons.

2 If ammonia is bubbled into water the pH of the solution will increase.

3 Ammonia gas can be made by warming ammonium sulfate with aqueous hydrochloric acid.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

18. O/N 19/P11/Q36, O/N 19/P13/Q36

Nitrogen gas is unreactive, whereas oxygen gas and chlorine gas are reactive.

Which statements help to explain this difference?

1 The two N atoms in an N_2 molecule are held together by a very strong triple bond.

2 The triple bond between two N atoms is not polar. The bonds in O_2 and Cl_2 are polar.

3 The atoms in N_2 have a full outer shell of electrons. The atoms in O_2 and Cl_2 do not have a full outer shell of electrons.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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19. M/J 18/P11/Q36

Which statements correctly describe an oxide of nitrogen acting as an atmospheric pollutant?

1 Nitrogen monoxide, NO, reacts with oxygen to form nitrogen dioxide which contributes to acid rain.
2 Nitrogen dioxide reacts with sulfur dioxide to form sulfur trioxide which reacts with water to form sulfuric acid.
3 Nitrogen oxides react with unburnt hydrocarbons in sunlight to form other pollutants.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

20. O/N 17/P11/Q36, O/N 17/P13/Q36

Which statements explain why nitrogen gas is unreactive?

1 Nitrogen atoms are highly electronegative.
2 Nitrogen molecules are non-polar.
3 The triple bond between nitrogen atoms is very strong.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

21. MAR 17/P12/Q31

Nitrogen and phosphorus are both in Group 15 of the Periodic Table. Phosphorus forms a chloride with the formula PCl_5 but nitrogen does not form NCl_5.

Which statements help to explain this?

1 Nitrogen's outer shell cannot contain more than eight electrons.
2 Nitrogen cannot have an oxidation state of +5.
3 Nitrogen is less electronegative than phosphorus.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

22. M/J 13/P12/Q36

Sulfur dioxide is an atmospheric pollutant that causes acid rain. One of the reactions in this process is the oxidation of sulfur dioxide to sulfur trioxide.

This oxidation takes place by a two stage reaction involving oxygen and nitrogen monoxide, NO.

$$NO + \frac{1}{2}O_2 \rightarrow NO_2$$

$$NO_2 + SO_2 \rightarrow SO_3 + NO$$

Which statements are correct?

1 Nitrogen monoxide is acting as a catalyst for the oxidation.
2 Nitrogen atoms are oxidised in the second stage.
3 Oxygen atoms are first reduced and are then oxidised.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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23. O/N 12/P12/Q31, O/N 12/P11/Q31

How may nitrogen exist in compounds?

1 bonded by a triple covalent bond
2 as part of a cation
3 having lost 3 electrons to form an anion

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

24. O/N 12/P13/Q31

How may nitrogen exist in compounds?

1 bonded by a triple covalent bond
2 as part of a cation
3 in an oxidation state of +5

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

25. O/N 10/P12/Q31

When ammonia, NH_3, is produced in a school or college laboratory, it is usually dried before being collected.
Which drying agents may be used to dry ammonia?

1 calcium oxide, CaO
2 phosphorus(V) oxide, P_4O_{10}
3 concentrated sulfuric acid, H_2SO_4

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

26. O/N 10/P12/Q35

In which ways are the main reactions in the Haber and Contact processes similar?

1 A higher yield is favoured by higher pressures.
2 The reaction is a redox process.
3 The forward reaction is exothermic.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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12.2: Sulfur: the formation of atmospheric sulfur dioxide, its role in acid rain

1. **M/J 20/P13/Q15**
Which element, when burned in oxygen, can form an oxide that is a reducing agent?
A Na **B** Mg **C** Al **D** S

2. **O/N 19/P12/Q19**
Ammonia, carbon dioxide and water react together to form ammonium carbonate.
Which statement about this reaction is correct?
A It is a redox reaction.
B It is an acid-base reaction.
C The H–N–H bond angle decreases as a consequence of this reaction.
D The three substances react in a 1 : 1 : 1 ratio in this reaction.

3. **M/J 19/P12/Q19**
Which reaction gives a product that is an atmospheric pollutant causing acid rain?
A $3Mg(s) + SO_2(g) \rightarrow MgS(s) + 2MgO(s)$
B $(NH_4)_2SO_4(s) + Ca(OH)_2(s) \rightarrow 2NH_3(g) + CaSO_4(s) + 2H_2O(l)$
C $2MnO_4^-(aq) + 5SO_2(g) + 2H_2O(l) \rightarrow 2Mn^{2+}(aq) + 4H^+(aq) + 5SO_4^{2-}(aq)$
D $2FeSO_4(s) \rightarrow Fe_2O_3(s) + SO_2(g) + SO_3(g)$

4. **O/N 18/P12/Q18**
The product of the Contact process is Z.
Which reaction or process leads to the formation of a gas that can neutralise an aqueous solution of Z?
A atmospheric lightning
B combustion of fuel in an internal combustion engine
C the Haber process
D thermal decomposition of Group 2 nitrates

5. **M/J 16/P11/Q19**
Which reaction **does not** contribute to the problem of acid rain?
A the combustion of fossil fuels
B the oxidation of sulfur dioxide to sulfur trioxide catalysed by nitrogen dioxide
C the reaction between nitrogen monoxide and carbon monoxide in a catalytic converter
D the reaction of sulfur trioxide with water

6. **M/J 16/P13/Q19**
Which statement does not describe an effect of acid rain on the environment?
A Acid rain causes erosion of stone buildings.
B Acid rain causes ozone depletion.
C Acid rain increases the corrosion of some metals.
D Acid rain increases the leaching away of essential nutrients and minerals from soils.

7. **O/N 14/P12/Q18, O/N 14/P11/Q18**
Total removal of the pollutant sulfur dioxide, SO_2, is difficult. The quantities emitted from furnace chimneys can be lowered by using desulfurisation plants. The gases are reacted with calcium hydroxide to remove the SO_2.
What is the main product formed initially?
A $Ca(HSO_4)_2$ **B** CaS **C** $CaSO_3$ **D** $CaSO_4$

8. **O/N 11/P12/Q8**
Which pollutant, present in the exhaust fumes of an internal combustion engine, has an element in the +2 oxidation state and an odd number of electrons in one molecule of the pollutant?
A CO **B** H_2S **C** NO **D** NO_2

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9. O/N 12/P12/Q16, O/N 12/P11/Q16

In a car engine, non-metallic element X forms a pollutant oxide Y. Y can be further oxidised to Z.
Two students made the following statements.
Student P The molecule of Y contains lone pairs of electrons.
Student Q The oxidation number of X increases by 1 from Y to Z.
X could be carbon or nitrogen or sulfur.
Which student could be correct if X were any of these elements?

A P only **B** Q only **C** both P and Q **D** neither P nor Q

10. O/N 11/P11/Q18, O/N 11/P13/Q20

Total removal of the pollutant sulfur dioxide, SO_2, is difficult, both for economic and technical reasons. The quantities emitted from furnace chimneys can be lowered by using desulfurisation plants. The gases are scrubbed (washed) with calcium hydroxide to remove the SO_2.
What is the main product formed **initially**?

A $Ca(HSO_4)_2$ **B** CaS **C** $CaSO_3$ **D** $CaSO_4$

11. O/N 10/P11/Q18, O/N 10/P13/Q18

Sulfur dioxide is used to bleach wood pulp in the production of paper. It is also used as an additive in the production of jam and marmalade, often in the form of sulfite compounds. When it is present in quantities greater than 10 mg / kg it is required to be listed as an ingredient of the jam.
Why is sulfur dioxide added to jam?

A It is a bleaching agent and removes the undesirable colours from the fruit used in the jam.
B It is a preservative that destroys unwanted bacteria and enzymes.
C It is a reducing agent and removes the acids that give the jam a sharp taste.
D It is an acidic gas and maintains the pH of the jam at a suitable value to give it a sharp taste.

12. O/N 10/P11/Q30, O/N 10/P13/Q30

Which environmental problem is **not** made worse by the release of oxides of nitrogen from car engines?

A acidification of lakes **C** photochemical smog
B corrosion of buildings **D** the hole in the ozone layer

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13. O/N 18/P11/Q33, O/N 18/P13/Q33

Which statements are correct for all exothermic reactions?
1 ΔH for the reaction is negative.
2 On a reaction pathway diagram the products are shown lower than the reactants.
3 The reaction will occur without heating.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

14. M/J 18/P11/Q31

One mole of sulfuric acid is used to make an aqueous solution. The solution contains H_2SO_4 molecules, H^+ ions, SO_4^{2-} ions and HSO_4^- ions.
Which statements are correct?
1 The solution contains 6.02×10^{23} sulfur atoms.
2 The solution contains an exactly equal number of H^+ ions and HSO_4^- ions.
3 One mole of SO_4^{2-} ions contains two moles of electrons.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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15. O/N 18/P11/Q34, O/N 18/P13/Q34

The factors affecting the rate of reaction between aqueous sodium thiosulfate and hydrochloric acid can be investigated. The ionic equation for the reaction is shown.

$$S2O_3^{2-}(aq) + 2H^+(aq) \rightarrow H_2O(l) + S(s) + SO_2(aq)$$

Which of the following can be used to investigate the rate of this reaction?

1 change of mass
2 change of appearance caused by formation of a precipitate
3 change of electrical conductivity

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

16. M/J 17/P12/Q36

Acid rain continues to be a problem.

Which statements about acid rain are correct?

1 Acid rain is formed when oxides of nitrogen or oxides of sulfur react with water in the atmosphere.
2 Acid rain causes an increase in the concentration of heavy metal ions in water courses.
3 Nitrogen dioxide will catalyse the formation of SO_3 from SO_2 in the atmosphere.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

17. M/J 17/P13/Q36

Sulfur dioxide is an atmospheric pollutant.

What might result from the release of sulfur dioxide gas into the atmosphere?

1 reduction of NO_2 to NO
2 depletion of aquatic life
3 corrosion of limestone statues

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

18. O/N 16/P11/Q34, O/N 16/P13/Q34

In the manufacture of sulfuric acid, the following exothermic reaction occurs.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

Which changes will move the position of the equilibrium to the right?

1 increasing the pressure
2 increasing the temperature
3 using twice as much catalyst

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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19. O/N 15/P11/Q36, O/N 15/P13/Q36

Sulfur dioxide is used as a food preservative.

Which statements about sulfur dioxide, SO_2, are correct?

1 SO_2 behaves as an antioxidant.
2 Aqueous SO_2 contains SO_3^{2-} ions.
3 SO_2 inhibits the growth of mould and yeasts.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

20. M/J 15/P11/Q35

Which statements about the industrial manufacture of sulfuric acid are correct?

1 Sulfur is burned to form sulfur dioxide.
2 The stage that forms sulfur trioxide involves a V_2O_5 catalyst.
3 The stage that forms sulfur trioxide is non-reversible.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

21. O/N 14/P13/Q36

Element **X** is a solid. It is found in some fuels.
Its oxide **Y** is formed in car engines. **Y** is acidic.
Further oxidation of **Y** to **Z** can occur in the atmosphere.

Which statements about **Y** and **Z** are correct?

1 Molecule **Y** has lone pairs of electrons.
2 The atmospheric oxidation of **Y** to **Z** is a catalysed reaction.
3 **Y** is a colourless gas.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

22. M/J 14/P12/Q34

Sulfuric acid is a Brønsted-Lowry acid.

In which reactions is sulfuric acid behaving as an acid?

1 $H_2SO_4 + HNO_3 \rightarrow H_2NO_3^+ + HSO_4^-$

2 $H_2SO_4 + CO_3^{2-} \rightarrow CO_2 + H_2O + SO_4^{2-}$

3 $H_2SO_4 + MgO \rightarrow MgSO_4 + H_2O$

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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12.3: Multiple Topics

1. **M/J 20/P12/Q19**
Most modern cars are fitted with catalytic converters in the exhaust system.
Which three gases are removed by a catalytic converter?
A carbon monoxide, hydrocarbons, nitrogen oxides
B carbon monoxide, carbon dioxide, nitrogen oxides
C carbon monoxide, nitrogen oxides, sulfur dioxide
D hydrocarbons, nitrogen oxides, sulfur dioxide

2. **O/N 19/P12/Q18**
Which emission from an internal combustion engine contributes to the erosion of marble statues?
A carbon monoxide
B nitrogen
C nitrogen dioxide
D unburnt hydrocarbons

3. **O/N 19/P11/Q18, O/N 19/P13/Q18**
Which type of reaction occurs when solid ammonium sulfate is heated with an excess of sodium hydroxide solution?
A acid-base
B precipitation
C redox
D thermal decomposition

4. **O/N 19/P11/Q19, O/N 19/P13/Q19**
Catalytic converters are fitted in the exhaust systems of many cars.
Which gas:
- causes acid rain if it is released into the air
- is removed from car exhaust fumes by a catalytic converter?

A carbon dioxide
B carbon monoxide
C hydrocarbon vapour
D nitrogen dioxide

5. **M/J 19/P12/Q18, MAR 16/P12/Q17**
Ammonium sulfate, $(NH_4)_2SO_4$, and ammonium nitrate, NH_4NO_3, are used as fertilisers.
These salts have different percentages by mass of nitrogen. They have the same effect as each other on the pH of neutral soil.
Which row is correct?

	higher percentage of nitrogen by mass	effect on pH of soil
A	ammonium nitrate	decrease
B	ammonium nitrate	increase
C	ammonium sulfate	decrease
D	ammonium sulfate	increase

6. **M/J 19/P13/Q18**
Which statement about the ammonium ion is correct?
A It can act as a Brønsted-Lowry base.
B It can react with OH^- to give ammonia.
C It is pyramidal with bond angles of 107°.
D The nitrogen atom is sp^2 hybridised.

7. **M/J 18/P13/Q18, M/J 13/P13/Q19**
Transition elements and their compounds are important as catalysts.
In which process is a transition element compound used, rather than the element itself?
A catalytic converters
B Contact process
C Haber process
D hydrogenation of oils

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8. M/J 18/P13/Q19

The gaseous products of heating a mixture of $Ca(OH)_2$ and NH_4Cl are passed through solid CaO.
This absorbs water vapour and a gas, **W**, is collected.
A sample of **W** is oxidised by $Cl_2(g)$ to produce two gases, **X** and **Y**.
X is an element. **Y** is acidic.
Y reacts with **W** to produce **Z**.
What are **X** and **Z**?

	X	Z
A	N_2	$CaCl_2$
B	N_2	NH_4Cl
C	O_2	$CaCl_2$
D	O_2	NH_4Cl

9. M/J 17/P12/Q19, M/J 14/P11/Q18

A chemist took 2.00 dm^3 of nitrogen gas, measured under room conditions, and reacted it with a large volume of hydrogen gas, in order to produce ammonia. Only 15.0% of the nitrogen gas reacted to produce ammonia.
What mass of ammonia was formed?

A 0.213 g **B** 0.425 g **C** 1.42 g **D** 2.83 g

10. M/J 17/P13/Q19

What would be produced when 60 g of nitrogen monoxide react with an excess of carbon monoxide in a catalytic converter?

A 12 g of carbon and 92 g of nitrogen dioxide
B 24 g of carbon and 92 g of nitrogen dioxide
C 88 g of carbon dioxide and 28 g of nitrogen
D 88 g of carbon dioxide and 56 g of nitrogen

11. MAR 17/P12/Q19

Methylamine, CH_3NH_2, has very similar chemical properties to ammonia, NH_3.
Methylamine reacts with hydrogen chloride to form a white crystalline salt, methylammonium chloride.

$$CH_3NH_2 + HCl \rightarrow CH_3NH_3^+Cl^-$$

A sample of methylammonium chloride is heated with aqueous sodium hydroxide.
What are the products?

A ammonia, sodium chloride and water
B ammonia, sodium hydrogencarbonate and sodium chloride
C methylamine, hydrogen chloride and water
D methylamine, sodium chloride and water

12. O/N 16/P12/Q19

Water and ammonia take part in a reaction that produces the ammonium ion.
Which statement about this reaction is correct?

A Neither the ammonia molecule nor the ammonium ion has a dipole moment.
B The bond angle changes from 109.5° in the ammonia molecule to 107° in the ammonium ion.
C The reaction is a redox reaction.
D The water is acting as an acid.

13. O/N 13/P13/Q16

Carbon, nitrogen and sulfur are non-metals.
Which statement about their oxides, XO_2, is correct? (Where X represents carbon, nitrogen or sulfur.)

A All of the XO_2 molecules are linear.
B In XO_2, each element has its highest oxidation number.
C All XO_2 molecules dissolve in water to form dibasic acids.
D All XO_2 molecules are formed as a result of burning petrol in a car engine.

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14. M/J 16/P12/Q15

Ammonia gas, NH_3, and hydrogen sulfide gas, H_2S, react together to form the salt ammonium sulfide, $(NH_4)_2S$. Ammonium sulfide dissolves in water to produce an orange alkaline solution.

$$(NH_4)_2S(aq) \rightleftharpoons NH_3(aq) + NH_4SH(aq)$$

The addition of NaOH(aq) to this solution produces a gas, X.
The addition of HCl(aq) to a separate portion of this solution produces a gas, Y.
What are the identities of X and Y?

	X	Y
A	H_2S	H_2S
B	H_2S	NH_3
C	NH_3	H_2S
D	NH_3	NH_3

15. M/J 16/P12/Q17

Nitrogen(II) oxide, NO, nitrogen(IV) oxide, NO_2, carbon monoxide, CO, and unburnt hydrocarbons are present in the exhaust gases of internal combustion engines. When catalytic converters are used to remove these compounds from the exhaust gases, redox reactions occur.
What happens to each compound in the catalytic converter?

	NO	NO_2	CO	hydrocarbons
A	oxidised	oxidised	reduced	oxidised
B	oxidised	oxidised	oxidised	oxidised
C	reduced	reduced	oxidised	oxidised
D	reduced	reduced	reduced	reduced

16. M/J 15/P12/Q18

Carbon monoxide, CO, nitrogen dioxide, NO_2, and sulfur dioxide, SO_2, are all atmospheric pollutants.
Which reaction concerning these compounds occurs in the atmosphere?

A CO is spontaneously oxidised to CO_2
B NO_2 is reduced to NO by CO
C NO_2 is reduced to NO by SO_2
D SO_2 is oxidised to SO_3 by CO_2

17. O/N 13/P12/Q18, O/N 13/P11/Q18

Transition metals and their compounds are used as catalysts.
Which row is correct?

	transition metal present in the catalyst used in the Contact process	transition metal present in the catalyst used in the Haber process
A	iron	iron
B	iron	vanadium
C	vanadium	iron
D	vanadium	vanadium

18. M/J 12/P12/Q13, O/N 02/P1/Q19

Which gas is present in the exhaust fumes of a car engine in a much greater amount than any other gas?

A carbon dioxide **B** carbon monoxide **C** nitrogen **D** water vapour

19. M/J 12/P12/Q19

Which substance does **not** produce a poisonous gas, when burnt in a limited amount of air?

A hydrogen **B** methane **C** propene **D** sulfur

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20. M/J 12/P13/Q20, M/J 12/P11/Q19
Carbon monoxide, CO, nitrogen monoxide, NO, and sulfur dioxide, SO_2, may all be present in the exhaust fumes from a car engine.
Which reaction concerning these compounds occurs in the atmosphere?

A CO is spontaneously oxidised to CO_2
B NO_2 is reduced to NO by CO
C NO_2 is reduced to NO by SO_2
D SO_2 is oxidised to SO_3 by CO_2

21. M/J 11/P12/Q18
In the Contact process, what is the nature of the gaseous product and what is the identity of the catalyst?

	nature of gaseous product	catalyst
A	acidic	Fe
B	acidic	V_2O_5
C	basic	Fe
D	basic	V_2O_5

22. O/N 09/P12/Q17, O/N 09/P11/Q18
Most modern cars are fitted with three-way catalytic converters in the exhaust system.
Which three gases are removed by such a catalytic converter?

A carbon monoxide, hydrocarbons, nitrogen oxides
B carbon monoxide, carbon dioxide, nitrogen oxides
C carbon monoxide, nitrogen oxides, sulfur dioxide
D hydrocarbons, nitrogen oxides, sulfur dioxide

23. M/J 09/P1/Q17
Deposits of ammonium compounds have been discovered in areas of high atmospheric pollution.
They are believed to arise from the following reaction.

$$SO_3 + H_2O + 2NH_3 \rightarrow (NH_4)_2SO_4$$

What does not occur in this reaction?

A acid / base neutralisation
B dative bond formation
C ionic bond formation
D oxidation / reduction

24. O/N 08/P1/Q14
Which salt is produced by adding aqueous ammonia to aqueous sulphur dioxide until just alkaline?

A NH_4SO_3 **B** NH_4SO_4 **C** $(NH_4)_2SO_3$ **D** $(NH_4)_2SO_4$

25. O/N 08/P1/Q18
When gaseous chemicals are transported by road or by rail they are classified as follows.

flammable non-flammable poisonous

Which gas is poisonous?

A butane **B** carbon dioxide **C** hydrogen **D** sulphur dioxide

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26. M/J 20/P12/Q35, M/J 15/P13/Q35
In the atmosphere, which transformations can involve sulfur dioxide as either a reagent or a catalyst?

1 NO_2 to NO
2 NO to NO_2
3 CO to CO_2

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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27. M/J 20/P11/Q35

The catalytic converters fitted to cars remove pollutants from the exhaust gases. Some of the reactions that occur involve oxygen, which comes from the air.

Which pollutants in the exhaust gases will react with oxygen on the surface of the catalytic converter?

1 NO_2
2 unburnt fuel
3 CO

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

28. M/J 20/P13/Q34

The Haber process is used in industry to form ammonia from hydrogen and nitrogen.

$$3H_2 + N_2 \rightleftharpoons 2NH_3$$

Which statements about the activation energy for this process are correct?

1 The activation energy for the forward reaction is the same as the activation energy for the reverse reaction.
2 The activation energy for the reverse reaction is decreased by the addition of iron.
3 The activation energy is the minimum energy that colliding particles must possess in order to react.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

29. M/J 19/P13/Q36

Which gases will dissolve in water causing a lowering of the pH?

1 ammonia
2 sulfur dioxide
3 nitrogen dioxide

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

30. MAR 19/P12/Q34

Some polluting gases are removed from car exhaust fumes using a catalytic converter.

Platinum or palladium can be used as the catalyst. The reactions are faster when platinum is the catalyst than they are when palladium is the catalyst.

Which statements are correct?

1 Platinum acts as a heterogeneous catalyst in these reactions.
2 The palladium-catalysed reactions have higher activation energies than the platinum-catalysed reactions.
3 The platinum-catalysed reactions are more exothermic than the palladium-catalysed reactions.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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31. M/J 18/P13/Q33

Ammonia and chlorine react as shown.

$$8NH_3 + 3Cl_2 \rightarrow N_2 + 6NH_4Cl$$

Which statements are correct?

1 Each nitrogen atom is oxidised.
2 Each chlorine atom is reduced.
3 Ammonia behaves as a base.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

32. O/N 17/P12/Q36

Modern cars are fitted with catalytic converters to reduce atmospheric pollution caused by unwanted reactions during the combustion of the fuel.

Which statements are correct?

1 Carbon monoxide is oxidised to carbon dioxide in a catalytic converter.
2 Catalytic converters have a very large surface area.
3 Nitrogen dioxide is reduced to nitrogen monoxide in a catalytic converter.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

33. M/J 17/P11/Q36, M/J 14/P11/Q35

Pollutant oxide **Y**, which contains non-metallic element **X**, is formed in a car engine.

Further oxidation of **Y** to **Z** occurs in the atmosphere. In this further oxidation, 1 mol of **Y** reacts with 0.5 mol of gaseous oxygen molecules.

X could be either nitrogen or sulfur.

Which statements about **X**, **Y** and **Z** can be correct?

1 The oxidation number of **X** increases by two from **Y** to **Z**.
2 **Y** has an unpaired electron in its molecule.
3 **Y** is a polar molecule.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

34. O/N 16/P12/Q36

Oxides of both sulfur and nitrogen are present in the atmosphere.

Which statements are correct?

1 Oxides of both sulfur and nitrogen can be formed in internal combustion engines.
2 Oxides of both sulfur and nitrogen can be produced by direct combination of the elements.
3 Oxides of both sulfur and nitrogen are involved in the formation of acid rain.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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35. O/N 16/P13/Q36, O/N 16/P11/Q36

Catalytic converters are used to modify exhaust emissions from motor vehicles.
Which reactions occur in catalytic converters?

1 $C_8H_{18} + 12\frac{1}{2}O_2 \rightarrow 8CO_2 + 9H_2O$

2 $2NO + 2CO \rightarrow N_2 + 2CO_2$

3 $NO + SO_3 \rightarrow NO_2 + SO_2$

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

36. MAR 16/P12/Q35

In some rice-growing parts of the world, farmers use a combination of paddy fields and a fish farm. Rice paddy fields are flooded for much of the growing cycle and water running off the fields flows through pens where fish are raised. Nitrogen-based fertilisers are generally very soluble in water.
Which problems could result from farmers applying excess nitrogen-based fertilisers to their paddy fields?

1 decreased fish production in the fish pens
2 decreased levels of oxygen in the water
3 increased growth of algae in the fish pens

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

37. M/J 15/P12/Q34

Which of these reactions are redox reactions?

1 $6NO(g) + 4NH_3(g) \rightarrow 5N_2(g) + 6H_2O(g)$

2 $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$

3 $SO_3(g) + H_2O(g) \rightarrow H_2SO_4(g)$

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

38. M/J 14/P12/Q36

A car has a catalytic converter fitted to its exhaust. On analysis its exhaust gases are shown to contain small quantities of nitrogen oxides.
Which modifications would result in lower exhaust concentrations of nitrogen oxides?

1 an increase in the surface area of the catalyst in the converter
2 an increase in the rate of flow of the exhaust gases through the converter
3 a much higher temperature of combustion in the engine

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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39. M/J 14/P13/Q35

Which statements explain why sulfur dioxide is used as a food preservative?

1 It is a reducing agent and therefore an anti-oxidant.
2 It prevents alcohols in foods forming sour-tasting acids.
3 It does not smell and therefore can be used in large quantities.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

40. O/N 13/P13/Q35

Which processes involve the conversion of sulfur dioxide into sulfur trioxide?

1 the combustion of sulfur contaminated fossil fuels
2 the Contact process for manufacturing sulfuric acid
3 the catalytic oxidation of sulfur dioxide by oxides of nitrogen

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

41. M/J 13/P13/Q36

Element **J** is a solid. It occurs as a contaminant of fossil fuels.
Its oxide **K** is formed in car engines.
In the atmosphere, **K** can be further oxidised to **L**.
Which statements about **J**, **K** and **L** are correct?

1 Atoms of **J** have paired p electrons.
2 The atmospheric oxidation of **K** to **L** is a catalysed reaction.
3 With water, **L** forms a strong acid.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

42. O/N 12/P12/Q35, O/N 12/P11/Q35

Which equations represent stages in the Contact process for manufacturing sulfuric acid?

1 $SO_2 + \frac{1}{2}O_2 \rightarrow SO_3$

2 $SO_2 + H_2O \rightarrow H_2SO_3$

3 $H_2SO_3 + \frac{1}{2}O_2 \rightarrow H_2SO_4$

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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43. M/J 12/P12/Q33

Concentrated sulfuric acid behaves as a strong acid when it reacts with water.

$$H_2SO_4(l) + aq \longrightarrow H^+(aq) + HSO_4^-(aq)$$

The HSO_4^- ion formed behaves as a weak acid.

$$HSO_4^-(aq) \rightleftharpoons H^+(aq) + SO_4^{2-}(aq)$$

Which statements are true for 1.0 mol dm^{-3} sulfuric acid?

1 $[H^+(aq)]$ is high

2 $[SO_4^{2-}(aq)]$ is high

3 $[HSO_4^-(aq)] = [SO_4^{2-}(aq)]$

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

44. M/J 12/P11/Q36, M/J 12/P13/Q35

In the manufacture of sulfuric acid the reaction $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ usually takes place at 400 °C and 1 atm pressure. In one industrial plant, it is decided to change the pressure to 20 atm.

What will be the consequences of this change?

1 increased running costs

2 an increased percentage of sulfur trioxide in the equilibrium mixture

3 the rate of the backward reaction increases

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

45. O/N 11/P13/Q36, O/N 11/P11/Q36

In a car engine, non-metallic element X forms a pollutant oxide Y.

Further oxidation of Y to Z occurs spontaneously in the atmosphere. In this further oxidation, 1 mol of Y reacts with 0.5 mol of gaseous oxygen.

Which statements about X, Y and Z are correct?

1 X forms a basic hydride.

2 Y is a diatomic molecule.

3 Z is a polar molecule.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

46. M/J 09/P1/Q34

The following reaction takes place using liquid ammonia as a solvent.

$$Na^+ NH_2^- + NH^+_4C/^- \rightarrow Na^+C/^- + 2NH_3$$

Which statements best explain why this reaction should be classified as a Brnsted-Lowry acidbase reaction?

1 The ammonium ion acts as a proton donor.

2 $Na^+C/^-$ is a salt.

3 Ammonia is always basic.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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Answers Sections

12.1		12.2		12.3			
1.	B	1.	D	1.	A	41.	A
2.	C	2.	B	2.	C	42.	D
3.	A	3.	D	3.	A	43.	D
4.	A	4.	C	4.	D	44.	A
5.	B	5.	C	5.	A	45.	A
6.	D	6.	B	6.	B	46.	D
7.	D	7.	C	7.	B		
8.	C	8.	C	8.	B		
9.	A	9.	A	9.	B		
10.	D	10.	C	10.	C		
11.	C	11.	B	11.	D		
12.	B	12.	D	12.	D		
13.	C	13.	D	13.	D		
14.	B	14.	D	14.	C		
15.	C	15.	C	15.	C		
16.	C	16.	A	16.	C		
17.	B	17.	A	17.	C		
18.	D	18.	D	18.	C		
19.	A	19.	A	19.	A		
20.	C	20.	B	20.	C		
21.	D	21.	A	21.	B		
22.	D	22.	A	22.	A		
23.	B			23.	D		
24.	A			24.	C		
25.	D			25.	D		
26.	A			26.	D		
				27.	C		
				28.	C		
				29.	C		
				30.	B		
				31.	C		
				32.	B		
				33.	A		
				34.	A		
				35.	B		
				36.	A		
				37.	B		
				38.	D		
				39.	B		
				40.	C		

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Unit 13
AN INTRODUCTION TO ORGANIC CHEMISTRY

A Level
Chemistry Paper 1
Classified/Topical MCQ's
Article Number: 231

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Syllabus

13.1 Formulae, functional groups and the naming of organic compounds
13.2 Characteristic organic reactions
13.3 Shapes of organic molecules; s and p bonds
13.4 Isomerism, structural and stereoisomerism
13.5 Multiple topics

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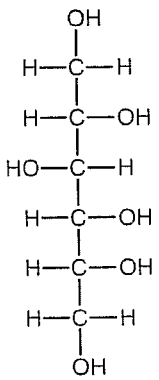
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Unit 13: An introduction to organic chemistry

13.1: Formulae, functional groups and the naming of organic compounds

1. **O/N 15/P11/Q29, O/N 15/P13/Q29**
Sorbitol is a naturally-occurring compound with a sweet taste. It is often used as a substitute for sucrose by the food industry.

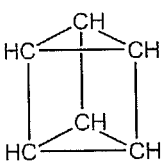


sorbitol

How many chiral centres are present in sorbitol?

A 3 **B** 4 **C** 5 **D** 6

2. **M/J 15/P11/Q28**
In 1869 Ladenburg suggested a structure for benzene, C_6H_6, in which one hydrogen atom is attached to each carbon atom.



Ladenburg structure

A compound $C_6H_4Cl_2$ could be formed with **the same** carbon skeleton as the Ladenburg structure.
How many **structural** isomers would this compound have?

A 3 **B** 4 **C** 5 **D** 6

3. **O/N 14/P11/Q28, M/J 11/P12/Q28, O/N 14/P12/Q28**
The ester $CH_3CH_2CH_2CO_2CH_3$ is responsible for the aroma of apples.
When this ester is hydrolysed by acid in the stomach, what is the empirical formula of the organic acid produced?

A CH_2O **B** CH_4O **C** C_2H_4O **D** $C_3H_6O_2$

4. **M/J 14/P11/Q28**
Compound X has the molecular formula $C_4H_{10}O_2$. X has an unbranched carbon chain and contains two OH groups.
On reaction with an excess of hot, acidified, aqueous manganate(VII) ions, X is converted into a compound of molecular formula $C_4H_6O_4$.
To which two carbon atoms in the chain of X are the two OH groups attached?

A 1st and 2nd **B** 1st and 3rd **C** 1st and 4th **D** 2nd and 3rd

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5. O/N 11/P13/Q23, O/N 11/P11/Q22

In the general formula of which class of compound, is the ratio of hydrogen atoms to carbon atoms the highest?

A alcohols **B** aldehydes **C** carboxyclic acids **D** halogenoalkanes

6. M/J 11/P11/Q22, M/J 11/P13/Q20

The formula CH_3 can represent an anion, a cation or a free radical. Species with the molecular formula CH_3 can act as an electrophile, a free radical or a nucleophile depending on the number of outer shell electrons on the central carbon atom.

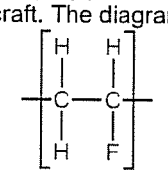
How many outer shell electrons must be present for CH_3 to act in these different ways?

	CH_3 as an electrophile	CH_3 as a free radical	CH_3 as a nucleophile
A	6	7	8
B	6	8	7
C	7	6	8
D	8	7	6

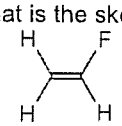
7. O/N 10/P12/Q28

Fluoroalkenes are used to make polymers such as poly(vinyl)fluoride (PVF).

PVF is used to make non-flammable interiors for aircraft. The diagram shows the repeat unit of the polymer PVF.



What is the skeletal formula of the monomer of PVF?

A 

B 

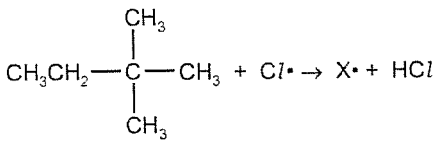
C 

D 

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13.2: Characteristic organic reactions

1. **M/J 16/P13/Q23, M/J 13/P12/Q22, M/J 10/P13/Q23,M/J 10/P11/Q21, M/J 10/P12/Q25**
When heated with chlorine, the hydrocarbon 2,2-dimethylbutane undergoes free radical substitution.
In a propagation step a free radical X• is formed.



How many different structures of X• are possible?
A 2 **B** 3 **C** 4 **D** 5

2. **M/J 14/P13/Q30**
The free radical substitution reaction between methane and chlorine involves initiation, propagation and termination stages. Which row is correct?

	involved in initiation stage	radical produced in a propagation stage
A	heterolytic fission	H•
B	heterolytic fission	CH_3•
C	homolytic fission	H•
D	homolytic fission	CH_3•

3. **M/J 09/P1/Q22**
Trichloroethanoic acid, CCl_3CO_2H, is used in cosmetic surgery to perform a 'chemical peel' to remove dead skin.
Trichloroethanoic acid can be made by reacting chlorine with ethanoic acid.
What is the mechanism of this reaction?
A electrophilic addition **C** free radical addition
B electrophilic substitution **D** free radical substitution

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4. **M/J 17/P13/Q37**
Which mechanisms are represented in this sequence of reactions?
$CH_3CH_2CH_3 \rightarrow CH_3CH_2CH_2Cl \rightarrow CH_3CH_2CH_2OH \rightarrow CH_3CHCH_2 \rightarrow CH_3CHBrCH_2Br$
1 electrophilic addition
2 nucleophilic substitution
3 free radical substitution

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

5. **M/J 13/P11/Q31**
Free-radicals play an important part in reactions involving the destruction of the ozone layer and the substitution of alkanes by chlorine.
Some free-radicals contain two unpaired electrons. Such species are called diradicals.
Which species are diradicals?
1 O 2 Cl 3 CH_3

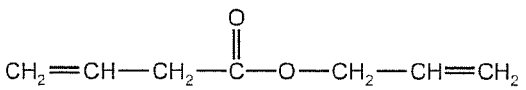
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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13.3: Shapes of organic molecules; s and p bonds

1. O/N 18/P12/Q21

The diagram shows a molecule that has σ bonds and π bonds.



How many s bonds are present in this molecule?

A 15 **B** 17 **C** 18 **D** 21

2. MAR 17/P12/Q20

Structural isomerism and stereoisomerism should be considered when answering this question.

How many isomers with the formula C_4H_8 have structures that contain a π bond?

A 1 **B** 2 **C** 3 **D** 4

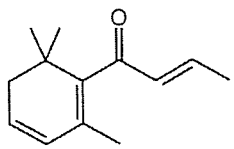
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13.4: Isomerism: structural and stereoisomerism

1. **M/J 20/P12/Q26**
The structure of damascenone is shown.

damascenone



Including damascenone, how many stereoisomers exist with this structural formula?

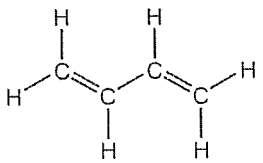
A 1 **B** 2 **C** 4 **D** 8

2. **M/J 20/P12/Q27, O/N 15/P13/Q20, O/N 15/P11/Q20, M/J 12/P13/Q23, M/J 12/P11/Q24**
How many isomeric esters have the molecular formula $C_4H_8O_2$?

A 2 **B** 3 **C** 4 **D** 5

3. **M/J 20/P12/Q30**
The diagram shows the structure of buta-1,3-diene.

buta-1,3-diene



The addition reaction between buta-1,3-diene and two molecules of hydrogen bromide can produce three structurally isomeric products.
How many of these products have at least one chiral centre?

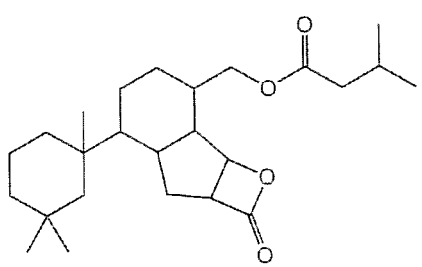
A 0 **B** 1 **C** 2 **D** 3

4. **M/J 20/P11/Q21**
Which statement is correct?

A 2,2-dimethylpropanoic acid is an isomer of propyl methanoate.
B 2-methylbutan-2-ol is an isomer of hexan-3-ol.
C 3-methylbutan-2-one is an isomer of pentanal.
D 3,3-dimethylbutan-2-one is an isomer of pentan-3-one.

5. **M/J 20/P11/Q28**
The structure of compound Q is shown.

compound Q



How many chiral centres are present in a molecule of Q?

A 4 **B** 5 **C** 6 **D** 7

6. **M/J 20/P13/Q20**
Structural and stereoisomerism should be considered when answering this question.
When trans-pent-2-ene reacts with HBr, how many different products can form?

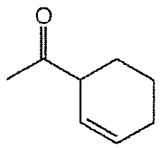
A 1 **B** 2 **C** 3 **D** 4

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7. M/J 20/P13/Q30

Compound X has the structure shown.

compound X



Which type of carbonyl group is present and how many chiral centres are there in one molecule of X?

	carbonyl group	chiral centres
A	aldehyde	0
B	aldehyde	1
C	ketone	0
D	ketone	1

8. MAR 20/P12/Q20

Which pair of compounds are functional group isomers of each other?

A butan-1-ol and butanal
B ethylpropanoate and pentanoic acid
C hex-1-ene and hex-2-ene
D propylamine and propanenitrile

9. MAR 20/P12/Q25

Structural isomerism and stereoisomerism should be considered when answering this question.
How many non-cyclic isomers have the molecular formula C_5H_{10}?

A 3 **B** 4 **C** 5 **D** 6

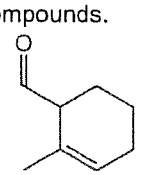
10. M/J 19/P12/Q21

Compound X does **not** show cis-trans isomerism.
What could be the identity of compound X?

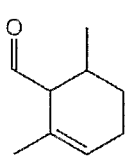
A 1,1,2-trichloropropene
B 1,2,3-trichloropropene
C 1-chlorobut-1-ene
D 1-chlorobut-2-ene

11. M/J 19/P11/Q20, M/J 16/P11/Q20

The diagrams show two different compounds.



1



2

What is

- the total number of structural isomers, including compound 2, that could be formed by adding a second methyl group to the ring of compound 1,
- the number of π electrons in each compound?

	number of isomers	number of π electrons
A	3	2
B	3	4
C	5	2
D	5	4

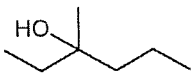
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12. M/J 19/P11/Q26

Structural isomerism and stereoisomerism should be considered when answering this question.

3-methylhexan-3-ol reacts with hot, concentrated sulfuric acid to form several isomeric compounds with the molecular formula C_7H_{14}.

3-methylhexan-3-ol



How many isomeric compounds could be formed in this reaction?

A 3 **B** 4 **C** 5 **D** 6

13. M/J 19/P11/Q30

Which compound is chiral?

A 1-chloro-3-methylbutane
B 2-chloro-2-methylbutane
C 2-chloro-3-methylbutane
D 3-chloropentane

14. M/J 19/P13/Q28

Structural isomerism only should be considered when answering this question.

A set of isomeric compounds, with molecular formula $C_5H_{10}O$, all react in a 1 : 1 ratio with an excess of HCN by nucleophilic addition.

How many isomeric compounds are in the set?

A 5 **B** 6 **C** 7 **D** 8

15. MAR 19/P12/Q20, O/N 10/P12/Q20

How many structural isomers are there of trichloropropane, $C_3H_5Cl_3$?

A 3 **B** 4 **C** 5 **D** 6

16. MAR 19/P12/Q23

Structural isomerism and stereoisomerism should be considered when answering this question.

2-bromopentane is heated with an excess of ethanolic sodium hydroxide.

How many different hydrocarbons are produced?

A 1 **B** 2 **C** 3 **D** 4

17. MAR 19/P12/Q27

Structural isomerism only should be considered when answering this question.

All the isomeric alcohols with the molecular formula $C_5H_{12}O$ are added separately to warm alkaline aqueous iodine.

How many of the isomers give a yellow precipitate?

A 0 **B** 1 **C** 2 **D** 3

18. O/N 18/P12/Q20

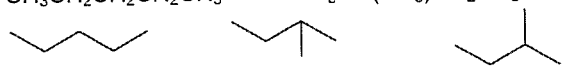
There are three structural isomers with the formula C_5H_{12}.

Which formulae correctly represent these three structural isomers?

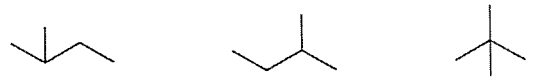
A $CH_3CH_2CH_2CH_2CH_3$ $CH_3CH(CH_3)CH_2CH_3$ $C(CH_3)_4$

B $CH_3CH_2CH_2CH_2CH_3$ $CH_3CH(CH_3)CH_2CH_3$ $CH_3CH_2CH(CH_3)CH_3$

C



D



19. O/N 18/P11/Q21, O/N 18/P13/Q21

X has the molecular formula $C_5H_{12}O$. X has a branched carbon skeleton and a secondary alcohol functional group.

How many structural isomers fit this description of X?

A 1 **B** 2 **C** 3 **D** 4

20. O/N 17/P12/Q20

Which compound does **not** exhibit stereoisomerism?

A CH_3CHC/CH_2CHO **B** $CH_3CHCHCH_3$ **C** $CH_2C/CH2CC/_2H$ **D** CHC/CHC/

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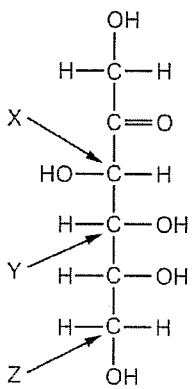
21. M/J 18/P12/Q24

Structural isomerism and stereoisomerism should be considered when answering this question.
A colourless liquid, $C_5H_{11}Cl$, exists as a mixture of two optical isomers.
When heated with sodium hydroxide in ethanol, a mixture of only two alkenes is formed.
What could the colourless liquid be?

A $(CH_3CH_2)_2CHCl$
B $CH_3CH_2CH_2CHClCH_3$
C $(CH_3)_2CHCHClCH_3$
D $CH_3CH_2CCl(CH_3)_2$

22. M/J 18/P11/Q20

Fructose is a sugar with more than one chiral centre. The fructose molecule is shown with X, Y and Z indicating three carbon atoms.



fructose

Which carbon atoms are chiral centres?

A X, Y and Z **B** X and Y only **C** X only **D** Y only

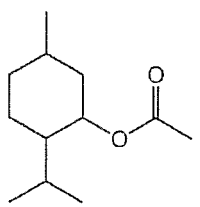
23. M/J 18/P11/Q21

Which pair of alcohols are isomers of each other?

A butan-1-ol and 2,2-dimethylpropan-1-ol
B butan-2-ol and 2-methylpropan-2-ol
C pentan-1-ol and 2-methylpropan-2-ol
D propan-2-ol and 2-methylpropan-2-ol

24. M/J 18/P13/Q20

Molecule G is shown.



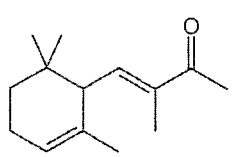
G

How many chiral centres are present in each molecule of G?

A 1 **B** 2 **C** 3 **D** 4

25. O/N 17/P11/Q20, O/N 17/P13/Q20

The structural formula of compound Q is shown.



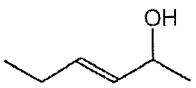
Q

How many stereoisomers exist with this structural formula?

A 1 **B** 2 **C** 4 **D** 8

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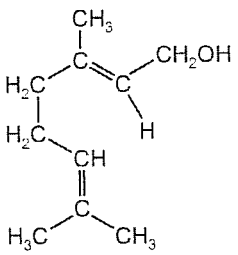
26. O/N 17/P11/Q21, O/N 17/P13/Q21
What is the name of compound **X**?



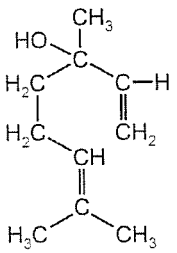
compound **X**

A *trans*-2-hydroxyhex-3-ene
B *trans*-2-hydroxyhexene
C *trans*-5-hydroxyhex-3-ene
D *trans*-5-hydroxyhexene

27. M/J 17/P12/Q21
Geraniol and linalool are compounds found in some flower fragrances.



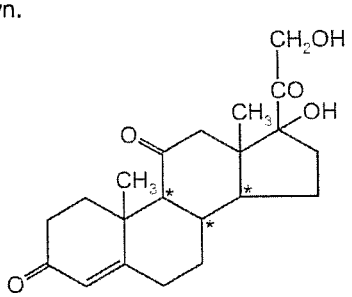
geraniol



linalool

Which statement is correct?
A They are chain isomers of each other.
B They are geometrical isomers of each other.
C They are optical isomers of each other.
D They are positional isomers of each other.

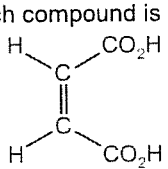
28. M/J 17/P11/Q21, O/N 09/P12/Q19, O/N 09/P11/Q20
The drug cortisone has the formula shown.



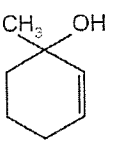
In addition to those chiral centres marked by an asterisk (*), how many other chiral centres are present in the cortisone molecule?
A 0 **B** 1 **C** 2 **D** 3

29. M/J 17/P12/Q29
Which compound is chiral and reacts with Na_2CO_3 to give CO_2?

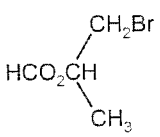
A



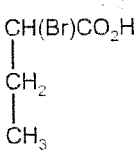
B



C



D



30. M/J 17/P11/Q29
Which compound gives a positive test with alkaline aqueous iodine and does not show optical isomerism?
A $CH_3COCH_2CH_2OH$
B $CH_3CH_2CH(OH)CHO$
C $CH_3COCH(OH)CH_3$
D $(CH_3)_2C(OH)CHO$

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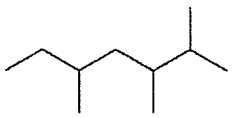
31. M/J 17/P13/Q20

Structural isomerism and stereoisomerism should be considered when answering this question.
Which formula identifies a single substance?

A CH_3CHC/CH_2CHO **B** $CH_3CHCHCH_3$ **C** CH_2C/CH_2CHCl_2 **D** C_4H_{10}

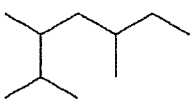
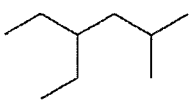
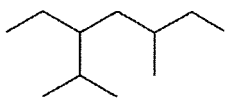
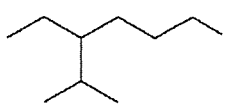
32. MAR 17/P12/Q21

Kerosene is used as an aircraft fuel. Q is one of the molecules in kerosene and has the skeletal formula shown.



Q

Other structural isomers of this molecule are also found in kerosene.
Which structure is a structural isomer of Q?

A  **B**  **C**  **D** 

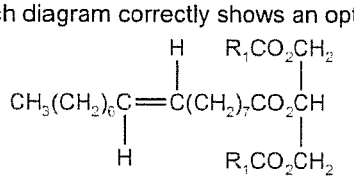
33. O/N 16/P12/Q24

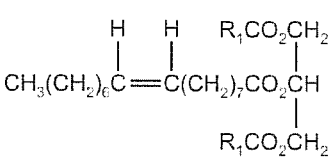
Which statement about stereoisomers is correct?

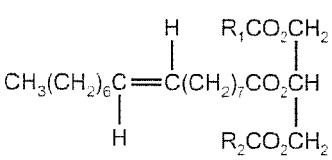
A Cis-trans isomers are mirror images of each other.
B Optical isomers must contain a double bond that restricts rotation.
C Stereoisomers have the same structural formula as each other.
D Stereoisomers must contain a chiral centre.

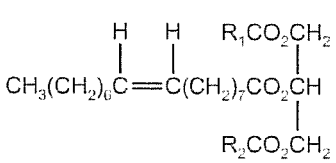
34. O/N 16/P12/Q30

Some vegetable oils contain 'trans fats' that are associated with undesirable increases in the amount of cholesterol in the blood. In these oils the word 'trans' describes, in the usual way, the arrangement of groups at a C=C double bond.
In the diagrams below, R_1 and R_2 are different unbranched hydrocarbon chains.
Which diagram correctly shows an optically active 'trans fat'?

A 

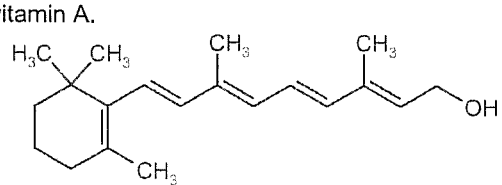
C 

B 

D 

35. O/N 16/P11/Q21, O/N 16/P13/Q21

The diagram shows the structure of vitamin A.



vitamin A

How many chiral centres are present in one vitamin A molecule?

A 0 **B** 1 **C** 2 **D** 3

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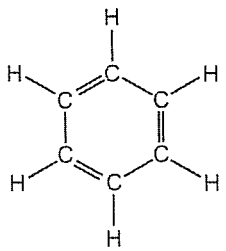
36. O/N 15/P12/Q21

Which compound shows optical isomerism?

A 2-chloropropane
B 1,2-dichloropropane
C 1,3-dichloropropane
D 2,2-dichloropropane

37. O/N 16/P13/Q20, O/N 16/P11/Q20

In 1865 Kekulé suggested a ring structure for benzene, C_6H_6, in which a hydrogen atom is attached to each carbon atom.



Kekulé structure

In this structure all of the bonds remain in the places shown. Assuming this is the structure of benzene, how many isomers of dichlorobenzene, $C_6H_4Cl_2$, would exist?

A 3 **B** 4 **C** 5 **D** 6

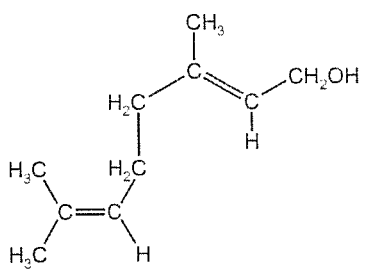
38. M/J 16/P12/Q29, M/J 13/P13/Q29

How many isomeric esters, including structural isomers and stereoisomers, can be made with the molecular formula $C_5H_{10}O_2$, if methanoic acid is one of the two reactants used?

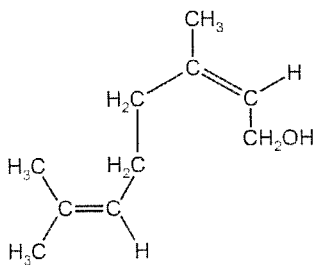
A 2 **B** 3 **C** 4 **D** 5

39. MAR 16/P12/Q21

Geraniol and nerol are compounds found in some flower fragrances. They are isomers of each other.



geraniol



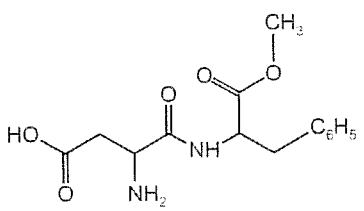
nerol

Which type of isomerism is shown here?

A chain
B geometrical(cis-trans)
C optical
D positional

40. M/J 15/P13/Q27

The compound *aspartame* is widely used as a sweetener in 'diet' soft drinks.



aspartame

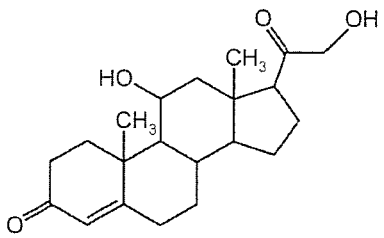
Aspartame is chiral. (There are no chiral carbon atoms in C_6H_5)
How many chiral carbon atoms are present in a molecule of aspartame?

A 1 **B** 2 **C** 3 **D** 4

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41. O/N 14/P12/Q26, O/N 14/P11/Q26

Corticosterone is a hormone involved in the metabolism of carbohydrates and proteins.



corticosterone

How many chiral centres are there in one molecule of corticosterone?

A 5 **B** 6 **C** 7 **D** 8

42. O/N 14/P13/Q20

In this question, structural isomerism and stereoisomerism should be considered.
How many isomeric aldehydes have the formula $C_5H_{10}O$?

A 3 **B** 4 **C** 5 **D** 6

43. O/N 14/P13/Q25

The compound known as 'gamma-linolenic acid' is found in the seeds of the evening primrose plant.

$CH_3(CH_2)_4CH{=}CHCH_2CH{=}CHCH_2CH{=}CH(CH_2)_4CO_2H$

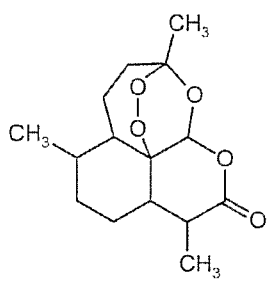
gamma-linolenic acid

How many cis-trans isomers are there with this structural formula?

A 3 **B** 6 **C** 8 **D** 12

44. M/J 14/P12/Q30

Artemisinin is a powerful anti-malarial drug.



artemisinin

How many chiral centres are there in each molecule of artemisinin?

A 4 **B** 6 **C** 7 **D** 8

45. M/J 14/P11/Q24

There are three structural isomers with the formula C_5H_{12}.
Which formulae correctly represent these three structural isomers?

A	$CH_3CH_2CH_2CH_2CH_3$	$CH_3CH_2CHCH_3CH_3$	$CH_3CH_3CCH_3CH_3$
B	$CH_3CH_2CH_2CH_2CH_3$	$CH_3CH_2(CH)CH_3CH_3$	$C(CH_3)_4$
C	$CH_3CH_2CH_2CH_2CH_3$	$CH_3CH(CH_3)CH_2CH_3$	$CH_3C(CH_3)_2CH_3$
D	$CH_3CH_2CH_2CH_2CH_3$	$CH_3CH(CH_3)CH_2CH_3$	$CH_3CH_2CH(CH_3)CH_3$

46. O/N 13/P13/Q21

Including structural and stereoisomers, how many isomers are there of $C_2H_2Br_2$?

A 2 **B** 3 **C** 4 **D** 5

47. O/N 13/P12/Q23, O/N 13/P11/Q23

Which compound exhibits stereoisomerism?

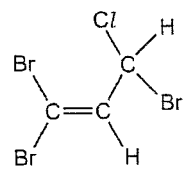
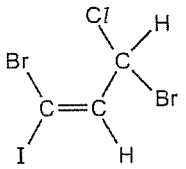
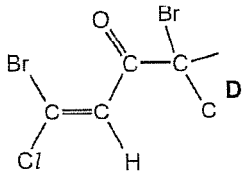
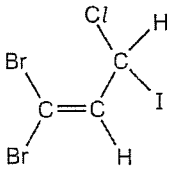
A $CH_3CHCICH_3$ **B** $CH_3CHCICH_2CI$ **C** $CH_3CCI_2CH_3$ **D** $CH_2CICH_2CH_2CI$

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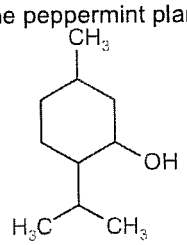
48. O/N 13/P13/Q24
Including structural and stereoisomers, how many isomeric products are produced when alcoholic KOH reacts with 2-chlorobutane?
A 1 **B** 2 **C** 3 **D** 4

49. M/J 13/P13/Q22
How many isomers, including structural and stereoisomers, with the formula C_4H_8 have structures that involve π bonding?
A 1 **B** 2 **C** 3 **D** 4

50. M/J 13/P11/Q20
The following compounds are found in the seaweed Asparagopsis taxiformis.
Which compound could show **both** cis-trans isomerism and optical isomerism?

A 
B 
C 
D 

51. O/N 12/P12/Q22, O/N 12/P11/Q22
Menthol is an important compound extracted from the peppermint plant.



menthol

How many chiral centres are there in one molecule of menthol?
A 1 **B** 2 **C** 3 **D** 4

52. O/N 12/P12/Q23, O/N 12/P11/Q23
The cracking of a single hydrocarbon molecule, C_nH_{2n+2}, produces two hydrocarbon molecules only. Each hydrocarbon product contains the same number of carbon atoms in one molecule.
Each hydrocarbon product has non-cyclic structural isomers.
What is the value of n?
A 4 **B** 6 **C** 8 **D** 9

53. O/N 12/P11/Q21, O/N 12/P12/Q21
An alkene has the formula $CH_3CH = CR\ CH_2CH_3$ and does **not** possess *cis-trans* isomers.
What is R?
A H **B** Cl **C** CH_3 **D** C_2H_5

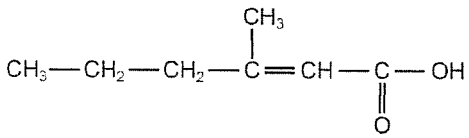
54. M/J 12/P11/Q25, M/J 12/P13/Q26
Which compound, on reaction with hydrogen cyanide, produces a compound with a chiral centre?
A CH_3CHO
B $CH_3CH_2COCH_2CH_3$
C $CH_3CO_2CH_3$
D HCHO

55. O/N 11/P12/Q20
Bromine and propene undergo an addition reaction.
Which is a property of the product?
A It exists in *cis*-trans isomers.
B It is more volatile than propene.
C It possesses a chiral centre.
D It possesses hydrogen bonding.

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56. O/N 11/P13/Q26, O/N 11/P11/Q28

An unpleasant smelling chemical produced in the human armpit is 3-methylhex-2-enoic acid.



If this compound is reacted with a cold, dilute, acidified solution of potassium manganate (VII), how many chiral centres will be produced?

A 0 **B** 1 **C** 2 **D** 3

57. M/J 11/P12/Q24

Which compound does **not** show cis-trans isomerism?

A 2-methylpent-2-ene
B 3-methylpent-2-ene
C 3,4-dimethylhex-3-ene
D pent-2-ene

58. M/J 11/P12/Q26

How many isomers with the formula C_5H_{10} have structures that involve π bonding?

A 3 **B** 4 **C** 5 **D** 6

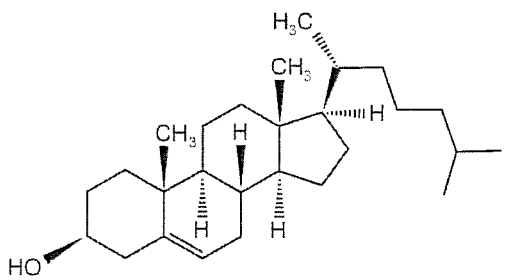
59. M/J 11/P11/Q23, M/J 11/P13/Q25

Pentanol, $C_5H_{11}OH$, has four structural isomers that are primary alcohols.
How many of these primary alcohols contain a chiral carbon atom?

A 0 **B** 1 **C** 2 **D** 3

60. M/J 11/P11/Q24, O/N 14/P13/Q29

The diagram shows the structure of the naturally-occurring molecule cholesterol.



cholesterol

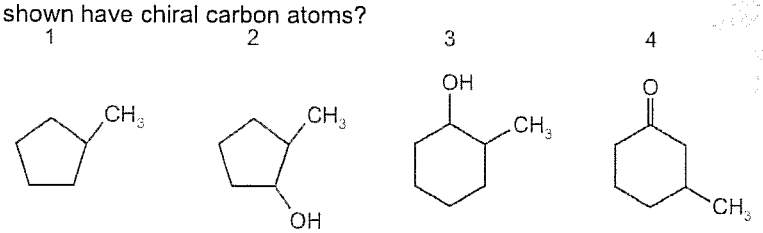
Student X claimed that the seventeen carbon atoms in the four rings all lie in the same plane.
Student Y claimed that this molecule displays *cis*-trans isomerism at the C=C double bond.
Which of the students are correct?

A both X and Y **B** neither X nor Y **C** X only **D** Y only

61. O/N 10/P12/Q30

Which of the compounds shown have chiral carbon atoms?

1 2 3 4



A 1, 2, 3 and 4 **B** 1 and 4 only **C** 2 and 3 only **D** 2, 3 and 4 only

62. M/J 10/P13/Q26, M/J 10/P12/Q28, M/J 10/P11/Q30

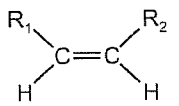
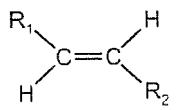
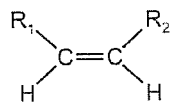
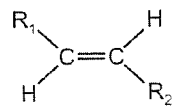
Which compound exhibits both *cis-trans* and optical isomerism?

A $CH_3CH{=}CHCH_2CH_3$
B $CH_3CHBrCH{=}CH_2$
C $CH_3CBr{=}CBrCH_3$
D $CH_3CH_2CHBrCH{=}CHBr$

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63. O/N 09/P12/Q20, O/N 09/P11/Q21

The presence of 11-*cis* retinal, $C_{20}H_{28}O$, in cells in the eye is important for vision.
The structure of retinal includes an aldehyde group, a cyclohexene ring and a long aliphatic side chain, in which a carbon-carbon double bond exists between carbons numbered 11 and 12.
Which pair of statements about 11-*cis* retinal could be correct?

	total number of >C=C< double bonds	arrangement around the adjacent carbons 11 and 12
A	5	
B	5	
C	6	
D	6	

64. O/N 09/P12/Q21, O/N 09/P11/Q22

What is the least number of carbon atoms in a non-cyclic alkane molecule that has a chiral centre?

A 7 **B** 8 **C** 9 **D** 10

65. M/J 09/P1/Q20

The compound known as 'gamma-linolenic acid' is found in significant amounts in the seeds of the Evening Primrose plant. There is evidence that the compound may help patients with diabetes.

$CH_3(CH_2)_4CH{=}CHCH_2CH{=}CHCH_2CH{=}CH(CH_2)_4CO_2H$

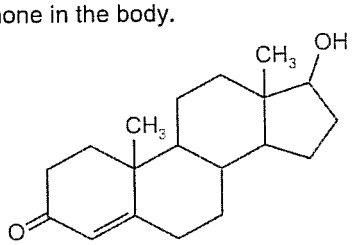
gamma-linolenic acid

How many cis-trans isomers does gamma-linolenic acid have?

A 3 **B** 6 **C** 8 **D** 12

66. M/J 09/P12/Q19

In recent years a number of athletes have been banned from sports because of their illegal use of synthetic testosterone, a naturally occurring hormone in the body.



testosterone

How many chiral centres are present in a testosterone molecule?

A 1 **B** 2 **C** 3 **D** 6

67. O/N 08/P1/Q22

Which hydrocarbon can form a monochloro-substitution derivative which shows **both** chirality **and** *cis*-trans isomerism?

A $CH_3CH{=}CH_2$
B $(CH_3)_2C{=}CH_2$
C $CH_3CH{=}C(CH_3)_2$
D $CH_3CH{=}CHCH_2CH_3$

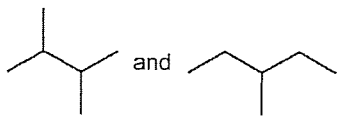
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68. M/J 20/P13/Q40

Which pairs are structural isomers of each other?

1 $CH_3CH_2CH_2CH_2CH_2CO_2H$ and $CH_3CH_2CH_2CO_2CH_2CH_3$



2

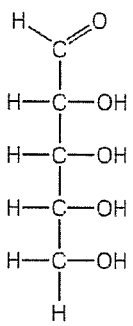
3 $CH_3CH_2CH_2CH(OH)CH_2CH_3$ and $CH_3CH_2CH(OH)CH_2CH_2CH_3$

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

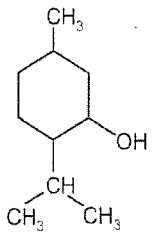
69. M/J 19/P13/Q37

Which compounds have optical isomers?

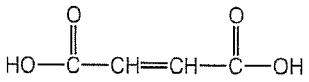
1



2



3



A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

70. M/J 18/P12/Q37

Which compounds show geometrical (cis-trans) isomerism?

1 $CH_3CH{=}C(CH_3)C_2H_5$

2 $CH_3CH{=}CHCH_2CH_2CH_3$

3 $C_2H_5CH{=}CHC_2H_5$

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

71. M/J 17/P11/Q37

P and Q are a pair of cis-trans isomers.

What **must** be the same for P and Q?

1 their empirical formula

2 their functional groups

3 their skeletal formula

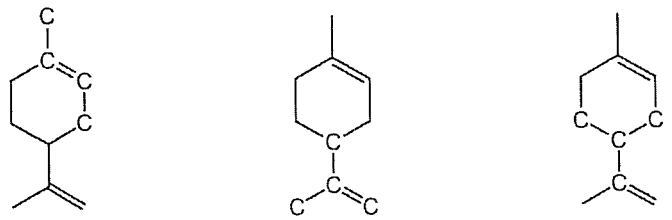
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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72. M/J 15/P12/Q37

In which structures do the four carbon atoms labelled C lie in the same plane?

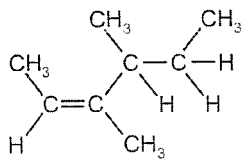
1 2 3



A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

73. M/J 15/P11/Q37

The diagram shows the structure of an alkene molecule.



Which statements about this molecule are correct?

1 All the carbon atoms are in the same plane.
2 It has geometrical isomers.
3 It is optically active.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

74. M/J 12/P12/Q38

What are the same for a pair of optical isomers?

1 their empirical formula
2 their functional groups
3 their structural formula

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

75. M/J 10/P12/Q39, M/J 10/P11/Q38, M/J 10/P13/Q37

Which structural formulae represent 2,2-dimethylpentane?

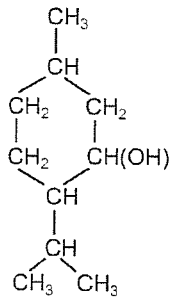
1 $(CH_3)_2CHCH_2CH(CH_3)_2$
2 $(CH_3)_3CCH_2CH_2CH_3$
3 $CH_3CH_2CH_2C(CH_3)_3$

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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76. M/J 07/P1/Q39

Menthol, from oil of mint, is used in soaps and perfumes.



menthol

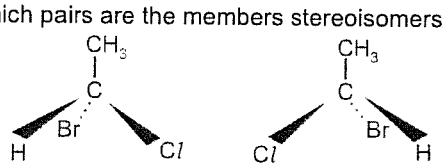
Which statements about menthol are correct?

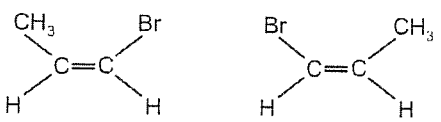
1 There is a total of two chiral centres present in the menthol molecule.
2 On reaction with concentrated sulphuric acid, menthol produces a mixture of two alkenes.
3 A solution of acidified potassium dichromate(VI), on warming with menthol, changes colour from orange to green.

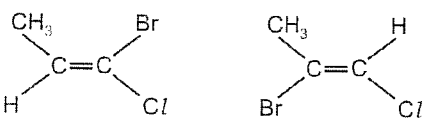
A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

77. M/J 06/P1/Q37

In which pairs are the members stereoisomers of each other?

1 

2 

3 

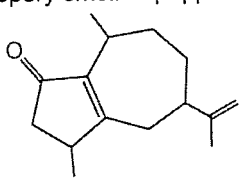
A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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13.5: Multiple Topics

1. O/N 16/P12/Q21

The compound rotundone is responsible for the peppery smell of pepper and is also found in some red wines.



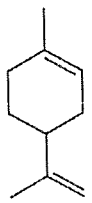
rotundone

How many hydrogen atoms are in one molecule of rotundone?

A 15 **B** 19 **C** 22 **D** 24

2. M/J 15/P11/Q29

The citrus flavour of lemons is due to the compound limonene, present in both the peel and the juice.



limonene

What is the mole ratio of carbon dioxide to water produced when limonene is completely burnt in oxygen?

	number of moles carbon dioxide	number of moles water
A	4	3
B	5	4
C	5	8
D	9	7

3. O/N 14/P12/Q29, O/N 14/P11/Q29

Which equation correctly represents the balanced equation for the complete combustion of a hydrocarbon with the formula C_xH_y?

A $C_xH_y + (x + \frac{y}{2})O_2 \rightarrow xCO_2 + \frac{y}{2}H_2O$

B $C_xH_y + (x + \frac{y}{4})O_2 \rightarrow xCO_2 + yH_2O$

C $C_xH_y + (x + \frac{y}{4})O_2 \rightarrow xCO_2 + \frac{y}{4}H_2O$

D $C_xH_y + (x + \frac{y}{4})O_2 \rightarrow xCO_2 + \frac{y}{2}H_2O$

4. M/J 14/P13/Q29

One reaction in the Krebs cycle, in which energy is released to the human body, is the conversion of fumaric acid into malic acid.

$$HO_2CCH{=}CHCO_2H \rightarrow HO_2CCH(OH)CH_2CO_2H$$

fumaric acid malic acid

Which reagent(s) could achieve this conversion in the laboratory?

A acidified $KMnO_4(aq)$

B $Br_2(aq)$ followed by hot NaOH(aq)

C $H_2O(l)$ with Pt catalyst

D $H_2O(g)$ with H_2SO_4

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5. M/J 09/P1/Q21

what always applies to nucleophile?

A It attacks a double bond.
B It has a lone pair of electrons.
C It is a single atom.
D It is negatively charged.

6. M/J 11/P12/Q25

Which formulae show propanone and propanal as different compounds?

A empirical, molecular, structural **and** displayed formulae
B molecular, structural and displayed formulae **only**
C structural and displayed formulae **only**
D displayed formulae **only**

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7. M/J 18/P12/Q31

For complete combustion, 1 mol of an organic compound X requires 2.5 mol of O_2.
Which compounds could be X?

1 C_2H_5OH 2 C_2H_2 3 CH_3CHO

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

8. M/J 18/P11/Q37

Polymer Z contains the length of polymer chain shown below.
This short length of chain is found many times within the chains of polymer Z, although it is not the repeat unit.

$$-CH_2-CHCl-CH_2-$$

What could be the name of polymer Z?

1 poly(2-chloropropene)
2 poly(chloroethene)
3 PVC

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

9. MAR 17/P12/Q38

Which statements help to explain the mechanism of the reaction between 1-chloropropane and ammonia?

1 1-chloropropane has a $\delta-$ chlorine atom that forms hydrogen bonds with a $\delta+$ hydrogen atom in ammonia.
2 1-chloropropane is a polar compound with a $\delta+$ carbon atom.
3 There is a lone pair of electrons on the nitrogen atom in ammonia.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

10. O/N 09/P12/Q37, O/N 09/P11/Q38

The chlorine free radical takes part in the destruction of the ozone layer.
Which statements about this free radical are correct?

1 It is formed by the heterolytic fission of the covalent bond in a chlorine-containing molecule.
2 It has a single unpaired electron.
3 It has the same electron arrangement as a chlorine atom.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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Answers Sections

13.1	13.2	13.3	13.4		13.5
1. B	1. B	1. C	1. B	41. C	1. C
2. A	2. D	2. D	2. C	42. C	2. B
3. C	3. D		3. C	43. C	3. D
4. C	4. A		4. C	44. C	4. D
5. A	5. D		5. D	45. C	5. B
6. A			6. C	46. B	6. C
7. B			7. D	47. B	7. C
			8. B	48. C	8. C
			9. D	49. D	9. C
			10. A	50. B	10. C
			11. D	51. C	
			12. C	52. C	
			13. C	53. D	
			14. C	54. A	
			15. C	55. C	
			16. C	56. C	
			17. C	57. A	
			18. A	58. D	
			19. A	59. B	
			20. C	60. B	
			21. C	61. D	
			22. B	62. D	
			23. B	63. A	
			24. C	64. A	
			25. C	65. C	
			26. A	66. D	
			27. D	67. D	
			28. D	68. B	
			29. D	69. B	
			30. A	70. A	
			31. C	71. B	
			32. D	72. B	
			33. C	73. C	
			34. B	74. A	
			35. A	75. C	
			36. B	76. C	
			37. B	77. D	
			38. D		
			39. B		
			40. B		

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A Level

Unit 14

HYDROCARBONS

A Level
Chemistry Paper 1
Classified/Topical MCQ's
Article Number: 231

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Syllabus

14.1 Alkanes
14.2 Alkenes
14.3 Hydrocarbons as fuel
14.4 Multiple topics

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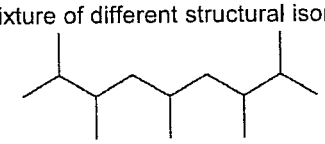
Unit 14: Hydrocarbons

14.1: Alkanes

1. **O/N 19/P11/Q21, O/N 19/P13/Q21**
Alkanes are saturated hydrocarbons.
Which type of reaction are alkanes most likely to undergo?
A electrophilic addition
B electrophilic substitution
C free radical substitution
D nucleophilic addition

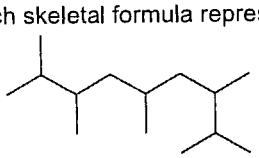
2. **M/J 19/P11/Q22**
What is the structural formula of the major product when hydrogen bromide reacts with 2-methylbut-2-ene?
A $CH_2BrCH(CH_3)CH_2CH_3$
B $(CH_3)_2CBrCH_2CH_3$
C $(CH_3)_2CHCHBrCH_3$
D $(CH_3)_2CHCH_2CH_2Br$

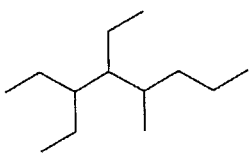
3. **O/N 18/P11/Q22, O/N 18/P13/Q22, O/N 15/P13/Q21, O/N 15/P11/Q21**
A new jet fuel has been produced that is a mixture of different structural isomers of compound Q

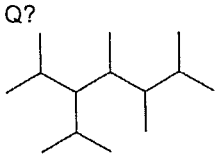


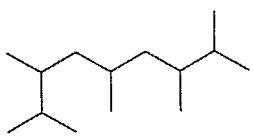
Q

Which skeletal formula represents a **structural isomer** of Q?

A


B


C


D


4. **O/N 18/P11/Q23, O/N 18/P13/Q23**
The conversion of propene to propan-2-ol can be carried out in two stages represented by the equations shown.
reaction 1 $CH_3CH{=}CH_2(g) + HI(g) \rightarrow CH_3CHICH_3(l)$
reaction 2 $CH_3CHICH_3(l) + KOH(aq) \rightarrow CH_3CH(OH)CH_3(aq) + K^+(aq) + I^-(aq)$
How can these two reactions be described?

	reaction 1	reaction 2
A	addition	elimination
B	addition	substitution
C	elimination	substitution
D	substitution	elimination

5. **M/J 18/P12/Q21**
Which equation represents a valid propagation step in the chlorination of ethane?
A $C_2H_6 + Cl^{\bullet} \rightarrow C_2H_5Cl + H^{\bullet}$
B $C_2H_5Cl + Cl^{\bullet} \rightarrow C_2H_4Cl^{\bullet} + HCl$
C $C_2H_5Cl + H^{\bullet} \rightarrow C_2H_5^{\bullet} + HCl$
D $C_2H_5^{\bullet} + Cl^{\bullet} \rightarrow C_2H_5Cl$

6. **M/J 17/P12/Q22**
Which equation represents the initiation step of the substitution reaction between methane and chlorine?
A $CH_4 \rightarrow CH_3^{\bullet} + H^{\bullet}$ **B** $CH_4 \rightarrow CH_3^- + H^+$ **C** $Cl_2 \rightarrow 2Cl^{\bullet}$ **D** $Cl_2 \rightarrow Cl^+ + Cl^-$

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7. MAR 17/P12/Q22

Which radical is most likely to form by the homolytic fission of one covalent bond in bromochloromethane, CH_2BrCl?

A $\bullet CH_2Cl$ **B** $\bullet CH_2Br$ **C** $\bullet CHBrCl$ **D** $\bullet CH2BrCl$

8. M/J 16/P12/Q11, O/N 13/P13/Q6

Which stage in the free radical substitution of ethane by chlorine has the lowest activation energy?

A $Cl_2 \rightarrow 2Cl\bullet$

B $Cl\bullet + C_2H_6 \rightarrow C_2H_5\bullet + HCl$

C $C_2H_5\bullet + Cl_2 \rightarrow C_2H_5Cl + Cl\bullet$

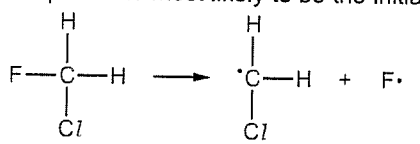
D $Cl\bullet + C_2H_5\bullet \rightarrow C_2H_5Cl$

9. M/J 16/P12/Q20

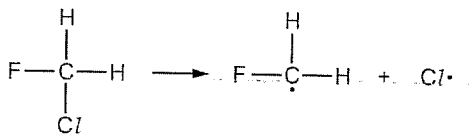
Chlorofluorocarbons damage the ozone layer by undergoing reactions with a free radical mechanism. The first stage of this is initiation.

Which equation is most likely to be the initiation stage when chlorofluoromethane is involved in such a reaction?

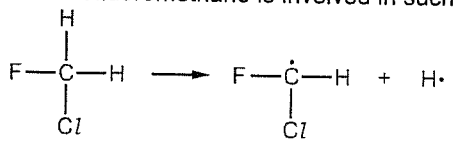
A



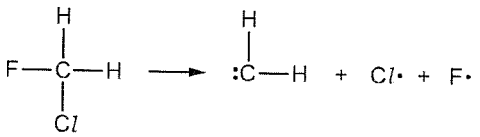
B



C



D



10. M/J 16/P12/Q22

Oct-1-ene, $CH_3(CH_2)_5CH=CH_2$, can be thermally cracked.

Which combination of compounds W, X, Y and Z can be obtained by thermally cracking oct-1-ene?

	W $CH_2=CH_2$	X $CH_3CH=CH_2$	Y $CH_3CH_2CH_3$	Z $CH_2=CHCH=CH_2$
A W, X, Y and Z	**B** W, X and Y only	**C** W, X and Z only	**D** W and X only	

11. M/J 16/P11/Q23

The first propagation step in the reaction between methane and chlorine is shown.

$$CH_4 + Cl\bullet \rightarrow CH_3\bullet + HCl$$

How many different first propagation steps are possible in the reaction between pentane and chlorine?

A 2 **B** 3 **C** 4 **D** 5

12. M/J 15/P12/Q22

Four students, W, X, Y and Z, made the following statements about alkanes and alkenes.

W 'Bromine reacts with alkanes by electrophilic substitution.'
X 'Bromine reacts with alkenes by a free-radical addition mechanism.'
Y 'Alkenes can be oxidised by acidified manganate(VII) ions.'
Z 'Alkenes are formed from alkanes by cracking.'

Which two students are correct?

A W and X **B** W and Z **C** X and Y **D** Y and Z

13. M/J 15/P13/Q26

Alkane X has molecular formula C_4H_{10}.

X reacts with $Cl_2(g)$ in the presence of sunlight to produce only two different monochloroalkanes, C_4H_9Cl. Both of these monochloroalkanes produce the same alkene Y, and no other organic products, when they are treated with hot ethanolic KOH.

What is produced when Y is treated with hot concentrated acidified $KMnO_4$?

A CO_2 and $CH_3CH_2CO_2H$

B CO_2 and CH_3COCH_3

C HCO_2H and CH_3COCH_3

D CH_3CO_2H only

14. O/N 13/P12/Q7, O/N 13/P11/Q7

Which stage in the free radical substitution of methane by chlorine will have the lowest activation energy?

A $CH_3\bullet + Cl_2 \rightarrow CH_3Cl + Cl\bullet$

B $Cl\bullet + Cl\bullet \rightarrow Cl_2$

C $Cl\bullet + CH_4 \rightarrow CH_3\bullet + HCl$

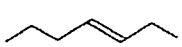
D $Cl_2 \rightarrow Cl\bullet + Cl\bullet$

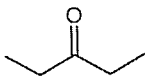
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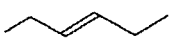
15. O/N 14/P11/Q21

Use of the Data Booklet is relevant to this question.
Which compound has an M_r of 84 and will react with HBr to give a product with an M_r of 164.9?

A 

B 

C 

D 

16. M/J 13/P13/Q25

A carbanion is an organic ion in which a carbon atom has a negative charge. A carbocation is an organic ion in which a carbon atom has a positive charge.
What is involved in the mechanism of the reaction between aqueous sodium hydroxide and 2-bromo-2-methylbutane?

A heterolytic bond fission followed by an attack by an electrophile on a carbanion
B heterolytic bond fission followed by an attack by a nucleophile on a carbocation
C homolytic bond fission followed by an attack by an electrophile on a carbanion
D homolytic bond fission followed by an attack by a nucleophile on a carbocation

17. O/N 12/P12/Q23

The cracking of a single hydrocarbon molecule, C_nH_{2n+2}, produces two hydrocarbon molecules only. Each hydrocarbon product contains the same number of carbon atoms in one molecule.
Each hydrocarbon product has non-cyclic structural isomers.
What is the value of n?

A 4 **B** 6 **C** 8 **D** 9

18. O/N 12/P11/Q26, O/N 12/P12/Q26

High-energy radiation in the stratosphere produces free-radicals from chlorofluoroalkanes, commonly known as CFCs.
Which free-radical is most likely to result from the irradiation of $CHFCl/CF_2Cl$?

A $CHFCl\dot{C}FCl$ **B** $\dot{C}HCl/CF_2Cl$ **C** $\dot{C}HFCF_2Cl$ **D** $\dot{C}FCl/CF_2Cl$

19. M/J 12/P12/Q24

Oct-1-ene, $CH_3(CH_2)_5CH{=}CH_2$, is subjected to thermal cracking.
Which combination of compounds W, X, Y and Z can be obtained?

$CH_2{=}CH_2$	$CH_3CH{=}CH_2$	$CH_3CH_2CH_3$	$CH_2{=}CHCH{=}CH_2$
W	X	Y	Z

A W, X, Y and Z **B** W, X and Y only **C** W, X and Z only **D** W and X only

20. O/N 11/P12/Q29

Compound X, molecular formula C_4H_8, undergoes the following reactions.

$$\underset{\mathbf{X}}{C_4H_8} \xrightarrow{Br_2} \underset{\mathbf{Y}}{C_4H_8Br_2} \xrightarrow{aq.NaOH\,/\,heat} \underset{\mathbf{Z}}{C_4H_{10}O_2}$$

$$\underset{\mathbf{X}}{C_4H_8} \xrightarrow{H_2/Ni} \text{methylpropane}$$

What is the formula of compound Z?

A $CH_3CH_2CH(OH)CH_2OH$
B $CH_3CH(OH)CH(OH)CH_3$
C $CH_3CH(CH_2OH)CH_2OH$
D $(CH_3)_2C(OH)CH_2OH$

21. M/J 11/P12/Q23

The products obtained by cracking an alkane, **X**, are methane, ethene and propene.
The mole fraction of ethene in the products is 0.5.
What is the identity of **X**?

A C_6H_{14} **B** C_8H_{18} **C** C_9H_{20} **D** $C_{11}H_{24}$

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22. O/N 11/P11/Q27, O/N 11/P13/Q28

A reaction between chlorine and propane in ultraviolet light produces two isomeric monochloropropanes, C_3H_7Cl, as products.

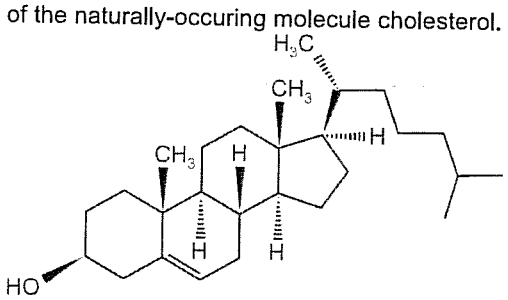
Which information about this reaction is correct?

	type of bond fission in initiation step	expected ratio of 1-chloropropane to 2-chloropropane produced
A	heterolytic	1 : 1
B	heterolytic	3 : 1
C	homolytic	1 : 1
D	homolytic	3 : 1

23. O/N 11/P13/Q18, O/N 11/P11/Q20

This question should be answered by considering the reactions of $KMnO_4$ with different functional groups under the stated conditions.

The diagram shows the structure of the naturally-occuring molecule cholesterol.



cholesterol

Separate oxidation reactions are carried out using different conditions.

- cold, dilute acidified $KMnO_4$
- hot, concentrated acidified $KMnO_4$

Which statements about the **products** formed are correct?

	cold, dilute acidified $KMnO_4$: number of hydroxy groups present	hot, concentrated acidified $KMnO_4$: number of 6-membered rings remaining
A	1	2
B	1	3
C	3	2
D	3	3

24. M/J 11/P13/Q22, M/J 11/P11/Q19

In the reaction pathway below, an alkane is converted into a carboxylic acid through several stages.

$$C_{10}H_{22} \xrightarrow{\text{stage 1}} C_2H_4 \xrightarrow[\text{catalytic hydration}]{\text{stage 2}} C_2H_5OH \xrightarrow{\text{stage 3}} CH_3CO_2H$$

Which processes occur at stage 1 and at stage 3?

	stage 1	stage 3
A	condensation	combustion
B	cracking	dehydration
C	cracking	oxidation
D	dehydration	combustion

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25. O/N 09/P12/Q25, O/N 09/P11/Q26

Which equation represents a valid propagation step in the free radical reaction between ethane and chlorine?

A $C_2H_6 + Cl\bullet \rightarrow C_2H_5Cl + H\bullet$

B $C_2H_5Cl + Cl\bullet \rightarrow C_2H_4Cl\bullet + HCl$

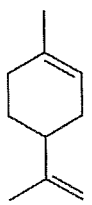
C $C_2H_6 + H\bullet \rightarrow C_2H_5^{\bullet} + HCl$

D $C_2H_5\bullet + Cl\bullet \rightarrow C_2H_5Cl$

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26. M/J 18/P11/Q38

Limonene is found in lemons.



limonene

Limonene is heated with concentrated acidified potassium manganate(VII).

Which compounds are produced?

1 $CH_3COCH_2CH_2CH(CH_2CO_2H)_2$

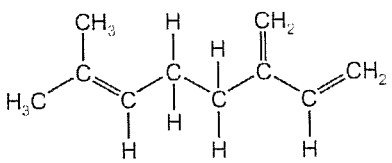
2 CO_2

3 $CH_3COCH_2CH_2CH(COCH_3)CH_2CO_2H$

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

27. O/N 16/P12/Q37

A species of termite produces a chemical defence secretion which contains the molecule shown.



To help determine the structure of this compound, it is treated with hot, concentrated, acidified manganate (VII) ions.

Which compounds are produced in this reaction?

1 CO_2 2 CH_3COCH_3 3 CH_3CO_2H

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

28. O/N 15/P12/Q38, O/N 11/P11/Q40, O/N 11/P13/Q37

X is an organic compound. **X** gives a precipitate with aqueous silver nitrate. Some or all of this precipitate remains undissolved when an excess of dilute aqueous ammonia is added.

What could be the identity of **X**?

1 2-chlorobutane 2 2-bromobutane 3 iodomethane

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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29. O/N 14/P13/Q37

Which statements about the photochemical chlorination of ethane are correct?

1 A propagation step in the mechanism is $C_2H_5\bullet + Cl_2 \rightarrow C_2H_5Cl + Cl\bullet$
2 Butane is present in the products.
3 The initiation step is the heterolytic fission of chlorine.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

30. M/J 13/P11/Q37

Which molecules would be present in the mixture produced by the photochemical chlorination of methane?

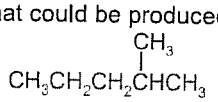
1 hydrogen
2 hydrogen chloride
3 dichloromethane

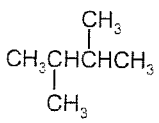
A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

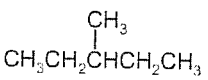
31. M/J 13/P13/Q37, O/N 08/P1/Q39

During the bromination of methane, the free radical $CH_3\bullet$ is generated. A possible terminating step of this reaction is the formation of C_2H_6 by the combination of two free radicals.

What could be produced in a terminating step during the bromination of **propane**?

1 

2 

3 

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

32. O/N 11/P12/Q38

Y is an organic compound. **Y** gives a precipitate with aqueous silver nitrate. All of this precipitate dissolves when concentrated aqueous ammonia is added.

What is a possible identity for **Y**?

1 1-bromopropane
2 chloroethane
3 2-iodo-2-methylpropane

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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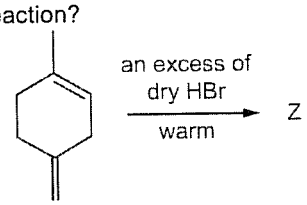
14.2: Alkenes

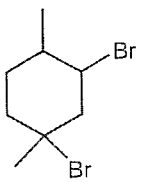
1. **M/J 20/P12/Q25**
Which substance forms propanoic acid as one of the products when it reacts with hot concentrated acidified potassium manganate(VII)?
A but-1-ene **B** but-2-ene **C** 2-methylpropene **D** 2-methylbut-1-ene

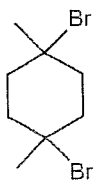
2. **M/J 20/P12/Q28, M/J 14/P12/Q24**
Ethene reacts with aqueous bromine to give two products, CH_2BrCH_2Br and CH_2BrCH_2OH.
Which statement about these products is correct?
A Both products are obtained in this reaction by electrophilic substitution.
B Both products are obtained in this reaction by nucleophilic addition.
C Both products can be hydrolysed to form the same organic compound.
D Both products can form hydrogen bonds with water.

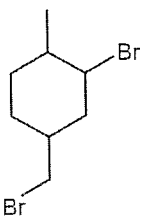
3. **M/J 20/P11/Q22**
But-1-ene and but-2-ene are treated separately with cold, dilute acidified manganate (VII) ions.
Four students, W, X, Y and Z, make statements about these alkenes and the diols formed from them.
W One diol contains two primary alcohol groups.
X One diol contains a primary and a secondary alcohol group.
Y One diol contains two secondary alcohol groups.
Z Both alkenes exhibit cis-trans isomerism.
Which two students are correct?
A W and Y **B** W and Z **C** X and Y **D** X and Z

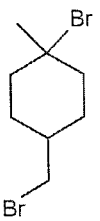
4. **M/J 20/P11/Q27**
What is the major product Z of the following reaction?



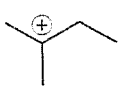
A


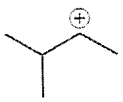
B


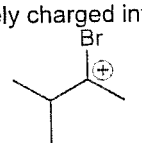
C


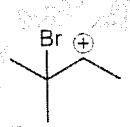
D


5. **M/J 20/P13/Q28**
2-methylbut-2-ene reacts with HBr(g) to form two isomeric products. During the reaction two positively charged intermediates can be made.
Which diagram shows the more stable of the two positively charged intermediates?

A


B


C


D


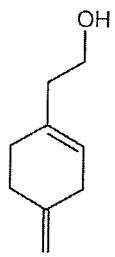
6. **MAR 20/P12/Q27**
Which reaction would produce propanoic acid as one of its products?
A heating $(CH_3)_2C{=}CHCH_2CH_3$ with concentrated, acidified $KMnO_4$
B heating $CH_3CH_2CO_2CH_2CH_2CH_3$ with NaOH(aq)
C heating CH_3CH_2OH with acidified $K_2Cr_2O_7$ under reflux
D reacting CH_3CHO with HCN then heating the organic product with H_2SO_4(aq)

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7. MAR 20/P12/Q26

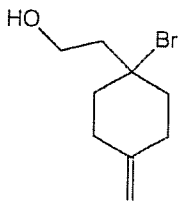
An excess of dry HBr is warmed with compound Y.

Y

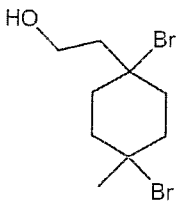


What is the major product of the reaction?

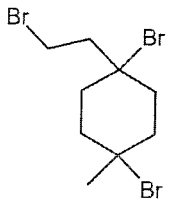
A



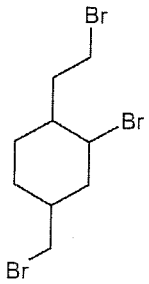
B



C



D



8. O/N 19/P12/Q20

Structural isomerism and stereoisomerism should be considered when answering this question.
How many isomers with the formula C_5H_{10} have structures that involve π bonding?

A 3 **B** 4 **C** 5 **D** 6

9. O/N 19/P11/Q20, O/N 19/P13/Q20

Which substance reacts with trichloroethene to give a chiral product?

A Br_2 **B** HCl **C** NaCN **D** NaOH

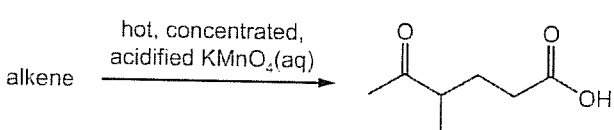
10. M/J 19/P12/Q26

Propene, bromine and hydrogen bromide are mixed in the dark.
A number of products are formed, some in very small quantities.
Which substance will **not** be present in the mixture of products?

A 1-bromopropane
B 2-bromopropane
C 1,1-dibromopropane
D 1,2-dibromopropane

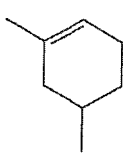
11. O/N 19/P11/Q22, O/N 19/P13/Q22

An alkene reacts with hot, concentrated, acidified potassium manganate(VII) to produce a single organic product as shown.

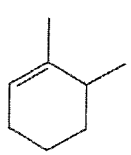


What is the structure of the alkene?

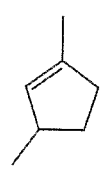
A



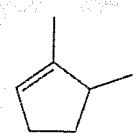
B



C



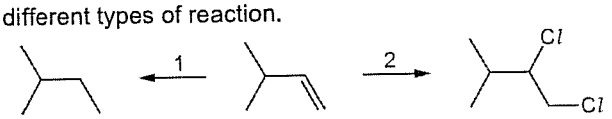
D



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12. M/J 19/P12/Q20

3-methylbut-1-ene can undergo different types of reaction.



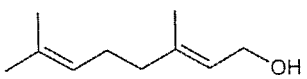
Which row correctly identifies the reaction types?

	reaction 1	reaction 2
A	oxidation	electrophilic addition
B	oxidation	nucleophilic addition
C	reduction	electrophilic addition
D	reduction	nucleophilic addition

13. M/J 19/P12/Q23

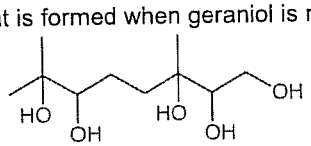
A molecule of geraniol is shown.

geraniol

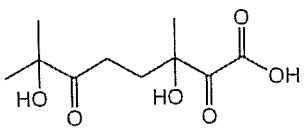


What is formed when geraniol is reacted with an excess of cold, dilute, acidified manganate(VII) ions?

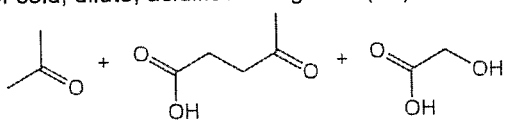
A



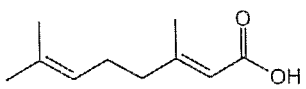
B



C



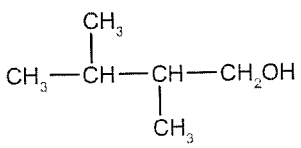
D



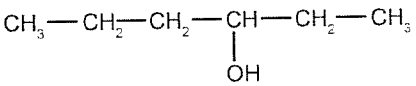
14. M/J 19/P13/Q26, M/J 11/P11/Q25, M/J 11/P13/Q26

Which isomer of $C_6H_{13}OH$ gives the greatest number of different alkenes when it is dehydrated?

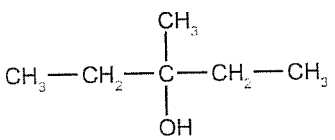
A



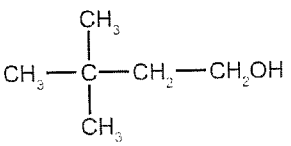
B



C

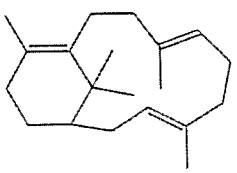


D



15. M/J 18/P12/Q20

Compound Y is treated with an excess of hydrogen gas in the presence of a nickel catalyst. The product is fully saturated.



compound Y

What is the number of chiral carbon atoms in the product?

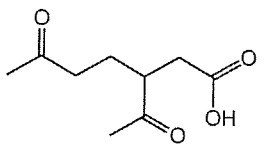
A 5 **B** 6 **C** 7 **D** 8

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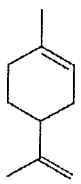
16. MAR 19/P12/Q21

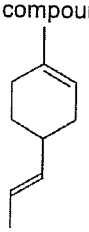
Compound L has the molecular formula $C_{10}H_{16}$.
A sample of L reacted with an excess of hot, concentrated, acidified potassium manganate (VII).
Compound M is produced.

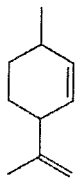
M

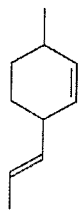


What could be the structure of compound L?

A


B


C


D


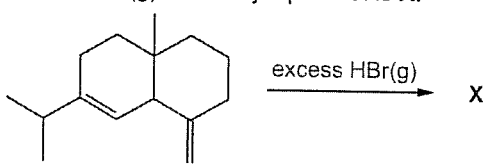
17. M/J 18/P11/Q24

Which reagent could detect the presence of alcohol in a mixture consisting mainly of alkanes and alkenes?

A Na
B Br_2 (in CCl_4)
C KMnO4(aq)
D 2,4-dinitrophenylhydrazine

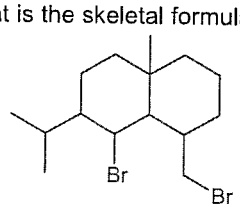
18. M/J 18/P13/Q21

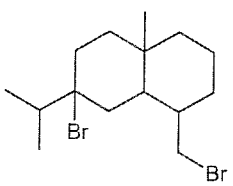
Sibirene, $C_{15}H_{24}$, is reacted with an excess of HBr(g). The major product is **X**.

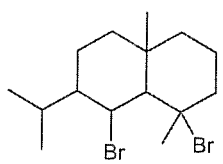


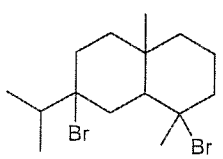
sibirene

What is the skeletal formula of X?

A


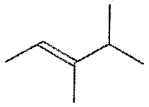
B


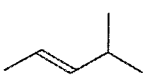
C


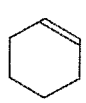
D


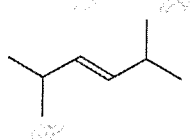
19. O/N 17/P12/Q22

Which compound would produce two different carboxylic acids when treated with hot, concentrated, acidified manganate(VII) ions?

A


B


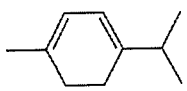
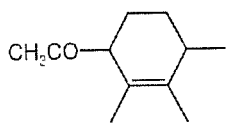
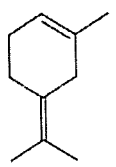
C


D


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20. M/J 18/P13/Q30

Compound **S** can be extracted from natural compounds. Reacting **S** with hot, concentrated $KMnO_4$ produces the organic product, T. Some of the absorptions found in the infra-red spectra of **S** and **T** are described.
S has no strong absorption between 1670 and 1740 cm^{-1}.
T has a strong absorption at 1720 cm^{-1} but has no strong, broad absorption between 2500 and 3000 cm^{-1}.
From this information, what could be the formulae of **S** and **T**?

	S	T
A	$CH_3(CH_2)_5CH=CH_2$	$CH_3(CH_2)_5CO_2H$
B		$CH_3COCH_2CH_2COCH(CH_3)_2$
C		$CH_3COCH(COCH_3)CH_2CH_2CH(COCH_3)CH_3$
D		$HO_2CCH_2CH_2COCH_2COCH_3$

21. O/N 17/P12/Q23

Which types of bond are broken and formed in the addition polymerisation of alkenes?

	type of bond broken	type of bond formed
A	π only	σ only
B	π only	σ and π
C	σ and π	σ only
D	σ and π	σ and π

22. O/N 17/P12/Q24

2,3-dimethylpent-2-ene, $(CH_3)_2C=C(CH_3)CH_2CH_3$, is treated with cold, dilute $KMnO_4$. The product of this reaction is treated with an excess of concentrated H_2SO_4 at 180 °C, giving a mixture of isomeric hydrocarbons with molecular formula C_7H_{12}.
What is the name of one of the isomeric hydrocarbons?

A 2,3-dimethylpenta-1,2-diene
B cis-2,3-dimethylpenta-1,3-diene
C 2,3-dimethylpenta-1,4-diene
D 3,4-dimethylpenta-1,3-diene

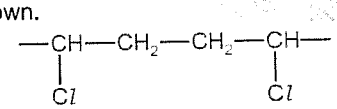
23. O/N 17/P11/Q22, O/N 17/P13/Q22

Many, but not all, organic reactions need to be heated before a reaction occurs.
Which reaction occurs quickly at room temperature, 20 °C?

A $C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$
B $C_2H_4 + H_2O \rightarrow CH_3CH_2OH$
C $CH_3CH_2OH \rightarrow C_2H_4 + H_2O$
D $CH_3CH_2OH + HBr \rightarrow CH_3CH_2Br + H_2O$

24. O/N 17/P11/Q23, O/N 17/P13/Q23

A section of an addition polymer chain is shown.



Which monomer could be used to make this polymer?

A CH_2CHCH_2Cl **B** CH_2CHCl **C** $CH_3CHCHCl$ **D** $CHCl/CHCH_2CH_2Cl$

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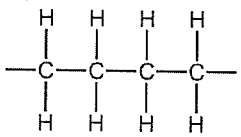
25. M/J 17/P11/Q22

An alkene is reacted with acidified manganate (VII) ions, MnO_4^-. The desired organic product has a relative molecular mass greater than that of the alkene by 34.
What conditions should be used?

A cold, concentrated MnO_4^-
B cold, dilute MnO_4^-
C hot, concentrated MnO_4^-
D hot, dilute MnO_4^-

26. M/J 17/P11/Q23

The diagram shows a short length of an addition polymer chain.

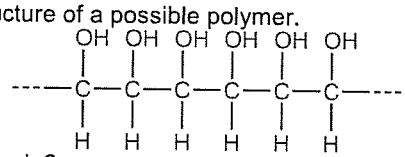


The polymer has a relative molecular mass of approximately 10 000.
Approximately how many monomer units are joined together in each polymer molecule?

A 180 **B** 360 **C** 625 **D** 710

27. M/J 17/P13/Q24, O/N 09/P12/Q22, O/N 09/P11/Q23

The following diagram represents the structure of a possible polymer.



By which method might this polymer be made?

A polymerise ethene followed by hydration
B polymerise ethene followed by oxidation with cold acidified $KMnO_4$
C polymerise 1,2-dichloroethene followed by hydrolysis
D polymerise 1,2-dichloroethene followed by oxidation with cold acidified $KMnO_4$

28. M/J 17/P13/Q25

Bromine reacts with ethene in the dark.
Which description of the organic intermediate in this reaction is correct?

A It has a negative charge.
B It is a free radical.
C It is a nucleophile.
D It is an electrophile.

29. MAR 17/P12/Q24, M/J 13/P12/Q30

Polymerisation of ethene gives poly(ethene).
How does the carbon-carbon bond in poly(ethene) compare with that in ethene?

A The carbon-carbon bond is longer and stronger in poly(ethene).
B The carbon-carbon bond is longer and weaker in poly(ethene).
C The carbon-carbon bond is shorter and stronger in poly(ethene).
D The carbon-carbon bond is shorter and weaker in poly(ethene).

30. MAR 17/P12/Q23

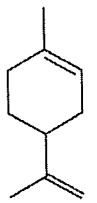
Propene undergoes a variety of reactions.
Which row is correct?

	reagent added to propene	products include
A	$Br_2(aq)$	1-bromopropane
B	cold, dilute, acidified $KMnO_4(aq)$	propanoic acid
C	HBr(g)	2-bromopropane
D	hot, concentrated, acidified $KMnO_4(aq)$	propanoic acid

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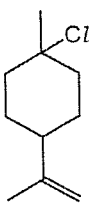
31. O/N 16/P12/Q20

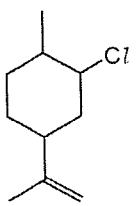
Limonene is found in lemon and orange oils.

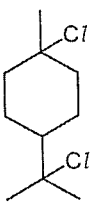


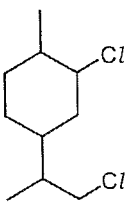
limonene

What will be the major product when limonene is reacted with an excess of dry hydrogen chloride?

A 

B 

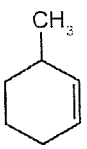
C 

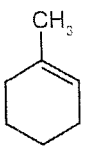
D 

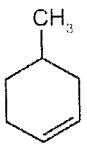
32. M/J 16/P12/Q23

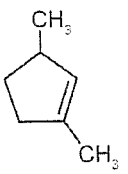
A cycloalkene with the molecular formula C_7H_{12} was oxidised by hot concentrated acidified MnO_4^-. The only organic product was 2-methylhexane-1,6-dioic acid.

What is the identity of the cycloalkene?

A 

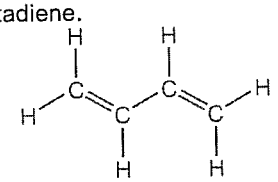
B 

C 

D 

33. M/J 16/P13/Q21

The diagram shows the structure of 1,3-butadiene.



1,3-butadiene

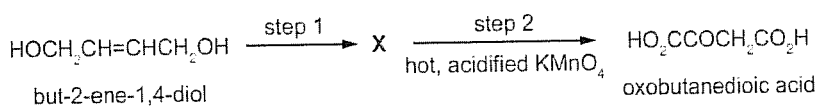
The addition reaction between 1,3-butadiene and two molecules of hydrogen bromide can produce three structurally isomeric products.

How many of these products have at least one chiral centre?

A 0 **B** 1 **C** 2 **D** 3

34. MAR 16/P12/Q23

But-2-ene-1,4-diol is converted in two steps through an intermediate **X** into oxobutanedioic acid.



but-2-ene-1,4-diol oxobutanedioic acid

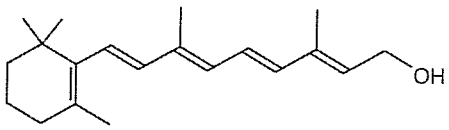
What could be the reagent for step 1 and what is the intermediate **X**?

	reagent for step 1	X
A	cold, acidified $KMnO_4$	$HOCH_2CH_2CH(OH)CH_2OH$
B	hot, acidified $K_2Cr_2O_7$	$HO_2CCH=CHCO_2H$
C	steam and concentrated H_2SO_4	$HOCH_2CH(OH)CH_2CH_2OH$
D	warm, acidified $K_2Cr_2O_7$	$OHCCH(OH)CH_2CHO$

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35. M/J 16/P13/Q24

Vitamin A contains retinol.



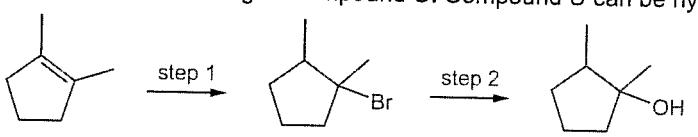
retinol

Under appropriate conditions, acidified $KMnO_4(aq)$ can be used to break apart C=C bonds.
After these bonds have been broken, further oxidation of the fragments may occur.
Under which conditions is the acidified $KMnO_4(aq)$ used and what do the final oxidation products include?

	conditions	final oxidation products
A	cold, dilute	aldehydes and carboxylic acids
B	cold, dilute	ketones and carboxylic acids
C	hot, concentrated	aldehydes and carboxylic acids
D	hot, concentrated	ketones and carboxylic acids

36. MAR 16/P12/Q24

Hydrogen bromide can be added to T to give compound U. Compound U can be hydrolysed to compound V.



T U V

Four students, W, X, Y and Z, made the following statements.

W All the atoms in a molecule of compound T lie in the same plane.
X Compound V contains only one chiral centre.
Y Step 1 is an electrophilic addition reaction.
Z Step 2 is a nucleophilic substitution reaction.

Which two students are correct?

A W and Y **B** W and Z **C** X and Y **D** Y and Z

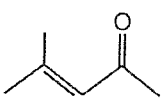
37. M/J 15/P11/Q23

Which intermediate ion forms in the greatest amount during the addition of HBr to propene?

A $CH_3CH^+CH_3$ **B** $CH_3CH_2CH_2^+$ **C** $CH_3CH^-CH_2Br$ **D** $CH_3CHBrCH_2^-$

38. O/N 15/P12/Q23

Compound Q can be made from propanone.



Q

Which types of reaction will Q undergo?

A nucleophilic addition and electrophilic addition
B nucleophilic addition and nucleophilic substitution
C nucleophilic addition only
D nucleophilic substitution and electrophilic addition

39. M/J 15/P12/Q24, M/J 09/P1/Q25

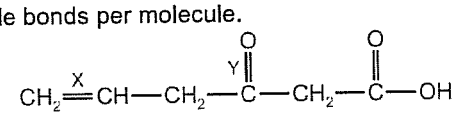
Which reaction would **not** give propene?

A adding excess hot concentrated sulfuric acid to propan-1-ol
B adding warm aqueous sodium hydroxide to 2-bromopropane
C adding warm ethanolic sodium hydroxide to 1-bromopropane
D passing propan-2-ol vapour over heated aluminium oxide

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40. O/N 15/P11/Q23, O/N 15/P13/Q23

Compound Q contains three double bonds per molecule.



Q

Which bond, X or Y, will be ruptured by hot, concentrated acidified $KMnO_4$ and how many lone pairs of electrons are present in one molecule of Q?

	bond ruptured by hot, concentrated acidified $KMnO_4$	number of lone pairs
A	X	5
B	X	6
C	Y	5
D	Y	6

41. M/J 15/P11/Q22

Cottonseed oil contains large amounts of polyunsaturated carboxylic acids. When this oil is used to make margarine, the C=C double bonds in the unsaturated carboxylic acids are hydrogenated.
What reagents and conditions would be suitable to bring about this hydrogenation reaction?

A H_2 gas, nickel catalyst, 400 °C

B $LiAlH_4$ in dry ether

C $NaBH_4$, aqueous solution

D steam, concentrated H_2SO_4, 300 °C and 60 atm pressure

42. M/J 13/P12/Q20, M/J 03/P1/Q22

The compound hex-3-en-1-ol, **P**, has a strong 'leafy' smell of newly cut grass and is used in perfumery.

$CH_3CH_2CH{=}CHCH_2CH_2OH$

P

What is produced when **P** is treated with an excess of hot concentrated acidified $KMnO_4$?

A $CH_3CH_2CH(OH)CH(OH)CH_2CH_2OH$

B $CH_3CH_2CH{=}CHCH_2CO_2H$

C CH_3CH_2CHO and $OCHCH_2CH_2OH$

D $CH_3CH_2CO_2H$ and $HO_2CCH_2CO_2H$

43. O/N 14/P11/Q20, O/N 14/P12/Q20

Which row correctly describes the reaction between propene and bromine, $Br_2(l)$?

	reaction mechanism	organic product
A	electrophilic addition	$CH_3CHBrCH_2Br$
B	electrophilic addition	$CH_3CH_2CH_2Br$
C	nucleophilic substitution	$CH_3CH_2CH_2Br$
D	nucleophilic substitution	$CH_3CHBrCH_2Br$

44. M/J 14/P11/Q20

Many organic reactions need to be heated before reaction occurs, but some do not require heating.
Which reaction occurs quickly at room temperature?

A $C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$

B $C_2H_4 + H_2O \rightarrow CH_3CH_2OH$

C $CH_3CH_2OH \rightarrow C_2H_4 + H_2O$

D $CH_3CH_2OH + HBr \rightarrow CH_3CH_2Br + H_2O$

45. M/J 14/P13/Q23

Which molecule could not be obtained from the cracking of a molecule of nonane, $CH_3(CH_2)_7CH_3$?

A $CH_2 = CHCH = CH_2$

B $CH_3CH_2CH_2CH_2CH_3$

C $CH_3CH_2CH_2CH_2CH_2CH = CH_2$

D $(CH_3CH_2CH_2)_3CH$

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46. M/J 14/P13/Q26

Hept-4-enal is present in cow's milk.

$$CH_3CH_2CH{=}CHCH_2CH_2CHO$$

hept-4-enal

Which row correctly shows the product formed when hept-4-enal is treated with the given reducing agent?

	reducing agent	product
A	H_2 + Ni	$CH_3(CH_2)_5CH_2OH$
B	H_2 + Ni	$CH_3(CH_2)_5CH_3$
C	$NaBH_4$	$CH_3(CH_2)_5CH_2OH$
D	$NaBH_4$	$CH_3(CH_2)_5CHO$

47. O/N 13/P13/Q23

Pent-2-ene, $CH_3CH_2CH{=}CHCH_3$, reacts in a similar way to ethene.
Pent-2-ene is reacted with cold, dilute, acidified manganate(VII) ions.
What will be produced in the greatest amount?

A $CH_3CH_2CH(OH)CH(OH)CH_3$

B $CH_3CH_2COCOCH_3$

C a mixture of $CH_3CH_2CH(OH)CH_2CH_3$ and $CH_3CH_2CH_2CH(OH)CH_3$

D CH_3CH_2COOH and CH_3COOH

48. M/J 13/P11/Q22, O/N 09/P12/Q24, O/N 09/P11/Q25

Bromine reacts with ethene to form 1,2-dibromoethane.
What is the correct description of the organic intermediate in this reaction?

A It has a negative charge.

B It is a free radical.

C It is a nucleophile.

D It is an electrophile.

49. M/J 13/P13/Q20

Ethene reacts with steam in the presence of sulfuric acid.

$$C_2H_4 + H_2O \rightarrow CH_3CH_2OH$$

What type of reaction is this?

A acid / base **B** addition **C** hydrolysis **D** substitution

50. O/N 12/P13/Q26

Which pair of reactions could have the same common intermediate?

W $CH_3CH_2CH_3 \longrightarrow$ intermediate $\longrightarrow (CH_3)_2CHCN$

X $CH_3CH(OH)CH_3 \longrightarrow$ intermediate $\longrightarrow (CH_3)_2C(OH)CN$

Y $CH_3CH{=}CH_2 \longrightarrow$ intermediate $\longrightarrow CH_3CH(OH)CH_3$

Z $CH_3CO_2CH_2CH_2CH_3 \longrightarrow$ intermediate $\longrightarrow CH_3CH_2CH_2Br$

A **W** and **X** **B** **W** and **Y** **C** **X** and **Z** **D** **Y** and **Z**

51. O/N 11/P13/Q27, O/N 11/P11/Q26

Energy is released in the human body by the oxidation of glucose in a complex sequence of reactions. Part of this sequence is the Krebs cycle. One reaction in the Krebs cycle is the conversion of fumaric acid into malic acid.

$$HO_2CCH{=}CHCO_2H \rightarrow HO_2CCH(OH)CH_2CO_2H$$

fumaric acid malic acid

Which reagents could achieve this transformation in the laboratory?

A acidified $KMnO_4$

B Br_2(aq) followed by hot NaOH(aq)

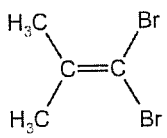
C H_2O with Pt catalyst

D steam with H_2SO_4

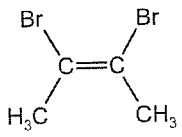
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52. M/J 12/P12/Q23

Isomers X and Y both react with HBr.



X



Y

A mixture of **X** and **Y** is reacted with HBr.

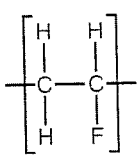
Which three structures represent three **different** possible products of this reaction?

A	$(CH_3)_2CHCBr_3$	$(CH_3)_2CBrCHBr_2$	$CH_3CHBrCHBrCH_3$
B	$(CH_3)_2CHCBr_3$	$(CH_3)_2CBrCHBr_2$	$CH_3CBr_2CHBrCH_3$
C	$(CH_3)_2CBrCBr_3$	$(CH_3)_2CHCBr_3$	$CH_3CBr_2CHBrCH_3$
D	$(CH_3)_2CBrCHBr_2$	$CHBr_2CBr(CH_3)CH_3$	$CH_3CHBrCBr_2CH_3$

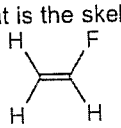
53. O/N 10/P12/Q28

Fluoroalkenes are used to make polymers such as poly(vinyl)fluoride (PVF).

PVF is used to make non-flammable interiors for aircraft. The diagram shows the repeat unit of the polymer PVF.



What is the skeletal formula of the monomer of PVF?

A 

B 

C 

D 

54. M/J 10/P13/Q30, M/J 10/P12/Q27, M/J 10/P11/Q29

Which isomer of $C_4H_{10}O$ forms three alkenes on dehydration?

A butan-1-ol

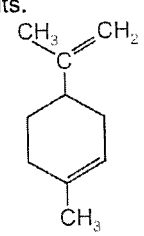
B butan-2-ol

C 2-methylpropan-1-ol

D 2-methylpropan-2-ol

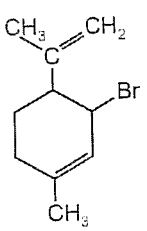
55. O/N 10/P11/Q25, O/N 10/P13/Q23

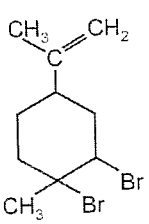
Limonene is an oil formed in the peel of citrus fruits.

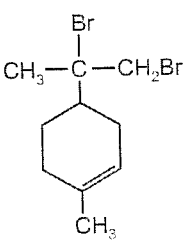


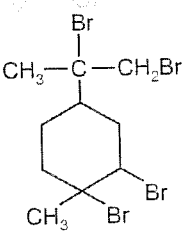
limonene

Which product is formed when an excess of bromine, $Br_2(l)$, reacts with limonene at room temperature in the dark?

A 

B 

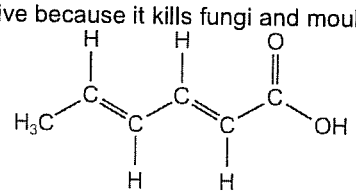
C 

D 

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56. O/N 09/P12/Q23, M/J 13/P12/Q21, O/N 09/P11/Q24

Sorbic acid is used as a food preservative because it kills fungi and moulds.



sorbic acid

Sorbic acid will react with

- hydrogen in the presence of a nickel catalyst,
- bromine in an organic solvent.

How many moles of hydrogen and of bromine will be incorporated into one mole of sorbic acid by these reactions?

	moles of hydrogen	moles of bromine
A	2	2
B	2	$2\frac{1}{2}$
C	3	2
D	3	$2\frac{1}{2}$

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57. MAR 20/P12/Q40

Which statements comparing ethene and ethane are correct?

1 The bond angles in ethene are larger than the bond angles in ethane.
2 Ethene reacts much more quickly with bromine in the dark than ethane does.
3 Complete combustion of 0.01 mol of ethene or ethane produces the same volume of gas measured at room temperature and pressure.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

58. O/N 18/P12/Q37

Which bromopropenes would react with cold bromine in the dark to form a product containing a chiral carbon atom?

1 $CHBr=CHCH_3$
2 $CH_2=CHCH_2Br$
3 $CH_2=CBrCH_3$

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

59. M/J 18/P13/Q31

Complete combustion of a sample of a hydrocarbon gave 0.132 g of carbon dioxide and 0.054 g of water.
Which formulae could correctly represent this hydrocarbon?

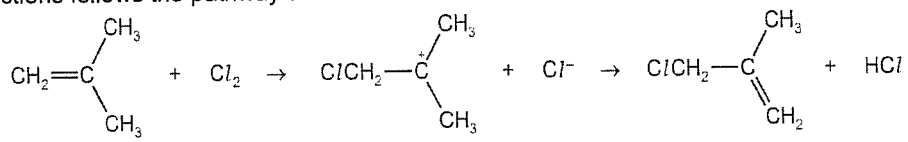
1 $CH_2=CH_2$
2 $CH_3CH=CH_2$
3 $CH_3CH=CHCH_3$

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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60. O/N 18/P11/Q37, O/N 18/P13/Q37

2-methylpropene can react in more than one way with chlorine.
One of the reactions follows the pathway shown.



2-methylpropene intermediate product

Which statements about this mechanism are correct?

1 The intermediate has all carbon atoms in the same plane.
2 There is an electrophilic attack on the double bond.
3 It is a free radical mechanism.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

61. MAR 17/P12/Q37

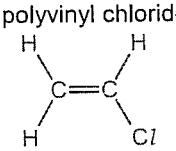
Which compounds can be obtained from but-2-ene in a single reaction?

1 $CH_3CH(OH)CH(OH)CH_3$
2 $CH_3CH(OH)CH_2CH_3$
3 CH_3CO_2H

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

62. M/J 17/P12/Q38

The diagram shows the monomer used to make polyvinyl chloride, PVC.



Assuming that one particular molecule of the polymer forms from n molecules of the monomer (where n is many thousands), which statements are correct?

1 The relative molecular mass of this polymer molecule is approximately 62.5*n*.
2 There are n chiral carbon atoms in this polymer molecule.
3 There are 5n s bonds in one polymer molecule.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

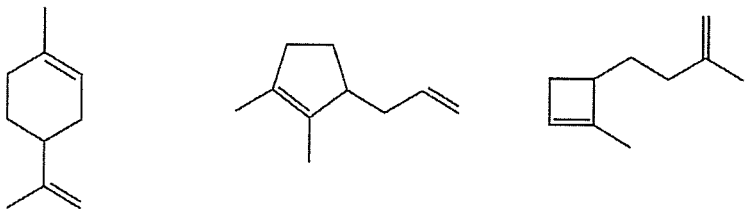
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63. O/N 15/P12/Q40

Compound **Z** is heated with concentrated acidified potassium manganate(VII). This produces an equimolar mixture of CO_2 and $CH_3COCH_2CH_2CH(COCH_3)CH_2CO_2H$.

What could be the structural formula of **Z**?

1 2 3

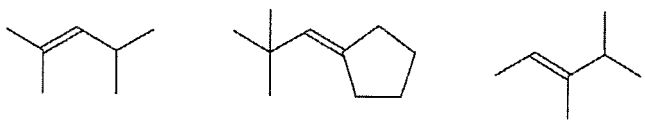


A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

64. O/N 16/P11/Q37, O/N 16/P13/Q37

Which compounds would produce a carboxylic acid and a ketone when treated with hot, concentrated, acidified $KMnO_4$?

1 2 3



A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

65. M/J 12/P12/Q37

Which compounds can be obtained from propene in a **single** reaction?

1 $CH_2OHCHOHCH_3$

2 $-(-CH_2CH(CH_3)-)_n-$

3 $CH_2BrCH_2CH_2Br$

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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66. M/J 12/P12/Q39

Which statements about the photochemical chlorination of ethane are correct?

1 Hydrogen gas is one of the products.

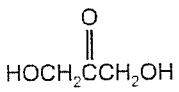
2 A propagation step in the mechanism is $C_2H_6 + Cl^{\bullet} \longrightarrow C_2H_5^{\bullet} + HCl$.

3 The initiation step is the homolytic fission of chlorine.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

67. O/N 11/P11/Q38, O/N 11/P13/Q40

DHA is a colourless liquid which reacts with protein in skin to cause it to darken. It has the structure shown.



DHA

Which observations would be made when testing this substance?

1 Hydrogen is produced when sodium is added.

2 A coloured precipitate is produced when 2,4-dinitrophenylhydrazine reagent is added.

3 A silver precipitate is produced when Tollens' reagent is added.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

68. M/J 11/P11/Q38, M/J 11/P13/Q37

Which alkenes, on reaction with steam at 600 K and 6×10^6 Pa pressure in the presence of a phosphoric acid catalyst, could produce an alcohol containing a chiral carbon atom?

1 $(CH_3)_2C=CH_2$

2 $CH_3CH=CHCH_3$

3 $CH_3CH_2CH=CH_2$

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

69. O/N 08/P1/Q37

Which statements about alkenes are correct?

1 They are formed when higher alkanes are cracked.

2 They are used as monomers for polymerisation.

3 They are less reactive than alkanes towards electrophiles.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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14.3: Hydrocarbons as fuels

1. MAR 19/P12/Q22

Many reactions take place in the engine and catalytic converter of a car.
Which pair of substances is produced both by the reactions in a car engine and in a catalytic converter?

A carbon dioxide and unburnt hydrocarbons
B carbon dioxide and water
C carbon monoxide and nitrogen
D carbon monoxide and unburnt hydrocarbons

2. M/J 17/P13/Q3

Which equation correctly describes the complete combustion of an alkene, C_nH_{2n}?

A $C_nH_2n + \frac{3}{2}nO_2 \rightarrow nCO_2 + 2nH_2O$
B $C_nH_2n + \frac{3}{2}nO_2 \rightarrow nCO_2 + nH_2O$
C $C_nH_2n + 2nO_2 \rightarrow nCO_2 + nH_2O$
D $C_nH_2n + 2nO_2 \rightarrow nCO_2 + 2nH_2O$

3. M/J 14/P11/Q27

The hydrocarbon $C_{17}H_{36}$ can be cracked.
Which compound is the **least** likely to be produced in this reaction?

A C_3H_8 **B** C_4H_8 **C** C_8H_{16} **D** $C_{16}H_{34}$

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4. O/N 10/P12/Q36

A car burning lead-free fuel has a catalytic converter fitted to its exhaust. On analysis its exhaust gases are shown to contain small quantities of nitrogen oxides.
Which modifications would result in lower exhaust concentrations of nitrogen oxides?

1 an increase in the surface area of the catalyst in the converter
2 an increase in the rate of flow of the exhaust gases through the converter
3 a much higher temperature of combustion in the engine

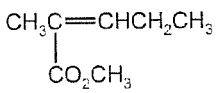
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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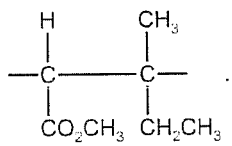
14.4: Multiple Topics

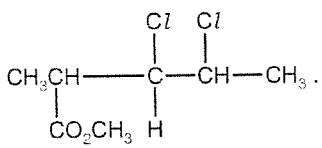
1. **O/N 18/P12/Q22**
Polyethene is made by the polymerisation of ethene.
Which statement is correct?
A The monomer and the polymer have different empirical formulae.
B The monomer can be oxidised without heat whereas the polymer cannot.
C The monomer can be used as a fuel whereas the polymer cannot.
D The monomer has greater van der Waals' forces than the polymer.

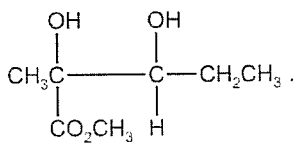
2. **O/N 18/P12/Q24**
Which statement about compound Q is correct?

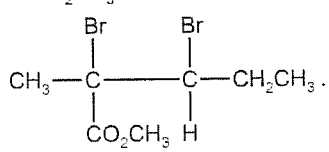


Q

A It could be polymerised to give a polymer with the repeat unit  .

B It reacts with chlorine by a free radical mechanism to give  .

C It reacts with cold, dilute acidified manganate(VII) to give  .

D It reacts with bromine via a free radical mechanism to give  .

3. **O/N 18/P11/Q24, O/N 18/P13/Q24**
An organic molecule W contains 3 carbon atoms. It requires 4.5 molecules of oxygen for complete combustion.
What could W be?
A propane **B** propanoic acid **C** propanone **D** propan-1-ol

4. **M/J 18/P11/Q3**
Which fuel would produce the largest mass of CO_2 when 10 kg of the fuel undergo complete combustion?
A biodiesel, $C_{17}H_{34}O_2$ **B** ethanol, C_2H_6O **C** octane, C_8H_{18} **D** propane, C_3H_8

5. **M/J 17/P13/Q4**
Two conversions are shown.

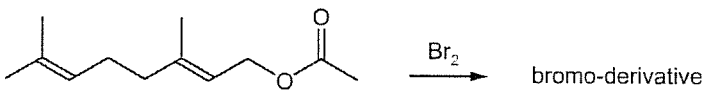
$$NH_4^+ \rightarrow NH_3$$
$$C_2H_4 \rightarrow C_2H_6$$

Which similar feature do these two conversions have?
A change in oxidation state of an element
B decrease in bond angle
C formation of a lone pair of electrons
D loss of a p bond

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6. M/J 16/P11/Q30

Geranyl ethanoate is present in ginger and cocoa, and is used in shampoos and soaps as a perfume. It reacts with an excess of bromine in an organic solvent to give X, a bromo-derivative.



geranyl ethanoate X

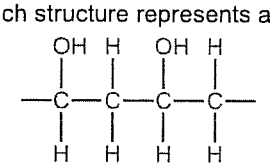
Including geranyl ethanoate, how many cis-trans isomers are there of geranyl ethanoate, and how many chiral centres are there in X?

	cis-trans isomers	chiral centres in X
A	2	3
B	2	4
C	4	3
D	4	4

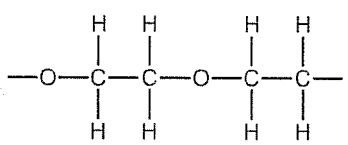
7. O/N 14/P13/Q28

Poly(ethenol) can be used to make plastic bags that dissolve in water.
It may be considered to be made by addition polymerisation of CH_2=CH(OH).
Which structure represents a length of the polymer chain consisting of two monomer residues?

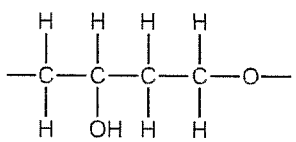
A



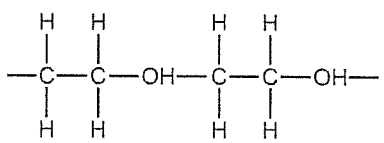
B



C



D



8. M/J 14/P11/Q29

How many geometrical (cis-trans) isomers are there of hex-2,4-diene, CH_3CH=$CHCH$=$CHCH_3$?

A none; hex-2,4-diene does not show geometric isomerism
B 2
C 3
D 4

9. O/N 13/P12/Q30

Which types of bond breakage and bond formation occur in the addition polymerisation of alkenes?

	bond breakage	bond formation
A	π only	σ only
B	π only	σ and π
C	σ and π	σ only
D	σ and π	σ and π

10. M/J 13/P13/Q30

CCl_2FCClF_2 can be converted into CH_2FCF_3 by the following route.

$$CCl_2FCClF_2 \xrightarrow{\text{step 1}} CCl_3CF_3 \xrightarrow{\text{step 2}} CCl_2FCF_3 \xrightarrow{\text{step 3}} CH_2FCF_3$$

What type of reaction is step 1?

A addition **B** elimination **C** isomerisation **D** oxidation

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11. O/N 13/P11/Q30

Which types of bond breakage and bond formation occur in the addition polymerisation of alkenes?

	bond breakage	bond formation
A	π only	σ only
B	π only	σ and π
C	σ and π	σ only
D	σ and π	σ and π

12. O/N 13/P13/Q30

Which fragment could appear in the chain produced by polymerising 1,1-dichloroethene?

A $-CH_2-CH_2-CCl_2-CCl_2-CH_2-CH_2-$

B $-CHCl-CHCl-CHCl-CHCl-CHCl-CHCl-$

C $-CH_2-CCl_2-CH_2-CH_2-CH_2-CCl_2-$

D $-CCl_2-CCl_2-CH_2-CH_2-CH_2-CCl_2-$

13. M/J 13/P11/Q29

Synthetic resins, plasticisers and many other chemicals can be made by polymerisation of a variety of monomers including prop-2-en-1-ol, $CH_2=CHCH_2OH$.

Which structure represents the repeat unit in poly(prop-2-en-1-ol)?

A $-CH_2-CH-CH_2-OH-$

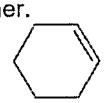
B $-CH_2-CH(CH_2OH)-$

C $-CH=C(CH_2OH)-$

D $-CH_2-CH(OH)-CH_2-$

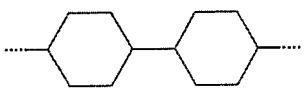
14. M/J 13/P13/Q28

Cyclohexene, shown below, can form an addition polymer.

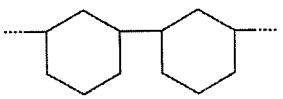


Which structure represents a section of the polymer including two cyclohexene residues?

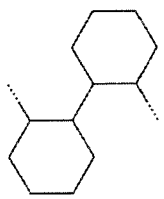
A



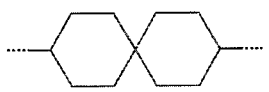
B



C



D



15. M/J 12/P11/Q30, M/J 12/P13/Q30

Which statement does **not** correctly describe the polymer PVC?

A Combustion of PVC waste produces a highly acidic gas.

B PVC molecules are saturated.

C The empirical formula of PVC is the same as the empirical formula of its monomer.

D The repeat unit of PVC is $\{CHCl/CHCl\}$.

16. O/N 11/P12/Q28

Which reagent could best be used to distinguish between cyclohexene and cyclohexanol?

A $Ag(NH_3)_2^+$ in H_2O

B Br_2 in CCl_4

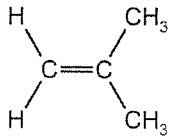
C 2,4-dinitrophenylhydrazine in CH_3OH

D $NaBH_4$ in CH_3OH

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17. O/N 10/P11/Q29, O/N 10/P13/Q29

The compound 2-methylpropene, C_4H_8, is a monomer used in the production of synthetic rubber.



In addition to 2-methylpropene there are x other isomers of C_4H_8, structural or otherwise, which contain a double bond.

What is the value of x?

A 1 **B** 2 **C** 3 **D** 4

18. M/J 10/P12/Q29, M/J 10/P13/Q27, M/J 10/P11/Q26, M/J 05/P1/Q30

In many countries plastic waste is collected separately and sorted. Some of this is incinerated to provide heat for power stations.

Why is pvc, polyvinylchloride, removed from any waste that is to be incinerated?

A It destroys the ozone layer.
B It does not burn easily.
C It is easily biodegradable.
D Its combustion products are harmful.

19. M/J 10/P11/Q20, M/J 10/P12/Q20, M/J 10/P13/Q20

When gaseous chemicals are transported by road or by rail they are classified as follows.

flammable non-flammable poisonous

Which commonly transported gas is non-flammable?

A butane **B** hydrogen **C** oxygen **D** propene

20. M/J 10/P13/Q28, M/J 10/P12/Q30, M/J 10/P11/Q27

Polymerisation of 1,1-dichloroethene produces a dense, high melting point substance that does not allow gases to pass through. It is used as cling wrapping.

Which sequence appears in a short length of the polymer chain?

A $\{CH_2CCl_2CH_2CCl_2CH_2CCl_2\}$
B $\{CHCl/CHCl/CHCl/CHCl/CHCl/CHCl/\}$
C $\{CCl_2CCl_2CCl_2CCl_2CCl_2CCl_2\}$
D $\{CH_2CCl_2CHCl/CHCl/CH_2CCl_2\}$

21. M/J 09/P1/Q6

In which reaction does the carbon-containing product have a smaller bond angle than the organic reactant?

A bromoethane refluxed with ethanolic sodium hydroxide
B complete combustion of methane in air
C methane and an excess of chlorine under ultraviolet light
D polymerisation of ethene

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22. M/J 20/P11/Q31

The definitions of many chemical terms can be illustrated by chemical equations.

Which terms can be illustrated by an equation that includes the formation of a positive ion?

1 first ionisation energy
2 heterolytic fission of a covalent bond
3 enthalpy change of atomisation

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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23. M/J 20/P13/Q39

On complete combustion, a sample of X produces 44 g of carbon dioxide and 27 g of water.
On complete combustion, a sample of Y produces 44 g of carbon dioxide and 18 g of water.
On complete combustion, a sample of Z produces 22 g of carbon dioxide and 9 g of water.
Which substances could be straight chain alkanes?

1 X
2 Y
3 Z

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

24. M/J 19/P13/Q38

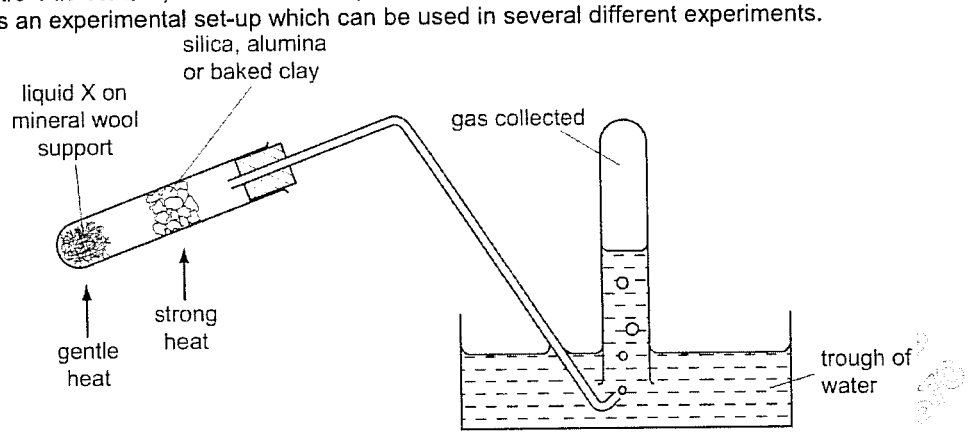
Bromine reacts with ethene in an addition reaction.
Which statements about this reaction are correct?

1 It is the basis of a test for unsaturation in alkenes.
2 It leads to an increase in each of the H–C–H bond angles.
3 A nucleophile attacks the C=C bond in ethene.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

25. M/J 18/P12/Q39, M/J 14/P13/Q40, O/N 09/P12/Q38, O/N 09/P11/Q39

The diagram shows an experimental set-up which can be used in several different experiments.



Which processes could be demonstrated by using the above apparatus?

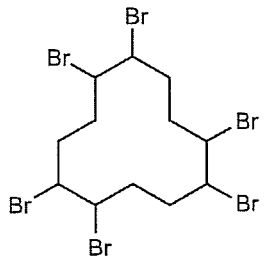
1 oxidation of ethanol (liquid X)
2 dehydration of ethanol (liquid X)
3 cracking of paraffin (liquid X)

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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26. M/J 15/P13/Q37

The diagram shows a molecule of a compound used as a flame retardant.



Which statements about this structure are correct?

1 Each brominated C atom is chiral.
2 The molecular formula is $C_{12}H_{20}Br_6$.
3 The C–C–C bond angles are all 120°.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

27. O/N 17/P11/Q37, O/N 17/P13/Q37

In which molecules do all the carbon atoms lie in the same plane?

1 2,3-dimethylbut-2-ene
2 propane
3 cyclohexane

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

28. O/N 10/P13/Q38, O/N 10/P11/Q39

An organic compound decolourises aqueous bromine and reacts with sodium to produce hydrogen.
Which molecular formula could represent this compound?

1 C_3H_6O 2 $C_3H_4O_2$ 3 C_3H_8O

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

29. O/N 09/P11/Q31

A monomer undergoes addition polymerisation. A 1 mol sample of the monomer is completely polymerised.
How many moles of polymer might, theoretically, be formed?

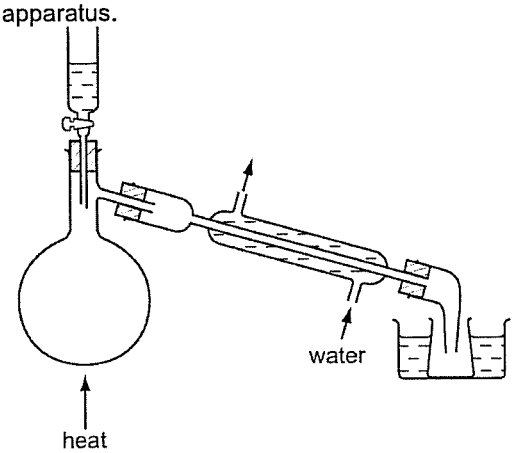
1 1 2 10^{-6} 3 $\frac{1}{6.02 \times 10^{23}}$

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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30. M/J 10/P12/Q40, M/J 10/P11/Q40, M/J 10/P13/Q40

The diagram shows some laboratory apparatus.



Which preparations could this apparatus be used for?

1 bromoethane, from ethanol, sodium bromide and concentrated sulfuric acid
2 ethanal, from ethanol, sodium dichromate(VI) and sulfuric acid
3 1,2-dibromoethane, from bromine and ethene

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

31. M/J 09/P1/Q37

A fraction of distilled crude oil contains molecules with between 15 and 19 carbon atoms. This fraction is cracked by strong heating.

Why is this done?

1 To produce alkenes.
2 To produce smaller molecules which are in higher demand.
3 To insert oxygen atoms into the hydrocarbons.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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Answers Sections

14.1		14.2		14.2		14.3		14.4	
1.	C	1.	A	41.	A	1.	B	1.	B
2.	B	2.	C	42.	D	2.	B	2.	C
3.	C	3.	C	43.	A	3.	D	3.	D
4.	B	4.	B	44.	A	4.	D	4.	C
5.	B	5.	A	45.	D			5.	B
6.	C	6.	A	46.	A			6.	A
7.	A	7.	C	47.	A			7.	A
8.	D	8.	D	48.	D			8.	C
9.	B	9.	A	49.	B			9.	A
10.	A	10.	C	50.	B			10.	C
11.	B	11.	D	51.	D			11.	A
12.	D	12.	C	52.	B			12.	A
13.	B	13.	A	53.	B			13.	B
14.	B	14.	B	54.	B			14.	C
15.	D	15.	A	55.	D			15.	D
16.	B	16.	A	56.	A			16.	B
17.	C	17.	A	57.	A			17.	C
18.	C	18.	D	58.	D			18.	D
19.	A	19.	B	59.	A			19.	C
20.	D	20.	B	60.	B			20.	A
21.	B	21.	A	61.	A			21.	D
22.	D	22.	B	62.	B			22.	B
23.	C	23.	A	63.	A			23.	D
24.	C	24.	B	64.	A			24.	D
25.	B	25.	B	65.	B			25.	C
26.	C	26.	B	66.	C			26.	D
27.	B	27.	C	67.	B			27.	B
28.	C	28.	D	68.	C			28.	B
29.	B	29.	B	69.	B			29.	C
30.	C	30.	C					30.	B
31.	B	31.	C					31.	B
32.	B	32.	A						
		33.	C						
		34.	C						
		35.	D						
		36.	D						
		37.	A						
		38.	A						
		39.	B						
		40.	B						

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Unit 15
HALOGEN DERIVATIVES

A Level
Chemistry Paper 1
Classified/Topical MCQ's
Article Number: 231

Editorial Board

Syllabus

15.1 Halogenalkanes and halogenoarenes
15.2 Relative strength of the C-Hal bound
15.3 Multiple topics

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Unit 15: Halogen derivatives

15.1: Halogenoalkanes and halogenoarenes

1. M/J 20/P11/Q23

2-bromo-2-methylpentane is a tertiary halogenoalkane.
Which organic products are formed when 2-bromo-2-methylpentane reacts with a hot concentrated ethanolic solution of sodium hydroxide?

A 2-methylpent-1-ene only
B 2-methylpent-1-ene and 2-methylpent-2-ene
C 2-methylpent-2-ene only
D 2-methylpent-2-ene and 4-methylpent-2-ene

2. M/J 20/P13/Q23

Butanoic acid can be produced from 1-bromopropane in two steps using reagents V and W as shown.

1-bromopropane $\xrightarrow{\text{reagent V}}$ compound Q $\xrightarrow{\text{reagent W}}$ butanoic acid

What could be reagents V and W?

	V	W
A	KCN in ethanol	HC*l*(aq)
B	KCN in ethanol	NaOH(aq)
C	NH_3 in ethanol	HC*l*(aq)
D	NaOH(aq)	$H^+ / Cr_2O_7^{2-}$(aq)

3. M/J 20/P13/Q27

1,2-dibromopropane can be made from 1-bromopropane in two steps.
Which row is correct?

	step 1	step 2
A	addition	substitution
B	elimination	addition
C	hydrolysis	elimination
D	substitution	hydrolysis

4. MAR 20/P12/Q21

Which row identifies a suitable starting material and reagent that can be used to produce butanenitrile?

	starting material	reagent
A	$CH_3CH_2CH_2Br$	HCN
B	$CH_3CH_2CH_2Br$	NaCN
C	$CH_3CH_2CH_2CH_2Br$	HCN
D	$CH_3CH_2CH_2CH_2Br$	NaCN

5. O/N 19/P11/Q24, O/N 19/P13/Q24

Bromoethane and chloroethane are added separately to water. Hydrolysis reactions occur.
Which compound hydrolyses more rapidly and what is the mechanism?

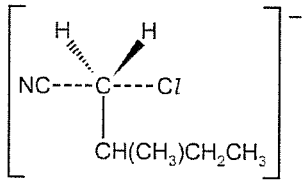
	compound that hydrolyses more rapidly	mechanism
A	bromoethane	electrophilic substitution
B	bromoethane	nucleophilic substitution
C	chloroethane	electrophilic substitution
D	chloroethane	nucleophilic substitution

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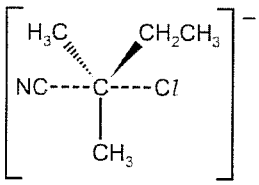
6. O/N 19/P12/Q23

1-chloro-2-methylbutane reacts with sodium cyanide in ethanol in a nucleophilic substitution reaction.
What is the most likely intermediate or transition state in this reaction?

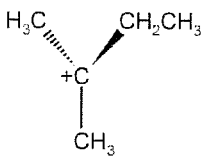
A



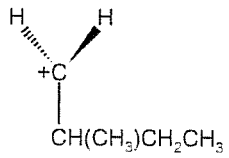
B



C

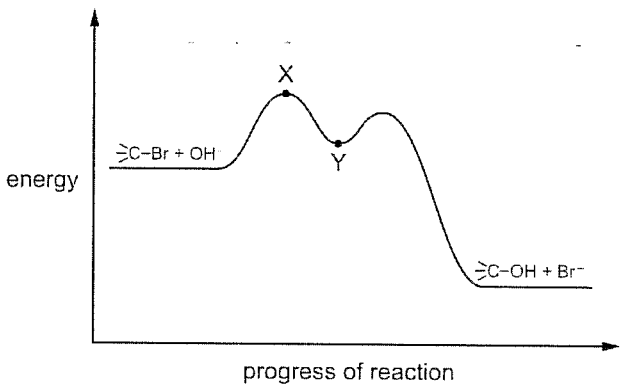


D



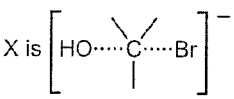
7. O/N 19/P11/Q23, O/N 19/P13/Q23, M/J 15/P13/Q28,

A tertiary bromoalkane, indicated here by ≥C–Br, reacts with aqueous NaOH. The mechanism has the reaction pathway below.

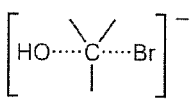


Which point in the diagram is correctly identified?

A X is ≥C+

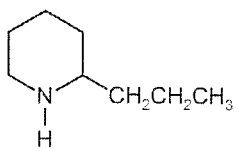
B X is 

C Y is ≥C+

D Y is 

8. M/J 19/P11/Q25, M/J 15/P11/Q24, M/J 12/P12/Q28

Coniine is the major constituent of the poison 'oil of hemlock'.



coniine

Coniine can be synthesised by reacting ammonia with a dibromo compound, **X**.

$$NH_3 + C_8H_{16}Br_2 \rightarrow \text{coniine} + 2HBr$$

X

What is the name of compound **X**?

A 1,1-dibromo-2-propylcyclopentane

B 1,2-dibromo-2-propylcyclopentane

C 1,4-dibromooctane

D 1,5-dibromooctane

9. M/J 19/P12/Q25

Which product can be made from bromoethane by an elimination reaction?

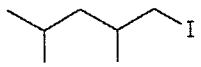
A ethanol **B** ethene **C** ethylamine **D** propanenitrile

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10. M/J 19/P13/Q20, M/J 15/P13/Q22

The Finkelstein reaction occurs when NaI in propanone reacts with a chloroalkane or bromoalkane. The halogen is directly replaced by I and the reaction only works for primary halogenoalkanes.

Which halogenoalkane would produce compound X?



compound X

A $(CH_3)_2CHCH(CH_3)CH_2CH_2Br$

B $(CH_3)_2CHCH(CH_3)CH_2Br$

C $(CH_3)_2CHCH_2CH_2CH(CH_3)Cl$

D $(CH_3)_2CHCH_2CH(CH_3)CH_2Cl$

11. M/J 19/P13/Q24

Water is added to a sample of 2,3-dibromohexane.

Some of the 2,3-dibromohexane undergoes complete hydrolysis and some of it undergoes partial hydrolysis.

What is **not** present in the mixture of products?

A $CH_3CH(OH)CHBrCH_2CH_2CH_3$

B $CH_3CH(OH)CH(OH)CH_2CH_2CH_3$

C $CH_3CH_2CH(OH)CH(OH)CH_2CH_3$

D $CH_3CH_2CH_2CH(OH)CHBrCH_3$

12. M/J 19/P13/Q25

Which statement about the mechanism of an S_N1 reaction of a halogenoalkane is correct?

A A nucleophile is substituted by an electrophile.

B One intermediate is formed from two reacting molecules.

C The intermediate is stabilised by adjacent alkyl groups.

D The intermediate is uncharged.

13. MAR 19/P12/Q24

Bromopropane reacts with water as shown.

$$CH_3CH_2CH_2Br + H_2O \rightarrow CH_3CH_2CH_2OH + HBr$$

Which statement is correct?

A This is an elimination reaction.

B This is a hydrolysis reaction.

C This is a redox reaction.

D This reaction tends to proceed via the S_N1 mechanism.

14. O/N 18/P12/Q23

Compound P reacts separately with KOH(aq) and HBr.

$CH_2CHCH_2CH_2Cl$

compound P

What are the mechanisms of these two reactions?

	KOH (aq)	HBr
A	nucleophilic addition	electrophilic addition
B	nucleophilic addition	free radical substitution
C	nucleophilic substitution	electrophilic addition
D	nucleophilic substitution	free radical substitution

15. O/N 18/P12/Q25

A halogenoalkane has the molecular formula $C_5H_{11}Br$. The halogenoalkane does not form an alkene when treated with ethanolic sodium hydroxide.

What could be the halogenoalkane?

A 1-bromo-2-methylbutane

B 2-bromo-2-methylbutane

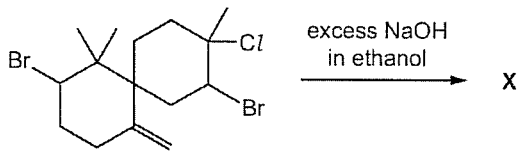
C 3-bromopentane

D bromodimethylpropane

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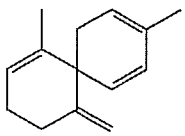
16. O/N 18/P11/Q25, O/N 18/P13/Q25

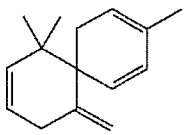
Compound J, $C_{15}H_{23}Br_2Cl$, is reacted with an excess of a hot concentrated solution of sodium hydroxide in ethanol. One of the products is X.

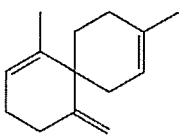


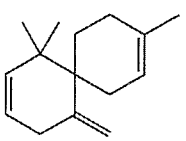
compound J

What could be the skeletal formula of X?

A 

B 

C 

D 

17. M/J 18/P12/Q25

When warm water is added to halogenoalkane X, an S_N1 reaction occurs.
$AgNO_3(aq)$ is then added; a yellow precipitate is formed.
What could be X?

A 1-chlorobutane
B 1-iodobutane
C 2-chloro-2-methylpropane
D 2-iodo-2-methylpropane

18. M/J 18/P11/Q22

Sodium methoxide, $Na^+CH_3O^-$, reacts with 2-chloro-2-methylpropane in a nucleophilic substitution reaction. The nucleophile is the CH_3O^- ion.
Which row is correct?

	intermediate or transition state	product
A	$(CH_3)_3C^+$	$(CH_3)_3COCH_3$
B	$(CH_3)_3C^+$	$(CH_3)_3CCH_2OH$
C	$[HOCH_2\text{- - -}C(CH_3)_3\text{- - -}Cl]^-$	$HOCH_2C(CH_3)_3$
D	$[H_3CO\text{- - -}C(CH_3)_3\text{- - -}Cl]^-$	$H_3COC(CH_3)_3$

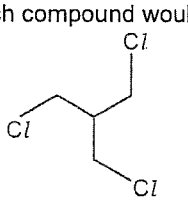
19. M/J 18/P13/Q22

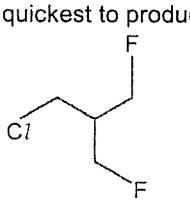
Which statement is not correct?

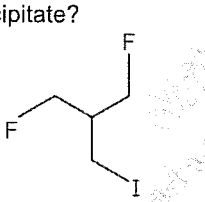
A Combustion of PVC produces a highly acidic gas.
B PVC molecules are saturated.
C The empirical formula of PVC is the same as the empirical formula of its monomer.
D The repeat unit of PVC is $\{CHCl/CHCl\}$.

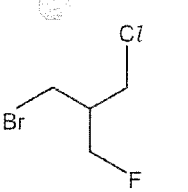
20. M/J 18/P13/Q23, M/J 15/P11/Q26

The presence of a halogen in an organic compound may be detected by warming the organic compound with aqueous silver nitrate.
Which compound would be the quickest to produce a precipitate?

A 

B 

C 

D 

21. M/J 18/P13/Q28

A student carried out a two-stage synthesis in which $CH_3CH_2CH_2Br$ was converted into $CH_3CH_2CH_2CO_2H$.
Which compound could have been formed by the first stage of this synthesis?

A $CH_3CH_2CH_2OH$ **B** $CH_3CH_2CH_2CHO$ **C** CH_3CH_2CN **D** $CH_3CH_2CH_2CN$

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22. M/J 18/P13/Q24

Halogenoalkanes react with NaOH(aq) either by an S_N1 mechanism or by an S_N2 mechanism.
The mechanism followed by the reaction depends on the structure of the halogenoalkane.
This question is about the reaction of 3-bromo-3-ethylpentane, $(C_2H_5)_3CBr$.
Which statement is correct?

A The mechanism is S_N1, due to the stabilisation of an intermediate anion by three alkyl groups.
B The mechanism is S_N1, due to the stabilisation of an intermediate cation by three alkyl groups.
C The mechanism is S_N2, due to the stabilisation of an intermediate anion by three alkyl groups.
D The mechanism is S_N2, due to the stabilisation of an intermediate cation by three alkyl groups.

23. MAR 18/P12/Q21, O/N 13/P12/Q24, O/N 13/P11/Q24

A carbanion is an organic ion in which a carbon atom has a negative charge. A carbocation is an organic ion in which a carbon atom has a positive charge.
The reaction between aqueous sodium hydroxide and 1-bromobutane proceeds by an S_N2 mechanism.
How should the first step in the mechanism be described?

A attack by a nucleophile on a carbon atom with a partial positive charge
B heterolytic bond fission followed by an attack by an electrophile on a carbanion
C heterolytic bond fission followed by an attack by a nucleophile on a carbocation
D homolytic bond fission followed by an attack by a nucleophile on a carbocation

24. M/J 17/P12/Q6

Which reaction involves a decrease in the bond angle at a carbon atom?

A bromoethane refluxed with ethanolic sodium hydroxide
B complete combustion of methane in air
C ethanol heated with conc. H_2SO_4
D polymerisation of ethene

25. M/J 17/P12/Q23, M/J 13/P11/Q24

Aqueous sodium hydroxide reacts with 1-bromopropane to give propan-1-ol.
How should the first step in the mechanism be described?

A by a curly arrow from a lone pair on the OH^- ion to the $C^{\delta+}$ atom of 1-bromopropane
B by a curly arrow from the $C^{\delta+}$ atom of 1-bromopropane to the OH^- ion
C by a curly arrow from the C–Br bond to the C atom
D by the homolytic fission of the C–Br bond

26. M/J 17/P12/Q26

2-bromo-2-methylpropane undergoes nucleophilic substitution when heated under reflux with an aqueous solution of sodium hydroxide.
Which row is correct?

	mechanism for this reaction	reason
A	S_N1	the hydroxide ion is helped in its approach to the central carbon atom by the methyl groups
B	S_N1	the intermediate carbocation is stabilised by the inductive effect of the methyl groups
C	S_N2	the hydroxide ion is hindered in its approach to the central carbon atom by the methyl groups
D	S_N2	the intermediate carbocation is destabilised by the inductive effect of the methyl groups

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27. M/J 17/P13/Q29, M/J 14/P11/Q30

Butanoic acid can be produced from 1-bromopropane using reagents X and Y as shown below.

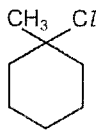
1-bromopropane $\xrightarrow{\text{reagent X}}$ compound Q $\xrightarrow{\text{reagent Y}}$ butanoic acid

What could be reagents X and Y?

	X	Y
A	KCN in ethanol	HC*l*(aq)
B	KCN in ethanol	NaOH(aq)
C	NH_3 in ethanol	HC*l*(aq)
D	NaOH(aq)	$H^+ / Cr_2O_7^{2-}$(aq)

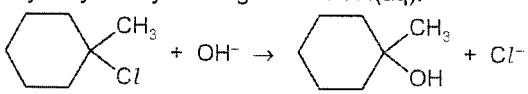
28. O/N 15/P11/Q24, O/N 15/P13/Q24

Which compound undergoes an S_N1 substitution reaction with NaOH(aq)?

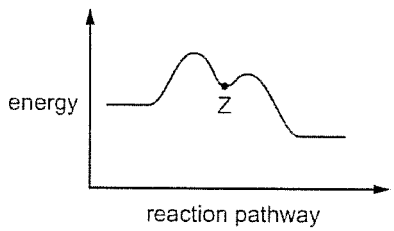
A $CH_3CH_2CH_2Br$ **B** $(CH_3)_3CCH_2I$ **C**  **D** $CH_2{=}CHCl$

29. M/J 16/P12/Q24

1-chloro-1-methylcyclohexane is hydrolysed by heating with NaOH(aq).



The reaction pathway is shown.



One carbon atom in 1-chloro-1-methylcyclohexane is bonded to three other carbon atoms.
What is the charge on this carbon atom at point Z?

A $\delta+$ **B** + **C** $\delta-$ **D** –

30. M/J 16/P11/Q25

A student prepares pentan-1-ol by the alkaline hydrolysis of 1-iodopentane. She gently warms the reaction mixture for 20 minutes.

$$CH_3CH_2CH_2CH_2CH_2I + OH^- \rightarrow CH_3CH_2CH_2CH_2CH_2OH + I^-$$

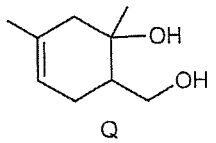
When the student uses 1-chloropentane to prepare the same alcohol she has to change the condition of the reaction.
Which change in condition should she use and what is the correct reason for its use?

	change in condition	reason
A	heat under reflux	C–C*l* bond is more polar than the C–I bond
B	heat under reflux	C–C*l* bond is stronger than the C–I bond
C	room temperature	C–C*l* bond is more polar than the C–I bond
D	room temperature	C–C*l* bond is shorter than the C–I bond

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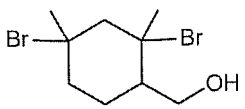
31. M/J 15/P12/Q21

What is the major product formed when compound Q is warmed with excess HBr?

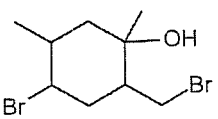


Q

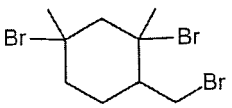
A



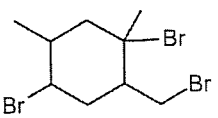
B



C



D



32. M/J 15/P12/Q23

Butanedioic acid may be synthesised in two steps from 1,2-dibromoethane.

$$BrCH_2CH_2Br \xrightarrow{\text{step 1}} X \xrightarrow{\text{step 2}} HO_2CCH_2CH_2CO_2H$$

Which reagents could be used for this synthesis?

	step 1	step 2
A	HCN(g)	HC*l*(aq)
B	HCO_2Na(aq)	HC*l*(aq)
C	KCN(alcoholic)	H_2SO_4(aq)
D	NaOH(aq)	$K_2Cr_2O_7/H_2SO_4$(aq)

33. M/J 15/P11/Q25

2-bromopropane reacts with a hot concentrated solution of sodium hydroxide in ethanol.
Which substance is the major product of this reaction?

A propan-1-ol **B** propan-2-ol **C** 2-hydroxypropene **D** propene

34. M/J 15/P13/Q29, O/N 08/P1/Q23

Four drops of 1-chlorobutane, 1-bromobutane and 1-iodobutane were put separately into three test-tubes containing 1.0 cm^3 of aqueous silver nitrate at 60 °C.
A hydrolysis reaction occurred. (R represents the butane chain C_4H_9 and X the halogen atom.)

$$H_2O(l) + R\text{–}X(l) + Ag^+(aq) \rightarrow R\text{–}OH(aq) + AgX(s) + H^+(aq)$$

The rate of formation of cloudiness in the tubes was in the order RC*l* < RBr < RI.
Why is this?

A The R–X bond polarity decreases from RC*l* to RI.
B The solubility of AgX(s) decreases from AgC*l* to AgI.
C The ionisation energy of the halogen decreases from C*l* to I.
D The bond energy of R–X decreases from RC*l* to RI.

35. O/N 14/P12/Q25, O/N 14/P11/Q25, M/J 09/P1/Q24

In the hydrolysis of bromoethane by aqueous sodium hydroxide, what is the nature of the attacking group and of the leaving group?

	attacking group	leaving group
A	electrophile	electrophile
B	electrophile	nucleophile
C	nucleophile	electrophile
D	nucleophile	nucleophile

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36. O/N 14/P12/Q22, O/N 14/P11/Q22

1,1-dichloropropane reacts with aqueous sodium hydroxide in a series of steps to give propanal.

$$CH_3CH_2CHCl_2 \xrightarrow{NaOH(aq)} CH_3CH_2CHO$$

Which term describes the first step of this reaction?

A addition **B** elimination **C** oxidation **D** substitution

37. O/N 14/P13/Q23

A compound **Y**, C_4H_9Br, undergoes hydrolysis in aqueous alkali to form an alcohol, C_4H_9OH. The rate of this reaction is found to be unaffected by changes in the concentration of OH^- ions present.

Which is the most likely molecular structure of **Y**?

A $CH_3CH_2CH_2CH_2Br$ **B** $CH_3CH_2CHBrCH_3$ **C** $(CH_3)_2CHCH_2Br$ **D** $(CH_3)_3CBr$

38. M/J 14/P12/Q29

When heated with KOH dissolved in ethanol, halogenoalkanes can undergo an elimination reaction to form alkenes.

What are the possible elimination products when 2-bromobutane is heated with KOH dissolved in ethanol?

A $CH_3CH{=}CHCH_3$ only

B $CH_3CH_2CH{=}CH_2$ only

C $CH_3CH{=}CHCH_3$ and $CH_3CH_2CH{=}CH_2$

D $CH_3CH{=}CHCH_3$ and $CH_2{=}CHCH{=}CH_2$

39. M/J 14/P13/Q21

In the presence of ultraviolet light, ethane and chlorine react to give a mixture of products.

Which compound could be present in the mixture of products?

A CH_3Cl

B $CH_3CH_2CH_2Cl$

C $CH_3CH_2CH_2CH_3$

D $CH_3CH_2CH_2CH_2CH_3$

40. M/J 13/P11/Q25

Pentane, C_5H_{12}, is reacted with chlorine in the presence of ultraviolet light. A compound R is found in the products. R has molecular formula $C_5H_{10}Cl_2$. Each molecule of R contains **one** chiral carbon atom.

Which two atoms of the pentane chain could be bonded to chlorine atoms in this isomer?

A 1 and 3 **B** 1 and 5 **C** 2 and 3 **D** 2 and 4

41. O/N 13/P13/Q22

Which reaction will give the best yield of 2-chloropropane?

A chlorine gas with propane gas in the presence of uv light

B chlorine gas with propene gas in the dark

C propan-2-ol with dilute NaCl(aq)

D propan-2-ol with PCl_5

42. M/J 13/P12/Q23

Aqueous sodium hydroxide reacts with 2-bromo-2-methylpropane to give 2-methylpropan-2-ol.

The reaction proceeds by an S_N1 mechanism.

How should the first step in the mechanism be described?

A by a curly arrow from a lone pair on the OH^- ion to the $C^{\delta+}$ atom of 2-bromopropane

B by a curly arrow from the C–Br bond to the Br atom

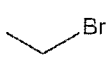
C by a curly arrow from the C–Br bond to the C atom

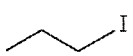
D by the homolytic fission of the C–Br bond

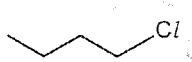
43. M/J 13/P12/Q24

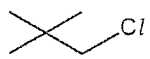
Compound **Y** can be hydrolysed by warm aqueous silver nitrate to form a precipitate that is soluble in dilute aqueous ammonia. Compound **Y** can undergo an elimination reaction to form an alkene.

What could be the skeletal formula of compound **Y**?

A 

B 

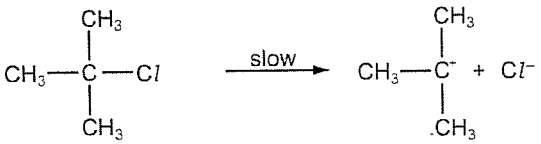
C 

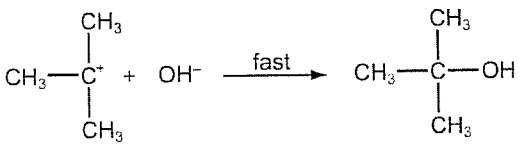
D 

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44. O/N 12/P13/Q30, O/N 08/P1/Q24

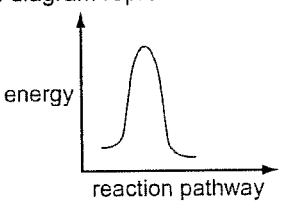
A possible mechanism for the exothermic hydrolysis of 2-chloro-2-methylpropane is shown.



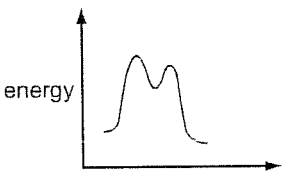


Which diagram represents the reaction pathway diagram for this mechanism?

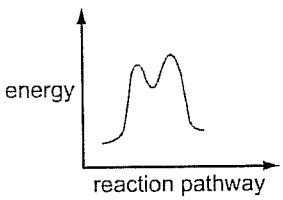
A



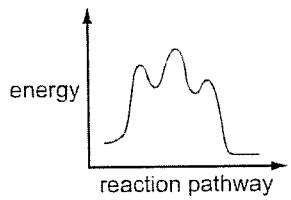
C



B



D



45. M/J 13/P11/Q23

Chloroethane can be used to make sodium propanoate.

chloroethane → Q → sodium propanoate

The intermediate, Q, is hydrolysed with boiling aqueous sodium hydroxide, to give sodium propanoate.
Which reagent would produce the intermediate, Q, from chloroethane?

A concentrated ammonia solution
B dilute sulfuric acid
C hydrogen cyanide
D potassium cyanide

46. M/J 12/P12/Q22

When 1-bromopropane is treated in succession with two reagents, X and Y, it produces propanoic acid.
What are reagents X and Y?

	X	Y
A	NaOH(aq)	$H^+ / Cr_2O_7^{2-}$(aq)
B	NaOH(aq)	CO_2
C	KCN in ethanol	HCl(aq)
D	KCN in ethanol	NaOH(aq)

47. M/J 12/P11/Q29, M/J 12/P13/Q27

The depletion of the ozone layer in the upper atmosphere reduces the Earth's natural protection from harmful ultraviolet radiation.
Which compound would cause the most depletion of the ozone layer?

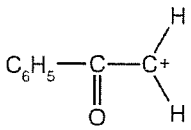
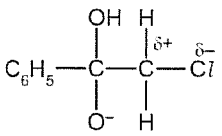
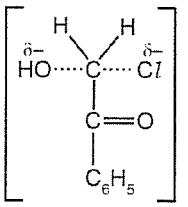
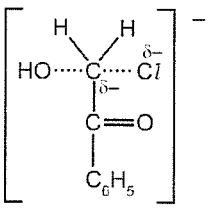
A CCl_3F **B** CF_4 **C** $CHCl F_2$ **D** CH_2F_2

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48. M/J 12/P12/Q25

When phenacyl chloride, $C_6H_5COCH_2Cl$, is reacted with aqueous NaOH, the substitution reaction follows an S_N2 mechanism.

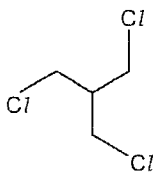
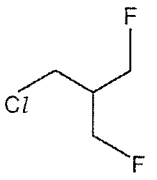
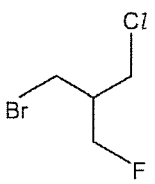
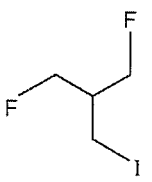
Which structure represents a species formed during the reaction?

A  **B**  **C**  **D** 

49. M/J 12/P13/Q28, M/J 12/P11/Q27

The presence of halogen in an organic compound may be detected by warming the organic compound with aqueous silver nitrate.

Which compound would produce a precipitate quickest?

A  **B**  **C**  **D** 

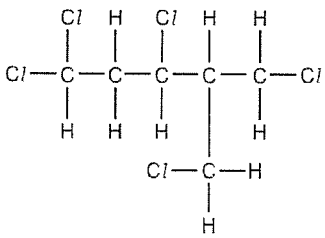
50. O/N 11/P12/Q25

What is involved in the mechanism of the reaction between aqueous sodium hydroxide and 2-bromo-2-methylbutane?

A heterolytic bond fission, attack by an electrophile on a carbanion
B heterolytic bond fission, attack by a nucleophile on a carbocation
C homolytic bond fission, attack by an electrophile on a carbanion
D homolytic bond fission, attack by an electrophile on a carbocation

51. O/N 11/P12/Q27

The molecule shown is optically active.



How many chiral carbon atoms are present in this molecule?

A 1 **B** 2 **C** 3 **D** 4

52. O/N 11/P11/Q24, O/N 11/P13/Q22

What is involved in the mechanism of the reaction between aqueous sodium hydroxide and 1-bromobutane?

A attack by a nucleophile on a carbon atom with a partial positive charge
B heterolytic bond fission and attack by a nucleophile on a carbocation
C homolytic bond fission and attack by an electrophile on a carbanion
D homolytic bond fission and attack by a nucleophile on a carbocation

53. M/J 11/P12/Q27, O/N 03/P1/Q25

1,1-dichloropropane reacts with aqueous sodium hydroxide in a series of steps to give propanal.

$$CH_3CH_2CHCl_2 \xrightarrow{NaOH(aq)} CH_3CH_2CHO$$

Which term describes the first step of this reaction?

A electrophilic addition **C** nucleophilic substitution
B elimination **D** oxidation

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54. O/N 10/P12/Q21

Nine compounds have molecular formula $C_4H_8Br_2$.

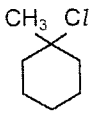
Which compound may be synthesised from an alkene by an addition reaction?

A 1,1-dibromobutane **C** 1,3-dibromobutane

B 1,2-dibromobutane **D** 1,3-dibromomethylpropane

55. O/N 10/P11/Q28, O/N 10/P13/Q28

Which compound undergoes an S_N1 substitution reaction?

A $CH_3CH_2CH_2Br$ **B** $(CH_3)_3CCH_2I$ **C**  **D** $CH_2 = CHCl$

56. M/J 10/P12/Q26, M/J 10/P13/Q29, M/J 10/P11/Q28

When an isomer Y of molecular formula C_4H_9Br undergoes hydrolysis in aqueous alkali to form an alcohol C_4H_9OH, the rate of reaction is found to be unaffected by changes in the concentration of OH^- ions present.

Which is the most likely molecular structure of Y?

A $CH_3CH_2CH_2CH_2Br$ **B** $CH_3CH_2CHBrCH_3$ **C** $(CH_3)_2CHCH_2Br$ **D** $(CH_3)_3CBr$

57. M/J 09/P1/Q23, M/J 02/P1/Q22

Polymerisation of chloroethene gives PVC.

How does the carbon-carbon bond in PVC compare with that in chloroethene?

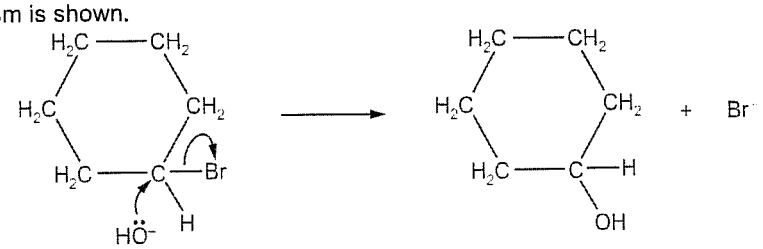
A longer and stronger **C** shorter and stronger

B longer and weaker **D** shorter and weaker

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58. M/J 20/P12/Q40

A reaction mechanism is shown.



Which statements about this reaction are correct?

1 Heterolytic bond fission occurs.
2 It is a substitution reaction.
3 OH^- behaves as an electrophile.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

59. MAR 20/P12/Q39

Which statements apply to tetrafluoromethane?

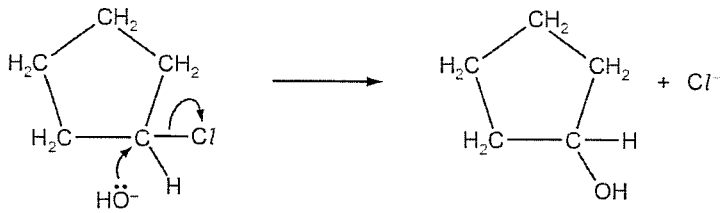
1 It is rapidly decomposed by ultraviolet radiation.
2 It is less harmful to the ozone layer than dichlorodifluoromethane.
3 It is a non-polar molecule.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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60. M/J 20/P13/Q38

A reaction mechanism is shown.



Which statements about this reaction are correct?

1 It is a substitution reaction.
2 OH^- behaves as a nucleophile.
3 Heterolytic bond fission is involved.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

61. O/N 19/P12/Q37

Following fractional distillation of crude oil, which processes can be used to produce propene from larger hydrocarbon molecules?

1 cracking
2 reduction
3 polymerisation

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

62. O/N 19/P12/Q38

Bromoethane undergoes nucleophilic substitution reactions.
Which statements are correct?

1 Bromoethane reacts with aqueous NaOH to make ethanol.
2 Bromoethane reacts with ethanolic NH_3 to make ethylamine.
3 Bromoethane reacts with ethanolic KCN to make ethanenitrile.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

63. M/J 19/P12/Q38

Halogenoalkanes can be hydrolysed using aqueous sodium hydroxide.
Which compounds tend to be hydrolysed by an S_N1 mechanism?

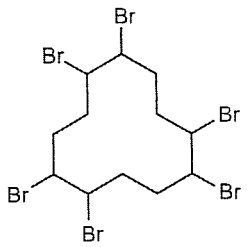
1 $CH_3CH_2CCl(CH_3)CH_2CH_3$
2 $CH_3CH_2CBr(CH_3)CH_2CH_3$
3 $CH_3CH_2CH(CH_3)CH_2CH_2Br$

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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64. M/J 19/P12/Q37, M/J 16/P12/Q37

The diagram shows a compound used as a flame retardant.



Which statements about this structure are correct?

1 The empirical formula is C_2H_3Br.
2 The C_{12} ring is not planar.
3 There are six chiral carbon atoms.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

65. O/N 18/P12/Q38

Halogenoalkanes can undergo reaction with hydroxide ions.

$$RBr + OH^- \rightarrow ROH + Br^-$$

The reaction of some halogenoalkanes proceeds by the S_N1 mechanism.

Which statements about the SN1 mechanism are correct?

1 A carbocation is formed which is stabilised by the inductive effect of the alkyl groups present.
2 Only tertiary halogenoalkanes are hydrolysed in this way.
3 The intermediate formed includes a carbon atom with five bonds attached to it.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

66. O/N 18/P11/Q38, O/N 18/P13/Q38

The halogenoalkanes listed below all react with NaOH(aq).

Which reactions proceed mainly by an S_N1 mechanism?

1 1-iodopropane
2 2-iodo-2-methylpropane
3 2-bromo-2-methylbutane

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

67. M/J 18/P13/Q38

Compound Y is a straight chain molecule with formula $C_nH_{2n+1}X$. X is a halogen. The M_r of Y is 137. The halogen atom is on the second carbon atom in the chain.

Which statements are correct?

1 Y contains a chiral centre.
2 Y can eliminate HX to form two structurally isomeric alkenes.
3 Y can eliminate HX to form two geometrically isomeric alkenes.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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68. MAR 18/P12/Q38, O/N 13/P12/Q37, O/N 13/P11/Q37

The organic compound X gives a precipitate when warmed with aqueous silver nitrate. This precipitate dissolves when concentrated aqueous ammonia is added.

What is a possible identity for X?

1 1-bromopropane
2 2-chlorobutane
3 2-iodo,2-methylpropane

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

69. O/N 17/P12/Q38

Bromoethane is heated under reflux with concentrated aqueous NaOH.

Which statements are correct?

1 The major product is a primary alcohol.
2 The major reaction is hydrolysis by an S_N2 mechanism.
3 The major product would be the same if the NaOH is dissolved in ethanol.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

70. M/J 17/P11/Q38

The following statements are about the reaction of NaOH(aq) with the three chloroalkanes shown.

$CH_3CH_2CHCl CH_3$ $(CH_3)_2CHCH_2Cl$ $(CH_3)_3CCl$

Which statements are correct?

1 $(CH_3)_2CHCH_2Cl$ reacts with NaOH(aq) by an S_N2 mechanism.
2 The tertiary chloroalkane reacts more quickly than the others because the carbon atom bonded to the Cl atom is more positive in this molecule.
3 The Cl atoms in the three chloroalkanes are attacked by OH^-.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

71. M/J 17/P13/Q38

Which compounds, on heating with ethanolic NaOH, produce more than one product with molecular formula C_4H_8?

1 2-bromobutane
2 2-bromo-2-methylpropane
3 1-bromo-2-methylpropane

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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72. M/J 16/P11/Q36

Which types of reaction can occur with 1-bromobutane?

1 elimination
2 hydrolysis
3 free radical substitution

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

73. M/J 15/P12/Q36

Halogenated hydrocarbons have many uses.
What have halogenated hydrocarbons been used for?

1 solvents
2 refrigerants
3 monomers in polymer manufacture

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

74. M/J 13/P12/Q37, O/N 06/P1/Q38

Which are properties of fluoroalkanes?

1 They are less reactive than the corresponding chloroalkanes.
2 They are non-flammable.
3 The C–F bond is stronger than the C–Cl bond.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

75. O/N 12/P12/Q37, O/N 12/P11/Q37

Which reagents and conditions will convert propane into 1-chloropropane?

1 Cl_2 and sunlight
2 conc. HCl, reflux
3 PCl_5

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

76. M/J 11/P11/Q39, M/J 11/P13/Q40

Bromoethane undergoes all of the conversions shown.
Which conversions are examples of nucleophilic substitution?

1 $C_2H_5Br \rightarrow C_2H_5CN$
2 $C_2H_5Br \rightarrow C_2H_5OH$
3 $C_2H_5Br \rightarrow C_2H_5NH_2$

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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77. O/N 12/P12/Q38, O/N 12/P13/Q37, M/J 03/P1/Q38, O/N 12/P11/Q38

Chloroethane can be formed from bromoethane in two steps.

$$C_2H_5Br \xrightarrow{\text{step X}} C_2H_5OH \xrightarrow{\text{step Y}} C_2H_5Cl$$

Which statements about these steps are correct?

1 Step **X** involves nucleophilic substitution.
2 Hot aqueous sodium hydroxide is the reagent in step **X**.
3 Hot aqueous sodium chloride is the reagent in step **Y**.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

78. O/N 10/P11/Q40, O/N 10/P13/Q39

Textiles for use in aircraft are treated with a finish containing a halogenoalkane.
What is the reason for this?

1 The textile burns less easily, improving safety.
2 The fabric forms hydrogen bonds to water more readily, making the fabric easier to wash.
3 The halogenoalkane undergoes addition polymerisation, stiffening the fabric.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

79. M/J 10/P12/Q37, M/J 10/P11/Q39, M/J 10/P13/Q38

Which reactions are examples of nucleophilic substitution?

1 $CH_3CH_2Br + OH^- \rightarrow CH_3CH_2OH + Br^-$
2 $CH_3I + H_2O \xrightarrow{H^+} CH_3OH + HI$
3 $CH_3CH_2CH_2Cl + NH_3 \rightarrow CH_3CH_2CH_2NH_2 + HCl$

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

80. O/N 09/P12/Q36, O/N 09/P11/Q37

Which statements are true for an S_N2 reaction?

1 One bond is broken as another bond is formed.
2 The formation of a transition state involves the collision of two molecules or ions.
3 A carbon atom in the transition state is bonded, either fully or partially, to five other atoms.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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15.2: Relative strength of the C-Hal bond

1. **M/J 19/P11/Q23**
   Which reaction is most likely to involve the formation of a positively charged intermediate?
   A 1-bromopentane and warm dilute NaOH(aq)
   B 1-bromo-2,2-dimethylpropane and warm dilute NaOH(aq)
   C 1-bromo-3-methylbutane and warm dilute NaOH(aq)
   D 2-bromo-2-methylbutane and warm dilute NaOH(aq)

2. **O/N 16/P12/Q22**
   The reaction $CH_3CH_2CH_2CH_2Br + OH^- \rightarrow CH_3CH_2CH_2CH_2OH + Br^-$ proceeds via an S_N2 mechanism.
   The reaction $(CH_3)_3CBr + OH^- \rightarrow (CH_3)_3COH + Br^-$ proceeds via an S_N1 mechanism.
   Which statement about these two reactions is correct?
   A Both reactions involve homolytic bond fission.
   B Both reactions involve hydroxide ions acting as electron pair donors.
   C Both reactions involve the formation of a positively-charged intermediate.
   D Both reactions occur in a single step.

3. **M/J 16/P13/Q28, M/J 11/P12/Q22**
   Which reaction will give 2-chloropropane in the best yield?
   A propane gas with chlorine gas in the presence of ultraviolet light
   B propan-2-ol with dilute NaCl(aq)
   C propan-2-ol with $SOCl_2(l)$
   D propene with dilute HCl(aq)

4. **O/N 15/P12/Q24**
   The depletion of the ozone layer in the upper atmosphere reduces the Earth's natural protection from harmful ultraviolet radiation.
   Which compound would cause the most depletion of the ozone layer?
   A CCl_3F **B** CF_4 **C** CO_2 **D** SO_2

5. **M/J 14/P11/Q23**
   The hydrolysis of 1-chloropropane to produce propan-1-ol is much slower than the corresponding hydrolysis of 1-iodopropane.
   Which statement explains this observation?
   A Chlorine is more electronegative than iodine.
   B The bond strength of the C – I bond is less than that of the C – Cl bond.
   C The carbon atom in the C – Cl bond is more $\delta+$ than that in the C – I bond.
   D The hydrolysis involves a nucleophilic addition reaction.

6. **O/N 12/P11/Q29, O/N 12/P12/Q29**
   Many, but not all, organic reactions need to be heated before reaction occurs.
   Which reaction occurs at a good rate at **room** temperature (20°C)?
   A $CH_3OH + PCl_5 \rightarrow CH_3Cl + POCl_3 + HCl$
   B $CH_3CH_2Br + KCN \rightarrow CH_3CH_2CN + KBr$
   C $CH_3CH_2OH \rightarrow C_2H_4 + H_2O$
   D $CH_3CH_2CN + 2H_2O \rightarrow CH_3CH_2CO_2H + NH_3$

7. **O/N 11/P11/Q21, O/N 11/P13/Q24**
   Many different compounds have been used in aerosol sprays, refrigerators and in making foamed plastics.
   Which compound will cause the **most** ozone depletion?
   A CCl_3F **B** CH_2FCHCl/F **C** $CH_3CH_2CH_2CH_3$ **D** N_2O

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8. M/J 11/P13/Q19, O/N 07/P1/Q26, M/J 11/P11/Q21

Butanedioic acid occurs in amber, algae, lichens, sugar cane and beets. It may be synthesised in two steps from 1,2-dibromoethane.

$$BrCH_2CH_2Br \xrightarrow{\text{step 1}} X \xrightarrow{\text{step 2}} HO_2CCH_2CH_2CO_2H$$

Which reagents could be used for this synthesis?

	step 1	step 2
A	HCN(g)	HCl(aq)
B	HCO_2Na(aq)	HCl(aq)
C	KCN(aq/alcoholic)	H_2SO_4(aq)
D	NaOH(aq)	$K_2Cr_2O_7/H_2SO_4$(aq)

9. O/N 08/P1/Q26

Ethyl phenylethanoate, $C_6H_5CH_2CO_2C_2H_5$, gives a characteristic flowery aroma to honey. Which sequence of reagents, with heating in each case, leads to the preparation of $C_6H_5CH_2CO_2C_2H_5$ from $C_6H_5CH_2Br$?

A $C_6H_5CH_2Br \xrightarrow{NaOH(aq)} \xrightarrow{C_2H_5COCl}$

B $C_6H_5CH_2Br \xrightarrow{NaOH(aq)} \xrightarrow{C_2H_5CO_2H,\ conc.\ H_2SO_4}$

C $C_6H_5CH_2Br \xrightarrow{NaCN(alcoholic)} \xrightarrow{H^+(aq)} \xrightarrow{C_2H_5OH,\ conc.\ H_2SO_4}$

D $C_6H_5CH_2Br \xrightarrow{NaOH(aq)} \xrightarrow{conc.\ MnO_4^-,\ H^+(aq)} \xrightarrow{C_2H_5OH,\ conc.\ H_2SO_4}$

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10. M/J 20/P11/Q39

Chlorofluoroalkanes that diffuse into the stratosphere are broken down by ultraviolet radiation.
Radicals are generated that cause depletion of ozone.
What are these radicals?

1 chlorine radicals
2 fluorine radicals
3 alkyl radicals

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

11. M/J 18/P11/Q39

Chlorofluoroalkanes have been used as the refrigerant in refrigerators but care has to be taken in disposing of old refrigerators.
Which statements about chlorofluoroalkanes are correct?

1 C–Cl bonds more readily undergo homolytic fission than C–F bonds.
2 Care is taken in the disposal of old refrigerators because of possible ozone depletion.
3 C_2H_4ClF is more volatile than C_2H_6.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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12. O/N 14/P12/Q38, O/N 14/P11/Q38

X is an organic compound that gives a precipitate with aqueous silver nitrate. This precipitate remains undissolved when concentrated aqueous ammonia is added.

What is a possible identity for **X**?

1 iodomethane
2 2-bromobutane
3 2-chlorobutane

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

13. O/N 08/P1/Q38

Which of the following would be suitable for use in a fire extinguisher?

1 $CBrF_3$
2 $CH_3(CH_2)_5CH_2Br$
3 HCl

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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15.3: Multiple Topics

1. M/J 20/P12/Q28, M/J 04/P1/Q27

Ethene reacts with aqueous bromine to give two products, CH_2BrCH_2Br and CH_2BrCH_2OH.
Which statement is correct for these products?

A Both products are obtained in this reaction by electrophilic substitution.
B Both products are obtained in this reaction by nucleophilic addition.
C Both products can be hydrolysed to form the same diol.
D Both products can form hydrogen bonds with water.

2. M/J 20/P11/Q30

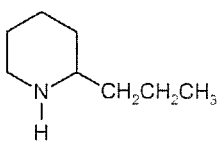
Which reaction produces an organic anion with a good yield?

A heating ethanenitrile under reflux with dilute sodium hydroxide
B heating ethanenitrile under reflux with dilute sulfuric acid
C heating ethane with sodium metal
D heating ethanol under reflux with dilute sodium hydroxide

3. M/J 19/P11/Q25

The structure of coniine is shown.

coniine



Coniine can be synthesised by reacting ammonia with a dibromo compound, X.

$$NH_3 + \underset{X}{C_8H_{16}Br_2} \rightarrow \text{coniine} + 2HBr$$

What is the name of compound X?

A 1,1-dibromo-2-propylcyclopentane
B 1,2-dibromo-2-propylcyclopentane
C 1,4-dibromooctane
D 1,5-dibromooctane

4. O/N 18/P11/Q20, O/N 18/P13/Q20, M/J 13/P13/Q21

What is true of every nucleophile?

A It attacks a double bond.
B It has a lone pair of electrons.
C It is a single atom.
D It is negatively charged.

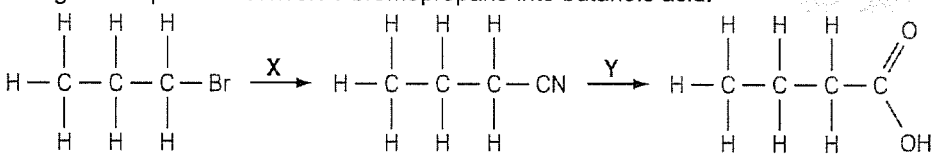
5. O/N 17/P11/Q24, O/N 17/P13/Q24

Which organic reaction is an example of nucleophilic substitution?

A $CH_3CH_2Br + NaOH \rightarrow CH_2CH_2 + H_2O + NaBr$
B $CH_3CH_2Br + NaOH \rightarrow CH_3CH_2OH + NaBr$
C $CH_2CH_2 + HCl \rightarrow C_2H_5Cl$
D $C_2H_6 + Cl \rightarrow C_2H_5Cl + HCl$

6. M/J 17/P11/Q26, M/J 07/P1/Q25

X and **Y** are the reagents required to convert 1-bromopropane into butanoic acid.



What are the correct identities of **X** and **Y**?

	X	Y
A	NH_3	HCl(aq)
B	KCN in C_2H_5OH	NaOH(aq)
C	KCN in C_2H_5OH	HCl(aq)
D	HCN	NaOH(aq)

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7. O/N 16/P11/Q24, O/N 16/P13/Q24

Chloroethane can be used to make sodium propanoate.

chloroethane → Q → sodium propanoate

The intermediate, Q, is hydrolysed with boiling aqueous sodium hydroxide to give sodium propanoate.

Which reagent would produce the intermediate, Q, from chloroethane?

A concentrated ammonia solution
B dilute sulfuric acid
C hydrogen cyanide in water
D potassium cyanide in ethanol

8. MAR 16/P12/Q25

Structural isomerism and stereoisomerism should be considered in answering this question.

Compound J is reacted with KOH dissolved in ethanol. Three isomeric alkenes with molecular formula C_4H_8 are formed.

What is J?

A $CH_3—CH_2—CH_2—CH_2—Br$

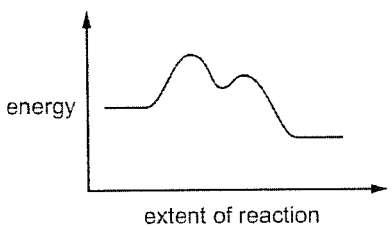
B $CH_3—CH(Br)—CH_2—CH_3$

C $CH_3—CH(CH_3)—CH_2—Br$

D $CH_3—C(CH_3)(CH_3)—Br$

9. M/J 16/P13/Q25

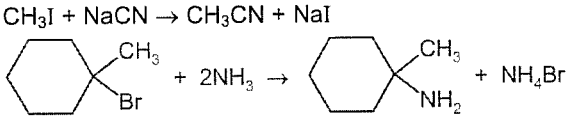
A reaction pathway diagram is shown.

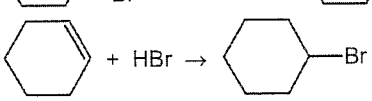


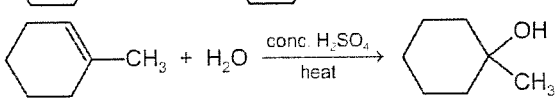
The four reactions that follow are all exothermic.

Which reaction would not have such a pathway?

A $CH_3I + NaCN \rightarrow CH_3CN + NaI$

B 

C 

D 

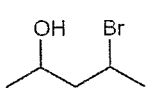
10. O/N 15/P11/Q25, O/N 15/P13/Q25

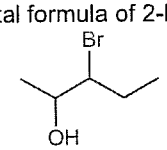
If the starting material is iodoethane, which sequence of reactions will produce propanoic acid as the main final product in good yield?

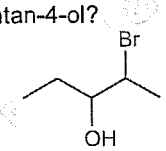
A add NaOH(aq), isolate the organic product, add acidified $K_2Cr_2O_7$ and boil under reflux
B add NaOH(aq), isolate the organic product, add H_2SO_4(aq) and boil under reflux
C heat with HCN in ethanol, isolate the organic product, add H_2SO_4(aq) and boil under reflux
D heat with KCN in ethanol, isolate the organic product, add H_2SO_4(aq) and boil under reflux

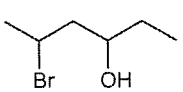
11. O/N 13/P13/Q20

Which diagram gives the skeletal formula of 2-bromopentan-4-ol?

A 

B 

C 

D 

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12. O/N 13/P13/Q25

Chlorofluorocarbons, CFCs, can be used as refrigerants, aerosol propellants and fire extinguishers.
CFCs such as CCl_3F and CCl_2F_2 are more stable than chloroalkanes such as CCl_4.
What is the reason for their greater stability?

A Fluorine has a higher first ionisation energy than chlorine.
B Fluorine radicals are more stable than chlorine radicals.
C The C–F bond energy is larger than the C–Cl bond energy.
D The C–F bond is more polar than the C–Cl bond.

13. O/N 13/P13/Q26

Halogenoalkanes react with aqueous NaOH to give alcohols. The mechanism involved is either S_N1 or S_N2.
Which halogenoalkane produces the highest percentage of product by an S_N1 mechanism, when treated with aqueous NaOH?

A 2-bromopropane
B 2-chloropropane
C 1-iodo-2-methylpropane
D 2-iodo-2-methylpropane

14. M/J 11/P12/Q21

Which halogenoalkane will undergo an S_N1 reaction and produce a yellow precipitate when $AgNO_3(aq)$ is added to it?

A 1-chlorobutane
B 1-iodobutane
C 2-chloro-2-methylpropane
D 2-iodo-2-methylpropane

15. O/N 08/P1/Q15, M/J 03/P1/Q14

Aluminium chloride catalyses certain reactions by forming carbocations (carbonium ions) with chloroalkanes as shown.

$$RCl + AlCl_3 \rightarrow R^+ + AlCl_4^-$$

Which property makes this reaction possible?

A $AlCl_3$ exists as the dimer Al_2Cl_6 in the vapour.
B $AlCl_3$ is a covalent molecule.
C The aluminium atom in $AlCl_3$ has an incomplete octet of electrons.
D The chlorine atom in RCl has a vacant p orbital.

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16. O/N 17/P12/Q37

Which statements are correct for an S_N2 mechanism?

1 One bond is being broken at the same time as another bond is being formed.
2 The formation of the intermediate involves the collision of two molecules or ions.
3 A carbon atom in the transition state is bonded, either fully or partially, to five atoms.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

17. M/J 16/P13/Q37

Halogenoalkanes show trends in their physical and chemical properties.
Which properties steadily increase from C_2H_5Cl to C_2H_5Br to C_2H_5I?

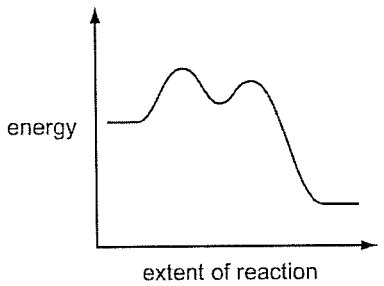
1 the polarity of the carbon-halogen bond
2 the boiling point of the halogenoalkane
3 the rate of reaction of the halogenoalkane with nucleophiles

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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18. O/N 17/P11/Q38, O/N 17/P13/Q38, O/N 14/P12/Q40, O/N 14/P11/Q40

A reaction pathway diagram is shown.



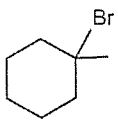
Which reactions would have this profile?

1 $(CH_3)_3CBr + NaOH \rightarrow (CH_3)_3COH + NaBr$
2 $CH_3CH_2Br + NaOH \rightarrow CH_3CH_2OH + NaBr$
3 $(CH_3)_3CCH_2CH_2Cl + 2NH_3 \rightarrow (CH_3)_3CCH_2CH_2NH_2 + NH_4Cl$

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

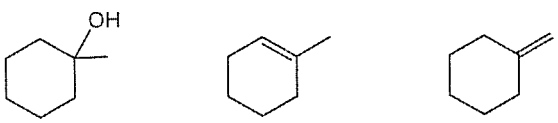
19. M/J 15/P11/Q39

Which compounds will react with HBr to give the compound R?



R

1 2 3



A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

20. M/J 15/P13/Q40

Which types of reaction are undergone by $CH_2BrCHCH_2$?

1 hydrolysis
2 free radical substitution
3 nucleophilic addition

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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21. O/N 14/P13/Q38

Which compounds produce pent-2-ene as either one of the products, or as the only product, on heating with potassium hydroxide in ethanol?

1 $CH_3CH_2CH_2CH_2CH_2Br$
2 $CH_3CHBrCH_2CH_2CH_3$
3 $CH_3CH_2CHBrCH_2CH_3$

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

22. M/J 13/P13/Q38

Fabrics for use in aircraft seating are treated with a coating containing a halogenoalkane.
Why is this coating used?

1 The treated fabric burns less easily, improving safety.
2 The treated fabric forms hydrogen bonds to water more readily, so it is easier to wash.
3 The halogenoalkane undergoes addition polymerisation, stiffening the fabric.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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Answers Sections

15.1				15.2		15.3	
1.	B	41.	D	1.	D	1.	C
2.	A	42.	B	2.	B	2.	A
3.	B	43.	C	3.	C	3.	D
4.	B	44.	C	4.	A	4.	B
5.	B	45.	D	5.	B	5.	B
6.	A	46.	A	6.	A	6.	C
7.	C	47.	A	7.	A	7.	D
8.	D	48.	C	8.	C	8.	B
9.	B	49.	D	9.	C	9.	A
10.	D	50.	B	10.	D	10.	D
11.	C	51.	A	11.	B	11.	A
12.	C	52.	A	12.	D	12.	C
13.	B	53.	C	13.	D	13.	D
14.	C	54.	B			14.	D
15.	D	55.	C			15.	C
16.	B	56.	D			16.	A
17.	D	57.	B			17.	C
18.	A	58.	B			18.	D
19.	D	59.	C			19.	A
20.	C	60.	A			20.	B
21.	D	61.	D			21.	C
22.	B	62.	B			22.	D
23.	A	63.	B				
24	D	64.	A				
25.	A	65.	D				
26.	B	66.	C				
27.	A	67.	A				
28.	C	68.	B				
29.	B	69.	B				
30.	B	70.	D				
31.	C	71.	D				
32.	C	72.	A				
33.	D	73.	A				
34.	D	74.	A				
35.	D	75.	D				
36.	D	76.	A				
37.	D	77.	B				
38.	C	78.	D				
39.	C	79.	A				
40.	A	80.	A				

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Unit 16

HYDROXY COMPOUNDS

A Level
Chemistry Paper 1
Classified/Topical MCQ's
Article Number: 231

Editorial Board

Syllabus

16.1 Alcohols
16.2 Multiple topics

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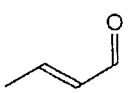
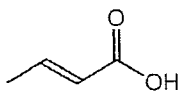
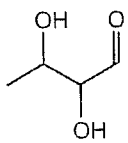
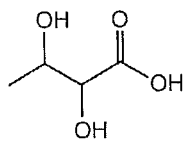
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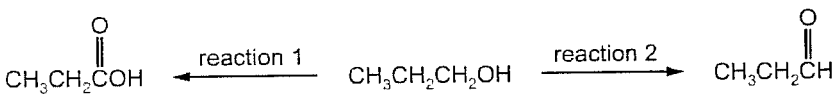
Unit 16: Hydroxy compounds

16.1: Alcohols

1. **M/J 20/P12/Q24**
Which reagent could be used to distinguish between propane-1,2-diol and ethane-1,2-diol?
A alkaline aqueous iodine
B aqueous acidified dichromate(VI)
C ethanol and a few drops of concentrated sulfuric acid
D sodium metal

2. **M/J 20/P11/Q25**
An alcohol has the molecular formula $C_5H_{12}O$. It has several isomers.
Which isomer forms a yellow precipitate with alkaline aqueous iodine?
A 2,2-dimethylpropan-1-ol
B 2-methylbutan-2-ol
C 3-methylbutan-2-ol
D pentan-3-ol

3. **MAR 20/P12/Q29**
What is the skeletal formula of the compound formed when $CH_3CH{=}CHCH_2OH$ is heated, under reflux, with $K_2Cr_2O_7 / H^+$?
A 
B 
C 
D 

4. **O/N 19/P12/Q24**
Propan-1-ol can be reacted with acidified potassium dichromate(VI) to form propanoic acid, reaction 1, or propanal, reaction 2.


How can the reaction be carried out to ensure that reaction 2 occurs rather than reaction 1?
A An excess of acidified potassium dichromate(VI) is used.
B An excess of concentrated sulfuric acid is added.
C The reaction mixture is distilled immediately after mixing.
D The reaction mixture is heated under reflux.

5. **O/N 19/P12/Q25**
What is the smallest amount of oxygen molecules needed for the complete combustion of 40.0 g of methanol?
A 1.88 moles **B** 2.50 moles **C** 3.75 moles **D** 5.00 moles

6. **M/J 19/P12/Q24**
Alcohol W **cannot** be made by reducing a carboxylic acid with LiAlH4. Alcohol W gives only one product when dehydrated with concentrated sulfuric acid.
What could be the identity of W?
A butan-1-ol **B** butan-2-ol **C** propan-1-ol **D** propan-2-ol

7. **M/J 19/P11/Q27**
An organic compound T undergoes the following reactions.
- T is oxidised by hot, acidified potassium manganate(VII).
- T reacts with sodium to give hydrogen.

What could be compound T?
A $CH_3CH_2CH(OH)CH_3$
B $CH_3CH_2CH_2CHO$
C $(CH_3)_3COH$
D $CH_3CH_2COCH_3$

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8. MAR 19/P12/Q25

Which product is formed when 3-methylpentane-1,3,4-triol is heated under reflux with an excess of acidified potassium dichromate(VI)?

A $HO_2CCH_2C(CH_3)(OH)COCH_3$

B $HO_2CCH_2COC(OH)(CH_3)_2$

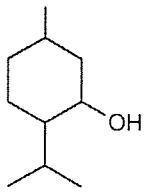
C $OHCCH_2C(CH_3)(OH)COCH_3$

D $HO_2CCH_2CO(CH_3)COCH_3$

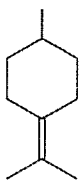
9. MAR 19/P12/Q26, M/J 13/P12/Q25

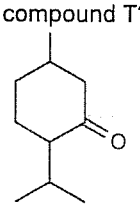
Menthol is a naturally occurring alcohol.

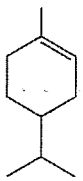
menthol

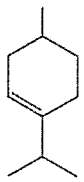


When menthol is heated with concentrated sulfuric acid it reacts. The products formed include compound T.
What could be the structure of compound T?

A


B


C


D


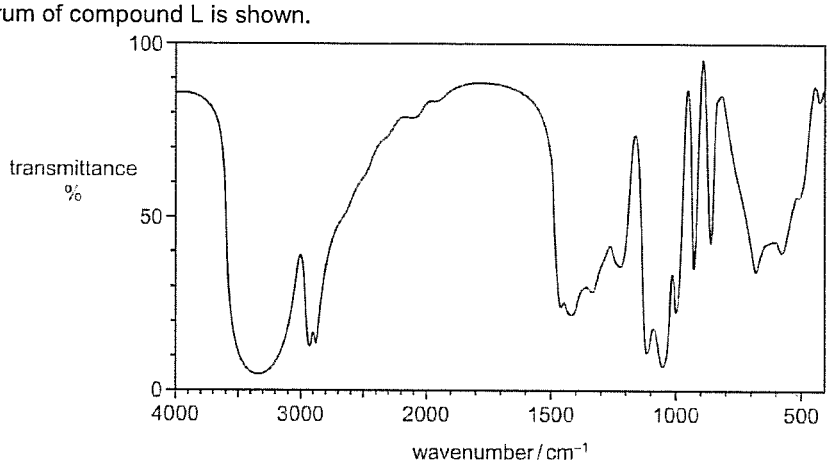
10. O/N 18/P12/Q26

The reactions of four organic compounds are given in the table.
Which compound could be propan-2-ol?

	reagent / observations	
	when oxidised with $Cr_2O_7^{2-}/H^+$, gives an organic product with a boiling point greater than the original compound	when added to ethanoic acid, and a few drops of conc. H_2SO_4, gives a sweet-smelling compound
A	no	no
B	no	yes
C	yes	no
D	yes	yes

11. O/N 18/P12/Q30

The infra-red spectrum of compound L is shown.



What could be the structure of L?

A $HOCH_2COCH_2OH$

B $HOCH_2CH(OH)CHO$

C $HOCH_2CH(OH)CH_2OH$

D $HOCH_2CH_2COOH$

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12. O/N 18/P11/Q26, O/N 18/P13/Q26

Sodium reacts with 1 mol of compound Y to produce 1 mol of $H_2(g)$.

Which compound could Y be?

A $CH_3CH_2CH_2CH_2OH$ **B** $(CH_3)_3COH$ **C** $CH_3CH_2CH_2CO_2H$ **D** $CH_3CH(OH)CO_2H$

13. O/N 18/P11/Q27, O/N 18/P13/Q27

Which compound shows optical isomerism and gives a positive test with alkaline aqueous iodine?

A $CH_3COCH(OH)CH_3$

B $CH_3COCH_2CH_2OH$

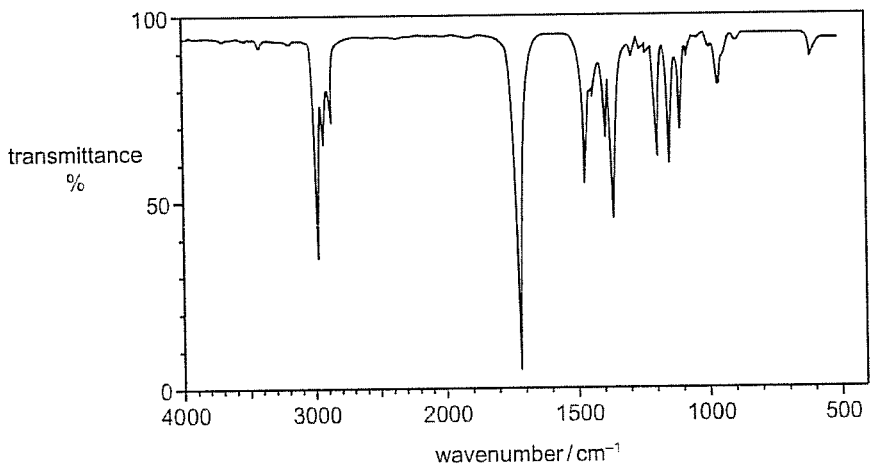
C $HOCH_2CH(CH_3)CHO$

D $(CH_3)_2C(OH)CHO$

14. O/N 18/P11/Q30, O/N 18/P13/Q30

J is a branched-chain alcohol, $C_5H_{12}O$. J is heated under reflux with an excess of $Cr_2O_7^{2-}$ / H^+ until no further reaction occurs. An organic compound K is formed in good yield.

The infra-red spectrum of K is shown.



What are the structures of the branched-chain alcohol J and compound K?

	J	K
A	$CH_3CH(CH_3)CH_2CH_2OH$	$CH_3CH(CH_3)CH_2CHO$
B	$CH_3CH_2CH(OH)CH_2CH_3$	$CH_3CH_2COCH_2CH_3$
C	$CH_3CH(CH_3)CH(OH)CH_3$	$CH_3CH(CH_3)COCH_3$
D	$CH_3CH(CH_3)CH_2CH_2OH$	$CH_3CH(CH_3)CH_2COOH$

15. M/J 18/P12/Q23

Primary halogenoalkanes undergo hydrolysis reactions.

Which reaction would occur most rapidly if they are all warmed to the same temperature?

A C_2H_5Br with H_2O

B C_2H_5Br with NaOH(aq)

C C_2H_5Cl with H_2O

D C_2H_5Cl with NaOH(aq)

16. M/J 18/P12/Q26, M/J 15/P12/Q20

Which alcohol will react with an acidified solution of potassium dichromate(VI) to produce a ketone containing six carbon atoms?

A 2,2-dimethylbutan-1-ol

B 2-methylpentan-3-ol

C 3,3-dimethylpentan-2-ol

D 3-methylpentan-3-ol

17. M/J 18/P11/Q25

Compound Q

- contains a chiral centre,
- gives a positive result with Fehling's reagent,
- gives a positive result with alkaline aqueous iodine.

What could compound Q be?

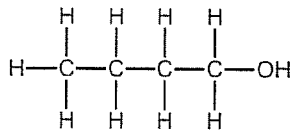
A 1-hydroxybutanone **B** 2-hydroxybutanal **C** 3-hydroxybutanal **D** 3-hydroxybutanone

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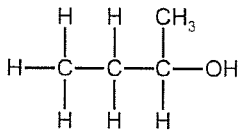
18. M/J 18/P11/Q23

Which alcohol can be dehydrated to give two products which are structural isomers of each other?

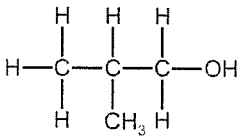
A



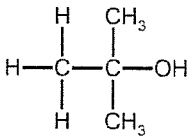
B



C

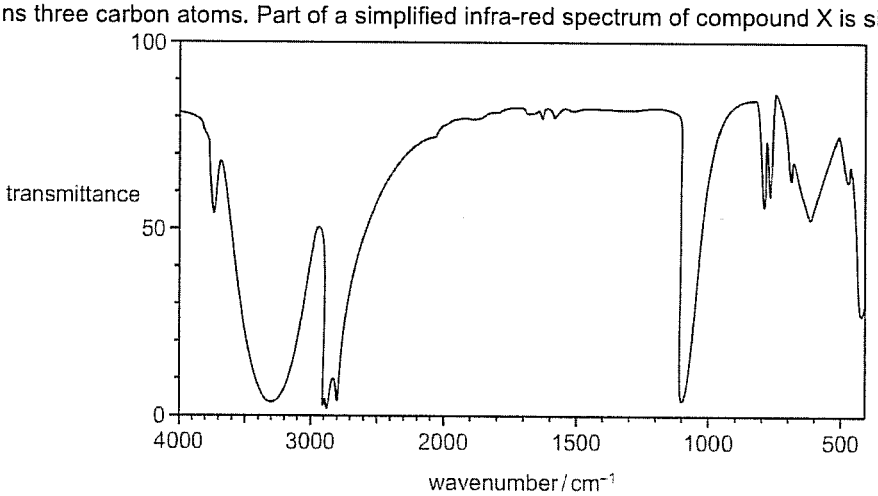


D



19. M/J 18/P11/Q30

Compound X contains three carbon atoms. Part of a simplified infra-red spectrum of compound X is shown.



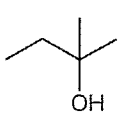
Which compound could be X?

A CH_3CH_2CHO **B** $CH_3CH_2CO_2H$ **C** $CH_3CH_2CH_2OH$ **D** $CH_3CO_2CH_3$

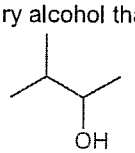
20. M/J 18/P13/Q25

Which compound is a secondary alcohol that can be dehydrated to form an alkene with $M_r = 70$?

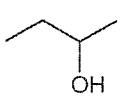
A



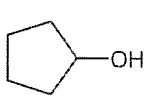
B



C



D



21. M/J 18/P13/Q26

When 0.0075 mol of alcohol X are completely burnt in excess oxygen and the gases produced are passed through an excess of limewater (calcium hydroxide solution), 3.0 g of calcium carbonate are produced.
When X is warmed with acidified potassium dichromate(VI) there is a colour change from orange to green.
What could be the identity of X?

A $CH_3CH(OH)CH_2CH_3$
B $(CH_3)_3COH$
C $CH_3CH_2CH_2OH$
D $CH_3CH(OH)CH_3$

22. M/J 18/P13/Q27, O/N 14/P12/Q23, O/N 14/P11/Q23

Considering only structural isomers, what is the number of alcohols of each type with the formula $C_5H_{12}O$?

	primary	secondary	tertiary
A	3	3	2
B	4	2	2
C	4	3	1
D	5	2	1

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23. MAR 18/P12/Q26, M/J 14/P13/Q22

Compound **X** produces a carboxylic acid when heated under reflux with acidified potassium dichromate(VI). Compound **X** has no reaction with sodium metal.

What could be the identity of compound **X**?

A propanol **B** propanone **C** propan-1-ol **D** propan-2-ol

24. O/N 17/P12/Q26

Many, but not all, organic reactions need to be heated before a reaction occurs.

Which reaction occurs quickly at room temperature (20 °C)?

A $CH_3OH + PCl_5 \rightarrow CH_3Cl + POCl_3 + HCl$

B $CH_3CH_2Br + KCN \rightarrow CH_3CH_2CN + KBr$

C $CH_3CH_2OH \rightarrow C_2H_4 + H_2O$

D $CH_3CH_2CN + 2H_2O \rightarrow CH_3CH_2CO_2H + NH_3$

25. O/N 17/P12/Q27

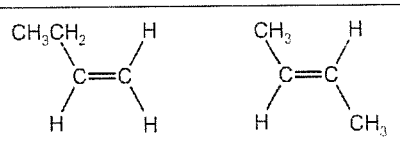
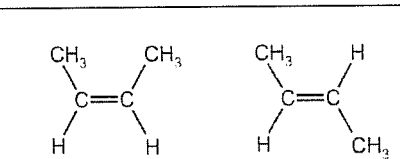
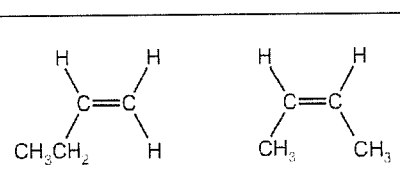
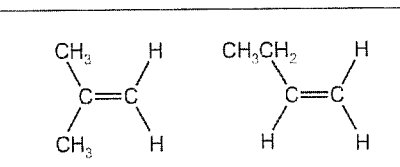
When compound X is warmed with dilute, acidified potassium dichromate(VI) there is no colour change. X does not give an orange precipitate with 2,4-dinitrophenylhydrazine reagent.

What could X be?

A butan-2-ol **B** ethanal **C** methylpropan-2-ol **D** propanone

26. O/N 17/P12/Q28, O/N 13/P12/Q25, O/N 13/P11/Q25

What are the only structures formed when butan-2-ol is heated with concentrated H_2SO_4?

A	
B	
C	
D	

27. M/J 17/P12/Q24

A sample of 2.76 g of ethanol was mixed with an excess of aqueous acidified potassium dichromate(VI). The reaction mixture was then boiled under reflux for one hour. The required organic product was then collected by distillation.

The yield of product was 75.0%.

Which mass of product was collected?

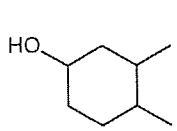
A 1.26 g **B** 1.98 g **C** 2.07 g **D** 2.70 g

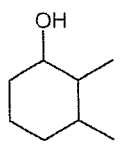
28. M/J 17/P12/Q25

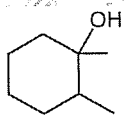
Compound X is a single, pure, optical isomer. X is heated with an excess of concentrated H_2SO_4.

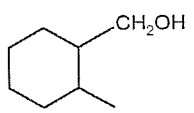
Only one organic product is formed.

What could X be?

A 

B 

C 

D 

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29. M/J 17/P11/Q27

Q is a compound with the molecular formula $C_4H_{10}O$. Q can be oxidised with acidified potassium dichromate (VI). **Q cannot** be made by reducing a carboxylic acid with $LiAlH_4$.
What is the structure of Q?

A $CH_3CH(OH)CH_2CH_3$
B $CH_3CH_2CH_2CH_2OH$
C $(CH_3)_3COH$
D $(CH_3)_2CHCH_2OH$

30. M/J 17/P13/Q26

Which statement about butan-1-ol, butan-2-ol, and 2-methylbutan-2-ol is **not** correct?

A They all react with methanoic acid to form an ester.
B They all react with sodium.
C They can all be dehydrated to form an alkene.
D They can all be oxidised to a carbonyl compound.

31. MAR 17/P12/Q26

Propan-2-ol undergoes many reactions.
Which row is correct?

	reagent added to propan-2-ol	product
A	acidified $KMnO_4$	CH_3CH_2CHO
B	Cl_2	$CH_3CHClCH_3$
C	conc. H_2SO_4	CH_3CHCH_2
D	methanoic acid	$HCO_2CH_2CH_2CH_3$

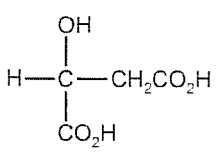
32. O/N 16/P13/Q25, O/N 16/P11/Q25

X, Y and Z are three isomeric alcohols.
X $CH_3CH_2CH_2CH_2CH_2OH$
Y $CH_3CH_2CH(OH)CH_2CH_3$
Z $(CH_3)_2C(OH)CH_2CH_3$
Two or more of these alcohols react with mild oxidising agents.
One of these alcohols, when dehydrated, will give a pair of cis-trans isomers with molecular formula C_5H_{10}.
Which row is correct?

	reacts with mild oxidising reagents	gives cis-trans isomers
A	X, Y and Z	Y only
B	X, Y and Z	Z only
C	X and Y only	Y only
D	X and Y only	Z only

33. M/J 16/P11/Q26

Malic acid is found in apples.



malic acid

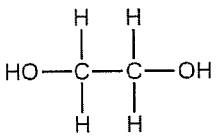
Which reagent will react with all three –OH groups present in the malic acid molecule?

A ethanol in the presence of concentrated sulfuric acid
B potassium hydroxide
C sodium
D sodium carbonate

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34. O/N 16/P13/Q30, O/N 16/P11/Q30

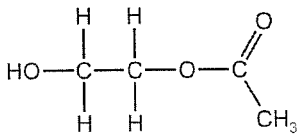
A solvent, **X**, used in printing inks has a molecular formula $C_6H_{10}O_4$. It may be made by reacting ethane-1,2-diol with ethanoic acid in the presence of an acid catalyst.



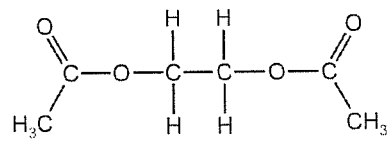
ethane-1,2-diol

What is the structure of solvent **X**?

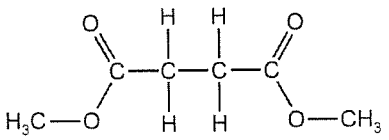
A



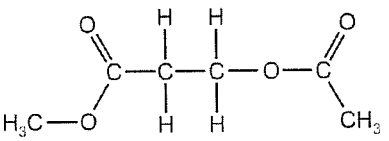
B



C

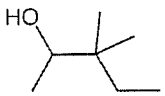


D



35. M/J 16/P13/Q20

What is the correct name of the molecule with the skeletal formula shown?



A 1,2,2-trimethylbutan-3-ol

B 2-ethyl-2-methylbutan-2-ol

C 3,3-dimethylpentan-2-ol

D 4-hydroxy-3,3-dimethylpentane

36. M/J 16/P13/Q27

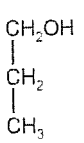
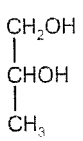
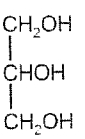
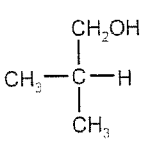
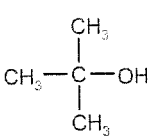
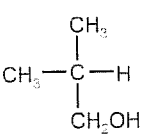
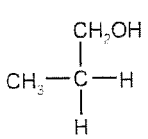
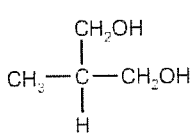
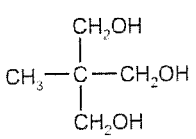
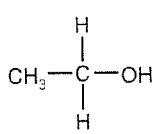
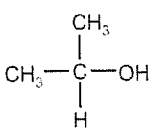
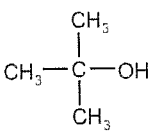
An unknown organic compound reacts with sodium to give a combustible gas as one product but does not give a yellow precipitate with alkaline aqueous iodine.

What is a possible identity of the unknown organic compound?

A propanal **B** propan-1-ol **C** propan-2-ol **D** propanone

37. MAR 16/P12/Q26

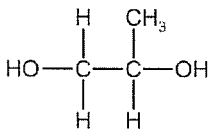
Which row correctly shows a primary, a secondary and a tertiary alcohol?

	primary	secondary	tertiary
A			
B			
C			
D			

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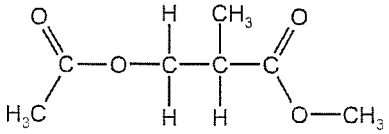
38. MAR 16/P12/Q27

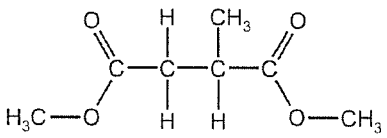
The fragrance compounds of perfumes are often dissolved in solvent **Y**, which has a molecular formula $C_7H_{12}O_4$.
It is made by reacting propane-1,2-diol with ethanoic acid in the presence of an acid catalyst.

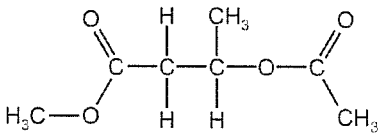


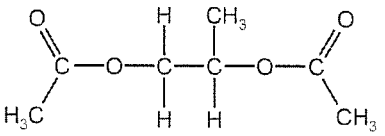
propane-1,2-diol

What is the structure of solvent **Y**?

A


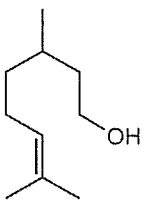
B


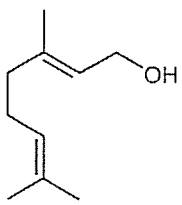
C


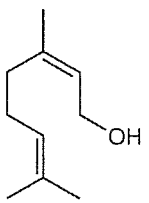
D


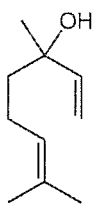
39. O/N 15/P12/Q26

The compounds below are all produced by plants.
Each compound is warmed with acidified potassium dichromate(VI).
Which compound will give a different observation to the other three?

A


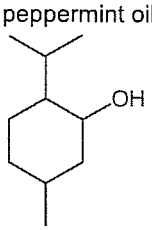
B


C


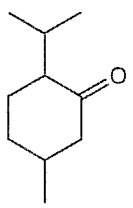
D


40. O/N 15/P12/Q28

Menthol and menthone are both found in peppermint oil.



menthol



menthone

Which statement about these compounds is correct?

A Both compounds can undergo mild oxidation.

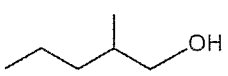
B Both compounds will give an orange precipitate with 2,4-dinitrophenylhydrazine reagent.

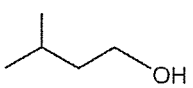
C Menthol can be formed from menthone by reaction with $NaBH_4$.

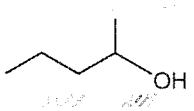
D Menthone gives a positive test when warmed with Tollens' reagent.

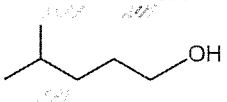
41. O/N 15/P12/Q29, O/N 12/P13/Q29

What is the skeletal formula of 2-methylpentan-1-ol?

A


B


C


D


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42. O/N 15/P11/Q27, O/N 15/P13/Q27

Butan-2-ol can be made by reducing X with H_2 / Ni.
Butan-2-ol can be dehydrated to form Y and Z which are structural isomers of each other.
Which row is correct?

	X is	*cis-trans* isomerism is shown by
A	an aldehyde	both Y and Z
B	an aldehyde	only one of Y and Z
C	a ketone	both Y and Z
D	a ketone	only one of Y and Z

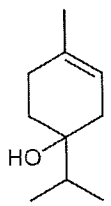
43. O/N 15/P11/Q26, O/N 15/P13/Q26

Which compound **cannot** be oxidised by acidified potassium dichromate(VI) solution but **does** react with sodium metal?

A $(CH_3)_3COH$
B $CH_3COCH_2CH_3$
C $CH_3CH_2CH_2CH_2OH$
D $CH_3CH_2CH(OH)CH_3$

44. M/J 15/P12/Q25

Terpinen-4-ol is one of the active ingredients in tea tree oil.



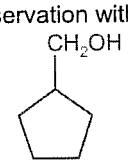
terpinen-4-ol

What is the molecular formula of terpinen-4-ol?

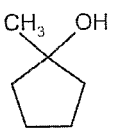
A $C_7H_{11}O$ **B** $C_{10}H_{16}O$ **C** $C_{10}H_{17}O$ **D** $C_{10}H_{18}O$

45. M/J 15/P11/Q27

Which reagent will give a different observation with compounds W and X?



W



X

A hot $SOCl_2$
B hot acidified $K_2Cr_2O_7$
C NaOH(aq)
D warm Fehling's reagent

46. M/J 15/P13/Q20

An organic compound **Z**

- is oxidised by hot acidified potassium manganate(VII),
- reacts with sodium to give hydrogen.

What could be compound **Z**?

A $(CH_3)_3COH$
B $CH_3CH_2CH_2CHO$
C $CH_3CH_2CH(OH)CH_3$
D $CH_3CH_2COCH_3$

47. M/J 14/P13/Q25

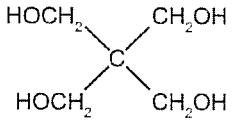
Most alcohols can be dehydrated to give alkenes.
Which alcohol can be dehydrated to give three different isomeric alkenes?

A $CH_3(CH_2)_3CH_2OH$
B $CH_3(CH_2)_2CH(OH)CH_3$
C $CH_3CH_2CH(OH)CH_2CH_3$
D $CH_3C(CH_3)_2CH_2OH$

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48. O/N 14/P13/Q22

Pentaerythritol is used as an intermediate in the manufacture of paint.



pentaerythritol

Which statement about pentaerythritol is correct?

A It can be dehydrated by concentrated sulfuric acid to form an alkene.

B Its empirical formula and its molecular formula are different.

C It does not react with acidified potassium manganate(VII).

D One mole of it gives two moles of hydrogen gas on reaction with an excess of sodium.

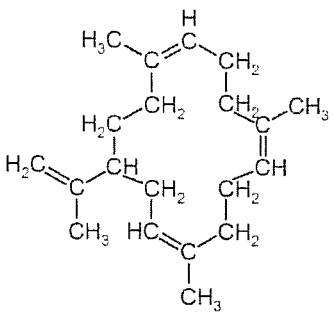
49. M/J 14/P12/Q22

Which alcohol has a chiral centre **and** can be oxidised to a ketone?

A pentan-2-ol **B** pentan-3-ol **C** 3-methylhexan-1-ol **D** 3-methylhexan-3-ol

50. M/J 14/P13/Q27

The naturally-occurring molecule shown below can be made by the addition of four identical monomer molecules.



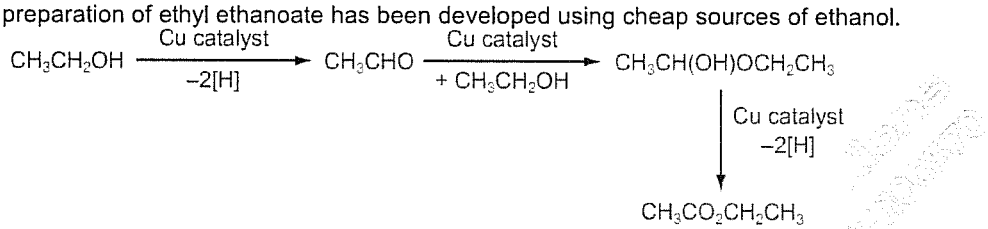
What could be the structural formula of the monomer?

A $CH_3CH_2CH_2CH = CH_2$ **C** $CH_2 = C(CH_3)CH_2CH_3$

B $CH_3CH = CHCH = CH_2$ **D** $CH_2 = C(CH_3)CH = CH_2$

51. O/N 13/P12/Q20, O/N 13/P11/Q20, M/J 06/P1/Q20

A new industrial preparation of ethyl ethanoate has been developed using cheap sources of ethanol.



Which process is involved at some stage in this reaction sequence?

A electrophilic addition **C** nucleophilic substitution

B nucleophilic addition **D** reduction

52. O/N 13/P12/Q22, O/N 08/P1/Q21, O/N 13/P11/Q22

The compound 'leaf alcohol' is partly responsible for the smell of new-mown grass.

$CH_3CH_2CH{=}CHCH_2CH_2OH$

leaf alcohol

What will be formed when 'leaf alcohol' is oxidised using an excess of hot, acidified $K_2Cr_2O_7(aq)$?

A $CH_3CH_2CH(OH)CH(OH)CH_2CO_2H$ **C** $CH_3CH_2CH{=}CHCH_2CO_2H$

B $CH_3CH_2COCOCH_2CO_2H$ **D** $CH_3CH_2CO_2H$ and $HO_2CCH_2CO_2H$

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53. O/N 13/P12/Q27, O/N 13/P11/Q27

Primary alcohols can be oxidised to aldehydes using either acidified potassium dichromate(VI) or acidified potassium manganate(VII). Both these oxidising agents change colour as they are reduced.
What is the colour of each oxidising agent before and after it has reacted?

	acidified potassium dichromate(VI)		acidified potassium manganate(VII)	
	before	after	before	after
A	green	orange	purple	colourless
B	orange	green	colourless	purple
C	orange	green	purple	colourless
D	purple	colourless	orange	green

54. O/N 13/P13/Q27

An alcohol with molecular formula $C_nH_{2n+1}OH$ has a chiral carbon atom but does not react with hot, acidified $K_2Cr_2O_7$.
What is the smallest possible value for n?

A 5 **B** 6 **C** 7 **D** 8

55. M/J 13/P12/Q26

Which volume of oxygen measured at room temperature and pressure is needed for complete combustion of 0.1 mol of propan-1-ol?

A 10.8 dm^3 **B** 12.0 dm^3 **C** 21.6 dm^3 **D** 24.0 dm^3

56. M/J 13/P11/Q21

Lactic acid (2-hydroxypropanoic acid), $CH_3CH(OH)CO_2H$, is found in sour milk.
Which reaction could occur with lactic acid?

A $CH_3CH(OH)CO_2H + CH_3OH \rightarrow CH_3CH(OCH_3)CO_2H + H_2O$

B $CH_3CH(OH)CO_2H + HCO_2H \rightarrow CH_3CH(O_2CH)CO_2H + H_2O$

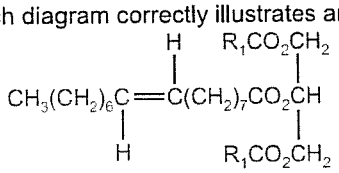
C $CH_3CH(OH)CO_2H + NaHCO_3 \rightarrow CH_3CH(ONa)CO_2H + H_2O + CO_2$

D $CH_3CH(OH)CO_2H + Cl_2 \rightarrow CH_3CH(Cl)CO_2H + HOCl$

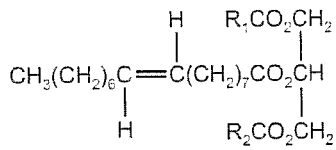
57. M/J 13/P11/Q30

Some vegetable oils contain 'trans fats' that are associated with undesirable increases in the amount of cholesterol in the blood.
In the diagrams below, R_1 and R_2 are different hydrocarbon chains.
Which diagram correctly illustrates an optically active 'trans fat'?

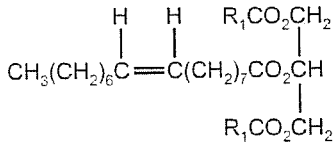
A



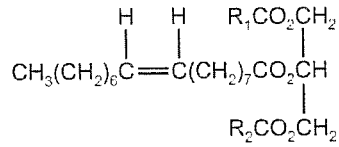
B



C



D



58. M/J 13/P13/Q24, O/N 10/P12/Q23

Which sequence of reagents may be used in the laboratory to convert propan-1-ol into 2-bromopropane?

A concentrated sulfuric acid, followed by bromine

B concentrated sulfuric acid, followed by hydrogen bromide

C ethanolic sodium hydroxide, followed by bromine

D ethanolic sodium hydroxide, followed by hydrogen bromide

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59. M/J 13/P13/Q26

Which compound gives an organic product with a lower boiling point when it is heated under reflux with an excess of acidified potassium dichromate(VI)?

A 2-methylbutan-1-ol **B** 2-methylbutan-2-ol **C** pentan-1-ol **D** pentan-2-ol

60. O/N 12/P12/Q27, O/N 12/P11/Q27

Which reagent reacts with ethanol and also reacts with ethanoic acid?

A acidified potassium dichromate(VI) **C** sodium carbonate

B sodium **D** sodium hydroxide

61. O/N 12/P13/Q20

An organic compound X

- is unaffected by hot acidified potassium manganate(VII),
- reacts with ethanoic acid in the presence of concentrated sulfuric acid.

What is compound X?

A $CH_3CO_2C_2H_5$ **B** $CH_3CH_2COCH_3$ **C** $(CH_3)_3COH$ **D** $CH_3CH_2CHOHCH_3$

62. O/N 12/P13/Q25

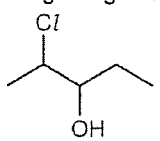
2.30 g of ethanol were mixed with aqueous acidified potassium dichromate(VI) and the desired organic product was collected by immediate distillation under gentle warming. The yield of product was 70.0 %.

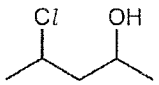
What mass of product was collected?

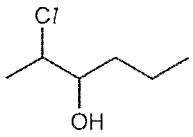
A 1.54 g **B** 1.61 g **C** 2.10 g **D** 2.20 g

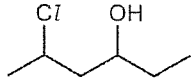
63. M/J 12/P12/Q21

Which diagram gives the skeletal formula of 2-chloropentan-3-ol?

A 

B 

C 

D 

64. M/J 12/P11/Q26, M/J 12/P13/Q25

$CH_3COCH_2CH_2OH$	CH_3COCH_2CHO	$CH_3CH(OH)CH_2CH_3$	$CH_3CH_2CH_2CHO$
W	*X*	*Y*	*Z*

Which of these compounds can be oxidised by acidified dichromate (VI) solution and also gives a positive response to Tollens' reagent?

A W and X only **B** W and Y only **C** X and Z only **D** Y and Z only

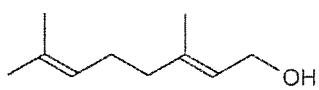
65. O/N 11/P12/Q30

How many of the isomeric alcohols with the formula C_4H_9OH will produce an alkene that has *cis* and *trans* isomers, on treatment with conc. H_2SO_4?

A 1 **B** 2 **C** 3 **D** 4

66. O/N 11/P13/Q30, O/N 11/P11/Q29

Geraniol is a constituent of some perfumes.



geraniol

Which statement about geraniol is **not** correct?

A Geraniol causes hot acidified potassium dichromate(VI) to change colour from orange to green.

B Geraniol decolourises bromine water.

C There are three methyl groups and three methylene (CH_2) groups in geraniol.

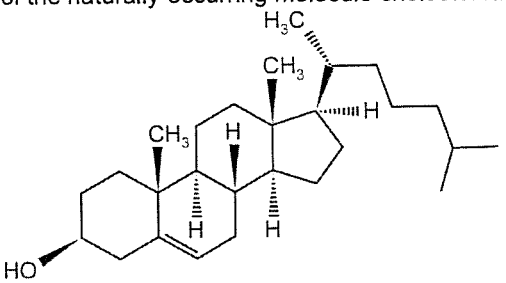
D There are two pairs of *cis*-trans isomers of geraniol.

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67. M/J 11/P12/Q29

This question should be answered by considering the reactions of $KMnO_4$ with different functional groups under the stated conditions.

The diagram shows the structure of the naturally-occurring molecule cholesterol.



cholesterol

Cholesterol is separately treated with

- cold, dilute acidified $KMnO_4$,
- hot, concentrated acidified $KMnO_4$.

What is the change in the **number** of chiral carbon atoms in the molecule during each reaction?

	cold, dilute acidified $KMnO_4$	hot, concentrated acidified $KMnO_4$
A	+1	0
B	+1	–1
C	+2	0
D	+2	–1

68. M/J 11/P11/Q26

Compound X changes the colour of warm acidified sodium dichromate(VI) from orange to green. 1 mol of X reacts with 2 mol of HCN in the presence of KCN.

What could X be?

A $CH_3CH_2CH_2CHO$ **B** $CH_3COCH_2COCH_3$ **C** $H_2C{=}CHCH_2CHO$ **D** $OHCCH_2CH_2CHO$

69. M/J 11/P11/Q30, M/J 11/P13/Q29, O/N 08/P1/Q25

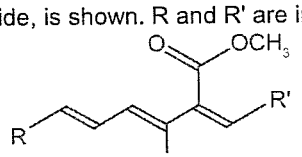
The functional group in a primary alcohol is $–CH_2OH$.

Which reagent reacts with a primary alcohol, under suitable conditions, to give an organic product with the same number of oxygen atoms as the alcohol?

A Al_2O_3 **B** CH_3CO_2H **C** HBr **D** Na

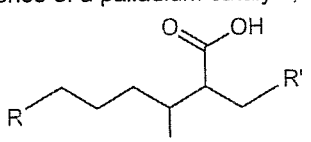
70. O/N 10/P12/Q27

Part of the structure of strobilurin, a fungicide, is shown. R and R' are inert groups.

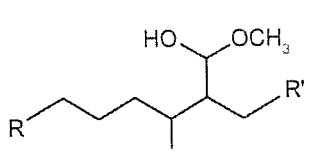


If strobilurin is first warmed with aqueous sulfuric acid, and its product then treated with hydrogen in the presence of a palladium catalyst, what could be the structure of the final product?

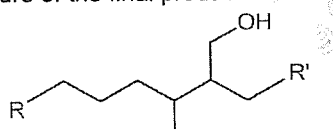
A



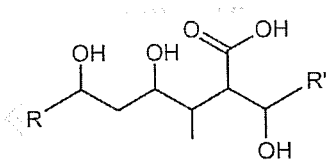
B



C



D



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71. O/N 10/P11/Q24, O/N 10/P13/Q25

Which alcohol gives only **one** possible oxidation product when warmed with dilute acidified potassium dichromate(VI)?

A butan-1-ol
B butan-2-ol
C 2-methylpropan-1-ol
D 2-methylpropan-2-ol

72. M/J 10/P12/Q21, M/J 10/P11/Q22, M/J 10/P13/Q21

What will react differently with the two isomeric alcohols, $(CH_3)_3CCH_2OH$ and $(CH_3)_2CHCH_2CH_2OH$?

A acidified aqueous potassium manganate(VII)
B concentrated sulfuric acid
C phosphorus pentachloride
D sodium

73. M/J 09/P1/Q26

Glycol, used in anti-freeze, has the formula $HOCH_2CH_2OH$. It can be oxidised to give a number of products.
What is the molecular formula of an oxidation product of glycol that will not react with sodium?

A $C_2H_2O_2$ **B** $C_2H_2O_3$ **C** $C_2H_2O_4$ **D** $C_2H_4O_2$

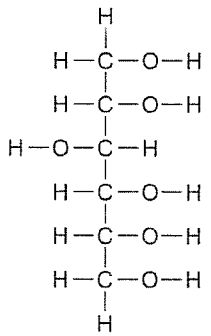
74. M/J 09/P1/Q29

2-Methylbuta-1,3-diene, $CH_2=C(CH_3)–CH=CH_2$, is used as a monomer in the manufacture of synthetic rubbers.
Which compound would not produce this monomer on treatment with concentrated sulfuric acid at 170 °C?

A $(CH_3)_2C(OH)CH(OH)CH_3$
B $HOCH_2CH(CH_3)CH_2CH_2OH$
C $HOCH_2CH(CH_3)CH(OH)CH_3$
D $HOCH_2C(CH_3)(OH)CH_2CH_3$

75. O/N 08/P1/Q20

Sorbitol is a naturally-occurring compound with a sweet taste. It is often used as a substitute for sucrose by the food industry.
The diagram shows its structure.

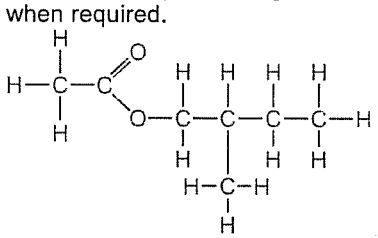


How many chiral centres are present in sorbitol?

A 1 **B** 2 **C** 3 **D** 4

76. O/N 08/P1/Q28

Bees use 2-methylbutyl ethanoate as an 'alarm' pheromone. When disturbed, individual bees on guard will raise their abdomen and emit the alarm pheromone, fanning their wings to aid its dispersal. This alerts other bees to a danger and makes them ready to sting when required.



2-methylbutyl ethanoate

Which starting materials would be required to synthesise 2-methylbutyl ethanoate?

A CH_3CH_2OH and $CH_3CH_2CH(CH_3)CO_2H$
B CH_3CO_2H and $CH_3CH_2CH(CH_3)CH_2OH$
C CH_3CH_2OH and $CH_3CH_2CH(CH_3)CH_2CO_2H$
D CH_3CO_2H and $CH_3CH_2CH(CH_3)CH_2CO_2H$

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77. M/J 20/P12/Q39, M/J 14/P12/Q37

Which alcohols **cannot** be dehydrated to form alkenes?

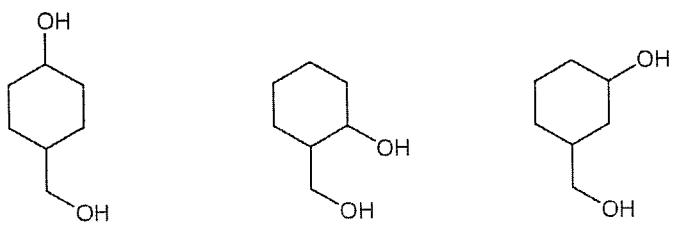
1 CH_3OH
2 $(CH_3)_3COH$
3 CH_3CH_2OH

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

78. O/N 19/P11/Q38, O/N 19/P13/Q38

Which compounds, on heating with an excess of concentrated sulfuric acid, produce **only one** product with molecular formula C_7H_{10}?

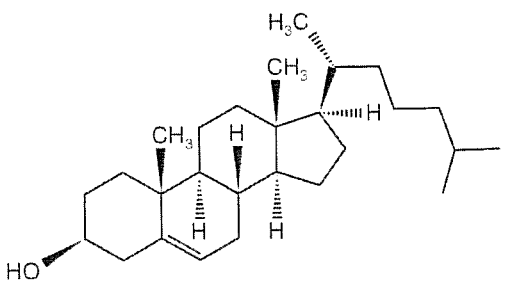
1 2 3



A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

79. MAR 19/P12/Q37, O/N 10/P11/Q37, O/N 10/P13/Q36

The diagram shows the structure of the naturally-occurring molecule cholesterol.



cholesterol

Which statements about cholesterol are correct?

1 The molecule contains a secondary alcohol group.
2 The molecule contains two π bonds.
3 All carbon atoms in the four rings lie in the same plane.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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80. MAR 19/P12/Q40

Carboxylic acids can be prepared from alcohols, nitriles or esters.
Which statements are correct?

1 Both primary and secondary alcohols can be oxidised to carboxylic acids.
2 Carboxylic acids can be made from nitriles by hydrolysis.
3 Ethyl propanoate gives propanoic acid when reacted with hydrochloric acid.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

81. O/N 18/P12/Q39, M/J 15/P12/Q38

Which statements about 2-methylbutan-1-ol are correct?

1 It can give HC*l* (g) on reaction with PCl_5.
2 It can be oxidised to give an aldehyde.
3 It exists in two optically active forms.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

82. M/J 18/P12/Q38

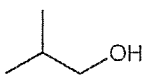
Which pairs of compounds may be distinguished from each other by testing with alkaline aqueous iodine?

1 ethane-1,2-diol and ethanol
2 propan-2-ol and methylpropan-2-ol
3 ethanol and butan-2-ol

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

83. M/J 17/P12/Q39

An organic compound, X, has the following skeletal formula.



X

Which statements about X are correct?

1 X is a primary alcohol.
2 X will dehydrate to give a single alkene.
3 X will undergo a substitution reaction with chloride ions.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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84. O/N 16/P12/Q34

Methanol, CH_3OH, can be produced industrially by reacting CO with H_2.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \quad \Delta H = -91 \text{ kJ mol}^{-1}$$

The process can be carried out at 4×10^3 kPa and 1150 K.

Which statements about this reaction are correct?

1 Increasing the temperature will increase the rate of reaction because more effective collisions will occur.
2 Lowering the temperature will reduce the rate of reaction because the forward reaction is exothermic.
3 Increasing the pressure will reduce the rate of reaction because there are a larger number of moles on the left-hand side of the equation.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

85. O/N 16/P12/Q38

1-bromopropane reacts with NaOH in different ways depending on the solvent used.

Which statements about this reaction are correct?

	solvent used	main organic product
1	ethanol	propene
2	water	propan-1-ol
3	ethanol	propane-1-2-diol

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

86. O/N 16/P11/Q38, O/N 16/P13/Q38

Bromoethane reacts with NaOH in different ways depending on the solvent used.

Which statements about these reactions are correct?

	solvent used	main organic product
1	water	ethane-1,2-diol
2	ethanol	ethene
3	water	ethanol

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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87. O/N 16/P11/Q39, O/N 16/P13/Q39

Several structural isomers of $C_3H_6O_3$ are listed below.

$HOCH_2COCH_2OH$
$HOCH_2CH(OH)CHO$
$HOCH_2CH_2CO_2H$
$CH_3CH(OH)CO_2H$

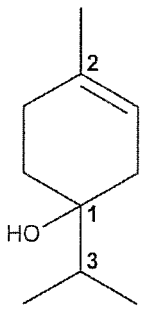
Which statements about these structural isomers are correct?

1 One mole of each reacts with two moles of sodium.
2 Only one of the isomers contains a tertiary alcohol group.
3 They all contain a primary alcohol group.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

88. M/J 16/P12/Q38

One of the active ingredients in tea-tree oil is terpinen-4-ol.
In the diagram of the skeletal formula of terpinen-4-ol, three of the carbon atoms are labelled 1, 2 and 3.
Which of the labelled carbon atoms are chiral?

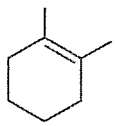


terpinen-4-ol

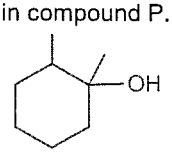
A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

89. O/N 15/P12/Q37

Compound Q is obtained by adding H_2O across the double bond in compound P.



P



Q

Which statements about these two compounds are correct?

1 P shows cis-trans isomerism.
2 Q contains two chiral centres.
3 Q is a tertiary alcohol.

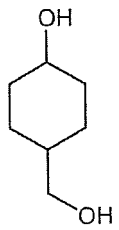
A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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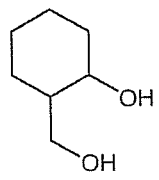
90. O/N 15/P12/Q39

Which compounds, on heating with excess concentrated sulfuric acid, produce only one product with molecular formula C_7H_{10}?

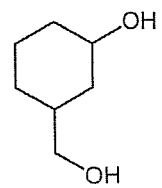
1



2



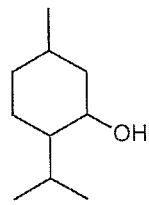
3



A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

91. M/J 14/P12/Q38

Menthol is a naturally-occurring alcohol found in peppermint oil.



menthol

Which reagents will react with menthol?

1 aqueous bromine
2 sodium metal
3 aqueous acidified manganate(VII)

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

92. M/J 14/P11/Q39

The compound pentan-1,4-diol has two OH groups per molecule and can be oxidised.

Which statements about pentan-1,4-diol or its oxidation products are correct?

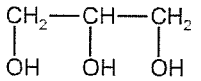
1 When one mole of pentan-1,4-diol reacts with an excess of sodium metal, one mole of hydrogen molecules is produced.
2 At least one of the possible oxidation products of pentan-1,4-diol will react with 2,4-dinitrophenylhydrazine reagent.
3 Dehydration of pentan-1,4-diol could produce a compound with empirical formula C_5H_8.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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93. M/J 14/P13/Q39

Propane-1,2,3-triol is the raw material for many important industrial chemical processes.



propane-1,2,3-triol

Which statements about propane-1,2,3-triol are correct?

1 It reacts with carboxylic acids to form compounds containing up to three ester groups.
2 It can be oxidised to form compounds with aldehyde and ketone functional groups.
3 It can be oxidised to form compounds with up to three carboxylic acid groups.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

94. O/N 13/P12/Q38, O/N 13/P11/Q38

An organic compound Y, molecular formula $C_6H_{14}O$, may be oxidised to compound Z, molecular formula $C_6H_{12}O_2$.

What could be the structural formula of Y?

1 $CH_3CH_2CH(CH_2OH)CH_2CH_3$
2 $(CH_3)_3CCH_2CH_2OH$
3 $CH_3CH_2CH(CH_3)CH_2CH_2OH$

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

95. O/N 13/P12/Q39, O/N 13/P11/Q39

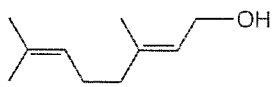
Which reactions can be used to make an alcohol in the laboratory?

1 hydrolysis of a bromoalkane with NaOH(aq)
2 reduction of a ketone with $NaBH_4$
3 reduction of an aldehyde with $NaBH_4$

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

96. M/J 09/P1/Q38

Geraniol is one of several compounds produced by the scent glands of honey bees to help them mark nectar-bearing flowers and locate the entrances to their hives.



geraniol

Which reactions will geraniol undergo?

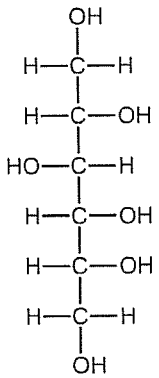
1 reaction with hot concentrated acidic $KMnO_4$ to give propanone
2 addition of halogens
3 reaction with aqueous $NaHCO_3$ to give CO_2

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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97. M/J 11/P11/Q40, M/J 11/P13/Q39

Sorbitol is an artificial sweetener used to sweeten chocolate which is suitable for diabetics.



sorbitol

Which functional groups can be produced when this molecule is subjected to oxidation under suitable conditions?

1 aldehyde
2 carboxylic acid
3 ketone

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

98. M/J 02/P1/Q40

Which alcohols on oxidation with acidified potassium dichromate(VI) give an organic product which causes an effervescence when reacted with sodium carbonate?

1 butan-1-ol
2 2-methylpropan-1-ol
3 2-methylpropan-2-ol

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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16.2: Multiple Topics

1. M/J 20/P13/Q22

There are many non-cyclic alcohols that cannot be oxidised by warm acidified MnO_4^- ions.
Alcohol X is the member of this set of alcohols with the lowest molecular mass.
How many moles of oxygen are required for the complete combustion of 1.0 mol of alcohol X?

A 3.5 mol **B** 4.5 mol **C** 6.0 mol **D** 6.5 mol

2. O/N 19/P11/Q25, O/N 19/P13/Q25

Alcohol X is oxidised to form compound Y.
The composition of Y is 54.54% carbon, 36.36% oxygen and 9.10% hydrogen. The M_r of Y is 88.0.
What could be the structure of alcohol X?

A $CH_3CH_2CH(OH)CH_3$ **C** $CH_3CH_2CH_2CH_2OH$
B $CH_3CH_2CH_2CH_2CH_2OH$ **D** $CH_3CH_2CH(OH)CH_2CH_3$

3. O/N 18/P12/Q28

Compound Y gives methanol and sodium ethanoate on treatment with aqueous sodium hydroxide.
What is the structure of Y?

A $CH_3CO_2CH_3$ **B** $HCO_2C_2H_5$ **C** HO_2CCH_2CHO **D** $HOCH_2CH_2COOH$

4. O/N 18/P12/Q29

Which compound can be used to make propanoic acid by treatment with a single reagent?

A $CH_2=CHCH_2CH_3$ **B** $CH_3CH_2CH_2CN$ **C** $CH_3CH(OH)CN$ **D** $CH_3CH(OH)CH_3$

5. M/J 17/P13/Q21

Structural isomerism and stereoisomerism should be considered when answering this question.
If a molecule contains two non-identical chiral carbon atoms, four optical isomers exist.
How many isomers are there with

- molecular formula $C_7H_{14}O$ and
- a five-membered ring and
- a tertiary alcohol group?

A 4 **B** 5 **C** 9 **D** 13

6. O/N 16/P12/Q26

Ethane-1,2-diol, $HOCH_2CH_2OH$, reacts with an excess of ethanoic acid, CH_3CO_2H, in the presence of an acid catalyst. A compound is formed with the molecular formula $C_6H_{10}O_4$.
What is the structure of this compound?

A $CH_3OCOCHCH_2CO_2CH_3$ **C** $CH_3CO_2CH_2CH_2OCOCH_3$
B $CH_3CO_2CH_2CH_2CO_2CH_3$ **D** $HOCH_2CH_2COCH_2OCOCH_3$

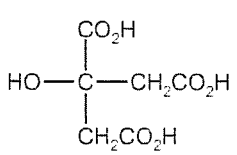
7. O/N 16/P12/Q27

Compound **X** is heated with a mild oxidising agent. One of the products of the reaction will react with hydrogen cyanide, forming 2-hydroxybutanenitrile.
What is compound **X**?

A butan-1-ol **B** butan-2-ol **C** propan-1-ol **D** propan-2-ol

8. O/N 13/P11/Q26, O/N 13/P12/Q26

How many moles of hydrogen, H_2 are evolved when an excess of sodium metal is added to one mole of citric acid?



citric acid

A 1 **B** 2 **C** 3 **D** 4

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9. O/N 12/P13/Q24

Complete combustion of compound X produces carbon dioxide and water only. **X** produces steamy fumes with PCl_5. **X** does not give any visible product with 2,4-dinitrophenylhydrazine reagent.
What can be deduced with certainty from this information?

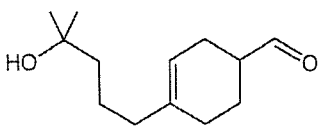
A X is a carboxylic acid.
B X is a hydrocarbon.
C X is an alcohol.
D X is not an aldehyde.

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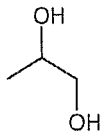
10. O/N 17/P11/Q39, O/N 17/P13/Q39

The compounds below are used to make perfumes.
Which compounds will produce a yellow precipitate with alkaline aqueous iodine?

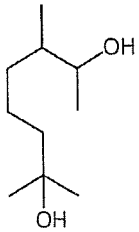
1



2



3



A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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Answers Sections

16.1						16.2	
1.	A	41.	A	81.	A	1.	C
2.	C	42.	D	82.	B	2.	C
3.	B	43.	A	83.	A	3.	A
4.	C	44.	D	84.	D	4.	A
5.	A	45.	B	85.	B	5.	C
6.	D	46.	C	86.	C	6.	C
7.	A	47.	B	87.	D	7.	C
8.	A	48.	D	88.	D	8.	B
9.	D	49.	A	89.	C	9.	D
10.	B	50.	D	90.	B	10.	C
11.	C	51.	B	91.	C		
12.	D	52.	C	92.	A		
13.	A	53.	C	93.	B		
14.	C	54.	C	94.	A		
15.	B	55.	A	95.	A		
16.	B	56.	B	96.	B		
17.	C	57.	B	97.	A		
18.	B	58.	B	98.	B		
19.	C	59.	D				
20.	B	60.	B				
21.	A	61.	C				
22.	C	62.	A				
23.	A	63.	A				
24.	A	64.	C				
25.	C	65.	A				
26.	B	66.	D				
27.	D	67.	D				
28.	D	68.	D				
29.	A	69.	D				
30.	D	70.	A				
31.	C	71.	B				
32.	C	72.	B				
33.	C	73.	A				
34.	B	74.	D				
35.	C	75.	D				
36.	B	76.	B				
37.	D	77.	D				
38.	D	78.	B				
39.	D	79.	D				
40.	C	80.	C				

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Unit 17
CARBONYL COMPOUNDS

A Level
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Syllabus

17.1 Aldehydes and ketones
17.2 Multiple topics

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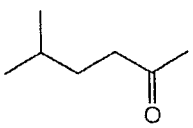
Unit 17: Carbonyl compounds

17.1: Aldehydes and ketones

1. M/J 20/P12/Q22
Which row correctly shows the type of mechanism of each of the two reactions?

	C_2H_5Br + KCN	CH_3COCH_3 + HCN
A	electrophilic substitution	electrophilic addition
B	electrophilic substitution	nucleophilic addition
C	nucleophilic substitution	electrophilic addition
D	nucleophilic substitution	nucleophilic addition

2. M/J 20/P11/Q20
The skeletal formula of compound X is shown.

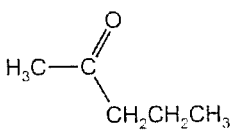


Which row is correct?

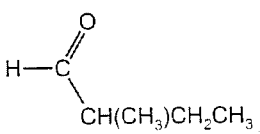
	molecular formula of X	observation on addition of X to Fehling's reagent
A	$C_7H_{14}O$	no change
B	$C_7H_{14}O$	red precipitate forms
C	$C_7H_{16}O$	no change
D	$C_7H_{16}O$	red precipitate forms

3. M/J 20/P13/Q24
Which statement about compound T and compound U is correct?

compound T

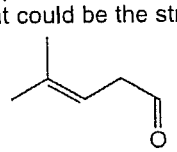


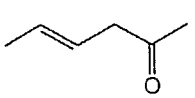
compound U

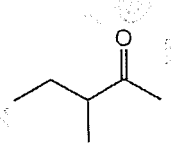


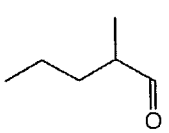
A T and U are stereoisomers.
B T can be distinguished from U by the use of alkaline aqueous iodine.
C T can be reduced by LiA/ H_4 but not by $NaBH_4$.
D U can be formed by the oxidation of 3-methylbutan-1-ol.

4. O/N 19/P12/Q26
Compound X has stereoisomers and forms a precipitate when warmed with Fehling's reagent.
What could be the structure of compound X?

A 

B 

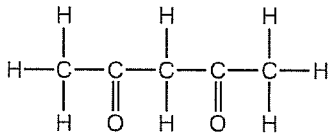
C 

D 

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5. O/N 19/P12/Q27

The diagram shows the structure of Y.



Two suggestions are made about Y.

1 Y can be oxidised by hot, acidified dichromate(VI) ions.

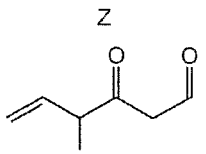
2 One mole of Y gives one mole of tri-iodomethane when it reacts with an excess of alkaline aqueous iodine.

Which suggestions are correct?

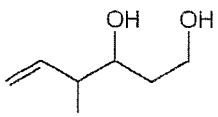
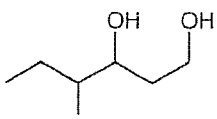
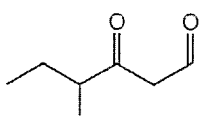
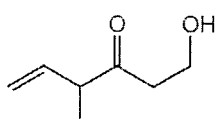
A both 1 and 2 **B** 1 only **C** 2 only **D** neither 1 nor 2

6. O/N 19/P11/Q26, O/N 19/P13/Q26

The diagram shows the structure of compound Z.



What is the product of the reaction between compound Z and an excess of $NaBH_4$?

A  **B**  **C**  **D** 

7. O/N 19/P11/Q27, O/N 19/P13/Q27

Compound Q shows the following reactions.

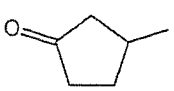
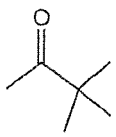
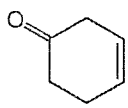
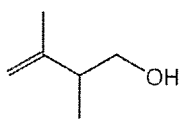
- It gives an orange precipitate with 2,4-dinitrophenylhydrazine.
- It gives a red-brown precipitate with Fehling's reagent.
- It gives a pale yellow precipitate with alkaline aqueous iodine.

What could be the identity of Q?

A ethanal **B** propan-2-ol **C** propanal **D** propanone

8. M/J 19/P11/Q21

Which compound has the molecular formula $C_6H_{10}O$?

A  **B**  **C**  **D** 

9. M/J 19/P12/Q27

Which reagent could be used to distinguish between ethanal and propanal?D

A 2,4-dinitrophenylhydrazine **C** $K_2Cr_2O_7$ / H_2SO_4(aq)

B I_2 / NaOH(aq) **D** Tollens' reagent

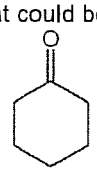
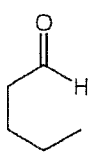
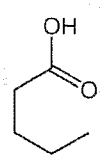
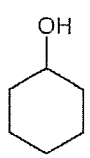
10. MAR 19/P12/Q28

When compound X is heated with $Cr_2O_7^{2-}/H^+$, a colour change from orange to green is observed.

Two tests are carried out on the organic product of this reaction.

test	result
Tollens' reagent	no change
2,4-dinitrophenylhydrazine	orange precipitate

What could be compound X?

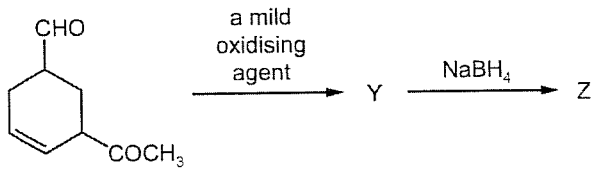
A  **B**  **C**  **D** 

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11. M/J 19/P11/Q28

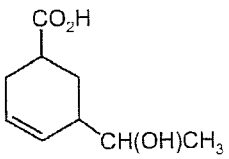
Compound X is treated with two reagents successively, forming compound Z.

X

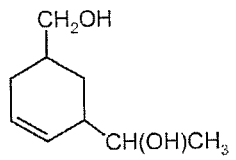


What could be Z?

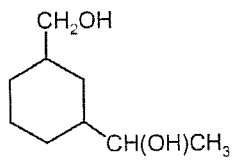
A



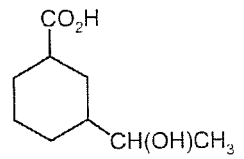
B



C



D



12. M/J 19/P11/Q29

Which reagent may be used to distinguish between propanone and ethanol?

A 2,4-dinitrophenylhydrazine
B bromine water
C Fehling's reagent
D Tollens' reagent

13. M/J 19/P13/Q27

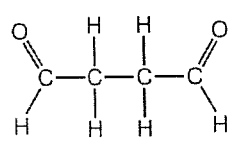
Compound Q reacts with 2,4-dinitrophenylhydrazine to give a precipitate.
Compound Q does not produce a precipitate when warmed with Fehling's solution.
What could be the identity of compound Q?

A CH_3COCH_3 **B** $CH_2(OH)CH_2CH_3$ **C** $CH_3CH_2CO_2H$ **D** CH_3CH_2CHO

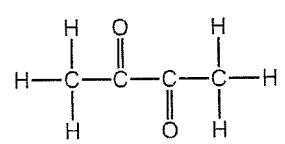
14. O/N 18/P12/Q27

Compound X has the empirical formula C_2H_3O.
Compound X reacts with 2,4-dinitrophenylhydrazine reagent to give an orange precipitate and also decolourises warmed acidified potassium manganate(VII) solution.
What could be the identity of X?

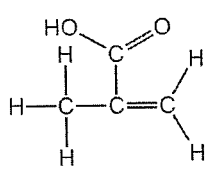
A



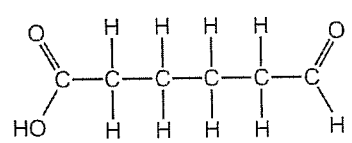
B



C



D



15. M/J 18/P12/Q27

Which statement about butanone is correct?

A Butanone can be dehydrated by concentrated sulfuric acid to give $CH_2=CHCH=CH_2$.
B Butanone gives a positive result with Tollens' reagent.
C Butanone reacts with HCN by an electrophilic addition mechanism.
D Butanone reacts with $NaBH_4$ to give a chiral product.

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16. M/J 18/P12/Q28

Ethanal, CH_3CHO, is used to make product R in a three-stage synthesis.

$$CH_3CHO \xrightarrow[/NaCN]{HCN} \text{product P} \xrightarrow[\text{reflux}]{H_2SO_4(aq),} \text{product Q} \xrightarrow[\text{(a few drops)}]{\text{conc. } H_2SO_4} \text{product R}$$

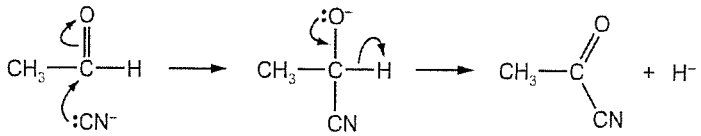
Two molecules of Q react to give one molecule of R plus two molecules of water.
R has two ester functional groups in each molecule. R does not react with sodium.
What is the empirical formula of R?

A CHO **B** $C_3H_4O_2$ **C** $C_3H_5O_2$ **D** $C_6H_{10}O_5$

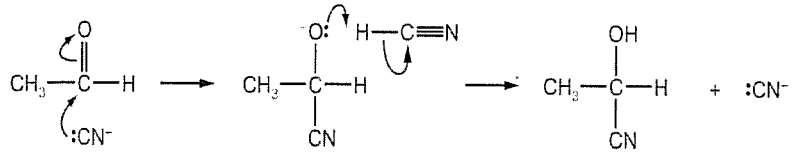
17. M/J 18/P11/Q26, O/N 15/P12/Q27

What is the mechanism for the reaction of ethanal, CH_3CHO, with hydrogen cyanide, HCN, in the presence of a base?

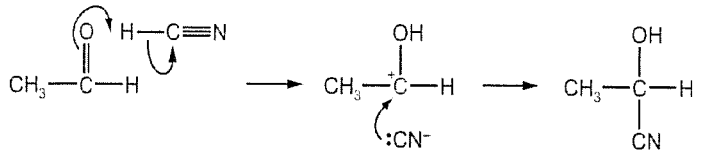
A



B

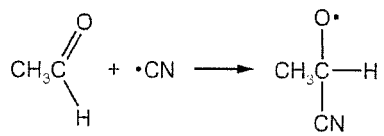


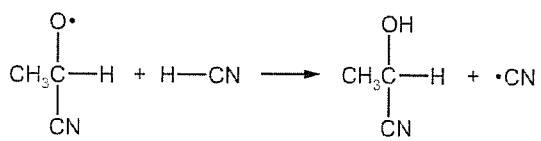
C



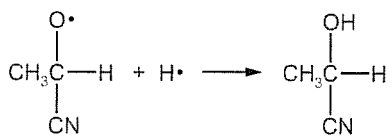
D initiation $HCN \longrightarrow H\bullet + \bullet CN$

propagation





termination



18. M/J 18/P11/Q28

Which reagent could be used to carry out the following reaction?



A a solution containing acidified dichromate(VI) ions
B a solution containing dilute, acidified manganate(VII) ions
C a solution containing hot, concentrated, acidified manganate(VII) ions
D concentrated sulfuric acid

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19. O/N 17/P12/Q29

Compound G

- has a chiral centre,
- gives a positive result with alkaline aqueous iodine,
- does not give a silver mirror with Tollens' reagent.

What could compound G be?

A 1-hydroxybutan-2-one
B 2-hydroxybutanal
C 3-hydroxybutanal
D 3-hydroxybutan-2-one

20. O/N 17/P11/Q27, O/N 17/P13/Q27

3-methylbutanone is treated with alkaline aqueous iodine. The mixture of products is then acidified.
Which compound is present in the final mixture of products?

A 3-methylbutanoic acid
B butanoic acid
C methylpropanoic acid
D propanoic acid

21. M/J 17/P12/Q20

A carbonyl compound **X** will react with HCN in the presence of NaCN to make a compound with M_r 85. Compound **X** does not react with Fehling's reagent.
What is **X**?

A butanal **B** butanone **C** propanal **D** propanone

22. M/J 17/P12/Q27, O/N 10/P12/Q25

Many, but not all, organic reactions need to be heated before reaction occurs.
Which reaction occurs at a good rate at room temperature (20 °C)?

A $C_{10}H_{22} \rightarrow C_8H_{18} + C_2H_4$
B $CH_3CH_2CH_2Br + NH_3 \rightarrow CH_3CH_2CH_2NH_2 + HBr$
C $CH_3CH_2OH + KBr \rightarrow CH_3CH_2Br + KOH$
D $(CH_3)_2CO + H_2NNHC_6H_3(NO_2)_2 \rightarrow (CH_3)_2C{=}NNHC_6H_3(NO_2)_2 + H_2O$

23. M/J 17/P13/Q22

The formulae of three compounds are shown.

C_3H_7CHO $C_2H_5COCH_3$ $CH_2CHCH_2CH_2OH$

Only one of these compounds will decolourise bromine water. Only one of these compounds will produce a silver mirror with Tollens' reagent.
Which row shows the correct results?

	decolourises bromine water	forms a silver mirror with Tollens' reagent
A	C_3H_7CHO	$C_2H_5COCH_3$
B	$C_2H_5COCH_3$	C_3H_7CHO
C	$CH_2CHCH_2CH_2OH$	$C_2H_5COCH_3$
D	$CH_2CHCH_2CH_2OH$	C_3H_7CHO

24. M/J 17/P11/Q25

Diols in which both hydroxy groups are bonded to the same carbon atom spontaneously eliminate a molecule of water to produce a carbonyl compound.
Which compound is hydrolysed to form a product that gives a positive reaction with 2,4-dinitrophenylhydrazine but not with Fehling's reagent?

A 1,1-dibromopropane
B 1,2-dibromopropane
C 1,3-dibromopropane
D 2,2-dibromopropane

25. M/J 17/P13/Q27

Which compound will react with acidified potassium dichromate(VI) and with alkaline aqueous iodine?

A $CH_3COCH_2CH_3$
B $CH_3CH(OH)CH_2CH_3$
C $CH_3CH_2CH_2CHO$
D $CH_3CH_2CH_2CH_2OH$

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26. MAR 17/P12/Q25

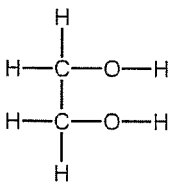
Diols in which both hydroxy groups are bonded to the same carbon can spontaneously eliminate a molecule of water to produce a carbonyl compound.

Which compound, after complete hydrolysis, gives a positive reaction with Tollens' reagent?

A 1,1-dibromobutane **B** 1,2-dibromobutane **C** 1,3-dibromobutane **D** 2,2-dibromobutane

27. MAR 17/P12/Q27

Ethane-1,2-diol has the following structure.



Without breaking the C–C bond, there are five possible oxidation products.

What is the total number of aldehyde groups and carboxylic acid groups in these five products?

	–CHO	–COOH
A	3	3
B	3	4
C	4	3
D	4	4

28. MAR 17/P12/Q28, M/J 14/P11/Q25

$CH_3CH_2COCH_2CH_3$ reacts with hydrogen cyanide to form an organic product called a cyanohydrin.

Which feature applies to the cyanohydrin product?

A It has one chiral centre.

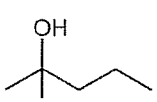
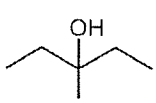
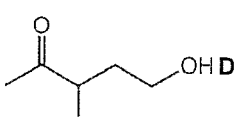
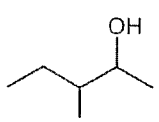
B It is formed by electrophilic addition.

C It is formed via an intermediate which contains the C–OH group.

D Its formation requires the use of cyanide ions as a catalyst.

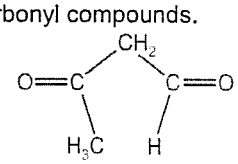
29. O/N 16/P12/Q25

Which compound can be oxidised by acidified potassium manganate (VII) to give 3-methylpentan-2-one?

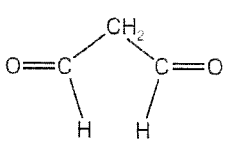
A  **B**  **C**  **D** 

30. O/N 16/P11/Q27, O/N 16/P13/Q27

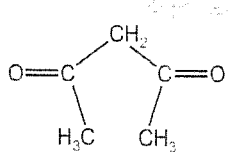
P, Q and R are carbonyl compounds.



P



Q



R

Fehling's solution can be used to help identify these compounds.

Which compounds form a red-brown precipitate on warming with Fehling's solution?

A P, Q and R **B** P and Q only **C** P only **D** Q only

31. M/J 16/P12/Q27

In which reaction is the organic compound oxidised?

A $CH_3CH_2CH_2CHO$ + Tollens' reagent

B $CH_3CH_2CH_2CHO$ + $LiAlH_4$

C $CH_3CH_2CH_2OH$ + concentrated H_3PO_4

D $CH_3CO_2C_2H_5$ + dilute H_2SO_4

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32. M/J 16/P12/Q28

How many of the following compounds produce a carboxylic acid on heating under reflux with an excess of hot acidified $K_2Cr_2O_7$?

1 CH_3CH_2CHO
2 CH_3COCH_3
3 $CH_3CH_2CH_2OH$
4 $CH_3CH(OH)CH_3$

A 1 **B** 2 **C** 3 **D** 4

33. M/J 16/P11/Q24

Alcohol Y gives product Z after mild oxidation. Z gives a positive result with Tollens' reagent and with 2,4-dinitrophenylhydrazine reagent.
What could be the identity of alcohol Y?

A butan-1-ol
B butan-2-ol
C butan-2,3-diol
D 2-methylbutan-2-ol

34. M/J 16/P11/Q28

Which reagent cannot be used to distinguish between ethanal and propanone?

A acidified sodium dichromate(VI) solution
B alkaline aqueous iodine
C cold acidified potassium manganate(VII) solution
D Fehling's reagent

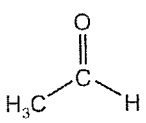
35. O/N 15/P12/Q22

Methanoic acid, HCO_2H, has acidic properties similar to those of other carboxylic acids. In addition it can be oxidised by the same oxidising agents that are capable of oxidising aldehydes.
Which pair consists of two compounds that will give the same observations with Fehling's reagent?

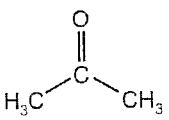
A HCO_2H and CH_3CO_2H
B HCO_2H and $CH_3CO_2CH_3$
C HCO_2H and $CH_3CH_2COCH_3$
D HCO_2H and CH_3CH_2CHO

36. O/N 15/P11/Q28, O/N 15/P13/Q28

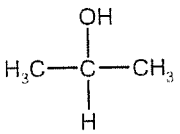
Tollens' reagent can be used to help identify compounds P, Q and R.



P



Q



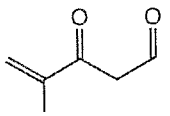
R

Which compound(s) form a silver precipitate on warming with Tollens' reagent?

A P and Q **B** P only **C** Q only **D** R only

37. M/J 15/P12/Q27

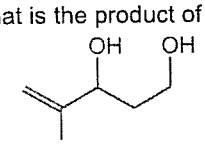
The diagram shows the structure of compound X.



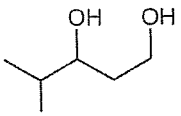
X

What is the product of the reaction between compound X and an excess of $NaBH_4$?

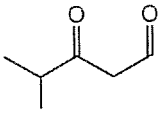
A



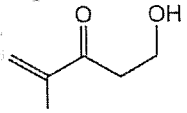
B



C



D



38. M/J 15/P11/Q30

What is the organic product when ethanamide, CH_3CONH_2, is boiled with excess aqueous sodium hydroxide?

A CH_3CN **B** $CH_3CO_2^-NH_4^+$ **C** $CH_3CONH^-Na^+$ **D** $CH_3CO_2^-Na^+$

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39. M/J 15/P11/Q20

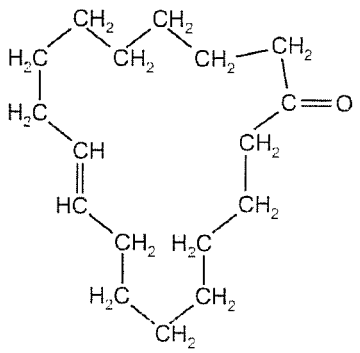
Which reagent will give a different observation with compounds P and Q?

$HOCH_2CH(OH)CHO$ (P) $HOCH_2COCH_2OH$ (Q)

A $Br_2(aq)$
B hot acidified $KMnO_4$
C silver nitrate in ammonia solution
D warm acidified $K_2Cr_2O_7$

40. M/J 15/P13/Q24, O/N 09/P12/Q26, O/N 09/P11/Q27

The naturally-occurring molecule civetone is found in a gland of the African civet cat and has been used in perfumery.



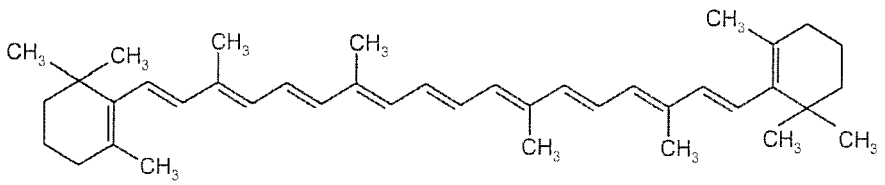
civetone

Which reagent will **not** react with civetone?

A 2,4-dinitrophenylhydrazine reagent
B Fehling's reagent
C hydrogen bromide
D sodium tetrahydridoborate(III), $NaBH_4$

41. O/N 14/P12/Q30

β-carotene is responsible for the orange colour of carrots.



β-carotene

β-carotene is oxidised by hot, concentrated, acidified $KMnO_4$.
When an individual molecule of β-carotene is oxidised in this way, many product molecules are formed.
How many of these product molecules contain a ketone functional group?

A 4 **B** 6 **C** 9 **D** 11

42. O/N 13/P12/Q28, O/N 13/P11/Q28

In which reaction is the organic compound oxidised?

A CH_3CH_2OH + concentrated H_3PO_4
B $CH_3CH_2CH_2CHO$ + Tollens' reagent
C CH_3COCH_3 + 2,4-dinitrophenylhydrazine reagent
D CH_3CN + dilute H_2SO_4

43. O/N 13/P13/Q29

How many hydrogen atoms are added to each molecule of ethanal when it is reacted with $NaBH_4$ in water?

A 1 **B** 2 **C** 4 **D** 6

44. M/J 13/P12/Q27

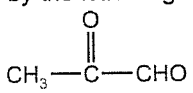
Which carbonyl compound reacts with hydrogen cyanide to form a product that has **no** chiral carbon atom?

A butanone **B** ethanal **C** propanal **D** propanone

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45. M/J 13/P13/Q23

Burnt sugar has a characteristic smell caused partly by the following compound.



This compound contains two functional groups.
Which reagent will react with **both** functional groups?

A acidified potassium dichromate(VI)
B Fehling's solution
C hydrogen cyanide
D sodium hydroxide

46. O/N 12/P13/Q28

Which compound is optically active and could also be oxidised to a ketone?

A 2-methylbutan-1-ol
B 3-methylhexan-3-ol
C 3-methylpentan-2-ol
D propan-2-ol

47. M/J 12/P12/Q29

A common industrial solvent is a mixture of propanone, CH_3COCH_3, and pentyl ethanoate $CH_3CO_2(CH_2)_4CH_3$.
Which reagent would have **no** reaction with this industrial solvent?

A HCl (aq)
B HCN(aq) with a little KCN
C Na(s)
D $NaBH_4$

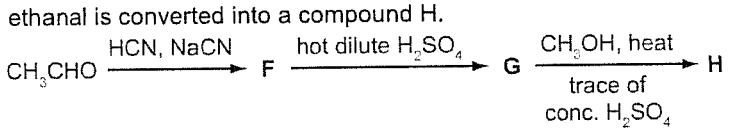
48. O/N 11/P12/Q23

Ethanal, CH_3CHO, can be reduced using $NaBH_4$ in aqueous ethanol.
This is a nucleophilic addition reaction.
What could be the first step of this mechanism?

A attack of an H^- ion at the carbon atom of the carbonyl group
B attack of an H^- ion at the oxygen atom of the carbonyl group
C attack of an H^+ ion at the carbon atom of the carbonyl group
D attack of an H^+ ion at the oxygen atom of the carbonyl group

49. O/N 11/P12/Q24

In a sequence of reactions, ethanal is converted into a compound H.



What could **H** be?

A $CH_3CH_2COOCH_3$
B $CH_3CH(OH)COOCH_3$
C $CH_3CH(OH)OCOCH_3$
D $CH_3CH(OCH_3)COOH$

50. M/J 11/P11/Q28, M/J 11/P13/Q23

A compound Y is treated with warm acidified potassium dichromate(VI). The resulting organic product gives an orange precipitate with 2,4-dinitrophenylhydrazine reagent but does not give a silver mirror with Tollens' reagent.
What is Y?

A butan-1-ol
B butan-2-ol
C butanal
D 2-methylpropan-2-ol

51. M/J 11/P11/Q29, M/J 11/P13/Q30

Aldehydes and ketones are carbonyl compounds.
Which of them react with $NaBH_4$ **and** react with Fehling's reagent?

A both aldehydes and ketones
B aldehydes only
C ketones only
D neither aldehydes nor ketones

52. O/N 10/P12/Q26

Which pair of reagents will take part in a redox reaction?

A CH_3CH_2OH + concentrated H_2SO_4
B CH_3CHO + Tollens' reagent
C $CH_3CO_2C_2H_5$ + dilute H_2SO_4
D CH_3COCH_3 + Fehling's solution

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53. O/N 10/P12/Q22

When ethanal, CH_3CHO, reacts with HCN and the organic product is hydrolysed by aqueous acid, organic compound Y is formed.

When propanal, C_2H_5CHO, is heated under reflux with acidified potassium dichromate(VI), organic compound Z is formed.

What is the difference in relative molecular mass of compounds Y and Z?

A 12 **B** 14 **C** 16 **D** 17

54. O/N 10/P11/Q27, O/N 10/P13/Q27, M/J 07/P1/Q29

Which compound would undergo nucleophilic addition?

A bromoethane, C_2H_5Br
B ethanal, CH_3CHO
C ethane, C_2H_6
D ethene, C_2H_4

55. O/N 10/P12/Q29, O/N 03/P1/Q29

$CH_3CH_2COCH_2CH_3$ reacts with hydrogen cyanide to form a cyanohydrin.

Which feature applies to the product?

A It has one chiral centre.
B It is formed by electrophilic addition.
C It is formed via a C–OH intermediate.
D Its formation requires the use of cyanide ions as a catalyst.

56. O/N 10/P11/Q23, O/N 10/P13/Q24

Tartaric acid is present in some wines. It may be synthesised in the laboratory in two steps.

$$OHCCHO \xrightarrow{\text{step 1}} \text{intermediate} \xrightarrow{\text{step 2}} \underset{\text{tartaric acid}}{HO_2CCH(OH)CH(OH)CO_2H}$$

Which reagents could be used for this synthesis?

	step 1	step 2
A	HCl(aq)	HCN(g)
B	HCN, NaCN(aq/alcoholic)	H_2SO_4(aq)
C	H_2SO_4(aq)	$K_2Cr_2O_7/H_2SO_4$(aq)
D	KCN(aq/alcoholic)	$K_2Cr_2O_7/H_2SO_4$(aq)

57. M/J 10/P12/Q22, M/J 10/P13/Q24, M/J 10/P11/Q23

Which reagent will give similar results with both butanone and butanal?

A acidified aqueous potassium dichromate(VI)
B an alkaline solution containing complexed Cu^{2+} ions (Fehling's solution)
C an aqueous solution containing $[Ag(NH_3)_2]^+$ (Tollens' reagent)
D 2,4-dinitrophenylhydrazine reagent

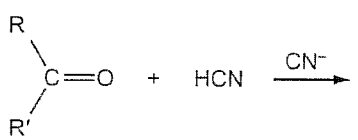
58. M/J 10/P12/Q23, M/J 10/P11/Q24, M/J 10/P13/Q22

What is formed when propanone is refluxed with a solution of $NaBH_4$?

A propanal **B** propan-1-ol **C** propan-2-ol **D** propane

59. O/N 09/P12/Q27, O/N 09/P11/Q28

Cyanohydrins can be made from carbonyl compounds by generating CN^- ions from HCN in the presence of a weak base.



In a similar reaction, $^-CH_2CO_2CH_3$ ions are generated from $CH_3CO_2CH_3$ by strong bases.

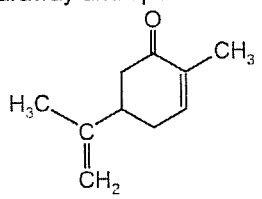
Which compound can be made from an aldehyde and $CH_3CO_2CH_3$ in the presence of a strong base?

A $CH_3CH(OH)CO_2CH_3$
B $CH_3CO_2CH_2CH(OH)CH_3$
C $CH_3CH_2CH(OH)CH_2CO_2CH_3$
D $(CH_3)_2C(OH)CH_2CO_2CH_3$

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60. M/J 09/P1/Q28

Carvone gives the characteristic flavour to caraway and spearmint.



carvone

Prolonged heating of carvone with hot concentrated acidified potassium manganate(VII) produces carbon dioxide and a compound **X**.
X contains nine carbon atoms and reacts with 2,4-dinitrophenylhydrazine reagent.
What is the maximum number of molecules of 2,4-dinitrophenylhydrazine that will react with one molecule of **X**?

A 1 **B** 2 **C** 3 **D** 4

61. O/N 08/P1/Q29, M/J 03/P1/Q30

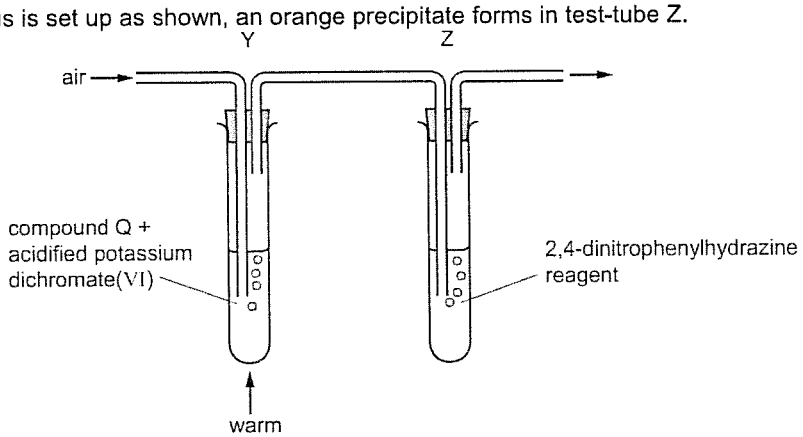
The product of the reaction between propanone and hydrogen cyanide is hydrolysed under acidic conditions.
What is the formula of the final product?

A $CH_3CH(OH)CO_2H$ **B** $CH_3CH_2CH_2CO_2H$ **C** $(CH_3)_2CHCONH_2$ **D** $(CH_3)_2C(OH)CO_2H$

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62. M/J 20/P11/Q38

When the apparatus is set up as shown, an orange precipitate forms in test-tube Z.



What could compound Q be?

1 $CH_3CH_2CH_2OH$
2 $CH_3CH(OH)CH_3$
3 $(CH_3)_3COH$

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

63. M/J 20/P11/Q37

In which of the reactions is the organic compound oxidised by the given reagent?

1 CH_3CHO + HCN reagent
2 $CH_3CH_2CH_2CHO$ + Tollens' reagent
3 CH_3CH_2CHO + Fehling's reagent

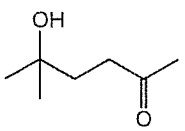
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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64. M/J 20/P12/Q37

Compound X has the structure shown.

compound X



Which statements about compound X are correct?

1 X will decolourise cold, acidified $KMnO_4(aq)$.
2 X gives an orange precipitate with 2,4-DNPH reagent.
3 X does not react with Tollens' reagent.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

65. M/J 20/P13/Q37, M/J 16/P12/Q39

Propanal reacts with hydrogen cyanide to form 2-hydroxybutanenitrile. A suitable catalyst for this reaction is sodium cyanide.

$$CH_3CH_2CHO + HCN \xrightarrow{NaCN} CH_3CH_2CH(OH)CN$$

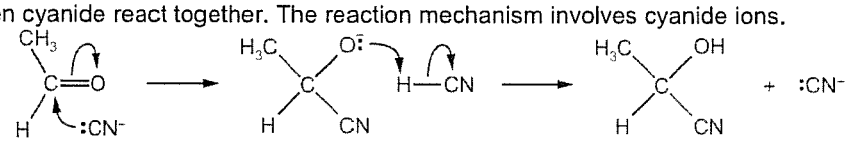
Which statements about the reaction of propanal with hydrogen cyanide are correct?

1 The sodium cyanide provides a stronger nucleophile than HCN.
2 The reaction can be classified as nucleophilic substitution.
3 The hydrogen cyanide molecule attacks the propanal molecule to form an intermediate ion.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

66. MAR 20/P12/Q37, M/J 16/P13/Q38

Ethanal and hydrogen cyanide react together. The reaction mechanism involves cyanide ions.



Which statements about this mechanism are correct?

1 CN^- acts as a catalyst.
2 CN^- is a nucleophile.
3 It is an addition reaction.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

67. O/N 19/P11/Q39, O/N 19/P13/Q39

Hydrogen cyanide reacts with propanone in the presence of potassium cyanide.

Which statements about this reaction are correct?

1 The cyanide ion is a catalyst for the reaction.
2 This is an addition reaction.
3 The intermediate behaves as a base.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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68. M/J 19/P11/Q38

Compound Y

- reacts with alkaline aqueous iodine to form a yellow precipitate
- changes the colour of warm, acidified potassium dichromate(VI) solution.

What could be compound Y?

1 

2 

3 

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

69. MAR 19/P12/Q39

The compounds listed are reacted with hydrogen cyanide.

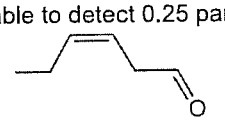
Which compounds produce a molecule containing a chiral centre?

1 butanal
2 butanone
3 pentan-2-one

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

70. O/N 18/P12/Q40, M/J 12/P11/Q39

The compound *cis*-hex-3-enal is responsible for the characteristic smell of cut grass. The human nose is particularly sensitive to this compound, being able to detect 0.25 parts per billion in air.



cis-hex-3-enal

Which reagents will react with cis-hex-3-enal?

1 sodium
2 sodium borohydride
3 Fehling's reagent

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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71. O/N 18/P11/Q40, O/N 18/P13/Q40

Ethanal reacts with HCN in the presence of KCN.
Which changes in bonding occur during this reaction?

1 A carbon-carbon bond is formed.
2 A carbon-hydrogen bond is broken.
3 A carbon-nitrogen bond is broken.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

72. M/J 18/P11/Q40

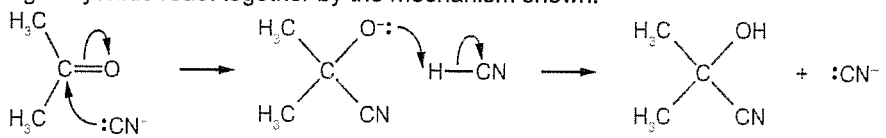
The M_r of compound X is 72. The composition by mass of X is 66.7% carbon, 11.1% hydrogen and 22.2% oxygen. X gives an orange precipitate with 2,4-dinitrophenylhydrazine reagent.
X does not react with Fehling's reagent.
What can be deduced from this information?

1 X is a carbonyl compound.
2 X is a ketone.
3 X is butanone.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

73. M/J 18/P13/Q39, M/J 15/P12/Q39

Propanone and hydrogen cyanide react together by the mechanism shown.



Which statements about this mechanism are correct?

1 CN^- is an electrophile.
2 It is an addition reaction.
3 Heterolytic bond breaking is involved.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

74. M/J 18/P13/Q37

Which compounds, on reaction with $NaBH_4$, form a compound with a chiral carbon atom?

1 $CH_3CH_2CH_2COCH_3$
2 $CH_2CHCOCH_2CH_3$
3 $CH_3CH_2COCH_2CH_3$

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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75. M/J 18/P13/Q40

Acrolein is an organic compound with the molecular formula C_3H_4O. It is used in water treatment and as a herbicide. When acrolein reacts with 2,4-dinitrophenylhydrazine an orange precipitate is obtained. Reaction of acrolein with Tollens' reagent produces a silver mirror.

Which statements are correct?

1 Acrolein reacts with alkaline aqueous iodine to produce a yellow precipitate.
2 Acrolein can be reduced to a primary alcohol.
3 Acrolein decolourises bromine water.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

76. O/N 17/P11/Q40, O/N 17/P13/Q40

The reaction of ethanal, CH_3CHO, with HCN to form 2-hydroxypropanenitrile is catalysed by NaCN.

What are features of the intermediate of this reaction?

1 It is chiral.
2 It has a single negative charge on one of its atoms.
3 It is a nucleophile.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

77. M/J 17/P12/Q40

2,2,4-trimethylpentanal is used in the manufacture of adhesives.

Which reagents would 2,2,4-trimethylpentanal react with?

1 2,4-dinitrophenylhydrazine reagent
2 Tollens' reagent
3 alkaline aqueous iodine

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

78. M/J 17/P11/Q39

For which reactions are the colour changes described correctly?

	reagents	colour change
1	pentanal + hot, acidified potassium dichromate(VI)	orange to green
2	pentan-2-one + warm Fehling's reagent	no change
3	cyclohexane + cold, acidified potassium manganate(VII)	purple to colourless

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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79. M/J 17/P13/Q40, O/N 14/P12/Q37, O/N 14/P11/Q37

Propanal will react with hydrogen cyanide to form 2-hydroxybutanenitrile. A suitable catalyst for this reaction is sodium cyanide.

$$CH_3CH_2CHO + HCN \overset{NaCN}{\rightleftharpoons} CH_3CH_2CH(OH)CN$$

Which statements about the reaction of propanal with hydrogen cyanide are correct?

1 The CN^- ion attacks the propanal molecule to form an intermediate ion.
2 The product of the reaction has a chiral carbon atom.
3 The CN^- ion is a stronger electrophile than the HCN molecule.

A	B	C	D
1, 2 and 3 are correct	**1 and 2** only are correct	**2 and 3** only are correct	**1** only is correct

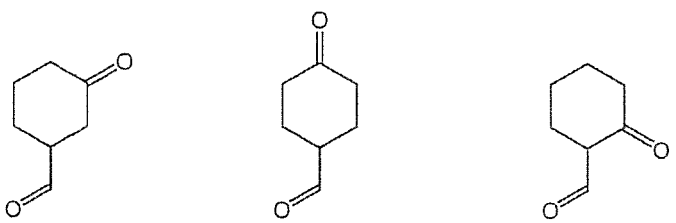
80. O/N 15/P11/Q38, O/N 15/P13/Q38

Each of the compounds below is treated separately with excess $NaBH_4$. The product of each reaction is then heated with excess concentrated H_2SO_4.

In each case, one or more products are formed with molecular formula C_7H_{10}.

Which compounds give **only one** final product with the molecular formula C_7H_{10}?

1 2 3



A	B	C	D
1, 2 and 3 are correct	**1 and 2** only are correct	**2 and 3** only are correct	**1** only is correct

81. M/J 14/P11/Q37

Which pairs of reagents will take part in a redox reaction?

1 CH_3COCH_3 + Tollens' reagent
2 CH_3CH_2CHO + Fehling's reagent
3 $CH_3CH{=}CH_2 + Br_2$

A	B	C	D
1, 2 and 3 are correct	**1 and 2** only are correct	**2 and 3** only are correct	**1** only is correct

82. M/J 14/P13/Q37

Which reactions must be warmed to form a solid product?

1 CH_3CH_2CHO + 2,4-dinitrophenylhydrazine reagent
2 CH_3CH_2CHO + Fehling's reagent
3 CH_3CH_2CHO + Tollens' reagent

A	B	C	D
1, 2 and 3 are correct	**1 and 2** only are correct	**2 and 3** only are correct	**1** only is correct

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83. O/N 13/P12/Q40, O/N 13/P11/Q40

The compounds below are treated with hydrogen cyanide.
Which compounds react and produce a molecule containing a chiral centre?

1 butanal
2 pentan-3-one
3 2-chlorobutane

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

84. M/J 13/P12/Q39

The M_r of compound X is 72. The composition by mass of X is 66.7 % carbon, 11.1 % hydrogen and 22.2 % oxygen. X gives an orange precipitate with 2,4-dinitrophenylhydrazine reagent. **X** does **not** react with Fehling's reagent.
What can be deduced from this information?

1 X is a carbonyl compound.
2 X is a ketone.
3 X is butanone.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

85. O/N 12/P12/Q39, O/N 12/P11/Q39

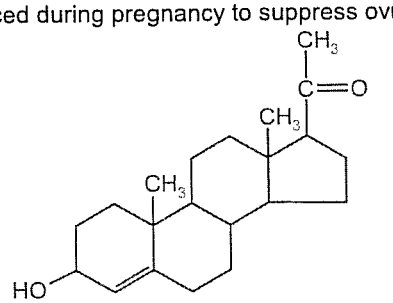
Which reagents react with butanone, $C_2H_5COCH_3$?

1 Tollens' reagent
2 sodium borohydride
3 2,4-dinitrophenylhydrazine reagent

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

86. M/J 12/P12/Q40, O/N 03/P1/Q39

The compound shown is a hormone produced during pregnancy to suppress ovulation.



Which reagents would give positive results with this compound?

1 aqueous bromine
2 2,4-dinitrophenylhydrazine
3 Fehling's reagent

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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87. O/N 12/P13/Q40

Which changes in bonding occur during the reaction of ethanal and hydrogen cyanide?

1 A carbon-carbon bond is formed.
2 A carbon-hydrogen bond is broken.
3 A carbon-nitrogen bond is broken.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

88. O/N 11/P12/Q37

Compound **X** has molecular formula $C_4H_{10}O$. Separate samples of **X** are tested with three different reagents.
Which results could not be obtained?

	Tollens' reagent	2,4-dinitrophenylhydrazine reagent	warm acidified potassium dichromate(VI) solution
1	silver mirror forms	orange precipitate forms	colour changes from orange to green
2	no change	no change	no change
3	no change	no change	colour changes from orange to green

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

89. O/N 11/P11/Q37, O/N 11/P13/Q39

Disaccharides, $C_{12}H_{22}O_{11}$, are important in the human diet. For example, sucrose is found in pastries and lactose occurs in milk products.
Both of these compounds can be hydrolysed.

$$\text{sucrose} + H_2O \rightarrow \underset{\text{glucose}}{CH_2OH(CHOH)_4CHO} + \underset{\text{fructose}}{CH_2OH(CHOH)_3COCH_2OH}$$

$$\text{lactose} + H_2O \rightarrow \underset{\text{glucose}}{CH_2OH(CHOH)_4CHO} + \underset{\text{galactose}}{CH_2OH(CHOH)_4CHO}$$

Which statements about these hydrolysis products are correct?

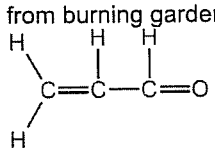
1 Glucose and fructose have structural isomers.
2 Glucose and galactose are optical isomers.
3 Glucose and galactose are ketones.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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90. O/N 10/P12/Q37

The diagram shows a compound present in smoke from burning garden waste.



Which reagents would undergo a colour change on reaction with this compound?

1 aqueous bromine
2 Fehling's reagent
3 warm acidified $K_2Cr_2O_7$

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

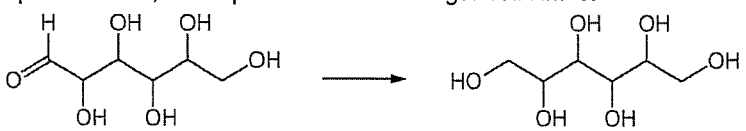
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17.2: Multiple Topics

1. O/N 17/P11/Q26, O/N 17/P13/Q26

Glucose can be used to prepare sorbitol, a compound used as a sugar substitute.



glucose sorbitol

Which reagent may be used for this conversion?

A acidified potassium dichromate(VI)
B sodium borohydride
C sodium hydroxide
D Tollens' reagent

2. M/J 17/P11/Q20

Structural isomerism and stereoisomerism should be considered when answering this question.

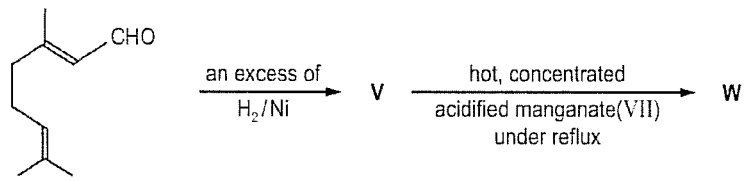
Each of the following carbonyl compounds is reacted with $NaBH_4$. The product of each reaction is heated with Al_2O_3 at 600 °C, generating one product or a mixture of isomers.

Which carbonyl compound will produce the most isomers?

A butanal **B** butanone **C** pentan-3-one **D** propanone

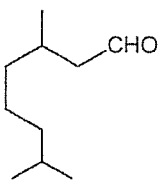
3. M/J 17/P11/Q30

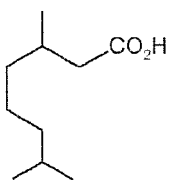
Citral is found in lemongrass oil. It can react to give compound **W**.

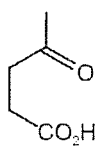


citral

What could compound **W** be?

A


B


C


D


4. MAR 17/P12/Q29

Compound X, $CH_3CH(OH)CH(CHO)CH_3$, is heated under reflux with an excess of acidified $K_2Cr_2O_7$ to form compound Y.

Both X and Y are separately warmed with Fehling's solution and the observations noted.

What are the observations?

A Both X and Y give a red precipitate.
B Only X gives a red precipitate.
C Only Y gives a red precipitate.
D Neither X nor Y gives a red precipitate.

5. O/N 16/P12/Q28

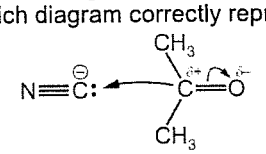
Which row correctly describes the reactivity of aldehydes and ketones?

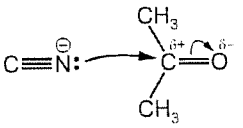
	with $NaBH_4$	with $H^+/Cr_2O_7^{2-}$(aq)
A	both react	both react
B	both react	only aldehydes react
C	only ketones react	both react
D	only ketones react	only aldehydes react

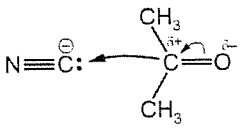
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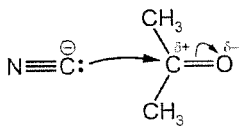
6. O/N 16/P11/Q26, O/N 16/P13/Q26

Propanone reacts with an aqueous mixture of HCN and NaCN by a nucleophilic addition mechanism.
The first stage of the mechanism involves attack by cyanide ions.
Which diagram correctly represents this?

A


B


C


D


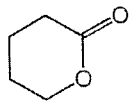
7. M/J 16/P12/Q26

Which organic compound would not give **either** a yellow precipitate when treated with alkaline aqueous iodine or an orange precipitate when treated with 2,4-dinitrophenylhydrazine reagent?

A propanal **B** propan-1-ol **C** propan-2-ol **D** propanone

8. M/J 16/P11/Q27

Cyclic esters are also known as lactones. Delta lactone is used as a solvent and in the manufacture of polyesters.

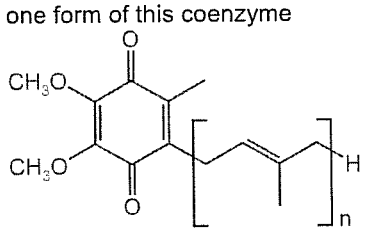


delta lactone

A $HOCH_2CH_2CH_2CH_2CHO$
B $HOCH_2CH_2CH_2CH_2CO_2H$
C $HOCH_2CH_2CH_2CH_2CH_2OH$
D $HOCH_2CH_2CH_2CH_2CH_2CO_2H$

9. MAR 16/P12/Q20

People who take statin drugs to control their blood cholesterol may also take 'coenzyme' Q_{10}.
The diagram shows a simplified structure of one form of this coenzyme



coenzyme Q_{10}

Which row describes this structure correctly?

	the coenzyme is	number of π bonds in one molecule
A	an aldehyde	$n + 2$
B	an aldehyde	$n + 4$
C	a ketone	$n + 2$
D	a ketone	$n + 4$

10. O/N 14/P13/Q21

Aldehydes and ketones are carbonyl compounds.
Which of them react with **both** LiAlH_4 and Tollens' reagent?

A aldehydes only
B both aldehydes and ketones
C ketones only
D neither aldehydes nor ketones

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11. M/J 13/P12/Q28

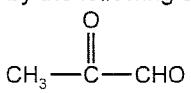
How many of the following compounds produce a carboxylic acid on heating under reflux with hot acidified $K_2Cr_2O_7$?

1 CH_3CH_2CHO
2 CH_3COCH_3
3 $CH_3CH_2CH_2OH$
4 $CH_3CHOHCH_3$

A 1 **B** 2 **C** 3 **D** 4

12. M/J 13/P11/Q27

Burnt sugar has a characteristic smell caused partly by the following compound.

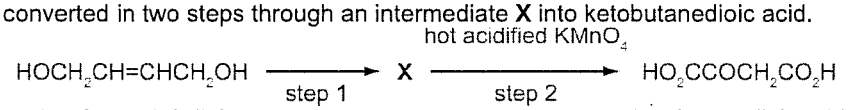


This compound contains two functional groups.
Which reagent will react with **only one** of the functional groups?

A acidified potassium dichromate(VI)
B 2,4-dinitrophenylhydrazine
C hydrogen cyanide
D sodium hydroxide

13. O/N 12/P12/Q24

But-2-ene-1,4-diol is converted in two steps through an intermediate **X** into ketobutanedioic acid.



What could be the reagent for step 1 and the intermediate **X**?

	reagent for step 1	**X**
A	cold acidified $KMnO_4$	$HOCH_2CH_2CH(OH)CH_2OH$
B	hot acidified $KMnO_4$	$OHCCH(OH)CH_2CHO$
C	steam and concentrated H_2SO_4	$HOCH_2CH(OH)CH_2CH_2OH$
D	warm acidified $K_2Cr_2O_7$	$HO_2CCH=CHCO_2H$

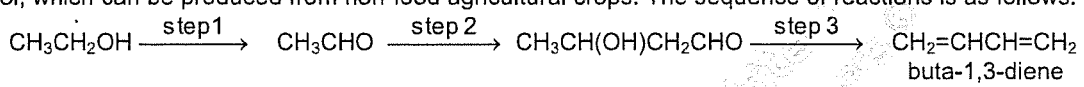
14. M/J 12/P12/Q26

Complete combustion of compound X gives carbon dioxide and water only. A sample of X is mixed with aqueous potassium(V) dichromate and boiled under reflux for one hour. The mixture is then distilled and the only organic substance present is collected.
The organic substance collected reacts with sodium to give hydrogen, but does not react with 2,4-dinitrophenylhydrazine reagent and does not react with ethanol in the presence of concentrated sulfuric acid to give an ester.
What can be deduced from this information?

A X is a carboxylic acid.
B X is a ketone.
C X is an alcohol.
D X is an alkane.

15. O/N 11/P12/Q21

Buta-1,3-diene is currently obtained from fossil fuel sources. In future it may be obtained from ethanol, which can be produced from non-food agricultural crops. The sequence of reactions is as follows.



Which term could be used to describe step 1?

A condensation **B** dehydration **C** dehydrogenation **D** hydrogenation

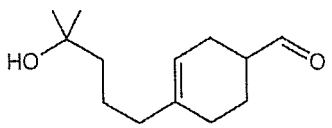
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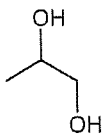
16. MAR 20/P12/Q38

Which compounds will produce a yellow precipitate with alkaline aqueous iodine?

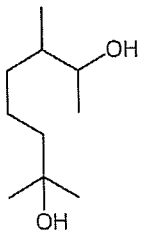
1



2



3

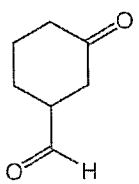


A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

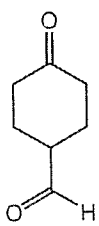
17. O/N 19/P12/Q40

Each of the compounds below is treated separately with an excess of $NaBH_4$.
The product of each reaction is then heated with an excess of concentrated H_2SO_4.
Which compounds give **only one** final product with the molecular formula C_7H_{10}?

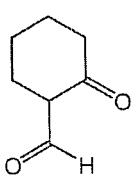
1



2



3



A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

18. M/J 19/P12/Q40, O/N 15/P11/Q37, O/N 15/P13/Q37

An oxidising agent that can oxidise ethanal to ethanoic acid, or to ethanoate ions, will also oxidise methanoic acid, HCO_2H, to carbon dioxide and water.
Which reagents, on heating, will react differently with HCO_2H and CH_3CO_2H?

1 $Na_2CO_3(aq)$
2 Fehling's reagent
3 dilute acidified $KMnO_4$

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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19. MAR 17/P12/Q39

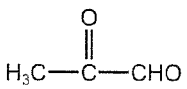
Which compounds react with alkaline aqueous iodine to give a pale yellow precipitate of tri-iodomethane?

1 butanone
2 ethanal
3 propan-2-ol

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

20. O/N 16/P12/Q39

The compound shown is produced when sugar burns.



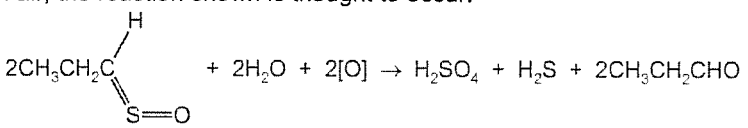
Which reagents would give a positive result with this compound?

1 alkaline aqueous iodine
2 2,4-dinitrophenylhydrazine
3 Fehling's solution

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

21. O/N 16/P11/Q40, O/N 16/P13/Q40

When onions are peeled in air, the reaction shown is thought to occur.



Which tests would give a positive reaction with the organic product?

1 warming with Tollens' reagent
2 warming with acidified potassium manganate(VII)
3 warming with alkaline aqueous iodine

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

22. M/J 16/P12/Q40

Which synthesis will be successful?

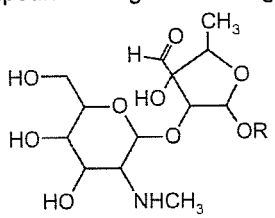
1 $CH_3CH_2CH_3$ from $CH_3CH{=}CH_2$ + $LiAlH_4$
2 $CH_3CH(OH)CH_3$ from CH_3COCH_3 + $NaBH_4$
3 $CH_3CH_2CH_2OH$ from CH_3CH_2CHO + $NaBH_4$

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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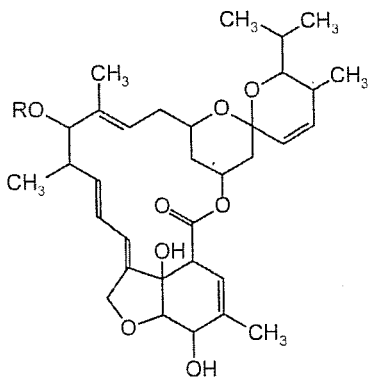
23. M/J 16/P13/Q39

Which compounds will give an orange precipitate with 2,4-dinitrophenylhydrazine reagent?

1 

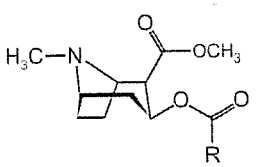
[R is an inert group]

streptomycin

2 

[R is an inert group]

avermectin B_{1b}

3 

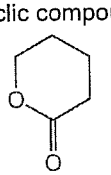
[R is an inert group]

cocaine

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

24. M/J 15/P11/Q40

5-hydroxypentanoic acid is readily converted into the cyclic compound L.



L

Which statements about this reaction are correct?

1 Acidified sodium dichromate(VI) is used as a reagent.
2 A water molecule is produced in the reaction.
3 The reaction is catalysed by concentrated H_2SO_4.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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25. M/J 15/P13/Q38

Which changes in bonding occur during the reaction of propanal and hydrogen cyanide?

1 A carbon-hydrogen bond is broken.
2 An oxygen-hydrogen bond is formed.
3 A carbon-carbon bond is formed.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

26. M/J 15/P13/Q39

Which pairs of reagents will react together in a redox reaction?

1 CH_3CHO + Fehling's reagent
2 $C_2H_4 + Br_2(aq)$
3 $CH_4 + Cl_2(g)$

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

27. O/N 14/P12/Q39, O/N 14/P11/Q39

For which mixtures of reagents are the colour changes described correctly?

	reagents	colour change
1	pentanal + hot, acidified potassium dichromate(VI)	orange to green
2	pentan-2-one + warm Fehling's reagent	no change
3	cyclohexane + cold, acidified potassium manganate(VII)	purple to colourless

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

28. O/N 14/P13/Q39

Which reactions have a coloured organic product?

1 ethanal + 2,4-dinitrophenylhydrazine reagent
2 ethanol + acidified potassium dichromate(VI)
3 ethene + cold dilute acidified potassium manganate(VII)

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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29. O/N 14/P13/Q40

Propanal will react with hydrogen cyanide to form 2-hydroxybutanenitrile. A suitable catalyst for this reaction is sodium cyanide.

$$CH_3CH_2CHO + HCN \xrightleftharpoons{NaCN} CH_3CH_2CH(OH)CN$$

Which statements about the reaction of propanal with hydrogen cyanide are correct?

1 The sodium cyanide provides a stronger nucleophile than HCN.
2 The reaction mechanism involves two steps.
3 The product of the reaction has a chiral carbon atom.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

30. M/J 14/P12/Q39

Which pairs of reagents will take part in a redox reaction under suitable conditions?

1 $CH_3(CH_2)_4CHO$ + Tollens' reagent
2 $CH_3(CH_2)_4CH_3 + Br_2$
3 $CH_3CO(CH_2)_4CH_3$ + Fehling's reagent

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

31. M/J 14/P13/Q38

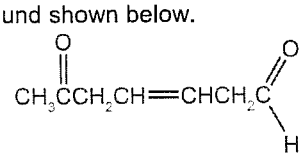
When hydrolysed with dilute sulfuric acid, which compounds produce propanoic acid?

1 $CH_3CH_2CO_2CH_3$
2 $CH_3CH_2CH_2CN$
3 $CH_3CH_2CH_2Cl$

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

32. O/N 13/P13/Q37

A series of tests was carried out on the compound shown below.



Which pairs of reagents would **both** give a positive result for this compound?

1 Tollens' reagent and a solution containing acidified dichromate(VI) ions
2 aqueous bromine and Fehling's reagent
3 2,4-dinitrophenylhydrazine reagent and sodium carbonate

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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33. O/N 13/P13/Q38

The reaction of ethanal, CH_3CHO, with HCN to form a cyanohydrin is catalysed by NaCN.
What are features of the intermediate of this reaction?

1 It is chiral.
2 It has a single negative charge on one of its atoms.
3 It is a nucleophile.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

34. M/J 13/P13/Q39

A liquid **X** is known to be either a single organic compound or a mixture of organic compounds.
When treated with sodium, **X** gives off hydrogen gas.
When treated with 2,4-dinitrophenylhydrazine reagent, **X** gives orange crystals.
Which deductions about **X** can definitely be made?

1 At least one component of **X** is a carbonyl compound.
2 Only one of the components of **X** is a carbonyl compound.
3 At least one component of **X** is an alcohol.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

35. M/J 13/P13/Q40

Ethanoic acid, CH_3CO_2H, is an important chemical which is used in the industrial manufacture of rayon and aspirin.
Which processes can be used to make ethanoic acid?

1 hydrolysis of ethanenitrile
2 oxidation of ethanol
3 oxidation of ethanal

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

36. M/J 13/P11/Q38

In which reactions is the organic compound oxidised by the given reagent?

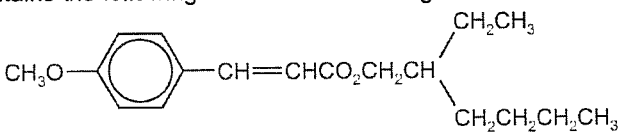
1 CH_3CH_2CHO + Fehling's reagent
2 $CH_3CH_2CH_2CHO$ + Tollens' reagent
3 CH_3CHO + 2,4-dinitrophenylhydrazine reagent

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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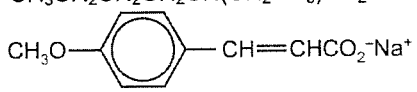
37. M/J 13/P11/Q39, M/J 09/P1/Q40, M/J 05/P1/Q40

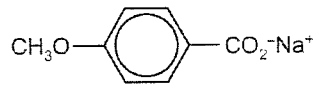
A sun protection cream contains the following ester as its active ingredient.



Which substances are present in the products of its hydrolysis by aqueous sodium hydroxide?

1 $CH_3CH_2CH_2CH_2CH(CH_2CH_3)CH_2OH$

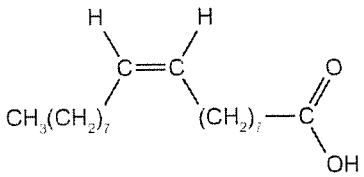
2 

3 

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

38. O/N 12/P12/Q40, O/N 12/P11/Q40

Oleic acid is found in olive oil. It has the following formula.



Which reagents will give a positive result with oleic acid?

1 aqueous bromine
2 acidified potassium dichromate(VI)
3 Fehling's reagent

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

39. O/N 12/P13/Q38

Which pairs of reagents will react together in a redox reaction?

1 CH_3CHO + Fehling's reagent
2 CH_4 + Cl_2
3 CH_3COCH_3 + Tollens' reagent

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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40. O/N 11/P12/Q40

Which pairs of homologous series have the same C : H ratio in their general formulae?

1 aldehydes and ketones
2 carboxylic acids and esters
3 alkenes and ketones

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

41. O/N 11/P13/Q38, O/N 11/P11/Q39

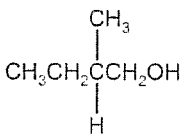
On acid hydrolysis, which compounds produce propanoic acid?

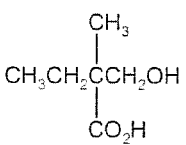
1 $CH_3CH_2CO_2CH_3$
2 $CH_3CH_2CH_2CN$
3 $CH_3CH_2CH_2C\mathit{l}$

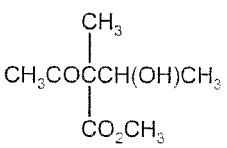
A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

42. M/J 11/P12/Q38

Which compounds when heated under reflux with an excess of hot acidified potassium dichromate(VI), give a product with a chiral centre?

1 

2 

3 

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

43. M/J 11/P12/Q39

In the reaction between an aldehyde and HCN, catalysed by NaCN, which statements about the reaction mechanism are correct?

1 A new carbon-carbon bond is formed.
2 In the intermediate, the oxygen carries a negative charge.
3 The last stage involves the formation of a hydrogen-oxygen bond.

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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44. O/N 10/P11/Q38

Glyceraldehyde, $HOCH_2CH(OH)CHO$, is formed during photosynthesis, and contains a chiral carbon atom.
Which reagents will react with glyceraldehyde to produce an organic product **without** a chiral carbon atom?

1 warmed acidified $K_2Cr_2O_7$
2 $NaBH_4$
3 Tollens' reagent

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

45. O/N 09/P12/Q39, O/N 09/P11/Q40

A compound has a relative molecular mass of 88 and its molecule contains only four carbon atoms.
What could this compound be?

1 a saturated non-cyclic diol
2 a secondary alcohol containing an aldehyde group
3 a primary alcohol containing a ketone group

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

46. M/J 09/P1/Q39, M/J 06/P1/Q39

How can the rate of reaction between ethanal and aqueous hydrogen cyanide be increased?

1 by irradiation with ultraviolet light
2 by a rise in temperature
3 by the addition of a small quantity of aqueous sodium cyanide

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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Answers Sections

17.1						17.2			
1.	D	**41.**	B	**81.**	C	**1.**	B	**41.**	D
2.	A	**42.**	B	**82.**	C	**2.**	B	**42.**	D
3.	B	**43.**	B	**83.**	D	**3.**	B	**43.**	A
4.	D	**44.**	D	**84.**	A	**4.**	B	**44.**	B
5.	D	**45.**	C	**85.**	C	**5.**	B	**45.**	C
6.	A	**46.**	C	**86.**	B	**6.**	D	**46.**	C
7.	A	**47.**	C	**87.**	B	**7.**	B		
8.	A	**48.**	A	**88.**	D	**8.**	B		
9.	B	**49.**	B	**89.**	B	**9.**	D		
10.	D	**50.**	B	**90.**	A	**10.**	A		
11.	A	**51.**	B			**11.**	B		
12.	A	**52.**	B			**12.**	A		
13.	A	**53.**	C			**13.**	C		
14.	A	**54.**	B			**14.**	C		
15.	D	**55.**	D			**15.**	C		
16.	B	**56.**	B			**16.**	C		
17.	B	**57.**	D			**17.**	C		
18.	A	**58.**	C			**18.**	C		
19.	D	**59.**	C			**19.**	A		
20.	C	**60.**	C			**20.**	A		
21.	D	**61.**	D			**21.**	B		
22.	D	**62.**	B			**22.**	C		
23.	D	**63.**	C			**23.**	D		
24.	D	**64.**	C			**24.**	C		
25.	B	**65.**	D			**25.**	A		
26.	A	**66.**	A			**26.**	A		
27.	D	**67.**	A			**27.**	B		
28.	D	**68.**	B			**28.**	D		
29.	D	**69.**	A			**29.**	A		
30.	B	**70.**	C			**30.**	B		
31.	A	**71.**	B			**31.**	D		
32.	B	**72.**	A			**32.**	B		
33.	A	**73.**	C			**33.**	A		
34.	B	**74.**	B			**34.**	D		
35.	D	**75.**	C			**35.**	A		
36.	B	**76.**	A			**36.**	B		
37.	A	**77.**	B			**37.**	B		
38.	D	**78.**	B			**38.**	D		
39.	C	**79.**	B			**39.**	B		
40.	B	**80.**	C			**40.**	A		

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Unit 18

CARBOXYLIC ACIDS AND DERIVATIVES

A Level
Chemistry Paper 1
Classified/Topical MCQ's
Article Number: 231

Editorial Board

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Syllabus

18.1 Carboxylic acids
18.2 Acyl chlorides
18.3 Esters
18.4 Multiple topics

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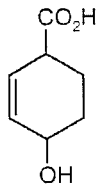
Unit 18: Carboxylic acids and derivatives

18.1: Carboxylic acids

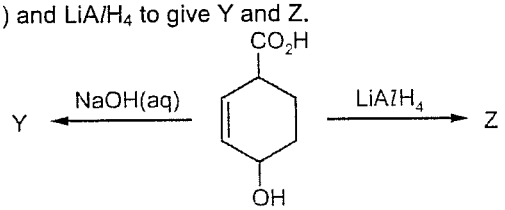
1. M/J 20/P12/Q20

Compound X is shown.

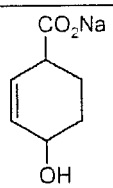
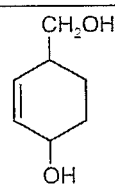
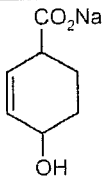
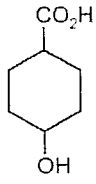
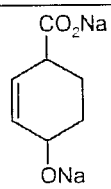
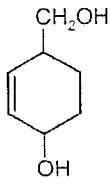
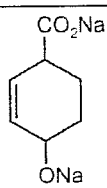
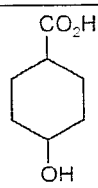
compound X



X is treated separately with NaOH(aq) and LiA/H_4 to give Y and Z.



What are Y and Z?

	Y	Z
A		
B		
C		
D		

2. M/J 20/P13/Q26

Which reagent reacts with both of the –OH groups in lactic acid, $CH_3CH(OH)CO_2H$?

A acidified potassium dichromate(VI)

B ethanol

C sodium

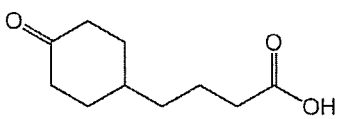
D sodium hydroxide

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3. MAR 20/P12/Q28

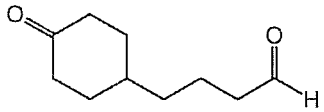
Compound X is treated with an excess of lithium aluminium hydride. The reaction is allowed to go to completion.

X

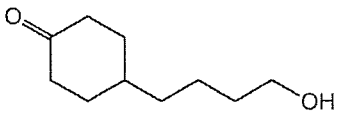


What is the structure of the organic product?

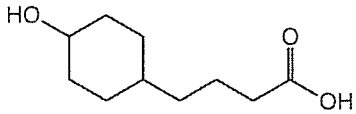
A



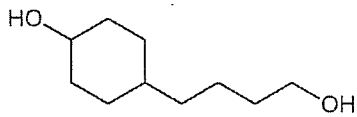
B



C



D

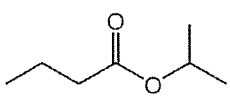


4. O/N 19/P12/Q28

Esters can be prepared by the reaction of a carboxylic acid with an alcohol in the presence of concentrated sulfuric acid.

Which row gives the correct names of the reagents that would be suitable to prepare ester Z?

Z



	alcohol	carboxylic acid
A	butan-1-ol	methyl propanoic acid
B	propan-1-ol	butanoic acid
C	propan-2-ol	butanoic acid
D	propan-2-ol	propanoic acid

5. O/N 19/P11/Q28, O/N 19/P13/Q28

Tartaric acid, $HO_2CCH(OH)CH(OH)CO_2H$, is found in many plants.

A sample of tartaric acid reacts with an excess of $LiAlH_4$ to form the organic product J.

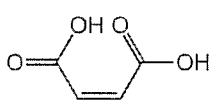
What happens when NaOH(aq) is added to separate samples of tartaric acid and J?

A Both tartaric acid and J react.
B Only tartaric acid reacts.
C Only J reacts.
D Neither tartaric acid nor J react.

6. M/J 19/P13/Q21

The diagram shows the skeletal formula of compound Y.

Y



What is the empirical formula of Y?

A CHO **B** CH_2O_2 **C** C_2HO_2 **D** $C_4H_4O_4$

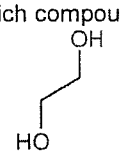
7. MAR 19/P12/Q29

1 mole of each of the following four compounds is reacted separately with:

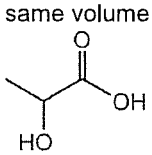
- an excess of sodium
- an excess of sodium carbonate.

Which compound produces the same volume of gas with each of the two reagents?

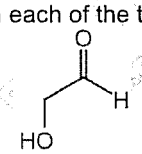
A



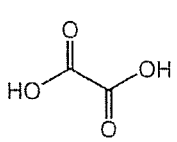
B



C



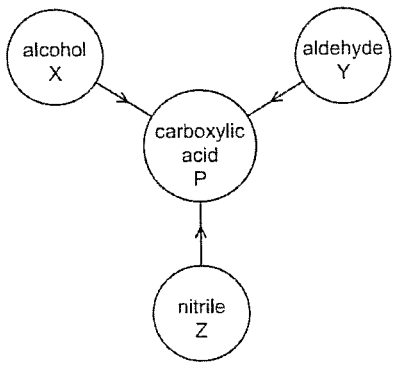
D



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8. M/J 19/P12/Q28

The diagram shows that a carboxylic acid P may be formed from X, Y or Z.



Which row is correct?

	alcohol X is	the change in M_r is greatest for
A	primary	Y to P
B	primary	Z to P
C	secondary	Y to P
D	secondary	Z to P

9. O/N 18/P11/Q28, O/N 18/P13/Q28

Ethanedioic acid, HO_2CCO_2H, is reduced using an excess of lithium aluminium hydride, $LiAlH_4$.

What is the organic product of the reaction?

A ethanol

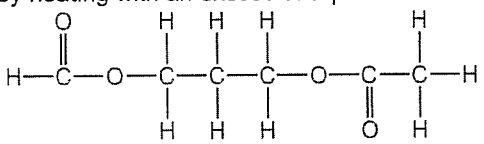
B ethane-1,2-diol

C ethanedial, OHCCHO

D methane

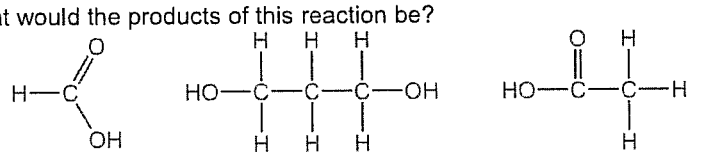
10. O/N 18/P11/Q29, O/N 18/P13/Q29

The diester shown can be hydrolysed by heating with an excess of aqueous sodium hydroxide.

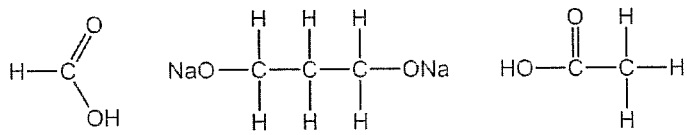


What would the products of this reaction be?

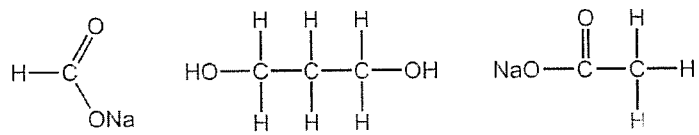
A



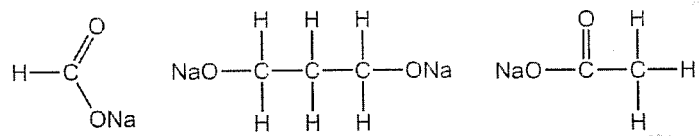
B



C



D



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11. M/J 18/P12/Q22

Maleic acid is used in the food industry and for stabilising drugs. It is the cis-isomer of butenedioic acid and has the structural formula $HO_2CCH=CHCO_2H$.

What is the product formed from the reaction of maleic acid with cold, dilute, acidified manganate(VII) ions?

A $HO_2CCH(OH)CH(OH)CO_2H$ **C** $HO_2CCH_2CH(OH)CO_2H$

B HO_2CCO_2H **D** $HO_2CCOCOCO_2H$

12. O/N 17/P11/Q28, O/N 17/P13/Q28

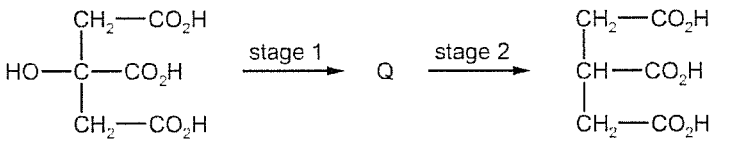
At room temperature, propanoic acid was reacted to produce sodium propanoate. No gas was produced during the reaction.

What could the propanoic acid have reacted with?

A $NaHCO_3(aq)$ **B** $NaOH(aq)$ **C** $Na_2CO_3(aq)$ **D** $Na_2SO_4(aq)$

13. O/N 17/P11/Q25, O/N 17/P13/Q25

Citric acid can be converted into tricarballylic acid in two stages. An intermediate, Q, is formed.



citric acid tricarballylic acid

Which reagents are needed for each stage?

	stage 1	stage 2
A	concentrated H_2SO_4	$H_2(g)$ and Ni
B	concentrated H_2SO_4	$LiAlH_4$
C	$LiAlH_4$	$H_2SO_4(aq)$
D	$NaOH(aq)$	$H_2(g)$ and Ni

14. O/N 17/P11/Q29, O/N 17/P13/Q29

Ethene is reacted with steam in the presence of concentrated H_3PO_4. The product of this reaction is added to acidified potassium dichromate(VI) and heated under reflux for one hour. The final organic product is collected and labelled X.

But-2-ene is treated with hot, concentrated, acidified potassium manganate(VII). The final organic product is collected and labelled Y.

Which statement is correct?

A One molecule of X has more carbon atoms than one molecule of Y.

B One molecule of Y has more carbon atoms than one molecule of X.

C X and Y have different functional groups.

D X is the same compound as Y.

15. M/J 17/P12/Q28

A carboxylic acid, P, has no possible chain isomers. It reacts with an alcohol, Q, that has only one positional isomer.

What could be the ester formed from a reaction between P and Q?

A butyl propanoate **B** ethyl butanoate **C** pentyl ethanoate **D** propyl pentanoate

16. O/N 16/P11/Q28, O/N 16/P13/Q28

Which reaction would **not** give ethanoic acid?

A heating ethanenitrile under reflux with dilute sodium hydroxide

B heating ethanenitrile under reflux with dilute sulfuric acid

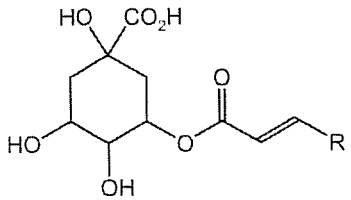
C heating ethanal under reflux with acidified sodium dichromate(VI)

D heating ethanol under reflux with acidified sodium dichromate(VI)

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17. M/J 17/P13/Q28

Chlorogenic acid is found in green coffee beans and is used in treatments for weight loss.

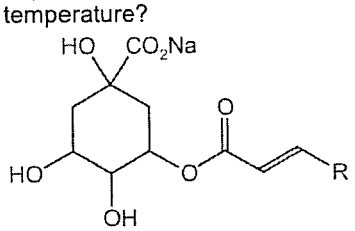


chlorogenic acid

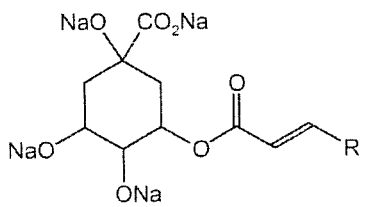
R = $C_6H_5O_2$ and takes no part in the reaction with sodium carbonate.

What is produced in good yield when chlorogenic acid is treated with an excess of sodium carbonate solution at room temperature?

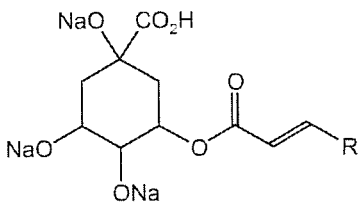
A



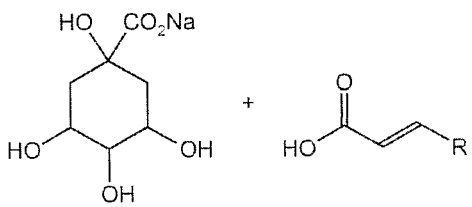
B



C

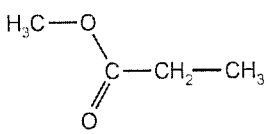


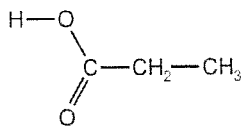
D

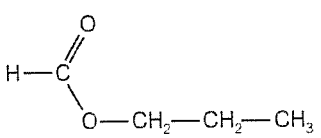


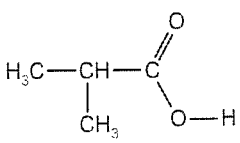
18. O/N 16/P12/Q29, O/N 13/P12/Q29

How many of the compounds shown will react with aqueous sodium hydroxide to form the sodium salt of a carboxylic acid?









A 1 **B** 2 **C** 3 **D** 4

19. M/J 15/P12/Q29

Citric acid is found in lemon juice.

$HO_2CCH_2C(OH)(CO_2H)CH_2CO_2H$

citric acid

What is the volume of 0.4 mol dm^{-3} sodium hydroxide solution required to neutralise a solution containing 0.005 mol of citric acid?

A 12.5 cm^3 **B** 25.0 cm^3 **C** 37.5 cm^3 **D** 50.0 cm^3

20. O/N 14/P12/Q24, O/N 14/P11/Q24

Lactic acid, $CH_3CH(OH)CO_2H$, causes pain when it builds up in muscles.

Which reagent reacts with **both** of the –OH groups in lactic acid?

A acidified potassium dichromate(VI)

B ethanol

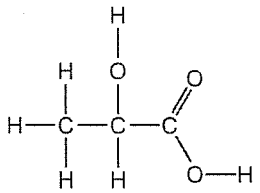
C sodium

D sodium hydroxide

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21. M/J 15/P12/Q28, O/N 10/P11/Q26, O/N 10/P13/Q26, O/N 05/P1/Q29

Lactic acid occurs naturally, for example in sour milk.



lactic acid

What is a property of lactic acid?

A It decolourises aqueous bromine rapidly.

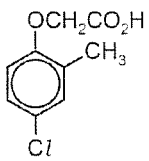
B It is insoluble in water.

C It reduces Fehling's reagent.

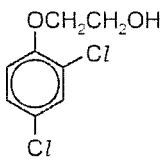
D Two molecules react with each other in the presence of a strong acid.

22. O/N 11/P11/Q23, O/N 11/P13/Q21

Y and **Z** are two widely-used selective weed killers.



Y



Z

Which reagent will distinguish **Y** from **Z**?

A acidified $AgNO_3(aq)$

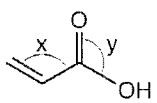
B Fehling's solution

C Na

D $Na_2CO_3(aq)$

23. M/J 11/P11/Q20, M/J 11/P13/Q21

Acrylic acid is produced from propene, a gaseous product of oil refineries.



acrylic acid

Which statement about acrylic acid is not correct?

A Both bond angles x and y are approximately 120°.

B It decolourises aqueous bromine.

C It gives an orange precipitate with 2,4-dinitrophenylhydrazine reagent.

D It reacts with an alcohol to give an ester.

24. O/N 10/P11/Q22, O/N 10/P13/Q20

A compound Y has all of the properties below.

- It is a liquid at 25 °C.
- It mixes completely with water.
- It reacts with aqueous sodium hydroxide.

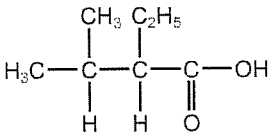
What could Y be?

A ethanoic acid **B** ethanol **C** ethene **D** ethyl ethanoate

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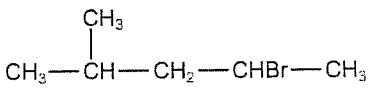
25. O/N 09/P12/Q28, O/N 09/P11/Q29

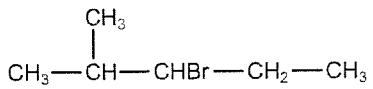
The characteristic odour of rum is attributed to the compound 2-ethyl-3-methylbutanoic acid.

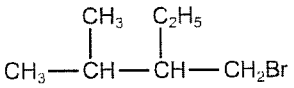


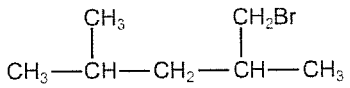
2-ethyl-3-methylbutanoic acid

Which compound will produce 2-ethyl-3-methylbutanoic acid by heating under reflux with alcoholic sodium cyanide and subsequent acid hydrolysis of the reaction product?

A 

B 

C 

D 

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26. O/N 19/P11/Q37, O/N 19/P13/Q37

The structure of tiglic acid is $CH_3CH=C(CH_3)CO_2H$.

Which statements about the properties of one molecule of this acid are correct?

1 It contains two π bonds.
2 It contains four lone pairs of electrons.
3 It has all its atoms in the same plane.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

27. M/J 19/P11/Q39

Carboxylic acids can be made by several different reactions.

Which statements are correct?

1 The acid hydrolysis of CH_3CH_2CN will make ethanoic acid.
2 The oxidation of $CH_3CH_2CH_2CH_2OH$ will make butanoic acid.
3 The oxidation of CH_3CH_2CHO will make propanoic acid.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

28. M/J 19/P11/Q40

Carboxylic acids react with alcohols to produce esters.

Carboxylic acid X forms one ester only with molecular formula $C_5H_{10}O_2$.

What could X be?

1 ethanoic acid
2 propanoic acid
3 butanoic acid

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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29. M/J 19/P13/Q39, MAR 16/P12/Q39

An unknown organic compound **Z** reacts with sodium to give a combustible gas as one product. **Z** does **not** give a yellow precipitate with alkaline aqueous iodine.

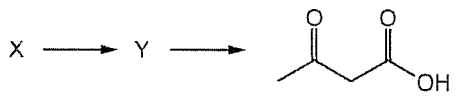
What is a possible identity of **Z**?

1 ethanoic acid
2 pentan-3-ol
3 propan-1-ol

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

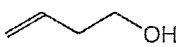
30. O/N 18/P11/Q39, O/N 18/P13/Q39

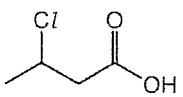
3-oxobutanoic acid can be synthesised in a two-step process.

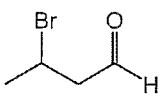


3-oxobutanoic acid

What could be the structure of X?

1 

2 

3 

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

31. O/N 17/P12/Q34

Methanoic acid, HCO_2H, and hydrocyanic acid, HCN, can both behave as acids.

A solution of methanoic acid has a lower pH than a solution of hydrocyanic acid of the same concentration.

Which statements explain this?

1 HCO_2H molecules dissociate more fully than HCN molecules do.
2 Each HCO_2H molecule has two hydrogen atoms; each HCN molecule only has one.
3 Methanoic acid is a weaker acid than hydrocyanic acid.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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32. O/N 17/P12/Q40

Carboxylic acids can be converted into their salts by a number of reactions at room temperature.
Which reactions would produce sodium butanoate and a gas?

1 sodium carbonate + butanoic acid
2 sodium + butanoic acid
3 sodium hydroxide + butanoic acid

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

33. M/J 17/P12/Q37

Which compounds contain a chiral centre?

1 2-hydroxybutanoic acid
2 3-hydroxybutanoic acid
3 4-hydroxybutanoic acid

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

34. O/N 16/P12/Q40

Which statements about the formation of a carboxylic acid are correct?

1 A carboxylic acid can be produced by hydrolysis of a nitrile.
2 A carboxylic acid can be produced by oxidation of a primary alcohol.
3 A carboxylic acid can be produced by reduction of an aldehyde.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

35. MAR 16/P12/Q37, M/J 13/P11/Q40

Which reagents, when used in an excess, can be used to make sodium lactate, $CH_3CH(OH)CO_2Na$, from lactic acid, $CH_3CH(OH)CO_2H$?

1 Na
2 $NaHCO_3$
3 NaOH

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

36. O/N 15/P11/Q39, O/N 15/P13/Q39

Which reactions result in the formation of propanoic acid?

1 $CH_3CH_2CO_2Na$ with dilute $H_2SO_4(aq)$
2 $CH_3CH{=}CHCH_3$ with hot, concentrated $H^+/MnO_4^-(aq)$
3 CH_3CH_2OH with $H^+/Cr_2O_7^{2-}(aq)$

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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37. MAR 16/P12/Q40

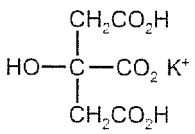
The responses **A** to **D** should be selected on the basis of
No other combination of statements is used as a correct response.
Compound **X** has the molecular formula $C_3H_6O_3$.
Heating **X** under reflux with acidified $K_2Cr_2O_7$ forms HO_2CCOCO_2H.
Reacting **X** with $NaBH_4$ forms $HOCH_2CH(OH)CH_2OH$.
What is a possible structural formula for **X**?

1 $HOCH_2CH_2CO_2H$
2 $HOCH_2CH(OH)CHO$
3 $HOCH_2COCH_2OH$

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

38. M/J 15/P12/Q40

Monopotassium citrate is used as an emulsifying agent in powdered milk and in powdered soups.
It may be represented by the formula shown.



monopotassium citrate

Which statements about monopotassium citrate are correct?

1 It does not have a chiral carbon atom.
2 It can act as a dibasic acid.
3 It reacts with $NaHCO_3$ to give CO_2.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

39. M/J 15/P11/Q38, O/N 12/P13/Q39

An organic compound, **X**, will react with calcium metal to produce a salt with the empirical formula $CaC_4H_4O_4$.
What could be the identity of **X**?

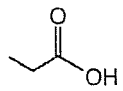
1 ethanoic acid
2 butanedioic acid
3 2-methylpropanedioic acid

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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40. M/J 14/P12/Q40, M/J 10/P12/Q38, M/J 10/P11/Q37, M/J 10/P13/Q39

Propanoic acid occurs naturally as a result of the bacterial fermentation of milk, and is partly responsible for the flavour of Swiss cheese.



propanoic acid

Which starting materials could be used to synthesise propanoic acid?

1 $CH_3CH_2CH_2OH$
2 CH_3CH_2CN
3 CH_3CH_2CHO

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

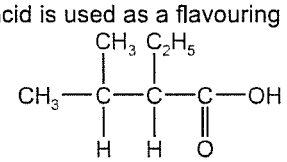
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18.2: Acyl chlorides

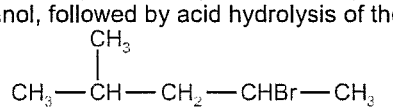
1. O/N 14/P13/Q27

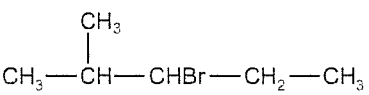
The compound 2-ethyl-3-methylbutanoic acid is used as a flavouring in some food.

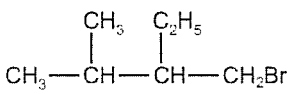


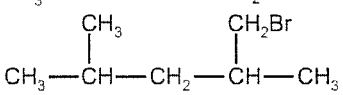
2-ethyl-3-methylbutanoic acid

Which compound will produce 2-ethyl-3-methylbutanoic acid when heated under reflux with sodium cyanide in ethanol, followed by acid hydrolysis of the reaction product?

A 

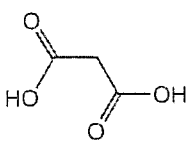
B 

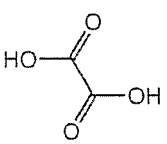
C 

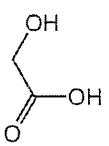
D 

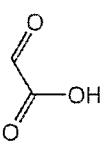
2. M/J 14/P11/Q21

Hydroxyethanal, $HOCH_2CHO$, is heated under reflux with an excess of acidified potassium dichromate(VI) until no further oxidation takes place. What is the skeletal formula of the organic product?

A 

B 

C 

D 

3. M/J 14/P13/Q28

The compound cetyl palmitate, $C_{15}H_{31}CO_2C_{16}H_{33}$, is a waxy solid.

When cetyl palmitate is heated under reflux with an excess of aqueous sodium hydroxide, which products will be formed?

A $C_{15}H_{31}ONa$ and $C_{16}H_{33}CO_2Na$

B $C_{15}H_{31}CO_2Na$ and $C_{16}H_{33}ONa$

C $C_{15}H_{31}OH$ and $C_{16}H_{33}CO_2Na$

D $C_{15}H_{31}CO_2Na$ and $C_{16}H_{33}OH$

4. M/J 12/P11/Q21

An organic compound **J** reacts with sodium to produce an organic ion with a charge of –3.**J** reacts with NaOH(aq) to produce an organic ion with a charge of –1.

What could be the structural formula of **J**?

A $HO_2CCH(OH)CH_2CO_2H$

B $HO_2CCH(OH)CH_2CHO$

C $HOCH_2CH(OH)CH_2CO_2H$

D $HOCH_2COCH_2CHO$

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5. M/J 13/P12/Q38

What can be produced when an aqueous solution of butan-2-ol is oxidised under suitable conditions?

1 butanone
2 butanoic acid
3 butanal

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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18.3: Esters

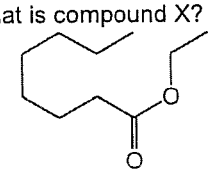
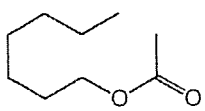
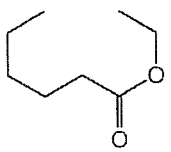
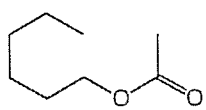
1. **M/J 20/P12/Q23**
Ester X is shown.

ester X
$CH_3CO_2(CH_2)_7CH_3$

Ester X is hydrolysed using aqueous sodium hydroxide.
What is the molecular formula of one of the products?

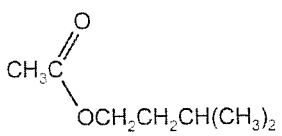
A $C_2H_4O_2$ **B** $C_2H_3O_2Na$ **C** $C_8H_{16}O$ **D** $C_8H_{17}O_2Na$

2. **M/J 20/P11/Q26**
When compound X is heated under reflux with aqueous sodium hydroxide solution two products are formed: sodium ethanoate and hexan-1-ol.
What is compound X?

A  **B**  **C**  **D** 

3. **M/J 20/P13/Q21**
Ester P has the following structural formula.

ester P

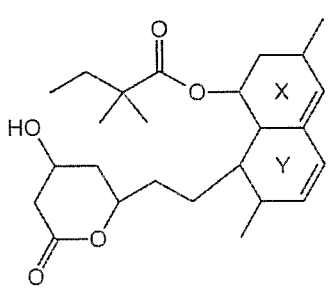


Which compounds are produced when P is hydrolysed using dilute hydrochloric acid?

A CH_3COCl and $(CH_3)_2CHCH_2CH_2OH$
B CH_3CH_2OH and $(CH_3)_2CHCH_2CO_2H$
C CH_3CO_2H and $(CH_3)_2CHCH_2CO_2H$
D CH_3CO_2H and $(CH_3)_2CHCH_2CH_2OH$

4. **MAR 20/P12/Q30**
The diagram shows the structure of compound Q.

Q



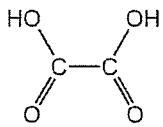
Two of the rings, X and Y, contain a C=C bond.
Which row is correct?

	number of ester groups in one molecule of Q	description of rings X and Y
A	1	both are planar
B	1	neither is planar
C	2	both are planar
D	2	neither is planar

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5. MAR 20/P12/Q22, M/J 14/P12/Q28

The diagram shows the structure of ethanedioic acid.



Ethanedioic acid reacts with ethanol in the presence of a few drops of concentrated sulfuric acid to form a diester. The molecular formula of the diester is $C_6H_{10}O_4$.

What is the structural formula of the diester?

A $CH_3CH_2CO_2CO_2CH_2CH_3$ **C** $CH_3CH_2O_2CO_2CCH_2CH_3$

B $CH_3CH_2OCOCO_2CH_2CH_3$ **D** $CH_3CO_2CH_2CH_2OCOCH_3$

6. O/N 19/P12/Q29

Compound Q can be hydrolysed by HCl(aq). The two products of this hydrolysis have the same empirical formula.

What could Q be?

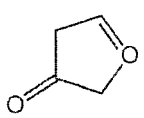
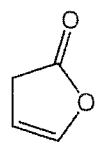
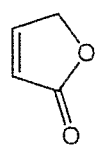
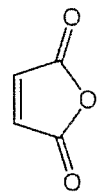
A $CH_3CO_2CH_2CH_2OH$ **C** $CH_3CH_2CO_2CH_2CH_2CH_3$

B $CH_3CO_2CH_2CH_2CO_2H$ **D** $CH_3CH_2CH(OH)CH(OH)CH_2CH_3$

7. O/N 19/P11/Q29, O/N 19/P13/Q29

When $CH_2(OH)CH{=}CHCO_2H$ is warmed with a little concentrated sulfuric acid, a cyclic compound is formed.

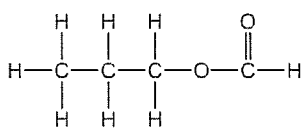
What is the skeletal formula of the cyclic compound?

A  **B**  **C**  **D** 

8. M/J 19/P12/Q29

One molecule of compound R is shown.

compound R



What is the name of compound R and how does its boiling point compare with that of butanoic acid?

	name of R	boiling point of R
A	methyl propanoate	higher than butanoic acid
B	methyl propanoate	lower than butanoic acid
C	propyl methanoate	higher than butanoic acid
D	propyl methanoate	lower than butanoic acid

9. M/J 19/P13/Q29, O/N 11/P13/Q29, O/N 11/P11/Q30

Which pair of substances could react to give the ester $CH_3CH_2CO_2CH_3$?

A ethanol and ethanoic acid **C** methanol and propanoic acid

B methanol and ethanoic acid **D** propan-1-ol and methanoic acid

10. M/J 18/P12/Q29

The ester ethyl butanoate can be hydrolysed using an excess of dilute sodium hydroxide solution.

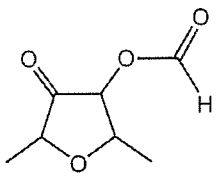
Which substance is a product of this reaction?

A $CH_3CH_2CH_2CO_2Na$ **B** CH_3CO_2Na **C** CH_3CH_2ONa **D** H_2O

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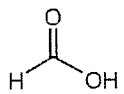
11. M/J 19/P13/Q30

An ester is shown.

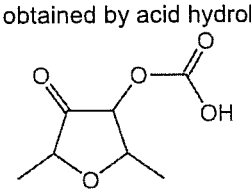


What is the structure of the carboxylic acid that would be obtained by acid hydrolysis of the ester linkage?

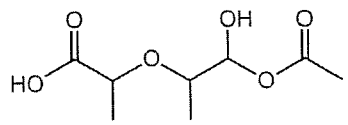
A



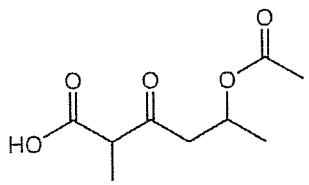
C



B



D



12. M/J 18/P11/Q11

Hydrogen ions catalyse the hydrolysis of esters.
Which statement is correct?

A The hydrogen ions act as a heterogeneous catalyst.

B The hydrogen ions are in the same phase as the reactants.

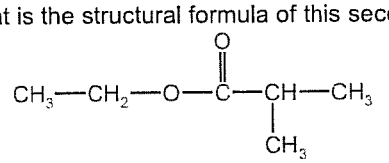
C The hydrogen ions are used up in the reaction.

D The hydrogen ions have no effect on the activation energy of the reaction.

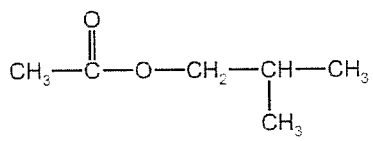
13. M/J 18/P11/Q27

Ethyl propanoate is refluxed with aqueous sodium hydroxide. The alcohol produced is then reacted with methyl propanoic acid to make a second ester.
What is the structural formula of this second ester?

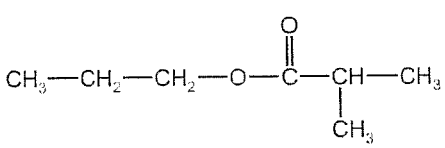
A



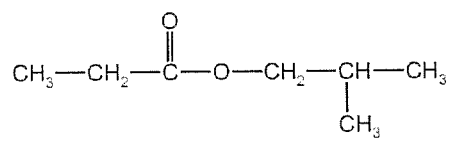
C



B

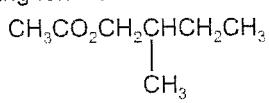


D



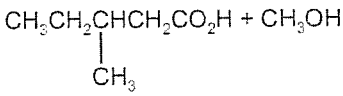
14. O/N 17/P12/Q30, M/J 14/P11/Q22, O/N 02/P1/Q30

An ester with an odour of banana has the following formula.

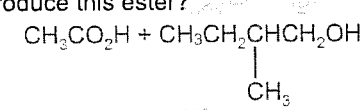


Which pair of reactants, under suitable conditions, will produce this ester?

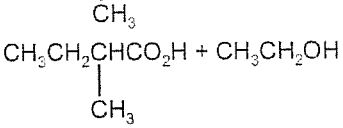
A



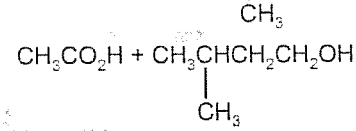
C



B



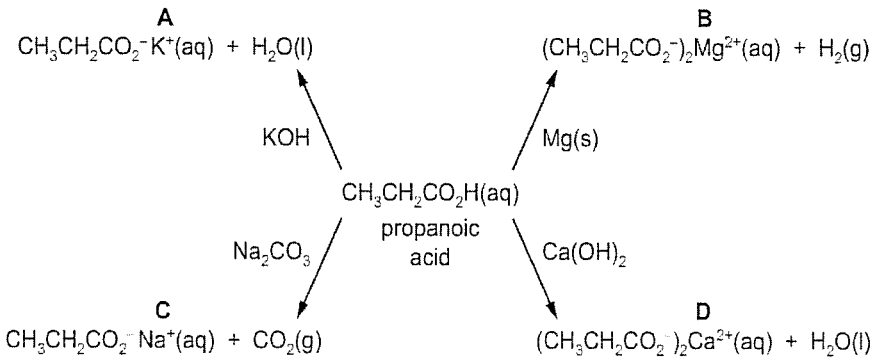
D



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15. M/J 18/P11/Q29

Four reactions of propanoic acid to form salts and other products are shown.
Which reaction does not show the formulae of all the correct products?



16. M/J 18/P13/Q29

An ester X has the structural formula $CH_3CO_2CH(CH_3)CH_2CH_3$. X can be prepared by heating an alcohol **Y**, under reflux, with ethanoic acid and an acid catalyst.
What is the correct name for **Y**?

A butan-1-ol **B** butan-2-ol **C** butan-3-ol **D** methylpropan-2-ol

17. O/N 17/P11/Q30, O/N 17/P13/Q30

A sample of the ester $CH_3CH_2CH_2CO_2CH_2CH_3$ is hydrolysed. The product mixture is then treated with hot, acidified $KMnO_4$.
What are the final carbon-containing products?

A $CH_3CH_2CO_2H$ only
B $CH_3CO_2H + CH_3CH_2CO_2H$
C $CH_3CO_2H + CH_3CH_2CH_2CO_2H$
D $CH_3CH_2OH + CH_3CH_2CH_2CO_2H$

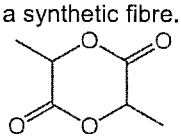
18. M/J 17/P12/Q30

Which compound, when hydrolysed, gives propanoic acid and propan-2-ol?

A $CH_3CH_2CO_2CH_2CH(CH_3)CH_3$
B $(CH_3)_2CHCO_2CH_2CH_3$
C $CH_3CH_2CO_2CH(CH_3)CH_3$
D $CH_3CH_2CH_2CO_2CH(CH_3)CH_3$

19. M/J 17/P11/Q24

Lactide is an intermediate in the manufacture of a synthetic fibre.



lactide

Which compound, on heating with an acid catalyst, can produce lactide?

A hydroxyethanoic acid
B 2-hydroxybutanoic acid
C 2-hydroxypropanoic acid
D 3-hydroxypropanoic acid

20. M/J 17/P13/Q23

Carboxylic acids may be prepared by several different methods.
In which reaction would propanoic acid be formed?

A adding ammonium propanoate to dilute sulfuric acid
B heating ethyl propanoate with aqueous sodium hydroxide
C heating propan-2-ol with acidified potassium manganate(VII) under reflux
D heating propyl ethanoate with dilute sulfuric acid

21. M/J 17/P13/Q30

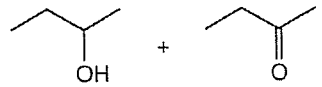
How many esters with the molecular formula $C_5H_{10}O_2$ can be made by reacting a **primary** alcohol with a carboxylic acid?

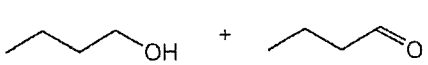
A 4 **B** 5 **C** 6 **D** 8

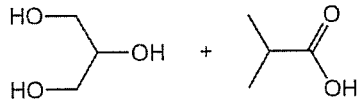
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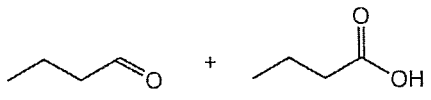
22. MAR 17/P12/Q30

Which two compounds can react together to produce an ester?

A 

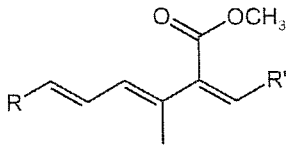
B 

C 

D 

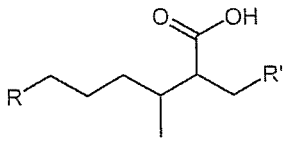
23. O/N 16/P11/Q23, O/N 16/P13/Q23

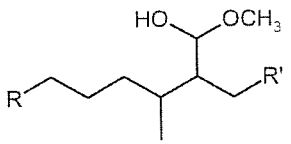
Part of the structure of a fungicide, strobilurin, is shown. R and R' are inert groups.

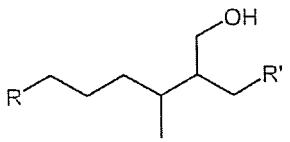


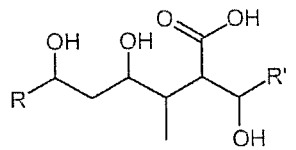
strobilurin

In this reaction, strobilurin is warmed with aqueous sulfuric acid producing compound X.
Compound X is then treated with hydrogen in the presence of a nickel catalyst producing compound Y.
What could be the structure of compound Y?

A 

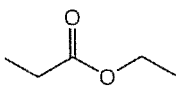
B 

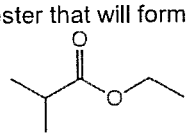
C 

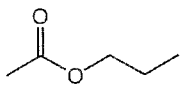
D 

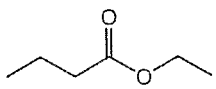
24. O/N 16/P11/Q29, O/N 16/P13/Q29

Which formula represents an ester that will form propanoic acid on hydrolysis with dilute sulfuric acid?

A 

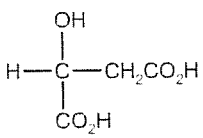
B 

C 

D 

25. M/J 16/P12/Q25

Malic acid is found in apples.



malic acid

Which reagent will react with only one of the – OH groups in the malic acid molecule?

A ethanoic acid in the presence of concentrated sulfuric acid
B sodium
C sodium hydrogen carbonate
D sodium hydroxide

26. M/J 16/P11/Q29

The ester $CH_3CH_2CH_2CO_2CH_2CH(CH_3)_2$ was hydrolysed under acidic conditions.
What are the organic products of this hydrolysis?

A butanoic acid and 2-methylpropan-1-ol
B butanoic acid and 2-methylpropan-2-ol
C butan-1-ol and 2-methylpropanoic acid
D propanoic acid and 2-methylpropan-1-ol

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27. M/J 16/P12/Q30

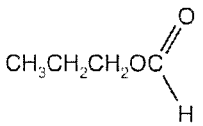
Compound X, $C_4H_8O_2$, has an unbranched carbon chain. An aqueous solution of X has an approximate pH of 3.
Compound Y, C_3H_8O, is a secondary alcohol.
X and Y are reacted together in the presence of a little concentrated sulfuric acid to form Z as the major organic product.
What is the structural formula of Z?

A $(CH_3)_2CHCO_2CH_2CH_2CH_3$ **C** $CH_3(CH_2)_2CO_2(CH_2)_2CH_3$

B $CH_3(CH_2)_2CO_2CH(CH_3)_2$ **D** $(CH_3)_2CHCO_2CH(CH_3)_2$

28. M/J 16/P11/Q21

The structural formula of compound X is shown below.



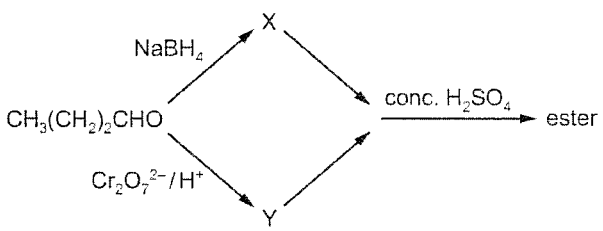
compound **X**

What is the name of compound X and how does its boiling point compare with that of butanoic acid?

	name of **X**	boiling point of **X**
A	methyl propanoate	higher than butanoic acid
B	methyl propanoate	lower than butanoic acid
C	propyl methanoate	higher than butanoic acid
D	propyl methanoate	lower than butanoic acid

29. M/J 16/P13/Q22

An ester with an aroma of pineapples can be synthesised in the laboratory from butanal using this reaction scheme.



What is the structural formula of the **ester**?

A $CH_3(CH_2)_2CO_2(CH_2)_2CH_3$ **C** $CH_3(CH_2)_3CO_2(CH_2)_2CH_3$

B $CH_3(CH_2)_2CO_2(CH_2)_3CH_3$ **D** $CH_3(CH_2)_3CO_2(CH_2)_3CH_3$

30. M/J 16/P13/Q29

The ester, $CH_3CH_2CO_2CH_3$, is hydrolysed by boiling with aqueous sodium hydroxide.
Which compound is one of the products?

A ethanol **C** sodium methanoate

B propan-1-ol **D** sodium propanoate

31. MAR 16/P12/Q28

Which mixture could be used to produce propyl methanoate?

A $CH_3CH_2CO_2H$ and CH_3OH **C** $CH_3CH_2CH_2OH$ and HCO_2H

B $CH_3CH_2CH_2CH_2OH$ and HCO_2H **D** $CH_3CH_2CH_2CO_2H$ and CH_3OH

32. O/N 15/P12/Q20, M/J 09/P1/Q27

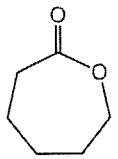
Which ester is formed when the alcohol CH_3CH_2OH is reacted with $CH_3CH_2CH_2CO_2H$?

A butyl ethanoate **B** ethyl butanoate **C** ethyl propanoate **D** propyl ethanoate

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33. M/J 16/P13/Q30

Caprolactone is a cyclic ester. It is being used increasingly for the manufacture of specialist polymers.



caprolactone

From which compound could caprolactone be made by a single reaction?

A $OHCCH_2CH_2CH_2CH_2CHO$

B $HOCH_2CH_2CH_2CH_2CH_2CH_2OH$

C $HOCH_2CH_2CH_2CH_2CH_2CO_2H$

D $HO_2CCH_2CH_2CH_2CH_2CO_2H$

34. O/N 15/P11/Q30

Which compound produces butan-2-ol and ethanoic acid on hydrolysis?

A $CH_3CO_2CH(CH_3)_2$

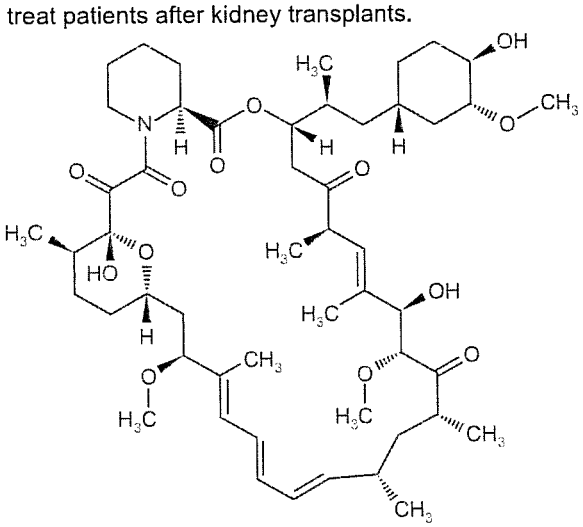
B $CH_3CO_2CH(CH_3)CH_2CH_3$

C $CH_3CH(CH_3)CO_2CH_2CH_3$

D $CH_3CH_2CO_2CH(CH_3)CH_2CH_3$

35. M/J 15/P12/Q30

The drug Sirolimus is used to treat patients after kidney transplants.

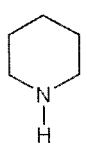


Sirolimus

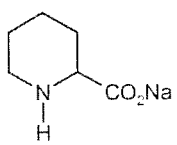
On reaction with hot aqueous sodium hydroxide, Sirolimus produces an equimolar mixture of two organic products.

What is the structural formula of the product with the lower relative molecular mass?

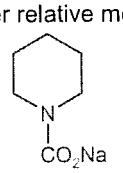
A



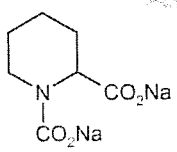
B



C

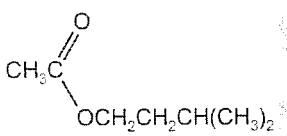


D



36. M/J 15/P13/Q23

An ester P with a fruity odour has the following structural formula.



Which compounds are produced when P is hydrolysed using hydrochloric acid?

A CH_3COCl and $(CH_3)_2CHCH_2CH_2OH$

B CH_3CHO and $(CH_3)_2CHCH_2CH_2OH$

C CH_3CO_2H and $(CH_3)_2CHCH_2CH_2CHO$

D CH_3CO_2H and $(CH_3)_2CHCH_2CH_2OH$

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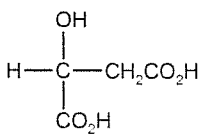
37. M/J 15/P13/Q25

Compound **X**, $C_5H_{12}O$, is oxidised by acidified sodium dichromate(VI) to compound **Y**.
Compound **Y** reacts with butan-2-ol in the presence of a little concentrated sulfuric acid to give liquid **Z**.
What could be the formula of **Z**?

A $CH_3(CH_2)_3CO_2CH(CH_3)CH_2CH_3$
B $CH_3(CH_2)_3CO_2(CH_2)_3CH_3$
C $CH_3(CH_2)_2CO_2CH(CH_3)CH_2CH_3$
D $(CH_3)_2CHCH_2CO_2C(CH_3)_3$

38. M/J 15/P13/Q30

Malic acid occurs in apples.



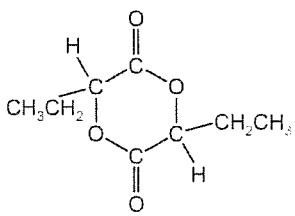
malic acid

Under suitable conditions, which substance will react with only one of the –OH groups in the malic acid molecule?

A $Cr_2O_7^{2-}/H^+(aq)$ **B** Na(s) **C** NaOH(aq) **D** $PCl_5(s)$

39. O/N 14/P13/Q24

Compound **X** can be made from 2-hydroxybutanoic acid.



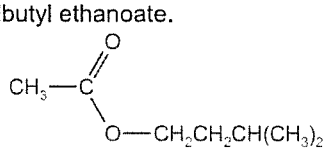
compound **X**

What should be heated with 2-hydroxybutanoic acid in order to make compound **X**?

A acidified potassium dichromate(VI)
B aluminium oxide
C concentrated sulfuric acid
D dilute sodium hydroxide

40. O/N 14/P13/Q26

Pheromones are used by insects and other animals as a means of communication.
The pheromone in a bee sting is 3-methylbutyl ethanoate.



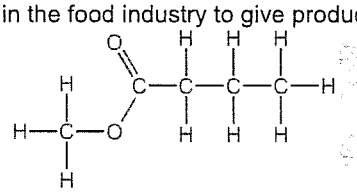
3-methylbutyl ethanoate

What are the organic products when 3-methylbutyl ethanoate is heated under reflux with aqueous sodium hydroxide?

A CH_3CO_2H and $(CH_3)_2CHCH_2CH_2OH$
B CH_3CO_2H and $(CH_3)_2CHCH_2CH_2O^-Na^+$
C $CH_3CO_2^-Na^+$ and $(CH_3)_2CHCH_2CH_2OH$
D $CH_3CO_2^-Na^+$ and $(CH_3)_2CHCH_2CH_2O^-Na^+$

41. O/N 14/P13/Q30

Methyl butanoate, $C_5H_{10}O_2$, is an ester used in the food industry to give products the flavour of apples.



methyl butanoate

Including methyl butanoate, how many structural isomers are there of $C_5H_{10}O_2$ that are esters?

A 6 **B** 8 **C** 9 **D** 10

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42. M/J 14/P12/Q23

An ester of structural formula $CH_3CO_2CH_3$ is heated with an aqueous solution of sodium hydroxide.
What are the two organic products of this reaction?

A ethanoic acid and methanol
B methanoic acid and ethanol
C sodium ethanoate and methanol
D sodium methanoate and ethanol

43. M/J 14/P13/Q20

Diesters can be made from diacids such as propane-1,3-dioic acid, $HO_2CCH_2CO_2H$.
Which combination of reactants would form the diester $CH_3CH_2OCOCH_2CH_2CO_2CH_2CH_3$?

A butane-1,4-dioic acid and ethanol
B ethanedioic acid and propan-1-ol
C ethanedioic acid, ethanol and butan-1-ol
D propane-1,3-dioic acid, ethanol and propan-1-ol

44. M/J 13/P12/Q29

Compound **Y** has M_r of 88. It does not fizz when added to a solution of sodium hydrogencarbonate. It can be hydrolysed by dilute sulfuric acid to produce two organic products with M_r values of 46 and 60.
What is the identity of compound **Y**?

A butanoic acid **B** ethyl ethanoate **C** 3-hydroxybutanal **D** butyl methanoate

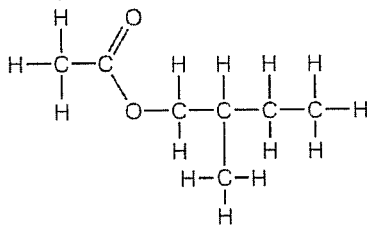
45. O/N 12/P12/Q30, O/N 12/P11/Q30

Compound **X**, $C_6H_{12}O$, is oxidised by acidified sodium dichromate(VI) to compound **Y**.
Compound **Y** reacts with ethanol in the presence of a little concentrated sulfuric acid to give liquid **Z**.
What is the formula of **Z**?

A $CH_3(CH_2)_4COCH_2CH_3$
B $CH_3(CH_2)_4CO_2CH_2CH_3$
C $CH_3CH_2CO_2(CH_2)_4CH_3$
D $CH_3CO_2(CH_2)_5CH_3$

46. O/N 12/P13/Q23

Bees use 2-methylbutyl ethanoate as an 'alarm' pheromone to alert other bees.



2-methylbutyl ethanoate

Which starting materials would be required to synthesise 2-methylbutyl ethanoate?

A CH_3CH_2OH and $CH_3CH_2CH(CH_3)CO_2H$
B CH_3CO_2H and $CH_3CH_2CH(CH_3)CH_2OH$
C CH_3CH_2OH and $CH_3CH_2CH(CH_3)CH_2CO_2H$
D CH_3CO_2H and $CH_3CH_2CH(CH_3)CH_2CO_2H$

47. M/J 12/P12/Q27, M/J 09/P1/Q30

A compound **Y** has the following properties.

- It is a liquid at room temperature and atmospheric pressure.
- It does not mix completely with water.
- It does not give steamy fumes with PCl_5.

What could **Y** be?

A ethane **B** ethanoic acid **C** ethanol **D** ethyl ethanoate

48. M/J 11/P12/Q30

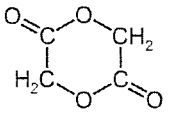
Which reaction would **not** give ethanoic acid as a product?

A heating ethanenitrile under reflux with dilute sodium hydroxide
B heating ethanenitrile under reflux with dilute sulfuric acid
C heating ethanal under reflux with acidified sodium dichromate(VI)
D heating ethanol under reflux with acidified sodium dichromate(VI)

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49. M/J 12/P11/Q23, M/J 12/P13/Q22

Compound C is used in textile and leather processing.

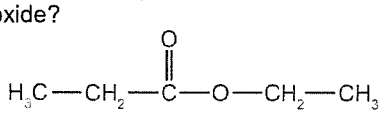
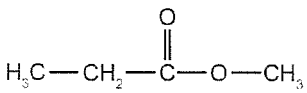
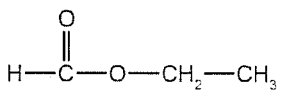
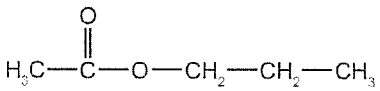

compound C

Which starting material(s), on gentle heating with a few drops of concentrated sulfuric acid, generates compound C?

A CH_3COOH only
B $HOCH_2COOH$ only
C CH_3COOCH_2COOH only
D CH_3COOH mixed with $HOCH_2COOH$

50. M/J 11/P11/Q27, M/J 11/P13/Q28

Which formula represents an ester which will form sodium ethanoate on hydrolysis with aqueous sodium hydroxide?

A 
B 
C 
D 

51. O/N 10/P12/Q24

Esters are frequently used as solvents and as flavouring agents in fruit drinks and confectionery.
An ester $C_8H_{12}Br_2O_4$ can be prepared in low yield by the reaction shown.

$$CH_3C(Br)(CH_2Br)CO_2H + (CH_3)_2C(OH)CO_2H \rightleftharpoons C_8H_{12}Br_2O_4 + H_2O$$

What is the structural formula of the ester $C_8H_{12}Br_2O_4$?

A $CH_3C(Br)(CH_2Br)CO_2C(CH_3)_2CO_2H$
B $CH_3C(Br)(CH_2Br)CO_2C(OH)(CH_3)CO_2CH_3$
C $CH_3C(Br)(CH_3)CO_2C(CH_3)_2CO_2CH_2Br$
D $(CH_3)_2C(Br)C(CO_2H)(CH_2Br)CO_2CH_3$

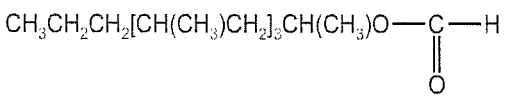
52. M/J 10/P13/Q25, M/J 10/P12/Q24, M/J 10/P11/Q25, M/J 06/P1/Q30

Which compound is a product of the hydrolysis of $CH_3CO_2C_3H_7$ by boiling aqueous sodium hydroxide?

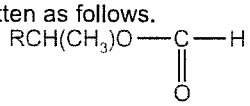
A CH_3OH **B** C_3H_7OH **C** $C_3H_7CO_2H$ **D** $C_3H_7CO_2^-Na^+$

53. O/N 09/P12/Q29, O/N 09/P11/Q30

The acarid mite releases *lardolure* to attract other mites to a host. This chemical can be destroyed by hydrolysis with acid.



A simplified formula for *lardolure* may be written as follows.



What are the products of its hydrolysis?

A $RCH(CH_3)CO_2H + CH_3OH$
B $RCH(CH_3)CO_2H + HCO_2H$
C $RCH(CH_3)OH + CO_2$
D $RCH(CH_3)OH + HCO_2H$

54. O/N 08/P1/Q30

Ethyl ethanoate can be obtained from ethanoic acid and ethanol by the following reaction.

$$CH_3CH_2OH + CH_3CO_2H \rightleftharpoons CH_3CO_2CH_2CH_3 + H_2O$$

Ethanol (30g) and ethanoic acid (30g) are heated under reflux together, and 22 g of ethyl ethanoate are obtained.
What is the yield of the ester?

A 25% **B** 38% **C** 50% **D** 77%

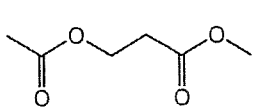
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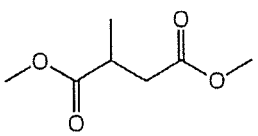
55. O/N 19/P11/Q40, O/N 19/P13/Q40

Which compounds produce three **different** organic products when hydrolysed?

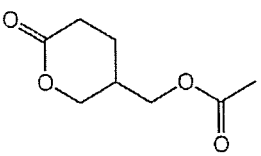
1



2



3



A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

56. M/J 18/P12/Q40, O/N 13/P13/Q39

The ester $C_2H_5CO_2CH_2CH_2CH_3$ can be made in a school or college laboratory by a sequence of reactions using compound **X** as the **only** organic material.

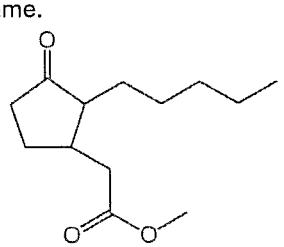
What might be the identity of compound **X**?

1 $CH_3CH_2CH_2OH$
2 CH_3CH_2CHO
3 CH_3COCH_3

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

57. O/N 17/P12/Q39

Compound M is an important ingredient in perfume.



compound M

M reacts with HCN.

Which statements about this reaction are correct?

1 A small amount of NaOH will speed up the reaction.
2 The reaction is initiated by the transfer of a proton to one of the C=O groups.
3 Both of the C=O groups react with HCN.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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58. M/J 17/P11/Q40

Which statements about ethanol and ethanoic acid are correct?

1 Both react with a suitable reagent to form an ester.
2 Both react with sodium.
3 Both are soluble in water.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

59. M/J 17/P13/Q39

Substance M is refluxed with aqueous sodium hydroxide. One of the products of this reaction reacts with alkaline aqueous iodine to give a pale yellow precipitate.

Which compounds could be substance M?

1 $CH_3CO_2CH_3$
2 $CH_3CO_2CH_2CH_3$
3 $HCO_2CH(CH_3)_2$

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

60. M/J 16/P11/Q39

Several steps are involved in the synthesis of 2-hydroxypropanoic acid from ethanol.

$$C_2H_5OH \longrightarrow \longrightarrow \longrightarrow CH_3CH(OH)CO_2H$$

Which statements concerning this synthesis are correct?

1 The chain length can be increased during a step involving reaction between HCN and an aldehyde.
2 The carboxyl group can be made by hydrolysis of a nitrile by boiling with NaOH(aq) and then acidifying.
3 The ethanol should be first oxidised by heating it under reflux with an excess of acidified potassium dichromate(VI).

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

61. M/J 14/P11/Q38

The molecule responsible for the pineapple flavour used in sweets is $CH_3CH_2CH_2CO_2CH_2CH_3$.

Which statements about this molecule are correct?

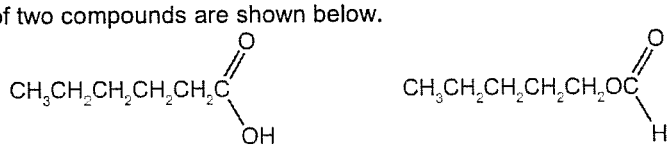
1 The name of this compound is ethyl butanoate.
2 This compound is a structural isomer of hexanoic acid.
3 When this compound is heated with aqueous sodium hydroxide, the products are butan-1-ol and sodium ethanoate.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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62. M/J 16/P13/Q40, O/N 13/P13/Q40

The structural formulae of two compounds are shown below.



Which statements about these compounds are correct?

1 The two compounds are structural isomers of each other.
2 The empirical formula of both compounds is C_3H_6O.
3 Both compounds are carboxylic acids.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

63. M/J 13/P12/Q40

An organic compound, **Z**, will react with calcium metal to produce a salt with the empirical formula $CaC_4H_6O_4$.
What could be the identity of **Z**?

1 ethanoic acid
2 butanedioic acid
3 methylpropanedioic acid

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

64. O/N 11/P12/Q39

Which compounds will produce ethanoic acid when boiled under reflux with dilute alkali followed by acidification?

1 $CH_3CH_2C\!\!\!/$
2 $CH_3CO_2CH_3$
3 CH_3CN

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

65. O/N 10/P12/Q38

Organic acids and alcohols react together to form esters.
Which pairs of compounds could produce a product of molecular formula $C_4H_6O_4$?

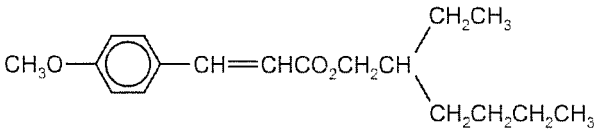
1 CH_3CO_2H and C_2H_5OH
2 HCO_2H and $HOCH_2CH_2OH$
3 HO_2CCO_2H and CH_3OH

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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66. M/J 09/P1/Q40, M/J 05/P1/Q40

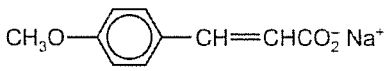
A sun protection cream contains the following ester as its active ingredient.



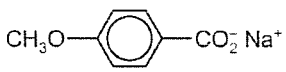
What are the products of its partial or total hydrolysis by aqueous sodium hydroxide?

1 $CH_3CH_2CH_2CH_2CH(CH_2CH_3)CH_2OH$

2



3



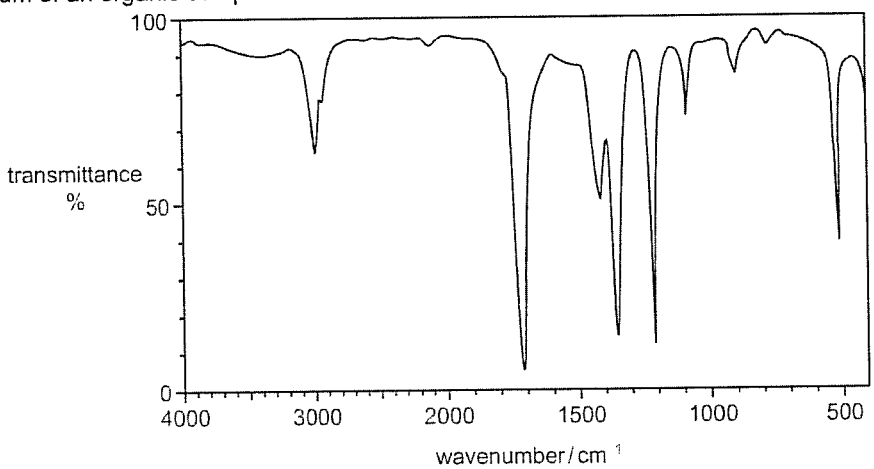
A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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18.4: Multiple Topics

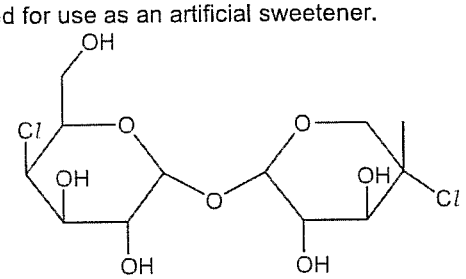
1. **M/J 20/P13/Q29**
The ester ethyl methanoate is prepared in a school laboratory by reacting a carboxylic acid with an alcohol.
During the reaction, only 50.0% of the alcohol is converted into the ester.
Which mass of alcohol is needed to prepare 10.0 g of the ester?
A 3.11 g **B** 8.65 g **C** 12.4 g **D** 32.2 g

2. **M/J 18/P12/Q30**
The infra-red spectrum of an organic compound is shown.



Which compound could give this spectrum?
A $CH_3CH_2CO_2H$ **B** $CH_3CH(OH)CH_3$ **C** CH_3COCH_3 **D** CH_3COCH_2OH

3. **O/N 15/P12/Q25**
Compound X has been investigated for use as an artificial sweetener.



X

The two C–C*l* bonds can be hydrolysed by hot NaOH(aq). The C-O-C bonds cannot be hydrolysed by hot NaOH(aq).
What are the numbers of specified types of –OH groups before and after hydrolysing the two C–C*l* bonds?

	before hydrolysis	after hydrolysis		
	secondary	primary	secondary	tertiary
A	0	1	2	4
B	0	2	1	4
C	4	1	5	1
D	4	2	4	1

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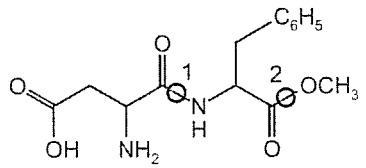
4. MAR 16/P12/Q30

Which row of the table is correct?

	increasing number of carbon atoms ⟶			
A	ethyl methanoate	methyl propanoate	pentyl pentanoate	propyl butanoate
B	ethyl methanoate	methyl propanoate	propyl butanoate	pentyl pentanoate
C	methyl propanoate	propyl butanoate	ethyl methanoate	pentyl pentanoate
D	propyl butanoate	ethyl methanoate	pentyl pentanoate	methyl propanoate

5. O/N 15/P12/Q30

The structure of aspartame, which is used as an artificial sweetener, is shown.



aspartame

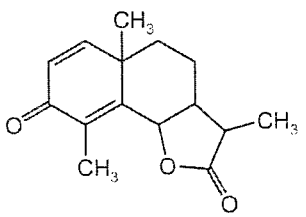
If aspartame is warmed in aqueous alkali, which of bonds 1 and 2 will be broken?

A both bond 1 and bond 2 **C** bond 2 only

B bond 1 only **D** neither bond 1 nor bond 2

6. O/N 12/P13/Q27

Santonin is a drug that was once widely used to expel parasitic worms from the body.



santonin

When santonin is first treated with warm dilute H_2SO_4, and then the product of this reaction is treated with cold acidified $KMnO_4$, a final product **X** is obtained.

How many atoms of hydrogen in each molecule of product **X** can be displaced with sodium metal?

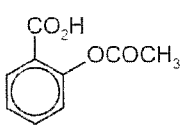
A 2 **B** 4 **C** 5 **D** 6

7. O/N 08/P1/Q27

The stomach wall can become sensitive to acidic compounds.

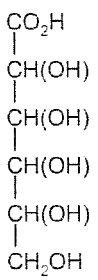
Which is the most acidic compound?

A



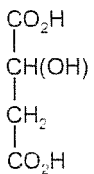
aspirin

B



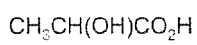
gluconic acid

C



malic acid

D



lactic acid

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8. M/J 12/P13/Q21

An organic compound **J** reacts with sodium to produce an organic ion with a charge of –3. **J** reacts with NaOH(aq) to produce an organic ion with a charge of –1.

What could be the structural formula of **J**?

A $HO_2CCH(OH)CH_2CO_2H$

B $HO_2CCH(OH)CH_2CHO$

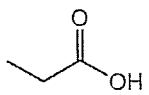
C $HOCH_2CH(OH)CH_2CO_2H$

D $HOCH_2COCH_2CHO$

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9. MAR 17/P12/Q40

Propanoic acid occurs naturally as a result of the bacterial fermentation of milk and is partly responsible for the flavour of Swiss cheese.



propanoic acid

Which starting materials can be used to produce propanoic acid?

1 $CH_3CH_2CH_2OH$
2 CH_3CH_2CHO
3 CH_3CH_2CN

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

10. O/N 13/P13/Q33

Methanoic acid molecules, HCO_2H, and hydrogen carbonate ions, HCO_3^-, can both behave as acids.

Why does a solution of methanoic acid have a lower pH than a solution of sodium hydrogen carbonate of the same concentration?

1 HCO_2H molecules dissociate more fully than HCO_3^- ions do.
2 Each HCO_2H molecule has two hydrogen atoms; each HCO_3^- ion only has one.
3 Methanoic acid is a weaker acid than sodium hydrogen carbonate.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

11. M/J 11/P12/Q40

An organic compound, **X**, will react with an excess of calcium metal to produce a salt with the empirical formula $CaC_4H_6O_4$.

What could be the identity of **X**?

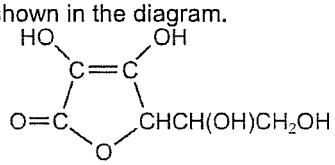
1 ethanoic acid
2 butanedioic acid
3 methylpropanedioic acid

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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12. O/N 08/P1/Q40

The structure of the antioxidant vitamin C is shown in the diagram.



On the basis of this structure, which properties is vitamin C likely to have?

1 It is soluble in water.
2 It decolourises aqueous bromine rapidly.
3 It reduces Fehling's reagent.

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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Answers Sections

18.1		18.2		18.3				18.4	
1.	A	1.	B	1.	B	41.	C	1.	C
2.	C	2.	B	2.	D	42.	C	2.	C
3.	D	3.	D	3.	D	43.	A	3.	C
4.	C	4.	C	4.	D	44.	B	4.	B
5.	B	5.	D	5.	B	45.	B	5.	A
6.	A			6.	B	46.	B	6.	D
7.	D			7.	C	47.	D	7.	C
8.	B			8.	D	48.	A	8.	C
9.	B			9.	C	49.	B	9.	A
10.	C			10.	A	50.	D	10.	D
11.	A			11.	A	51.	A	11.	D
12.	B			12.	B	52.	B	12.	B
13.	A			13.	A	53.	D		
14.	D			14.	C	54.	C		
15.	A			15.	C	55.	D		
16.	A			16.	B	56.	B		
17.	A			17.	C	57.	D		
18.	D			18.	C	58.	A		
19.	C			19.	C	59.	C		
20.	C			20.	A	60.	B		
21.	D			21.	C	61.	B		
22.	D			22.	C	62.	B		
23.	C			23.	A	63.	D		
24.	A			24.	A	64.	C		
25.	B			25.	A	65.	C		
26.	B			26.	A	66.	B		
27.	C			27.	B				
28.	C			28.	D				
29.	A			29.	B				
30.	A			30.	D				
31.	D			31.	C				
32.	B			32.	B				
33.	B			33.	C				
34.	B			34.	B				
35.	C			35.	B				
36.	D			36.	D				
37.	C			37.	A				
38.	A			38.	A				
39.	C			39.	C				
40.	A			40.	C				

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Unit 19
NITROGEN COMPOUNDS

A Level
Chemistry Paper 1
Classified/Topical MCQ's
Article Number: 231

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Syllabus

19.1 Primary amines
19.2 Multiple topics

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Unit 19: Nitrogen compounds

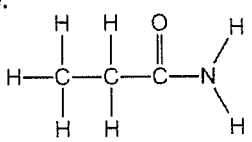
19.1: Primary amines

1. **M/J 14/P12/Q21**
Halogenoalkanes undergo a range of nucleophilic substitution reactions.
Which reaction proceeds only by an S_N1 mechanism?

A $CH_3CH_2Br + NH_3$
B $CH_3CH_2CH_2I + OH^-$
C $CH_3CHBrCH_3 + NH_3$
D $(CH_3)_3CI + OH^-$

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2. **O/N 15/P11/Q40, O/N 15/P13/Q40**
The diagram shows the structure of propanamide.

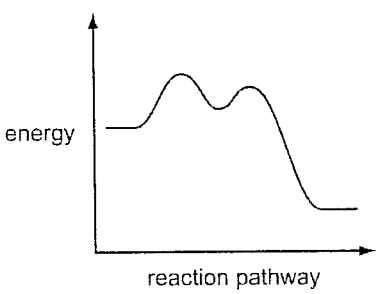


propanamide

Which statements about the hydrolysis of propanamide are correct?
1 Propanamide can be hydrolysed by heating under reflux with $H_2SO_4(aq)$.
2 Propanamide can be hydrolysed by heating under reflux with NaOH(aq).
3 Propanamide can be hydrolysed by cold water.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

3. **O/N 10/P12/Q40**
A reaction pathway diagram is shown.



Which reactions would have such a profile?
1 $(CH_3)_3CBr + NaOH \rightarrow (CH_3)_3COH + NaBr$
2 $CH_3CH_2Br + NaOH \rightarrow CH_3CH_2OH + NaBr$
3 $(CH_3)_3CCH_2CH_2Cl + 2NH_3 \rightarrow (CH_3)_3CCH_2CH_2NH_2 + NH_4Cl$

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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19.2: Multiple Topics

1. O/N 16/P12/Q23

The equation shows a reaction that occurs between carbon monoxide and nitrogen monoxide in a catalytic converter.

$$2CO(g) + 2NO(g) \rightarrow 2CO_2(g) + N_2(g)$$

Which statement is correct?

A The catalyst used is finely divided iron.

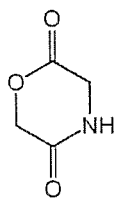
B The reaction prevents greenhouse gas emissions into the atmosphere.

C The reaction reduces the possibility of the formation of photochemical smog.

D The reaction results in increased ozone depletion.

2. M/J 15/P11/Q21

The cyclic compound M is heated with dilute hydrochloric acid.



compound M

What are the products of the reaction?

A $HOCH_2CO_2H$ and $H_2NCH_2CO_2H$

B HO_2CCH_2OH and $HO_2CCH_2NH_3^+$

C H_2NCOCH_2OH and $HOCH_2CHO$

D $HOCH_2CONH_3^+$ and $HOCH_2CHO$

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Answers Sections

19.1	19.2
1. D	1. C
2. B	2. B
3. D	

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Unit 20

POLYMERISATION

A Level
Chemistry Paper 1
Classified/Topical MCQ's
Article Number: 231

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Syllabus

20.1 Predicating the type of polymerisation
20.2 Multiple topics

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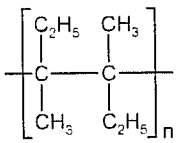
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Unit 20: Polymerisation

20.1: Predicting the type of polymerisation

1. **O/N 19/P12/Q22**
An organic compound X reacts with hot, concentrated acidified potassium manganate(VII) solution to give a single carbon-containing product.
What could be X?
A $CH_2C(CH_3)_2$ **B** $CH_3CHCHCH_3$ **C** $CH_2CHCH_2CH_3$ **D** $CH_3CH_2CH_2CH_3$

2. **M/J 19/P12/Q22**
The diagram shows the repeat unit of an addition polymer.

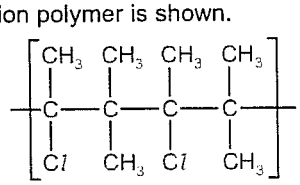


What is the correct name for the monomer that would form this polymer?
A cis-1,2-diethyl-1,2-dimethylethene
B cis-2-ethyl-3-methylpent-2-ene
C trans-2-ethyl-3-methylpent-2-ene
D trans-3,4-dimethylhex-3-ene

3. **O/N 16/P11/Q22, O/N 16/P13/Q22**
PVC is difficult to dispose of. Two possible methods are burying it in landfill sites and disposal by combustion.
Which row of the table is correct?

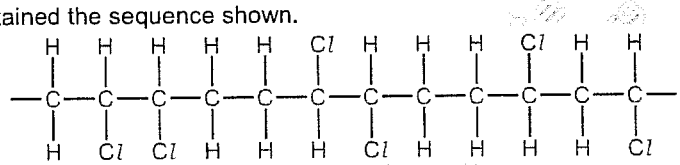
	rate of biodegradation of PVC in landfill sites	gases produced when PVC combusts
A	fast	CO_2, H_2O, HCl
B	fast	CO_2, H_2O, Cl_2
C	slow	CO_2, H_2O, Cl_2
D	slow	CO_2, H_2O, HCl

4. **MAR 16/P12/Q22**
A section showing two repeat units of an addition polymer is shown.



What is the identity of the monomer that produced this polymer?
A 2-chloro-3-methylbutane
B 2-chloro-3-methylbut-2-ene
C 2-chloropent-2-ene
D 2,4-dichloro-3,3,4,5-tetramethylhexane

5. **O/N 12/P13/Q22**
A molecule of a polymer contained the sequence shown.

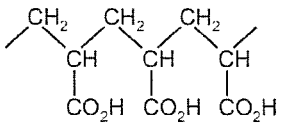


Which monomer could produce this polymer by addition polymerisation?
A $CHCl = CHCl$ **B** $CH_2 = CHCl$ **C** $CH_3CCl = CHCl$ **D** $CH_3CCl = CH_2$

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6. O/N 10/P11/Q20, O/N 10/P13/Q21

One of the characteristics of addition polymerisation is that the empirical formulae of the polymer and of its monomer are the same. The absorbent material in babies' disposable nappies is made from the addition polymer shown.



From which monomer could this addition polymer be obtained?

A $CH_3CH(OH)CO_2H$ **B** $HOCH_2CH_2CO_2H$ **C** $H_2C{=}CHCO_2H$ **D** $HO_2CCH{=}CHCO_2H$

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7. M/J 19/P11/Q37

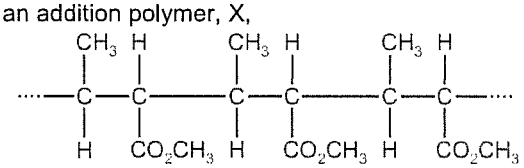
Which statements about poly(alkene)s are correct?

1 Poly(alkene)s do not react with $Br_2(aq)$ in the dark.
2 Disposal of poly(alkene)s by combustion can produce harmful products.
3 Poly(alkene)s do not readily biodegrade.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

8. M/J 16/P11/Q40

The diagram shows the structrue of an addition polymer, X,



Which reagents react with polymer X?

1 aqueous sulfuric acid
2 aqueous sodium hydroxide
3 sodium

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

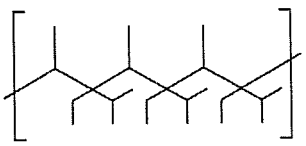
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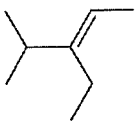
20.2: Multiple Topics

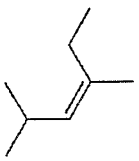
1. MAR 20/P12/Q24

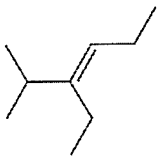
A section of a polymer chain is shown.

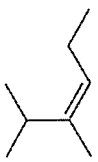


What is the correct monomer?

A 

B 

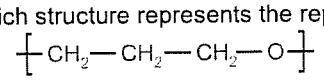
C 

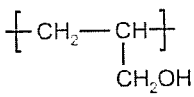
D 

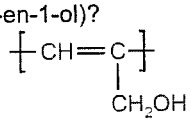
2. M/J 16/P12/Q21

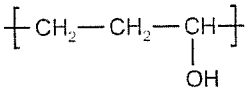
Synthetic resins can be made by polymerisation of a variety of monomers including prop–2ûen–1–ol, $CH_2{=}CHCH_2OH$.

Which structure represents the repeat unit in poly(prop-2-en-1-ol)?

A 

B 

C 

D 

3. MAR 16/P12/Q29

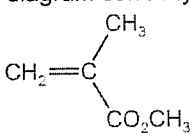
Which statement about poly(chloroethene) is correct?

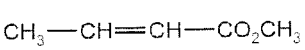
A The polymer can be cracked to produce chlorinated alkenes.
B The polymer has harmless combustion products.
C The polymer is readily biodegradable when buried.
D The repeat unit of the polymer has an M_r of 97.

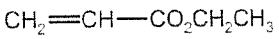
4. O/N 14/P12/Q27, O/N 14/P11/Q27

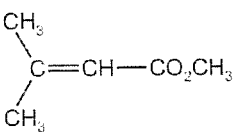
Methyl methylpropenoate is the monomer used to make Perspex.

Which diagram correctly shows methyl methylpropenoate?

A 

B 

C 

D 

5. M/J 14/P12/Q25

Which statement does not correctly describe a problem related to the disposal of PVC?

A PVC is slowly degraded in the environment by bacteria and fungi.
B PVC is slowly degraded in the environment by sunlight.
C When PVC is burnt, a significant amount of ethene gas is present in the products.
D When PVC is burnt, a significant amount of HCl gas is present in the products.

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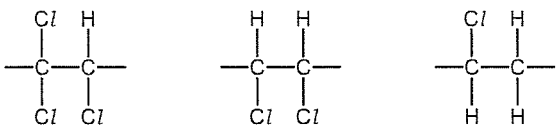
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6. M/J 20/P11/Q40

A mixture of the three isomers of $C_2H_2Cl_2$ is polymerised.

Which sequences will be seen within the polymer chains?

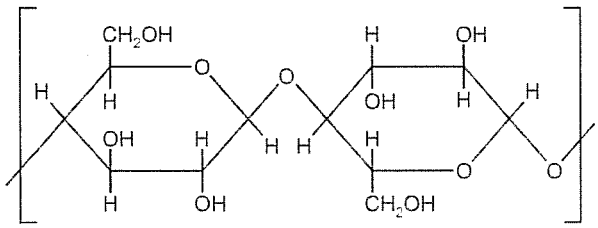
1 2 3



A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

7. O/N 16/P12/Q32

A cathedral in New Zealand has been constructed from cardboard. Cardboard contains polymer molecules. Part of one such polymer molecule is shown below.



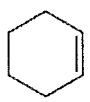
Which statements about this polymer are correct?

1 The polymer molecules can form hydrogen bonds with each other.
2 The polymer can form intermolecular forces with water molecules.
3 The polymer will not burn easily because it is a secondary alcohol.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

8. M/J 16/P11/Q38

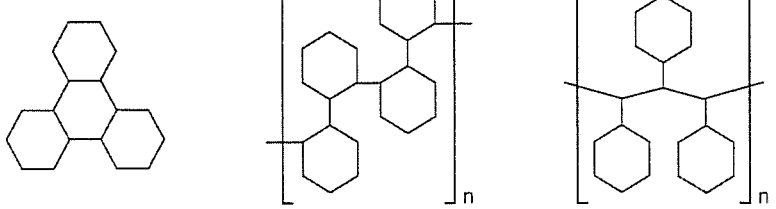
The diagram shows the structure of cyclohexene.



cyclohexene

Which structures could be formed by addition reactions with cyclohexene as the only reactant?

1 2 3



A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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Answers Sections

20.1		20.2	
1.	B	**1.**	A
2.	D	**2.**	B
3.	D	**3.**	A
4.	B	**4.**	A
5.	B	**5.**	C
6.	C	**6.**	A
7.	A	**7.**	B
8.	B	**8.**	B

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Unit 21
ANALYTICAL TECHNIQUES

A Level
Chemistry Paper 1
Classified/Topical MCQ's
Article Number: 231

Editorial Board

Syllabus

21.2 Infra-red spectroscopy
21.2 Multiple topics

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Unit 21: Analytical techniques

21.1: Infra-red spectroscopy

1. M/J 20/P12/Q21

The table shows the molecular formulae of three molecules P, Q and R. None of the molecules are cyclic.

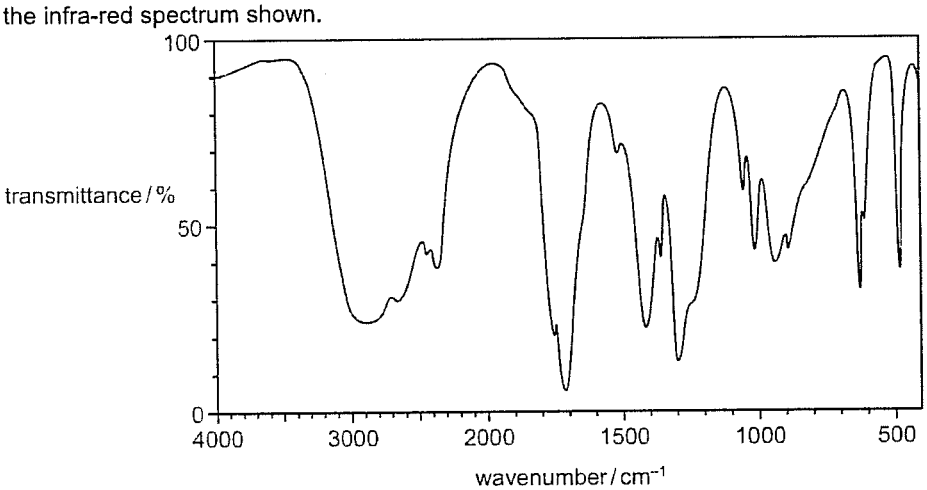
molecule	molecular formula
P	CH_4O
Q	CH_2O_2
R	CH_2O

Which molecules show a strong absorption between 1610 cm^{-1} and 1750 cm^{-1} in their infra-red spectra?

A Q only **B** R only **C** Q and R only **D** P, Q and R

2. M/J 20/P11/Q29

Compound X has the infra-red spectrum shown.

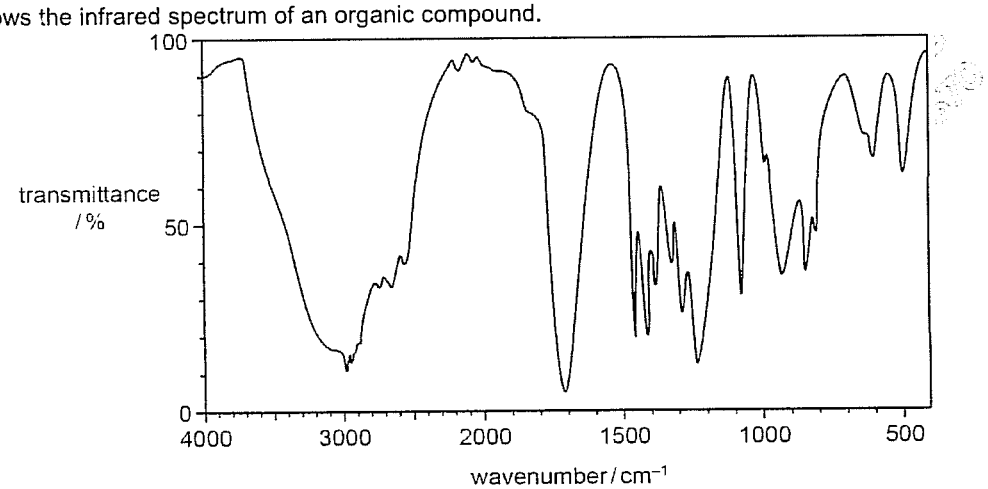


What could be the identity of compound X?

A ethanoic acid **B** ethanol **C** ethylethanoate **D** propanone

3. M/J 20/P13/Q25

The diagram shows the infrared spectrum of an organic compound.



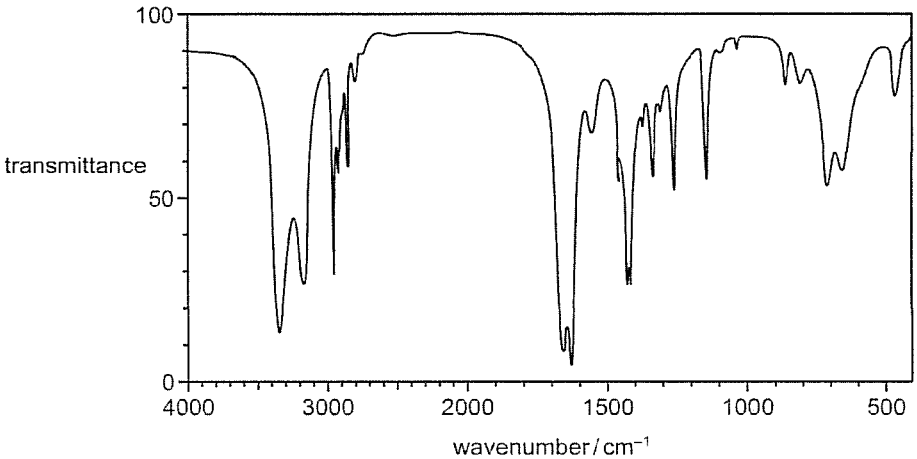
What could be the identity of this compound?

A propan-1-ol **B** propanal **C** propanoic acid **D** propanone

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4. MAR 20/P12/Q23

The infrared spectrum shown was obtained from a compound J.



Which statement about J is correct?

A Both C=O and C=N are present.

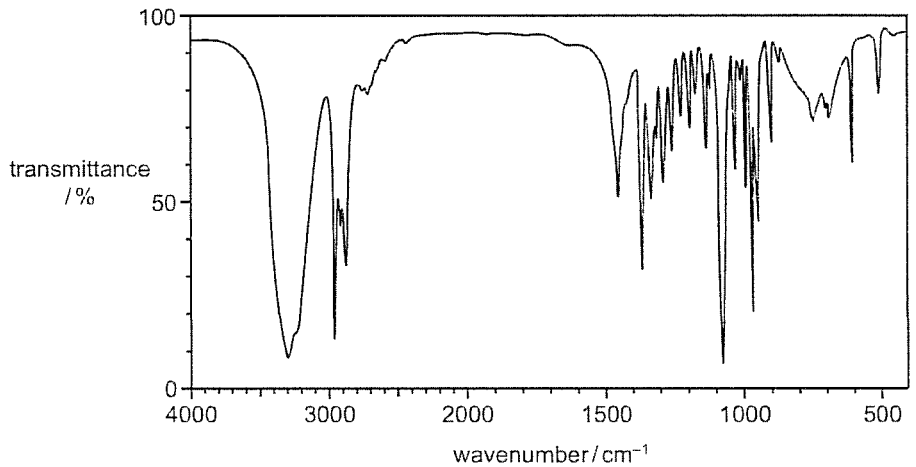
B Neither C=O nor C=N are present.

C C=O is present but not C=N.

D C=N is present but not C=O.

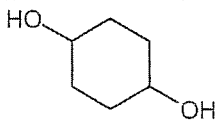
5. O/N 19/P12/Q30

Substance T was analysed and found to contain 62.07% carbon, 10.34% hydrogen and 27.59% oxygen.
The infra-red spectrum of substance T is shown.

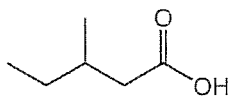


Which substance could be T?

A



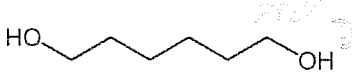
B



C



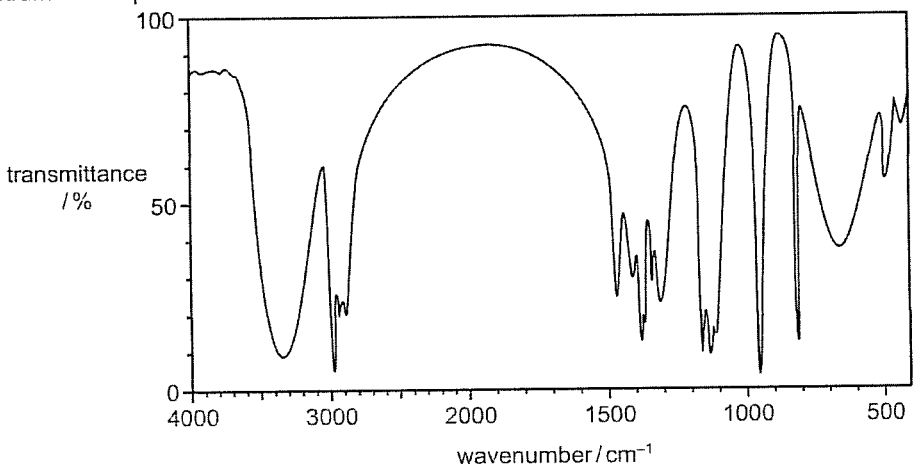
D



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6. O/N 19/P11/Q30, O/N 19/P13/Q30

The infra-red spectrum of compound P is shown.

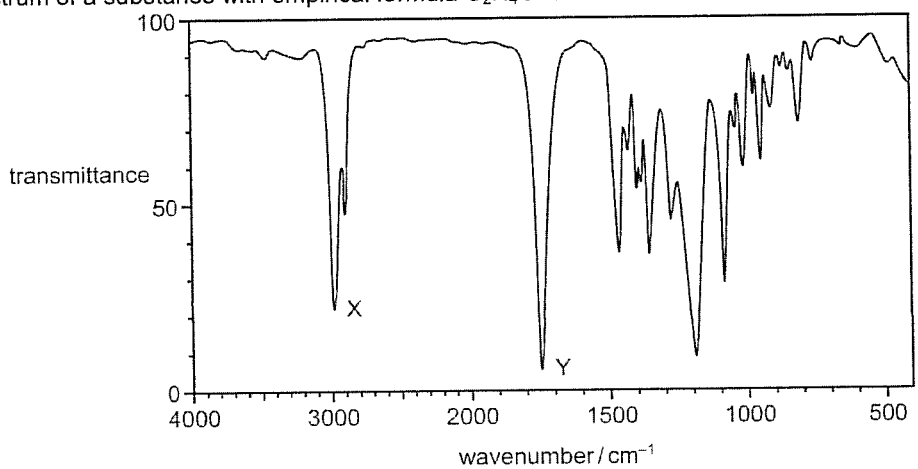


What could be compound P?

A methyl ethanoate **B** propanal **C** propanoic acid **D** propan-2-ol

7. M/J 19/P11/Q24

The infra-red spectrum of a substance with empirical formula C_2H_4O is shown.



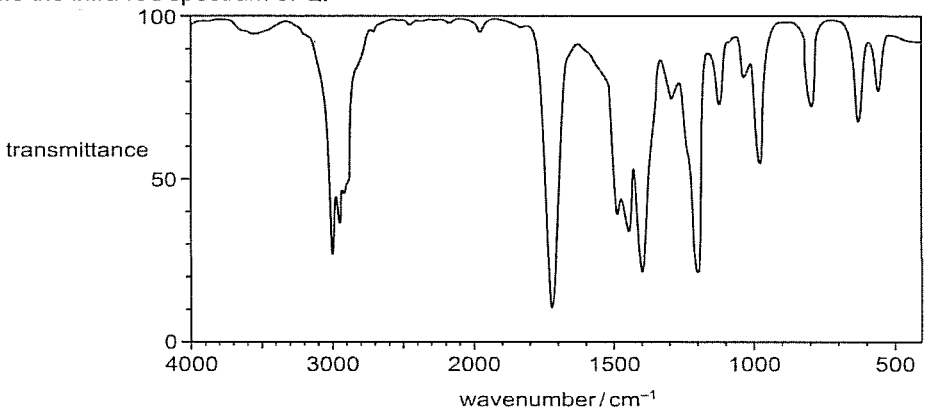
Which bonds are responsible for peak X and peak Y?

	peak X	peak Y
A	C–H	C=C
B	C–H	C=O
C	O–H	C=C
D	O–H	C=O

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8. M/J 19/P12/Q30

The diagram shows the infra-red spectrum of Q.



What could be Q?

A butan-1-ol **B** butanoic acid **C** butanone **D** 3-hydroxybutanal

9. MAR 19/P12/Q30

An infra-red spectrum shows a broad peak at 3000 cm^{-1} and a strong peak at 1710 cm^{-1}.
Which substance could have produced this spectrum?

A methyl propanoate **B** propan-2-ol **C** propanoic acid **D** propanone

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10. M/J 20/P12/Q38

Propanal reacts with hydrogen cyanide.
Which absorptions are present in the infra-red spectrum of the product?

1 a weak absorption in the range 2200–2250 cm^{-1}
2 a strong absorption in the range 3200–3600 cm^{-1}
3 a strong absorption in the range 1040–1300 cm^{-1}

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	1 only is correct

11. M/J 19/P13/Q40

An organic molecule X has a molecular formula of $C_5H_{10}O_2$. Its infra-red spectrum has a strong peak at 1250 cm^{-1}, a strong peak at 1720 cm^{-1} but no strong peak above 3100 cm^{-1}.
What could X be?

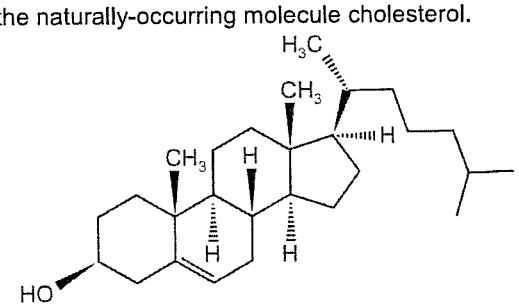
1 ethyl propanoate
2 methyl butanoate
3 1-hydroxypentan-3-one

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	1 only is correct

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21.2: Multiple Topics

1. **M/J 11/P13/Q27**
The diagram shows the structure of the naturally-occurring molecule cholesterol.



cholesterol

Student X claimed that the seventeen carbon atoms in the four rings all lie in the same plane.
Student Y claimed that this molecule displays *cis*-trans isomerism at the C=C double bond.
Which of the students are correct?

A both X and Y **B** neither X nor Y **C** X only **D** Y only

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Answers Sections

21.1		21.2	
1.	C	**1.**	D
2.	A		
3.	C		
4.	C		
5.	A		
6.	D		
7.	B		
8.	C		
9.	C		
10.	A		
11.	B		

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Unit 22

ORGANIC SYNTHESIS

A Level
Chemistry Paper 1
Classified/Topical MCQ's
Article Number: 231

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Syllabus

22.1 Multiple topics

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Unit 22: Organic synthesis

22.1: Multiple Topics

1. **M/J 16/P11/Q22**
Which pair of reagents will take part in a redox reaction?

A $CH_3CHCH_2 + Br_2$

B $CH_3CH_2CH_2OH$ + concentrated H_3PO_4

C $CH_3COCH_3 + HCN$

D $HCO_2C_2H_5$ + dilute H_2SO_4

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2. **O/N 16/P11/Q31, O/N 16/P13/Q31**
A sample of boron contains aluminium as the only impurity. A mass spectrum of the mixture shows three lines corresponding to three ions, X^+, Y^+ and Z^+.

ion	X^+	Y^+	Z^+
m/e	10	11	27
percentage abundance	15.52	74.48	10.00

Which statements are correct?
1 There are more electrons in Z^+ than in X^+.
2 The A_r of boron in the sample is 10.83 to four significant figures.
3 There are more protons in Y^+ than in X^+.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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Answers Sections

22.1	
1.	A
2.	B

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The Periodic Table of Elements

Group 1	Group 2											Group 13	Group 14	Group 15	Group 16	Group 17	Group 18
							1 H hydrogen 1.0										2 He helium 4.0
3 Li lithium 6.9	4 Be beryllium 9.0											5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2
11 Na sodium 23.0	12 Mg magnesium 24.3	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5	18 Ar argon 39.9
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium –	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
55 Cs caesium 132.9	56 Ba barium 137.3	57–71 lanthanoids	72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

Key

atomic number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.4	61 Pm promethium –	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.3	65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.1	71 Lu lutetium 175.0
actinoids	89 Ac actinium –	90 Th thorium 232.0	91 Pa protactinium 231.0	92 U uranium 238.0	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

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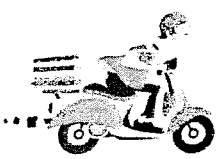
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