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**ST. MARY'S DSG, KLOOF
PHYSICAL SCIENCES
TRIALS PAPER 2: CHEMISTRY**

**GRADE 12
August 2019**

**TIME: 3 hours + 10 minutes reading
MARKS: 200**

Examiners and Moderators: Mrs K. Bolton, Mrs G. Main and Mrs T. Kirsten

Read the Following Instructions Carefully:

1. This paper consists of:
 - A question paper of 18 pages
 - An answer sheet
 - Data sheet
2. Read the questions carefully.
3. Answer **ALL** questions.
4. Number your answers exactly as the questions are numbered.
5. Write legibly and present your work neatly.
6. All working should be shown and units **MUST** be given with answers. Work to two significant figures. **Make sure your calculator is in the correct mode.**
7. Consult the data sheet where necessary.
8. Answers are to be collated in **four** separate parts:
 1. **Questions 2 and 3 and ANSWER SHEET (double folio)**
 2. **Questions 4 and 5 (double folio)**
 3. **Questions 6 – 8 (double folio)**
 4. **Question 9 (double folio)**

ACKNOWLEDGEMENTS:

- CIE International A level Chemistry – October 2016, March 2017, October 2017
- Physicsandmathstutor.com
- Lumen Learning – Chemistry for majors
- St. John's 2016 Prelim Paper 2
- St. Mary's Waverley 2017 Prelim Paper 2
- St. Anne's 2018 Prelim Paper 2
- Physics and maths tutor- Chemistry/A-level/Topic- Edexcel/12-Acid-Base-Equilibria
- Physics and maths tutor- Chemistry/A-level/Topic-CIE/AS-Organic
- AQA-74041-QP-JUN18
- AQA-74042-QP-JUN17
- AQA-74042-QP-JUN18

QUESTION 1 – MULTIPLE CHOICE

Answer these questions on the multiple choice grid on the **ANSWER SHEET** provided.

- 1.1 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 vapour
A	Induced dipole-dipole	I
B	Induced dipole-dipole	I ₂
C	covalent	I
D	covalent	I ₂

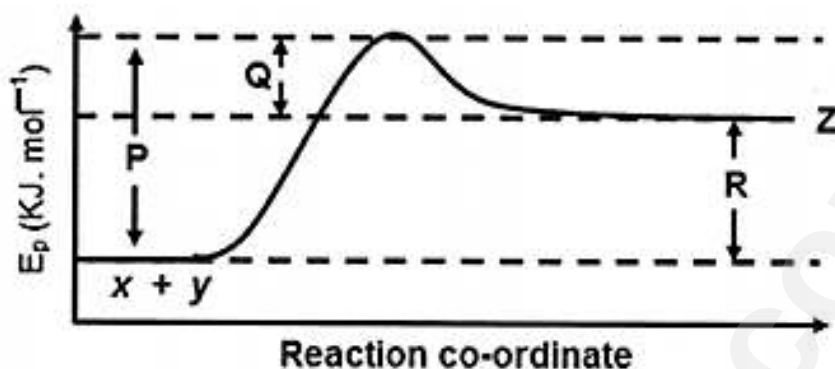
- 1.2 Crushing a solid into a powder will increase reaction rate because:

- A the particles will collide with more energy
- B the orientation of colliding particles will be improved
- C the activation energy barrier will be lowered
- D the powdered form has more surface area.

- 1.3 Aluminum chlorate dissociates in solution producing aluminium ions and chlorate ions. The ratio of aluminium chlorate to chlorate ions is:

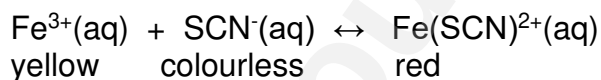
- A 1 : 2
- B 1 : 1
- C 3 : 1
- D 1 : 3

- 1.4 The sketch below represents the changes in potential energy occurring for the reaction:



The magnitude of the heat of reaction of the reverse reaction is represented by the interval:

- | | |
|---|-------|
| A | P |
| B | Q |
| C | R |
| D | X + Y |
- 1.5 The equation below represents a system in equilibrium:



What colour change will be seen if the concentration of SCN^{-} ions is decreased? The solution will...

- | | |
|---|---------------------------|
| A | turn a pale yellow colour |
| B | turn a red colour |
| C | turn colourless |
| D | not change colour |
- 1.6 The reaction between concentrated sulfuric acid and pure ethanoic acid is:



The Brønsted-Lowry acids in this equilibrium are:

- | | |
|---|--|
| A | CH_3COOH and H_2SO_4 |
| B | $\text{CH}_3\text{COOH}_2^{+}$ and HSO_4^{-} |
| C | H_2SO_4 and $\text{CH}_3\text{COOH}_2^{+}$ |
| D | CH_3COOH and HSO_4^{-} |

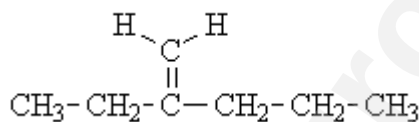
1.7 When copper is extracted from its ores, the impure copper, which contains small amounts of silver and gold, is purified by electrolysis. During this process, a "sludge" forms beneath the anode which is found to contain silver and traces of gold. Why is silver found in this sludge?

- A Silver is a weaker reducing agent than copper.
- B Silver is more dense than copper and falls off the cathode.
- C Silver reacts with the electrolyte to form an insoluble salt.
- D Silver is a weaker oxidising agent than copper.

1.8 An example of an unsaturated hydrocarbon is:

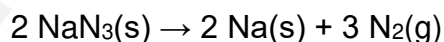
- A C_2H_5Cl
- B C_3H_6
- C C_2H_6
- D C_2H_5OH

1.9 Give the correct IUPAC name for the organic compound below:

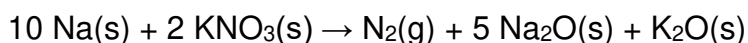


- A 3-methylhexane
- B 2-propylbut-1-ene
- C 4-ethylpent-4-ene
- D 2-ethylpent-1-ene

1.10 In a car airbag, sodium azide (NaN_3) decomposes to form sodium metal and nitrogen gas.



The sodium metal then reacts with potassium nitrate to produce more nitrogen gas, in the following balanced reaction.



If **2 mol** of sodium azide react in this way, how many molecules of N_2 will be formed in total?

- A $2,41 \times 10^{24}$
- B $1,93 \times 10^{24}$
- C $1,81 \times 10^{24}$
- D $1,20 \times 10^{23}$

10 x 2 = [20]

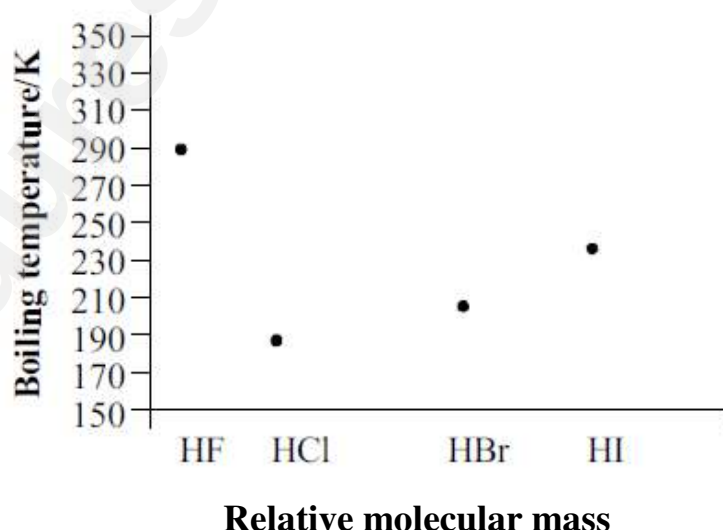
QUESTION 2 – CHEMICAL BONDING – START THIS QUESTION ON A NEW DOUBLE FOLIO SHEET

- 2.1 Use only substances from the list below when answering Questions 2.1.1 to 2.1.7. The phase indicators (state symbols) represent the physical state of each of the substances at room temperature. Only write down the question number and the formula of the substance next to it. The substances may be used more than once, or not at all.

CO₂(g)	NaCl(s)	SiO₂(s)	H₂O(l)	N₂(g)
Ne(g)	Fe(s)	CO(g)	graphite(s)	PH₃(g)

Select one substance from the list that:

- 2.1.1 Has a giant covalent network structure between its identical atoms.
 2.1.2 Has London forces between its atoms.
 2.1.3 Has dipole-dipole forces between its molecules.
 2.1.4 Has polar covalent bonds between its atoms but is a non-polar molecule.
 2.1.5 Has non-polar covalent bonds between its non-identical atoms.
 2.1.6 Conducts electricity when melted into a liquid, but cannot conduct as a solid.
 2.1.7 Is unstable as a solid and vaporises. (7)
- 2.2.1 Define *ionic bond*. (2)
- 2.2.2 Show by means of a Lewis diagram the bonding process in calcium fluoride. (4)
- 2.3 The diagram below shows a plot of boiling temperature vs relative molecular mass for four halides, HF, HCl, HBr and HI.

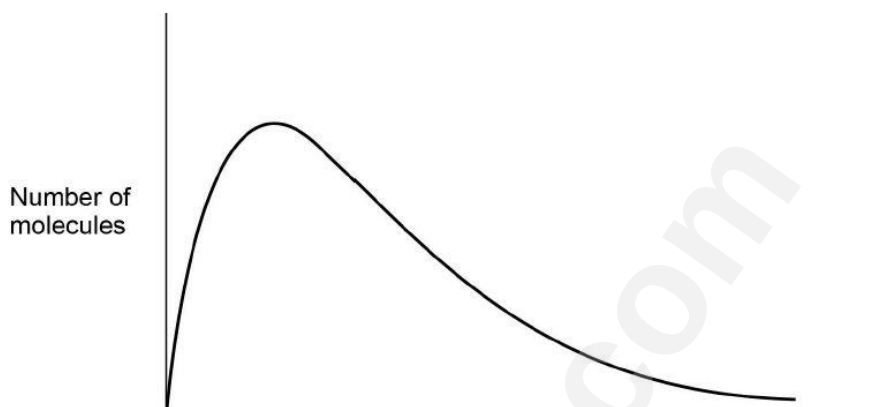


- 2.3.1 Explain the increase in the boiling temperature from HCl to HI. (3)
- 2.3.2 HF is an outlier in the trend observed in the graph above. To what can this be attributed? (2)

[18]

QUESTION 3 – ENERGY CHANGES AND RATES OF REACTION

- 3.1 The graph below shows the Maxwell-Boltzmann distribution of molecular energies in a sample of gas at a fixed concentration.



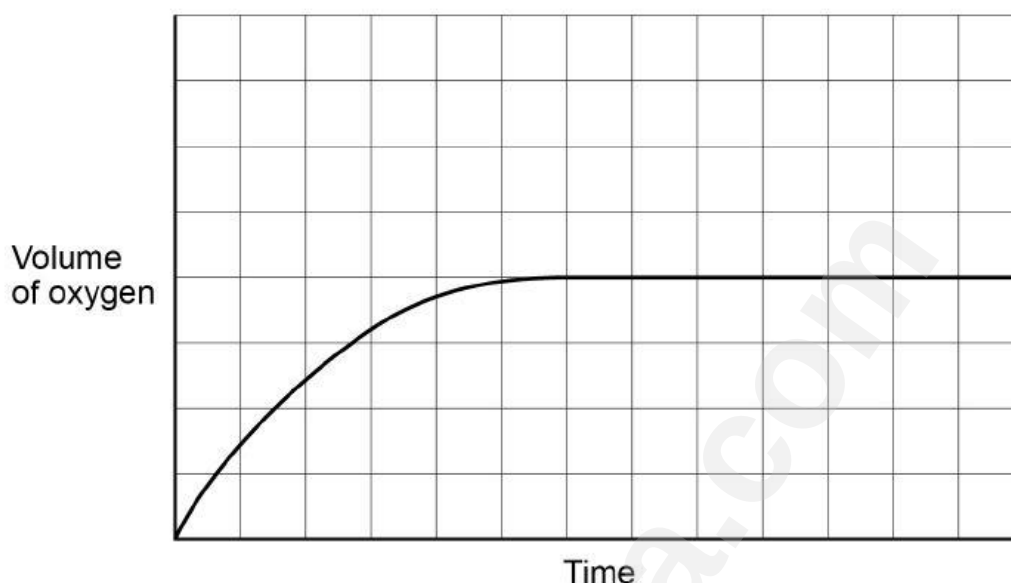
- 3.1.1 On the Answer Sheet provided, give a suitable label for the horizontal axis. (1)
- 3.1.2 Define *concentration*. (2)
- 3.1.3 On the Answer Sheet provided, sketch a distribution of molecular energies for this sample of gas at a higher concentration. (2)
- 3.1.4 This gas decomposes on heating. Explain why an increase in **temperature** increases the rate at which this gas decomposes. (4)
- 3.2 Hydrogen peroxide solution decomposes slowly to form water and oxygen. The reaction is much faster in the presence of a manganese (IV) oxide catalyst.



Three experiments, shown in the table below, were carried out to investigate how the volume of oxygen produced varied over time under different conditions. The same mass of catalyst was used in each experiment.

Experiment	Concentration of $\text{H}_2\text{O}_2(\text{aq})$ ($\text{mol}\cdot\text{dm}^{-3}$)	Volume of $\text{H}_2\text{O}_2(\text{aq})$ (cm^3)	Temperature ($^{\circ}\text{C}$)	Catalyst
1	1	50	20	lumps
2	1	50	20	powder
3	0,5	50	20	lumps

The graph below shows how the volume of oxygen collected varied with time in **Experiment 1**.



3.2.1 Explain how a catalyst increases the rate of a reaction. (3)

3.2.2 Draw two lines on the graph on the Answer Sheet provided to show how the volume of oxygen collected varied with time in Experiments 2 and 3. Label each line with the experiment number. (4)

3.3 An industrial process makes an acid. The table below shows the percentage yield of the acid made at different temperatures and pressures.

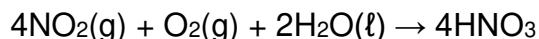
Pressure in atmospheres	Percentage yield at 200 °C	Percentage yield at 400 °C	Percentage yield at 600 °C
100	80%	22%	8%
200	92%	40%	14%
300	95%	56%	18%
400	96%	67%	22%

3.3.1 Define *yield*. (2)

3.3.2 How does increasing the temperature change the percentage yield? (1)

3.3.3 A temperature of 400 °C, a pressure of 200 atmospheres and a catalyst are actually used to make the acid. These conditions do not give the highest percentage yield. Suggest why these conditions are chosen. (4)

- 3.3.4 The final equation in the Ostwald process for the formation of nitric acid is given below.

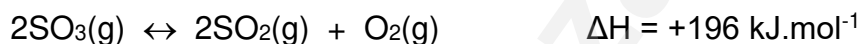


Using the conditions in Q3.3.3, if 504 g of HNO_3 was produced and having a yield of 40%, what mass of NO_2 was used? (4)

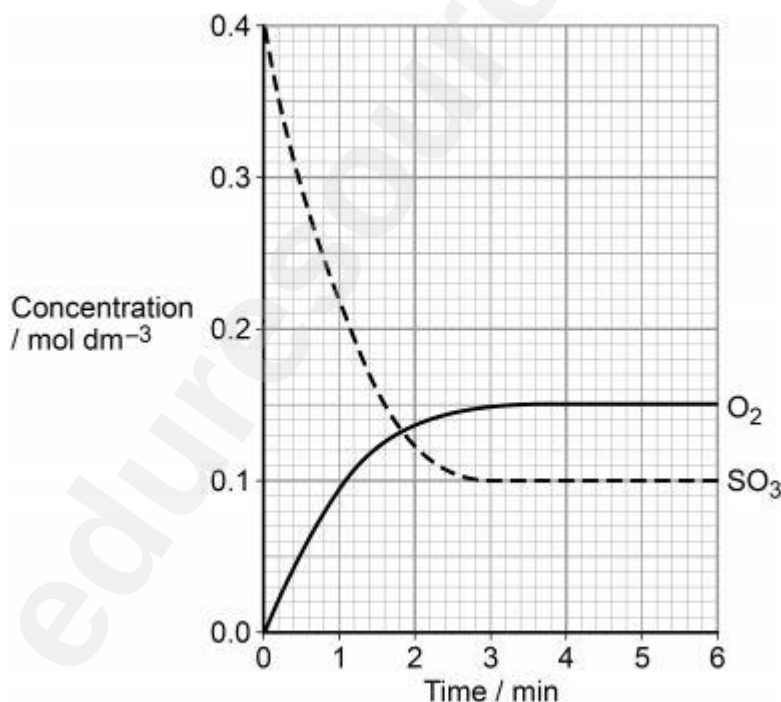
[27]

QUESTION 4 – CHEMICAL EQUILIBRIUM – START THIS QUESTION ON A NEW DOUBLE FOLIO SHEET

- 4.1 Sulphur trioxide decomposes to form sulphur dioxide and oxygen at temperature T_1 according to the equilibrium shown.



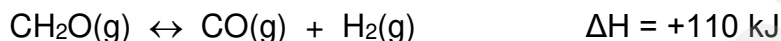
The graph below shows the concentrations of sulphur trioxide and of oxygen over a period of 6 minutes at temperature T_1 .



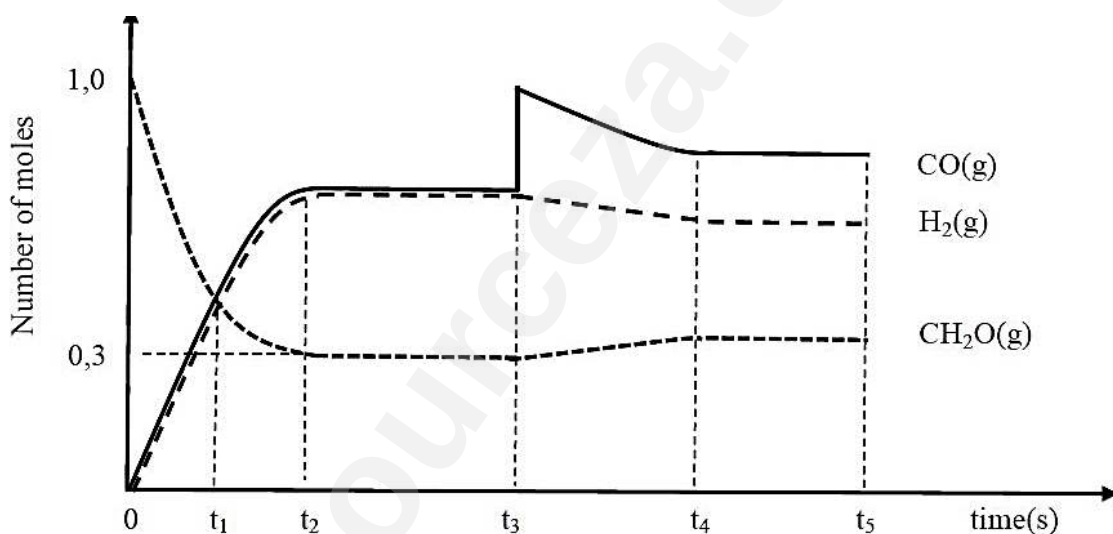
- 4.1.1 Sketch on the graph on the Answer Sheet how the concentration of sulphur dioxide changes over these 6 minutes at temperature T_1 . (2)
- 4.1.2 State *Le Chateliers principle*. (2)

- 4.1.3 The temperature of the mixture was changed to T_2 and the mixture left to establish a new equilibrium. In the new equilibrium mixture the concentration of sulphur trioxide was found to be $0,07 \text{ mol.dm}^{-3}$. Deduce which of T_1 and T_2 is the higher temperature. Explain. (4)

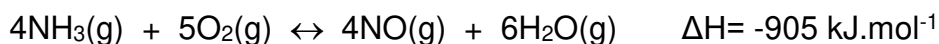
- 4.2 1 mol of $\text{CH}_2\text{O(g)}$ is placed in a 2 dm^3 container. The CH_2O decomposes according to the chemical equation below.



Refer to the equation and the graph below (not drawn to scale) to answer the questions.

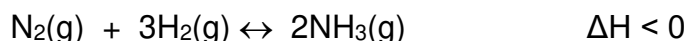


- 4.2.1 At what time ($t_1 - t_5$) did the system first reach equilibrium? (1)
- 4.2.2 Explain your reasoning for your answer to Q4.2.1. (1)
- 4.2.3 Compare the rate of the forward and reverse reactions at time t_1 . (1)
- 4.2.4 Explain the changes occurring from time t_3 to t_4 . (4)
- 4.2.5 How will K_c be influenced by the change in Q4.2.4? State one of *no change / increase / decrease*. (1)
- 4.3 The first stage in the Ostwald process used in the manufacture of nitric acid involves the catalytic oxidation of ammonia. The balanced chemical equation for this reaction is given below.



What volume change must be made to the reaction container so that a high yield of products is obtained? Explain by referring to Le Chateliers principle. (4)

- 4.4 The ammonia used in the Ostwald process is prepared by the reaction of hydrogen and nitrogen as shown in the following balanced chemical equation:



3,4 mol of $\text{N}_2(\text{g})$ and 7,2 mol of $\text{H}_2(\text{g})$ were injected into a $0,5 \text{ dm}^3$ reaction vessel which was then sealed and allowed to reach equilibrium 460°C .

When equilibrium was reached it was found that the concentration of $\text{NH}_3(\text{g})$ was $2,4 \text{ mol}\cdot\text{dm}^{-3}$.

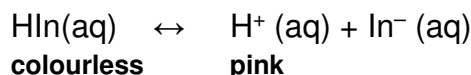
- 4.4.1 Write down the expression for the equilibrium constant, K_c , for this reaction. (2)
- 4.4.2 Calculate the equilibrium constant (K_c) at 460°C . (7)
- 4.4.3 What information does your answer for Q4.4.2 give regarding the expected yield of products (HIGH or LOW) in this reaction? (1)

[30]

QUESTION 5 – ACIDS AND BASES

- 5.1 Define *ionisation*. (2)
- 5.2 The value of the acid dissociation constant (K_a) for the monoprotic acid HX is 144.
- 5.2.1 What does this suggest about the concentration of undissociated HX in dilute aqueous solution? (1)
- 5.2.2 Write out the reaction equation for the ionisation of the monoprotic acid HX. (3)
- 5.2.3 State whether HX should be classified as a strong acid or a weak acid. Justify your answer. (3)
- 5.3 The K_a for a $0,15 \text{ mol}\cdot\text{dm}^{-3}$ solution of an acid, HA, is $1,53 \times 10^{-5}$ at 298 K.
- 5.3.1 Calculate the concentration of hydroxide ions in this solution. Assume 100% dissociation. (5)
- 5.3.2 The dissociation of HA into its ions in aqueous solution is an endothermic process. How would its pH change if the temperature were increased? Explain your answer. (3)

- 5.4 The indicator phenolphthalein is a weak acid which can be represented by the formula HIn . It dissociates in solution:



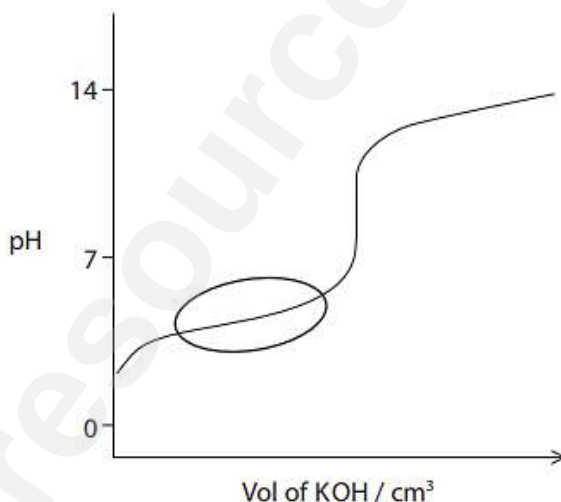
State the **colour change** that would be observed at the end point in an acid-base titration using phenolphthalein if sodium hydroxide solution were being added from the burette. Explain why this colour is formed. (3)

- 5.5 A student carried out a titration by adding $0,032 \text{ mol.dm}^{-3}$ potassium hydroxide solution to 25 cm^3 of $0,024 \text{ mol.dm}^{-3}$ propanoic acid. The balanced equation for this reaction is shown below:



- 5.5.1 Draw the structural formula for propanoic acid. (2)

A sketch graph of pH against volume of potassium hydroxide solution added is shown below.

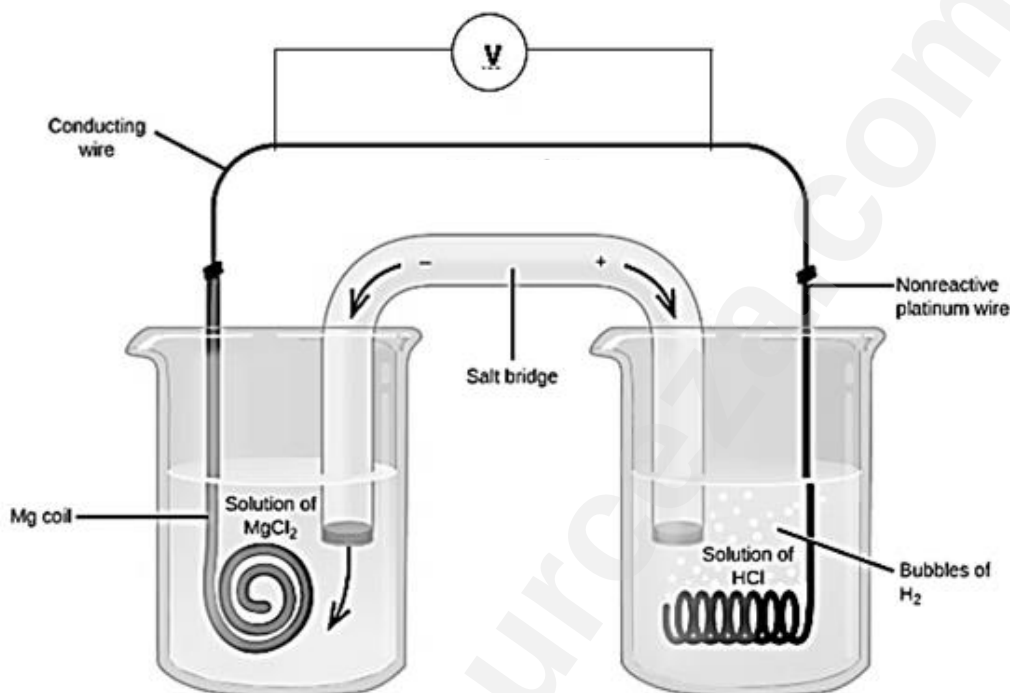


- 5.5.2 Define *hydrolysis*. (2)
- 5.5.3 Explain why the pH at the equivalence point of this titration is greater than 7 by referring to the interaction of the salt formed with water. (4)
- 5.5.4 Calculate the volume in **cm³** of a $0,032 \text{ mol. dm}^{-3}$ potassium hydroxide solution required to neutralise 25 cm^3 of $0,024 \text{ mol.dm}^{-3}$ propanoic acid. (4)

[32]

QUESTION 6 – GALVANIC CELLS - START THIS QUESTION ON A NEW DOUBLE FOLIO SHEET

Two students set up a galvanic cell under standard conditions using a magnesium coil as one electrode and an inert platinum coil as the other electrode, as shown below. The magnesium electrode is immersed into a solution of magnesium chloride, $\text{MgCl}_2(\text{aq})$, and the platinum electrode is immersed into a solution of $\text{HCl}(\text{aq})$. A very high resistance voltmeter **V** is connected in parallel across the conducting wire.

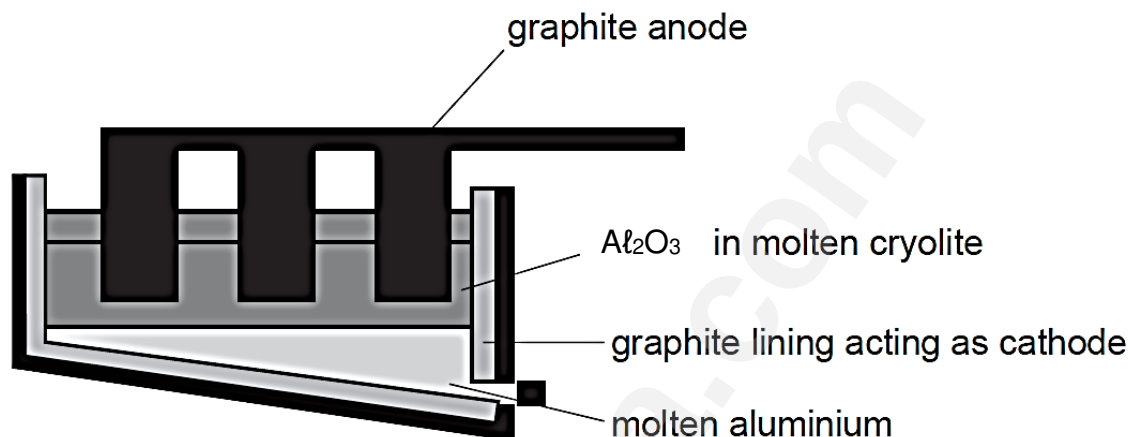


- 6.1 Define *cathode*. (2)
- 6.2 Write down the equation for the reaction occurring at the cathode. (2)
- 6.3 Write down the cell notation for this cell, including phases and conditions. (4)
- 6.4 Calculate the initial reading on the voltmeter under standard conditions. (3)
- 6.5 The students have a discussion. One of the students wants to add a solution of sodium hydroxide to the magnesium half cell, but the other student tells her that this addition would affect the reading on the voltmeter. Explain *how* and *why* this would affect the reading on the voltmeter. (4)
- 6.6 After the cell has been in operation for a while, the reading on the voltmeter decreases, and eventually reads 0,00 V. Explain, using equilibrium principles, why this occurs. (3)
- 6.7 Suggest ONE change the students could make to the *construction* of the cell which would increase the maximum current the cell could deliver. (1)

[19]

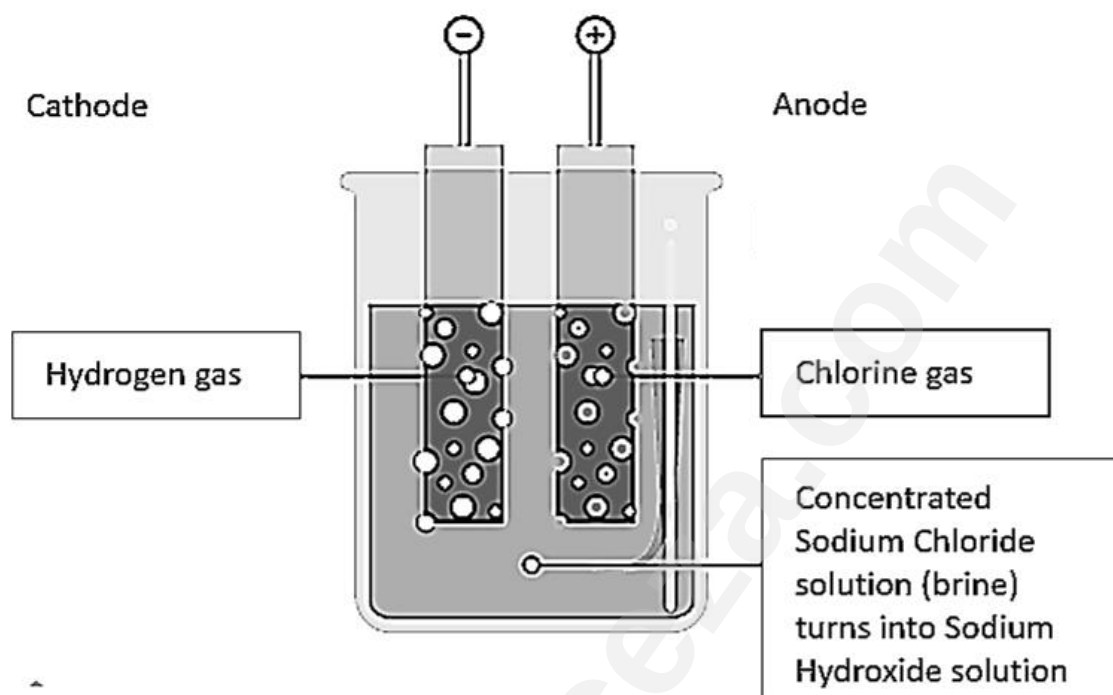
QUESTION 7 – ELECTROLYTIC CELLS

- 7.1 The apparatus shown below is used in the Hall-Heroult electrolytic process for the extraction of aluminium from alumina (Al_2O_3). The melting point of alumina is 2000°C , and the melting point of aluminium metal is 660°C .



- 7.1.1 Suggest one advantage and one disadvantage of the use of molten cryolite in this cell. (2)
- 7.1.2 The carbon anodes need to be replaced fairly often in this process. Explain, with the aid of an equation, why this is necessary. (2)
- 7.1.3 Why is it important that the alumina-cryolite mixture be kept at a high temperature (of $\pm 900^\circ\text{C}$)? (2)
- 7.1.4 Explain, with the use of a reaction equation from your SEP table, why aluminium cannot be produced by the electrolysis of an aqueous solution of an aluminium salt. (3)
- 7.1.5 13,5 g of aluminium is required to make one aluminium cooldrink can. Calculate the time taken, IN HOURS, to make one aluminium can if a current of 10 A is passed through the molten alumina. (6)

- 7.2 Consider the diagram below of the hypothetical electrolysis of a concentrated brine (NaCl) solution. The three products of this process are Cl_2 and H_2 gas, and aqueous NaOH .

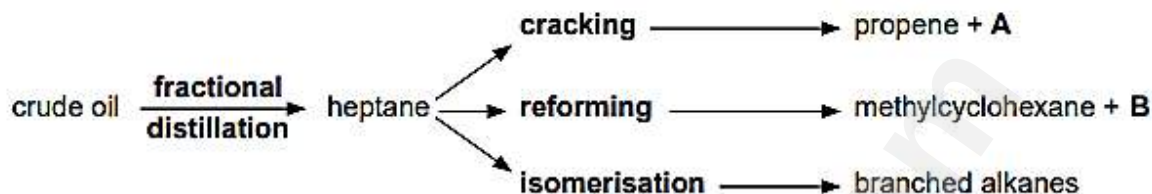


- 7.2.1 In reality, this cell could never be used in the chlor-alkali industry. Suggest ONE reason why. (2)
- 7.2.2 Why is it important to keep the brine solution concentrated? (2)
- 7.2.3 The diaphragm and mercury cells have the ability to produce good quality sodium hydroxide (particularly the mercury cell) yet **membrane cell** technology is by far the most widely used in the worldwide chlor-alkali industry today. Suggest TWO reasons the membrane cell has advantages over the diaphragm and mercury cells. (2)

[21]

QUESTION 8 – ORGANIC CHEMISTRY

- 8.1 Crude oil is first separated by fractional distillation. The fractions can then be refined further by cracking, reforming and isomerisation. The reaction sequence below shows the production of heptane, C_7H_{16} , from fractional distillation of crude oil, followed by cracking, reforming and isomerisation.



- 8.1.1 Explain what is meant by the term “cracking”. (2)
- 8.1.2 Define *structural isomer*. (2)
- 8.1.3 The cracking of heptane produces propene and A. Write a balanced equation for this cracking of heptane using molecular formulae. (2)
- 8.2 The isomerisation of heptane produces eight branched alkanes, five of which are shown below.

$\begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3\text{CHCH}_2\text{CH}_2\text{CH}_2\text{CH}_3 \end{array}$ A: 2-methylhexane	B: 2,4-dimethylpentane
$\begin{array}{c} \text{CH}_3 \quad \text{CH}_3 \\ \quad \\ \text{CH}_3-\text{CH}-\text{C}-\text{CH}_3 \\ \\ \text{CH}_3 \end{array}$ C: 2,2,3-trimethylbutane	$\begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_2 \\ \\ \text{CH}_3\text{CH}_2\text{CHCH}_2\text{CH}_3 \end{array}$ D:
$\begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3\text{CHCHCH}_2\text{CH}_3 \\ \\ \text{CH}_3 \end{array}$ E: 2,3-dimethylpentane	

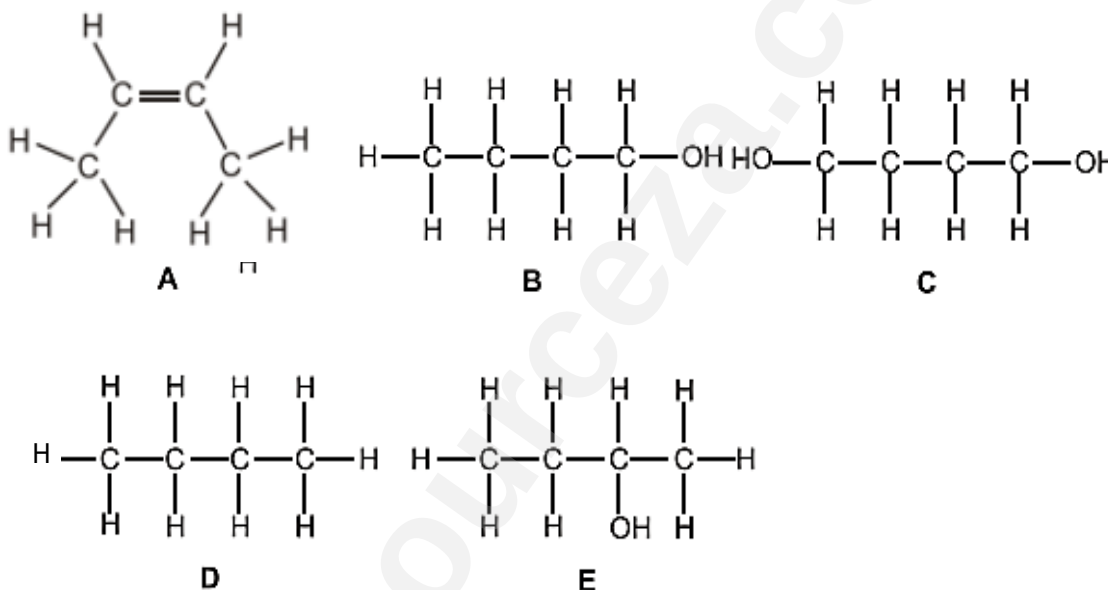
- 8.2.1 What type of isomers are illustrated here? (2)
- 8.2.2 Name compound D. (2)
- 8.2.3 Name and draw the structural formula of a branched alkane isomer of heptane that is not shown in the table. (3)
- 8.2.4 Give the condensed structural formulae for 2,2,3-trimethylbutane. (2)

- 8.2.5 Predict which of 2-methylhexane, 2,3-dimethylpentane and 2,2,3-trimethylbutane has the *lowest* boiling point. Explain why 2-methylhexane, 2,3-dimethylpentane and 2,2,3-trimethylbutane have different boiling points. (5)

[20]

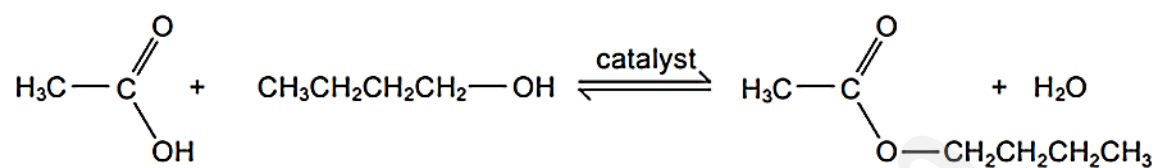
QUESTION 9 – ORGANIC CHEMISTRY - START THIS QUESTION ON A NEW SINGLE FOLIO SHEET

This question is about the compounds A - E below. Answer the following questions by referring to the compounds A - E.



- 9.1 Which two compounds are positional isomers of each other? (2)
- 9.2 Name compound C. (2)
- 9.3 Name the functional group for compound B, C and E. (1)
- 9.4 Compound E can be dehydrated to form compound A. What are the reaction conditions for this reaction? (2)
- 9.5 Compound D under certain conditions, reacts with Cl_2 to form a mixture of chlorinated products. One possible product is $\text{C}_4\text{H}_9\text{Cl}$. Name this GENERAL type of reaction. (1)
- 9.6 Compound A can be used to form compound D
- 9.6.1 Suggest a suitable catalyst for this reaction. (1)
- 9.6.2 Name this SPECIFIC type of reaction. (1)

9.7 Compound B can also be reacted with a carboxylic acid as illustrated below.



9.7.1 Name the organic product of this reaction.

(2)

9.7.2 Name the homologous series to which the organic product belongs.

(1)

[13]