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Enlightened Minds

**Gr 12
Physical Science
Paper II**

29 JULY 2019

Examiner: K Trenor

Moderator: J McBride, H Bezuidenhout & D Henry

Time: 180 min

200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 16 pages, an Answer Sheet of 2 pages (i-ii) and a Data Sheet of 3 pages (i-iii). Please check that your question paper is complete.
2. **Write your name on the Answer Booklet.**
3. Read the questions carefully.
4. Use the data and formulae whenever necessary.
5. **All graphs and diagrams must be done in pencil.**
6. **Start each new question on a new page and rule off at the end.**
7. It is in your own interest to write legibly and to set your work out neatly.
8. Show your working in all calculations.
9. Answers must be expressed in decimal format, not left as proper fractions. Round answers to two decimal places where appropriate.
10. Units need not be included in the working of calculations, but appropriate units should be shown in the answer.
11. Non-programmable calculators may be used.

Question 1

[10 x 2 =20 marks]

Answer these questions on the Multiple-choice Answer Sheet. Make a cross (X) in the box corresponding to the letter that you consider to be correct.

1.1. Which one of the following substances contains the most polar covalent bond?

- A. NaF
- B. HCl
- C. H₂O
- D. CH₄

1.2. Which of the following compounds has dipole-dipole forces between its molecules?

- A. Ethene
- B. Hydrochloric acid
- C. Magnesium atoms
- D. Carbon dioxide

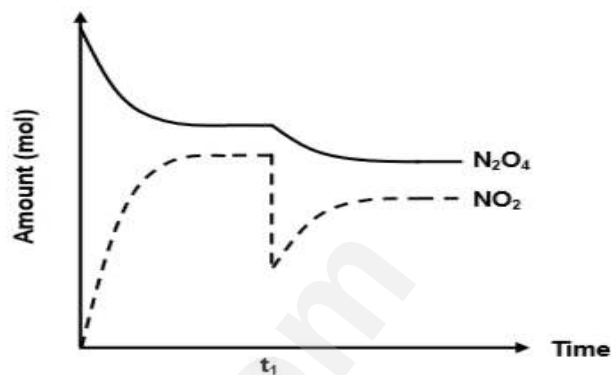
1.3. Consider the following statements with respect to a chemical reaction in a state of dynamic chemical equilibrium:

- I. The concentrations of the reactants and products are identical provided the reaction occurs in a closed system.
- II. The rates of the forward and reverse reactions are identical provided the reaction occurs in a closed system.
- III. The amounts of reactant and product remain unchanged provided the reaction occurs in a closed system.

Which of the statement(s) above is/are true?

- A. I only
- B. II only
- C. I and III
- D. II and III

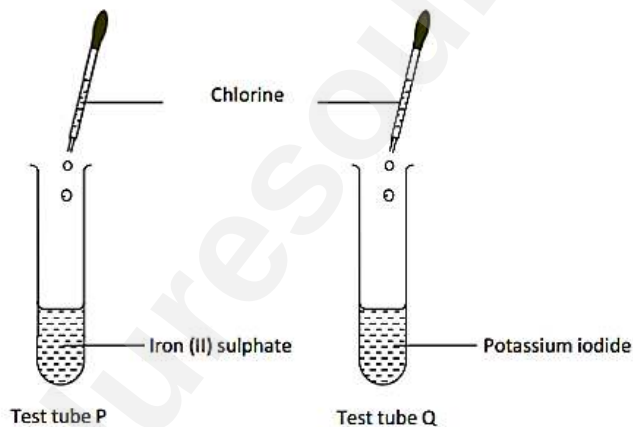
- 1.4. Consider the balanced chemical equation and the graph of amount vs time that follows.



Which one of the following stresses occurred at time t_1 ?

- A. NO_2 was removed.
- B. N_2O_4 was removed.
- C. The temperature was decreased.
- D. The pressure was increased.

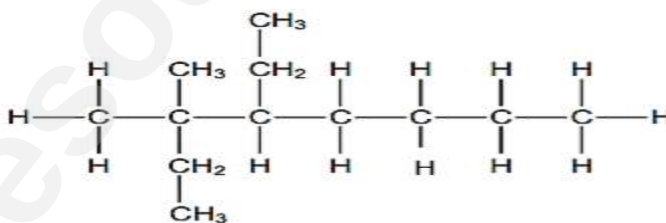
- 1.5. Identify the reducing agents in the following reactions.



- 1.6.

	Test Tube P	Test Tube Q
A	Fe^{2+} ion	K^+ ion
B	Fe^{2+} ion	I^- ion
C	SO_4^{2-} ion	K^+ ion
D	SO_4^{2-} ion	I^- ion

- 1.7. Which one of the following statements about the extraction of aluminium from alumina is false?
- Oxide ions are reduced at the graphite electrodes.
 - Alumina dissolves in molten cryolite reducing the energy cost of running the smelter.
 - Carbon dioxide is a by-product of the extraction process.
 - Aluminium is formed at the negative electrode through the process of reduction.
- 1.8. In which option, do all the compounds belong to the same homologous series?
- ethane, ethene, ethyne
 - dimethylpropane, methylbutane, pentane
 - propan-1-ol, propan-1,2,3-triol, propanoic acid
 - ethyl methanoate, methyl ethanoate, propanoic acid
- 1.9. Choose the correct name for the compound below:



- 4-ethyl-3,3-dimethyloctane
- 2,3-diethyl-2-methylheptane
- 5,6-diethyl-6-methylheptane
- 5-ethyl-6,6-dimethyloctane

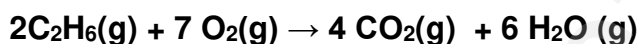
- 1.10. Hydrocarbons can be cracked to produce smaller molecules. The equation shows the reaction for a hydrocarbon,



Which product of the reaction shown is saturated?

- A. C_4H_8
- B. C_3H_6
- C. C_6H_{14}
- D. C_2H_4

- 1.11. Consider the balanced chemical equation for the complete combustion of ethane:



Which one of the following shows the maximum volume of gas that can be produced (at STP) if 100g of ethane is completely combusted?

- A. $\frac{100 \times 10 \times 22.4}{30 \times 2}$
- B. $\frac{100 \times 2 \times 22.4}{30 \times 10}$
- C. $\frac{100 \times 4 \times 22.4}{30 \times 2}$
- D. $\frac{100 \times 6 \times 22.4}{60 \times 2}$

QUESTION 2:**[16 marks]**

- 2.1. Define a *covalent bond*. (2)
- 2.2. Use only substances from the list below when answering Questions 2.2.1 to 2.2.8. The phase indicators (state symbols) represent the physical state of each of the substances at room temperature.

SiO₂(s)	NH₃(g)	H₂O(l)	KBr(s)	C₆H₁₂(l)
Kr(g)	Pt(s)	PH₃(g)	NH₄Cl(aq)	I₂(s)

From the list select ONE: (Only write down the question number and the formula of the substance next to it. Substances may be used more than once or not at all.)

- 2.2.1. Substance that has a giant covalent network structure. (1)
- 2.2.2. Compound with pure covalent bonds. (1)
- 2.2.3. Substance that has non-polar molecules, despite the presence of polar covalent bonds within the molecules. (1)
- 2.2.4. Substance that exists as individual atoms, which interact through London forces only. (1)
- 2.2.5. Substance that exists in a giant ionic lattice. (1)
- 2.2.6. Slightly acidic salt. (1)
- 2.2.7. A Substance that can conduct electricity in both solid and liquid phases. (1)
- 2.2.8. Substance that can undergo oxidation to form oxygen gas. (1)
- 2.3. Define *intermolecular force*. (2)
- 2.4. At room temperature, I₂ is a solid, whereas H₂O is a liquid. Explain this difference in phase, with reference to the intermolecular forces present in each substance. (4)

Question 3**[15 marks]**

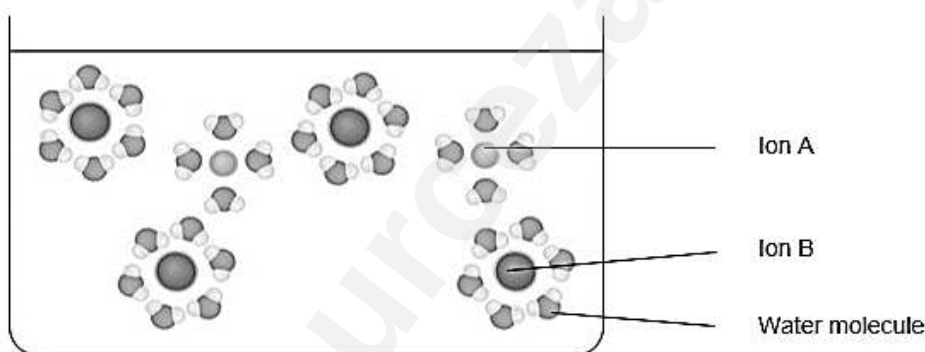
The lime water we use in the lab is simply a solution of calcium hydroxide that has been filtered. A standard solution of $\text{Ca}(\text{OH})_2$ is made up so that it will have a volume of $0,5 \text{ dm}^3$ and a concentration of $0,6 \text{ mol.dm}^{-3}$.

The standard solution is made up using distilled water.

3.1. Name the solute used to make this solution. (2)

3.2. Calculate the number of hydroxide ions present in solution. (4)

The diagram below shows ions of $\text{Ca}(\text{OH})_2$ dissolved in water.



3.3. Name the **specific type** of force that holds the solid $\text{Ca}(\text{OH})_2$ crystal together before dissolution. (1)

3.4. Give the formula for ion B. Explain your answer. (3)

3.5. Name the **general** and **specific type** of force between the ions and the water molecules. (2)

3.6. In an unfiltered solution of limewater a chemical equilibrium is established.

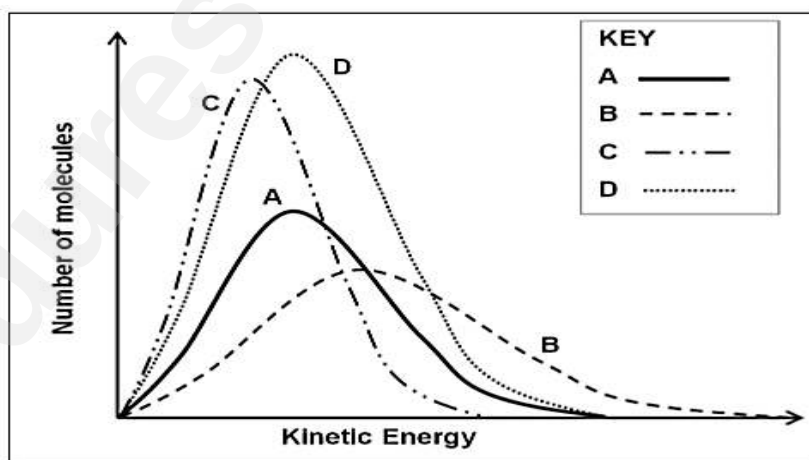
The K_{sp} value or solubility product for calcium hydroxide is given as

$$K_{sp} = 5,5 \times 10^{-6} \quad \text{for} \quad K_{sp} = \frac{[\text{Ca}^{2+}][\text{OH}^-]^2}{[\text{Ca}(\text{OH})_2]}$$

3.6.1. What does the value of the K_{sp} tell you about the relative strengths of the forces between the ions in solution and the ions in the precipitate? (3)

Question 4**[21 marks]**

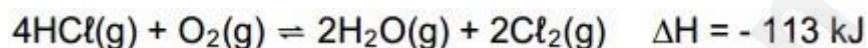
- 4.1. Define the following terms:
- 4.1.1. *Heat of reaction.* (2)
 - 4.1.2. *Activated complex.* (2)
- 4.2. According to the collision theory, in order for a chemical reaction to occur reactant particles must collide. State TWO requirements for an effective collision. (4)
- 4.3. Excess dilute hydrochloric acid is added to a single large piece of zinc metal in an open test-tube.
- 4.3.1. Write a balanced chemical equation for the reaction which takes place in the test-tube. (3)
 - 4.3.2. Other than using a suitable catalyst, explain **THREE** different ways of increasing the rate of this particular reaction. (6)
 - 4.3.3. Explain in simple terms how a catalyst increases the rate of a chemical reaction. (2)
- 4.4. The Maxwell-Boltzmann curve labelled **A** shows the distribution of molecular energies in 0,5 mol of ozone gas (O_3) at STP.



- 4.4.1. Which of curves B, C or D represents 0,5 mol of ozone gas at a lower temperature? (1)
- 4.4.2. Which of curves B, C or D represents 1,0 mol of ozone gas at STP? (1)

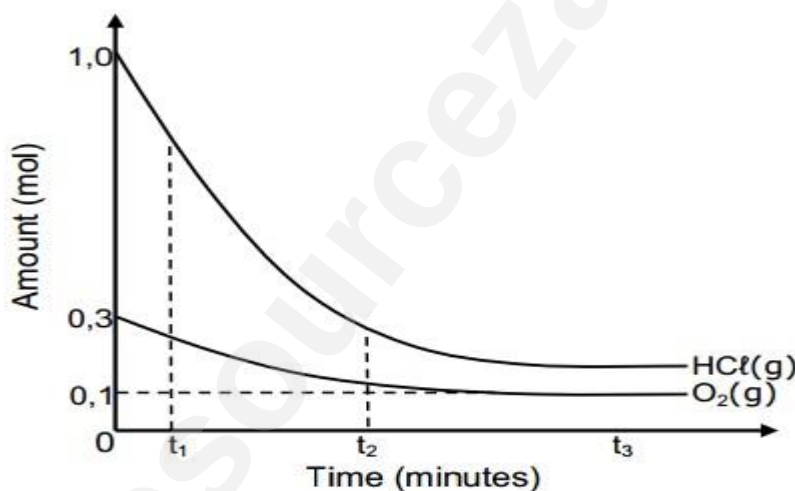
QUESTION Question 5
marks]**[19 marks]**

The reaction between hydrogen chloride and oxygen reaches equilibrium in a closed container according to the following balanced equation:



- 5.1. Is this reaction exothermic or endothermic? Give a reason for the answer. (2)

The graphs below, not drawn to scale, show how the amounts of reactants present in the container change with time at a specific temperature. The volume of the container is 5 dm³.

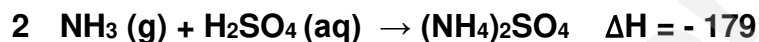


- 5.2. How does the rate of the forward reaction at time t_1 compare to that at time t_2 ?
Write down GREATER THAN, SMALLER THAN or EQUAL TO. Use the graphs to give a reason for the answer. (2)
- 5.3. How does the rate of the forward and the reverse reactions compare at time t_3 ?
Write down only GREATER THAN, SMALLER THAN or EQUAL TO. (1)
- 5.4. Write the K_c expression for this reaction. (2)
- 5.5. Calculate the equilibrium constant (K_c) for this reaction at this temperature. (7)
- 5.6. State *Le Châtelier's principle*. (2)
- 5.7. Explain what would happen in the system when the amount of water is increased. (3)

Question 6**[25 marks]**

6.1 Define *an acid* in terms of the Bronsted-Lowry theory. (2)

Ammonium sulphate $(\text{NH}_4)_2\text{SO}_4$ is used as a fire retardant and wood preservative, it is prepared industrially by the reaction of gaseous ammonia with sulphuric acid.



6.2. Define salt hydrolysis. (2)

6.3. Write an equation that would show the hydrolysis that would occur with this salt (Ammonium sulphate). (2)

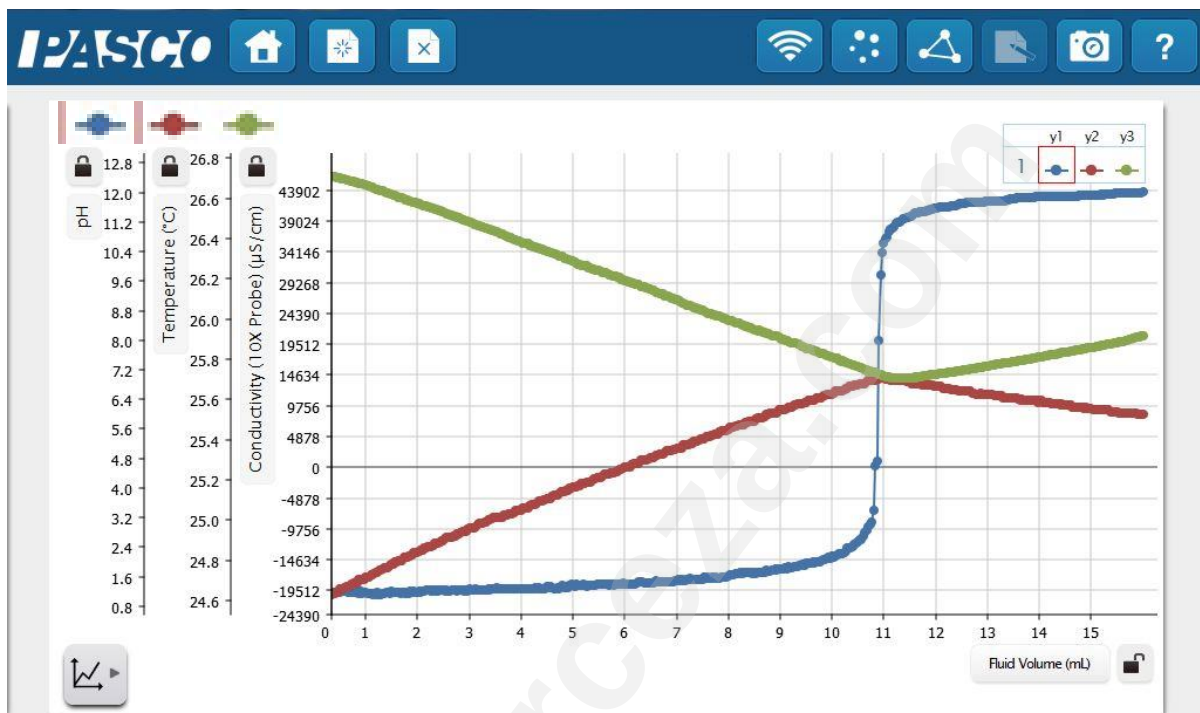
6.4. Explain whether the salt formed in the above reaction, would be basic, acidic or neutral. (4)



50 mL of a $0,01 \text{ mol.dm}^{-3}$ standard solution of H_2SO_4 is titrated with $0,2 \text{ M NH}_3$ just until a change in the indicator solution is obtained.

6.5. Calculate the volume of NH_3 needed to reach this point. (4)

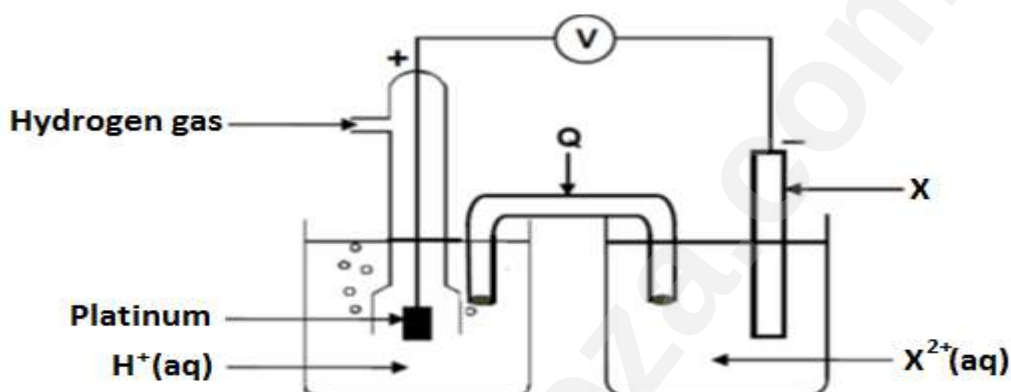
The following graph is obtained during a similar experiment of pH, temperature and conductivity vs volume. Study the graphs and answer the questions that follow:



- 6.6. Describe and explain the change in pH. (3)
- 6.7. Describe the change in temperature (2)
- 6.8. In detail, explain the changes and the reason for these changes in the conductivity, as shown by this graph. (4)
- 6.9. State and define the term given to the point where the lines intersect. (2)

Question 7**[18 marks]**

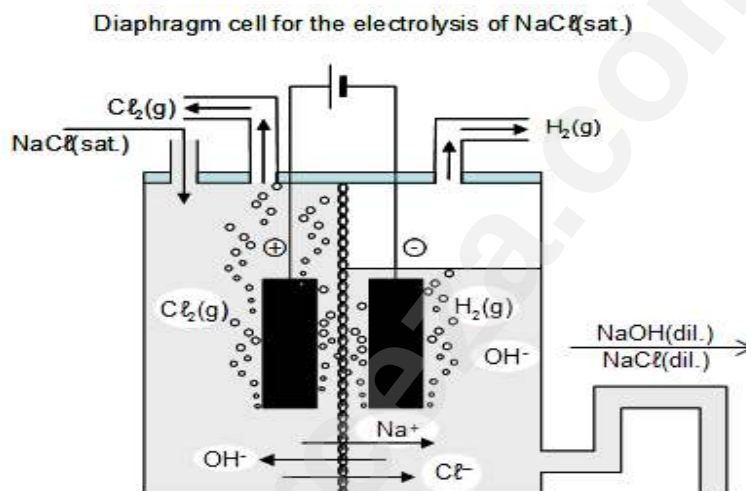
A standard electrochemical cell is set up using a standard hydrogen half-cell and a standard $X|X^{2+}$ half-cell as shown below. A voltmeter connected across the cell, initially registers 0,28 V.



- 7.1. Give two reasons, besides being a solid, which makes the use of Platinum suitable as an electrode in this cell? (2)
- 7.2. A salt bridge is pivotal for the above cell to function optimally.
 - 7.2.1. Explain how it maintains cell neutrality in the half cell containing electrode **X**. (3)
 - 7.2.2. How would a wider, shorter salt bridge effect the emf? (2)
- 7.3. Define the term *oxidation*. (1)
- 7.4. Write down the
 - 7.4.1. the value of the standard reduction potential of the X/X^{2+} cell (1)
 - 7.4.2. the half reaction that takes place at the anode. (2)
- 7.5. Provide the cell notation for the above cell under standard conditions. (6)
- 7.6. Is this cell reaction exothermic or endothermic? (1)

Question 8**[12 marks]**

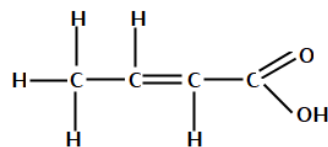
The electrolysis of brine to produce chlorine, sodium hydroxide and hydrogen is carried out on a massive scale in the chlor-alkali industry. Below is a schematic diagram of a Diaphragm Cell. Refer to this diagram when answering the questions that following.



- 8.1. What is brine? (1)
- 8.2. Write down the chemical equations for:
- 8.2.1. the reaction at the anode of this cell. (1)
- 8.2.2. the overall cell reaction. (2)
- 8.3. What current is required to produce 40 dm^3 of hydrogen gas, measured at STP, from the electrolysis of the water in 1 hour? (8)

Question 9**[35 marks]**

German pharmacist Ludwig Andreas Buchner isolated **angelic acid** in 1842 from the roots of garden angelica (*Angelica archangelica*) which gave the molecule its name.



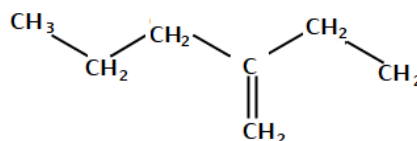
9.1. Define the following terms

9.1.1. *functional group*. (2)

9.1.2. *homologous series*. (2)

9.1.3. Name all the functional groups in angelic acid. (2)

9.2. The structural formula of compound B is:

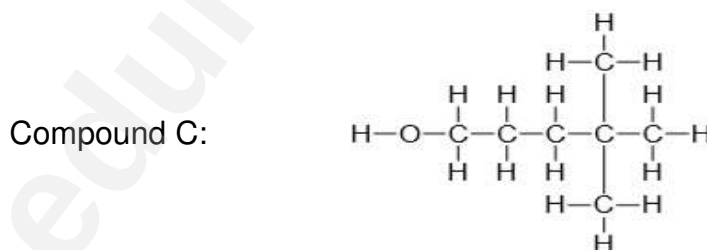


9.2.1. Name the homologous series to which that compound B belongs. (2)

9.2.2. Provide the IUPAC name for compound B. (3)

9.2.3. What is the chemical test used to test for unsaturated compounds in the lab? (3)

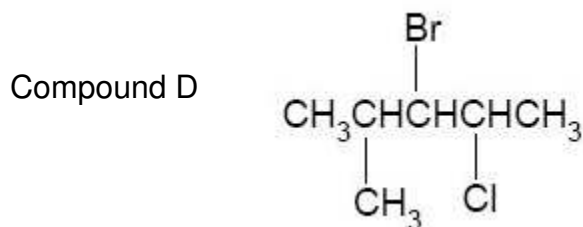
9.3. The structural formula of compound C is shown:



9.3.1. Provide the IUPAC name for compound C. (3)

9.3.2. Compound C burns completely in excessive oxygen. Provide the balanced equation for this reaction. (3)

9.4. The structural formula of compound D is shown:



9.4.1. Provide the IUPAC name for compound D. (3)

9.5. Knowledge of boiling points can be used to identify chemical compounds. The boiling points of four organic compounds, represented by the letters E, F, G and H, are given in the table below:

	Compound	Boiling point (°C)
E	Propane	-42
F	Pentane	36
G	2-methylbutane	27,8
H	Pentan-1-ol	137

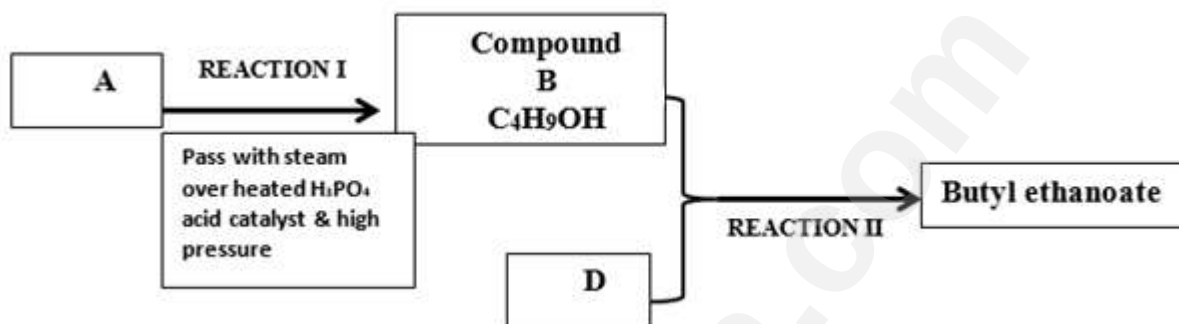
9.5.1. Decide whether E or F has the higher vapour pressure? Explain. (4)

9.5.2. Explain why F has a higher boiling point than G. (4)

9.5.3. Explain why F has a lower boiling point than H. (4)

Question 10**[19 marks]**

Butyl ethanoate is the major component that accounts for the banana-like aroma and flavour in many flavoured substances.



The formation of compound B is shown with **Reaction I**.

- 10.1. Name the homologous series to which compound B belongs. (1)
- 10.2. Name the specific type of reaction labelled **Reaction I**. (1)
- 10.3. Give the IUPAC name of compound A. (2)

Butyl ethanoate is produced in **Reaction II**

- 10.4. Identify the functional group of Butyl ethanoate (1)
- 10.5. Name the type of reaction labelled **Reaction II**. (1)
- 10.6. Name the catalyst required for this reaction. (1)
- 10.7. Give the IUPAC name of compound D. (2)
- 10.8. Using structural formula, write a balanced equation for the formation of butyl ethanoate, including all the reactants. (6)
- 10.9. Define the term *isomer*. (2)
- 10.10. Give the name of the *functional isomer* of butyl ethanoate. (2)