NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2019

PHYSICAL SCIENCES: PAPER II

Time: 3 hours 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 15 pages, a yellow ANSWER SHEET of 2 pages (i–ii) and a green DATA SHEET of 3 pages (i–iii). Please make sure that your question paper is complete.
2. Answer ALL the questions.
3. Read the questions carefully.
4. Use the data and formulae whenever necessary.
5. **START EACH QUESTION ON A NEW PAGE.**
6. Please ensure that you number your answers as the questions are numbered.
7. Unless instructed otherwise, it is NOT necessary to give state symbols (phase indicators) when asked to write a balanced chemical equation.
8. Show all the necessary steps in calculations.
9. Where appropriate, express final answers correct to TWO decimal places.
10. It is in your interest to write legibly and to present your work neatly.

QUESTION 1 MULTIPLE CHOICE

Answer these questions on the multiple-choice Answer Sheet on the inside front cover of your Answer Book. Make a cross (X) in the box corresponding to the letter of the option that you consider to be most correct. Every question has only one correct answer.

A	B	C	D

Here the answer C has been marked.

1.1 Which of the following covalent bonds is the most polar?

A C−F
B S−Br
C O−H
D Cℓ−Cℓ

1.2 Identify the predominant intermolecular force in pure liquid carbon tetrafluoride, CF_4.

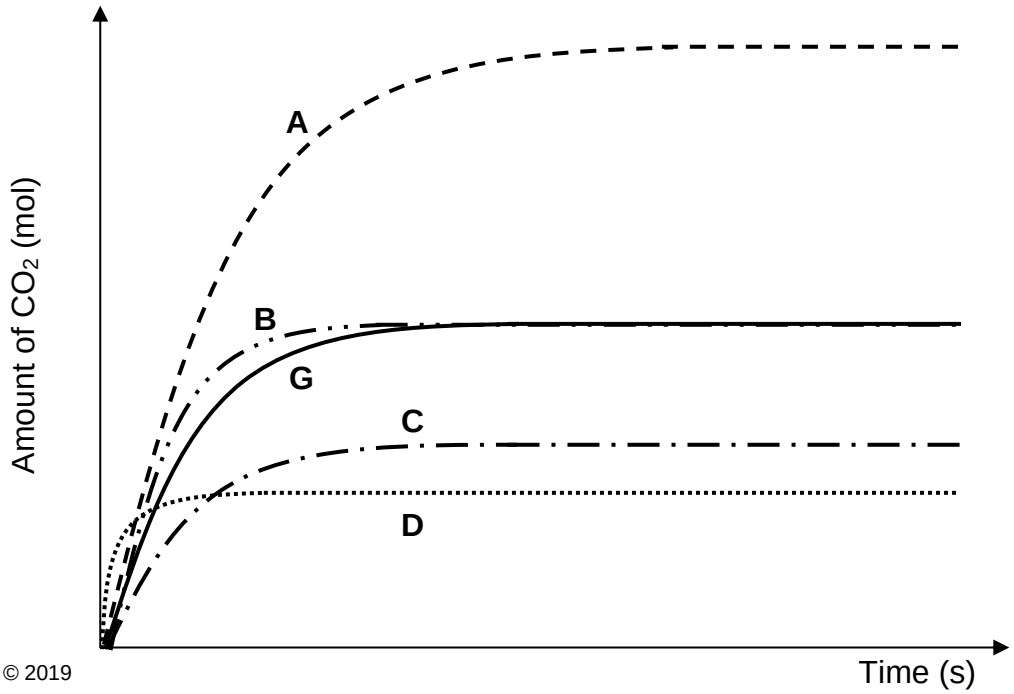
A London forces
B dipole-dipole interactions
C hydrogen bonds
D ionic bonds

1.3 The reaction represented by the balanced chemical equation below was used to investigate how certain factors affect the reaction rate.

$$MgCO_3(s) + 2HC\ell(aq) \rightarrow MgC\ell_2(aq) + H_2O(\ell) + CO_2(g)$$

The amount of carbon dioxide produced from the reaction vessel was monitored. Graph **G** (the solid line) below was obtained for the reaction of 100 cm^3 of a **0,2 mol·dm^{-3}** HCℓ solution with a **SINGLE LUMP** of excess $MgCO_3$.

Which graph (**A**, **B**, **C**, or **D**) represents the reaction of 100 cm^3 of a **0,1 mol·dm^{-3}** HCℓ solution with excess $MgCO_3$ **POWDER**?



1.4 Consider the reaction represented by the following balanced chemical equation. The system is initially at equilibrium.

$$H_2(g) + Br_2(g) \rightleftharpoons 2HBr(g)$$

The pressure is increased by decreasing the volume of the container at constant temperature. How will the **amount** of HBr and the **concentration** of HBr change due to this increase in pressure?

	AMOUNT of HBr	**CONCENTRATION of HBr**
A	Increase	Increase
B	Decrease	Decrease
C	Remain the same	Increase
D	Remain the same	Decrease

1.5 Hydrated iron(II) ions react with hydroxide ions in **aqueous solution** as represented by the following balanced chemical equation:

$$Fe(H_2O)_6^{2+}(aq) + 4OH^-(aq) \rightleftharpoons Fe(OH)_4^{2-}(aq) + 6H_2O(\ell)$$

Water is added to this system at equilibrium. Which one of the following correctly identifies the stress and the system's response to the stress?

	Stress	**Response**
A	Increase in the concentration of water	Forward reaction favoured to use up the water
B	Increase in the concentration of water	Reverse reaction favoured to use up the water
C	Decrease in the concentration of all ions	Forward reaction favoured to produce more ions
D	Decrease in the concentration of all ions	Reverse reaction favoured to produce more ions

1.6 Water is added to a 0,01 $mol \cdot dm^{-3}$ solution of hydrochloric acid. Which one of the following describes the change in strength and concentration of the acid as water is added?

	Strength	**Concentration**
A	Remains the same	Remains the same
B	Remains the same	Decreases
C	Decreases	Decreases
D	Decreases	Remains the same

1.7 Which of the following statements is/are TRUE regarding the *neutralisation point* of a reaction between ammonia and hydrochloric acid?

i It is the point where the acid and base have reacted so that neither is in excess
ii $[H_3O^+] = [OH^-]$
iii pH = 7

A i only
B i and ii
C i, ii and iii
D ii and iii

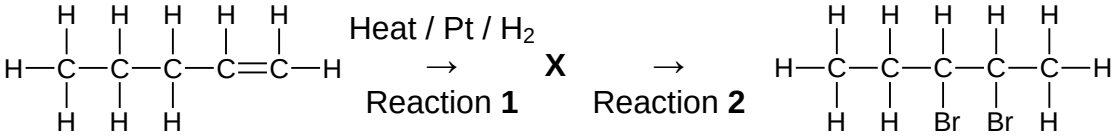
1.8 Which one of the half-reactions below will be predominant at the POSITIVE electrode during the electrolysis of concentrated $CuC\ell_2(aq)$?

A $Cu^{2+} + 2e^- \rightarrow Cu$
B $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$
C $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$
D $2C\ell^- \rightarrow C\ell_2 + 2e^-$

1.9 Which one of the following statements is TRUE regarding the cathode in the electrorefining of copper?

A It is made of impure copper.
B Zinc metal deposits onto the cathode.
C It is the electrode where reduction occurs.
D It is the positive electrode.

1.10 Consider the following sequence of reactions. Compound **X** is an unknown organic compound, and Reactions **1** and **2** are organic reactions.



Which one of the following is the correct SPECIFIC type and GENERAL type for Reaction **2**?

	SPECIFIC TYPE	**GENERAL TYPE**
A	Halogenation	Substitution
B	Hydrolysis	Substitution
C	Halogenation	Addition
D	Hydrohalogenation	Addition

[20]

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QUESTION 2

A single 6,5 g piece of aluminium metal reacts with 400 cm^3 of a 2,6 $mol \cdot dm^{-3}$ sodium hydroxide solution to produce sodium aluminate and hydrogen gas as represented by the following balanced chemical equation:

$$2A\ell(s) + 6NaOH(aq) \rightarrow 2Na_3A\ell O_3(aq) + 3H_2(g) \qquad \Delta H < 0$$

2.1 Determine the amount (in moles) of aluminium metal present at the beginning of the reaction. (3)

2.2 Use suitable calculations to show that the sodium hydroxide is in excess. (4)

2.3 The percentage yield of the sodium aluminate is 92%. Calculate the final concentration of the sodium aluminate solution. (Assume the volume of the solution remains constant at 400 cm^3.) (5)

2.4 2.4.1 Define *exothermic reaction*. (2)

2.4.2 Referring to the energies absorbed and released, describe why this reaction is considered to be exothermic. Marks will not be awarded for restating the definition. (2)

2.5 2.5.1 Other than **correct orientation** of reacting particles, state ONE condition for an effective collision. (1)

2.5.2 Using the collision theory, explain the effect of using a LESS-concentrated sodium hydroxide solution on the rate of its reaction with aluminium. (4)

2.6 How would an increase in pressure (at constant temperature) affect the rate of this reaction? State only INCREASE, DECREASE, or REMAIN THE SAME. (2)

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QUESTION 3

Consider the reaction of aluminium with sodium hydroxide:

$$2A\ell(s) + 6NaOH(aq) \rightarrow 2Na_3A\ell O_3(aq) + 3H_2(g)$$

3.1 Under high pressure and very low temperature, hydrogen gas may be condensed into a liquid, giving evidence for **London forces** between the molecules of hydrogen. Explain how these London forces originate. (3)

3.2 The hydrogen gas produced is collected by the downward displacement of water. Data collected in this experiment is given in the table below.

Time (s)	**Volume of H_2 gas (dm^3)**
0	0
20	3,0
40	4,7
60	5,7
80	5,9
100	5,9
120	5,9

3.2.1 Using the information given in the table, state the time at which the reaction ended. (1)

3.2.2 Hence, calculate the average rate of formation of hydrogen in units of $dm^3 \cdot s^{-1}$. Express your answer in **scientific notation**. (2)

3.2.3 A graph showing the relationship between the volume of H_2 gas and time has been partially plotted on the axes provided in your ANSWER SHEET. Complete this graph by providing all the missing information and drawing a line of best fit. (6)

3.3 If sulfur powder is added to an aqueous sodium hydroxide solution, a spontaneous reaction will occur, producing a sodium sulfite solution, a precipitate of sodium sulfide and water. Write a balanced chemical equation for this reaction, including state symbols (phase indicators). (4)

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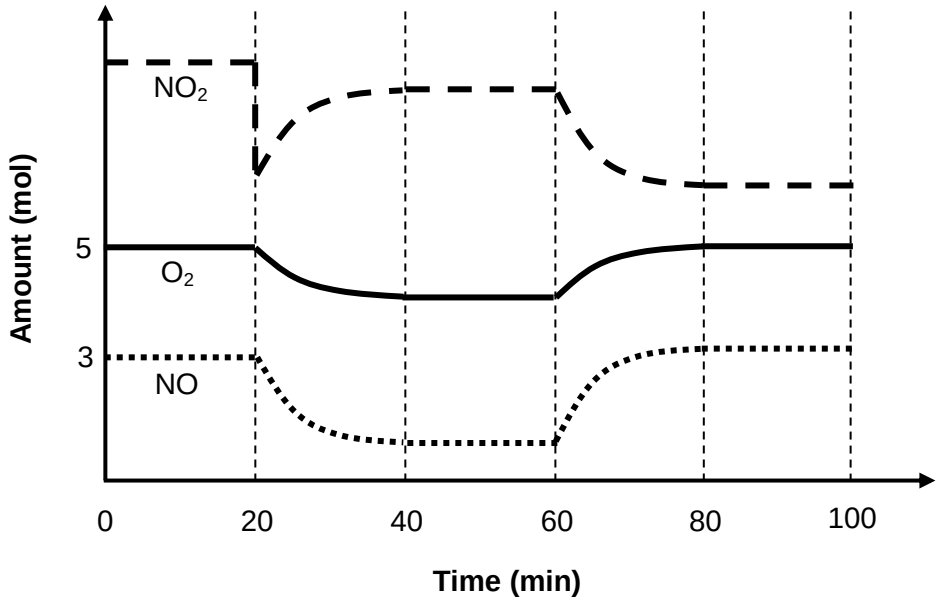
QUESTION 4

Nitrogen monoxide gas reacts with oxygen gas in a closed container according to the balanced chemical equation below.

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$$

The volume of the container remains constant at 3 dm^3. The amounts of each gas were tracked over time and the following graph (NOT TO SCALE) was obtained.

At t = 0 min, the temperature is 25 °C and the **equilibrium constant is 256**.



4.1 Identify the stress that occurred at 20 min. (1)

4.2 Use Le Châtelier's principle to explain the changes seen in the graph between 20 min and 40 min. (3)

4.3 How does the value of the equilibrium constant at t = 50 min compare to that at t = 0 min? State only LARGER, SMALLER, or THE SAME. (1)

4.4 Write down the expression for the equilibrium constant (K_c) for this reaction. (2)

4.5 Calculate the amount (in moles) of NO_2 that was in the container at t = 0 min. (4)

4.6 At t = 60 min the temperature was increased. Explain, using Le Châtelier's principle, whether the **reverse** reaction is EXOTHERMIC or ENDOTHERMIC. (5)

4.7 A partial graph of reaction rate vs time is provided on your ANSWER SHEET. Complete this graph for the full 100 min time period. Use the **solid line for the forward reaction rate** and the dotted line for the reverse reaction rate. (5)

4.8 Define *intramolecular bond*. (2)

4.9 Classify the specific type of intramolecular bond that is found in O_2. (2)

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QUESTION 5

Consider the hypothetical strong base $Z(OH)_2$. 0,4 dm^3 of a 0,12 $mol \cdot dm^{-3}$ solution of this base is prepared at 30 °C.

5.1 What does it mean that $Z(OH)_2$ is a *strong base*? (2)

5.2 Define *standard solution*. (2)

5.3 Determine the amount (in moles) of $Z(OH)_2$ needed to prepare the solution. (3)

The autoionisation of water is shown by the following balanced chemical equation. Note that K_w at 30 °C is $1,44 \times 10^{-14}$.

$$2H_2O \rightleftharpoons H_3O^+ + OH^-$$

5.4 Classify the autoionisation of water as EXOTHERMIC or ENDOTHERMIC. Give a reason for your answer. (2)

5.5 Calculate the concentration of hydronium ions in the $Z(OH)_2$ solution at 30 °C. (4)

The $Z(OH)_2$ solution is now titrated with a solution of hydrofluoric acid.

5.6 Classify hydrofluoric acid as WEAK or STRONG. (1)

5.7 Write down the formula of the salt formed in this reaction. (2)

5.8 Define *hydrolysis of a salt*. (2)

5.9 Rewrite and complete the following protolytic reaction, showing the hydrolysis of F^-:

$$F^- + H_2O \rightleftharpoons$$ (2)

5.10 Refer to the table of indicators below and state which indicator would be most suitable for this titration.

Indicator	pH range where colour change is observed	Colour in lower pH	Colour in higher pH
congo red	3–5	blue	red
bromothymol blue	6–8	yellow	blue
alizarin yellow	10–12	yellow	orange

(2)
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QUESTION 6

Kwazi sets up a standard galvanic cell that is represented by the cell notation below.

$$Zn(s) \mid Zn^{2+}(aq) \parallel Sn^{4+}(aq), Sn^{2+}(aq) \mid Pt(s)$$

6.1 NAME the component of the cell represented by the two vertical lines (||) in the cell notation above. (1)

6.2 State TWO standard conditions that are applicable to the tin half-cell. (2)

6.3 Give ONE property of platinum that makes it suitable for use as the electrode for the tin half-cell. (1)

6.4 Define *cathode*. (2)

6.5 Write down the SYMBOL for the cathode. (1)

6.6 Write the chemical equation that represents the reduction half-reaction. (2)

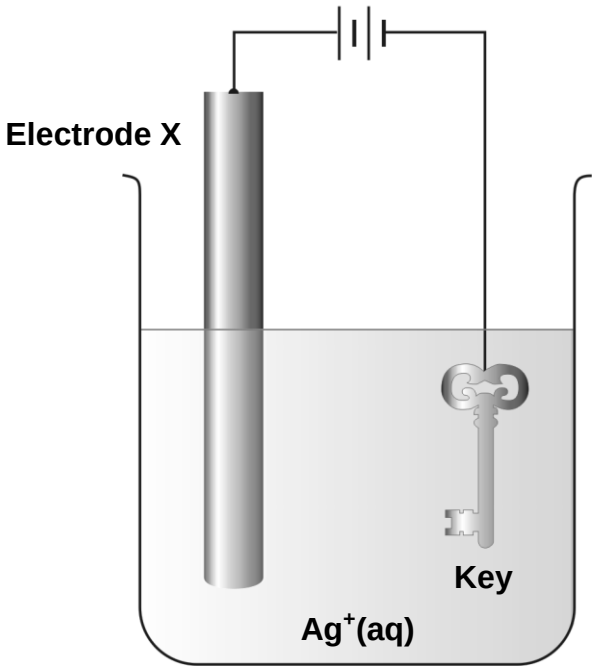
6.7 Define *reducing agent*. (1)

6.8 Write down the SYMBOL for the reducing agent. (1)

6.9 Determine the initial cell emf. (4)

6.10 How will the initial cell emf be affected if the concentration of Zn^{2+} ions in the $Zn \mid Zn^{2+}$ half-cell was increased? Write down only INCREASES, DECREASES, or NO EFFECT. (2)

6.11 Kwazi now sets up the following electrolytic cell with the aim of coating a key with silver metal:



6.11.1 What is this electrolytic process called? (1)

6.11.2 Is the key the ANODE or the CATHODE? (1)

6.11.3 With reference to the relative strengths of the reacting substances (relative strengths of agents), explain why silver will be the predominant substance formed at the key. (3)

6.11.4 What is electrode **X** usually made from? (1)

6.11.5 With reference to the **bonding** in electrode **X**, give a reason why this substance is a suitable **conductive** material. (2)

6.11.6 A constant current of 3,2 A is run through the cell for 6 hours. Calculate the total charge (in C) that is transferred through the cell. (3)

6.11.7 Determine the amount (in mol) of electrons transferred through the cell in this time. (2)

6.11.8 Determine the mass of silver that would be deposited onto the key in this time. (3)

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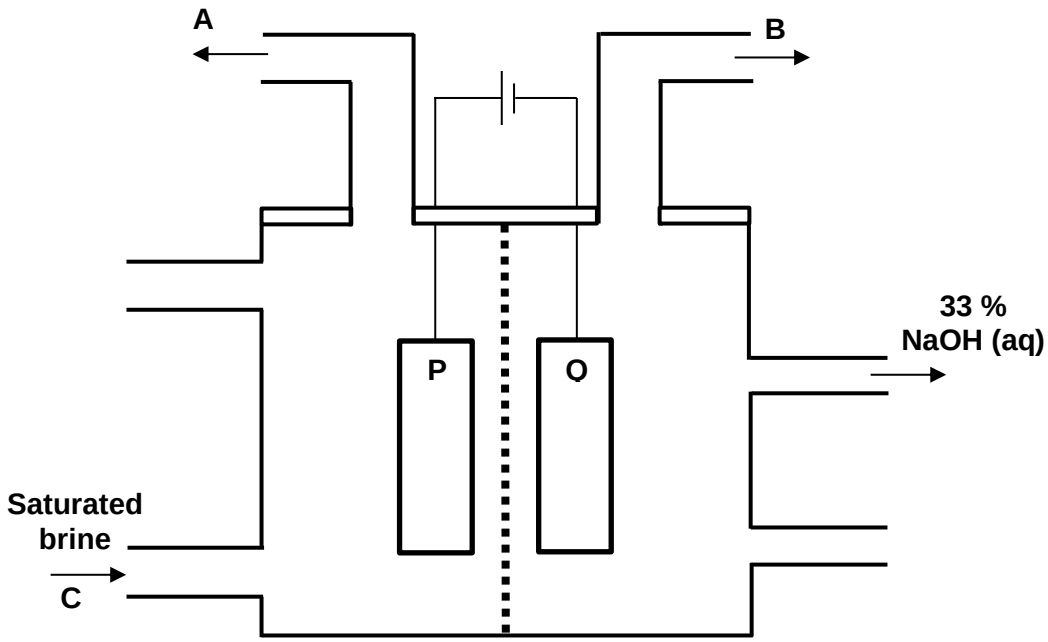
QUESTION 7

The diagram below shows a representation of a membrane cell used in the Chlor-Alkali Industry. Electrode **P** is made from titanium, which is inert.



7.1 What is *brine*? (3)

7.2 Identify which electrode is the cathode. Write down only **P** or **Q**. (1)

7.3 Chlorine gas is produced at electrode **P** and collected at **A**.

7.3.1 Write down the equation for the half-reaction that produces the chlorine gas. (2)

7.3.2 At **C**, brine enters the cell. FULLY explain why chlorine is produced **predominantly** at electrode **P**. In your answer, you should refer to the following:

- the inherent reactivities of the reacting species (with reference to the standard electrode potentials)
- the concentration of the ions present (3)

7.3.3 What substance will the chlorine gas be contaminated with? (1)

7.4 In terms of the purity of the sodium hydroxide solution produced, explain the benefits of using a membrane instead of a diaphragm (2)

7.5 7.5.1 Write the formula of the product collected at **B**. (1)

7.5.2 State one change that could be made to electrode **Q** to increase the rate of production of this product collected at **B**. (1)

7.6 With reference to intermolecular forces, compare the boiling points of chlorine and hydrogen and FULLY explain this difference. (6)

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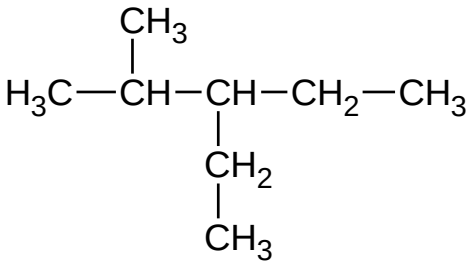
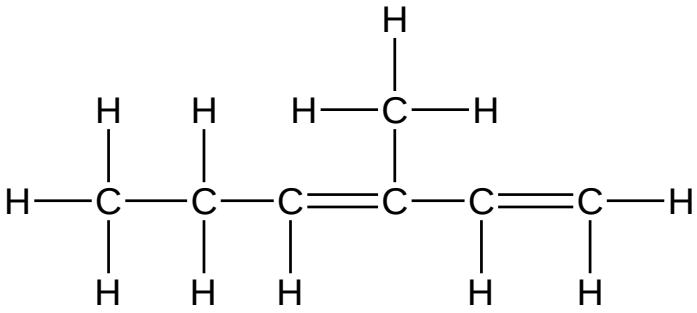
QUESTION 8

Consider the two hydrocarbons, compounds **X** and **Y**, shown below.



Compound X



Compound Y

8.1 Define *homologous series*. (2)

8.2 Write down the general formula for the homologous series to which compound **X** belongs. (1)

8.3 NAME the homologous series to which compound **Y** belongs. (1)

8.4 Classify compound **X** as SATURATED or UNSATURATED. (1)

8.5 Draw the structural formula for the POSITIONAL ISOMER of compound **X**. (2)

8.6 Describe the functional group of compound **Y**. (1)

8.7 Write the IUPAC name for compound **Y**. (3)

8.8 Write down the name of the homologous series of the organic product that would result if compound **Y** were hydrogenated fully. (2)

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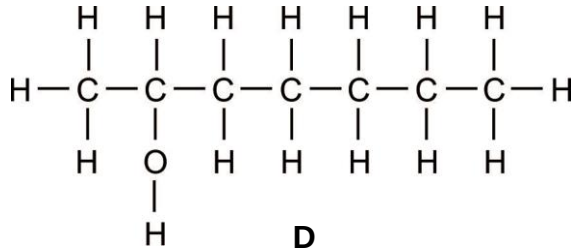
QUESTION 9

Consider the following organic reactions **I** to **IV** involving organic compounds **A** to **E**.

I $\mathbf{A} + Br_2 \xrightarrow{UV\ light} \mathbf{B} + HBr$

II $\mathbf{B}$ + concentrated alcoholic KOH $\rightarrow$ $\mathbf{C}$ + KBr + H_2O

III $\mathbf{C} + H_2O \xrightarrow{Dilute\ H_3PO_4}$ **D**



IV $\mathbf{A} \xrightarrow{600\ °C,\ Zeolite\ catalyst} C_4H_{10} + \mathbf{E}$

9.1 Name the GENERAL TYPE of reaction for each of the following:

9.1.1 Reaction **I** (1)

9.1.2 Reaction **III** (1)

9.2 Name the SPECIFIC TYPE of reaction for each of the following:

9.2.1 Reaction **II** (1)

9.2.2 Reaction **III** (1)

9.3 Write down the IUPAC name for compound **D**. (3)

9.4 Write the molecular formula for each of the following:

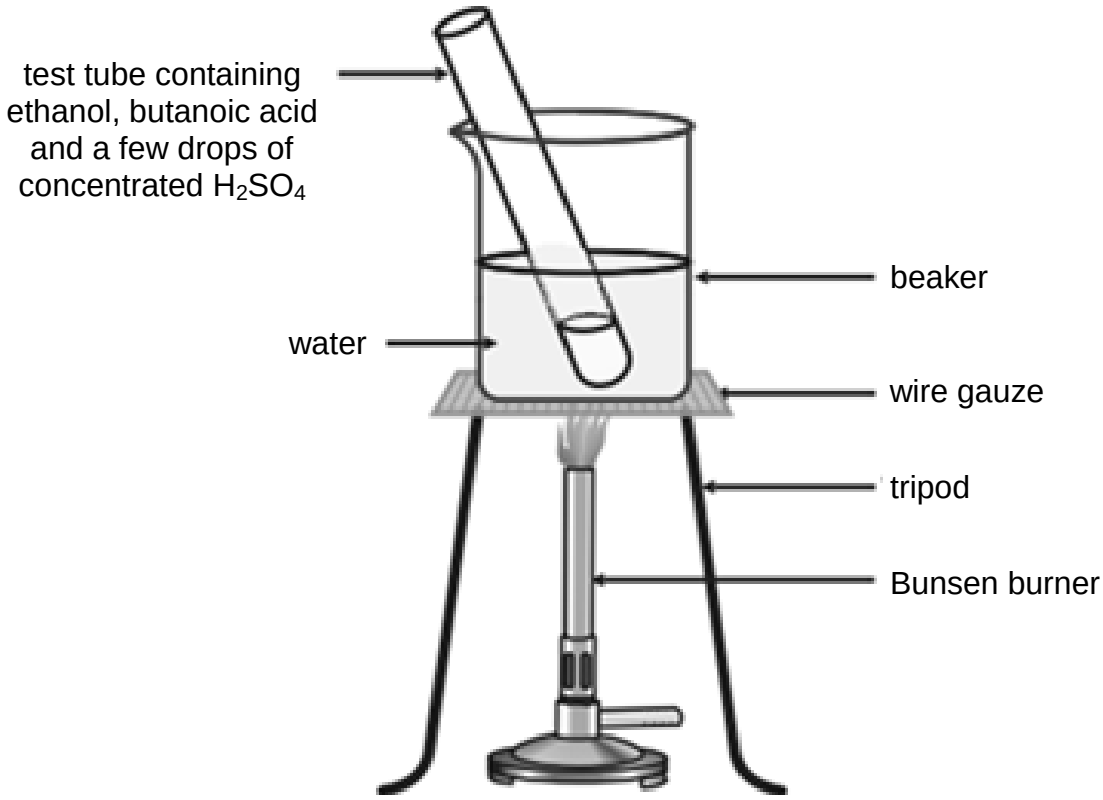
9.4.1 Compound **A** (2)

9.4.2 Compound **E** (2)

9.5 Draw the structural formula of compound **B**. (2)

9.6 Draw the structural formula of compound **C**. (2)

9.7 Arielle sets up an experiment to perform an esterification reaction using ethanol (CH_3CH_2OH) and butanoic acid. She uses an experimental setup as shown below:



9.7.1 Using **molecular** formulae, write a balanced chemical equation for the complete combustion of ethanol. (3)

9.7.2 Hence, fully explain why a water bath is the preferred method used to heat the mixture. (2)

9.7.3 Using condensed-structural formulae, write a balanced chemical equation for the esterification reaction represented in this experiment. (4)

9.7.4 Write the IUPAC name for the ester formed. (2)

9.7.5 State TWO purposes of the H_2SO_4. (2)

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Total: 200 marks