Please paste the barcoded label here	TOTAL MARKS

NATIONAL SENIOR CERTIFICATE EXAMINATION
MAY 2022

PHYSICAL SCIENCES: PAPER II

EXAMINATION NUMBER													

Time: 3 hours 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 28 pages as well as a green DATA SHEET of 3 pages (i–iii). Please make sure that your question paper is complete.
2. Read the questions carefully.
3. Answer all the questions.
4. Unless instructed otherwise, you do NOT have to give state symbols (phase indicators) when asked to write a balanced chemical equation.
5. Use the data and formulae whenever necessary.
6. Show all the necessary steps in calculations.
7. Where appropriate, take your answers to two decimal places.
8. It is in your interest to write legibly and to present your work neatly.
9. Three blank pages (page 26–28) are included at the end of the question paper. If you run out of space for a question, use these pages. Clearly indicate the question number of your answer, should you use this extra space.

FOR OFFICE USE ONLY: MARKER TO ENTER MARKS

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Total
Mark										
Marker's initial										
Moderated mark										
Moderator's initial										
Question Total	20	27	19	25	30	19	16	26	18	
Re-mark										
Initial										
Code										

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QUESTION 1 MULTIPLE CHOICE

Answer these questions on the multiple-choice answer grid below. Make a clear cross (X) in the box corresponding to the letter that you consider to be correct. Every question has only one correct answer.

A	B	C	D

Here the option C has been marked as an example.

1.1	**A**	**B**	**C**	**D**
1.2	**A**	**B**	**C**	**D**
1.3	**A**	**B**	**C**	**D**
1.4	**A**	**B**	**C**	**D**
1.5	**A**	**B**	**C**	**D**
1.6	**A**	**B**	**C**	**D**
1.7	**A**	**B**	**C**	**D**
1.8	**A**	**B**	**C**	**D**
1.9	**A**	**B**	**C**	**D**
1.10	**A**	**B**	**C**	**D**

1.1 Which one of the following statements best describes ALL intramolecular bonds?

A Any one of ionic, covalent, or metallic bonds.
B A bond which occurs between atoms within molecules.
C An equal sharing of electrons within molecules.
D A bond which occurs between molecules, ions or atoms of a noble gas.

1.2 Which one of the following does NOT have a giant covalent network structure?

A Diamond
B Graphite
C Silicon dioxide
D Iodine

1.3 Which one of the following statements regarding a system at chemical equilibrium is FALSE?

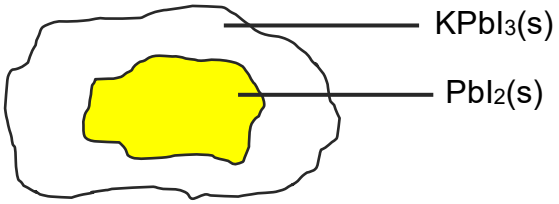
A It can only occur in a closed system.
B The concentration of reactants and products remains constant.
C The rates of the forward and back reactions are zero.
D The rates of the forward and back reactions are identical.

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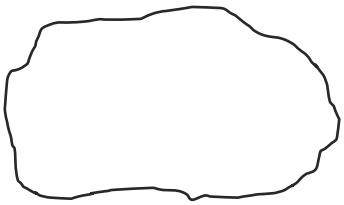
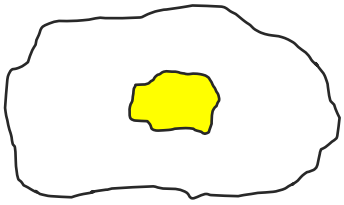
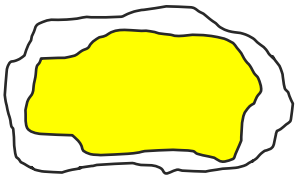
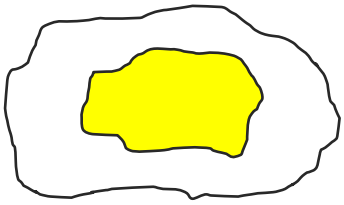
1.4 Excess potassium iodide reacts with solid lead(II) iodide to form solid potassium lead triiodide ($KPbI_3$). The mixture reached chemical equilibrium as represented by the chemical equation below:

$$\underset{\text{colourless}}{KI(aq)} + \underset{\text{yellow}}{PbI_2(s)} \rightleftharpoons \underset{\text{white}}{KPbI_3(s)}$$

The white crystals of $KPbI_3$ surround the yellow PbI_2, giving the whole system an appearance of a fried egg.



A drop of pure water is now added to the equilibrium mixture, changing the appearance of the 'fried egg'. Which one of the diagrams below best represents the new appearance? (Assume the scale used is the same.)

A		C	
B		D	

1.5 Consider a reaction that happens in multiple steps as shown below:

$W + X \rightarrow WX$
$WX + Y \rightarrow WXY$
$WXY \rightarrow X + Z$

Which one of the following combinations correctly identifies the catalyst and the activated complex?

	Catalyst	Activated Complex
A	X	WXY
B	Y	WXY
C	X	WX
D	Y	WX

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1.6 Which one of the following is NOT a conjugate acid–base pair.

A NH_4^+ and NH_3
B H_3O^+ and OH^-
C H_2S and HS^-
D NH_3 and NH_2^-

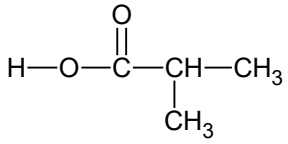
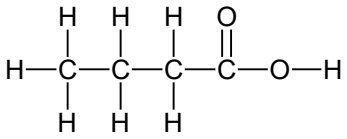
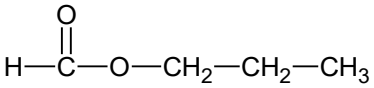
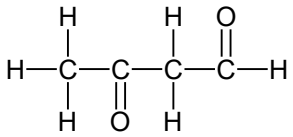
1.7 The stronger the acid, …

A the more concentrated is the acid.
B the less concentrated is the acid.
C the higher its pH.
D the weaker is its conjugate base.

1.8 Which one of the following can act as an oxidising agent as well as a reducing agent?

A HSO_4^-
B $C\ell^-$
C Fe
D Sn^{2+}

1.9 Which one of the following is a FUNCTIONAL isomer of butanoic acid?

A		C	
B		D	

1.10 Consider the two reactions, **X** and **Y**, below:

X: propane + Br_2 → 1−bromopropane + HBr
Y: propene + Br_2 → 1,2−dibromopropane

Identify the reaction that has the **LOWER activation energy** and the reaction that has the **LOWER reaction rate** under identical external conditions?

	LOWER activation energy	**LOWER reaction rate**
A	X	X
B	X	Y
C	Y	X
D	Y	Y

[20]

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QUESTION 2

When a piece of sodium is heated in air, it reacts with oxygen to form sodium oxide. Sodium oxide is a white, crystalline solid with a high melting point.

2.1 Write a balanced chemical equation for the reaction of sodium with oxygen. Include phase indicators.

(4)

2.2 Identify and describe the bonding that occurs when sodium reacts with oxygen.

(2)

2.3 Explain why sodium oxide has a high melting point.

(4)

2.4 When molten sodium oxide is electrolysed using carbon electrodes, sodium and oxygen are formed.

2.4.1 Write a balanced chemical equation for the half-reaction that occurs at the negative electrode.

(2)

2.4.2 Explain why molten sodium oxide conducts electricity, but solid sodium oxide does not.

(2)

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2.5 Sodium oxide reacts with excess water at 25 °C according to the following balanced chemical equation:

$$Na_2O(s) + H_2O(\ell) \rightarrow 2NaOH(aq)$$

50 g of sodium oxide reacts with water to produce 500 cm^3 of sodium hydroxide solution.

2.5.1 Calculate the amount (in moles) of sodium oxide dissolved.

(3)

2.5.2 Define *concentration*.

(2)

2.5.3 Calculate the concentration of hydroxide ions in the final solution.

(5)

2.5.4 Hence, determine the concentration of hydronium ions in the final solution at 25 °C.

(3)

[27]

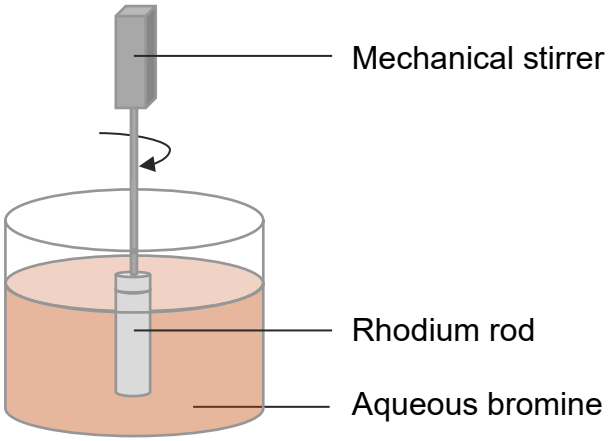
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QUESTION 3

Rhodium metal reacts with dilute aqueous bromine according to the balanced chemical equation:

$$2Rh(s) + 3Br_2(aq) \rightarrow 2RhBr_3(aq)$$

The rate of this reaction is investigated using the apparatus shown below.



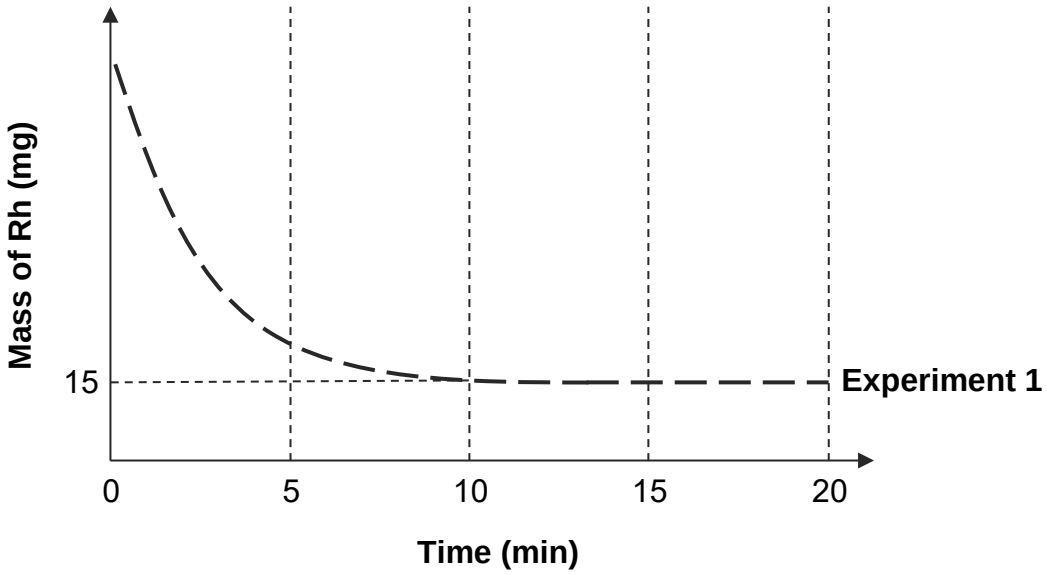
The rhodium rod was removed at regular intervals, washed, dried and weighed. The rhodium rod was then placed into the solution again.

The experiment was repeated using the same initial mass of rhodium and different concentrations of bromine. The conditions of each experiment are shown in the table below and the results of **Experiment 1** are shown in the graph that follows.

Table showing conditions of Experiments 1 and 2

Experiment	$[Br_2]$ $(mol \cdot dm^{-3})$
1	0,15
2	0,05

Graph showing the relationship between the mass of Rh and time for Experiment 1



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3.1 The average rate of consumption of Rh for **Experiment 1** is 27,6 mg·min^{-1}.

3.1.1 It was experimentally determined that: rate α $[Br_2]^3$. Hence, what is the average rate of consumption (in mg·min^{-1}) of Rh in **Experiment 2**?

(2)

3.1.2 Which substance is the limiting reagent in **Experiment 1**? Give a reason.

(2)

3.1.3 How long did it take for the reaction in **Experiment 1** to complete?

(1)

3.1.4 Hence, calculate the initial mass of rhodium (in mg) used in **Experiment 1**.

(3)

3.1.5 On the same axes as the graph on the previous page, sketch the graph that would result from **Experiment 2**. (2)

3.1.6 Use the collision theory to explain the difference in reaction rates for **Experiments 1** and **2**.

(4)

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3.2 The reaction between rhodium and bromine is highly exothermic and so the temperature must be kept at about 10 °C.

$$2Rh(s) + 3Br_2(aq) \rightarrow 2RhBr_3(aq)$$

3.2.1 Define *heat of reaction (ΔH)*.

_____

_____

_____

(2)

3.2.2 Is the heat of this reaction POSITIVE or NEGATIVE?

_____

(1)

3.2.3 The cooling mechanism keeping the temperature at 10 °C fails. Explain what possible effect this will have on the reaction.

_____

_____

_____

_____

_____

_____

(2)

[19]

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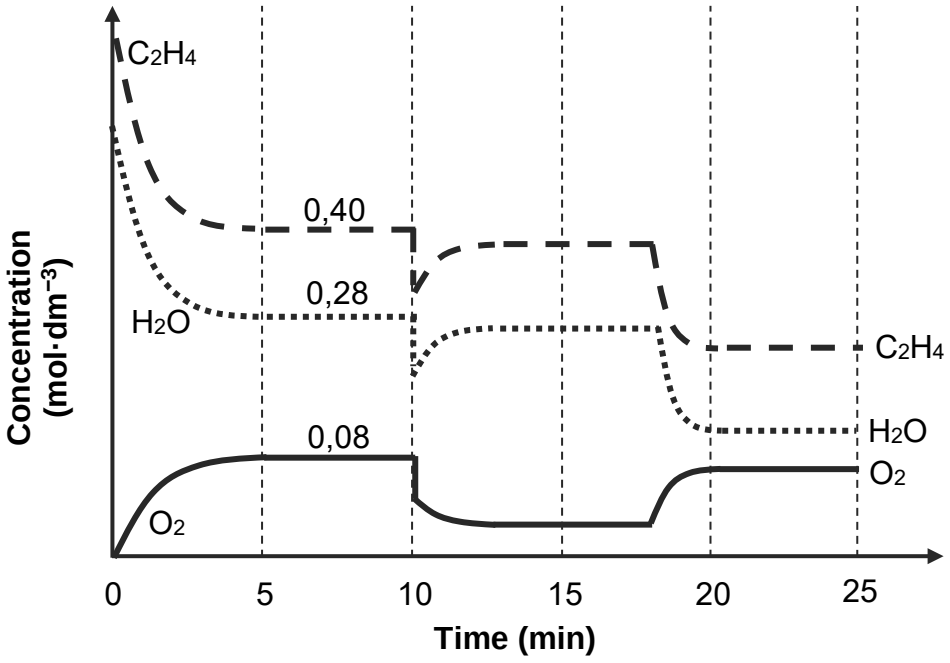
QUESTION 4

4.1 Consider the reversible reaction of ethene with steam in the ABSENCE of an acid, as shown below:

$$2C_2H_4(g) + 2H_2O(g) \rightleftharpoons 2C_2H_6(g) + O_2(g)$$

The reaction was done in a 3 dm^3 closed container. The temperature was kept constant at $\mathbf{T_1}$ for the first 18 minutes.

The graph below (NOT to scale) shows the changes in concentration of $\mathbf{C_2H_4}$, $\mathbf{H_2O}$ and $\mathbf{O_2}$ as a function of time.



4.1.1 Write an expression for the equilibrium constant for this reaction.

(2)

4.1.2 The equilibrium constant at temperature $\mathbf{T_1}$ is 0,025. Calculate the equilibrium amount (in moles) of C_2H_6 at 7 minutes.

(4)

4.1.3 Describe fully the change made to the system at 10 minutes.

(2)

4.1.4 State *Le Châtelier's principle*.

(2)

4.1.5 At 18 min, the temperature was INCREASED to $\mathbf{T_2}$. With reference to Le Châtelier's principle and the graph, fully explain whether the forward reaction is endothermic or exothermic.

(5)

4.1.6 At 35 minutes, argon (an inert gas) is added to the container. What effect does this have on the amount of C_2H_6 at equilibrium? State only INCREASES, DECREASES, or NO EFFECT.

(2)

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4.2 A saturated solution of calcium hydroxide has solid calcium hydroxide in equilibrium with its aqueous ions.

$$Ca(OH)_2(s) \rightleftharpoons Ca^{2+}(aq) + 2OH^-(aq)$$

4.2.1 What is the effect on the concentration of hydroxide ions if more solid calcium hydroxide is added? State only INCREASES, DECREASES, or NO EFFECT.

(2)

4.2.2 Explain the concept of *pH*.

(2)

4.2.3 A few drops of a concentrated $CaC\ell_2$ solution are added to the equilibrium mixture at 25 °C. Explain fully how this will affect the pH of the solution.

(4)
[25]

QUESTION 5

Hydrocyanic acid, HCN, is a weak, monoprotic acid with a K_a of $6,2 \times 10^{-10}$ at 25 °C.

Morgan prepares 0,25 dm^3 of a standard HCN solution with a concentration of 0,05 $mol \cdot dm^{-3}$.

5.1 Morgan uses the following method:

- Fills a 250 cm^3 beaker to the mark with tap water
- Adds 0,63 g of HCN(s) to the water and mixes completely

Besides safety, describe and correct TWO mistakes Morgan has made during this preparation.

(4)

5.2 Define *weak acid*.

(2)

5.3 What is meant by the term *monoprotic*?

(1)

5.4 Define *ionisation*.

(2)

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5.5 Write a balanced chemical equation for the ionisation of hydrocyanic acid in water.

(2)

5.6 Show that the concentration of hydronium ions in the standard solution is $5{,}57 \times 10^{-6}$ mol·dm^{-3}. Assume Morgan's mistakes have been corrected.

(6)

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5.7 0,025 dm^3 of the HCN standard solution (concentration 0,05 $mol \cdot dm^{-3}$) is titrated against a solution of sodium hydroxide. The balanced chemical equation for this reaction is shown below:

$$HCN(aq) + NaOH(aq) \rightarrow NaCN(aq) + H_2O(\ell)$$

5.7.1 It takes 0,03344 dm^3 of sodium hydroxide solution to reach the equivalence point. Calculate the concentration of sodium hydroxide used.

(5)

A table of common indicators, together with the pH range over which their colour changes take place, is given below.

Indicator	Colour in lower pH	Colour in higher pH	pH Range
Methyl orange	Red	Yellow	3,1–4,4
Bromothymol blue	Yellow	Blue	6,0–7,6
Phenolphthalein	Colourless	Pink	8,3–10

5.7.2 What colour will methyl orange be at pH 5?

(1)

5.7.3 Which indicator is most suitable for indicating the equivalence point for this titration?

(2)

5.7.4 Define a *salt*.

(2)

5.7.5 Write a balanced chemical equation for the hydrolysis reaction that will take place here.

(3)
[30]

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QUESTION 6

Consider the cell notation below for a galvanic cell.

$$Pt(s) \mid C\ell^-(aq) \mid C\ell_2(g) \parallel Au^{3+}(aq) \mid Au(s)$$

6.1 The platinum electrode is considered to be inert. What is the purpose of this electrode?

_____

_____

(1)

6.2 Define *reduction*.

_____

(1)

6.3 Write a balanced chemical equation for the half-reaction at the anode.

_____

(2)

6.4 Write a balanced chemical equation for the overall cell reaction.

_____

(3)

6.5 The concentration of the solution in the salt bridge is now decreased.

6.5.1 What are the TWO functions of the salt bridge?

_____

_____

_____

(2)

6.5.2 What is the effect of decreasing the concentration of KNO_3 in the salt bridge on: (State only INCREASES, DECREASES, or NO EFFECT.)

(a) the maximum current the cell can provide?

_____

(2)

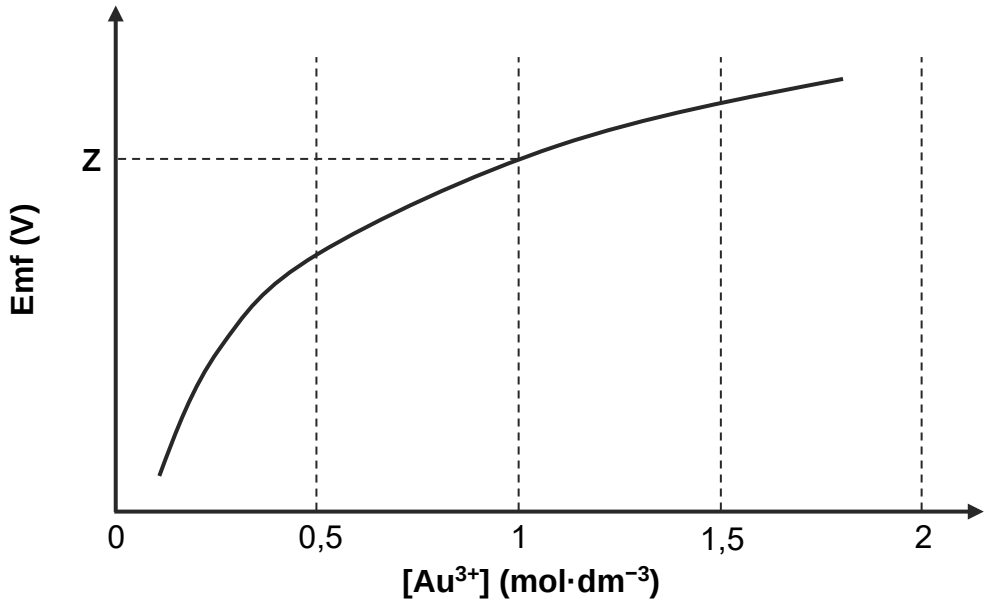
(b) the initial emf of the cell?

_____

(2)

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The graph below shows how the emf of this cell is affected by the concentration of Au^{3+} at 25 °C.



6.6 Is the emf **directly proportional** to the concentration of Au^{3+}? Give a reason.

(2)

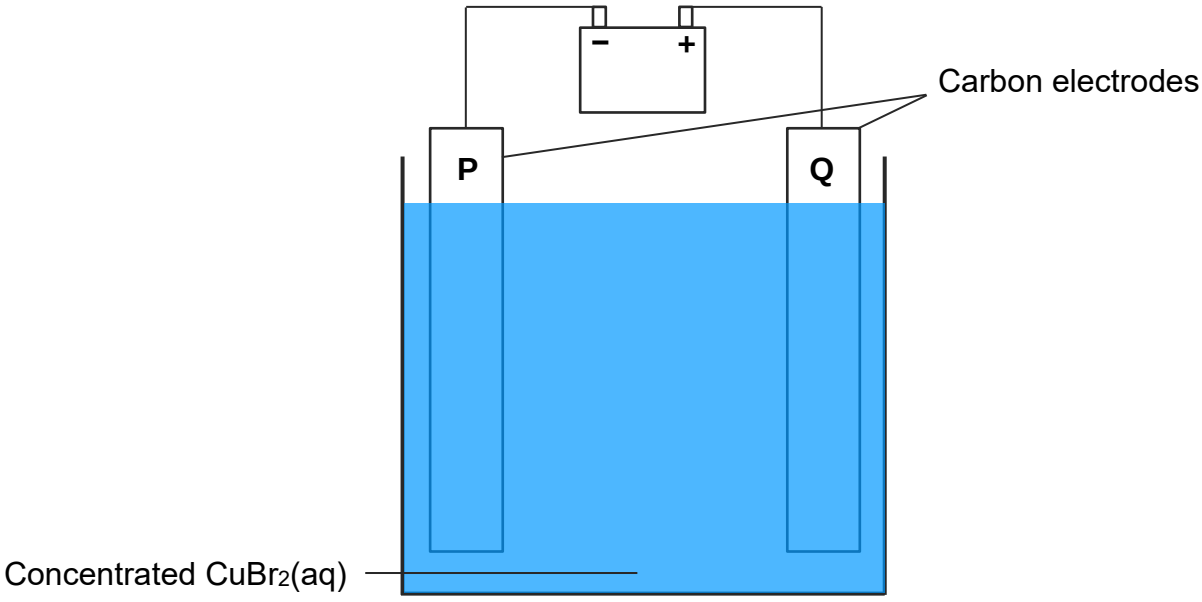
6.7 Determine the value of **Z** as indicated on the graph.

(4)
[19]

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QUESTION 7

A CONCENTRATED solution of copper(II) bromide is electrolysed using carbon (graphite) electrodes. The diagram shows a representation of this cell.



A red-brown liquid is observed pooling below the anode.

7.1 State the energy conversion that occurs in this cell.

_____

_____

(2)

7.2 Which electrode is the anode? State only **P** or **Q**.

_____

(1)

7.3 Write a balanced chemical equation for the predominant half-reaction that occurs at the anode.

_____

(2)

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7.4 Consider the species competing for reaction at the cathode.

7.4.1 Define *cathode*.

(2)

7.4.2 Define *oxidising agent*.

(2)

7.4.3 Give the formula of the substance produced at the cathode.

(1)

7.4.4 Fully explain why this substance is produced. Refer to the strengths of the relevant agents.

(4)

7.4.5 The carbon electrode at the CATHODE is now replaced with a copper electrode. How will this affect the reaction at the cathode? Circle your choice:

A Cu^{2+} ions will be produced.

B Water will react.

C There will be no effect. (2)

[16]

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QUESTION 8

Consider the following organic compounds, labelled **A**, **B**, and **C**:

A: $CH_3CH_2CHC\ell CH_3$

B: $(C_2H_5)_3CCH_2Br$

C: $CH_3(CH_2)_7Br$

8.1 Identify the homologous series to which compounds **A**, **B** and **C** all belong.

(1)

8.2 Give the IUPAC name for compound **A**.

(3)

8.3 In the space below, draw the full structural formula for compound **B**.

(3)

8.4 Give the IUPAC name for compound **B**.

(4)

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8.5 Why are compounds **B** and **C** *structural isomers*?

(2)

8.6 What **type** of structural isomers are compounds **B** and **C**?

(1)

8.7 Although compounds **B** and **C** have the same number of electrons, they have significantly different boiling points. Which compound has the higher boiling point? Fully explain, with reference to their intermolecular forces.

(6)

8.8 Compound **B** reacts with dilute aqueous sodium hydroxide with gentle heating.

8.8.1 Identify the GENERAL **type** of this reaction.

(1)

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8.8.2 Using condensed-structural formulae, write a balanced chemical equation to show this reaction. Use the space below.

(3)

8.9 Compound **C**, $CH_3(CH_2)_7Br$, is heated with concentrated alcoholic sodium hydroxide.

8.9.1 Identify the SPECIFIC **type** of this reaction.

(1)

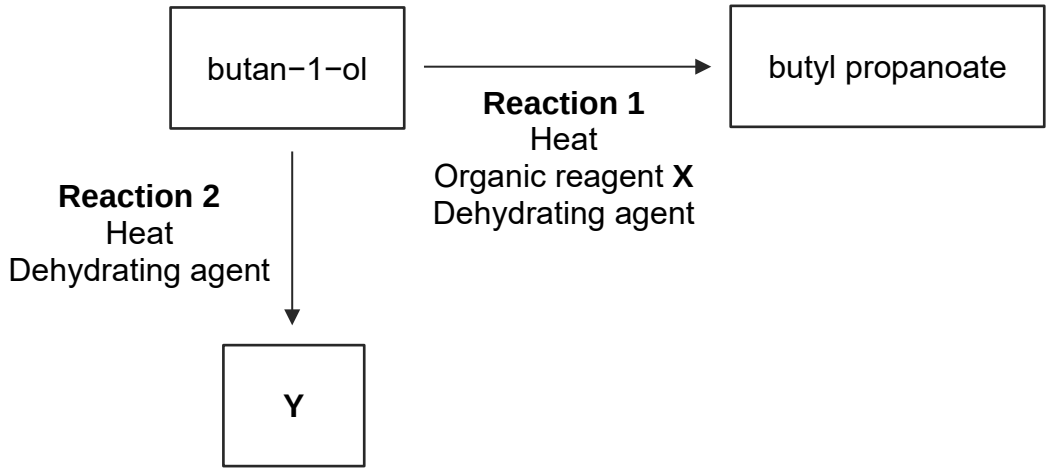
8.9.2 Describe the **functional group** of this organic product.

(1)
[26]

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QUESTION 9

Two reactions of butan−1−ol are shown in the flow diagram below. Both reactions **1** and **2** use the same inorganic dehydrating agent.



9.1 Give the FORMULA for the inorganic dehydrating agent used in both of these reactions.

_____

(1)

9.2 Write the IUPAC name for the organic reagent **X** in **Reaction 1**.

_____

(2)

9.3 Identify the homologous series to which the product **Y** of **Reaction 2** belongs.

_____

(2)

9.4 In the space below, draw the full structural formula for butyl propanoate.

(3)

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9.5 Hydrocarbons and alcohols are both useful as fuels as they can undergo combustion reactions.

9.5.1 Explain why hydrocarbons are such useful fuels.

(2)

9.5.2 Using molecular formulae, write a balanced chemical equation showing the complete combustion of butan−1−ol.

(4)

9.6 Hydrocarbons are obtained from crude oil, but this supply is not sufficient to meet demand. In order to meet demand, some larger hydrocarbons are shortened.

9.6.1 NAME the process that is used to make these larger hydrocarbons shorter.

(1)

9.6.2 Using molecular formulae, write a balanced chemical equation showing $C_{12}H_{26}$ being shortened to heptane and TWO other products.

(3)
[18]

Total: 200 marks

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ADDITIONAL SPACE (ALL questions)

REMEMBER TO CLEARLY INDICATE AT THE QUESTION THAT YOU USED THE ADDITIONAL SPACE TO ENSURE THAT ALL ANSWERS ARE MARKED.

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