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PHYSICAL SCIENCE PAPER II - Chemistry
PRELIMINARY EXAMINATION 2019
GRADE 12

Examiner: R. Goodhead

Marks: 200

Moderator: D.R. Raath

Time: 3 hours

Please read the following instructions carefully.

1. This examination script consists of 17 pages of which pages 16 and 17 are the **Answer sheet**.
2. The Answer sheet is attached to the front of your Answer book.
3. You are encouraged to make use of the IEB data sheets provided.
4. Only non-programmable calculators and appropriate mathematical instruments may be used.
5. Answer all the questions and number your answers **EXACTLY** as the questions are numbered in this script.
6. **Start each question on a new page** and leave a line between each sub – section, i.e.: 1.1 and 1.2.
7. All rough work must be deleted by a diagonal line drawn across your work.
8. You may only write in **BLUE or BLACK pen**. Write legibly.
9. Round off to **two decimal places** unless otherwise stated in the question.

QUESTION 1 – Multiple Choice

Answer these questions on the Multiple Choice Answer sheet provided. Make a cross(X) on the letter of the response which you consider to be the most correct.

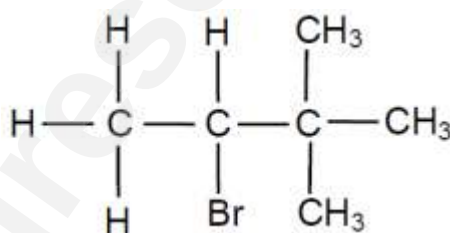
1.1 The chemical formula for ammonium phosphate is:

- A $(\text{NH}_3)_3\text{PO}_3$
- B $(\text{NH}_4)_3\text{PO}_3$
- C $\text{NH}_4(\text{PO}_4)_3$
- D $(\text{NH}_4)_3\text{PO}_4$

1.2 In which of the following reactions would an increase in pressure have NO EFFECT on the amount of product at equilibrium?

- A $\text{C}_2\text{H}_4(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{C}_2\text{H}_5\text{OH}(\text{g})$
- B $\text{CH}_3\text{CHO}(\text{g}) \rightleftharpoons \text{CH}_4(\text{g}) + \text{CO}(\text{g})$
- C $4\text{HCl}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{H}_2\text{O}(\text{g}) + 2\text{Cl}_2(\text{g})$
- D $\text{CO}(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{H}_2(\text{g}) + \text{CO}_2(\text{g})$

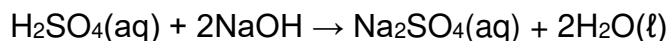
1.3 Consider the following structural formula of an organic compound.



The IUPAC name of this compound is:

- A 2-bromo-2,2-dimethylbutane
- B 2-bromo-3,3-dimethylbutane
- C 3-bromo-2,2-dimethylbutane
- D 2-bromo-1,1,1-trimethylpropane

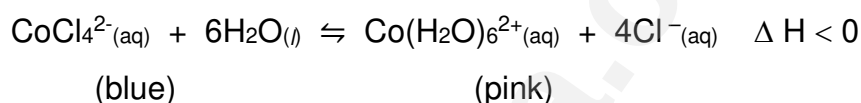
1.4 Study the reaction shown below:



The rate of the reaction, in terms of the number of moles of H_2SO_4 used up, is $2.3 \times 10^{-3} \text{ mol}\cdot\text{s}^{-1}$. What is the rate (in $\text{mol}\cdot\text{s}^{-1}$) at which H_2O is formed?

- A 2.3×10^{-3}
 B $2.3 \times 10^{-3} \div 2$
 C $2.3 \times 10^{-3} \times 2$
 D $(2.3 \times 10^{-3} \times 2) \div 60$

1.5 Cobalt chloride crystals are dissolved in a water/alcohol mixture to form a purple solution as represented by the following equilibrium equation.



A few drops of silver nitrate are added to the above solution. What colour change is observed and for what reason?

	Colour Change	Reason
A	Purple to Blue	H ₂ O molecules are removed
B	Purple to Pink	Cl ⁻ ions are removed
C	Purple to Blue	H ₂ O was added
D	Remains purple	AgNO ₃ contains no common ions

1.6 In the reaction $\text{Cl}_{2(\text{g})} + 2\text{I}^{-}(\text{aq}) \rightarrow 2\text{Cl}^{-}(\text{aq}) + \text{I}_{2(\text{s})}$, which of the following is true?

- A Iodide ions are reduced.
B Chloride ions are reduced.
C Iodide ions act as a reducing agent.
D Chlorine acts as a reducing agent.

1.7 Which one of the following substances will reduce Pb^{2+} to Pb , but will not reduce Fe^{2+} to Fe under standard conditions?

- | | |
|---|----------------|
| A | Cu |
| B | Al |
| C | H ₂ |
| D | Ni |

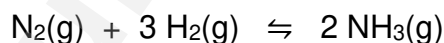
1.8 How many hydrogen atoms are present in 8,5 g of NH_3 ?

- A $3,01 \times 10^{23}$
 B $6,02 \times 10^{23}$
 C $9,03 \times 10^{23}$
 D $2,40 \times 10^{24}$

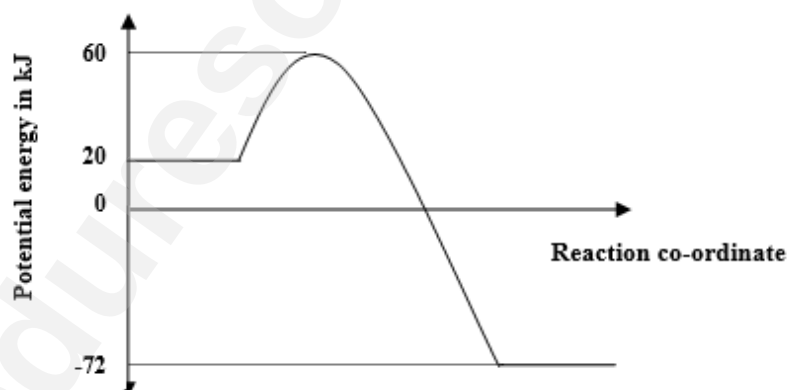
1.9 Two hydrocarbons A and B are tested with bromine water. Which row in the table correctly shows what happens to the bromine water?

	With hydrocarbon A - C_2H_6	With hydrocarbon B - C_2H_4
A.	Turns green	Turns colourless
B.	Turns colourless	Stays yellow-brown
C.	Stays yellow-brown	Turns colourless
D.	Stays yellow-brown	Turns green

1.10 Ammonia is manufactured by the Haber-Bosch process according to the equation:



Consider the following potential energy curve for the above reaction:



What are ΔH and E_a for the **reverse** reaction?

	$\Delta H/\text{kJ}$	E_a/kJ
A	+92	20
B	+92	40
C	-92	132
D	+92	132

[10 x 2 = 20]

QUESTION 2 – Chemical Bonding and Stoichiometry (Adapted from Beaulieu College prelim 2018)

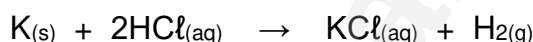
2.1 Consider the table below, which shows the boiling point of the halogens.

Halogens	F ₂	Cl ₂	Br ₂	I ₂
Boiling point (°C)	-188	-35	59	184

2.1.1 Name the **specific** type of intramolecular bond that occurs between the atoms in a chlorine molecule. (1)

2.1.2 The table shows that the boiling point of the halogens increases from F₂ to I₂. Explain this trend by referring to the relevant intermolecular force between the halogen molecules and the factors influencing its strength. (4)

2.2 Potassium chloride is prepared according to the following balanced chemical equation:



Hydrochloric acid is produced for this preparation by the ionisation of hydrogen chloride gas in water.

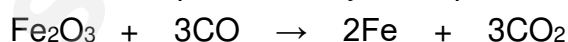
2.2.1 Define the term *ionic bond*. (2)

2.2.2 Define the term *electronegativity*. (2)

2.2.3 HCl molecules are described as 'dipoles'. Explain why. (3)

2.2.4 An aqueous solution of potassium chloride will conduct electricity while crystalline potassium chloride will not. Explain why this is the case. (5)

2.3 Iron is reduced from its haematite ore in a blast furnace. The overall reaction occurring in a blast furnace is represented by the equation:



80 kg of haematite ore containing 30% Fe₂O₃ is reacted with 12 kg of CO.

2.3.1 Calculate the number of moles of iron oxide in the ore. (2)

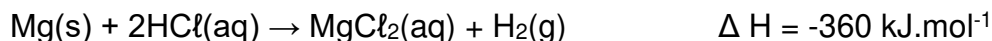
2.3.2 Determine the limiting reagent in this chemical reaction. (4)

2.3.3 Calculate the percentage yield of iron if 14 kg was the actual yield. (6)

[29]

QUESTION 3: (Start on a new page.)

A group of learners uses the reaction of clean magnesium ribbon with dilute hydrochloric acid to investigate factors that influence reaction rate. The balanced equation for the reaction is:

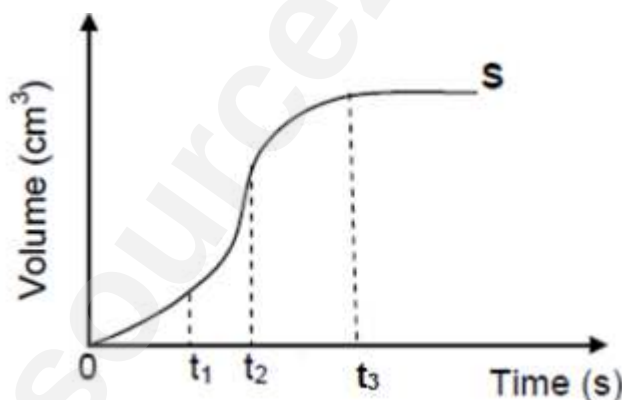


- 3.1 Rewrite the above equation including the enthalpy of reaction as part of the chemical equation. (1)

In one of the experiments 5 g magnesium ribbon was added to the hydrochloric acid solution.

- 3.2 If 30 cm³ dilute hydrochloric acid solution of concentration 1.5 mol·dm⁻³ is used up in 2 minute, calculate the average reaction rate. (3)

The volume of hydrogen gas produced as a function of time in this experiment is represented by graph S below. (The graph is NOT drawn to scale.)

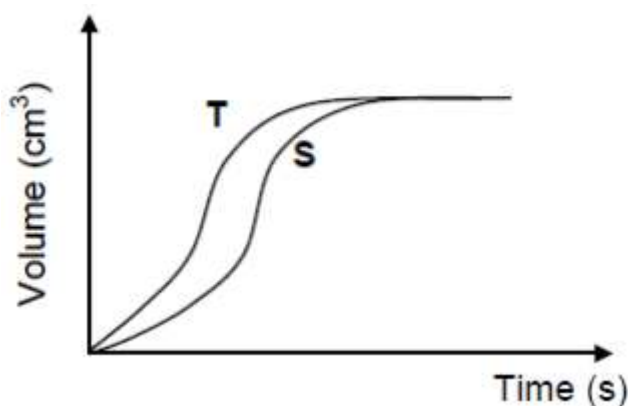


- 3.3 Explain the term *effective collision*. (2)
- 3.4 The reaction rate increases between 0 s and t₂. By looking at the graph how would you know this? (1)
- 3.4.1 Refer to the reaction conditions and collision theory to explain why the reaction rate increases between 0 s and t₂. (4)
- 3.5 The reaction rate decreases from t₂ to t₃. Refer to the reaction conditions and collision theory to explain why this is so. (3)

3.6 In another experiment the learners add 5 g of magnesium to 30 cm³ of dilute hydrochloric acid of concentration 1.5 mol·dm⁻³.

They obtained graph T shown below. (The graph is NOT drawn to scale.)

Give TWO possible reasons why graph T differs from graph S. (2)

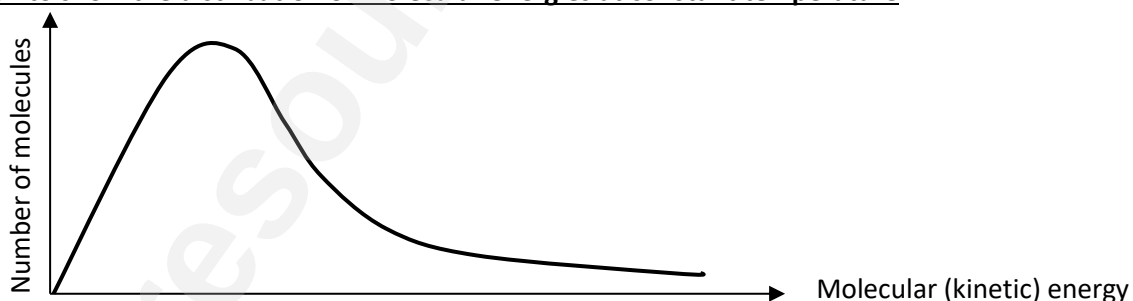


3.6 A copy of the Boltzman Distribution Graph below is on the **Answer sheet**.

Use it to explain how adding a catalyst increases the rate of the reaction.

Add suitable labels to the graph to assist in your explanation. (Answer this question on the answer sheet.) (4)

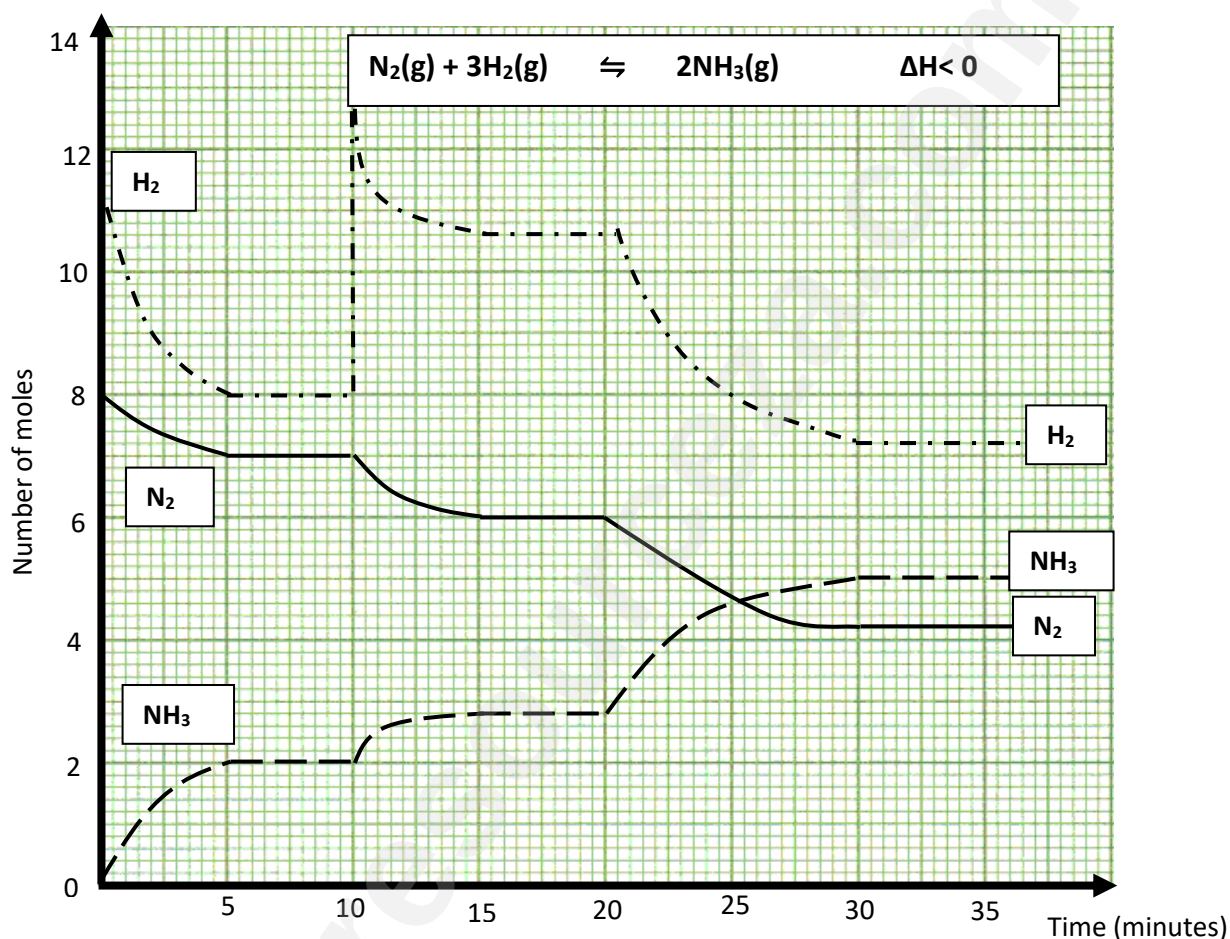
Graph to show the distribution of molecular energies at constant temperature



[20]

Question 4:

In the Haber Process reaction to make ammonia 8 mol of N_2 gas and 11 mol of H_2 gas is introduced into a container of volume 10 dm^3 at a temperature of 450°C . The container is sealed immediately after the gases are added. The graph below represents the changes in the number of moles of the gases in the reaction vessel over a period of 35 minutes.



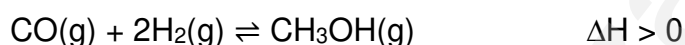
- 4.1 Show that the equilibrium constant, K_c at 450°C , for this reaction, at a time of 8 minutes is 0.11. (5)
- 4.2 Evaluate the significance of the K_c value at 450°C in terms of yield. (2)
- 4.3 What change was made to the equilibrium mixture at a time of 10 minutes? (1)
- 4.4 Use Le Chatelier's Principle, to explain why the number of moles of the various gases changed as they did after the change at 10 minutes was made. (3)
- 4.5 On your **answer sheet** complete the Rate of Reaction sketch graph for the reaction between 0 and 18 min. (4)

- 4.6 At time 20 minutes the temperature was decreased. Explain using Le Chatelier's principle what will happen to the rate of reaction of the system in order to increase the number of moles of ammonia gas as shown in the no. of moles versus time graph above. (5)

[21]

Question 5:

Methanol (CH_3OH) is manufactured by compressing a mixture of carbon monoxide (CO) and hydrogen (H_2) to 300 times atmospheric pressure. The mixture is passed over zinc oxide, which acts as a catalyst at 300°C . The chemical equation is presented as follows:



Initially X mol of CO and 8 mol of H_2 are placed in a container with a volume of 5 dm^3 . It is heated to 300°C to produce methanol. When equilibrium is established, the concentration of hydrogen in the container is $0.225\text{ mol}\cdot\text{dm}^{-3}$ and the concentration of CO is $3.68\text{ mol}\cdot\text{dm}^{-3}$.

- 5.1 Define the term *dynamic chemical equilibrium*. (2)
- 5.2 Determine the initial amount (X) of CO that was placed in the container. (4)

[6]

Question 6:

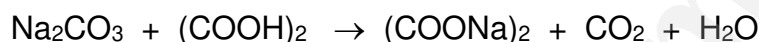
- 6.1 The K_a values for two weak acids, carbonic acid and oxalic acid, are as follows:

Name	Formula	K_a
Carbonic Acid	H_2CO_3	4.3×10^{-7}
Oxalic Acid	$(\text{COOH})_2$	5.6×10^{-2}

- 6.1.1 Define the term *weak acid*. (2)
- 6.1.2 Which acid, carbonic acid or oxalic acid, is stronger? (1)
- 6.1.3 Write the balanced ionisation reaction for Oxalic acid in water. (4)
- 6.1.4 Define the term *Lowry-Brønsted base*. (2)
- 6.1.5 Write down the formulae of the two Lowry-Bronsted bases in the equation in Q 6.1.3. Write if they are strong or weak bases. (4)

6.2 Calculate the concentration of hydroxide ions in an aqueous solution of oxalic acid solution if the concentration of hydronium ions (H_3O^+) is $0.03 \text{ mol}\cdot\text{dm}^{-3}$ at equilibrium at 25°C . (3)

6.3 During an acid-base titration, 20 cm^3 of oxalic acid of concentration $0.4 \text{ mol}\cdot\text{dm}^{-3}$ is needed to neutralise sodium carbonate solution of concentration $0.25 \text{ mol}\cdot\text{dm}^{-3}$, according to the reaction. The sodium carbonate is the analyte and is placed in the conical flask.



6.3.1 Oxalic acid is a diprotic acid. Explain what is meant by a diprotic acid. (1)

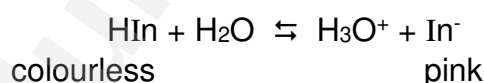
6.3.2 What volume of sodium carbonate was required to neutralise the oxalic acid? (6)

6.3.3 The table below shows information about certain indicators. Phenolphthalein was used in this titration.

Indicator	pH Range
Methyl Orange	3.2-4.4
Bromothymol Blue	6.0-7.6
Phenolphthalein	8.2-10.0

The salt formed in the titration is sodium oxalate $(\text{COONa})_2$. Use hydrolysis of salts to explain the reason Phenolphthalein is used as the indicator. (6)

6.3.4 Consider the balanced chemical equation for the indicator used in this titration. The indicator (HIn) is a weak acid and is dropped into the conical flask which contains the aqueous sodium carbonate solution before the titration is started.



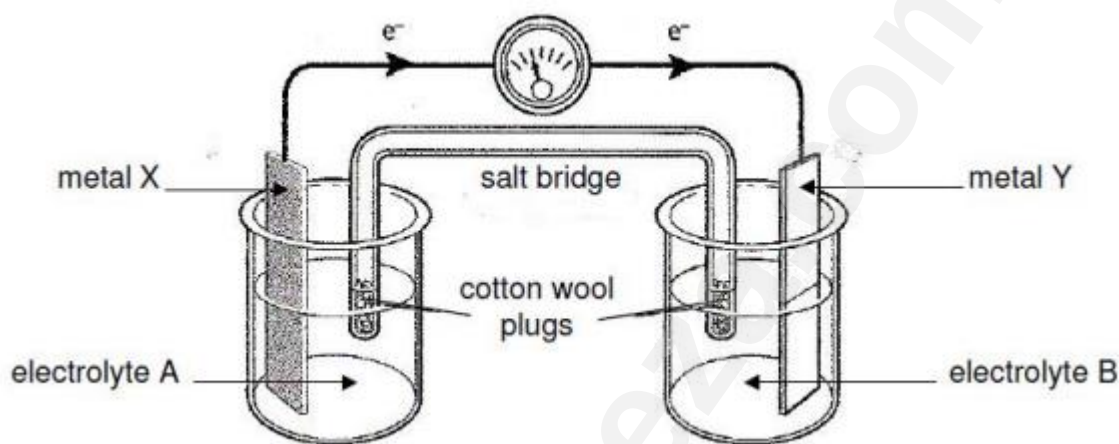
The indicator is pink in the sodium carbonate solution at the start of the titration. Explain why the indicator is pink by referring to the reaction between the indicator and the carbonate ions in the aqueous solution. (3)

[32]

Question 7:

- 7.1 The diagram below shows an electrochemical cell set up under standard conditions using aluminium (Al) and nickel (Ni) electrodes. $\text{AlCl}_3(\text{aq})$ and $\text{NiCl}_2(\text{aq})$ are used as electrolytes, and a solution of sodium nitrate ($\text{NaNO}_3(\text{aq})$) is used in the salt bridge.

Answer each of the following questions on this electrochemical cell:



- 7.1.1 Identify:
- (a) Metal X (1)
 - (b) Electrolyte B (1)
- 7.1.2 What is the initial concentration of electrolyte B under standard conditions? (1)
- 7.1.3 Write down the half reaction that occurs at the cathode half-cell. (2)
- 7.1.4 Write down the FORMULA of the ions that moves from the salt bridge towards the half-cell that contains metal Y in the cell. (1)
- 7.1.5 Calculate the initial reading on the voltmeter. (3)
- 7.2 The cell notation for another Galvanic cell which runs under Standard conditions is shown below:
- $\text{Pt (s)} / \text{H}_2 \text{ (g)} / \text{H}^+ \text{ (aq)} // \text{Al}^{3+} \text{ (aq)} / \text{Al (s)}$ $E_{\text{cell}} = -1.66 \text{ V}$
- 7.2.1 Write down the anode half reaction in this cell. (2)
 - 7.2.2 Write down the net ionic equation for this reaction. (3)

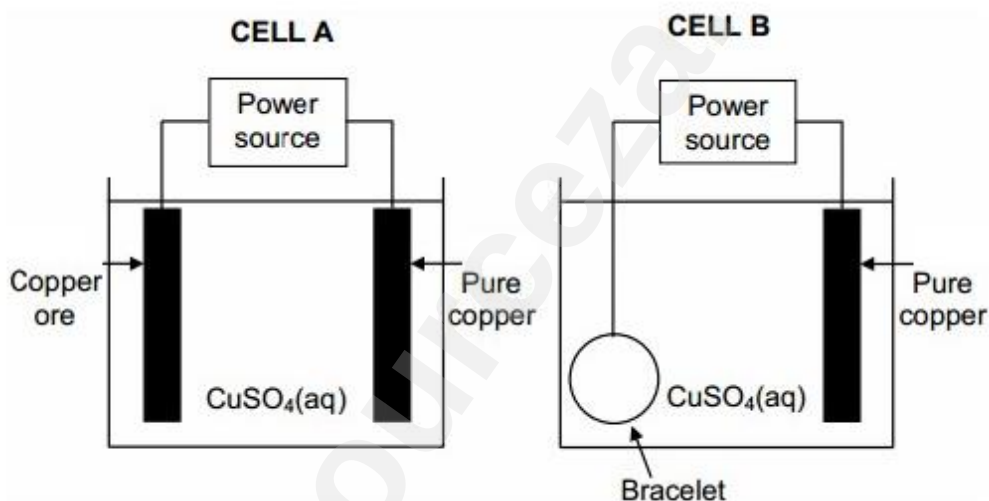
7.2.3 If a higher concentration of electrolyte, AlCl_3 , is added to the Al half cell at the start of the reaction, what will happen to the reading on the voltmeter? Write only INCREASE, DECREASE or REMAINS THE SAME. (1)

7.2.4 Explain your answer to Q 7.2.3 (3)

[18]

Question 8:

The simplified diagrams below represent two electrochemical cells, A and B, used in industry. Cell A is used in the purification of copper ore containing silver and platinum impurities. Cell B is used to coat a bracelet with a layer of copper.



8.1 Give the name for the specific type of electrolytic process shown in Cell B. (1)

8.2 Pure copper is used as one of the electrodes in each of the cells above. In which cell (A or B) is the pure copper...

8.2.1 the cathode? (1)

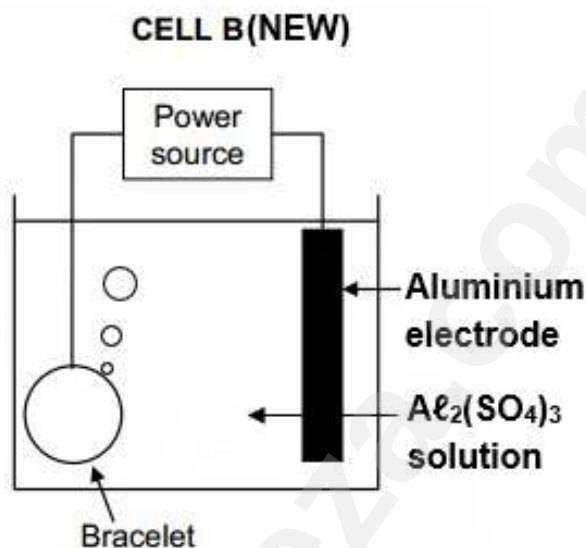
8.2.2 the anode? (1)

8.3 Consider Cell B. Initially the $\text{CuSO}_4(\text{aq})$ has a blue colour. How will the intensity of the blue colour change whilst the cell is functioning? Write down INCREASES, DECREASES or REMAINS THE SAME and then give a reason for the answer. (4)

8.4 Write down the half-reaction that takes place at the pure copper electrode in Cell B. (2)

8.5 At the bottom of Cell A there is a deposit of metals that form including gold. Explain why this should happen? (3)

- 8.6 In an attempt to coat the bracelet with **aluminium metal** *instead of copper*, the technician uses a solution of aluminium sulfate in the electrolytic cell, as shown below.



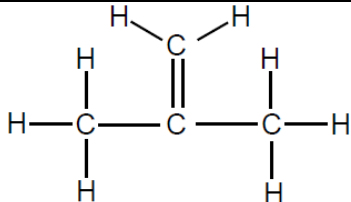
When the technician connects the battery though, she notices that there is no shiny plating of aluminium metal appearing on the bracelet. Instead, there is a stream of colourless bubbles forming.

- 8.6.1 Over time, what will be observed at the aluminium electrode? (1)
- 8.6.2 Give the name of the gas being produced at the bracelet. (1)
- 8.6.3 Explain why this gas is produced at the bracelet and not $\text{Al}_{(\text{s})}$ as the technician hoped. Refer to the relevant reaction occurring at this electrode in your answer. (3)

[17]

Question 9:

The letters **A** to **D** in the table below represent four organic compounds.

A	Ethyl propanoate	B	pentanol-1-ol
C		D	2,2-dimethylbutane

9.1 Answer the following questions with respect to Compound **A**.

- 9.1.1. Name the homologous series to which this compound belongs. (1)
- 9.1.2. Give the reaction conditions for the reaction that will lead to the formation of this compound. (2)
- 9.1.3. Write the balanced chemical equation for the formation of this compound using structural formulae. (4)
- 9.1.4. Give the IUPAC NAME of a functional isomer of Compound **A** with no substituents (side chains). (2)

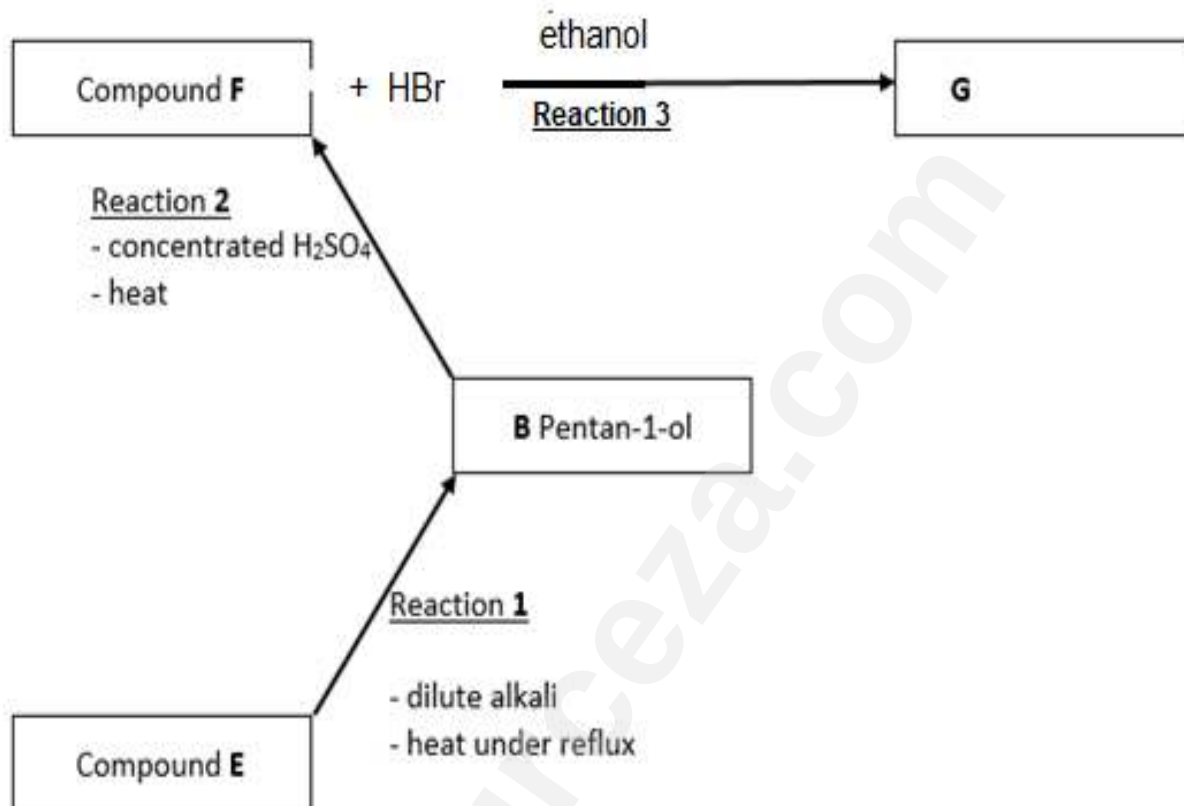
9.2 Study compound **C**.

- 9.2.1 Is this compound SATURATED or UNSATURATED? (1)
- 9.2.2 Write a balanced chemical equation, using molecular formulae, for the combustion of Compound **C**. (4)

9.3 Rank the boiling points of compounds **A**, **B** and **D** from lowest to highest. (1)

9.4 Explain your order by referring to the relative strengths of intermolecular forces. (5)

9.5 Some of the reactions of Compound **B** are represented in the flow diagram below.



- 9.5.1 Define the term *functional* group. (2)
- 9.5.2 Name the functional group present in Compound **B**. (1)
- 9.5.3 Give the IUPAC name for Compound **E**. (2)
- 9.5.4 Give the IUPAC name for Compound **F**. (2)
- 9.5.5 Give the general and specific type of reaction for Reaction 2. (2)
- 9.5.6 Name the general and specific type of reaction for Reaction 3. (2)
- 9.5.7 Write the chemical equation for Reaction 3. Use condensed structural formula. (3)
- 9.5.8 Explain why ethanol is necessary as a reaction condition in Reaction 3. (4)

[38]

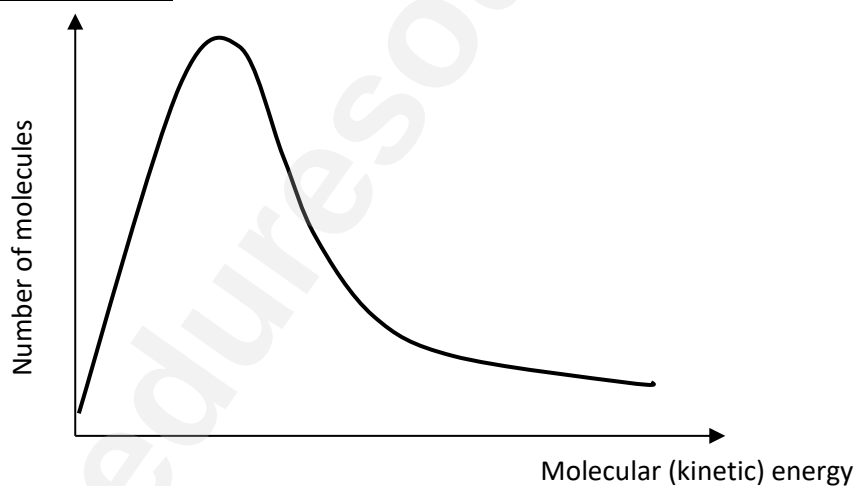
[Total Marks 200]

Answer Sheet**QUESTION 1**

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

[10 X 2 = 20]

- Q 3.6** Use the Boltzman Distribution Graph to explain how adding a catalyst increases the rate of the reaction. Add suitable labels to the graph to assist in your explanation. (Answer this question on the answer sheet.) (4)

Graph to show the distribution of molecular energies at constant temperature

Answer Sheet

Q 4.5 On this **answer sheet** complete the Rate of Reaction sketch graph below for the reaction between 0 and 18 min.

