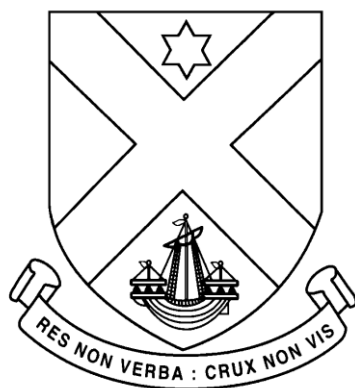




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ST ANNE'S DIOCESAN COLLEGE

TRIAL EXAMINATION

PHYSICAL SCIENCES

PAPER 2 CHEMISTRY

August 2020

Time: 3 hours

200 Marks

Examiner: J FORREST

Moderator: K SANDERS

The use of other IEB teachers' questions, in whole or in part, is gratefully acknowledged.

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of:
 - p2-18 Questions 1 to 7
 - p19-21 Chemistry Data Sheets
 - p23 ANSWER SHEET Question 1 and page 24 Graph paper for Question 3

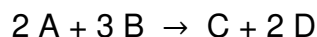
Please make sure that your question paper is complete.

2. The data sheets may be detached if necessary.
 3. Read the questions carefully and answer in any order, with clear numbering.
 4. Show your working in all calculations, including equations used.
 5. Units need not be included in the working of calculations, but appropriate units must be shown in the answer.
-

QUESTION 1 MULTIPLE CHOICE QUESTIONS
(Record answers on the ANSWER SHEET on page 23)

Four options are provided as possible answers to the following questions.
Each question has only ONE correct answer.

- 1.1 The rate of removal of A in the hypothetical reaction below is $x \text{ mol}\cdot\text{s}^{-1}$.



What is the rate of appearance of C in $\text{mol}\cdot\text{s}^{-1}$?

- A $2x$
- B x
- C $\frac{1}{2}x$
- D $\frac{2}{3}x$

- 1.2 A salt can be defined as a substance in which the hydrogen of

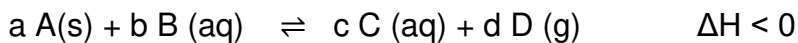
- A an acid has been replaced by an anion.
- B an acid has been replaced by a cation.
- C a base has been replaced by an anion
- D a base has been replaced by a cation.

- 1.3 A system is at equilibrium. If the system is cooled, which of the following will change?

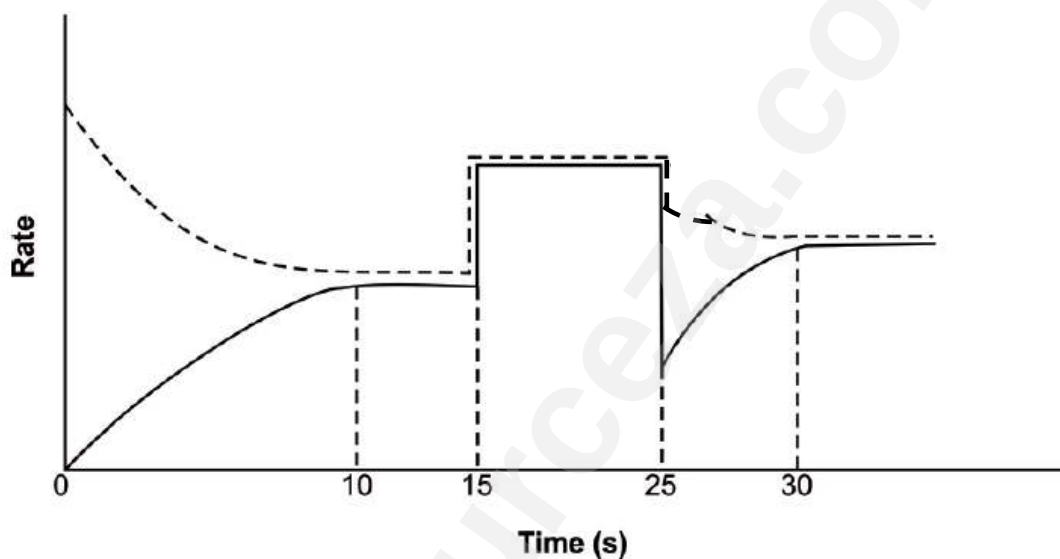
- I rates of the forward and reverse reactions
- II K_c
- III equilibrium position

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

- 1.4 A hypothetical chemical reaction in a closed container is represented by the following chemical equation.



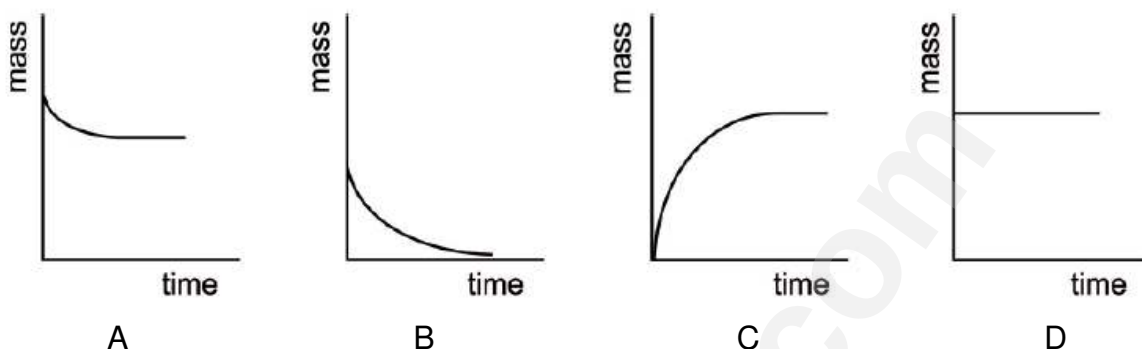
The graph below represents the rates of the forward and reverse reactions plotted as a function of time.



Which one of the following statements could correctly describe the factors that caused the change in reaction rate.

	Disturbance at 15 s	Disturbance at 25 s
A	Surface area of A was increased	The pressure of the system was increased.
B	A catalyst was added.	The temperature was decreased.
C	The temperature of the system was increased.	The surface area of A was decreased.
D	The pressure of the system was decreased.	The temperature of the system was increased.

- 1.5 Which of the following graphs shows the change in mass of a catalyst during the course of a reaction?



- 1.6 Consider the list of metals below. Identify the metal that will be able to reduce $\text{Cd}^{2+}(\text{aq})$ to $\text{Cd}(\text{s})$ but which will not reduce $\text{Mn}^{2+}(\text{aq})$ to $\text{Mn}(\text{s})$.

- A Zinc
- B Magnesium
- C Nickel
- D Silver

- 1.7 The aqueous solution with the highest conductivity is

- A $0,1 \text{ mol} \cdot \text{dm}^{-3} \text{ HF}$
- B $0,2 \text{ mol} \cdot \text{dm}^{-3} \text{ HCl}$
- C $0,3 \text{ mol} \cdot \text{dm}^{-3} \text{ NH}_4\text{OH}$
- D $0,2 \text{ mol} \cdot \text{dm}^{-3} \text{ H}_3\text{PO}_4$

- 1.8 During the extraction of aluminium from aluminium oxide, cryolite is added to ...
- A increase the yield of aluminium.
 - B decrease the yield of aluminium.
 - C increase the melting point of aluminium oxide.
 - D decrease the melting point of aluminium oxide.
- 1.9 Hydrohalogenation reactions could involve
- A the substitution of HBr in an alcohol.
 - B the addition of H₂O to an alkene.
 - C the addition of HCl to an alkene.
 - D the addition of HI to an alcohol.
- 1.10 Which of the following molecules has the highest boiling point?
- A hexane
 - B propane
 - C 2,3-dimethylbutane
 - D propene

[20]

QUESTION 2

- 2.1 2.1.1 Write down the name of the compound LiMnO_4 . (1)
- 2.1.2 Write down the formula for potassium hydrogen carbonate. (1)
- 2.1.3 Define *electronegativity*. (2)

- 2.2 You are provided with a list of substances below. The state labels of each substance is at room temperature. Answer the questions below.

Ni(s) CS₂(g) C(s) NH₃(g) NaNO₃(s) SiO₂ (s) He(g)

Select only **one** substance from the list above that:
(only write down the question number and the formula of the substance)

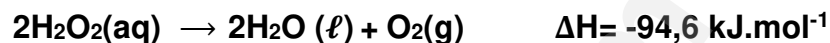
- 2.2.1 is an inert, monatomic substance. (1)
- 2.2.2 has a high melting point due to strong electrostatic forces between the cations and anions. (1)
- 2.2.3 has 3 polar covalent bonds and one lone pair of electrons. (1)
- 2.2.4 has delocalised valence electrons. (1)
- 2.2.5 has non-polar covalent bonds and has an extremely high melting point due to the giant lattice structure. (1)
- 2.2.6 has hydrogen bonding intermolecular forces. (1)
- 2.2.7 can conduct electricity when molten. (1)
- 2.2.8 is a weak base. (1)
- 2.3 Iodine is a solid at room temperature.
- 2.3.1 Identify the specific type of **intramolecular** bond that holds atoms of iodine (I_2) together. (2)
- 2.3.2 Identify the **intermolecular force** that holds molecules of iodine together. (1)
- 2.3.3 With reference to the intermolecular force identified in **question 2.3.2** above, explain why iodine crystals are **solid** at room temperature but change from solid to gas when heated gently over a Bunsen burner. (2)
- 2.3.4 Give one reason why iodine crystals do not conduct electricity. (1)

[18]

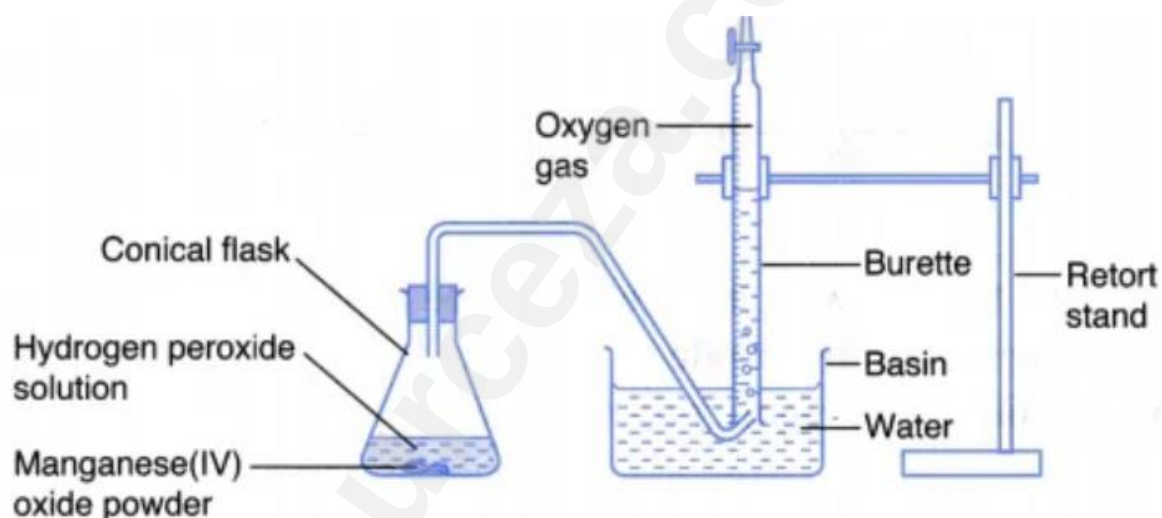
QUESTION 3

3.1 Define *activation energy*. (2)

3.2 Caelan and Kate record the data in the table below for the decomposition of an aqueous solution of hydrogen peroxide using solid manganese (IV) oxide as a catalyst. The set-up for the experiment is shown below and the balanced equation for this reaction is:



The total volume of oxygen gas was collected and measured at different times and recorded in the table below.



3.2.1 What do we call this method of collecting a gas? (1)

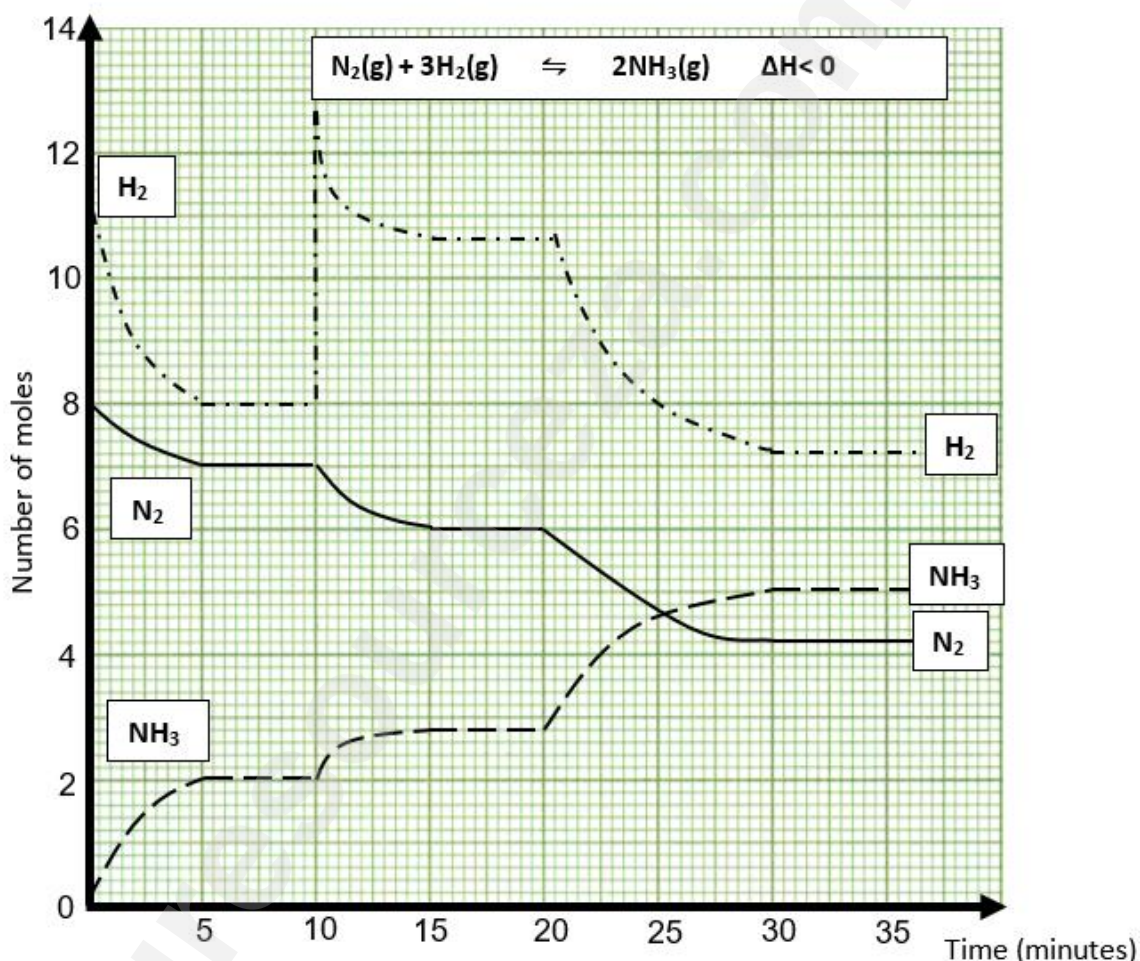
Time (min)	Total volume of oxygen gas collected (cm ³)
0	0
1	18
2	32
3	42
4	50
5	56
6	61
7	64
8	64
9	64
10	64

- 3.2.2 Draw a suitable graph of total volume of oxygen collected versus time. (6)
The graph paper can be found attached.
- 3.2.3 Use values from the table to calculate the average rate of this reaction (3)
during the time interval **1 to 4 minutes**.
- 3.2.4 Use your graph to determine, in seconds, how long it took for (1)
40 cm³ of oxygen to be collected.
- 3.3. Hydrogen peroxide is sold as different “percentage by volume” amounts according to the required use. Generally, the availability of oxygen from hydrogen peroxide is defined as **1% of hydrogen peroxide will yield 3,3 volumes (cm³) of oxygen**.
- 3.3.1 Use the total volume of oxygen gas produced in the experiment to (2)
calculate the “percentage by volume” of the hydrogen peroxide used by Caelan and Kate.
- 3.3.2 Using the collision theory, explain how using a greater concentration of (3)
hydrogen peroxide would increase the rate of oxygen produced in the reaction.
- 3.3.3 Define *catalyst*. (2)
- 3.3.4 On the graph paper for **question 3.2.2**, draw a second graph to (2)
indicate the change that an increase in the surface area of the catalyst, (manganese (IV) oxide), would result in.
Label this second graph as “change”.
- 3.3.5 How would the heat of this reaction be affected when the (1)
catalyst was added? Just answer **increase, decrease or no change**.

[23]

QUESTION 4

- 4.1 In a 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.



- 4.1.1 Write an equilibrium constant expression, K_c for the Haber Process reaction. (2)
- 4.1.2 Use figures from the graph to determine the equilibrium **concentrations** of H_2 , N_2 and NH_3 at a time of 8 minutes. (5)
- 4.1.3 Show that the equilibrium constant, K_c at 450°C , for this reaction, at a time of 8 minutes is 0.11. (2)
- 4.1.4 Evaluate the significance of the K_c value at 450°C in terms of whether the reactants or products will be favored. (2)

- 4.1.5 Give one advantage of performing the process at such a high temperature. (1)
- 4.1.6 What change was made to the equilibrium mixture at a time of 10 minutes? (1)
- 4.1.7 State *Le Chatelier's Principle*. (2)
- 4.1.8 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)
- 4.2 A chemical engineer, Ogodiseng, is investigating the Haber process and so performs an experiment. She places 0.5 mol of N_2 and 2.3 mol of H_2 into a 2 dm^3 container and waits for the equilibrium to be established. She then measures the amount of N_2 present and discovers that there is 0.35 mol at equilibrium.
- 4.2.1 Using the information given above and the expression for K_c , calculate the value of K_c at the temperature at which Ogodiseng did her experiment. (7)
- 4.2.2 Compare the value calculated in Question 4.2.1 to that calculated in Question 4.1.3. Did Ogodiseng do her experiment at a temperature above or below 450°C ? (2)
- 4.2.3 Explain your answer to Question 4.2.2. (4)

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QUESTION 5

5.1 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	$(COOH)_2$	5.6×10^{-2}

5.1.1 Define the term *weak acid*. (2)

5.1.2 Which acid, carbonic acid or oxalic acid, is stronger? Give a reason for the answer. (2)

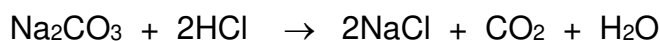
5.1.3 Oxalic acid ionises in water.

a. Define the term *ionisation*. (2)

b. Write down the balanced chemical equation for the ionization of Oxalic acid. (4)

5.2 The ionisation constant for water (K_w) is 1×10^{-14} at $25^\circ C$. Calculate the concentration of hydroxide ions in a solution of hydrofluoric acid solution if the concentration of hydronium ions (H_3O^+) is $0,03 \text{ mol} \cdot \text{dm}^{-3}$ at equilibrium at $25^\circ C$. (3)

5.3 During an acid-base titration, 20 cm^3 of hydrochloric acid of concentration $0.4 \text{ mol} \cdot \text{dm}^{-3}$ is needed to neutralize a sodium carbonate solution of concentration $0.25 \text{ mol} \cdot \text{dm}^{-3}$, according to the reaction:



5.3.1 Hydrochloric acid is a monoprotic acid. Explain what is meant by monoprotic acid. (2)

5.3.2 Why are both Na_2CO_3 and HCl standard solutions in this titration? (2)

5.3.3 Calculate the number of moles of acid present in 20 cm^3 of HCl with a concentration $0.4 \text{ mol} \cdot \text{dm}^{-3}$. (3)

5.3.4 What volume of sodium carbonate was required to neutralise the 20 cm^3 hydrochloric acid? (4)

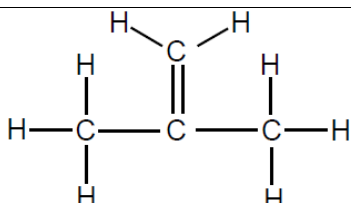
- 5.3.5 Using the information in the table below, suggest a suitable indicator to use for this titration. Explain your reasoning. (4)

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

[28]

QUESTION 6

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

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

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

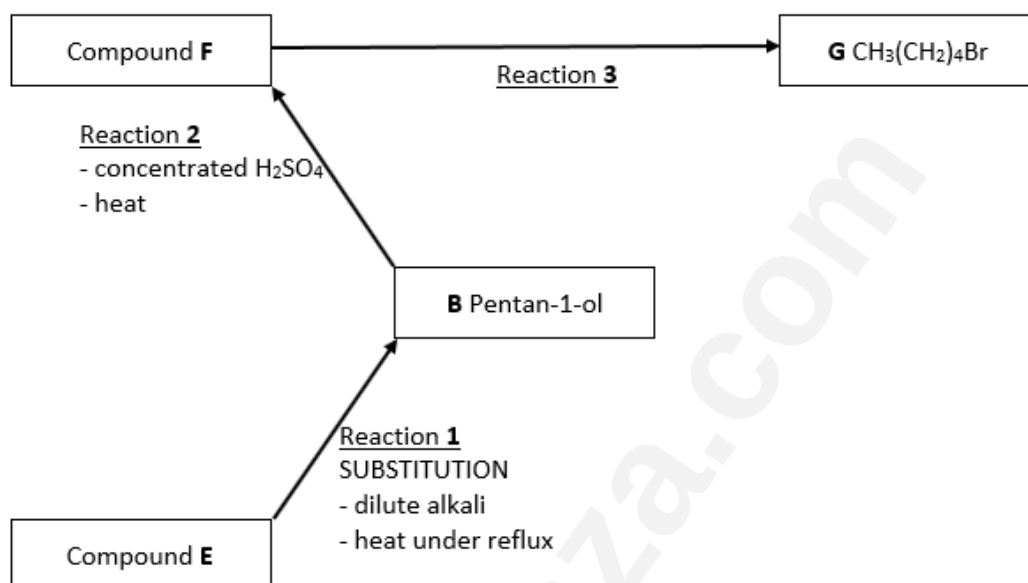
- 6.1.1 Name the homologous series to which this compound belongs. (1)
- 6.1.2 Name of the type of reaction of which this compound is the product. (1)
- 6.1.3 Give the reaction conditions for the reaction that will lead to the formation of this compound. (2)
- 6.1.4 Write the balanced chemical equation for the formation of this compound using structural formulae. (5)
- 6.1.5 Give the IUPAC NAME of a functional isomer of Compound **A** with no substituents (side chains). (2)

6.2 Study compound **C**.

- 6.2.1 Write down the IUPAC name of this compound. (2)
- 6.2.2 Is this compound SATURATED or UNSATURATED? Give a reason for the answer. (2)
- 6.2.3 Write a balanced chemical equation, using molecular formulae, for the combustion of Compound **C**. (4)

6.3 Rank the boiling points of compounds **A**, **B** and **D** from lowest to highest. Explain your order by referring to the relative strengths of intermolecular forces. (5)

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

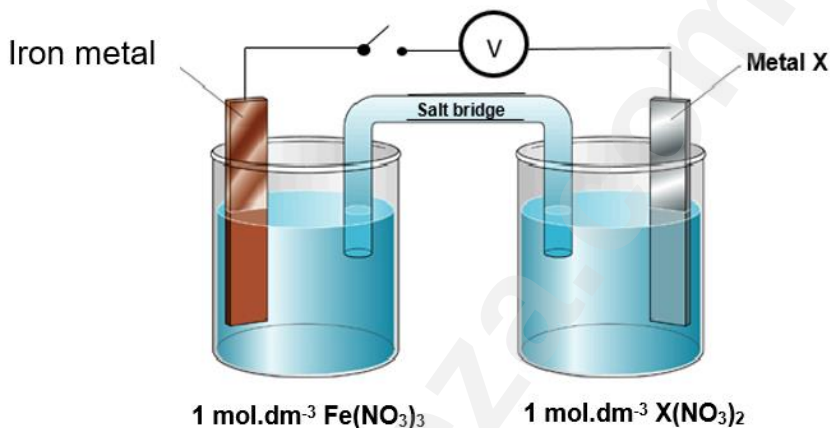


- 6.4.1 Define the term *functional* group. (2)
- 6.4.2 Name the functional group present in Compound **B**. (1)
- 6.4.3 Give the condensed structural formula of Compound **B**. (2)
- 6.4.4 Give the IUPAC name for Compound **E**. (2)
- 6.4.5 Give the structural formula for Compound **F**. (2)
- 6.4.6 What type of reaction is Reaction **2**? (1)
- 6.4.7 Name the type of reaction and give the necessary reagent for Reaction **3**. (2)

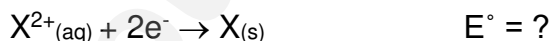
[36]

QUESTION 7

- 7.1 Namhla and Sophie construct the following electrochemical cell with an open switch, as shown in the diagram below. A strip of Iron (Fe) and a strip of unknown metal, X are used as electrodes. When the switch is closed, the mass of the Fe electrode increases.



The half-reactions involved in this cell are shown as follows:



- 7.1.1 Define the term *cathode*. (2)
- 7.1.2 In the diagram above, which electrode is the cathode? Justify your answer. (3)
- 7.1.3 In the diagram above, state the direction of electron flow in the external circuit when the switch is closed. (1)
- 7.1.4 If the standard cell potential E°_{cell} is +0.72 V, calculate the standard electrode potential, in volts for the X^{2+}/X electrode. (3)
- 7.1.5 Identify metal X. (1)
- 7.1.6 Write the balanced net-ionic equation for the overall chemical reaction occurring in the cell. (2)
- 7.1.7 Write down the cell notation for this cell. No phase labels required. (2)
- 7.1.8 Give two functions of the salt bridge. (2)

7.1.9 The salt bridge is replaced by one which is narrower, longer and less conductive than that shown in the diagram. With the cell operating under standard conditions, state how each of the following will be affected.

You need only state **increase**, **decrease** or **no effect**.

- a. the emf (1)
- b. the internal resistance (1)
- c. the ability of the cell to deliver current. (1)

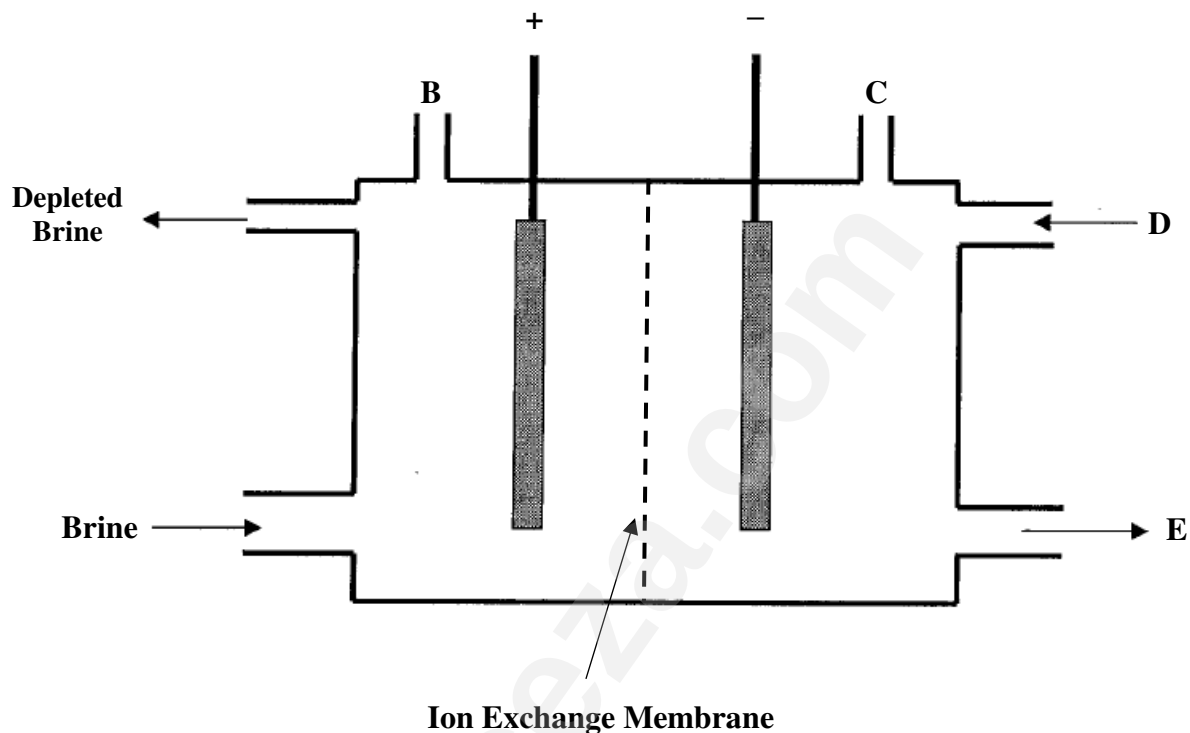
7.2 Rhodium is a very white, brilliantly shiny metal, but is far too hard to work into jewellery itself. It is also the most expensive precious metal. So, nowadays, white gold jewellery is often coated with rhodium to create a bright white, highly durable and tarnish resistant surface. The most frequently used method of applying rhodium finishes is the electroplating process.



Rebecca realizes that her knowledge in Chemistry class can finally be applied when helping her sister to design a wedding ring. She will need a white gold ring and an electroplating cell containing a concentrated **rhodium(III) chloride (RhCl_3)** and sulfuric acid electrolyte.

- 7.2.1 Other than for appearance, state TWO reasons for electroplating objects. (2)
- 7.2.2 Which electrode is the ring made to be? (1)
- 7.2.3 Write down the reduction half-reaction that occurs in this cell. (2)
- 7.2.4 What is the reason for using the sulfuric acid in the electrolyte? (1)
- 7.2.5 Jewellers suggest that a gold, and not a steel, hook should be used to suspend the ring in the electrolyte. Explain the reason for this. (1)
- 7.2.6 In order for the rhodium plating to last a sufficiently long time, the ring needs to be coated with 288 mg of rhodium. Considering a current of 1,5 A is used in the cell, calculate how long it would take to coat the ring. (6)
- 7.2.7 This particular cell does not use a rhodium electrode.
- For what reason would the other electrode normally be made of the metal being plated? (2)

- 7.3 The chlor-alkali industry is based on the electrolysis of brine. Consider the cell shown below and answer the questions that follow.



- 7.3.1 What is brine? (1)
- 7.3.2 Give ONE use for the chlorine produced in this cell. (1)
- 7.3.3 Identify the products B, C, and E. (3)
- 7.3.4 What is input at D? (1)
- 7.3.5 In what way does the membrane contribute to the safe functioning of this cell? (2)
- 7.3.6 Explain fully how the ion exchange membrane contributes to the purity of the sodium hydroxide produced. (2)

[44]

THE END
YOU MADE IT!

EXAMINATION DATA SHEET FOR THE PHYSICAL SCIENCES (CHEMISTRY)

TABLE 1 PHYSICAL CONSTANTS

NAME	SYMBOL	VALUE
Magnitude of charge on electron	e	$1,6 \times 10^{-19} \text{ C}$
Mass of an electron	m_e	$9,1 \times 10^{-31} \text{ kg}$
Standard pressure	p^θ	$1,01 \times 10^5 \text{ Pa}$
Molar gas volume at STP	V_m	$22,4 \text{ dm}^3 \cdot \text{mol}^{-1}$
Standard temperature	T^θ	273 K
Avogadro's constant	N_A	$6,02 \times 10^{23} \text{ mol}^{-1}$
Faraday's constant	F	$96\,500 \text{ C} \cdot \text{mol}^{-1}$

TABLE 2 CHEMISTRY FORMULAE

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$	$n = \frac{V}{V_m}$
$c = \frac{n}{V}$ OR $c = \frac{m}{MV}$	$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14} \text{ at } 298 \text{ K}$	
$Q = It$	$E_{\text{cell}}^\theta = E_{\text{cathode}}^\theta - E_{\text{anode}}^\theta$ $E_{\text{cell}}^\theta = E_{\text{oxidising agent}}^\theta - E_{\text{reducing agent}}^\theta$	

TABLE 3 PERIODIC TABLE

[illegible]

TABLE 4 STANDARD ELECTRODE POTENTIALS

Half-reaction			E°/volt
$\text{Li}^+ + \text{e}^- \rightleftharpoons \text{Li}$			-3,05
$\text{K}^+ + \text{e}^- \rightleftharpoons \text{K}$			-2,93
$\text{Cs}^+ + \text{e}^- \rightleftharpoons \text{Cs}$			-2,92
$\text{Ba}^{2+} + 2\text{e}^- \rightleftharpoons \text{Ba}$			-2,90
$\text{Sr}^{2+} + 2\text{e}^- \rightleftharpoons \text{Sr}$			-2,89
$\text{Ca}^{2+} + 2\text{e}^- \rightleftharpoons \text{Ca}$			-2,87
$\text{Na}^+ + \text{e}^- \rightleftharpoons \text{Na}$			-2,71
$\text{Mg}^{2+} + 2\text{e}^- \rightleftharpoons \text{Mg}$			-2,37
$\text{Al}^{3+} + 3\text{e}^- \rightleftharpoons \text{Al}$			-1,66
$\text{Mn}^{2+} + 2\text{e}^- \rightleftharpoons \text{Mn}$			-1,18
$2\text{H}_2\text{O} + 2\text{e}^- \rightleftharpoons \text{H}_2(\text{g}) + 2\text{OH}^-$			-0,83
$\text{Zn}^{2+} + 2\text{e}^- \rightleftharpoons \text{Zn}$			-0,76
$\text{Cr}^{3+} + 3\text{e}^- \rightleftharpoons \text{Cr}$			-0,74
$\text{Fe}^{2+} + 2\text{e}^- \rightleftharpoons \text{Fe}$			-0,44
$\text{Cd}^{2+} + 2\text{e}^- \rightleftharpoons \text{Cd}$			-0,40
$\text{Co}^{2+} + 2\text{e}^- \rightleftharpoons \text{Co}$			-0,28
$\text{Ni}^{2+} + 2\text{e}^- \rightleftharpoons \text{Ni}$			-0,25
$\text{Sn}^{2+} + 2\text{e}^- \rightleftharpoons \text{Sn}$			-0,14
$\text{Pb}^{2+} + 2\text{e}^- \rightleftharpoons \text{Pb}$			-0,13
$\text{Fe}^{3+} + 3\text{e}^- \rightleftharpoons \text{Fe}$			-0,04
$2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{H}_2(\text{g})$			0,00
$\text{S} + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{H}_2\text{S}(\text{g})$			+0,14
$\text{Sn}^{4+} + 2\text{e}^- \rightleftharpoons \text{Sn}^{2+}$			+0,15
$\text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{SO}_2(\text{g}) + 2\text{H}_2\text{O}$			+0,17
$\text{Cu}^{2+} + 2\text{e}^- \rightleftharpoons \text{Cu}$			+0,34
$2\text{H}_2\text{O} + \text{O}_2 + 4\text{e}^- \rightleftharpoons 4\text{OH}^-$			+0,40
$\text{SO}_2 + 4\text{H}^+ + 4\text{e}^- \rightleftharpoons \text{S} + 2\text{H}_2\text{O}$			+0,45
$\text{I}_2 + 2\text{e}^- \rightleftharpoons 2\text{I}^-$			+0,54
$\text{O}_2(\text{g}) + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{H}_2\text{O}_2$			+0,68
$\text{Fe}^{3+} + \text{e}^- \rightleftharpoons \text{Fe}^{2+}$			+0,77
$\text{Hg}^{2+} + 2\text{e}^- \rightleftharpoons \text{Hg}$			+0,79
$\text{NO}_3^- + 2\text{H}^+ + \text{e}^- \rightleftharpoons \text{NO}_2(\text{g}) + \text{H}_2\text{O}$			+0,80
$\text{Ag}^+ + \text{e}^- \rightleftharpoons \text{Ag}$			+0,80
$\text{NO}_3^- + 4\text{H}^+ + 3\text{e}^- \rightleftharpoons \text{NO}(\text{g}) + 2\text{H}_2\text{O}$			+0,96
$\text{Br}_2 + 2\text{e}^- \rightleftharpoons 2\text{Br}^-$			+1,09
$\text{Pt}^{2+} + 2\text{e}^- \rightleftharpoons \text{Pt}$			+1,20
$\text{MnO}_2 + 4\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{Mn}^{2+} + 2\text{H}_2\text{O}$			+1,21
$\text{O}_2 + 4\text{H}^+ + 4\text{e}^- \rightleftharpoons 2\text{H}_2\text{O}$			+1,23
$\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \rightleftharpoons 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$			+1,33
$\text{Cl}_2(\text{g}) + 2\text{e}^- \rightleftharpoons 2\text{Cl}^-$			+1,36
$\text{Au}^{3+} + 3\text{e}^- \rightleftharpoons \text{Au}$			+1,42
$\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^- \rightleftharpoons \text{Mn}^{2+} + 4\text{H}_2\text{O}$			+1,51
$\text{H}_2\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons 2\text{H}_2\text{O}$			+1,77
$\text{F}_2(\text{g}) + 2\text{e}^- \rightleftharpoons 2\text{F}^-$			+2,87

Increasing oxidising ability

Increasing reducing ability

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APPENDIX A

Name: _____

QUESTION 1

MULTIPLE CHOICE ANSWER GRID

MARK ONLY THE CORRECT ANSWER WITH A CROSS.

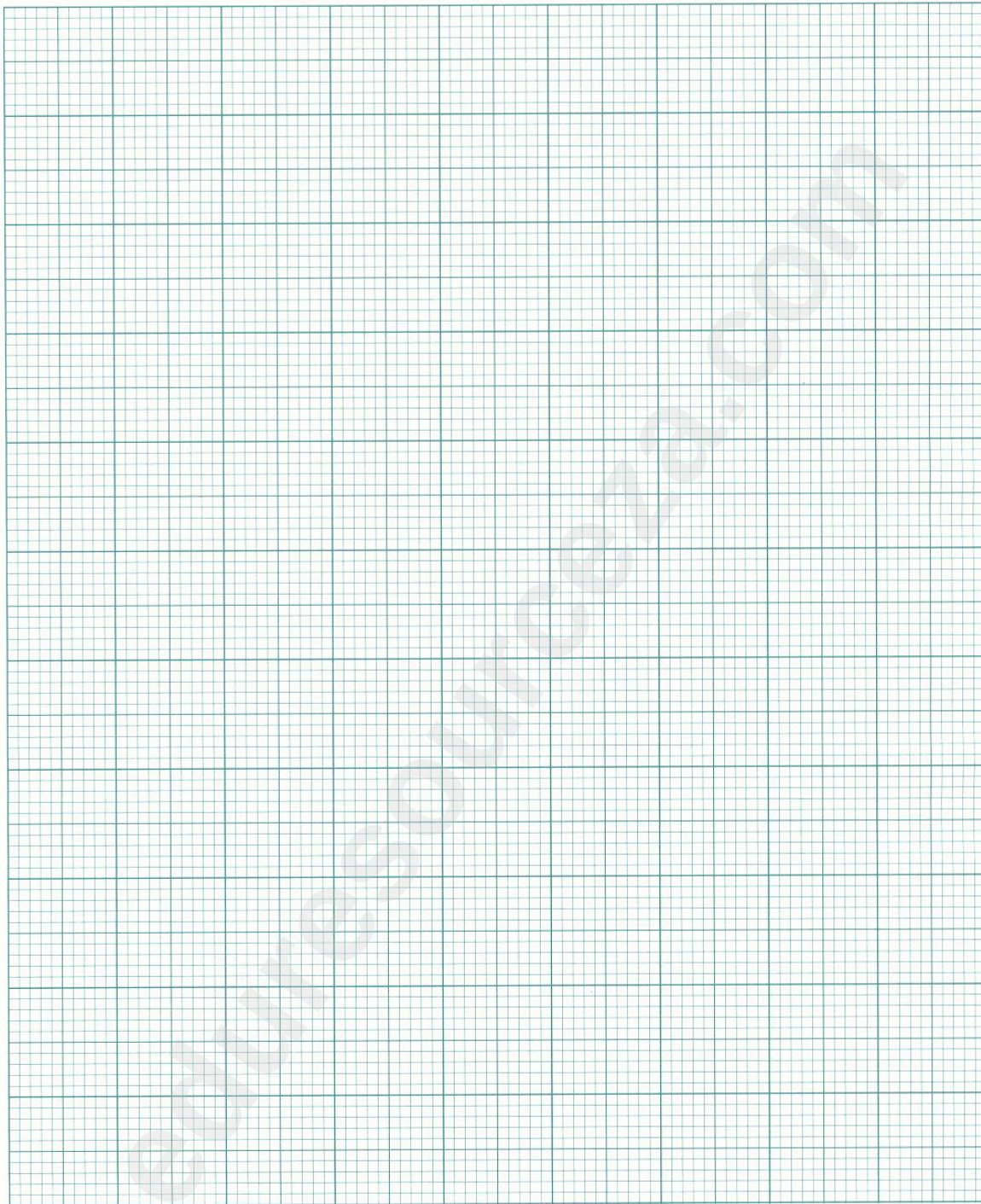
eg.	A	~~B~~	C	D
-----	---	--------------	---	---

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

For marking purposes only:

Q1	Q2	Q3	Q4	Q5	Q6	Q7	TOTAL	
/20	/18	/23	/31	/28	/36	/44	/200	%

QUESTION 3.2.2



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QUESTION 1

1.1	C
1.2	B
1.3	D
1.4	B
1.5	D

1.6	A
1.7	B
1.8	D
1.9	C
1.10	A

[10x2=20]

QUESTION 2

- 2.1.1 Lithium permanganate (1)
- 2.1.2 KHCO_3 (1)
- 2.1.3 *a measure of the tendency of an atom to attract a bonding pair of electrons* (2)
- 2.2.1 He (1)
- 2.2.2 NaNO_3 (1)
- 2.2.3 NH_3 (1)
- 2.2.4 Ni or C (graphite) (1)
- 2.2.5 C(s) diamond or SiO_2 (1)
- 2.2.6 NH_3 (1)
- 2.2.7 NaNO_3 (1)
- 2.2.8 NH_3 (1)
- 2.3.1 (non-polar) ✓ Covalent ✓ (pure) (2)
- 2.3.2 VD Waals forces/London forces (1)
- 2.3.3. Weak London forces that are overcome with low energy ✓ so solid will change directly to gas (2)
But strong enough to hold molecules together in solid due to large mass and large number of electrons ✓
- 2.3.4 No free ions/electrons (1)

[18]

QUESTION 3

3.1 the minimum energy required to start a chemical reaction (2)
OR the energy required to form the activated complex✓✓

3.2.1 Downward displacement of water✓ (1)

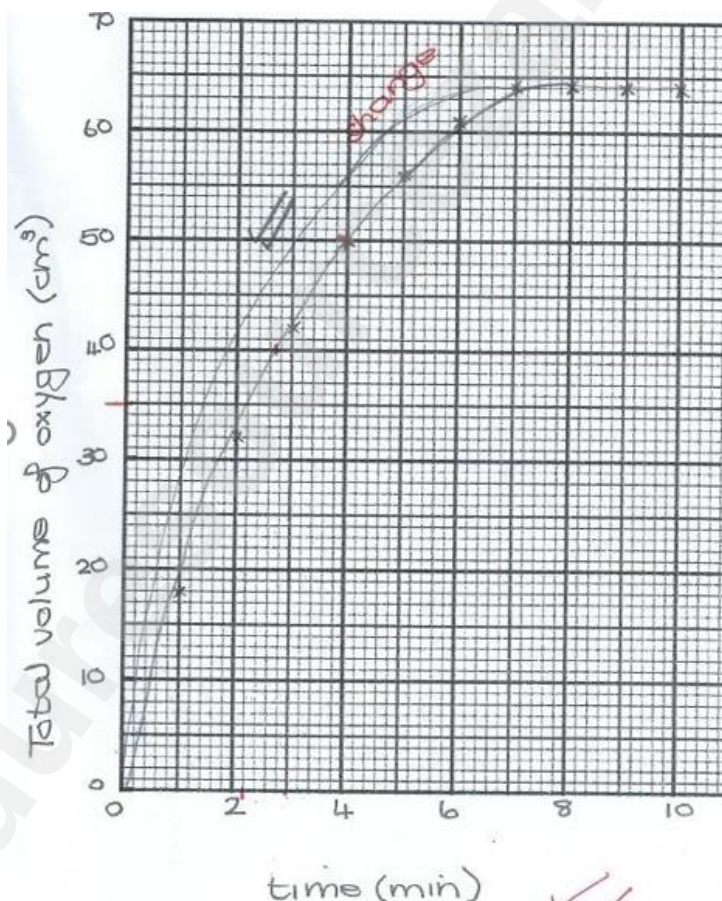
3.2.2 Heading✓ (6)

suitable scale both axes with 0 at origin✓

two plotted points correct (3,42 and 7,64) ✓✓

line of best fit ✓

Y and X axis correct label and unit ✓



3.2.3 Average rate = from table = $\frac{\text{final-initial}}{\text{change in time}} = \frac{50-18}{4-1} = 10.67 \text{ cm}^3 \cdot \text{min}^{-1}$ ✓ (3)

3.2.4 2,8 minutes = 168 seconds✓ (1)
(2,7 minutes accept 162 seconds)

- 3.3.1 1% produces 3.3 cm³ of oxygen (2)
Accept 20% (19.39%)✓✓ produces 64 cm³ of peroxide
- 3.3.2 Greater number of H₂O₂ molecules per unit volume (3)
✓increased number of effective collisions✓
[with catalyst] per unit time✓
- 3.3.3 *substance that increases the rate of the reaction but* (2)
remains unchanged at the end of the reaction✓✓
- 3.3.4 On graph: steeper gradient and same end point (2)
- 3.3.5 No change✓ (1)
[23]

QUESTION 4 – Chemical Equilibrium

$$4.1.1 \quad K_c = \frac{[NH_3]^2}{[N_2][H_2]^3} \checkmark \checkmark \quad (2)$$

$$4.1.2 \quad c = \frac{n}{V} \checkmark$$

$$i. [N_2] = \frac{7}{10} \checkmark = 0.7 \text{ mol} \cdot \text{dm}^{-3} \checkmark$$

$$ii. [H_2] = \frac{8}{10} = 0.8 \text{ mol} \cdot \text{dm}^{-3} \checkmark$$

$$iii. [NH_3] = \frac{2}{10} = 0.2 \text{ mol} \cdot \text{dm}^{-3} \checkmark \quad (5)$$

$$4.1.3 \quad K_c = \frac{[NH_3]^2}{[N_2][H_2]^3} = \frac{(0.2)^2}{(0.7)(0.8)^3} \checkmark \checkmark = 0.11 \quad (2)$$

4.1.4 K_c value is small $\checkmark$ so the reactants will be favoured. $\checkmark \quad (2)$

4.1.5 Faster reaction rate $\checkmark \quad (1)$

4.1.6 Hydrogen was added. $\checkmark$ (don't say increase concentration) $\quad (1)$

4.1.7 Le Châtelier's principle: When an external stress (change in pressure, temperature or concentration) is applied to a system $\checkmark$ in dynamic chemical equilibrium, the equilibrium point will change $\checkmark$ in such a way as to counteract the stress $\checkmark \quad (2)$

4.1.8 Response: Forward reaction favoured $\checkmark$

Reason: to use up excess $H_2 \checkmark$

Result: $\therefore [N_2]$ & $[H_2]$ decreased and $[NH_3]$ increased. $\checkmark \quad \text{coe}(3)$

4.2

4.2.1

	N_2	$3H_2$	$2NH_3$
Initial	0.5	2.3	0
Change	-0.15 $\checkmark$	-0.45 $\checkmark$	+0.3 $\checkmark$
Equilibrium	0.35	1.85	0.3 $\checkmark$
[Equilibrium]	0.175	0.925	0.15 $\checkmark$

$$K_c = \frac{[NH_3]^2}{[N_2][H_2]^3} = \frac{(0.15)^2}{(0.175)(0.925)^3} \checkmark = 0.16 \checkmark \quad (7)$$

4.2.2 below $450^\circ\text{C} \checkmark \checkmark \quad (2)$

4.2.3 Reason: Forward reaction exothermic $\checkmark$;

Response: Decreased temperature favours forward reaction $\checkmark$

Result: making more product $\checkmark$ and increasing K_c value $\checkmark \quad \text{coe}(4)$

[31]

QUESTION 5 – Acids and Bases

5.1.1 Weak Acid: An acid that only ionises partially in an aqueous solution ✓✓ (2)

5.1.2 Oxalic Acid ✓; larger K_a value ✓ (2)

5.1.3 a. Ionisation: The reaction of a molecular substance with water to produce ions ✓✓ (2)

b. $(\text{COOH})_2 \checkmark + 2\text{H}_2\text{O} \checkmark \rightleftharpoons (\text{COO}^-)_2 \checkmark + 2\text{H}_3\text{O}^+ \checkmark$
Accept $\text{C}_2\text{O}_2\text{H}_2$ (-1 single arrow)(4)

5.2 $K_w = [\text{OH}^-][\text{H}_3\text{O}^+] = 1 \times 10^{-14}$

$$[\text{OH}^-] = \frac{K_w}{[\text{H}_3\text{O}^+]} \checkmark = \frac{1 \times 10^{-14}}{0.03} \checkmark = 3.33 \times 10^{-13} \text{ mol} \cdot \text{dm}^{-3} \checkmark \quad (3)$$

5.3.1 monoprotic – one acidic hydrogen ✓donators ✓ (2)

5.3.2 Sodium carbonate and HCL are solutions of known concentration (2)

5.3.3 $n = cV \checkmark = 0.4 \times 0.02 \checkmark = 0.008 \text{ mol} \checkmark$ (3)

5.3.4 $v = \frac{n}{c} \checkmark = \frac{0.004 \checkmark}{0.25} \checkmark = 0.016 \text{ dm}^3 \checkmark$ or 16 cm^3 (4)

5.3.5 Methyl orange ✓, strong acid ✓ reacting with a weak base ✓ gives an end point which is acidic ✓ and methyl orange changes colour at an acidic pH. (4)

[28]

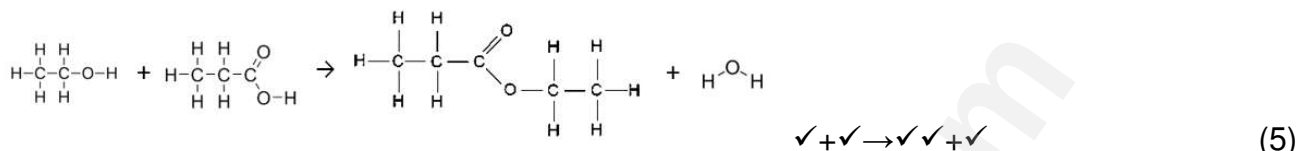
QUESTION 6 - Organic Chemistry

6.1.1 Esters ✓ (1)

6.1.2 esterification ✓ or condensation (1)

6.1.3 heat ✓ and sulfuric acid ✓ or concentrated acid catalyst (2)

6.1.4



6.1.5 pentanoic acid ✓✓ (2)

6.2.1 2-methylpropene ✓✓ (accept 2-methylprop-1-ene) (2)

6.2.2 Unsaturated ✓ as it has a double bond ✓ (2)

6.2.3 C_4H_8 ✓ + 6O_2 ✓ → 4CO_2 ✓ + $4\text{H}_2\text{O}$ ✓ (4)

6.3 $\text{D} < \text{A} < \text{B}$ ✓✓

Compound D – London forces, which is weaker than the ✓

Dipole-dipole forces between molecules of compound A, ✓

Which is weaker than the hydrogen bonds of compound B ✓ (5)

6.4.1 Functional Group: An atom or a group of atoms that form the centre of chemical activity in the molecule. ✓✓ (2)

6.4.2 Hydroxyl group ✓ (1)

6.4.3 $\text{CH}_3(\text{CH}_2)_4\text{OH}$ ✓✓ or $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$ (2)

6.4.4 1-bromopentane ✓✓ or 1-chloro (2)

6.4.5



6.4.6 Elimination ✓ (Accept dehydration) (1)

6.4.7 Addition ✓; HBr ✓ (Accept Hydrohalogenation) (2)

[36]

QUESTION 7 – Electrochemistry

7.1

- 7.1.1 Cathode: The electrode where reduction takes place ✓✓ (2)
- 7.1.2 Iron (Fe) electrode ✓ – mass increases ✓ and thus Fe^{3+} ions gain electrons to be reduced to Fe. ✓ (3)
- 7.1.3 Metal X to Iron electrode ✓ (right to left) (accept Anode to cathode only if 7.1.1 is correct) (1)
- 7.1.4 $E^\ominus_{\text{cell}} = E^\ominus_{\text{cathode}} - E^\ominus_{\text{anode}}$ ✓
 $E^\ominus_{\text{anode}} = E^\ominus_{\text{cathode}} - E^\ominus_{\text{cell}}$
 $X = -0.04 - 0.72 \checkmark = -0.76 \text{ V} \checkmark$ (3)
- 7.1.5 Zn ✓ (1)
- 7.1.6 $2 \text{Fe}^{3+} + 3 \text{Zn} \checkmark \rightarrow 2 \text{Fe} + 3 \text{Zn}^{2+} \checkmark$ (2)
- 7.1.7 $\text{Zn} \mid \text{Zn}^{2+} \checkmark \parallel \text{Fe}^{3+} \mid \text{Fe} \checkmark$ (2)
- 7.1.8 Two of the following: ✓+✓
 To complete the circuit or
 to maintain electrical neutrality of the two half cells or
 to allow the electrolytes in the anode and cathode to be physically separate but electrically connected. (2)
- 7.1.9
- No effect ✓ (1)
 - Increase ✓ (1)
 - Decrease ✓ (1)

7.2

- 7.2.1 • To change the surface properties, e.g. making the metal more conductive ✓
 • To protect the metal from corrosion ✓
 • To change its mechanical properties, e.g. make it stiffer or harder (2)
- 7.2.2 Cathode ✓ (1)
- 7.2.3 $\text{Rh}^{3+} + 3\text{e}^- \rightarrow \text{Rh} \checkmark \checkmark$ (2)
- 7.2.4 To increase the conductivity of the electrolyte ✓ (1)
- 7.2.5 The steel hook would corrode in the acidic electrolyte ✓ or oxidise (1)
- 7.2.6 $n(\text{Rh}) = \frac{m}{M} = \frac{(0.288)}{(103)} = 2,796 \times 10^{-3} \text{ mol} \checkmark_{\text{conversion}} \checkmark$
 $n(\text{e}^-) = n(\text{Rh}) \times 3 = (2,796 \times 10^{-3}) \times 3 \checkmark = 8,388 \times 10^{-3} \text{ mol}$
 $Q = nF = (8,388 \times 10^{-3})(96500) \checkmark = 809,476 \text{ C}$
 $\Delta t = \frac{Q}{I} = \frac{(809,476)}{(1,5)} \checkmark = 539,65 \text{ s} \checkmark$ (6)

- 7.2.7 In order to ensure the concentration of Rh^{3+} ions remains high, in order to ensure they compete effectively for collisions with the cathode instead of, e.g. H_2O ✓✓ (2)
- 7.3.1 Concentrated (saturated) sodium chloride solution ✓ (1)
- 7.3.2 Any suitable use, e.g. purification of water ✓ (1)
- 7.3.3 B – Cl_2 gas ✓
C – H_2 gas ✓
E – (33 %) NaOH solution ✓ (3)
- 7.3.4 30 % sodium hydroxide solution ✓ (1)
- 7.3.5 It prevents the Cl_2 and H_2 gases from mixing✓, which would create an explosive mixture✓ OR it prevents the OH^- ions from flowing back into the cathode chamber and reacting with the Cl_2 gas and forming an unstable compound. (2)
- 7.3.6 The membrane does not allow Cl^- ions through ✓ and so the sodium hydroxide is not contaminated with sodium chloride ✓. (2)

[44]