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Brescia House School

Physical Science Paper II **MEMO**

Grade 12
22 July 2024

QUESTION 1:

Answer these questions on the multiple-choice grid.

Make a cross (X) in the box corresponding to the letter that you consider to be correct.

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

QUESTION 2:

2.1. Intermolecular forces hold compounds together in the liquid or solid state.

2.1.1. Explain the formation of London forces between molecules. (3)

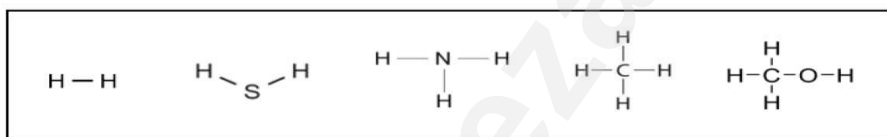
- London forces develop between molecules that are nonpolar ✓
- Electron cloud becomes distorted when an electron wobble occurs ✓
- This polarizes the molecule and results in a temporary or instantaneous dipole forming. ✓
- Thus a weak London force develops.

2.2. Consider the substances: CO and N₂. State the specific type of intramolecular bond found in: (2)

CO Polar covalent bond ✓

N₂ Pure covalent bond (Nonpolar covalent bond) ✓

2.3. Given the following substances, answer the questions that follow.



2.3.1. **NAME** the substance which will have the lowest boiling point. (1)

Hydrogen ✓

2.3.2. Which intermolecular forces are responsible for the low boiling point in question 2.3.1? (1)

(Weak) London forces ✓

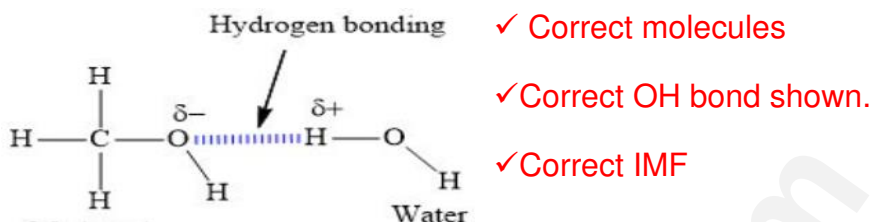
2.3.3. Classify the SPECIFIC TYPE of bond between the hydrogen and sulfur atoms in hydrogen disulfide. (2)

Polar ✓ covalent ✓

2.3.4. Name the substance/s that has/have non-polar molecules. (2)

Hydrogen ✓ and methane ✓

- 2.3.5. An aqueous solution of methanol, CH₃OH, exhibits hydrogen bonding. Using structural formulae, draw a diagram showing the hydrogen bonding in a methanol solution. Clearly label one of the hydrogen bonds. (3)



- 2.4. Magnesium and oxygen react to form magnesium oxide, which has a high melting point.

- 2.4.1. Write a balanced equation to represent the reaction that takes place. State symbols are not required. (3)



- 2.4.2. Explain, in terms of its bonding and structure, why magnesium oxide

- i. has a high melting point. (3)

- ionic bond ✓
- **the negative ion and the positive ion both have a strong charge. Resulting in a strong electrostatic force between the charged ions** ✓
- requires a lot of energy to overcome this force. ✓

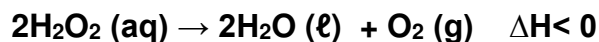
- ii. does not conduct electricity when solid. (2)

- in an ionic substance there are no free ions or free electrons ✓ to be able to conduct electrical energy
- ions in a fixed positions ✓ and unable to move freely

[22 marks]

QUESTION 3:

Hydrogen peroxide, H_2O_2 , in aqueous solution at room temperature, decomposes slowly and irreversibly to form water and oxygen, as shown by the following equation:



3.1. Define rate of reaction. (2)

as the change in amount or concentration per unit time of either a reactant or product ✓✓

3.2. What effect does an increase in temperature have on the rate of O_2 production? Circle the correct answer: **INCREASE**✓ or DECREASE. (2)

3.3. Use the collision theory to explain your answer. (4)

- increase in temperature increases the average kinetic energy of all molecules✓
- leading to increased frequency of effective collisions/increased number of collisions per unit time and increased energy of collisions ✓
- increase in temperature leads to an increased proportion (percentage/ratio) of (total) collisions per unit time that are successful, ✓
- i.e. more collisions with energy greater than the activation energy. ✓

When a lump of manganese (IV) dioxide (MnO_2) is added to the H_2O_2 solution, the rate of the O_2 production increases, but when powdered MnO_2 is added instead, the rate of the O_2 production is significantly increased. All the MnO_2 is recovered at the end of the reaction.

3.4. State the function of MnO_2 in this reaction, and explain its effect. (2)

- MnO_2 acts a catalyst✓
- which lowers activation energy by providing an alternate pathway which allows for more effective collisions per unit time. ✓ (OR introduction of a catalyst increases the proportion of collisions that are successful. ✓)

3.5. Explain how and why the two different forms of MnO_2 affect the reaction differently. (2)

Powdered catalyst has increased surface area✓ therefore there will be greater chance of successful collisions per unit time. ✓ (OR The greater the surface area of the catalyst, the more effective it is in providing an alternative pathway (lowering the activation energy)).

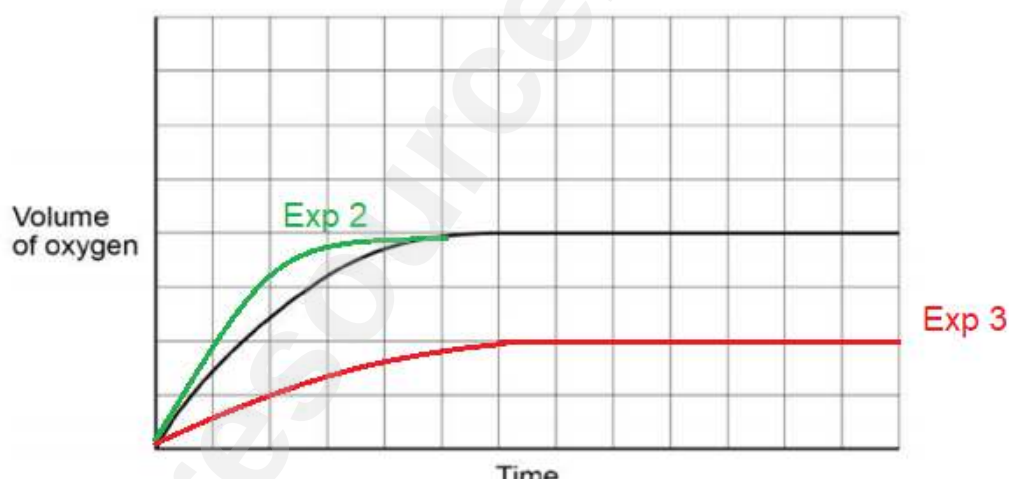
Three experiments, as shown in the table below, are carried out to investigate how the volume of oxygen produced varies with time under different conditions. The same mass of MnO_2 is used in each experiment.

Expt.	Concentration of H_2O_2 (aq) ($\text{mol}\cdot\text{dm}^{-3}$)	Volume of H_2O_2 (aq) (cm^3)	Temperature ($^{\circ}\text{C}$)	State of MnO_2
1	1	50	20	Lumps
2	1	50	20	Powder
3	0,5	50	20	Lumps

3.6. Identify the independent variable in Experiments 1 and 2. (2)

State (of division) of MnO_2 ✓✓

The graph below shows how the volume of oxygen collected varies with time in



Experiment 1.

3.7. Draw two lines on the graph, to show how the volume of oxygen collected varies with time in Experiments 2 and 3. Label each line with the correct Experiment number. (4)

- Exp 2: Steeper gradient ✓ Same volume of oxygen ✓
- Exp 3: Gradient about half as steep ✓ Half the volume of gas ✓

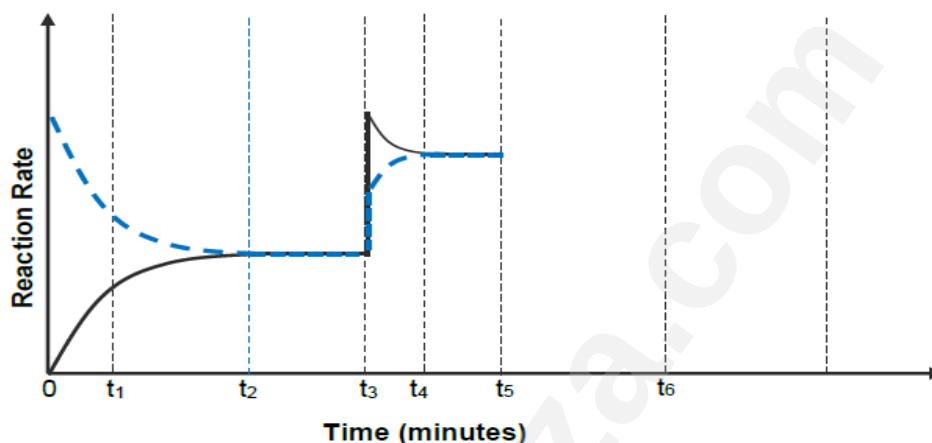
[18 marks]

QUESTION 4:

Gas AB decomposes according to the following equation:



A certain amount of AB is sealed in a container and allowed to decompose. The graph of the reaction rate vs time is shown below.



- 4.1. 'At t_1 the graph indicates that the concentration of AB is greater than the concentrations of A and B_2 .'

Circle only the correct answer: Is the statement TRUE or FALSE✓? (2)

- 4.2. What is represented by the blue dashed line (———) on the graph? (2)

The rate✓ of the forward reaction ✓ (OR $2\text{AB} \rightarrow 2\text{A} + \text{B}_2$)

- 4.3. Between t_2 and t_3 , the concentrations of AB, A and B_2 are EQUAL TO EACH OTHER / **CONSTANT**✓ / CHANGING. (Circle only the correct answer) (1)

- 4.4. The **temperature** of the system was **increased** at time t_3 .

Is the forward reaction EXOTHERMIC or ENDOTHERMIC? Explain by applying Le Châtelier's principle. (3)

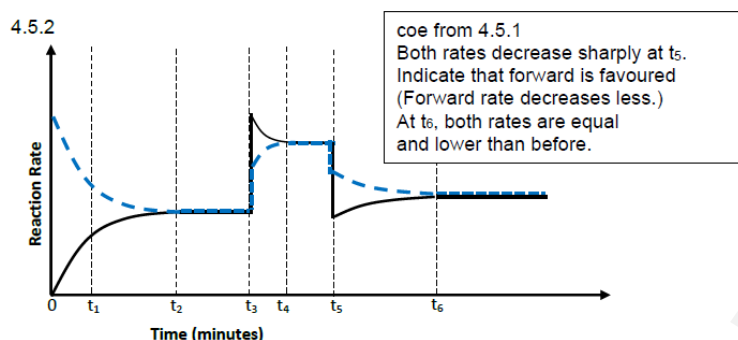
- A temperature increase favours the endothermic reaction ✓ because the system absorbs heat and thereby reduces the temperature.
- The graph shows that the reverse reaction is favoured. ✓
- The forward reaction is exothermic. ✓

- 4.5. At t_5 , the volume of the container was increased at constant temperature, resulting in a **decrease** in the **pressure**.

- 4.5.1. Explain the effect of this change by applying Le Châtelier's principle. (3)

- The forward reaction is favoured (faster than reverse) ✓
- as it produces more particles of gas✓
- and thereby increases the pressure. ✓

- 4.5.2. On the graph, complete the rate vs time graph from t_5 until after equilibrium is re-established at t_6 . (3)



Shape of graph from t_5 to t_6 (dotted line ✓ solid line ✓)

At equilibrium (equal rate) from t_6 onwards ✓

- 4.6. Gas AB was pumped into an evacuated container until the concentration was $X \text{ mol} \cdot \text{dm}^{-3}$. The container was sealed. Once equilibrium was established at 25°C , the concentration of gas B_2 was $0,025 \text{ mol} \cdot \text{dm}^{-3}$.

The reaction equation is: $2AB(g) \rightleftharpoons 2A(g) + B_2(g)$

- 4.6.1. Write the equilibrium constant expression, K_c , for the reaction. (2)

$$K_c = \frac{[A]^2[B_2]}{[AB]^2} \quad \text{top bottom -1 if no square brackets}$$

The value of K_c for the reaction at 25°C is $1,56 \times 10^{-3}$.

- 4.6.2. Show that the equilibrium concentration of gas AB is $0,2 \text{ mol} \cdot \text{dm}^{-3}$. (2)

$$1,56 \times 10^{-3} = \frac{(0,05)^2(0,025)}{[AB]^2} \quad \text{all correct}$$

$$[AB] = 0,2 \text{ mol} \cdot \text{dm}^{-3} \quad (\text{given})$$

- 4.6.3. Hence, calculate X , the initial concentration of gas AB in the container. (3)

Concentration of AB that reacts = $0,025 \times 2 = 0,05 \text{ mol} \cdot \text{dm}^{-3}$
Starting concentration of AB = $0,2 + 0,05 = 0,25 \text{ mol} \cdot \text{dm}^{-3}$

OR

R(ratio)	2AB	$\rightleftharpoons$	2A	+	B ₂
I(initial)	X		0		0
C(change)	-0,05		+ 0,05		+0,025
E(equilibrium)	0,2		0,05		0,025

$$X - 0,05 = 0,2$$

$$X = [AB]_{\text{initial}} = 0,25 \text{ mol} \cdot \text{dm}^{-3} \quad \text{with unit}$$

[21 marks]

QUESTION 5:

Consider the reaction equation shown below:



- 5.1. The compound NaOH is a base. Circle the correct words between the brackets in the following sentence:

NaOH is a (**STRONG**✓ / WEAK) base that (**COMPLETELY**✓ / PARTIALLY) (IONISES / **DISSOCIATES**✓) in water. (3)

- 5.2. Name the compound Na₂S. (2)

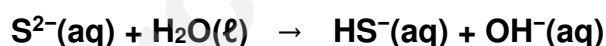
sodium sulfide ✓✓

- 5.3. The compound Na₂S can be classified as a salt.

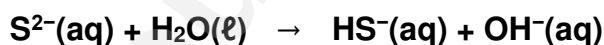
- 5.3.1. Define *salt*. (2)

a substance in which the hydrogen of an acid has been replaced by a cation ✓✓

- 5.3.2. Na⁺ ions do not react with water. However, the S²⁻ ion reacts with water as follows:



Label and draw lines to link the conjugate acid-base pairs in the equation. (2)



B	A	CA	CB
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- 5.3.3. Name this type of reaction of an ion (from a salt) reacting with water. (1)

Hydrolysis✓

- 5.3.4. Classify Na₂S as an ACIDIC or a BASIC salt. Give a reason. (2)

- basic salt✓
(Na⁺ ions don't react with water
The sulfide ion (S²⁻), however, is the conjugate base of a weak acid (H₂S), which means it has a strong tendency to accept protons (H⁺) from water).
- Na₂S produces OH⁻ ions upon hydrolysis, it creates a basic environment in aqueous solutions. [OH⁻] > [H⁺] ✓

- 5.3.5. Define an amphiprotic substance. (2)

a substance that can act as either an acid or a base ✓✓

- 5.3.6. Consider the statement: 'The S²⁻ ion is amphiprotic.' (1)

Circle the correct option between the brackets: Statement is (TRUE / FALSE✓).

- 5.4. 2,24 g of S is added to 0,5 dm³ of a 0,3 mol·dm⁻³ NaOH solution. The reaction equation is rewritten below:



- 5.4.1. Perform suitable calculations to determine the limiting reagent. (6)

$$\text{Moles of NaOH} = cV = 0.3 \text{ mol} \cdot \text{dm}^{-3} \times 0.5 \text{ dm}^3 = 0.15 \text{ mol} \checkmark$$

$$\text{Moles of S} = \frac{\text{mass}}{\text{molar mass}} = \frac{2.24}{32} = 0.07 \text{ mol} \checkmark$$

$$6 : 4$$

$$0.15 \div 0.1 \text{ not possible}$$

$$0.105 : 0.07 \text{ Possible} \checkmark$$

Sulfur is the limiting reagent ✓

- 5.4.2. Calculate the mass of Na₂S₂O₃ produced if the reaction has a 75% yield. (5)

$$0.07 \text{ moles of sulfur} : 0.0175 \text{ moles Na}_2\text{S}_2\text{O}_3 \checkmark$$

$$\text{Molar mass of Na}_2\text{S}_2\text{O}_3 = 158 \text{ g/mol} \checkmark$$

$$\text{Mass of Na}_2\text{S}_2\text{O}_3 = 0.0175 \text{ mol} \times 158 \text{ g/mol} = 2.765 \text{ g} \checkmark$$

$$\frac{\text{actual}}{\text{theoretical}} \times 100 = \text{Percentage yield}$$

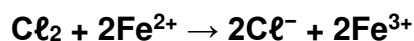
$$\text{Actual yield} = 2.765 \text{ g} \times 0.75 \checkmark (\text{method}) = 2.07 \text{ g} \checkmark$$

Therefore, the mass of Na₂S₂O₃ produced with a 75% yield is approximately 2.07 g

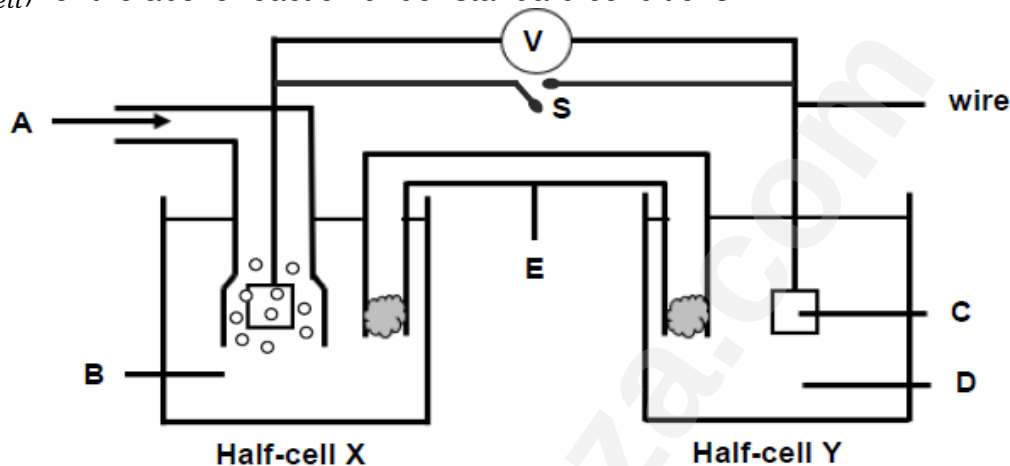
[26 marks]

QUESTION 6:

Chlorine gas and iron(II) ions react in aqueous solution as follows:



The diagram below shows a galvanic cell used to determine the cell potential (E_{cell}^θ) for the above reaction under standard conditions.



6.1. Give the **chemical formulae** of the substances represented by the letters: (4)

- A Cl_2 ✓
- B Cl^- ✓
- C Pt ✓
- D Fe^{2+} , Fe^{3+} (ONO -both) ✓

6.2. Consider the part labelled **E**.

6.2.1. What does **E** represent?

(1)

salt bridge ✓

6.2.2. Give the **chemical formula** of a suitable compound that could be dissolved in water to make the solution to fill **E**. (1)

Formula of any Group 1 metal nitrate e.g. KNO_3 ✓

- Give two reasons why your choice of compound in QUESTION 8.2.2 is suitable for this purpose. (2)

- Nitrate ions are highly soluble ✓
- Inert - K^+ ions have low ox ability ✓

6.3. Calculate the initial cell potential ($E_{cell\theta}$) for this cell under standard conditions. (4)

$$\begin{aligned} E^{\theta}_{cell} &= E^{\theta}_{cathode} - E^{\theta}_{anode} \checkmark \\ &= 1,36 \checkmark - 0,77 \checkmark \\ &= 0,59 \text{ V} \checkmark \end{aligned}$$

6.4. Identify the reducing agent in this cell. (1)

Fe^{2+} or iron(II) ion $\checkmark$

6.5. Circle the correct options between brackets in the statement below. (2)

When switch **S** is closed, electrons will flow from half-cell (**X to Y** OR **Y to X** $\checkmark$) through (**THE WIRE** $\checkmark$ OR **E**).

6.6. The standard solution of the Fe^{3+} electrolyte is prepared using $\text{Fe}_2(\text{SO}_4)_3$. Explain what concentration of $\text{Fe}_2(\text{SO}_4)_3$ solution should be prepared. (3)

- standard solution = $1 \text{ mol} \cdot \text{dm}^{-3}$ $\checkmark$
- $2 \times \text{Fe}^{3+}$ ions are produced per mol of $\text{Fe}_2(\text{SO}_4)_3$; $\checkmark$
- use a concentration of $0,5 \text{ mol} \cdot \text{dm}^{-3}$ since it will produce $[\text{Fe}^{3+}]$ of $1 \text{ mol} \cdot \text{dm}^{-3}$ $\checkmark$

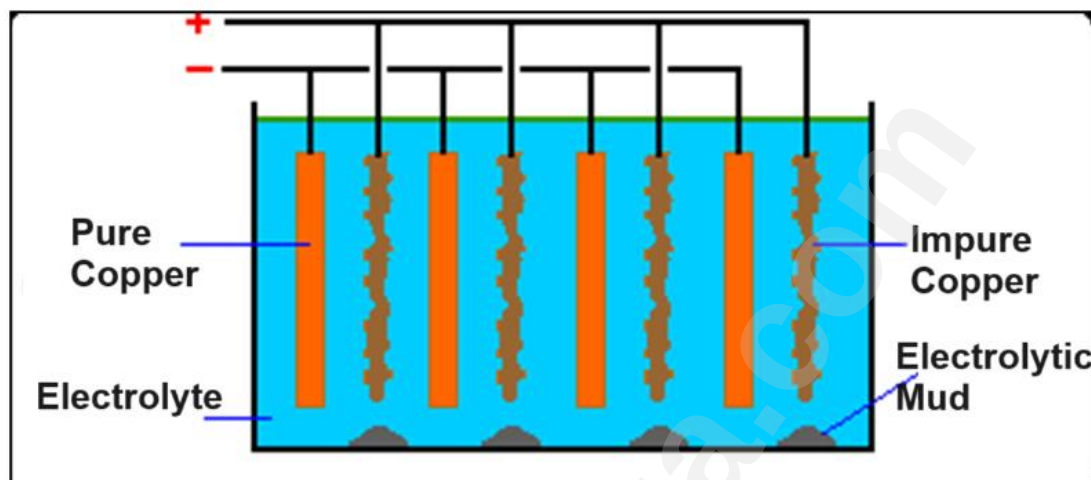
6.7. Iron(III) hydroxide is far less soluble than iron(II) hydroxide. Make use of this fact and Le Châtelier's principle to explain how the emf of the cell will be affected if some NaOH is added to the $\text{Fe}^{2+} | \text{Fe}^{3+}$ half-cell. (4)

- $[\text{Fe}^{3+}]$ will decrease more than $[\text{Fe}^{2+}]$ since its less soluble $\checkmark$
- The forward reaction will be favoured to increase the $[\text{Fe}^{3+}]$ $\checkmark$
- Increases the rate of the forward reaction $\checkmark$
- The emf will increase $\checkmark$.

[22 marks]

QUESTION 7:

The copper metal that is used in electric cables must be pure if it is to be an efficient current carrier. An electrolytic cell is set up, as shown below, to purify copper.



7.1. Define an electrolyte.

(2)

Substance that can conduct electricity ✓ due to the presence of free (mobile) ions when molten or dissolved in solution ✓

7.2. Which electrode is the cathode?

(1)

Circle the correct answer: **THE PURE COPPER PLATE ✓**, or THE IMPURE COPPER PLATE.

7.3. Mg and Pt are two impurities found in the impure copper. Explain why there would be magnesium ions in the electrolyte and platinum metal in the electrolytic mud. (4)

Mg atoms in impure Cu ✓ are oxidized to Mg^{2+} ions ✓

Mg is a stronger reducing agent than Cu ✓

Pt atoms in impure Cu are weaker reducing agents than Cu ✓ and will remain in the sludge/will not be oxidised ✓

A laboratory technician is tasked to determine the relationship between current strength and the time taken to deposit a specific mass, **m**, of pure copper at electrode **B**. The technician's results are represented in the table below.

Time (s)	$\frac{1}{\text{time}} \text{ (s}^{-1}\text{)} (\times 10^{-3})$	Current (A)
60	16,6	50
120	8,3	24
180	5,6	17
240	4,2	12
300	3,3	9

7.4. Complete the table above by filling in the missing value. (2)

5,6 ✓✓ (unit included = 1 mark only)

$5,6 \times 10^{-3}$ (1 mark only)

0,0056 (1 mark only)

7.5. Plot a line of best-fit for the graph of current (y-axis) vs 1/time (x-axis), on the graph sheet provided. (6)

Heading ✓

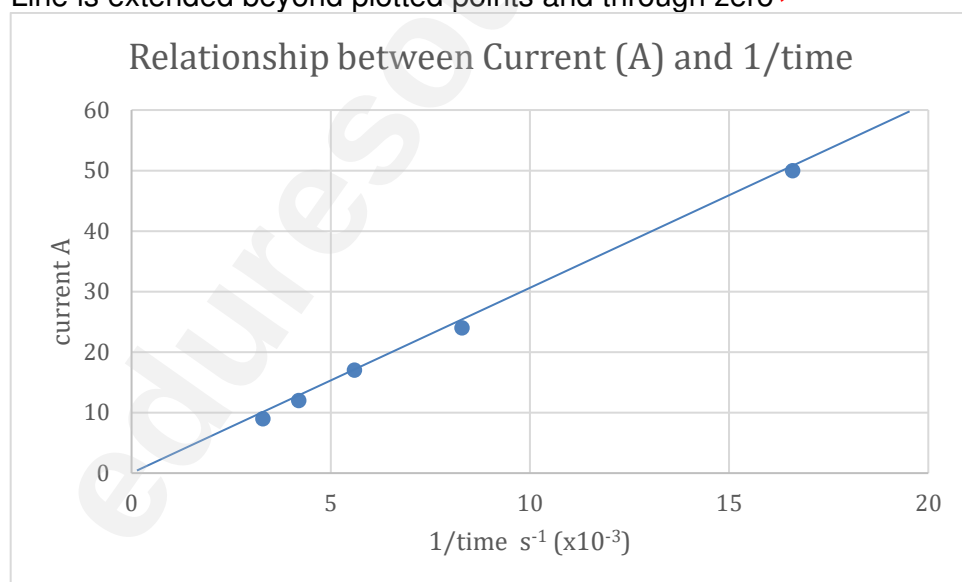
Correct label and unit on x-axis ✓ (unit s^{-1} , $\times 10^{-3}$)

Correct label and unit on y-axis ✓

Correctly plotted points ✓

Best-fit line correctly drawn ✓

Line is extended beyond plotted points and through zero ✓



- 7.6. Calculate the gradient of the graph. The points you use must be clearly indicated on the graph plotted in question 7.5. (3)

$$\text{Gradient} = \Delta y / \Delta x \checkmark$$

$$= (37 - 4) / (12,5 \times 10^{-3} - 1,5 \times 10^{-3}) \checkmark$$

$$= 3000 \text{ A/s}^{-1} \text{ or A.s or C} \checkmark \text{ (must have unit)}$$

(-1 if points not shown on graph and -1 if they used plotted points)

Please check their calculated gradient using the points from their graph and if correct then award marks.

- 7.7. Using the gradient and relevant equations, determine:

- 7.7.1. The number of moles of electrons transferred in this cell, when mass, **m**, of copper is deposited at electrode B. (4)

$$y = mx + c$$

$$I = \text{gradient} (1/t)$$

Using formula $Q = It$

Then gradient = $Q \checkmark$

$$Q = 3000 \text{ C} \checkmark$$

$$Q = nF$$

$$n = \frac{Q}{F} = \frac{3000}{96500} \checkmark = 0,0311 \text{ mol} \checkmark$$

- 7.7.2. The mass, **m**, of Cu deposited at the electrode **B**. (3)



e-: Cu

2 : 1

0,031 : x (**coe from 7.7.1.**)

$$x = 0,0155 \text{ Cu} \checkmark$$

$$n = m/M$$

$$0,0155 = m / 63,5 \checkmark$$

$$m = 0,98 \text{g} \checkmark$$

[25 marks]

QUESTION 8:

Three structural isomers with molecular formula C_6H_{14} are used to investigate the effect of branching on the physical properties of hydrocarbons.

- 8.1. Define a saturated hydrocarbon. (2)

Saturated = compound in which all of the bonds between carbon atoms are single bonds ✓

Hydrocarbon = compound containing only carbon and hydrogen atoms ✓

- 8.2. The structural formulae of three hydrocarbons, A, B, and C, are shown in the table below.

Hydrocarbon	Structural formula
A	$\begin{array}{c} \text{CH}_3 \\ \\ \text{H}_3\text{C}-\text{CH}-\text{CH}_2-\text{CH}_2-\text{CH}_3 \end{array}$
B	$\begin{array}{c} \text{H}_3\text{C} \quad \quad \text{CH}_3 \\ \diagdown \quad \diagup \\ \text{CH}-\text{HC} \\ \diagup \quad \diagdown \\ \text{H}_3\text{C} \quad \quad \text{CH}_3 \end{array}$
C	$\begin{array}{c} \text{CH}_3 \\ \\ \text{H}_3\text{C}-\text{C}-\text{CH}_2-\text{CH}_3 \\ \\ \text{CH}_3 \end{array}$

8.2.1 Define intermolecular force. (2)

a force of attraction between molecules or between atoms of noble gases ✓✓

8.2.2 Write down the type of intermolecular forces present between molecules of these isomers. (2)

Weak van der Waals forces ✓✓ (London forces, dispersion forces, etc.)

8.2.3 Explain why these three organic compounds are called structural isomers. (2)

compounds having the same molecular formula but different structural formulae ✓✓

8.2.4 Name compound A. (2)

2-methylpentane ✓ correct chain ✓ correct branch

8.2.5 Name compound C. (2)

2,2-dimethylbutane ✓ correct chain ✓ correct branches

- 8.3 The boiling points of the substances, A, B, and C were measured in an experiment to compare their vapour pressures. The results are shown in the table.

Substance	Boiling point (°C)
A	60
B	58
C	50

8.3.1 Name the independent variable in this investigation. (1)

The molecular structure of the substance. ✓

8.3.2 A table of vapour pressure (in mm Hg) measured at 25°C is shown below.

Vapour Pressure (mm Hg)		
235	319	211
B	C	A

8.3.3 Using the information given on the structures of molecules of substances A, B and C, and their boiling points, match the correct vapour pressure with the appropriate molecule (A – C). Write down with the corresponding substance A, B or C, below the appropriate vapour pressure in the table above. (2)

✓ One correctly positioned

✓ Second (and third) correctly positioned

8.3.4 Explain the answer in QUESTION 8.3.3. (3)

- The weaker the IMF, the lower is its boiling point. ✓✓
- The lower the boiling point, the greater the vapour pressure. ✓

8.4 Write down the balanced equation using MOLECULAR FORMULAE for the complete combustion of compound A. (3)

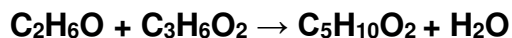


✓ correct formulae ✓✓ balanced

[21 marks]

QUESTION 9:

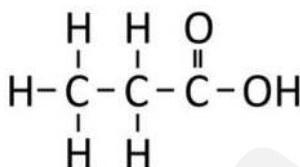
9.1 A group of Grade 12 learners is in a school laboratory preparing an organic compound with the distinct smell of pineapple. They use ethanol and propanoic acid. The balanced chemical equation for this reaction is:



9.1.1 What type of reaction takes place? (1)

Esterification ✓ or condensation

9.1.2 Draw the structural formula for propanoic acid. (2)



9.1.3 Write down the IUPAC name of the organic compound that is formed. (2)

Ethyl ✓ propanoate ✓

9.1.4 When 50 g of impure ethanol fully reacts with excess propanoic acid, it produces 68,88 g $\text{C}_5\text{H}_{10}\text{O}_2$.

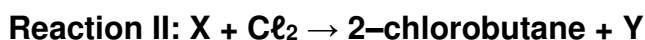
Calculate the percentage purity of the ethanol. (5)

$$\begin{aligned} n\text{C}_5\text{H}_{10}\text{O}_2 &= mM \\ &= 68,88 \times 102 \checkmark \\ &= 0,675 \text{ mol } \checkmark \end{aligned}$$

$$\begin{aligned} m &= n \times M \\ &= 0,675 \times 46 \checkmark \\ &= 31,05\text{g} \end{aligned}$$

$$\begin{aligned} \% \text{purity} &= \text{actual} / \text{theory} \times 100 \\ &= 31,05 / 50 \times 100 \checkmark \\ &= 62,1\% \checkmark \quad (\text{range } 61,13 \text{ to } 62,1) \end{aligned}$$

- 9.2 Prop-1-ene, an UNSATURATED hydrocarbon, and compound **X**, a SATURATED hydrocarbon, react with chlorine, as represented by the incomplete equations below.



- 9.2.1 What type of reaction takes place in Reaction I and Reaction II? (2)

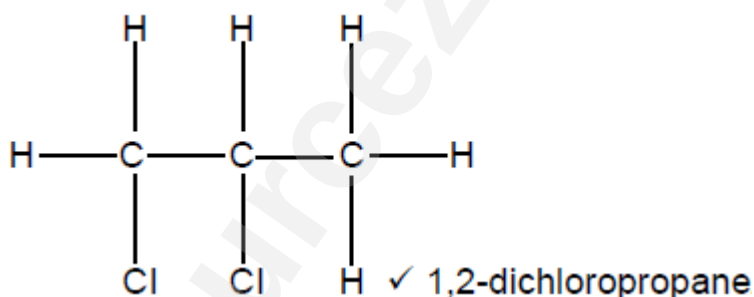
Circle the correct answer only.

Reaction I: ELIMINATION, **ADDITION**✓ or SUBSTITUTION

Reaction II: ELIMINATION, ADDITION or **SUBSTITUTION**✓

- Write down the STRUCTURAL FORMULA and NAME of the product formed in Reaction I.

(2)



- 9.2.2 List the reaction condition necessary for reaction II to take place. (1)

Heat or Light ✓

- 9.2.3 Write down the IUPAC name for reactant X. (1)

Butane✓

- 9.2.4 Write down the NAME or FORMULA of product Y. (1)

Hydrogen Chloride or HCl✓

- 9.3 Consider the organic compound of 2-chlorobutane. This compound can undergo either elimination or substitution reactions in the presence of a strong base such as sodium hydroxide.

- 9.3.1 Which reaction will preferably take place when 2-chlorobutane is heated in the presence of CONCENTRATED sodium hydroxide in ethanol. (1)

Circle the correct answer: SUBSTITUTION or **ELIMINATION**. ✓

