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ST BENEDICT'S

SUBJECT	Physical Science: Paper 2	DATE	21 September 2020
GRADE	12	MARKS	200
EXAMINER NAME	Mr F. McCoy	MODERATOR	Mr D. du Toit
		DURATION	3 hours + 10 min reading time
CLASS			
LOW ORDER	55%	HIGH ORDER	45%

INSTRUCTIONS

1. This question paper consists of 17 pages, an Answer Sheet of 2 pages and a Data Sheet of 3 pages. Please make sure that your question paper is complete.
2. Answer ALL the questions.
3. Read the questions carefully.
4. Use the data and formulae whenever necessary.
5. **Start each question on a new page.**
6. Show your working in all calculations.
7. Units need not be included in the working of calculations, but appropriate units should be shown in all answers.
8. Express all answers to **TWO** decimal places unless told otherwise.
9. It is in your own interest to write legibly and to present your work neatly.

Question	1	2	3	4	5	6	7	8	9	Total
Marks	20	11	26	26	25	19	20	19	34	200

QUESTION 1

20 MARKS

Answer the following multiple-choice questions on your separate ANSWER SHEET. Make a cross (X) in the box corresponding to the letter which you consider to be the most correct.

- 1.1 The very high melting point of diamond can be attributed to the strong _____ holding the _____ together.
- A covalent bonds, atoms
 - B London forces, molecules
 - C electrostatic forces, ions
 - D ionic bonds, positive kernels
- (2)

- 1.2 Hydrogen bonds exist between polar molecules in which hydrogen is bonded to
- i) a small atom;
 - ii) an atom with a high electronegativity;
 - iii) an atom with least one lone pair of electrons.

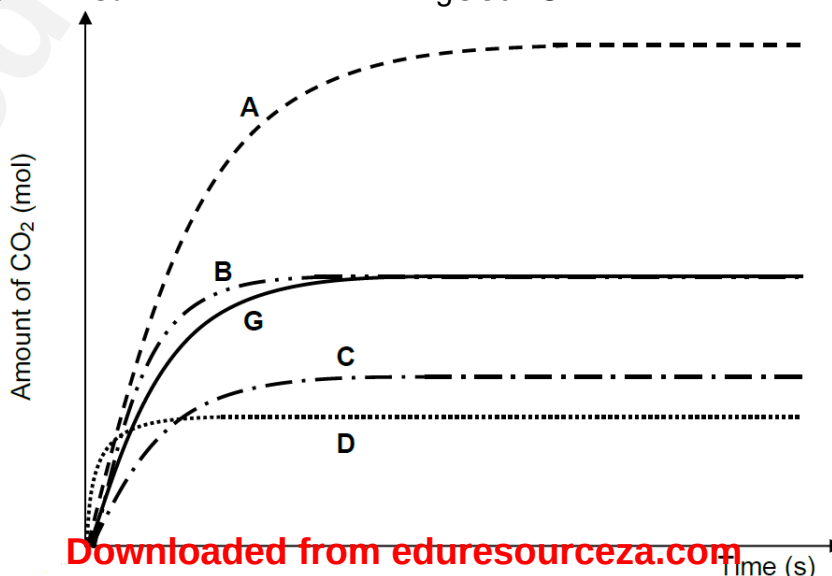
Select the condition/s that is/are true.

- A (i) only
 - B (ii) only
 - C (i) and (ii) only
 - D (i), (ii) and (iii)
- (2)
- 1.3 The reaction represented by the balanced chemical equation below was used to investigate how certain factors affect the reaction rate. (IEB 2019)



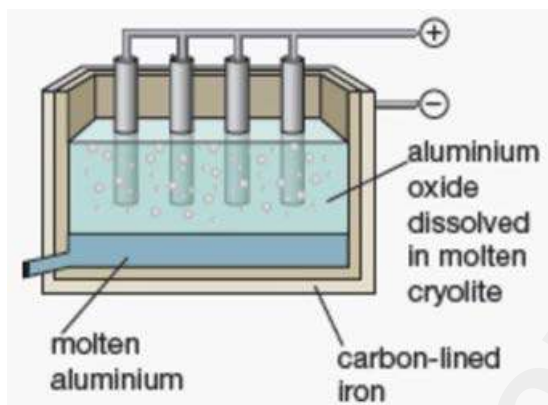
The amount of carbon dioxide produced from the reaction vessel was monitored. Graph **G** (the solid line) below was obtained for the reaction of 100 cm³ of a 0,2 mol·dm⁻³ HCl solution with a **SINGLE LUMP** of excess MgCO₃.

- Which graph (**A**, **B**, **C**, or **D**) represents the reaction of 100 cm³ of a 0,1 mol·dm⁻³ HCl solution with excess MgCO₃ **POWDER**? (2)



- 1.4 Magnesium nitrate forms ions in an aqueous solution. What number of ions is formed by the dissociation of 15 g magnesium nitrate?
- A 0,1
 - B $6,1 \times 10^{22}$
 - C $1,22 \times 10^{23}$
 - D $1,83 \times 10^{23}$ (2)
- 1.5 If the equilibrium is established by initially adding 0,10 mol each of A and B to a 1L container, then which of the following must be true once the mixture achieves equilibrium?
- $$\text{A} + 2\text{B} \rightleftharpoons 2\text{C}$$
- A $[\text{A}] = [\text{B}]$
 - B $[\text{B}] = 2[\text{C}]$
 - C $[\text{A}] > [\text{B}]$
 - D $[\text{A}] < [\text{B}]$ (2)
- 1.6 A strong base is defined as one which ...
- A neutralises a strong acid.
 - B dissociates completely in an aqueous solution.
 - C ionises completely in an aqueous solution.
 - D has a pH between 8 and 10. (2)
- 1.7 Ships made of iron have blocks of a specific metal attached to the hull to prevent the iron from being oxidised. Which metal would be most suitable?
- A Copper
 - B Magnesium
 - C Sodium
 - D Zinc (2)

- 1.8 Consider the electrolytic cell below with molten aluminium oxide dissolved in molten cryolite:



Give the half-reaction at the anode.

- A $\text{Al}^{3+} + 3\text{e}^- \rightarrow \text{Al}$
 B $\text{Al} \rightarrow \text{Al}^{3+} + 3\text{e}^-$
 C $\text{O}_2 + 4\text{e}^- \rightarrow 2\text{O}^{2-}$
 D $2\text{O}^{2-} \rightarrow \text{O}_2 + 4\text{e}^-$

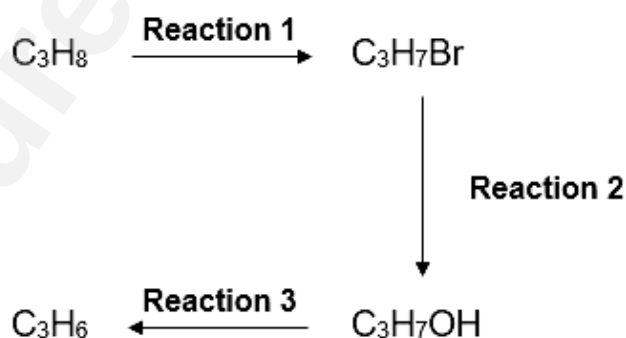
(2)

- 1.9 Which of the following is an isomer of 2,2-dimethylpentan-1-ol?

- A $\text{CH}_3\text{CH}_2\text{CH}_2\text{C}(\text{CH}_3)_2\text{CH}_2\text{OH}$
 B $(\text{CH}_3)_3\text{CCH}(\text{CH}_3)\text{CH}_2\text{OH}$
 C $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$
 D $\text{CH}_3\text{CHC}(\text{CH}_3)_2\text{CH}_2\text{OH}$

(2)

- 1.10 Which line in the table correctly describes the types of reaction in the following sequence?



	Reaction 1	Reaction 2	Reaction 3
A	addition	substitution	elimination
B	addition	addition	condensation
C	substitution	substitution	elimination
D	substitution	addition	condensation

(2)

QUESTION 2

11 MARKS

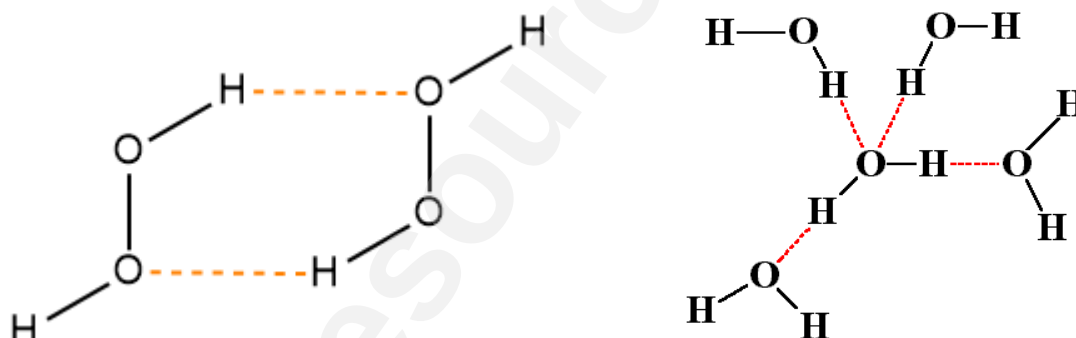
The structural formula of hydrogen peroxide and water are given below along with their respective boiling points.

	Structural Formula	Boiling Point (°C)
Water	$\begin{array}{c} \cdot\cdot \\ \cdot\text{O}\cdot \\ / \quad \backslash \\ \text{H} \quad \text{H} \end{array}$	100
Hydrogen Peroxide	$\begin{array}{c} \text{H} \\ \backslash \\ \cdot\text{O} \cdot \\ \cdot\cdot \end{array} - \begin{array}{c} \cdot\cdot \\ \cdot\text{O}\cdot \\ / \quad \backslash \\ \text{H} \end{array}$	150

2.1 Define *intramolecular bond*. (2)

2.2 Identify the intramolecular bonds in peroxide and give a clear explanation for your answer. (4)

The images below show how the intermolecular forces hold molecules of hydrogen peroxide and water together in the liquid phase.



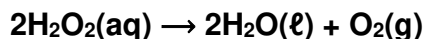
2.3 Identify the predominant (strongest) type of intermolecular force present as illustrated in the images. (1)

2.4 Use the images to provide a detailed explanation for the higher boiling point of hydrogen peroxide. (4)

QUESTION 3

26 MARKS

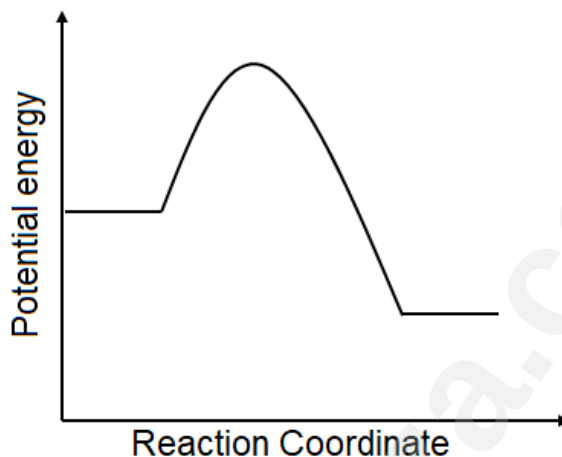
3.1 Hydrogen peroxide solution decomposes slowly to form water and oxygen.



3.1.1 Define *reaction rate*.

(2)

The following energy profile is for the above reaction.



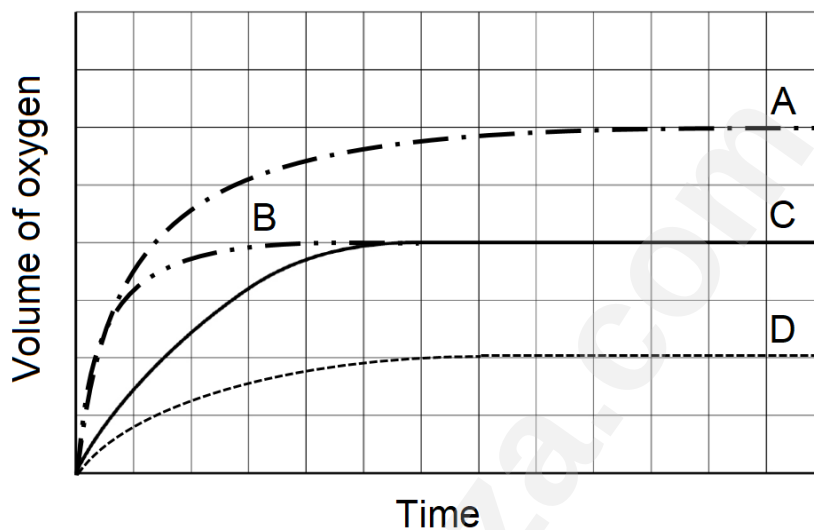
3.1.2 The profile has been reproduced on the ANSWER SHEET.

- Indicate the change in enthalpy on the profile, and label it as either $\Delta H > 0$ OR $\Delta H < 0$. (2)
- Draw in a dotted line to represent the addition of a catalyst to the reaction. (2)

Jack performs a series of four experiments, shown in the table below, which were carried out to investigate how the volume of oxygen produced varied over time under different conditions.

Experiment	Concentration of $\text{H}_2\text{O}_2(\text{aq})$ ($\text{mol} \cdot \text{dm}^{-3}$)	Volume of $\text{H}_2\text{O}_2(\text{aq})$ (cm^3)	Temperature ($^{\circ}\text{C}$)
1	1,0	50	20
2	0,5	50	20
3	1,0	50	40
4	1,0	75	40

- 3.1.3 Compare the results of **Experiment 1** and **Experiment 2**.
State the independent variable. (2)
- 3.1.4 Explain fully, in terms of the collision theory, how the reaction rate of **Experiment 1** would compare with **Experiment 3**. (4)
- 3.1.5 Jack obtains the graphs A, B, C and D below from experiments 1 to 4.



Which of the graphs represent:

- a) Experiment 2 (2)
- b) Experiment 3 (2)
- c) Experiment 4 (2)
- 3.2 Ozone reacts with water at 35°C to produce hydrogen gas and oxygen gas.
The molar volume of gases at 35°C is 25 dm³·mol⁻¹.
- $$\text{O}_3(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2(\text{g}) + 2\text{O}_2(\text{g})$$
- 3.2.1 If 4 kg of ozone reacts with 1,15 kg of water, determine the limiting reagent. All calculations must be shown. (5)
- 3.2.2 Determine the volume of oxygen gas formed at 35°C. (3)

QUESTION 4

26 MARKS

- 4.1 The balanced chemical equation below shows a hydrated cobalt(II) ion, which is **pink** in colour, reacting with chloride ions to form the complex cobalt tetrachloride ion, which is **blue** in colour.

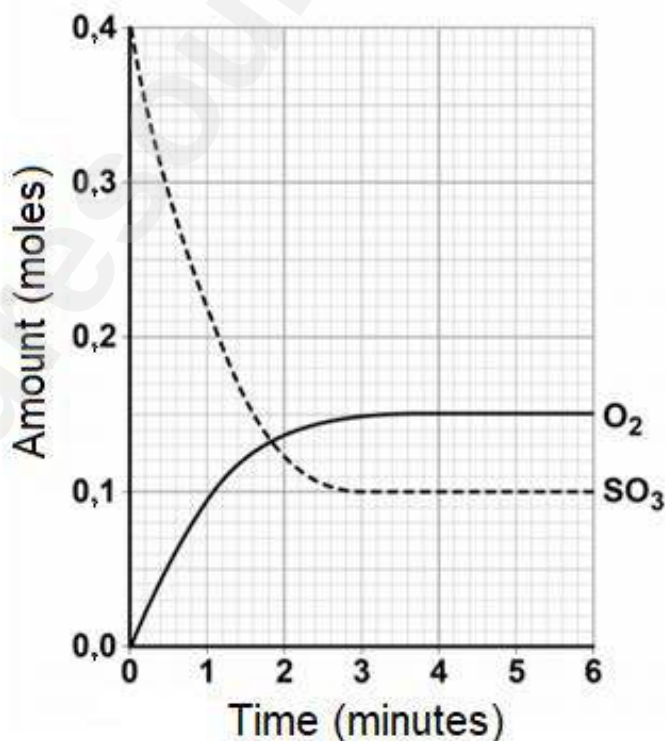
An aqueous equilibrium mixture is prepared in order to obtain a mixture that is initially **purple** in colour at 25°C.



- 4.1.1 What would happen to the equilibrium colour, if a few drops of concentrated HCl were added to the reaction mixture at equilibrium? State only **TURNS PINK**, **TURNS BLUE** or **REMAINS PURPLE**. (2)
- 4.1.2 Which reaction will be favoured by the addition of CoCl_4^{2-} ions to the reaction mixture? State only **FORWARD** or **REVERSE**. (2)
- 4.1.3 Water is added to the reaction mixture at equilibrium. With reference to Le Châtelier's principle, fully explain what would happen to the **colour** of the mixture. (4)
- 4.2 Sulphur trioxide decomposes to form sulphur dioxide and oxygen at temperature T_1 according to the equilibrium shown.



The graph below shows the amount of sulphur trioxide and of oxygen over a period of 6 minutes at temperature T_1 .



- 4.2.1 State the time, to the nearest minute, when equilibrium is first established. Explain your answer by referring to dynamic chemical equilibrium. (3)
- 4.2.2 Sketch on the ANSWER SHEET how the amount of sulphur dioxide changes over these 6 minutes at temperature T_1 (3)

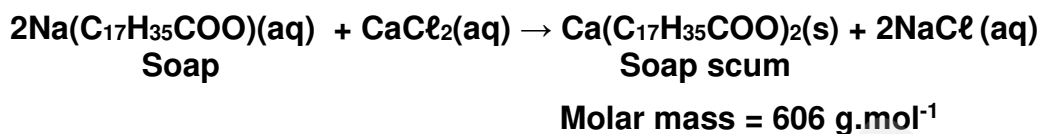
4.2.3 The temperature of the mixture was changed to T_2 and the mixture left to establish a new equilibrium, in a 1 dm^3 container.

- a) Define what a *closed system* is in chemistry. (2)
 - b) In the new equilibrium mixture the amount of sulphur trioxide was found to be 0,07 mol.
Calculate the K_c for T_2 (6)
 - c) Which of T_1 and T_2 is the higher temperature. Explain your answer by referring to Le Châtelier's principle. (4)
-

QUESTION 5

25 MARKS

Soap (sodium stearate) reacts with calcium chloride to form **soap scum** (calcium stearate, Molar mass = 606 g.mol⁻¹) and sodium chloride according to the balanced equation below:



Stearate is the strong conjugate base of steric acid.

- 5.1 Define the *hydrolysis of a salt*. (2)
 - 5.2 Write the hydrolysis reaction of stearate. (5)
 - 5.3 If a 600 g soap bar produces 145 g of soap scum in the presence of sufficient calcium chloride, determine the percentage sodium stearate in the bar of soap. (6)
- Calcium chloride is used to treat wastewater. The same soap bar, used in question 5.3, reacts with only 0,198 moles of calcium chloride in 500 ml **treated** water.
- 5.4 Define *concentration*. (2)
 - 5.5 Determine the concentration of calcium chloride in the **treated** water. (3)
 - 5.6 Determine the hydronium ion concentration in the water as a result of the unreacted sodium stearate. Assume the water is at 25 °C. (7)
-

QUESTION 6

19 MARKS

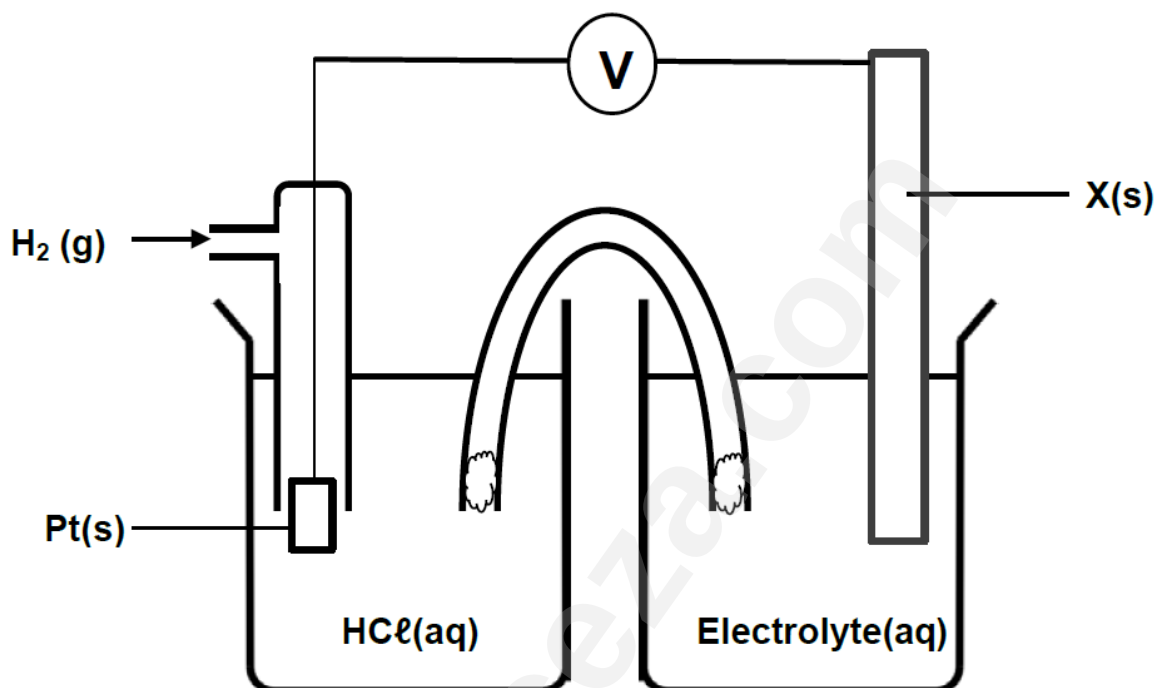
- 6.1 Sodium hydroxide (NaOH) is considered a strong base while magnesium hydroxide (Mg(OH)₂) is considered a weak base.
- 6.1.1 Define *dissociation*. (2)
- 6.1.2 Write down a balanced chemical equation for the dissociation of magnesium hydroxide in water. State symbols (phase indicators) need not be shown. (3)
- 6.1.3 Explain the relative strengths of these bases by referring to the strength of intramolecular bonds present in each. (4)
- 6.2 A student titrates sodium carbonate with a dilute solution of hydrochloric acid.
- 6.2.1 Write down a balanced chemical equation for the reaction. State symbols (phase indicators) need not be shown. (4)
- 6.2.2 The sodium carbonate is placed in a conical flask and hydrochloric acid is slowly added. How will the following change? Only write, INCREASE, DECREASE or STAY THE SAME.
- a) the pH in the conical flask (2)
- b) the hydronium ion concentration in the conical flask (2)
- 6.2.3 Refer to the table of indicators below and state which indicator would be most suitable for this titration. (2)

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

QUESTION 7

20 MARKS

Juliette sets up a galvanic cell, using a standard hydrogen electrode and various other standard half-cells, as shown in the diagram below.



Voltmeter readings are taken for the various half-cells with the standard hydrogen electrode.

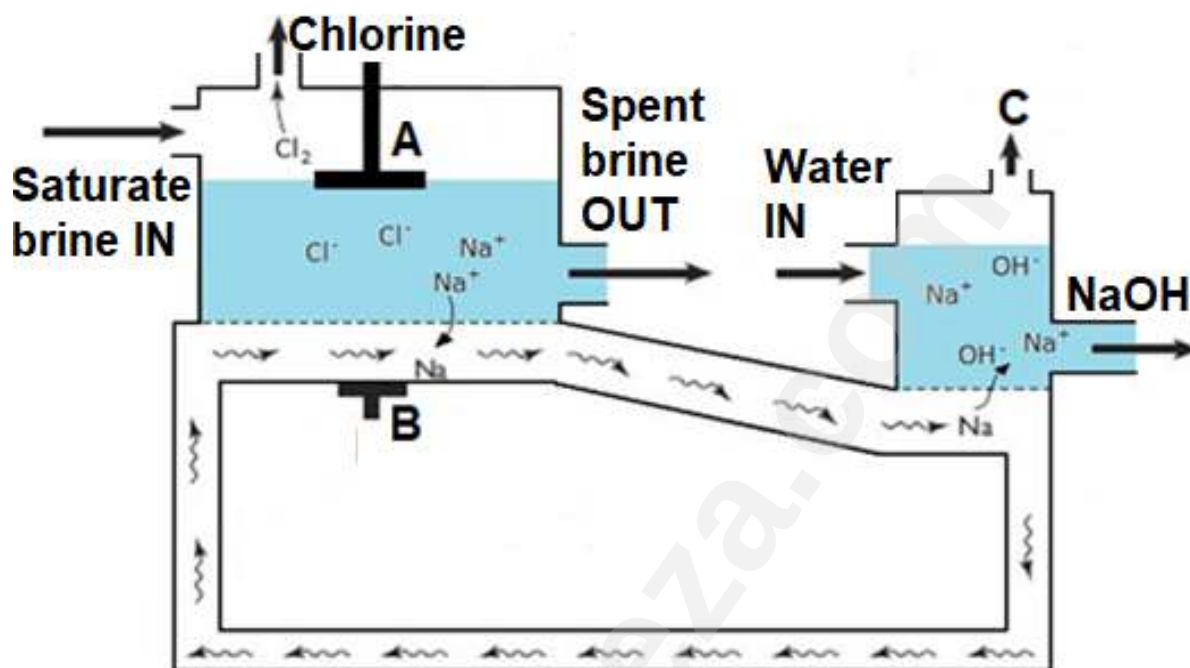
Cell	Electrode at X	Electrolyte	Voltage (V)
1	Copper	Copper sulphate	+0,34
2	Magnesium	7.2	-2,37
3	Unknown	$\text{Fe}^{2+}/\text{Fe}^{3+}$ solution	+0,77

- 7.1 Define *electrolyte*. (2)
- 7.2 Give the chemical formula of a suitable electrolyte for the cell 2. (1)
- 7.3 Suggest a suitable electrode for the unknown electrode in cell 3. (1)
- 7.4 Write the cell notation for cell 2, including relevant conditions. State symbols need not be shown. (5)
- 7.5 Explain why the voltage reading is positive in cell 1 and not in cell 2. (3)
- 7.6 The voltmeter is now replaced with an ammeter.
 - 7.6.1 Write down the half-reaction that occurs in the copper half-cell. (2)
 - 7.6.2 Hence, state TWO changes that will be observed in the copper half-cell after a significant amount of time has passed. (2)
 - 7.6.3 Explain how the salt bridge maintains electrical neutrality with reference to the changing ionic conditions in the copper half-cell. (2)
 - 7.6.4 How will the ammeter reading be affected if the concentration of copper sulphate is increased in cell 1? Write down only INCREASES, DECREASES, or NO EFFECT. (2)

QUESTION 8

19 MARKS

- 8.1 The diagram below shows a representation of a mercury cell used in the Chloralkali Industry. Electrode **A** is made from titanium, which is inert.

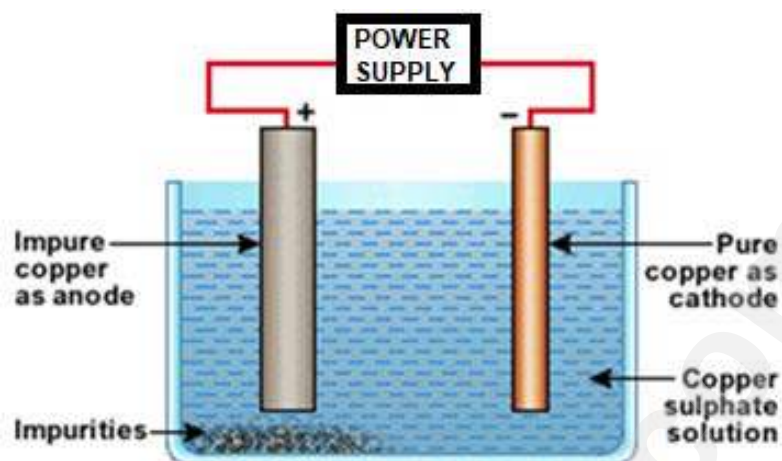


- 8.1.1 What is brine? (3)
- 8.1.2 Identify which electrode is the cathode. Write down only **A** or **B**. (2)
- 8.1.3 The membrane cell, also used in the Chlor-Alkali Industry, has a different reaction occurring at electrode B.
- Write down the equation for the half-reaction that occurs at electrode B in the membrane cell. (2)
 - How is it possible for the mercury/sodium amalgam to form at electrode B in the mercury cell? (2)
- 8.1.4 The amalgam is poured into a separate vessel, where it decomposes into sodium and mercury according to the following reaction:



- Name product C and give one of its uses. (2)
- Compare the purity of the NaOH in the mercury cell to the membrane cell. Give a reason for the difference. (2)

- 8.2 The following cell is use for the electro-refining of copper. An anode is used that contains a mixture of metal atoms, zinc and silver, but with mainly copper atoms.



- 8.2.1 Define *oxidation* (2)
- 8.2.2 Explain what happens to each of the metal atoms (Zn, Ag and Cu) at the anode during the electro-refining of copper. (4)
-

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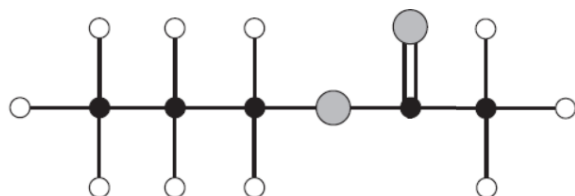
QUESTION 9

34 MARKS

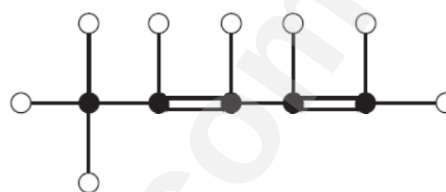
The diagrams show the structure of four different organic compounds, **A**, **B**, **C**, and **D**. Use the diagrams with the key provided to answer the questions that follow.

Key:

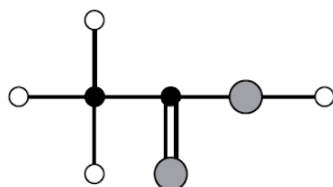
- carbon atom
- oxygen atom
- hydrogen atom



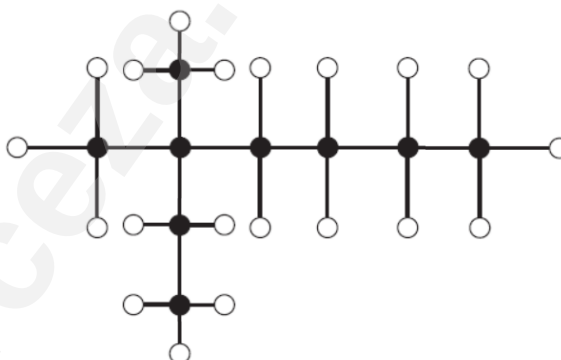
Compound A



Compound B



Compound C



Compound D

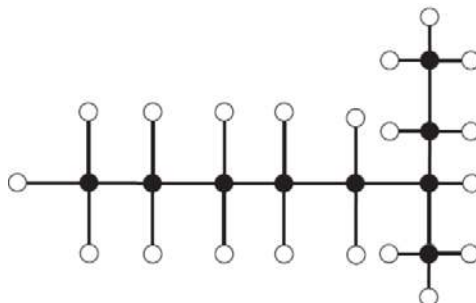
- 9.1 Briefly state why these molecules are considered organic molecules. (1)
- 9.2 Each compound belongs to a different homologous series.
 - 9.2.1 Define *homologous series*. (2)
 - 9.2.2 To which homologous series does compound **C** belong to? (1)
 - 9.2.3 Give the structural formula for the functional group in compound **A**. (1)
 - 9.2.4 Compound **D** belongs to the homologous series, alkanes. Give the general formula that can be used to identify all alkanes. (1)
- 9.3 Identify the compound(s) from the diagrams that is/are saturated. (1)
- 9.4 Identify the compound(s) from the diagrams that is/are hydrocarbons. (1)
- 9.5 Give the IUPAC name for compound **B**. (3)

9.6 These compounds have different structural isomers.

9.6.1 Define *structural isomers*. (2)

9.6.2 Give the structural formula for a functional isomer of compound **A**. (2)

9.6.3 The diagram below shows a structural isomer of compound **D**. Identify the type of structural isomerism. (1)



9.7 Compound **A** and compound **B** have different boiling points, which compound, **A** or **B**, will have the highest boiling point? Explain your answer in full. (4)

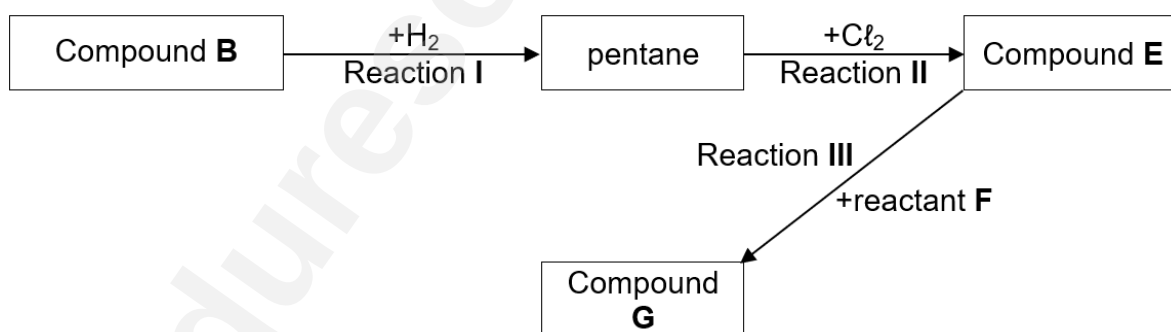
9.8 Compound **A** can be formed from one of the other compounds and an alcohol.

9.8.1 Which compound (**B**, **C**, or **D**) can react with an alcohol to form compound **A**? (1)

9.8.2 Give the condensed-structural formula for the alcohol that needs to be used to form compound **A**. (2)

9.8.3 What type of reaction takes place? (1)

9.9 The following reaction scheme involves compound **B**. Use the reaction scheme to answer questions (9.9.1 – 9.9.5). The reaction scheme shows the organic reactants and products in the boxes; additional reactants are indicated on the arrow. The reaction scheme does not necessarily indicate all the products formed.



9.9.1 Identify the GENERAL TYPE of reaction for reaction **I**. (1)

9.9.2 Identify the SPECIFIC TYPE of reaction for reaction **II**. (1)

9.9.3 Give the reaction conditions necessary for reaction **I** to take place. (2)

9.9.4 Using condensed-structural formulae, write a balanced chemical equation for Reaction **II**. (3)

9.9.5 Reaction **III** is a hydrolysis reaction

a) Give the chemical name for reactant **F**. (1)

b) Give the structural formula for compound **G**. (2)

END OF PAPER