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QUESTION 1

Choose the most correct answer from the options presented. Each question has only ONE correct answer. Mark the answer of your choice with a cross (X) on the ANSWER GRID that has been provided.

1.1 Consider the structure of hexane.

A molecule of hexane is considered to be non-polar. Which one of the following statements best describes the reason why hexane is non-polar?

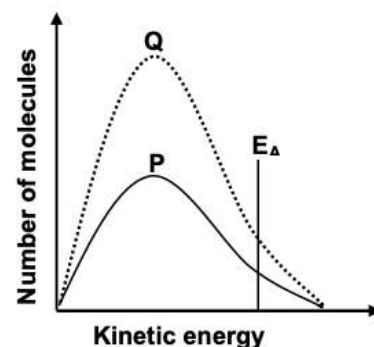
- A. Hexane contains only single bonds between atoms.
- B. The electronegativity difference between C and H atoms is so small as to be considered non-polar.
- C. Hexane is a linear molecule hence is symmetrical.
- D. The charge distribution of electrons within the hexane molecule is symmetrical. (2)

1.2 Maxwell-Boltzmann distribution curve P represents the number of molecules plotted against the kinetic energy of the particles for a certain reaction.

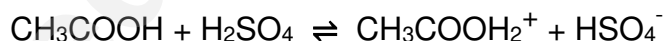
Curve Q is obtained after a change was made to one reaction condition.

Which ONE of the following changes resulted in curve Q?

- A. Addition of a catalyst
- B. Increase in temperature
- C. Increase in activation energy
- D. Increase in the concentration of the reactants (2)



1.3 The reaction between concentrated sulfuric acid and pure ethanoic acid is



The Brønsted-Lowry acids in this equilibrium are:

- A CH_3COOH and H_2SO_4
- B $\text{CH}_3\text{COOH}_2^+$ and HSO_4^-
- C H_2SO_4 and $\text{CH}_3\text{COOH}_2^+$
- D CH_3COOH and HSO_4^- (2)

- 1.4 When sodium nitrite is dissolved in water,
- A The solution is acidic because of hydrolysis of the sodium ion.
 - B The solution is basic because of hydrolysis of the sodium ion.
 - C The solution is acidic because of hydrolysis of the NO_2^- ion.
 - D The solution is basic because of hydrolysis of the NO_2^- ion. (2)

- 1.5 Choose a FUNCTIONAL isomer of the following carboxylic acid; $\text{C}_6\text{H}_{12}\text{O}_2$
- A. ethyl methanoate
 - B. propyl butanoate.
 - C. butyl ethanoate
 - D. methyl hexanoate. (2)

- 1.6 The reaction represented by the equation below takes place in the presence of a catalyst.



This reaction is an example of:

- A. addition
 - B. elimination
 - C. combustion
 - D. substitution (2)
- 1.7 A student has set up three electrolytic cells. Each cell contains inert electrodes. The electrolytes used by the student are listed below.

Cell 1: Aqueous sodium chloride

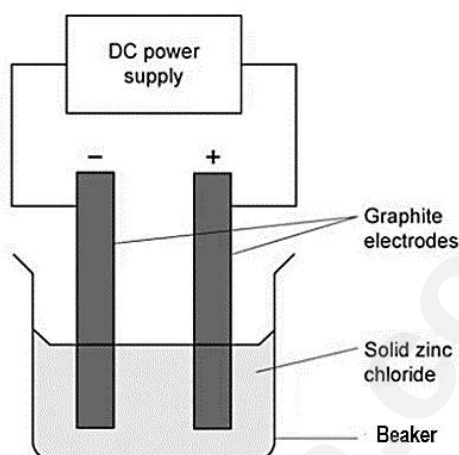
Cell 2: Dilute sulfuric acid

Cell 3: Molten lead(II) bromide

In which of these cells is a gas formed at **both electrodes**?

- A Cell 1 and Cell 2
- B Cell 1 and Cell 3
- C Cell 2 only
- D Cell 3 only (2)

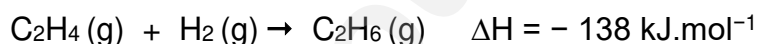
- 1.8 A student arranged an electrolytic cell as shown below in the laboratory.



He observed that the zinc chloride did not decompose to produce chlorine gas at the anode and zinc deposits at the cathode. What is the reason for this observation?

- A The electrodes used do not conduct electricity.
- B The power supply is not correctly connected.
- C Solid zinc chloride is used.
- D Zinc is a stronger reducing agent than chlorine. (2)

- 1.9 For the following system:



Which change will increase the equilibrium concentration of $\text{C}_2\text{H}_4(\text{g})$?

- A Increase in pressure
- B Addition of $\text{H}_2(\text{g})$
- C Increase in temperature
- D Addition of a catalyst (2)

- 1.10 If the equilibrium constant for the reaction $2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{SO}_3$ is 64 at 500 K, then the equilibrium constant for the reaction $\text{SO}_3 \rightarrow \text{SO}_2 + \frac{1}{2}\text{O}_2$ at the same temperature is:

- A 8
- B $\frac{1}{8}$
- C 32
- D $\frac{1}{32}$ (2)

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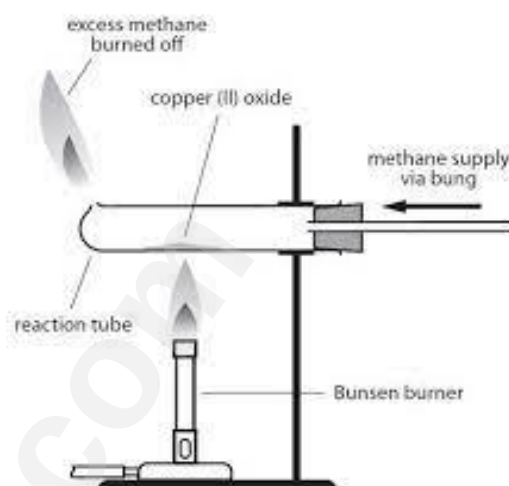
1.1	A	B	C	D
1.2	A	B	C	D
1.3	A	B	C	D
1.4	A	B	C	D
1.5	A	B	C	D
1.6	A	B	C	D
1.7	A	B	C	D
1.8	A	B	C	D
1.9	A	B	C	D
1.10	A	B	C	D

QUESTION 2

Copper can be produced in the laboratory by the reaction of copper(II) oxide with methane gas at high temperatures as shown in the chemical equation below.



Use the substances from this reaction to answer the questions that follow.



2.1 From the chemical equation, give the chemical formula of ONE substance that: (Substances may be used more than once or not at all.)

2.1.1 has a sea of delocalised electrons surrounding positive kernels.

2.1.2 has London forces as the predominant intermolecular force between its molecules.

2.1.3 conducts electricity when molten, but not as a solid.

2.1.4 is a linear, non-polar molecule.

2.1.5 has polar covalent bonds but is a non-polar symmetrical molecule (5)

2.2 When referring to molecules, what is the word dipole used to describe? (2)

- 2.3 Write the chemical formula of one molecule from the above chemical equation that has dipoles. (1)
- 2.4 State the name of the predominant intermolecular force that exists between the molecules of the compound identified in question 2.3. (1)
- 2.5 Define the term *intermolecular force*. (2)
- 2.6 Explain the origin of the intermolecular force you have named in question 2.4 above. (3)

- 2.7 Both CO_2 and H_2O are gases at the temperature required for the reaction. As the gas cools, which compound would you expect to condense first? Explain your answer, referring to the intermolecular forces present in each. (4)

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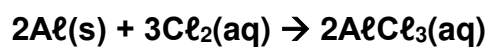
2.8 1,8 dm³ of CH₄ (g) (measured at STP) reacts with 15 g of an 84% pure sample of CuO.

2.8.1 Calculate the theoretical yield of copper (in grams). (8)

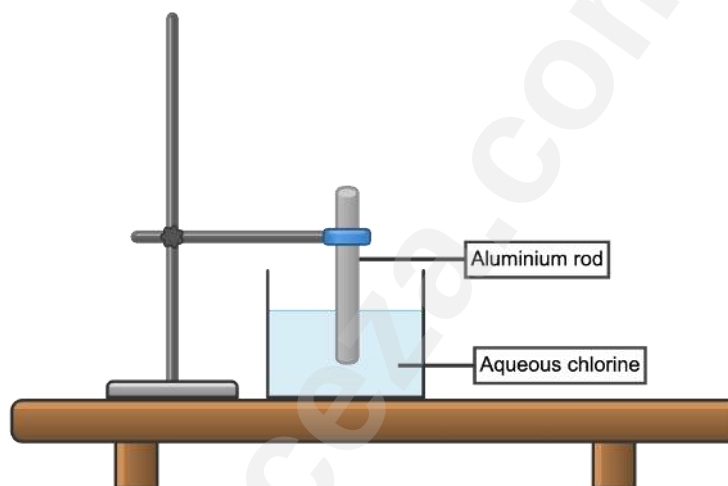
2.8.2 Calculate the percentage yield of copper if 7,45 g copper is produced in this reaction. (2)

QUESTION 3

Aluminium metal reacts with dilute aqueous chlorine according to the balanced chemical equation:



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



The aluminium rod was removed at regular intervals, washed, dried and weighed.

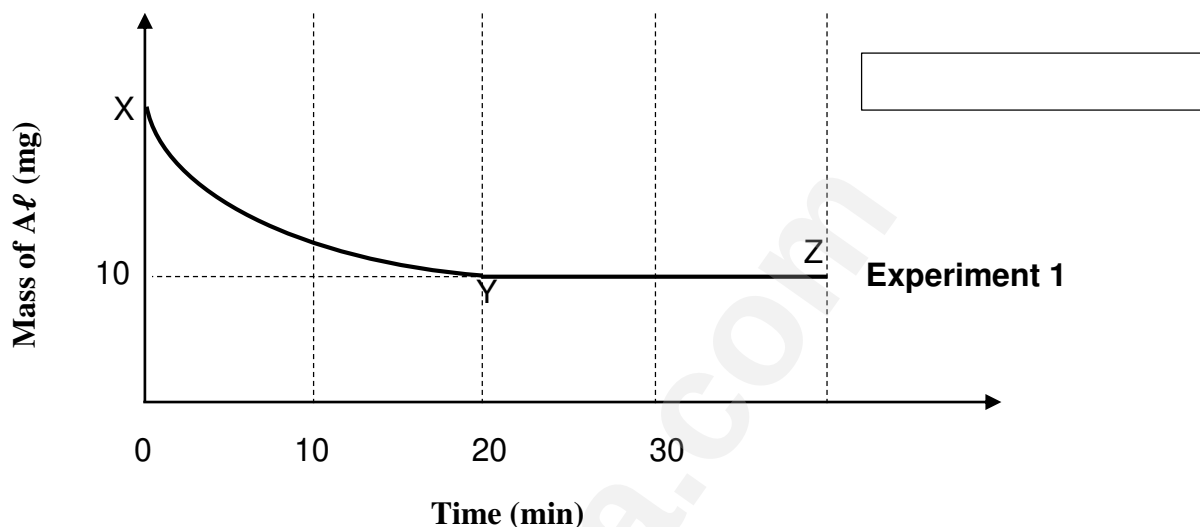
The aluminium rod was then placed into the solution again.

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

Table showing conditions of Experiment 1 and 2

Experiment	$[\text{Cl}_2] \text{ mol.dm}^{-3}$
1	0,1
2	0,05

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



3.1 Define *reaction rate*. (2)

3.2(a) **Circle** the correct option between the brackets: (1)

The rate of consumption of the reagent Al is (EQUAL TO / HALF / DOUBLE) the rate of formation of the product, aluminium chloride (AlCl_3).

3.2(b) Consider the intervals shown on the graph. **Circle** the correct option between the brackets. (Do not refer to the shape of the graph in your answer.)

In interval XY, the shape of the graph shows that the rate of consumption of Al is ...

(INCREASING / DECREASING / CONSTANT / ZERO) (1)

3.2(c) Name **two** reasons for your choice in question 3.2(a) (2)

3.2(d) In interval YZ, the shape of the graph shows that the rate of consumption of Al is ... (**circle** your answer)
(INCREASING / DECREASING / CONSTANT / ZERO) (1)

3.3 The average rate of consumption of Al for **Experiment 1** is $36 \text{ mg} \cdot \text{min}^{-1}$.

3.3.1 State the limiting reagent in **Experiment 1**. Give a reason. (2)

3.3.2 How long did it take for the reaction in **Experiment 1** to complete? (1)

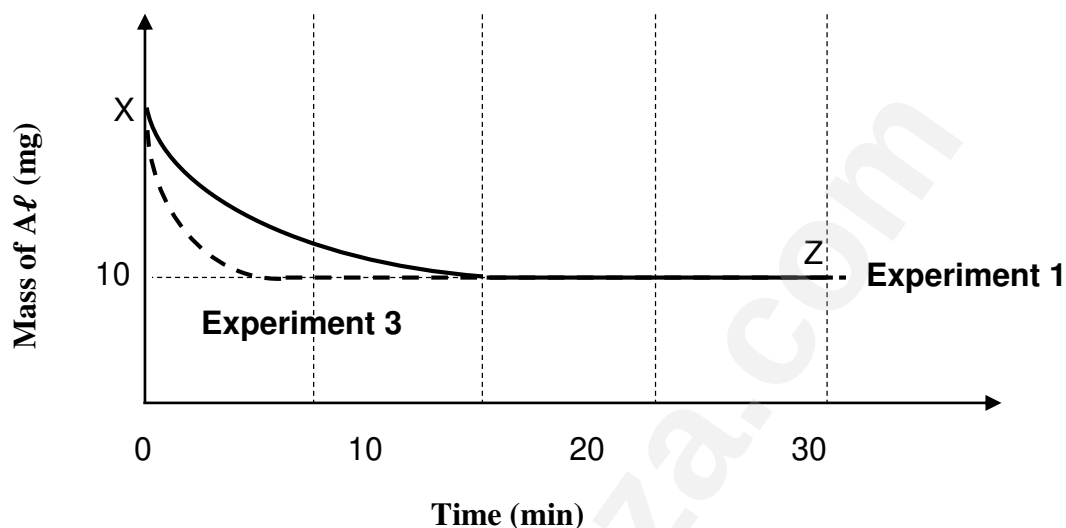
3.3.3 Hence, calculate the initial mass of aluminium, X, (in mg) used in **Experiment 1**. (3)

3.3.4 Use the **collision theory** to explain the difference in reaction rates for **Experiments 1 and 2**. (4)

- 3.3.5 The percentage yield of the product, aluminium chloride (AlCl_3) in **Experiment 1** is 90%. Calculate the mass of the aluminium chloride produced during the reaction. (Assume the volume of the solution remains constant at 400 cm^3 .) (5)

3.3.6

Graph showing the relationship between the mass of Al and time for Experiment 1, 2 and 3

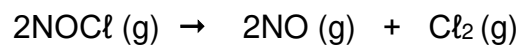


- (i) On the axes given above, draw a labelled graph that will be obtained for **experiment 2**? (2)
- (ii) In **experiment 3**, an identical rod of aluminium is placed in an aqueous solution of chlorine of concentration $0,1 \text{ mol.dm}^{-3}$ and a volume of 400 cm^3 . Name one reaction condition, that must be changed to obtain the curve for **experiment 3** as shown on the graph above. (2)

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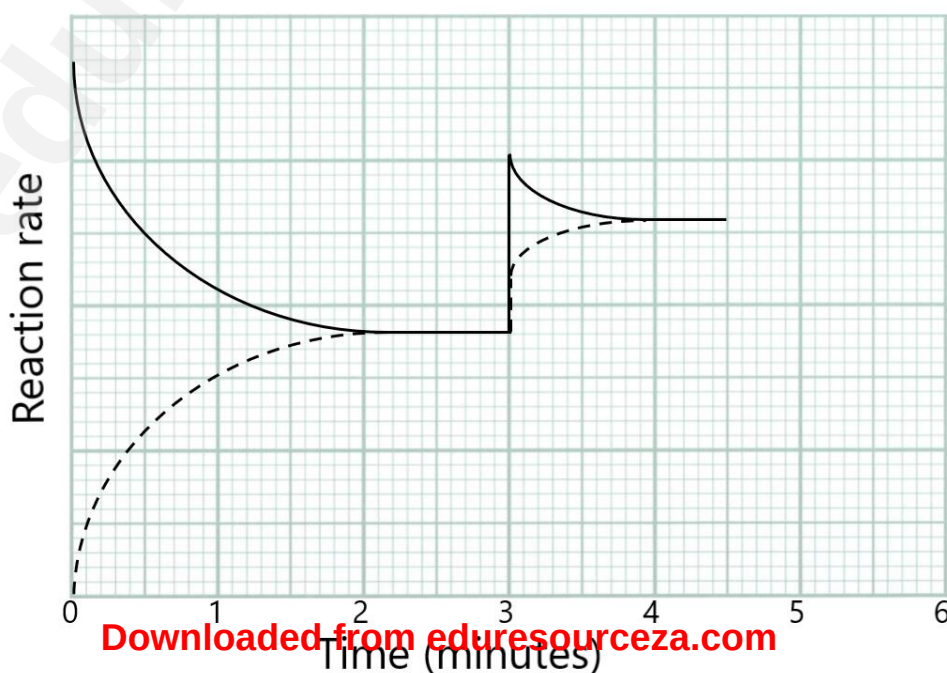
QUESTION 4

- 4.1 Nitrosyl chloride, NOCl , decomposes on heating, reaching a dynamic chemical equilibrium as shown below:



- 4.1.1 What is a dynamic chemical equilibrium? (3)

- 4.2 Consider the following reaction rate vs time graph shown for the above reaction.



4.2.1 At what time is dynamic chemical equilibrium reached for the first time? (1)

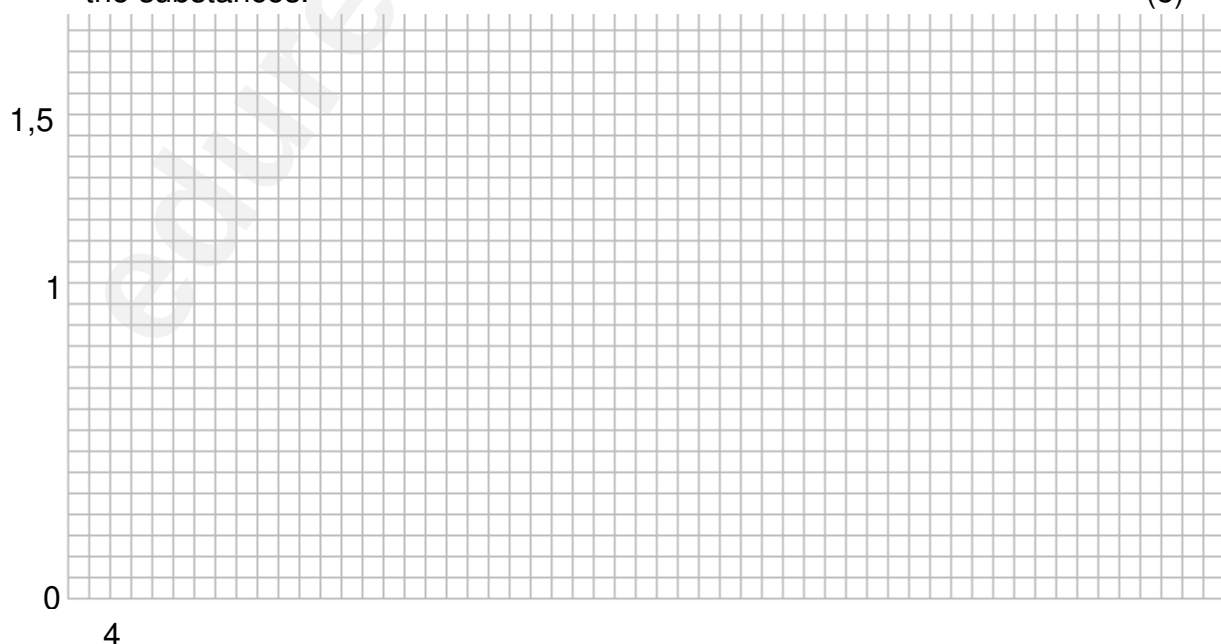
4.2.2 Identify the stress that is imposed on the system at t time t = 3 minutes. (2)

4.2.3 Explain why both the forward and reverse reaction rates increase when this stress is imposed. (4)

4.2.4 State *Le Chatelier's principle*. (2)

- 4.2.5 Use Le Chatelier's Principle to fully explain whether the forward reaction is exothermic or endothermic. (3)

- 4.3 Draw a neat concentration vs time graph of NOCl(g) in equilibrium with NO(g) and $\text{Cl}_2\text{(g)}$ at 4 minutes. **Begin the graph at the 4 minute time interval.** Label the axes. Assume that the concentrations of NOCl , NO and Cl_2 are $0,009 \text{ mol.dm}^{-3}$, $0,015 \text{ mol.dm}^{-3}$ and $0,007 \text{ mol.dm}^{-3}$ respectively when equilibrium was reached at 4 minutes. One minute later the volume of the reaction vessel is **decreased**. Draw the resultant affect this stress will have on the substances. (8)



4.4 When a 1,50 g sample of pure NOCl (g) is heated at $350\text{ }^{\circ}\text{C}$ in a volume of 1 l , the percent dissociation is found to be $57,2\%$ at dynamic chemical equilibrium.

4.4.1 Calculate the number of moles of NOCl (g) that decomposes to form NO (g) and $\text{Cl}_2\text{ (g)}$. Round off your answer to **four significant figures**. (3)

4.4.2 Calculate the concentration of the NO (g) and $\text{Cl}_2\text{ (g)}$ at equilibrium. Round off your answer to **four significant figures**. (4)

- 4.4.3 Calculate the concentration of unreacted NOCl (g) at equilibrium. Round off your answer to **four significant figures**. (4)

- 4.4.4 Calculate K_c at $350\text{ }^\circ\text{C}$ for the reaction as written. Round off your answer to **four decimal places**. (5)

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QUESTION 5

5.1 The table below shows acid ionisation constants, K_a of group VII hydrides.

Group VII hydrides	K_a (mol.dm ⁻³) at 25° C
HF	$6,6 \times 10^{-4}$
HCl	$1,3 \times 10^6$
HBr	$1,0 \times 10^9$
HI	$3,2 \times 10^9$

5.1.1 Describe and explain the trend in the strength of the first four acids.

(3)

5.1.2 Define a *weak acid*.

(2)

5.1.3 Give the NAME of the weakest acid in the table above.

(1)

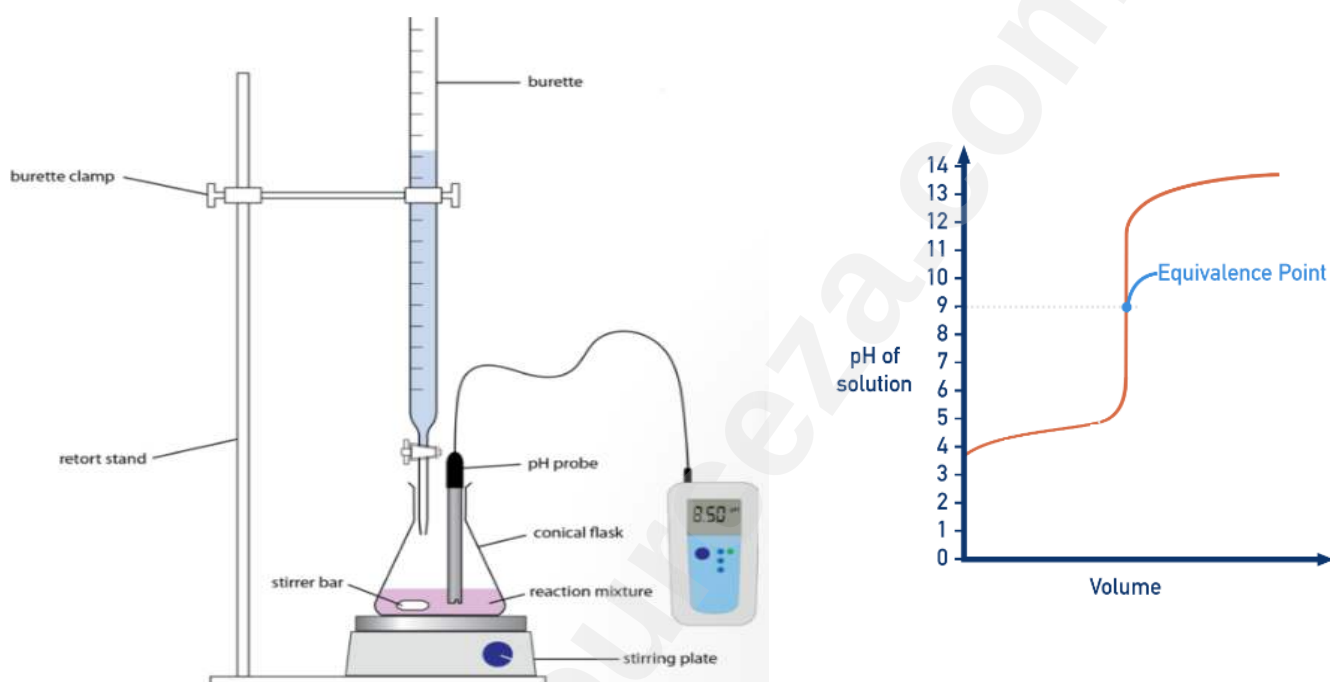
5.1.4 Which of the following two acid solutions would you expect to have the greater electrical conductivity. **Circle** the correct option between the brackets and **explain** your answer.

(4)

(HF / HCl)

- 5.2 A group of Grade 12 students found a solution of Nitrous acid in the Science laboratory and decided to determine the concentration of the solution using a standard solution of sodium hydroxide.

The diagram shows the equipment used for an acid-base titration and the pH curve obtained. An electronic pH meter was used to keep track of the changing pH in the solution in the conical flask.



- 5.2.1 Which solution is in the burette?

(1)

- 5.2.2 What is meant by the term *equivalence point*?

(2)

5.3 During the titration $25,0 \text{ cm}^3$ of an aqueous solution of HNO_2 was neutralised by $34,5 \text{ cm}^3$ of $0,12 \text{ mol.dm}^{-3}$ NaOH solution.

5.3.1 Write down a balanced equation to represent this protolytic reaction. (2)

5.3.2 Select the most suitable indicator for this titration from the table below. **Explain your choice.** (3)

Indicator	pH range
Methyl orange	3.1 – 4.4
Phenolphthalein	8.3 – 10.0
Bromothymol blue	6.0 – 7.6

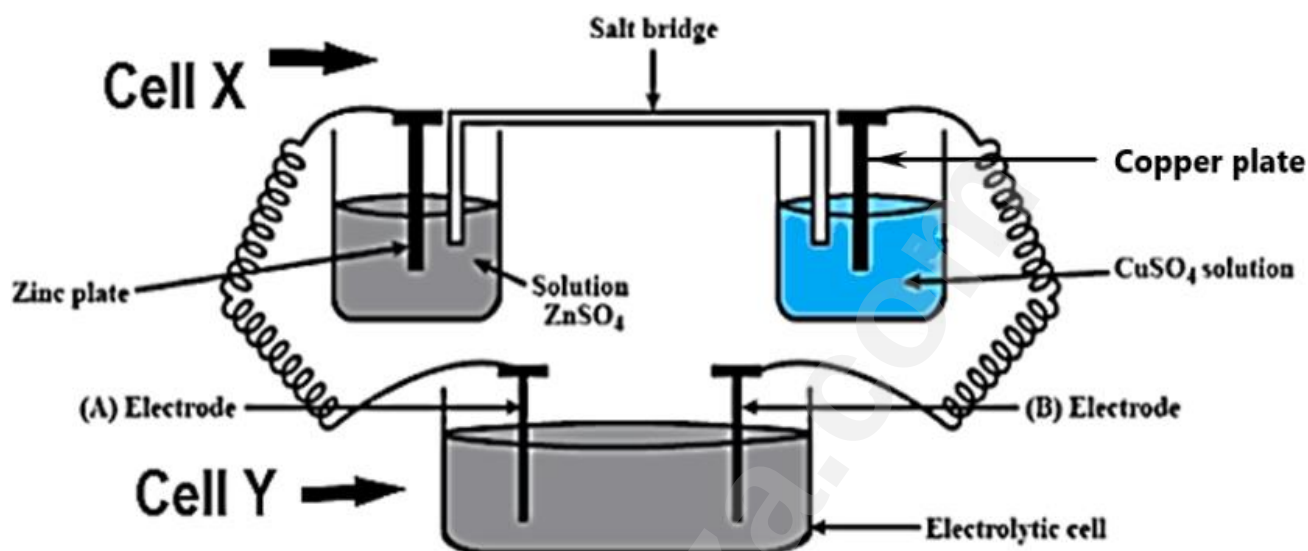
5.3.3 Calculate the concentration of the HNO_2 solution. (3)

5.3.4 Make use of a hydrolysis reaction to explain whether the pH of the resulting salt solution will be equal to 7, less than 7 or greater than 7. (4)

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QUESTION 6

Consider the diagram below in which a galvanic cell is coupled with an electrolytic cell.

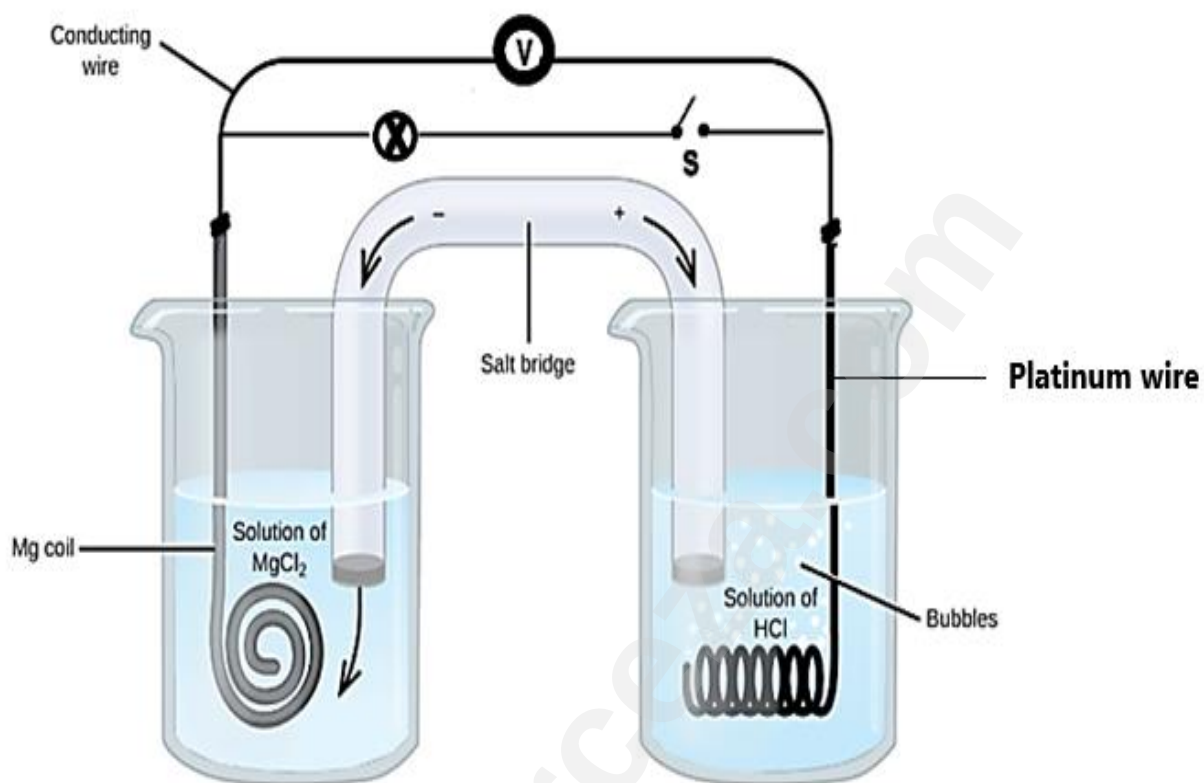


- 6.1 What energy conversion takes place in Cell X ? (1)
- 6.2 Which cell labeled above represents the electrolytic cell? (1)
- 6.3 Write down the formula of the oxidizing agent in Cell X (1)
- 6.4 Define the term oxidation? (1)
- 6.5 Which substance undergoes oxidation in Cell X? (1)
- 6.6 What is the polarity of electrode A and is this electrode known as the cathode or anode? (2)

- 6.7 Which **type** of reaction takes place in Cell X? (1)
- 6.8 Explain your answer in question 6.7 above? (2)
- 6.9 Write down the cell notation for Cell X. Include the PHASE INDICATORS and **standard conditions**. (4)
- 6.10 A student replaces the zinc plate with **solid chunks of I_2** and notices that the cell does not function as she expected. Explain why I_2 is not suitable to be used as an electrode? (1)

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QUESTION 7



7.1 At which electrode does Reduction occur? (1)

7.2 What is the function of the salt bridge (2)

7.3 Name the bubbles of gas released in the solution of HCl ? (1)

7.4 Write down the oxidation half reaction (1)

7.5 How would adding 100 cm^3 of a $1\text{ mol}\cdot\text{dm}^{-3}$ of hydrochloric acid solution to the HCl half-cell influence the initial emf of the cell?

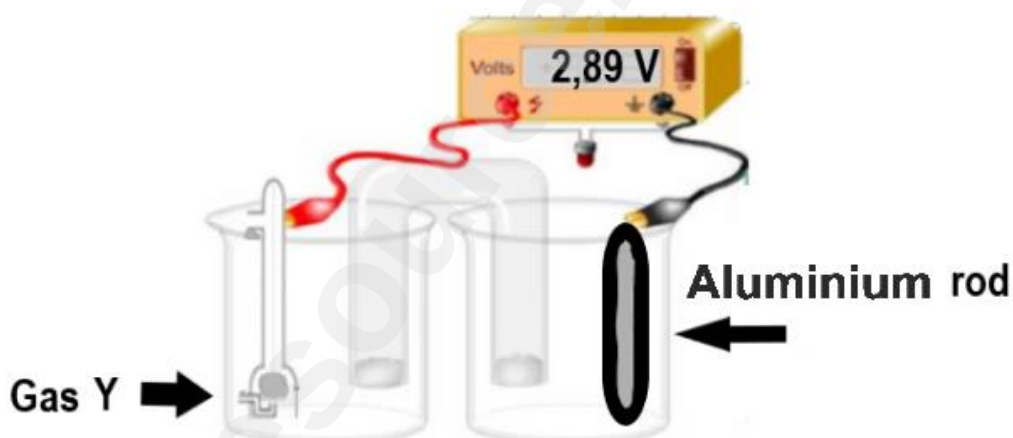
State only INCREASES / DECREASES / REMAINS THE SAME (1)

7.6 Give a reason for your answer in question 7.5. (1)

[7]

QUESTION 8

An electrochemical cell is set up as shown below using an aluminum rod and gas Y. The initial reading on the voltmeter is $2,89\text{ V}$ at standard conditions.

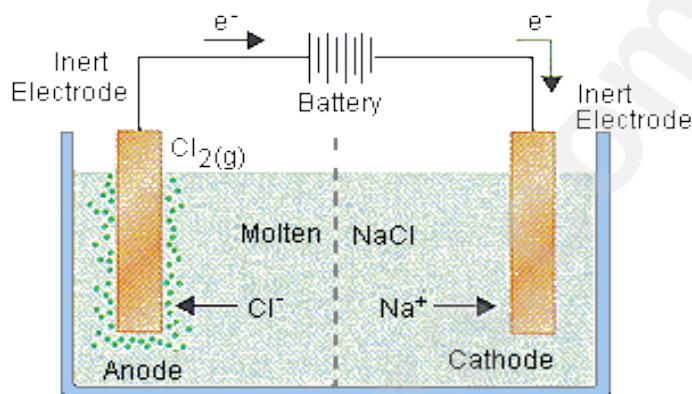


8.1 By means of calculations, identify gas Y. (4)

8.2 Write down the half reaction that takes place at the cathode. (2)

- 8.3 The reading on the voltmeter becomes ZERO after this cell operates for several hours. Give a reason as to why this occurs. (2)

- 8.4 The diagram below represents the electrolysis of molten table salt.



During the electrolysis of molten sodium chloride, 0,10 moles of chlorine gas was produced using 3 A of current. Calculate the time it took to produce 0,10 moles of gas. (5)

QUESTION 9

But-1-ene, an unsaturated hydrocarbon, and compound X, a saturated hydrocarbon, both react with chlorine, as represented by the incomplete equations below:



9.1 Define *homologous series*. (2)

9.2 To which homologous series does the hydrocarbon in **reaction 1** belong? (1)

9.3 Explain what is meant by the term “unsaturated”. (2)

9.4 Describe a test that can be performed to confirm that but-1-ene is unsaturated. (3)

9.5 Identify the **general type** of reaction that occurs in:

9.5.1 **Reaction 1** (1)

9.5.2 **Reaction 2** (1)

- 9.6 Write down the **structural formula** of the product formed in **Reaction 1**. (2)
- 9.7 What reaction condition is necessary for **reaction 2** to take place? (1)
- 9.8 Write down the IUPAC name of **reactant X**. (1)
- 9.9 Write down the name or formula of **product Y**. (1)
- 9.10 2-chloropropane is then heated under reflux (at about 70°C) in the presence of a **concentrated** solution of NaOH in an ethanol solvent.
- 9.10.1 Identify the **general type** and **specific name** of the reaction that occurs under the conditions listed above. (2)
- 9.10.2 Write down the IUPAC name of the organic product formed in the reaction identified in Question 9.10.1 above. (2)

- 9.10.3 Use structural formulae to write a balanced equation for the reaction that takes place when 2-chloropropane reacts with a **dilute** sodium hydroxide solution. (4)
- 9.10.4 A small quantity of the final solution containing the products from the reaction between 2-chloropropane and dilute sodium hydroxide is poured into another clean test tube and a few drops of aqueous **silver nitrate** are added to this solution. A white precipitate is observed. **Write a balanced symbol equation to show the formation of the white precipitate.** (4)

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