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ST. MARY'S DSG KLOOF

**Physical Sciences
Paper 2
Chemistry**

**GRADE 12
Trials 2016**

**Time: 3 hours
Marks: 200**

**Examiners: T. Kirsten and G. Main
Moderator: K. Bolton**

Read the Following Instructions Carefully:

1. This paper consists of:
A question paper of 15 pages
Data sheet
2. Read the questions carefully.
3. Answer **ALL** questions.
4. Number your answers exactly as the questions are numbered.
5. It is in your own interest to write legibly and to set your work out neatly.
6. Use the data and formulae whenever necessary.
7. Start questions 1, 5 and 7 on a new page.
8. Answers are to be collated in three separate parts:
 1. Question 1 - 4
 2. Question 5 and 6
 3. Question 7 and 8

Acknowledgements: Certain questions have been sourced and adapted from the following papers and resources: NSC Feb/Mar 2015, 2016; IEB 2013, 2015; Kearsney College 2006, 2012; St. Anne's 2015; St. Stithian's 2013; Cambridge International AS and A Level Chemistry Coursebook; Mind Action series Grade 12

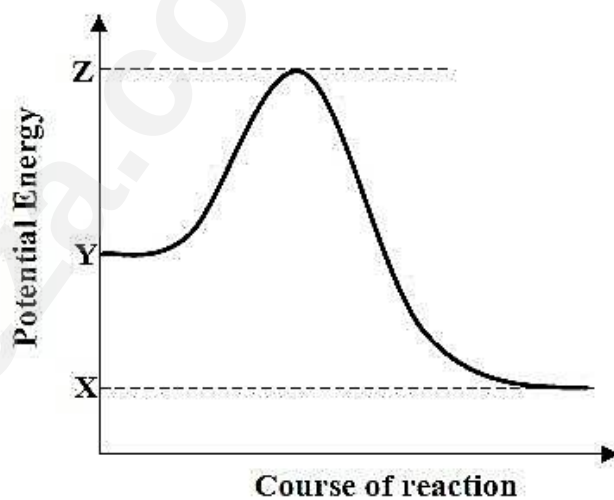
QUESTION 1 - MULTIPLE CHOICE

1.1 The name of the compound $\text{Fe}_2(\text{SO}_3)_3$ is:

- A iron sulphide
- B iron III sulphate
- C iron III sulphite
- D iron II sulphite

1.2 Consider the following energy profile graph. Potential energy values X, Y and Z are indicated on the graph. The activation energy for the forward reaction is given by:

- A $X - Y$
- B $Z - X$
- C $Z - Y$
- D Z



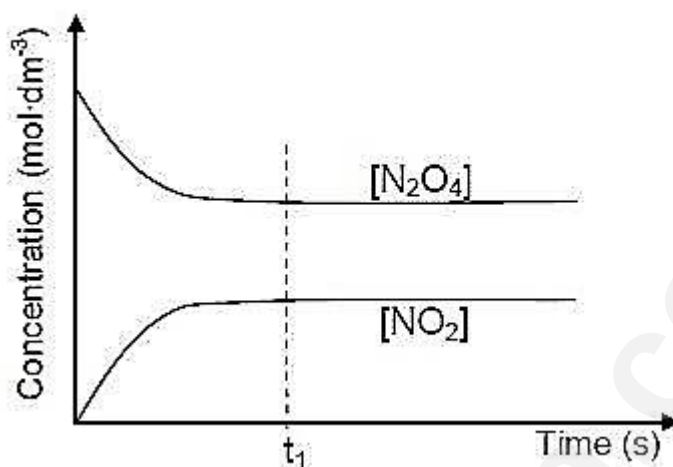
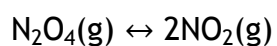
1.3 The expression for the equilibrium constant (K_c) of a hypothetical reaction is given as follows:

$$K_c = \frac{[\text{D}]^2[\text{C}]}{[\text{A}]^3}$$

Which one of the following equations for a reaction at equilibrium matches the above expression?

- A $3\text{A}(\text{s}) \leftrightarrow \text{C}(\text{g}) + 2\text{D}(\text{g})$
- B $3\text{A}(\text{l}) \leftrightarrow \text{C}(\text{aq}) + 2\text{D}(\text{aq})$
- C $3\text{A}(\text{aq}) + \text{B}(\text{s}) \leftrightarrow \text{C}(\text{g}) + \text{D}_2(\text{g})$
- D $3\text{A}(\text{aq}) + \text{B}(\text{s}) \leftrightarrow \text{C}(\text{aq}) + 2\text{D}(\text{aq})$

- 1.4 The graph below represents the decomposition of $\text{N}_2\text{O}_4(\text{g})$ in a closed container according to the following equation:



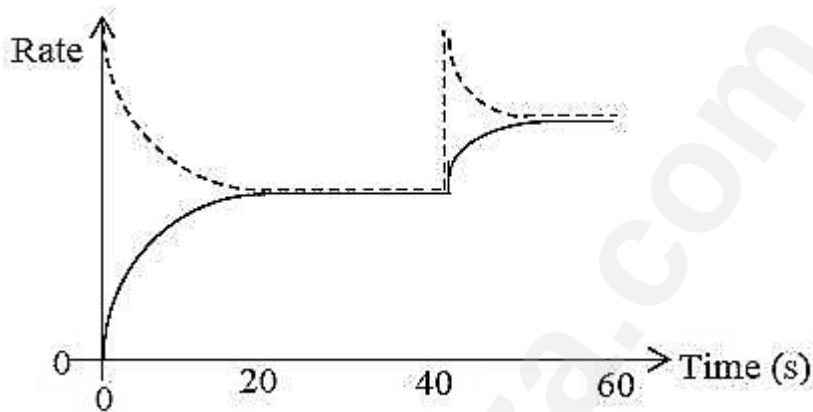
Which one of the following correctly describes the situation at t_1 ?

- A The N_2O_4 gas is used up.
- B The NO_2 gas is used up.
- C The rate of the forward reaction equals the rate of the reverse reaction.
- D The concentrations of the reactant and product are equal.

- 1.5 Nitrogen and hydrogen gas are introduced into a container, which is then sealed, and then allowed to reach equilibrium. The balanced chemical equation for the reaction is:



At $t = 40 \text{ s}$, a change is made to the reaction in equilibrium. The graph below shows the changes in the rates of the forward and reverse reactions with time.



Which one of the following best describes the change made at $t = 40 \text{ s}$?

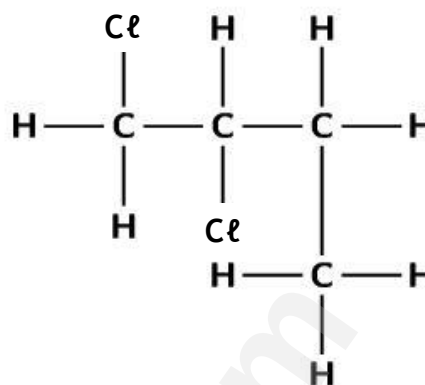
- A Increase in pressure
 - B Increase in temperature
 - C Decrease in pressure
 - D Decrease in temperature
- 1.6 A pupil performing a titration consulted the following table of available indicators:

INDICATOR	pH RANGE OF INDICATOR
bromothymol blue	6,0 – 7,6
phenolphthalein	8,4 – 10,0
methyl orange	3,1 – 4,4

The pupil decided the indicator she should use would be *methyl orange*. The two species she was titrating against each other were:

- A ethanoic acid and sodium carbonate
- B ethanoic acid and sodium hydroxide
- C nitric acid and sodium hydroxide
- D nitric acid and sodium carbonate

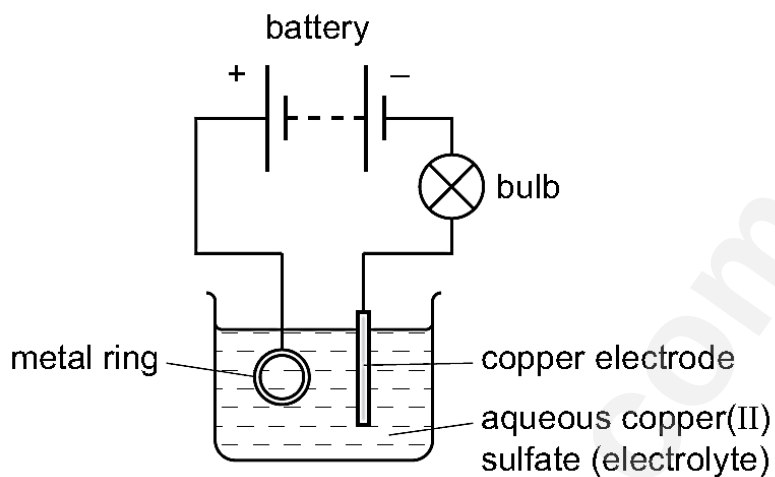
- 1.7 What is the IUPAC name for the compound represented by the following structure?



- A 1,2-dichloro-3-methylpropane
 B 3,4-dichlorobutane
 C 1,1-dichloro-3-methylpropane
 D 1,2-dichlorobutane
- 1.8 The reaction of ethane with chlorine in the presence of ultra-violet light is given by the balanced chemical equation:
- $$\text{C}_2\text{H}_6 + \text{Cl}_2 \rightarrow \text{C}_2\text{H}_5\text{Cl} + \text{HCl}$$
- Which one of the following describes the type of chemical reaction taking place?
- A elimination
 B substitution
 C combustion
 D addition
- 1.9 Which of the following combinations of hexanol and methanol have the highest viscosity and highest solubility respectively?

	HIGHEST VISCOSITY	HIGHEST SOLUBILITY
A	$\text{C}_6\text{H}_{13}\text{OH}$	CH_3OH
B	CH_3OH	$\text{C}_6\text{H}_{13}\text{OH}$
C	CH_3OH	CH_3OH
D	$\text{C}_6\text{H}_{13}\text{OH}$	$\text{C}_6\text{H}_{13}\text{OH}$

- 1.10 The diagram shows apparatus used in an attempt to electroplate a metal ring with copper.



The experiment did not work. Which change is needed to make the experiment work?

- A Add solid copper sulphate to the electrolyte.
- B Increase the temperature of the electrolyte.
- C Replace the copper electrode with a carbon electrode.
- D Reverse the connection to the battery.

10 x 2 = [20]

QUESTION 2 - CHEMICAL BONDING

- 2.1 Electronegativity values can be used to predict the polarity of intramolecular bonds, and generally the type of bond between atoms.
- 2.1.1 Define *electronegativity*. (2)
- 2.1.2 Use electronegativity values to help state the specific type of intramolecular bond present between the following bonded atoms:
- 2.1.2.1 $\text{PH}_3(\text{g})$
- 2.1.2.2 $\text{HF}(\text{g})$ (4)
- 2.2.1 Define *intermolecular force*. (2)
- 2.2.2 State the specific type of intermolecular force present between the following molecules:
- 2.2.2.1 $\text{PH}_3(\text{g})$
- 2.2.2.2 $\text{HF}(\text{g})$ (2)
- 2.3.1 Name the type of bonding between copper atoms in a sheet of copper metal. (1)
- 2.3.2 Draw a simple, labelled sketch showing the bonding between copper atoms in a sheet of copper metal. (3)
- 2.3.3 Use the features sketched in question 2.3.2 to explain why copper is such a good conductor of electricity. (2)

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QUESTION 3 - ENERGY CHANGE AND REACTION RATES

Learners use the reaction between IMPURE POWDERED calcium carbonate and excess hydrochloric acid to investigate reaction rate. The balanced equation for the reaction is:



They perform four experiments under different conditions of concentration, mass and temperature as shown in the table below. They use identical apparatus in the four experiments and measure the volume of gas released in each experiment.

	EXPERIMENT			
	1	2	3	4
Concentration of acid ($\text{mol} \cdot \text{dm}^{-3}$)	1	0,5	1	1
Mass of impure calcium carbonate (g)	15	15	15	25
Initial temperature of acid ($^{\circ}\text{C}$)	30	30	40	40

3.1 The results of experiments 1 and 3 are compared in the investigation.

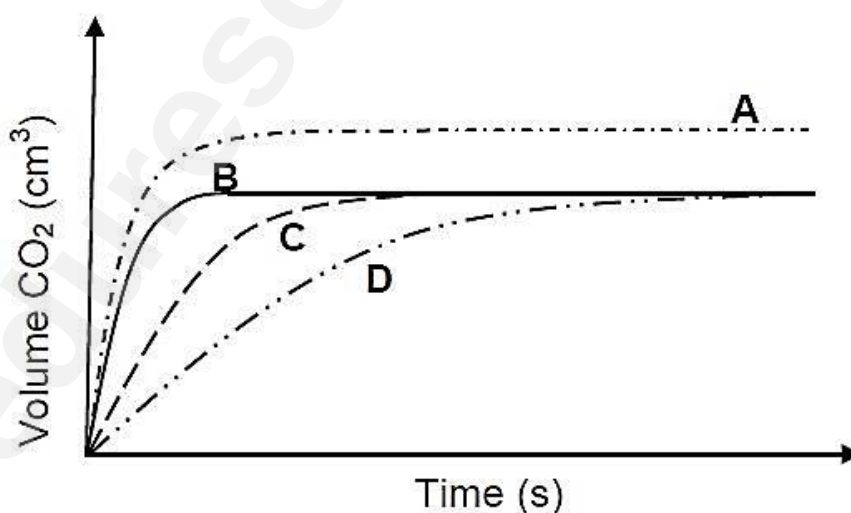
Write down the:

3.1.1 Independent variable (1)

3.1.2 Dependent variable (1)

3.2 Use the collision theory to explain why the reaction rate in experiment 4 will be higher than that in experiment 3. (3)

The learners obtain graphs A, B, C and D below from their results.



3.3 Which ONE of the graphs (A, B, C or D) represents experiment 1? Fully explain the answer by comparing experiment 1 with experiments 2, 3 and 4 and the shape of the graphs. (6)

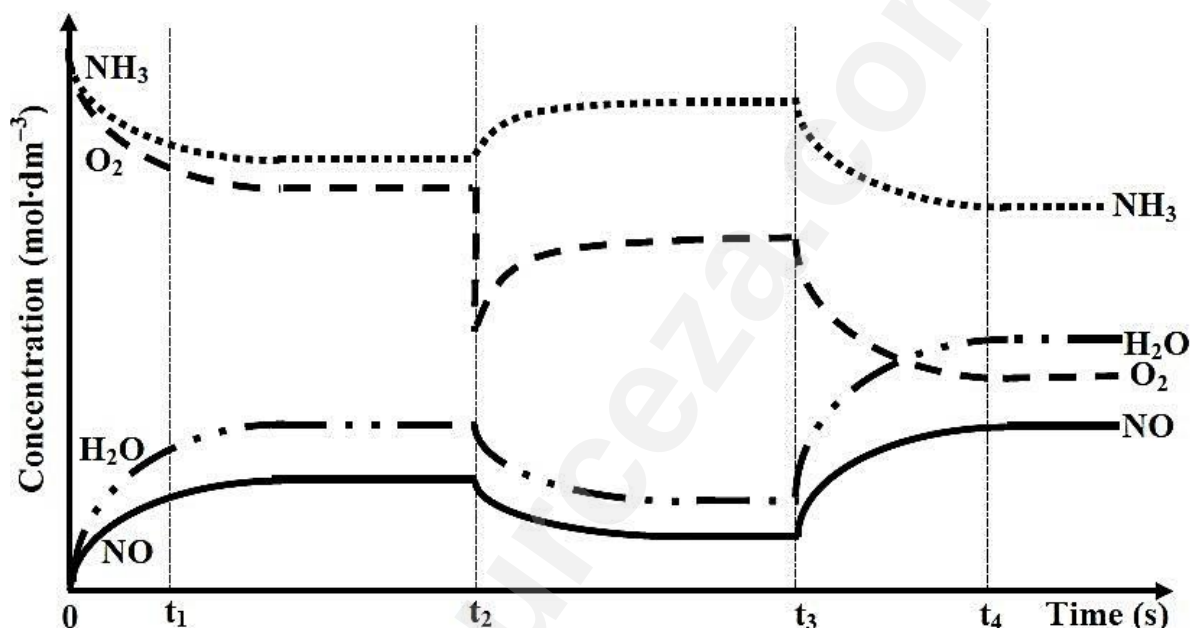
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QUESTION 4 - EQUILIBRIUM

- 4.1 In an experiment, ammonia gas and oxygen gas are introduced into a container at a certain temperature, which is then sealed and the reaction taking place reaches dynamic equilibrium, according to the following balanced chemical equation:

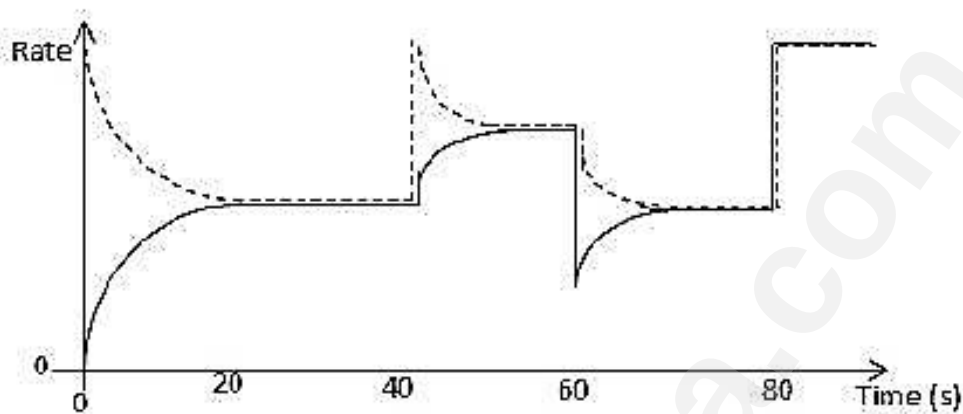
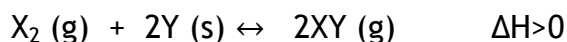


The graph below shows the changes in the concentration of $\text{NH}_3(\text{g})$, $\text{O}_2(\text{g})$, $\text{NO}(\text{g})$ and $\text{H}_2\text{O}(\text{g})$ with time.



- 4.1.1 State what is meant by **dynamic chemical equilibrium**. (2)
- 4.1.2 State *Le Chatelier's principle*. (3)
- 4.1.3 If numerical values were given for concentration on the concentration-axis, would it be possible to calculate the equilibrium constant (K_c) for this reaction at time t_1 ? Explain your answer. (2)
- 4.1.4 Identify the change (stress) which was introduced to the reaction at time t_2 and explain the subsequent changes in the concentrations of all substances immediately after time t_2 . (4)
- 4.1.5 At time t_3 the temperature in the container is decreased.
- 4.1.5.1 Is the forward reaction exothermic or endothermic? (1)
- 4.1.5.2 Consider the changes in concentration shown in the graph between time t_3 and t_4 and apply Le Chatelier's principle to explain your answer to Question 4.1.5.1. (4)

- 4.2 Study the graph below showing the change in the rates of the forward and reverse reactions of the following hypothetical reaction.



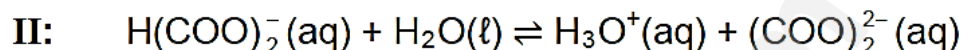
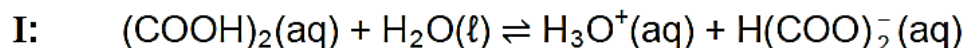
- 4.2.1 State whether the forward or reverse reaction is represented by the solid line. (1)
- 4.2.2 Explain the shape of the graph represented by the solid line for the first 30 seconds of the reaction. (3)
- 4.2.3 Refer to Le Chatelier's Principle to explain the cause of the disturbance at 40 s. (4)
- 4.2.4 State whether the disturbance at 40 s would increase, decrease or not affect the K_c value. (1)
- 4.2.5 A disturbance at $t = 60$ s causes another shift in the equilibrium.
- 4.2.5.1 Which reaction (forward or reverse) was favoured in response to the disturbance to the equilibrium? (1)
- 4.2.5.2 State whether the disturbance at 60 s would increase, decrease or not affect the K_c value. (1)
- 4.2.6 What could have caused the change in the graph at 80 s? (1)

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QUESTION 5 - ACIDS AND BASES

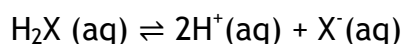
- 5.1 Anhydrous oxalic acid is an example of an acid that can donate two protons and thus ionises in two steps as represented by the equations below:



- 5.1.1 Write down ONE word for the underlined phrase in the above sentence. (1)
- 5.1.2 Write down the FORMULA of each of the TWO bases in reaction II (2)
- 5.1.3 Write down the FORMULA of the substance that acts as the *ampholyte* in reactions I and II. Give a reason for the answer. (2)
- 5.1.4 A standard solution of $(\text{COOH})_2$ of concentration $0,20 \text{ mol} \cdot \text{dm}^{-3}$ is prepared by dissolving a certain amount of $(\text{COOH})_2$ in water in a 250 cm^3 volumetric flask. Calculate the mass of $(\text{COOH})_2$ needed to prepare the standard solution. (4)
- 5.2 The acid ionisation constant K_a for the ionisation of each of the hypothetical acids H_2X , HY and HZ in water at 25°C is given in the table below.

Acid	K_a
H_2X	$2,8 \times 10^{-3}$
HY	$1,2 \times 10^6$
HZ	6×10^{-4}

- 5.2.1 State the difference between a *strong acid* and a *weak acid*. Give one example of each. (Choose from H_2X , HY or HZ .) (4)
- 5.2.2 Which acid, H_2X , HY or HZ , has the lowest pH in water? Justify your choice. Assume that the concentration of each acid is the same. (3)
- 5.2.3 Which acid, H_2X , HY or HZ , is the weakest electrical conductor in water? Justify your choice. Assume that the concentration of each acid is the same. (3)
- 5.2.4 The equation for the ionisation of H_2X in an aqueous solution is:



The concentration of unionised H_2X in a solution at 25°C is $0,2 \text{ mol} \cdot \text{dm}^{-3}$.

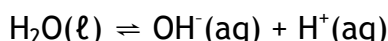
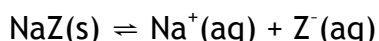
- 5.2.4.1 Write an expression for K_a for H_2X . (2)
- 5.2.4.2 Calculate the concentration of X^- ions in the solution. (4)

5.2.5 25,0 cm³ of acid HZ is neutralised in a titration by 32,4 cm³ of 0,1 mol.dm⁻³ NaOH solution. An aqueous solution of the salt NaZ is produced in the reaction.

5.2.5.1 Write down a balanced chemical equation for the reaction of HZ with NaOH. (The phase of each substance is not required.) (2)

5.2.5.2 Calculate the concentration of acid HZ. (3)

5.2.6 Consider the equations given below for the dissociation of NaZ in water and for the ionisation of water.

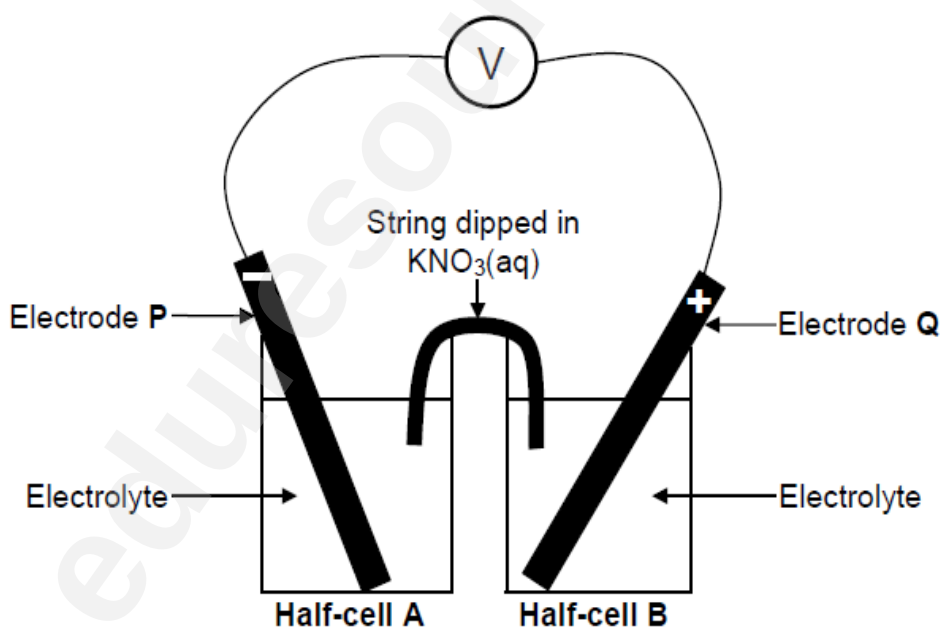


Consider the interaction between the ions in the aqueous solution of the salt NaZ and hence predict whether the solution would have a pH of LESS THAN 7, EQUAL TO 7, OR GREATER THAN 7. Explain your answer fully. (5)

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QUESTION 6 - GALVANIC CELL

Pupils set up a galvanic cell, shown in the simplified diagram below, using magnesium and iron as electrodes. Magnesium nitrate and iron (III) nitrate solutions are used respectively as electrolytes in the half-cells.



6.1 Which electrode, P or Q, is magnesium? Give a reason for the answer. (2)

6.2 Write down the cell notation for this cell. (3)

6.3.1 Define *oxidising agent*. (2)

6.3.2 Give the symbol of the oxidising agent in this cell. (2)

6.4 Calculate the initial emf of the cell above under standard conditions. (3)

6.5 How will the voltmeter reading change if the:

(Write down only INCREASES, DECREASES or REMAINS THE SAME.)

6.5.1 String used is wider and shorter? (1)

6.5.2 Electrolyte in half-cell B has sodium hydroxide (NaOH) added to it? (1)

6.6 After the cell has been operating for a period of time, the gain in mass at the cathode is 1,12 g.

6.6.1 Calculate the number of moles of metal which have been deposited at the cathode. (2)

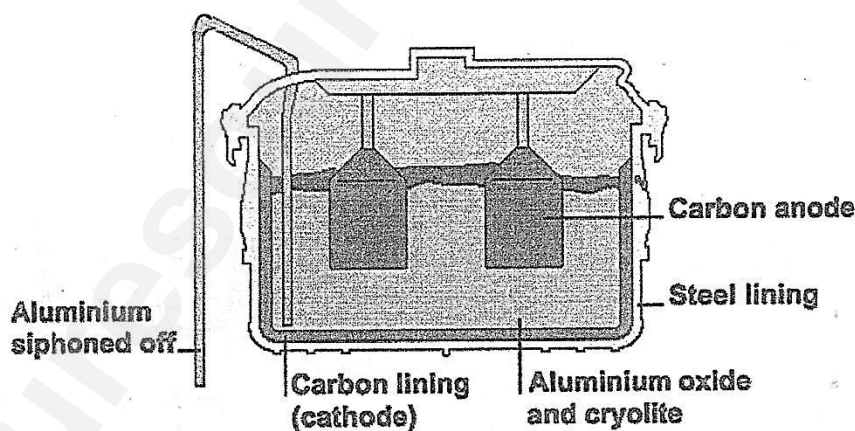
6.6.2 Calculate the subsequent loss in mass at the anode. (4)

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QUESTION 7 - ELECTROLYSIS

7.1 Aluminium is extracted from its mineral ore, bauxite, using electrolysis. The main production of aluminium in South Africa occurs at BHP Billiton, in Richard's Bay, KZN. The aluminium oxide (alumina) is dissolved in molten cryolite (Na_3AlF_6), and then electrolysed in huge carbon-lined tanks. The molten aluminium is then siphoned off, as shown in the diagram below:



7.1.1 Write down the half-reaction which occurs at the anode. (2)

7.1.2 Write down the half-reaction which occurs at the cathode. (2)

7.1.3 What is the benefit of the alumina being dissolved in molten cryolite? (2)

7.1.4 How is CO_2 produced in the process? (2)

7.1.5 The melting point of aluminium is 660°C . Why is the aluminium siphoned off in liquid form? (2)

7.1.6 One can of aluminium, (14,9 g) is produced when a current of 10 A is passed through the molten alumina.

7.1.6.1 How many moles of aluminium are present in one can? (2)

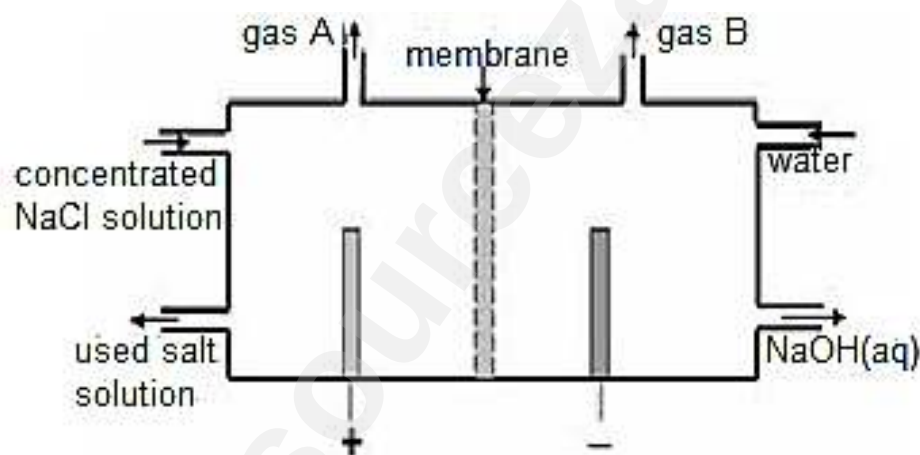
7.1.6.2 How many moles of electrons are transferred in this reaction when producing one can of aluminium? (2)

7.1.6.3 How many electrons is your answer to 7.1.6.2? (2)

7.1.6.4 Calculate the total charge transferred. (2)

7.1.6.5 Calculate how long it takes to make one can of aluminium. (3)

7.2 Approximately 30 million tons of chlorine gas are used throughout the world annually. Chlorine gas is produced industrially by the electrolysis of a concentrated solution of NaCl. The diagram below represents a membrane cell used in the production of chlorine gas in the chlor-alkali industry.



7.2.1 State the energy conversion in this cell. (2)

7.2.2 What is the common name for the saturated NaCl solution used in the chlor-alkali process? (1)

7.2.3 What is the function of the membrane in the membrane cell? (2)

7.2.4 Before chemical engineers designed the membrane cell the diaphragm cell was used. Explain, with reference to **quality of the product** and **cost** why the industry decided to convert to the membrane cell. (4)

7.2.5 Write down the formula of the gas released at the anode in this cell. (1)

7.2.6 Write down the half reaction occurring at the **cathode** in this cell. (2)

7.2.7 Refer to the Table of Standard Reduction Potentials to explain why sodium metal is NOT produced at the cathode in the membrane cell. (3)

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QUESTION 8 - ORGANIC CHEMISTRY

Consider the information given in the table below before answering the questions that follow.

Compound	Name	Molecular formula	Molar mass (g.mol ⁻¹)	Boiling point (°C)
X	2,2-dimethylpropane	C ₅ H ₁₂	72	9,5
Y	Methylethanoate	C ₃ H ₆ O ₂	74	57,1
Z	butan-1-ol	C ₄ H ₁₀ O	74	117,7

- 8.1 Define *homologous series*. (3)
- 8.2 Name the homologous series to which compound X belongs. (1)
- 8.3 Draw the structural formula of compound Y. (2)
- 8.4 Give the IUPAC name of the organic reactants needed to make compound Y. (2)
- 8.5 Identify the functional group of compound Z. (1)
- 8.6 Which one of compounds X, Y or Z can be classified as a saturated hydrocarbon?(1)
- 8.7 Compound Z is dehydrated using heat and an acid catalyst.
 - 8.7.1 Use condensed structural formulae to write a balanced chemical equation for the dehydration of compound Z. It is not necessary to show heat and the acid catalyst in your equation. (3)
 - 8.7.2 Give the IUPAC name of the organic product formed in Question 8.7. (2)
 - 8.7.3 State what type of reaction the dehydration of butan-1-ol is. (1)
- 8.8 Write a balanced equation, using molecular formulae, for the complete combustion of compound X. (4)
- 8.9 Structural isomers of organic compounds can exist as chain isomers, functional isomers and positional isomers.
 - 8.9.1 Define the term *isomers*. (2)
 - 8.9.2 Give the IUPAC name of a straight **chain** isomer of compound X. (2)
 - 8.9.3 Give the IUPAC name of a **functional** isomer of compound Y. (2)
 - 8.9.4 Draw the structural formula of a **positional** isomer of compound Z. (2)
- 8.10 Although compounds X, Y and Z have similar molar masses, they have significantly different boiling points. With reference to the relevant intermolecular forces, explain this difference in boiling points. (6)

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