THE UNITED REPUBLIC OF TANZANIA
NATIONAL EXAMINATIONS COUNCIL OF TANZANIA
DIPLOMA IN SECONDARY EDUCATTION EXAMINATION

732/2A **CHEMISTRY 2A**

Time: 3 Hours **ANSWERS** **Year: 2023**

Instructions.

1. This paper consists of **three (3)** questions.
2. Answer **all** questions.
3. Question **one (1)** carries **twenty (20)** marks and the rest carry **fifteen (15)** marks.
4. Cellular phones are **note** allowed in the examination room.
5. Write your **examination Number** on every page of your answer booklet(s).

1. Your tutor meets you and your friend in the laboratory arguing about the name and atomic mass of a certain metal present in the metal hydroxide. She then decides to give both of you an experiment to identify the metal present in the hydroxide. For the smooth running of the experiment, the tutor provides you with the following solutions:

A1: A solution containing metal hydroxide (MOH) where M is unknown metal.
B2: A solution of 3.65 g of pure hydrochloric acid in 1.00 dm^3 of aqueous solution.
Methyl orange indicator.

Perform the experiment using the procedures given and answer the questions that follow.

Procedure
(i) Pipette 20 or 25cm^3 of solution A1 into a conical flask.
(ii) Add 2 to 3 drops of methyl orange indicator.
(iii) Titrate solution B2 against solution A1 until a colour change is observed.
(iv) Record up to four titre values.

Questions

(b) What is the colour change of the indicator?

(c) Calculate the concentration of solution B2 in mol/dm^3.

(d) Calculate the concentration of A1 in mol/dm^3.

(e) Calculate the atomic mass of metal M if the concentration of MOH is 5.6 g/dm^3.

(f) Identify the element M in MOH.

(a) (i) What is the volume of the pipette used?

The volume of the pipette used is **20 cm^3**.

(ii)
Titre Results Table

Titre Number	**Final Burette Reading (cm^3)**	**Initial Burette Reading (cm^3)**	**Volume Used (cm^3)**
1	20.0	0.0	20.0
2	20.0	0.0	20.0
3	20.0	0.0	20.0
4	20.0	0.0	20.0

Average titre = **20.0 cm^3**

(b) The colour change of the indicator is from **yellow to pink**.

Methyl orange turns yellow in alkaline solution and pink in acidic solution. At the endpoint of this titration, when acid neutralises alkali, it changes from yellow to pink.

(c) Calculate the concentration of solution B2 in mol/dm^3

Given:
Mass of HCl = 3.65 g
Molar mass of HCl = 1 + 35.5 = 36.5 g/mol
Volume of solution = 1.00 dm^3

Number of moles of HCl = mass / molar mass
= 3.65 g / 36.5 g/mol
= 0.100 mol

Concentration of B2 = 0.100 mol / 1.00 dm^3 = 0.100 mol/dm^3

(d) Calculate the concentration of A1 in mol/dm^3

Balanced reaction equation:
MOH + HCl → MCl + H2O

From the equation:
1 mole of MOH reacts with 1 mole of HCl

Using the titration formula:
$C_1V_1 = C_2V_2$

C_1 = concentration of A1 (unknown)
V_1 = volume of A1 = 20.0 cm^3 = 0.0200 dm^3
C_2 = concentration of B2 = 0.100 mol/dm^3
V_2 = average titre = 20.0 cm^3 = 0.0200 dm^3

$C_1 \times 0.0200 = 0.100 \times 0.0200$

$C_1 = (0.100 \times 0.0200) / 0.0200$
C_1 = 0.100 mol/dm^3

Therefore, the concentration of A1 is **0.100 mol/dm^3**

(e) Calculate the atomic mass of metal M if the concentration of MOH is 5.6 g/dm³

Given:
Concentration in g/dm³ = 5.6 g/dm³
Concentration in mol/dm³ = 0.100 mol/dm³

Molar mass (M) = mass / moles
= 5.6 g / 0.100 mol
= 56 g/mol

Atomic mass of M = 56 g/mol − 17 (since M + 17 = molar mass of MOH)
M = 56 − 17
M = 39 g/mol

(f) Identify the element M in MOH

The element with atomic mass 39 is **Potassium (K)**.

So, MOH = KOH.

2. One of the factors that affect the rate of a chemical reaction is the concentration of the reactants. Therefore, in this experiment you are required to investigate the effect of concentration on the rate of reaction between sodium thiosulphate ($Na_2S_2O_3 \cdot 5H_2O$) and hydrochloric acid (HCl).

You are given the following materials:

- **AA:** A solution containing 0.25 M $Na_2S_2O_3 \cdot 5H_2O$
- **BB:** A solution containing 0.5 M HCl
- Distilled water, stopwatch and a white paper with a cross "+".

Procedures
(i) Put an empty beaker (50 cm³) on top of the mark "+" drawn on the given piece of paper. Make sure the mark is clearly visible.
(ii) Using a measuring cylinder, transfer 10 cm³ of AA into a beaker positioned on top of the mark "+".
(iii) Using another measuring cylinder, measure 5 cm³ of BB.
(iv) Hold the measuring cylinder containing 5 cm³ of BB in one hand and hold the stopwatch in another hand.
(v) Simultaneously, pour 5 cm³ of BB into the beaker positioned on top of the mark "+" and start the stopwatch.
(vi) Stir gently the contents in the beaker and record the time of disappearance of the mark "+".

(vii) Repeat the procedure (i) to (vi) by using 8 cm^3, 6 cm^3, 4 cm^3 instead of 10 cm^3 of AA in procedure (ii).

(a) Complete the Table of Results

Experiment	**Volume of AA (cm^3)**	**Volume of Water (cm^3)**	**Volume of BB (cm^3)**	**Time t (s)**	**Rate (s^{-1})**
1	10	0	5	21	0.048
2	8	2	5	25	0.040
3	6	4	5	27	0.037
4	4	6	5	35	0.029

(b) Write the ionic equation representing the reaction between thiosulphate ion and an acid

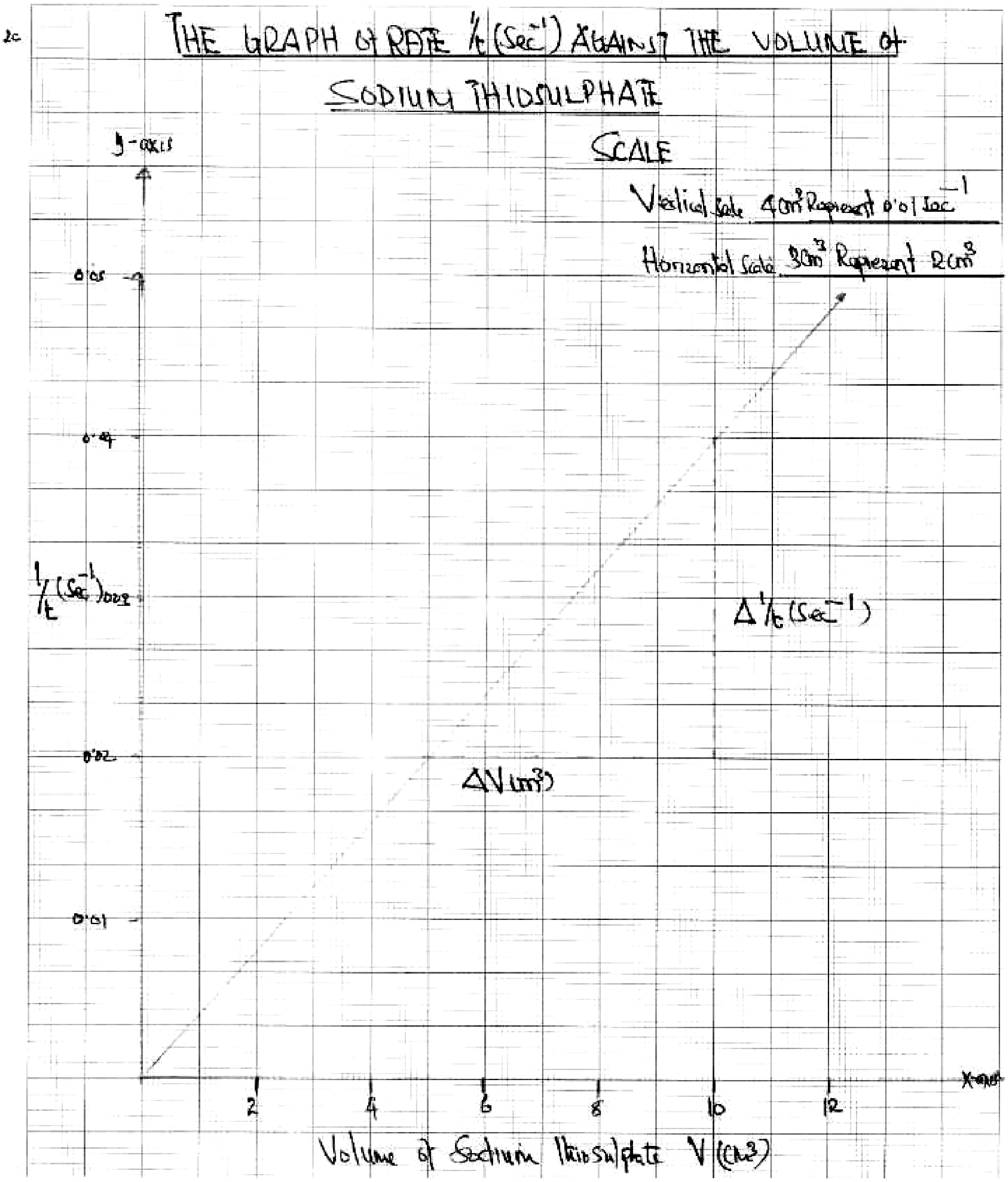
$S_2O_3^{2-}(aq) + 2H^+(aq) \rightarrow S(s) + SO_2(g) + H_2O(l)$

Explanation:
Thiosulphate reacts with acid to form a precipitate of sulfur (which clouds the solution making the "+" mark disappear), sulfur dioxide gas, and water.

(c) Plot a graph of rate (1/t) of reaction as a function of volume of sodium thiosulphate

Points to Plot:

Volume of $Na_2S_2O_3$ (cm^3)	**Rate (s^{-1})**
10	0.048
8	0.040
6	0.037
4	0.029



(d) Comment on the relationship between concentration of sodium thiosulphate and the rate of reaction

The graph indicates that **as the concentration of sodium thiosulphate increases, the rate of reaction also increases**.
This is because increasing the concentration of thiosulphate increases the number of reacting particles per unit volume, leading to more frequent and effective collisions per second, hence a faster reaction.

(e) Use the data in (a) to find the value of a rate constant, k, given: Rate = k$[S_2O_3^{2-}]^2[H^+]$

Given:

- Rate = 0.048 s^{-1}
- $[S_2O_3^{2-}]$ initial concentration = (0.25 M × 10 cm^3) / (10 + 5) cm^3
  = (0.25 × 10) / 15
  = 0.1667 M
- $[H^+]$ concentration = (0.5 M × 5 cm^3) / 15 cm^3
  = (0.5 × 5) / 15
  = 0.1667 M

Substituting into: Rate = k $[S_2O_3^{2-}]^2$ $[H^+]$

$0.048 = k \times (0.1667)^2 \times 0.1667$
$0.048 = k \times (0.02778 \times 0.1667)$
$0.048 = k \times 0.00463$

k = 0.048 / 0.00463
$k \approx 10.37\ mol^{-3}\ dm^9\ s^{-1}$

Answer:
The rate constant, k ≈ **10.37 mol^{-3} dm^9 s^{-1}**

3. Sample K: Systematic qualitative analysis

(a) Table of qualitative analysis results

Test	Observation	Inference
(i) Appearance of sample K	Blue crystalline solid	Indicates presence of a transition metal salt
(ii) Action of heat on sample K in a test tube	Water droplets on cooler parts of the tube and white anhydrous residue remains; turns white upon strong heating	Suggests presence of hydrated salt
(iii) Action of dilute H_2SO_4 or HCl on the solid sample	Effervescence with colourless gas evolving; gas turns limewater milky	Gas is CO_2 or SO_2; likely sulphate presence

(iv) Action of concentrated H_2SO_4 on solid sample	Effervescence; choking pungent gas with white fumes produced	Suggests sulphate ion producing SO_2 gas
(v) Flame test	Greenish-blue flame	Indicates presence of copper(II) ion
(vi) Solubility of the sample	Soluble in water forming a blue solution	Soluble salt of a transition metal
(vii) Confirmatory test for anion ($BaCl_2$ solution + dilute HCl)	White precipitate forms	Presence of sulphate ion (SO_4^{2-})
(viii) Confirmatory test for cation (add NaOH solution dropwise then excess)	Light blue precipitate forms, insoluble in excess	Presence of copper(II) ion (Cu^{2+})

(b) Cation and anion present in the unknown sample

Cation present: Copper(II) ion (Cu^{2+})

Anion present: Sulphate ion (SO_4^{2-})

(c) Reaction equation for test (vii)

When $BaCl_2$ is added to a solution containing sulphate ions:

$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

A white precipitate of barium sulphate forms, confirming the presence of sulphate ions.