CHRISTIAN SOCIAL SERVICES COMMISSION (CSSC)

NORTHEN ZONE JOINT EXAMINATIONS SYNDICATE (NZJES)

FORM FOUR PRE-NATIONAL EXAMINATIONS AUGUST 2024

CHEMISTRY 2A

ACTUAL PRACTICAL A

MARKING SCHEME

Question No. 1

Provided Solutions and materials;

(i) **R:** Solution containing 18.25g of hydrochloric acid (HCl) in 0.5 dm^3 of solution

(ii) **S:** Solution containing 14.30g of hydrated Sodium Carbonate (Na_2CO_3. xH_2O) in 1 dm^3 of solution.

(iii) **Indicators**: Methyl Orange (MO)

Table of results (**Titration data**)

TITRATION/Burette Readings	**PILOT**	**1**	**2**	**3**
Final reading (cm^3)	21.60	41.70	22.00	41.90
Initial reading (cm^3)	1.00	21.60	2.00	22.00
Volume of Acid used (Va) (cm^3)	20.60	20.10	20.00	19.90

Correct data entry in the above table 0**5 Marks.**

QUESTIONS

(a) Calculate the average volume of the acid solution used in this experiment.

$$V_a = \frac{(20.10 + 20.00 + 19.90)}{3} cm^3$$

$$Va = \frac{60.00}{3} cm^3 = \mathbf{20.00}\ cm^3 \qquad (\mathbf{01\ Mark})$$

Summary;

20.00 cm^3 of solution **R1** required **20.00** cm^3 of solution **S** for complete neutralization reaction.

(**01 Mark**)

(b) Name of indicator: **Methyl Orange (MO)** **(0.5 Mark)**

Reason:

The neutralization reaction was between **HCl (strong acid)** and **Weak base (Na_2CO_3)**

(0.5 Mark)

(c) The color change at the end point was from **Yellow** to **Orange-Red**

(01 Mark)

(d) Balanced chemical equation for the reaction between solution R1 and S.

$$2HCl\ (aq) + Na_2CO_3\ (aq) \longrightarrow 2NaCl\ (s) + CO_2\ (g) + H_2O\ (l)$$

(**1.5 Marks**)

(e) Calculate concentration of acid Solution R

(i) concentration of acid Solution R in (i) gdm^{-3}

From the given information above;

Soln R contains: 18.25g of (HCl) acid in 0.5 dm^3 of solution

i.e. 18.25g = 0.5 dm^3

xg = 1.0dm^3 (**0.5 Mark**)

$$x = \frac{18.25g \times 1.0dm^3}{0.5dm^3}$$

$$x = 36.5g/dm^3$$

therefore, concentration of acid Solution R in (a) gdm^{-3} = 36.5g/dm^3 (01Mark)

(ii) Concentration of acid Solution R in moles/dm^3

Note: This is same as finding Molarity of given acid solution

We use formula;

$$\textbf{Molarity (Acid) HCl} = \frac{\textbf{Concentration in g/dm}^3}{\textbf{Molar mass}} \quad (0.5\ \text{Marks})$$

$$= \frac{36.5g/dm^3}{36.5g/mol} = \mathbf{1}.00\ moles/dm^3$$

Concentration/Molarity soln R HCl acid = 1.0M or **1**.00 moles/dm^3 (1 Mark)

(f) Calculate concentration of acid Solution R1 in

(i) moles/dm^3

concentration of acid Solution R1 in gdm^{-3}

Given Data:

Molarity of Conc acid (Mc) = 1.0M
Volume of Conc. acid (Vc) = 10 cm^3
Volume of dilution (Vd) = 100 cm^3
Molarity of diluted acid (Md) = ? **(0.5 Marks)**

Then we use Dilution law to get concentration of acid R1 in moles/dm^3

Mc.Vc = Md.Vd **(0.5 Mark)**

Making Md the subject of the formula

$$Md = \frac{Mc.Vc}{Vd} \qquad Md = \frac{1M \times 10\ cm^3}{100\ cm^3} = \mathbf{0.1}\ moles/dm^3$$

Therefore; ***Concentration of acid Solution R1 = 0.1 moles/dm^3***

(1 Mark)

(ii) To calculate concentration of acid Solution R1 in gdm^{-3}

We use the formula;

$$\textbf{Molarity}\ \text{of R1}_{(HCl)} = \frac{\textbf{Concentration in g/dm}^3}{\textbf{Molar mass}}$$ (**0.5** Mark)

Concentration of R1 (HCl) = **Molarity** of R1 (HCl) x **Molar mass** (HCl)
= 0.1moles/dm^3 x 36.5g/mol
= 3.65 g/dm^3

Thus; ***concentration of acid Solution R1 in gdm^{-3} = 3.65 g/dm^3***

(1 Mark)

(g) Compute the following;

(i) Molarity of hydrated Sodium Carbonate ($Na_2CO_3.xH_2O$) in solution S

Here we use the following information

Molarity of acid (Ma) = 0.1 M

Volume of acid (Va) = 20.00 cm^3

Number of acid (na) = 2
From balanced eqn in (iii) above

Number of base (nb) = 1 (**0.5 Mark**)
From balanced eqn in (iii) above

From formula;

$$\mathbf{Ma.Va.nb = Mb.Vb.na}$$

$$Mb = \frac{Ma.Va.nb}{Vb.na} \quad \textbf{(0.5 Marks)}$$

$$Mb = \frac{0.1M \times 20.00cm^3 \times 1}{20.00cm^3 \times 2}$$

Mb = **0.05 M** or **0.05 moles/dm^3** (1 Mark)

Thus;

Molarity of hydrated Sodium Carbonate ($Na_2CO_3.xH_2O$) in solution S = **0.05 M** or **0.05 moles/dm^3**

(ii) Value of **x** in hydrated Sodium Carbonate ($Na_2CO_3.\mathbf{x}H_2O$) in solution S

To get value of x in $Na_2CO_3.\mathbf{x}H_2O$ we must calculate its **Molar mass** (g/mol).

Form the information given when the solution was prepared;
Concentration of $Na_2CO_3.\mathbf{x}H_2O$ = 14.30 g/dm^3

We use the formula;

$$\textbf{Molarity of S (Na2CO3.xH2O)} = \frac{\textbf{Concentration in g/dm}^3}{\textbf{Molar mass}}$$

$$\text{Molar mass (Na2CO3.xH2O)} = \frac{\text{Concentration g/dm}^3}{\text{Molarity (moles/dm}^3\text{)}} \quad \textbf{(0.5 Mark)}$$

$$= \frac{14.30 g/dm^3}{0.05 \text{ moles/dm}^3}$$

= 286g/mol (**0.5 MARK**)

Molar mass of **$Na_2CO_3.xH_2O$** = 286g/mol.

$Na_2CO_3.xH_2O$ = 286

$(23 \times 2) + 12 + (16 \times 3) + x[(1x2)+10] = 286$

$46 + 12 + 48 + 18x = 286$ **(0.5 Mark)**

$106 + 18x = 286$

$18x = 286 - 180$

$18x = 180$

Dividing by 18 both sides, gives

$$x = \frac{180}{18}$$

$x = 10$ **(1 Mark)**

thus; chemical formula for hydrated sodium carbonate is Na_2CO_3. **10**H_2O

(iii) Percentage of water of crystallization in hydrated Sodium Carbonate ($Na_2CO_3.xH_2O$)

% of water of crystallization in Na_2CO_3. **10**H_2O = $\frac{180 \times 100}{286}$ = **62.9371 % (0.5 MARKS)**

% of water of crystallization in Na_2CO_3. 10H_2O = 62.94% **(01 Mark)**

H) Effect if each of the following conditions were applicable in this experiment;

(I) The pipette used was not rinsed with sodium carbonate

There could be water impurities which could affect the concentration of the base solution by lowering it. **(01 Mark)**

(II) The air space in the burette tip was not removed before titration.

Air space in the burette could affect the concentration of acid solution by lowering its volume.. **(01 Mark)**

Question No. 2

Table 1

Experiment No	Volume of V (HNO_3) (cm^3)	Volume of U ($Na_2S_2O_3$) (cm^3)	Volume of distilled water (cm^3)	Concentration of U ($Na_2S_2O_3$) ($moles/dm^3$)	Time (s)	Rate (s^{-1})
(i)	10	10	0			
(ii)	10	8	2			
(iii)	10	6	4			
(iv)	10	4	6			

Questions

a) Complete (fill) blank columns in Table 1 above

(06 Marks)

b) (i) To write a net ionic equation for the reaction between solution U and V

Ionic equation is usually written in five steps as follows;

@ step 01 = 05 Marks

Step 1: writing chemical equations in words

Nitric acid reacts with sodium thiosulphate to form sodium nitrate, sulphur, sulphur dioxide and water.

Step 2: Equation in chemical symbols and balancing it.

$$2HNO_3\,(aq) + Na_2S_2O_3\,(aq) \longrightarrow 2NaNO_3(aq) + S_{(s)} + SO_{2(g)} + H_2O_{(l)}$$

Step 3: Splitting all soluble ionic compounds into individual ions

$$2H^+(aq) + 2NO_3^-\,(aq) + 2Na^+(aq) + 2S_2O_3^-\,(aq) \longrightarrow 2Na^+(aq) + 2NO_3^-(aq) + S_{(s)} + SO_{2(g)} + H_2O_{(l)}$$

Step 4: Cancel out spectator ions

$$2H^+(aq) + \cancel{2NO_3^-}\,(aq) + \cancel{2Na^+}(aq) + 2S_2O_3^-\,(aq) \longrightarrow \cancel{2Na^+}(aq) + \cancel{2NO_3^-}(aq) + S_{(s)} + SO_{2(g)} + H_2O_{(l)}$$

Step 5: Writing the net ionic equation

$$2H^+(aq) + 2S_2O_3^-\,(aq) \longrightarrow S_{(s)} + SO_{2(g)} + H_2O_{(l)}$$

(ii) The name of product which causes the solution to cloud letter X is **Sulphur**

(01 Mark)

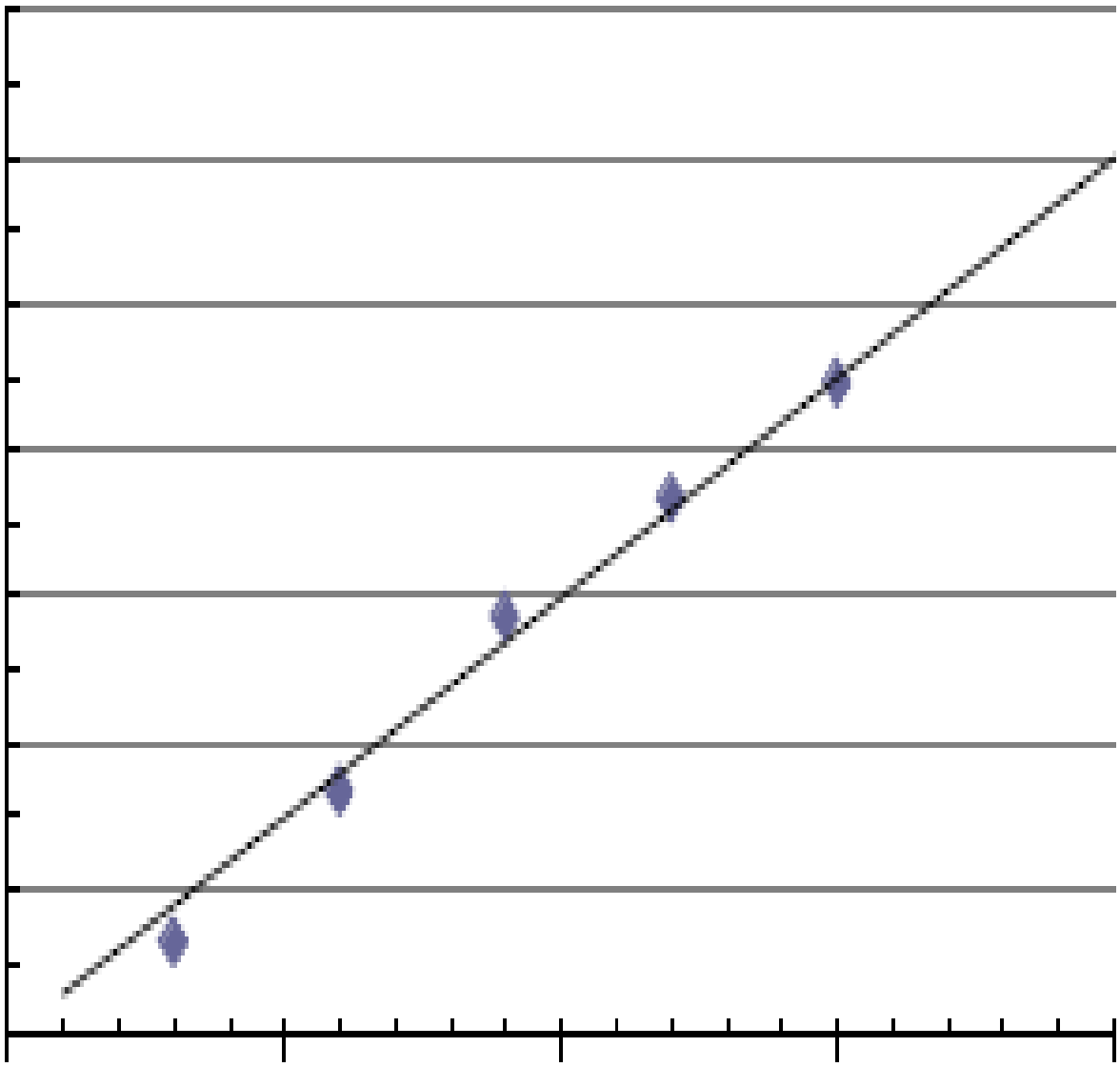
c) (i) Plot the graph of Volume of $Na_2S_2O_3$ solution against Rate (s^{-1})

The nature of graph

Volume (cm^3) of $Na_2S_2O_3$ solution against Rate (s^{-1}) (**02 Marks**)

Things to Note:

- Title of the graph (with its respective units) (**01 MARK**)
- Correct labeled axes (with units) (**01 MARKS**)
- Scale: (Horizontal and Vertical scale) – with respective units (**02 MARKS**)



(ii) Conclusion to be drawn from the graph above

Decrease in concentration of Sodium thiosulphate solution decreases the rate of chemical reaction and vice versa. (**01.5 Mark)**

d) The aim of this experiment was to *demonstrate the effect of concentration on the rate of chemical reaction for the reaction between $Na_2S_2O_3$ solution and HNO_3 acid*.

(**01.5 Mark)**

e) Two (2) possible sources of errors that might hinder this experiment and in each case, state how to overcome the error.

Any two errors: @ error = 01 x 2 = **02 Marks**

@ control measure 01 x 2 = **02 Marks**

Source of error	**How to overcome/ correct**
(i) Water droplets or remains (impurities) on vessels like beaker, measuring cylinder.	- Make sure all impurities from vessels are removed/emptied completely.
(ii) Delay in starting and or stopping stop watch during experiment.	- Make sure stop watch is started and stopped carefully (on time) as reaction starts or ends.
(iii) Use of dirty or broken apparatus like measuring cylinder.	- Never use dirty or broken apparatus