THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL

ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

132/3A **CHEMISTRY 3A**

(For Both School and Private Candidates)

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

Instructions

1. This paper consists of THREE questions.

2. Answer all questions.

1. You are provided with the following solutions:

T1: A solution containing a mixture of NaOH and Na_2CO_3

T2: 0.2 M hydrochloric acid

POP: Phenolphthalein indicator

MO: Methyl orange indicator

Questions

(a) Record your results in a tabular form.

Answer:

Burette Readings (cm^3)	First end point	Second end point	First titre volume	Second titre volume
Pilot	13.6	34.0	13.6	20.4
1	13.6	34.0	13.6	20.4
2	13.6	34.0	13.6	20.4
3	13.6	34.0	13.6	20.4
Average	13.6	34.0	13.6	20.4

What was the volume of the pipette used?

The volume of the pipette used was 25 cm^3.

Calculate the average titre values (cm^3) of T2 in presence of POP and MO.

Average titre value with POP = 13.6 cm^3

Average titre value with MO = 34.0 cm^3

What is the colour change when:

(i) POP was used?

The colour changed from pink to colourless.

(ii) MO was used?

The colour changed from yellow to red.

Write a balanced chemical equation for the reaction under:

(i) POP

$NaOH + HCl \text{ -----> } NaCl + H_2O$

(ii) MO

$Na_2CO_3 + 2HCl \text{ -----> } 2NaCl + H_2O + CO_2$

Why was POP used first instead of MO in this experiment?

POP was used first to identify the amount of sodium hydroxide, which is a strong base. Since phenolphthalein changes colour at higher pH levels and reacts only with strong bases, it gives an accurate endpoint for NaOH before Na_2CO_3 begins to react. MO is used afterward to detect the endpoint for sodium carbonate, which is a weaker base.

Calculate:

(i) the concentration of sodium carbonate in g/dm^3

Volume of T2 used for Na_2CO_3 = 34.0 - 13.6 = 20.4 cm^3

Moles of HCl = 0.2 × 20.4 / 1000 = 0.00408 mol

Moles of Na_2CO_3 = 0.00408 ÷ 2 = 0.00204 mol

Concentration in 25 cm^3 = 0.00204 mol

In 1 dm^3 = 0.00204 × (1000 ÷ 25) = 0.0816 mol

Mass = 0.0816 × 106 = 8.6496 g/dm^3

(ii) the concentration of sodium hydroxide in g/dm^3

Volume of T2 used = 13.6 cm^3

Moles of HCl = 0.2 × 13.6 / 1000 = 0.00272 mol

Moles of NaOH = 0.00272 mol

In 1 dm^3 = 0.00272 × (1000 ÷ 25) = 0.1088 mol

Mass = 0.1088 × 40 = 4.352 g/dm^3

(iii) the percentage composition of each component in T1

Total mass = 8.6496 + 4.352 = 13.0016 g

% Na_2CO_3 = (8.6496 ÷ 13.0016) × 100 = 66.5%

% NaOH = (4.352 ÷ 13.0016) × 100 = 33.5%

2. You are provided with the following:

P1: A solution containing 49.6 g/dm^3 of $Na_2S_2O_3 \cdot 5H_2O$

P2: Dilute HCl

Distilled water

A white plain paper marked X

Stop watch/clock

Questions

(a) Record your results in a tabular form.

Answer:

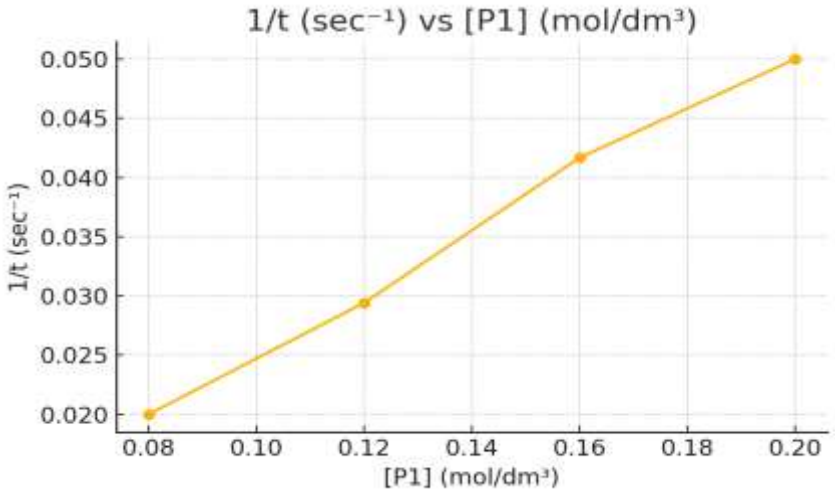
Volume of P1 (cm^3)	Volume of Distilled Water (cm^3)	Volume of P2 (cm^3)	[P1] (mol/dm^3)	t (Sec)	$1/t$ (Sec^{-1})	[P1] × t ($mol/dm^3 \cdot Sec$)
10	0	5	0.200	20	0.0500	4.00

8	2	5	0.160	24	0.0417	3.84	
6	4	5	0.120	34	0.0294	4.08	
4	6	5	0.080	50	0.0200	4.00	

(b) Plot a graph of [P1] (mol/dm³) against time, t (sec).

The graph should show a negative correlation: as [P1] increases, time decreases.

(c) Plot a graph of 1/t (sec^{-1}) against [P1] (mol/dm³).



(d) Study the results and the graphs then answer the following questions:

(i) What is the effect of concentration of $Na_2S_2O_3$ on the rate of reaction?

As the concentration of $Na_2S_2O_3$ increases, the rate of reaction increases (reaction is faster, time is shorter).

(ii) What is the order of reaction with respect to $Na_2S_2O_3$?

The reaction is first order with respect to $Na_2S_2O_3$.

(iii) How did you reach your conclusion in (c)(ii)?

Because the graph of 1/t against [P1] is a straight line through the origin, which is characteristic of a first-order reaction.

(iv) Comment on the value of the product of concentration and time; that is [P1] × t.

The values of [P1] × t remain nearly constant across all trials, further supporting that the reaction is first-order with respect to $Na_2S_2O_3$.

3. You are provided with sample U containing two cations and one anion. Perform the experiments given in Table 2 and record the observations. Make appropriate inferences and hence identify the two cations and anion.

Table 2: Experimental Table

S/n	Experiments	Observations	Inferences
(a)	Observe sample U.	Green crystalline solid	Presence of iron(II) salt
(b)	Heat a small portion of the sample in a dry test tube.	Colourless pungent gas evolved	Ammonium ion present
(c)	Perform a flame test.	No characteristic flame colour	No Group I or II metal cations
(d)	Add concentrated sulphuric acid to a small portion of the sample.	Effervescence with colourless gas evolved	Likely presence of carbonate or sulfite
(e)	To the small portion of solution, add dilute sodium hydroxide.	Green precipitate formed	Fe^{2+} present
(f)(i)	To the filtrate, add potassium hexacyanoferrate(II).	Deep blue precipitate forms	Confirm Fe^{2+} (Turnbull's blue)
(f)(ii)	Dissolve residue in aqua regia, then add excess ammonia solution.	White fumes evolved, pungent gas released	NH_4^+ confirmed
(g)	To solution, add dilute nitric acid followed by silver nitrate.	No precipitate formed	Absence of Cl^-, Br^-, I^-

Questions

(i) Write the molecular formula for the sample.

The molecular formula is $(NH_4)_2Fe(SO_4)_2 \cdot 6H_2O$ — ammonium iron(II) sulfate (Mohr's salt)

(ii) What are the cations and anion in the sample?

Cations: NH_4^+ and Fe^{2+}

Anion: SO_4^{2-}