

Candidate's Name : *Mutesasira Julius Kakumba*

Signature *Kakumba*

Random No.	Personal No.

(Do not write your School /Centre Name or Number anywhere on this booklet.)

P525/3

CHEMISTRY

Paper 3

(Practical)

Nov./Dec. 2023

3 $\frac{1}{4}$ hours



UGANDA NATIONAL EXAMINATIONS BOARD

Uganda Advanced Certificate of Education

CHEMISTRY

Paper 3
(Practical)

3 hours 15 minutes

INSTRUCTIONS TO CANDIDATES:

Answer all questions. Use blue or black ink. Any work done in pencil will not be marked except drawings.

All your answers must be written in the spaces provided.

Mathematical tables and silent non-programmable scientific calculators may be used.

Reference books (i.e. text books, booklets on qualitative analysis etc.) should not be used.

You are not allowed to start working with the apparatus for the first 15 minutes. This time is to enable you read the question paper and make sure you have all the apparatus and chemicals that you may need.

For Examiners' Use Only			
Q.1	Q.2	Q.3	Total
30	30	20	X 180
JKM	JKM	JKM	JKM

1. You are provided with the following:

FA1, which is a solution of hydrochloric acid of an unknown concentration.

FA2, which is a solution containing 5 g of a mixture of sodium hydroxide and anhydrous sodium carbonate in a litre.

FA3, which is a solution of barium chloride.

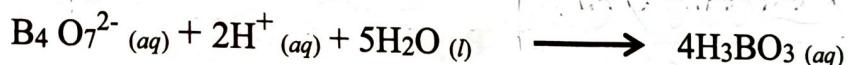
Solid T, which is sodium tetraborate decahydrate, $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$.

You are required to;

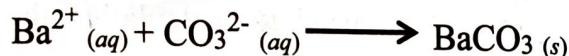
- (i) standardise the solution of hydrochloric acid, FA1.
- (ii) determine the composition of the mixture in FA2.

Theory

A solution of sodium tetraborate reacts with hydrochloric acid according to the following equation:



When FA3 is added to FA2, the carbonate ions in FA2 are precipitated out according to the following equation:



PART I

Procedure

Weigh accurately 2.4 g of solid T and transfer it into a beaker. Add about 100 cm³ of hot water and stir to dissolve. Transfer the solution into a 250 cm³ volumetric flask and fill up to the mark with distilled water.

Label the solution FA4.

Results

Mass of the weighing container + T = 102.4 g (½ mark)

Mass of the weighing container alone = 100 g (½ mark)

Mass of T weighed = 2.4 g (½ mark)

(0.14)

PART II

Procedure

Pipette 25.0 cm³ (or 20.0 cm³) of FA4 into a conical flask. Add 2-3 drops of methyl orange indicator and titrate with FA1 from the burette until the end-point.

Repeat the titration to obtain consistent results and record your results in table 1.

Results

Table 1

Volume of pipette used = 25.0 cm³. (½ mark)

Titration number	1	2	3
Final burette reading (cm ³)	12.10	24.10	36.10
Initial burette reading (cm ³)	0.00	12.10	24.10
Volume of FA1 used (cm ³)	12.10	12.00	12.00

(0.5) (4½ marks)

(a) (i) Record the volumes of FA1 used for calculating the average volume. (½ mark)

..... (12.00), 12.00 cm³

(ii) Calculate the average volume of FA1 used. (2½ marks)

$$\frac{12.00 + 12.00}{2} = 12.00 \text{ cm}^3$$

(b) Calculate the concentration of;

(i) FA4 in mol dm⁻³. (2½ marks)

$$(Na = 23; B = 11; O = 16; H = 1)$$

Molar mass of $Na_2B_4O_7 \cdot 10H_2O = 2 \times 23 + 11 \times 4 + 16 \times 7 + 10 \times (18) = 382g$

382g of T contain 1 mole

1/5 of T contain $(\frac{1}{5} \times 1) \text{ mole}$

$$= 0.006 \text{ mole}$$

(0.2L)

Molarity of FA4 = $\frac{(1000 \times 0.006)}{250}$

$$= 0.024M$$

Turn Over

Alternatively

$\Rightarrow 200 \text{ cm}^3 \text{ of FA}_2 \text{ contain } 0.006 \text{ moles}$
 $\therefore 1000 \text{ cm}^3 \text{ of FA}_2 \text{ contain } \frac{1000 \times 0.006}{200} \text{ moles}$
 $\therefore \text{Molarity of FA}_2 \text{ is } 0.024 \text{ M}$

(ii) **FA1 in mol dm⁻³** (3½ marks)
Moles of FA₂ that reacted = $\frac{25 \times 0.024}{1.000}$
= 0.0006 moles ✓

1 mole of T reacted with 2 moles of HCl ✓
moles of HCl that reacted = (2×0.0006) moles

Molarity of FA₁ = $\frac{(1000 \times 0.0012)}{12.00}$ = 0.1 M ✓ (B1)

PART III Procedure

Pipette 25.0 cm³ (or 20.0 cm³) of **FA2** into a conical flask, add 6.0 cm³ of **FA3**, shake and allow to stand for one minute. Add 4 – 5 drops of phenolphthalein indicator and titrate the solution with **FA1** from the burette until the end-point. Repeat the titration until you obtain consistent results. Record your results in table 2.

Results

Table 2

Volume of pipette used = 25.0 ✓ cm³. (½ mark)

Titration number	1	2	3
Final burette reading (cm ³)	16.30 ✓	32.50 ✓	48.70 ✓
Initial burette reading (cm ³)	0.00 ✓	16.30 ✓	32.50 ✓
Volume of FA1 used (cm ³)	16.30 ✓	16.20 ✓	16.20 ✓

(0.4h)

(4½ marks)

- (a) (i) Record the volumes of FA1 used for calculating the average volume. (1/2 mark)

(16.20, 16.20) \checkmark (01) cm³.

- (ii) Calculate the average volume of FA1 used. (2 1/2 marks)

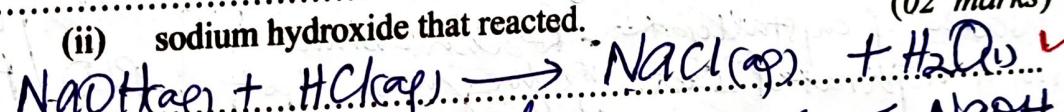
$\frac{(16.20 + 16.20)}{2} = 16.20$ \checkmark (02 1/2) cm³.

- (b) Calculate the number of moles of;

- (i) hydrochloric acid that reacted.

Moles of HCl that reacted = $\left(\frac{16.20 \times 10^{-3}}{1000} \right) \checkmark$ = 0.00162. \checkmark (01)

- (ii) sodium hydroxide that reacted. (02 marks)



1 mole of HCl reacted with 1 mole of NaOH. \checkmark
 \therefore Moles of NaOH that reacted = 0.00162 \checkmark (02)

- (c) Determine the mass of;

- (i) sodium hydroxide in FA2 in grammes per litre. (2 1/2 marks)

Molarity of NaOH in FA2 = $\frac{1000 \times 0.00162}{25} \checkmark$ 0.0648 M \checkmark

Molar mass of NaOH = (23x1) + (1x16) + (1x1) = 40 g
 \therefore Mass of NaOH in g/l = $40 \times 0.0648 \checkmark$ 2.592 g/l \checkmark (02 1/2)

- (ii) sodium carbonate in FA2 in grammes per litre. (01 mark)

Mass of Na₂CO₃ in g/l = $(50 - 2.592) \checkmark$ 2.408 g/l \checkmark (01)

2. You are provided with substance X which contains **two** cations and **two** anions. Carry out the following tests to identify the cations and anions present in X. Identify any gas(es) evolved.

Record your observations and deductions in table 3. (30 marks)

Table 3

TESTS	OBSERVATIONS	DEDUCTIONS
(a) Heat two spatula end-fuls of X in a dry test tube strongly until there is no further change.	<ul style="list-style-type: none"> - White solid powder - Colourless gas, turns a damp blue commiss test, lime water milk turns - Another colourless gas, with an instant smell, turns, lime, turns red, turn acquifed K₂Cr₂O₇ H₂Cr₂O₇ purple to green - Reddish brown residue when heat, reflected in water 	<ul style="list-style-type: none"> - CO_2 gas / CO_3^{2-}, HCO_3^- (12) CaO or CaCO_3 purple - SO_2 gas / SO_3^{2-} (13) SO_3^{2-} or SO_4^{2-} purple - PbO / Pb^{2+} (12) purple
(b) To two spatula end-fuls of X in a test tube, add 4 cm^3 of distilled water, shake and filter. Keep both the filtrate and the residue. Divide the filtrate into three portions.	<ul style="list-style-type: none"> - Partially soluble dissolves - Colourless filtrate - white residue 	<ul style="list-style-type: none"> - Ba^{2+}, Ca^{2+}, Mg^{2+}, Zn^{2+}, Al^{3+}, Pb^{2+}, N^{+4} (14) purple
(i) To the first portion, add 2 – 3 drops of barium nitrate solution followed by dilute nitric acid until in excess.	<ul style="list-style-type: none"> - White ppt disolves in acid with effervescence 	<ul style="list-style-type: none"> - SO_3^{2-} purple suspected (12)

TESTS	OBSERVATIONS	DEDUCTIONS
(ii) To the second portion, add 3-4 drops of iodine solution.	- Brown solution turns colorless	- SO_4^{2-} suspected Confirmed present (OH^-)
(iii) To the third portion, add dilute hydrochloric acid and warm.	- White ppt dissolves on warming	- Pb^{2+} suspected (OH^-)
(c) Wash the residue in (b) with little distilled water and dissolve it in dilute nitric acid. Add dilute sodium hydroxide solution drop-wise until in excess and then filter. Keep the residue for use in part (e)	<ul style="list-style-type: none"> - White residue dissolves in acid with effervescence bubbles of a colourless gas, turns damp blue litmus red and lime water - Colorless solution - White ppt insoluble - White residue - Colorless filtrate 	<ul style="list-style-type: none"> - CO_3^{2-} gas evolved / CO_3^{2-} confirmed (OP) - $\text{Ba}^{2+}, \text{Ca}^{2+}, \text{Mg}^{2+}, \text{Zn}^{2+}$, $\text{Al}^{3+}, \text{Pb}^{2+}$, my not - $\text{Ba}^{2+}, \text{Ca}^{2+}, \text{Mg}^{2+}$, OH^- my (OH^-) - $\text{Ba}^{2+}, \text{Ca}^{2+}, \text{Mg}^{2+}$ - $\text{Zn}^{2+}, \text{Al}^{3+}, \text{Pb}^{2+}$ (OP)
(d) To the filtrate from part (c), add dilute nitric acid drop-wise until the solution is just acidic. Divide the solution into four portions.	- White ppt soluble in acid to form colourless solution	- $\text{Zn}^{2+}, \text{Al}^{3+}, \text{Pb}^{2+}$ my (OH^-)
(i) To the first portion of the acidified solution, add dilute sodium hydroxide solution drop-wise until in excess.	- White ppt soluble	- $\text{Zn}^{2+}, \text{Al}^{3+}, \text{Pb}^{2+}$ my not

TESTS	OBSERVATIONS	DEDUCTIONS
(ii) To the second portion of the acidified solution, add dilute ammonia solution drop-wise until in excess.	- White ppt insoluble	Al^{3+} or Pb^{2+} Al by me Al (OH_4^-)
(iii) To the third portion of the acidified solution, add 2-3 drops of dilute sulphuric acid.	- White ppt	Pb^{2+} Al
(iv) Use the fourth portion of the acidified solution to carry out a test of your own choice to confirm one of the cations in X.	- Fehling ppt	Pb^{2+} confirmed Al
Test: To the fourth portion, add 3 drops of KI solution		
(e) Wash the residue from part (c) with dilute sodium hydroxide, transfer it into a test tube, add dilute nitric acid and shake to dissolve. Divide the resulting solution into four portions.	- White residue dissolve to form a colourless solution	Al - Ba^{2+} , Ca^{2+} Mg^{2+} my two (O_2)
(i) To the first portion, add dilute sodium hydroxide solution drop-wise until in excess.	- White ppt insoluble	Al - Ba^{2+} , Ca^{2+} Mg^{2+} my two

TESTS	OBSERVATIONS	DEDUCTIONS
(ii) To the second portion, add dilute ammonia solution drop-wise until in excess.	- White ppt insoluble	Ba^{2+} or Mg^{2+} by me (OH_2^-)
(iii) To the third portion, add 3-4 drops of sodium sulphate solution.	- White ppt	Ba^{2+} (1)
(iv) Use the fourth portion to carry out a test of your own choice to confirm the second cation in X.		
Test: To the first part, add 3 drops of potassium chromate followed by dilute NaOH (aq).	- Yellow ppt insoluble in NaOH (aq)	Ba^{2+} confirmed (2h)

(f) (i) The cations in X are and
(ii) The anions in X are and

3. You are provided with substance M, which is an organic compound. You are required to carry out the tests in table 4 and determine the nature of M.

Record your observations and deductions in the table.

(20 marks)

Table 4

TESTS	OBSERVATIONS	DEDUCTIONS
(a) Burn a small amount of M on a spatula-end or in a porcelain dish.	- Burns with a yellow min-sooty flame	- Aliphatic cpd with low carbon content (02)
(b) To 1cm ³ of M in a test tube, add 2cm ³ of distilled water and shake. Test the mixture with litmus paper.	- No effect on both blue and red litmus papers	- Polar organic cpd - Neutral cpd (02)
(c) To 0.5 cm ³ of M, add one spatula end-ful of solid sodium carbonate.	- No observable change	- Carboxylic acid absent (01)
(d) To 0.5 cm ³ of M, add 2-3 drops of neutral iron(III) chloride solution.	- No observable change	- Phenol absent (01)
(e) To about 0.5 cm ³ of M, add 2-3 drops of Brady's reagent.	- No observable change	- Carbonyl cpd absent (01)
(f) To 3 cm ³ of M, add 2-3 drops of acidified potassium dichromate solution and warm. Divide the resultant solution into two portions.	- Orange soln turns green	- 1° or 2° alcoh / oxidised to aldehyde / carbonyl or ketone (04)

TESTS	OBSERVATIONS	DEDUCTIONS
(i) To the first portion, add 2-3 drops of Brady's reagent.	- yellow ppt	- Carbonyl cpd formed from the oxidation of 1° or 2° alcohol Aldehyde absent
(ii) To the second portion, add 1 cm^3 of Fehling's solution and heat.	No observable change	- 1° alcohol absent 2° alcohol oxidised to a ketone (83)
(g) To about 1 cm^3 of M, add an equal volume of ethanoic acid followed by 2-3 drops of concentrated sulphuric acid and warm the mixture.	sweet fruity smell	- Ester formed, Esterification of alcohol observed ∴ Alcohol present (82)
(h) To about 1 cm^3 of M, add 2 cm^3 of iodine solution and shake to mix, then add dilute sodium hydroxide solution drop-wise until the brown colour of iodine is just discharged. Allow to stand.	yellow ppt	CH_3 formed, 2° alcohol of the structure $\text{CH}_3\text{C}(=\text{O})\text{OH}$ present (82)

- (i) Describe the nature of M.

M: Aliphatic bending alcohol
with $\text{CH}_3\text{C}(=\text{O})\text{OH}$ in it