Candidate's Name : Muttesasira Julius Kakumba.....

Signature : .....

Random No.					Personal No.		

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

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P525/3
CHEMISTRY
Paper 3
(Practical)
Nov./Dec. 2023
3¼ 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/80
JKM	JKM	JKM	JKM.

Turn Over

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, $Na_2B_4O_7 \cdot 10H_2O$.

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:

$$B_4O_7^{2-}{}_{(aq)} + 2H^+{}_{(aq)} + 5H_2O_{(l)} \longrightarrow 4H_3BO_{3\,(aq)}$$

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

$$Ba^{2+}{}_{(aq)} + CO_3^{2-}{}_{(aq)} \longrightarrow BaCO_{3\,(s)}$$

PART I

Procedure

Weigh accurately 2.4 g of solid **T** and transfer it into a beaker. Add about 100 cm^3 of hot water and stir to dissolve. Transfer the solution into a 250 cm^3 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*)

(01½)

PART II

Procedure

Pipette 25.0 cm^3 (or 20.0 cm^3) 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 ✓ .....cm^3. *(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 ✓

(04½)

(4½ marks)

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

..... (12.00, 12.00) ✓ (01) .....cm^3

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

..... $\frac{12.00+12.00}{2}$ ✓✓ = 12.00 .....

..... ✓ (02½) ..... 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 $Na_2B_4O_7 \cdot 10H_2O$ = 2x23 + 11x4 + 16x7 + 10(18) = 382g ✓

382g of T contain 1mole

2.45g of T contain $\left(\frac{2.4}{382}\right)$ mole ✓

= 0.006 moles ✓ (02½)

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

= 0.024M

Turn Over

Alternatively

⇒ 250 cm³ of FA2 contain 0.006 moles

∴ 1000 cm³ of FA2 contain $\left(\frac{1000 \times 0.006}{250}\right)$ moles

∴ Molarity of FA2 is $= 0.024$

(ii) **FA1 in mol dm^{-3}.** **(3½ marks)**

Moles of FA2 that reacted $= \frac{25 \times 0.024}{1000}$

$= 0.0006$ moles

1 mole of T reacted with 2 moles of HCl

Moles of HCl that reacted $= (2 \times 0.0006)$ moles

$= 0.0012$ moles

Molarity of FA1 $= \left(\frac{1000 \times 0.0012}{12.00}\right)$

$= 0.1\,M$ (03½)

PART III

Procedure

Pipette 25.0 cm^3 (or 20.0 cm^3) of **FA2** into a conical flask, add 6.0 cm^3 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 cm^3. **(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

(04½)

(4½ marks)

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

(16.20, 16.20) ✓ (0½)

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

$\frac{(16.20 + 16.20)}{2}$ ✓✓ = 16.20 ✓ (02½) cm^3.

(b) Calculate the number of moles of;

(i) hydrochloric acid that reacted. *(01 mark)*

Mole of HCl that reacted = $\left(\frac{16.20 \times 0.1}{1000}\right)$ ✓✓

= 0.00162 ✓ (01)

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

$NaOH_{(aq)} + HCl_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$ ✓

1 mole of HCl reacted with 1 mole of NaOH ✓

∴ Mole of NaOH that reacted = 0.00162 ✓ (02)

(c) Determine the mass of;

(i) sodium hydroxide in **FA2** in grammes per litre. *(2½ marks)*

Molarity of NaOH in FA2 = $\frac{1000 \times 0.00162}{25}$ ✓✓

0.0648 M ✓

Molar mass of NaOH = (23×1) + (1×16) + (1×1) = 40g ✓

Mass of NaOH in gl^{-1} = 40 × 0.0648 ✓ (02½)

= 2.592 gl^{-1} ✓

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

Mass of Na_2CO_3 in gl^{-1} = (5 − 2.592) g ✓✓

= 2.408 gl^{-1} ✓ (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. Observation - Colourless condensate, turns anhydrous $CuSO_4$ from white to blue Deduction - Water of crystallisation from a hydrated salt.	- White solid/powder - Colourless gas, turns a damp blue litmus red, lime water milky - Another colourless gas, with an irritating smell, turns, blue, litmus red, turns acidified $K_2Cr_2O_7$ from orange to green - Reddish brown residue when hot, yellow on cooling	- CO_2 gas / CO_3^{2-}, HCO_3^- (02) C_2O_4 or CH_3COO^- ignore - SO_2 gas / SO_3^{2-} (03) or SO_4^{2-} ignore - PbO / Pb^{2+} (02) any two
(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.	- Partially dissolves - Colourless filtrate - White residue (02)	- Ba^{2+}, Ca^{2+}, Mg^{2+}, Zn^{2+}, Al^{3+}, Pb^{2+}, NH_4^+ any two
(i) To the **first** portion, add 2 – 3 drops of barium nitrate solution followed by dilute nitric acid until in excess.	- White ppt dissolves in acid with effervescence	- SO_3^{2-} suspected (02)

TESTS	OBSERVATIONS	DEDUCTIONS
(ii) To the **second** portion, add 3-4 drops of iodine solution.	- Brown solution turns colorless	- SO_3^{2-} suspected Confirmed present (0½)
(iii) To the **third** portion, add dilute hydrochloric acid and warm.	- White ppt dissolves on warming	- Pb^{2+} suspected (0½)
(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)	- 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	- CO_2 gas evolved / CO_3^{2-} confirmed (0½) - $Ba^{2+}, Ca^{2+}, Mg^{2+}, Zn^{2+}, Al^{3+}, Pb^{2+}$ - $Ba^{2+}, Ca^{2+}, Mg^{2+}$ - $Ba^{2+}, Ca^{2+}, Mg^{2+}$ - $Zn^{2+}, Al^{3+}, Pb^{2+}$ (0½) (0½)
(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 colorless solution	- $Zn^{2+}, Al^{3+}, Pb^{2+}$ any two (0½)
(i) To the **first** portion of the acidified solution, add dilute sodium hydroxide solution drop-wise until in excess.	- White ppt Soluble	- $Zn^{2+}, Al^{3+}, Pb^{2+}$ any two

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+} Any one (OH^-)
(iii) To the **third** portion of the acidified solution, add 2-3 drops of dilute sulphuric acid.	- White ppt	Pb^{2+} (01)
(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**. **Test:** To the first portion, add 3 drops of KI solution	- Yellow ppt	Pb^{2+} confirmed (02)
(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 dissolved to form a colourless solution	- Ba^{2+}, Ca^{2+} Mg^{2+} Any two (02)
(i) To the **first** portion, add dilute sodium hydroxide solution drop-wise until in excess.	- White ppt insoluble	- Ba^{2+}, Ca^{2+}, Mg^{2+} Any 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+} any one (01)
(iii) To the **third** portion, add 3-4 drops of sodium sulphate solution.	- White ppt	Ba^{2+} (01)
(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 (02)

(f) (i) The cations in **X** are Pb^{2+} and Ba^{2+}

(ii) The anions in **X** are SO_3^{2-} and CO_3^{2-} (02)

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 non-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.	- Miscible to form a colourless solution - 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 turn green	- 1° or 2° alcohol oxidised to aldehyde / carboxylic acid (01)

(08½)

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 ∴ 1° alcohol absent ∴ 2° alcohol oxidised to a ketone (03)
(ii) To the **second** portion, add 1 cm^3 of Fehling's solution and heat.	No observable change	
(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 ✓ ∴ alcohol present (02)
(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	CHI_3 formed, 2° alcohol of the structure $CH_3-\underset{OH}{\underset{|}{C}}H-$ present (02)

(i) Describe the nature of **M**.

M: Aliphatic ✓ secondary ✓ alcohol ✓ with $CH_3-\underset{OH}{\underset{|}{C}}H-$ in it (02)

1 1/2

END