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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
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**
X	X	X	X
30	30	20	80

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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** = ...35.5....g (½ *mark*)

Mass of the weighing container alone = ...33.1....g (½ *mark*)

Mass of **T** weighed = ...2.4....g (½ *mark*)

Must be recorded to the same decimal points (dps)
⊗ Ignore all if the decimal places are not the same

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

Award for; 25 25.00

Volume of pipette used = ... 25.0 ✓ (½) .....cm^3. (½ mark)

Titration number	**1**	**2**	**3**
Final burette reading (cm^3)	13.20 ✓	25.70 ✓	38.30 ✓
Initial burette reading (cm^3)	0.50 ✓	13.20 ✓	25.70 ✓
Volume of **FA1** used (cm^3)	12.70 ✓	12.50 ✓	12.60 ✓

(4½)

Centre Range ±3.00 (9.50 — 15.50) (4½ marks)

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

..... 12.50, 12.60 ✓ (½) .....cm^3

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

..... $\frac{(12.50 + 12.60)}{2} = 12.55$ ✓ ✓ ✓ (2½) ..... cm^3

±0.1 2½
±0.2 02
±0.3 1½
±0.4 01
±0.5 ½

(b) Calculate the concentration of;

(i) **FA4** in mol dm^{-3}. (2½ marks)

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

Must show working

Molar mass of $Na_2B_4O_7 \cdot 10H_2O$ = (23x2)+(4x11)+(7x16)+(10x18)

= 3829 ✓

3829 g of borax Contain 1 mole ✓

2.49 g of borax Contain $\frac{1 \times 2.4}{382}$ moles ✓

= 0.006282722 51 moles of borax

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250 cm³ of FA4 contain 0.00628272251 moles of borax

1000 cm³ of FA4 contain $\left(\frac{0.00628272251 \times 1000}{250}\right)$ moles of borax

$= 0.025130890095$ mol dm^{-3} (2½)

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

1000 cm³ of FA4 contain 0.025130890095 moles of borax

25 cm³ of FA4 contain $\left(\frac{0.025130890095 \times 25}{1000}\right)$ moles of borax

$= 0.000628272225$ moles of borax

1 mole of $B_4O_7^{2-}$ reacts with 2 moles of H^+ or HCl

0.000628272225 moles of $B_4O_7^{2-}$ (borax) react with $(2 \times 0.000628272225)$ moles

$= 0.001256544450$ moles of HCl acid

12.55 cm³ of FA1 contain 0.001256544450 moles of HCl acid

1000 cm³ of FA1 contain $\left(\frac{0.001256544450 \times 1000}{12.55}\right)$ moles of HCl acid

$= 0.100123067730$ mol dm^{-3} (3½)

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

Award for; 25 25.00

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

Titration number	**1**	**2**	**3**
Final burette reading (cm³)	16.00	31.10	46.20
Initial burette reading (cm³)	0.70	16.00	31.10
Volume of **FA1** used (cm³)	15.30	15.10	15.10

Centre Range ±3.00 (12.30 — 18.30) (4½)

(4½ marks)

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

15.10, 15.10 ✓ (½)

.....cm³.

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

Award (½) for missing the working

$\left(\frac{15.10 + 15.10}{2}\right) = 15.10$ ✓ ✓ (2½)

..... cm³.

±0.1 2½
±0.2 02
±0.3 1½
±0.4 01
±0.5 ½

(b) Calculate the number of moles of;

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

1000 cm³ of FA1 Contain 0.100123067773 moles of HCl aid

15.10 cm³ of FA1 Contain $\left(\frac{0.100123067773 \times 15.10}{1000}\right)$ moles of HCl aid ✓

= 0.00151185832 moles of HCl aid ✓ (01)

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

NaOH(aq) + HCl(aq) ⟶ NaCl(aq) + H₂O(l) ✓

1 mole of HCl acid reacts with 1 mole of NaOH (02)

0.00151185832 moles of HCl acid react with (1×0.00151185832) moles ✓

= 0.00151185832 moles of NaOH ✓

(c) Determine the mass of;

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

25 cm³ of FA2 Contain 0.00151185832 moles of NaOH

1000 cm³ of FA2 Contain $\left(\frac{0.00151185832 \times 1000}{25}\right)$ moles of NaOH ✓

= 0.0604743328 moles of NaOH ✓

Molar mass of NaOH = (23×1) + (16×1) + (1×1) = 40 g ✓ (2½)

1 mole of NaOH weighs 40 g ✓

0.0604743328 moles of NaOH weigh $\left(\frac{40 \times 0.0604743328}{1}\right)$ g ✓

= 2.418973 g/l ✓

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

Mass of sodium Carbonate in FA2 = (5.0 − 2.418973) g ✓

= 2.581039 g/l ✓ (01)

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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.	A white solid A colourless gas that turns lime water milky and moist blue litmus paper red OR A colourless pungent gas that turns moist blue litmus paper red and acidified potassium manganate(VII) from purple to colourless Ignore SO_2 gas A reddish brown solid residue when hot and turns yellow on cooling	Non-transition cations CO_2 gas evolved; CO_3^{2-}, $C_2O_4^{2-}$, CH_3COO^-, HCO_3^- SO_2 gas evolved; SO_4^{2-} or SO_3^{2-} PbO; Pb^{2+} 04
(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 to form; A colourless filtrate A white residue	Non-transition metal cations 1½ Non-transition cations
(i)	To the **first** portion, add 2 – 3 drops of barium nitrate solution followed by dilute nitric acid until in excess.	A white precipitate Soluble in acid without effervescence	$C_2O_4^{2-}$ or SO_3^{2-} 1½

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TESTS	OBSERVATIONS	DEDUCTIONS
(ii) To the **second** portion, add 3-4 drops of iodine solution.	Brown solution turns colourless	SO_3^{2-} (01)
(iii) To the **third** portion, add dilute hydrochloric acid and warm.	Effervescence of a colourless pungent gas; turns moist blue litmus paper red and bleaches it and turns acidified potassium permanganate solution from purple to colourless	SO_2 gas evolved; SO_3^{2-} confirmed (01)
(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).	Effervescence of a colourless gas that turns moist blue litmus paper red and lime water milky A colourless solution formed A white precipitate insoluble A colourless filtrate A white residue	CO_2 gas; CO_3^{2-} confirmed Zn^{2+}, Pb^{2+}, Al^{3+}, Sn^{2+}, Sn^{4+}, Mg^{2+}, Ca^{2+}, Ba^{2+} Mg^{2+}, Ca^{2+} or Ba^{2+} Zn^{2+}, Pb^{2+}, Al^{3+}, Sn^{2+} or Sn^{4+} (-1/2) Mg^{2+}, Ca^{2+} or Ba^{2+}
(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.	A white precipitate soluble to form a colourless solution	Pb^{2+}, Al^{3+}, Zn^{2+}, Sn^{2+} or Sn^{4+} (01)
(i) To the **first** portion of the acidified solution, add dilute sodium hydroxide solution drop-wise until in excess.	A white precipitate soluble to form a colourless solution	Pb^{2+}, Al^{3+}, Zn^{2+}, Sn^{2+} or Sn^{4+} (1/2)

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TESTS	OBSERVATIONS	DEDUCTIONS
(ii) To the **second** portion of the acidified solution, add dilute ammonia solution drop-wise until in excess.	A white precipitate insoluble	Pb^{2+}, Al^{3+}, Sn^{2+} or Sn^{4+} (1½)
(iii) To the **third** portion of the acidified solution, add 2-3 drops of dilute sulphuric acid.	A white precipitate	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:** 3 drops of potassium iodide solution are added OR 3 drops of potassium chromate solution are added followed by dilute sodium hydroxide solution drop-wise until in excess	A yellow precipitate A yellow precipitate soluble in sodium hydroxide solution to form a yellow solution	Pb^{2+} Confirmed (1½) Pb^{2+} Confirmed.
(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.	Dissolves to form a colourless solution	Mg^{2+}, Ca^{2+} or Ba^{2+} (01)
(i) To the **first** portion, add dilute sodium hydroxide solution drop-wise until in excess.	A white precipitate insoluble	Mg^{2+}, Ca^{2+} or Ba^{2+} (1½)

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TESTS	OBSERVATIONS	DEDUCTIONS
(ii) To the **second** portion, add dilute ammonia solution drop-wise until in excess.	A white precipitate insoluble	Mg^{2+} or Ba^{2+} (1½)
(iii) To the **third** portion, add 3-4 drops of sodium sulphate solution.	A white precipitate	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:** 3 drops of potassium chromate(VI) solution are added followed by dilute sodium hydroxide solution drop-wise until in excess	Yellow precipitate insoluble in sodium hydroxide solution	Ba^{2+} Confirmed (02)

Accept Ammonium oxalate solution followed by ethanoic acid

(f) (i) The cations in **X** are Pb^{2+} d(iv) and Ba^{2+} e(iv) (02)

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

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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 saturated Compound with low Carbon Content present
(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 with water to form a colourless solution The solution has no effect on both blue and red litmus papers	Polar aliphatic compound with low molecular mass present Neutral Compound presently Carbonyls or alcohols present.
(c)	To 0.5 cm^3 of **M**, add one spatula end-ful of solid sodium carbonate.	No observable change	Carboxylic acid absent
(d)	To 0.5 cm^3 of **M**, add 2-3 drops of neutral iron(III) chloride solution.	No observable change	Phenol absent
(e)	To about 0.5 cm^3 of **M**, add 2-3 drops of Brady's reagent.	No observable change	Carbonyl compound absent
(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.	An orange solution turns green	A reducing compound present, Primary or Secondary alcohol present

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	TESTS	OBSERVATIONS	DEDUCTIONS
(i)	To the **first** portion, add 2-3 drops of Brady's reagent.	A yellow precipitate formed	Carbonyl compound formed from an oxidation of primary or secondary alcohol
(ii)	To the **second** portion, add 1 cm^3 of Fehling's solution and heat.	No observable change	Aldehyde not formed; secondary alcohol oxidised to a ketone.
(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 or pleasant fruity smell	Ester formed; Secondary alcohol confirmed present
(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.	A yellow precipitate formed	CHI_3 formed; A secondary alcohol with a methyl group attached on carbon carrying a hydroxyl-group Probable structure; $CH_3-\underset{OH}{\underset{\vert}{C}}-R$

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

M is an aliphatic secondary alcohol with a methyl group attached on carbon carrying a hydroxyl group that is $CH_3-\underset{OH}{\underset{\vert}{C}}-R$

END

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