

Candidate's Name : **MARKING GUIDE**

Signature :

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

3½ 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	80

1. You are provided with the following:

30

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.

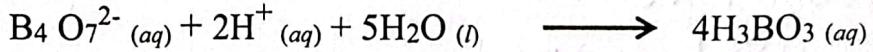
Solid T, which is sodium tetraborate decahydrate, $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$.

You are required to;

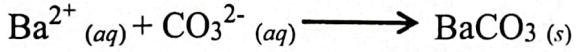
- (i) standardise the solution of hydrochloric acid, FA1.
- (ii) determine the composition of the mixture in FA2.

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.

- Accept masses recorded to 1dp or 2dp

Mass of the weighing container + T = 32.60 g ✓ (½ mark)

Mass of the weighing container alone = 30.20 g ✓ (½ mark)

Mass of T weighed = 3.40 g (1) (½ mark)

- Reject masses recorded to no dp

- Reject the mass of the container alone = zero

- Reject the mass of container + T less than the mass of container alone

- Check out for the correct subtraction of the masses

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 = 25/25.0/25.00 cm³. (½ mark)

Titration number	1	2	3
Final burette reading (cm ³)	14.50	27.70	18.20
Initial burette reading (cm ³)	0.00	14.50	5.00
Volume of FA1 used (cm ³)	14.50	13.20	13.20

Centre Range ±3 (4½ marks) (1½)

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

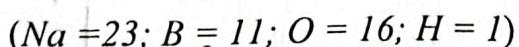
13.20, 13.20 ✓ (±0.1 cm³ agree) (1)

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

$$\frac{13.20 + 13.20}{2} = 13.20$$

- (b) Calculate the concentration of;

- (i) FA4 in mol dm⁻³. (2½ marks) 5 → $\frac{1}{2}$ mks



Molar mass of Na₂B₄O₇ · 10H₂O = (23 × 2) + (11 × 4) + (16 × 7) + 10(18)

382 g of Borax contain 1 mole = 382 g

2.4 g of Borax contain $\frac{2.4}{382}$ moles = 6.2827×10^{-3} (2)

25.0 cm³ of solution FA4 contain 6.2827×10^{-3} moles of borax.

1000 cm³ of solution FA4 contain $\frac{(6.2827 \times 10^{-3}) \times 1000}{250}$ moles

Deny Rfm with units

Deny Rfm with out working or wrong working

$$= 0.02513 \text{ mol dm}^{-3}$$

Turn Over

10½

ALTERNATIVE

250 cm³ of FA4 contain 2.4 g of borax ✓
 1000 cm³ of FA4 contain $\frac{(2.4 \times 1000)}{250}$ g = 9.6 g per litre

Molar mass of Na₂B₄O₇ · 10H₂O = (23×2) + (11×4) + (16×7) + 10(18) = 382 g

382 g of borax contain 1 mole

9.6 g of borax contain $\frac{9.6}{382}$ moles = 0.02513 mol dm⁻³

1000 cm³ of FA4 contain 0.02513 moles of borax (3½ marks)

25 cm³ of FA4 contain $\frac{0.02513 \times 25}{1000}$ moles = 6.2825 × 10⁻⁴

Pipette volume

1 mole of borax(FA4) reacts with 2 moles of FA1 (HCl)

6.2825 × 10⁻⁴ moles of borax reacts with $(2 \times 6.2825 \times 10^{-4})$

$$= 1.2565 \times 10^{-3} \text{ moles}$$

→ 13.20 cm³ of FA1 contain 1.2565 × 10⁻³ moles of acid (3½)

Average Volume of Table I 1000 cm³ of FA1 contain $\frac{1.2565 \times 10^{-3} \times 1000}{13.20}$ moles = 0.0952 mol dm⁻³

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 / 25.0 / 25.00 cm³. (½ mark)

Titration number	1	2	3
Final burette reading (cm ³)	16.30	31.70	25.40
Initial burette reading (cm ³)	0.00	16.30	10.00
Volume of FA1 used (cm ³)	16.30	15.40	15.40

Centre Range ±3

(4½ marks)

4½

4

108½

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

~~15.40, 15.40~~ ✓ $\frac{1}{2}$ mark
 $\frac{1}{2} \text{ cm}^3$ agree

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

~~$$\frac{15.40 + 15.40}{2} = 15.40$$~~

$\frac{1}{2} \rightarrow 2\frac{1}{2} \text{ mks}$
 $\frac{1}{2} \rightarrow 2 \text{ mks}$
 $\frac{1}{2} \rightarrow 1\frac{1}{2} \text{ mks}$
 $\frac{1}{2} \rightarrow 1 \text{ mks}$
 $\frac{1}{2} \rightarrow \frac{1}{2} \text{ mks}$

- (b) Calculate the number of moles of;

- (i) hydrochloric acid that reacted.

1000 cm³ of FA1 contain 0.0952 moles of acid

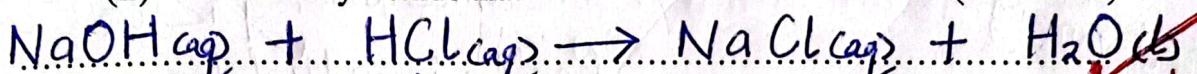
~~$$15.40 \text{ cm}^3 \text{ of FA1 contain } \frac{(0.0952 \times 15.4)}{1000} \text{ moles}$$~~

(1)

$= 1.46608 \times 10^{-3}$

- (ii) sodium hydroxide that reacted.

(02 marks)



1 mole of HCl reacts with 1 mole of NaOH

~~1.46608 \times 10^{-3}~~ moles of HCl react with ~~1.46608 \times 10^{-3}~~ moles of NaOH

(2)

- (c) Determine the mass of;

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

~~25 cm³ of FA2 contain 1.46608 \times 10^{-3}~~ moles of NaOH

~~1000 cm³ of FA2 contain (1.46608 \times 10^{-3} \times 1000)~~ moles = 0.0586 M

Deduct from with units

Deduct from without working or wrong working

Molar mass of NaOH = (3×1) + (16×1) + (1×1) = 40 g

1 mole weighs 40 g of NaOH

0.0586 mole weigh $(40 \times 0.0586) \text{ g} = 2.344 \text{ g per litre}$

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

~~Mass of Na₂CO₃ = (5 - 2.344) g = 2.656 g per litre~~

should be from c(i) and in g per litre

c(i) Molar mass of NaOH = 23 + 16 + 1 = 40 g

Mass of NaOH in 25 cm³ of FA2 = $(40 \times 1.46608) \text{ g} \times \frac{3}{1000} = 0.0586$

25 cm³ of FA2 contain 0.0586 g of NaOH

1000 cm³ of FA2 contain $(\frac{0.0586 \times 1000}{25}) \text{ g} = 2.346 \text{ g per litre}$

ALT FOR

09 1/2

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.

30

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.	<p>X is a white solid Colourless liquid or Condensate turned white anhydrous Copper(II)sulphate from white to blue Colourless gas turned CO_2 gas evolved moist blue litmus to red and lime water milky Residue is reddish brown when hot and yellow when cooling</p>	<p>Non-transition metal ions (Zn^{2+}, Ba^{2+}, Mg^{2+}, Pb^{2+}, etc.) Water of crystallisation evolved hence X is hydrated</p> <p>⑥ $\text{C}_2\text{O}_4^{2-}$ or CH_3COO^- PbO formed, Pb^{2+}</p>
(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.	<p>Partially soluble in water Colourless filtrate White residue</p>	<p>Non-transition cations (Zn^{2+}, Ba^{2+}, Al^{3+}, Mg^{2+} etc.) Non-transition cations (Zn^{2+}, Al^{3+}, Pb^{2+} etc.)</p> <p>②</p>
(i) To the first portion, add 2 – 3 drops of barium nitrate solution followed by dilute nitric acid until in excess.	<p>White precipitate Soluble in acid</p>	<p>PO_4^{3-} or SO_4^{2-} or $\text{C}_2\text{O}_4^{2-}$</p> <p>①</p>

TESTS	OBSERVATIONS	DEDUCTIONS
(ii) To the second portion, add 3-4 drops of iodine solution.	<u>Brown solution turns to colourless</u>	SO_3^{2-} ✓ (1)
(iii) To the third portion, add dilute hydrochloric acid and warm.	<u>No observable change in cold</u> <u>On warming bubbles effervescence of a colourless gas that turned orange solution of potassium dichromate (VI) to green or Acidified potassium</u>	SO_3^{2-} ✓ (2)
(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).	<u>Manganate(VII) from purple to colourless</u> <u>Residue dissolves to form colourless solution</u> <u>Bubbles of colourless gas that turned wet blue litmus red and lime water milky</u> <u>White precipitate insoluble</u> Ca^{2+} , Mg^{2+} or Ba^{2+} <u>Colourless filtrate</u> Zn^{2+} , Pb^{2+} or Al^{3+}	CO_3^{2-} ✓ confirmed (5)
(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.	<u>White residue</u> <u>White precipitate soluble in acids to form a colourless solution</u>	Zn^{2+} , Pb^{2+} or Al^{3+} (1)
(i) To the first portion of the acidified solution, add dilute sodium hydroxide solution drop-wise until in excess.	<u>White precipitate soluble in excess</u>	Zn^{2+} , Pb^{2+} or Al^{3+} (1)

TESTS	OBSERVATIONS	DEDUCTIONS
(ii) To the second portion of the acidified solution, add dilute ammonia solution drop-wise until in excess.	<u>White precipitate</u> <u>insoluble</u>	\checkmark Pb^{2+} or Al^{3+} 1
(iii) To the third portion of the acidified solution, add 2-3 drops of dilute sulphuric acid.	<u>White precipitate</u> <u>formed</u>	\checkmark Pb^{2+} 1
(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: <u>Add potassium iodide solution</u>	<u>Yellow precipitate</u>	\checkmark Pb^{2+} 1½
DR <u>Potassium chromate(VI)</u> out of solution followed by sodium hydroxide solution et al. dilute nitric acid white precipitate VI or V (e) Wash the <u>residue</u> 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. <u>Rej White precipitate</u> <u>soluble in acid</u>	<u>Yellow precipitate</u> <u>Soluble</u> <u>Residue dissolves</u> <u>to form a Colourless</u> <u>Solution</u>	\checkmark Ca^{2+}, Mg^{2+} or Ba^{2+} 1
(i) To the first portion, add dilute sodium hydroxide solution drop-wise until in excess.	<u>White precipitate</u> <u>insoluble</u>	\checkmark Ca^{2+}, Mg^{2+} or Ba^{2+} 1

TESTS	OBSERVATIONS	DEDUCTIONS
(ii) To the second portion, add dilute ammonia solution drop-wise until in excess.	<u>White precipitate</u> <u>insoluble</u>	Mg^{2+} or Ba^{2+} 1
(iii) To the third portion, add 3-4 drops of sodium sulphate solution.	<u>White precipitate</u>	Ba^{2+} 0
(iv) Use the fourth portion to carry out a test of your own choice to confirm the second cation in X. Test: Add potassium chromate(VI) solution followed by sodium hydroxide or ethanoic acid	<u>Yellow precipitate</u> <u>insoluble</u>	Ba^{2+} 1½

except Ammonium oxalate solution
followed by ethanoic acid
and warm

- (f) (i) The cations in X are Pb^{2+} d(iv) and Ba^{2+} e(iv)
(ii) The anions in X are SO_4^{2-} b(ii) or b(iii) and CO_3^{2-} c(2)

5½

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.

20

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.	Colourless liquid burns with a non-sooty flame.	Aliphatic compound with low carbon content (2)
(b) To 1 cm ³ of M in a test tube, add 2 cm ³ of distilled water and shake. Test the mixture with litmus paper.	Miscible/soluble / dissolves to form a colourless solution that has not effect on litmus.	Polar Compound with a low molecular weight Neutral compound (Carbonyl compound) (25) (alcohols etc)
(c) To 0.5 cm ³ of M, add one spatula end-ful of solid sodium carbonate.	No observable change	Carboxylic acid absent (1)
(d) To 0.5 cm ³ of M, add 2-3 drops of neutral iron(III) chloride solution.	No observable change	Phenol absent (1)
(e) To about 0.5 cm ³ of M, add 2-3 drops of Brady's reagent.	No observable change <i>(Or both ketone and aldehyde absent)</i>	Carbonyl compound absent (15)
(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 solution turned to green. <i>(Reject reducing agent alone)</i>	Reducing agent probably; primary alcohol, secondary alcohol present (2)

OR Reducing agent other than aldehyde and methanoic acid present.

OR Primary alcohol oxidised to ~~aldehyde~~
Secondary alcohol oxidised to ketone

TESTS	OBSERVATIONS	DEDUCTIONS
(i) To the first portion, add 2-3 drops of Brady's reagent.	Yellow/orange precipitate formed	Carbonyl compound formed from oxidation of either Primary alcohol or Secondary alcohol (2)
(ii) To the second portion, add 1 cm ³ of Fehling's solution and heat.	No observable change or No reddish-brown precipitate formed	Aldehydes not formed, Secondary alcohol oxidised to ketone (2)
(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/Esterification occurred Secondary alcohol confirmed (2)
(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.	Pale yellow precipitate formed	Secondary alcohol with a methyl group attached to the carbon atom with a functional group or hydroxyl group. (2)

- (i) Describe the nature of M.

M is an aliphatic secondary alcohol (a) (g) (f) or (f)(ii)
with a methyl group (h) directly attached to the (2)
carbon atom with a functional group / hydroxyl group.
or M is an aliphatic secondary alcohol with the
structure $\text{CH}_3\text{CH}(\text{OH})$