1. You are provided with the following;

FA1 which is 1M hydrochloric acid solution

FA2 which is approximately 1M sodium hydroxide solution

FA3 which is a 0.1Msulphuric acid

Solid T, which is impure tribasic acid H_3X

You are required to;

- **Standardize solution FA2 using FA1**
- **Determine the percentage purity of solid T using FA2 and FA3.**

Theory

Sodium hydroxide reacts with the acids according to the equations below:

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

$$3NaOH_{(aq)} + H_3X_{(aq)} \longrightarrow Na_3X_{(aq)} + 3H_2O_{(l)}$$

Procedure A:

a) Pipette $10cm^3$ of **FA2** into a clean conical flask followed by 2drops of phenolphthalein indicator and then titrate with **FA1** from the burette until the end point. Repeat the titration until you obtain consistent readings. Enter your results in the table I below:

Table I

Volume of pipette used = 10.0 cm^3 (½ marks)

Experiment	I	II	III
Final burette reading $/cm^3$	9.90	19.90	29.90
Initial burette reading $/cm^3$	0.00	10.00	20.00
Volume of **FA 1** used $/cm^3$	9.90	9.90	9.90

(4½ marks)

Titre values used to calculate average volume of FA1 (½ marks)

9.90 and 9.90

Therefore Average volume of FA1 = $\frac{9.90+9.90}{2}$ = 9.90 cm^3. (2 ½ marks)

±0.1
±0.2
±0.3
±0.4
±0.5

Questions

Calculate the molar concentration of in FA2. (4 ½ marks)

1000cm³ of FA1 Contains 1 mole of HCl

9.90cm³ of FA1 Contains $\left(\frac{1 \times 9.90}{1000}\right)$ moles of HCl $= 9.9 \times 10^{-3}$ m

1 mole of HCl reacted with 1 mole of NaOH

9.9×10^{-3} moles of HCl reacted with 1 mole of $\left(\frac{9.9 \times 10^{-3} \times 1}{1}\right)$ moles $= 9.9 \times 10$

10.0cm³ of FA2 Contains 9.9×10^{-3} moles of NaOH

1000cm³ of FA2 Contains $\left(\frac{9.9 \times 10^{-3} \times 1000}{10.0}\right)$ moles of NaOH

Procedure B

b) Weigh accurately 3.4g of **T** and add about 50cm^3 of water in a beaker. Stir to dissolve and transfer the contents of the beaker into a 250cm^3 volumetric flask. Make up to the mark with distilled water. Label the resultant solution **FA4**.

c) Pipette 10cm^3 of **FA4** into a conical flask. Add 10cm^3 of **FA2** using a measuring cylinder. Titrate the mixture with solution **FA3** from the burette until the end point. Repeat the titration until you obtain consistent readings. Enter your results in table II below.

Table II

Mass of empty bottle + T = 23.40 g

Mass of empty bottle alone = 20.00 g

Mass of T alone = 3.40 g 2

Volume of pipette used = 10.0 cm^3 (2marks)

Experiment	I	II	III
Final burette reading /cm^3	39.10	49.00	44.00
Initial burette reading /cm^3	0.00	10.00	5.00
Volume of FA 1 used /cm^3	39.10	39.00	39.00

$4\frac{1}{2}$

Titre values used to calculate average volume of FA1 used are

39.00 and 39.00 cm^3 (½ marks)

Therefore average volume of FA1 used = $\frac{39.00+39.00}{2}$ cm^3 (2½ marks)

$= 39.00$

±0.1 ±0.2 ±0.3 ±0.4 ±0.5

Questions

d) Calculate the number of moles of;

i) Sulphuric acid that reacted with the excess sodium hydroxide in FA4.

(1½ marks)

1000cm^3 of FA3 contains 0.1 moles of H_2SO_4 1½

39.00cm^3 of FA3 contains $\left(\frac{0.1 \times 39.00}{1000}\right)$ moles of H_2SO_4

$= 3.9 \times 10^{-3}$ moles

(ii) Sodium hydroxide in 10cm^3 of FA2 added to FA4 (1½ marks)

$2NaOH_{(aq)} + H_2SO_{4(aq)} \longrightarrow Na_2SO_{4(aq)} + 2H_2O_{(l)}$

1 mole of H_2SO_4 reacted with 2moles of NaOH 1½

3.9×10^{-3} moles of H_2SO_4 reacted with $\left(\frac{2 \times 3.9 \times 10^{-3}}{1}\right)$ moles

$= 7.8 \times 10^{-3}$ moles.

ii) tribasic acid in 10cm^3 of **FA4** that reacted with sodium hydroxide (1marks)

moles added $= \left(\frac{10 \times 0.99}{1000}\right)$ moles $= 9.9 \times 10^{-3}$ moles

moles of NaOH ~~that~~ reacted with T $= (9.9 \times 10^{-3} - 7.8 \times 10^{-3}) = 2.1 \times 10^{-3}$ moles

3moles of NaOH reacted with 1mole of T

2.1×10^{-3} moles of NaOH reacted with $\left(\frac{2.1 \times 10^{-3} \times 1}{3}\right) = 7.0 \times 10^{-4}$ moles

e) Determine the percentage purity of **T** (H=1 X= 189) (2½ marks)

10cm^3 of FA4 contains 7.0×10^{-4} moles of T

250cm^3 of FA4 contains $\left(\frac{7.0 \times 10^{-4} \times 250}{10}\right)$ moles of T $= 0.0175$ moles

Rfm of T $= (1 \times 3) + (189)$
$= 192$

1mole of T weighs 192g

0.0175moles of T weighs (192×0.175)g $= 3.36$g 4

%age purity $= \frac{3.36}{3.4} \times 100\% = 98.8\%$

2. You are provided with substance **Y** which contains three cations and one anion. You are required to carry out the following tests on **Y** to identify the cations and anion in it. Identify any gases evolved. Record your observations and deductions in the table below.

Tests	Observations	Deductions
a). Heat a spatula end-ful of **Y** in a dry test tube until there is no further change.	Y is a mixture of white and brown crystals - Colourless gas that turns red litmus paper blue, ~~and~~ forms dense white fumes with HCl - colourless gas that turns acidified $K_2Cr_2O_7$ green - Brown residue	Zn^{2+}, Al^{3+}, Fe^{3+} or Pb^{2+} NH_3, NH_4^+ SO_2, SO_4^{2-} Fe_2O_3, Fe^{3+}
b) Shake two spatula end-ful of **Y** in a boiling tube with about 3cm^3 of water. Add dilute sodium hydroxide solution to the mixture drop wise until in excess. Warm and filter keep both the filtrate and the residue.	- Brown solution - Brown ppt insoluble in excess NaOH - Colourless gas that turns damp ~~blue~~ red litmus paper blue and dense white fumes with HCl - Brown residue - Colourless filtrate	Fe^{3+} Fe^{3+} NH_3 ∴ NH_4^+ Fe^{3+} ~~Zn^{2+}, Al^{3+}, Pb^{2+}~~

c) To the filtrate, add dilute nitric acid drop wise until the solution is just acidic. Divide the acidic solution into six parts.	~~White~~ White ppt soluble forming colourless solution	Zn^{2+}, Al^{3+} or Pb^{2+}
i) To the first part of the acidic solution, add dilute sodium hydroxide solution drop wise until in excess.	White ppt soluble forming colourless solution	Zn^{2+}, Al^{3+} or Pb^{2+}
ii) To the second part of the acidic solution, add dilute ammonia solution drop-wise until in excess.	White ppt insoluble	Al^{3+} or Pb^{2+}
iii) To the third part of the acidic solution, add 2-3 drops of potassium iodide solution.	No observable change	Pb^{2+} absent ∴ Al^{3+} present
iv) To the fourth part of the acidic solution, add 2-3 drops of litmus solution followed by ammonia solution drop-wise until in excess.	Blue lake solution	Al^{3+} confirmed present
v) To the fifth part of the acidic solution, add 2-3 drops of lead (II) nitrate solution and heat.	White precipitate insoluble on heating	SO_4^{2-}
vi) Use the sixth part to carry out a test of your own choice to confirm the anion in Y Add $Ba(NO_3)_2$ followed by HNO_3 / $BaCl_2$ and HCl	White ppt insoluble in the acid	SO_4^{2-} confirmed
d) Wash the residue with water and dissolve it in dilute hydrochloric acid and divide the solution into three parts.	Brown solution	Fe^{3+}

i) To the first part of the acidic solution, add dilute sodium hydroxide solution drop-wise until in excess.	Brown ppt insoluble	Fe^{3+}
ii) To the second part of the acidic solution, add dilute ammonia solution drop wise until in excess.	Brown ppt Insoluble	Fe^{3+}
iii) To the third part of the acidic solution add 3-4 drops of potassium thiocyanate solution.	Blood-red Colouration	Fe^{3+} Confirmed present

The cations in Y

are..............NH_4^+..........Al^{3+}..............and............Fe^{3+}..............................

The anion in Y is ....SO_4^{2-}..................

3. You are provided with an organic compound Q. You are required to identify the nature of compound Q. Carry out the following tests on the compound and record your observations and deductions in the table below.

Tests	Observations	Deductions
• Burn a spatula end-ful of Q on a porcelain dish or at the end of a spatula.	Q burns with a yellow/blue non-sooty flame	Q is a saturated aliphatic organic compound of low carbon content.
• Shake 1cm^3 of Q with about 2cm^3 of water and test with litmus.	Q was miscible with water. Has no effect on the litmus paper	Polar organic compound of low molecular mass. Neutral organic compound. Probably carbonyl or alcohol
• To 0.5cm^3 of Q add 2-3 drops of sodium carbonate solution.	No effervescence or No bubbles	Carboxylic acid absent
• To 0.5cm^3 of Q, add 2-3 drops of acidified potassium dichromate solution and heat.	The orange colour turns green	Reducing agent probably primary alcohol, secondary alcohol or aldehyde

• To 0.5cm³ of Q, add 2-3 drops of Brady's reagent.	No yellow precipitate or No observable change	Carbonyl compound absent.
• To about 1cm³ of Q, add acidified potassium dichromate solution and heat. Then add ethanol followed by 4-5 drops of concentrated sulphuric acid. Pour the mixture into a small beaker of cold water	Sweet fruity smell.	Ester formed Primary alcohol oxidised to carboxylic acid
• To about 0.5cm³ of Q, add about 4cm³ of iodine solution followed by sodium hydroxide solution drop-wise until the brown color of iodine is just discharged. Warm the mixture and allow to stand.	Yellow precipitate	Ethanol
• To about 1cm³ of Q, add about 5 drops of tollen reagent and heat gently	No Silver mirror	Aldehyde absent

Comment on the nature of Q

Q is a saturated aliphatic primary alcohol with a methyl group on the same carbon as the hydroxyl group. or Ethanol

END

18½