Instructions

1. This paper consists of two questions.

2. Answer all questions.

1. You are provided with the following solutions:

1.1 Solution R containing 4 g of pure sodium hydroxide per cubic decimeter of solution

1.2 Solution Q containing 5.2 g of impure sulphuric acid in 1 litre

1.3 Methyl orange indicator

PROCEDURE

Pipette 25.00 cm³ of solution R into a conical flask. Add few drops of methyl orange indicator. Titrate the solution against Q until a colour change is observed.

Repeat the procedure to obtain three more readings and record your results in tabular form as shown below:
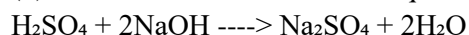
(a)

(i) Table of results:

Titration	Final reading (cm³)	Initial reading (cm³)	Volume used (cm³)
Pilot	24.80	0.00	24.80
1	25.00	0.00	25.00
2	25.00	0.00	25.00
3	24.90	0.00	24.90

(ii) Volume of pipette used was 25.00 cm³

(iii) Summary: 25.00 cm³ of solution R required 24.97 cm³ of solution Q for complete reaction

(b) Write down a well balanced equation for this reaction

$H_2SO_4 + 2NaOH ----> Na_2SO_4 + 2H_2O$

(c)

(i) Calculate the molarity of R

Mass of NaOH = 4 g

Molar mass = 40 g/mol

Moles = 4 ÷ 40 = 0.1 mol

Volume = 1 dm³

Molarity = 0.1 mol/dm³

(ii) Calculate the molarity of Q

Moles of NaOH in 25 cm³ = 0.1 × 0.025 = 0.0025 mol

From equation: 2 mol NaOH react with 1 mol H_2SO_4

Moles of H_2SO_4 = 0.0025 ÷ 2 = 0.00125 mol

Volume of Q used = 24.97 cm³ = 0.02497 dm³

Molarity of Q = 0.00125 ÷ 0.02497 = 0.05004 mol/dm³

(iii) Calculate the concentration of pure sulphuric acid in g/dm³

Molar mass of H_2SO_4 = 98 g/mol

Concentration = $0.05004 \times 98 = 4.90$ g/dm³

(iv) Calculate the percentage purity of sulphuric acid
Given mass = 5.2 g
Pure mass = 4.90 g
Purity = $(4.90 \div 5.2) \times 100 = 94.23\%$

(d) The colour change during titration was from yellow to pink-orange

2. Sample Z is a pure salt containing ONE cation and ONE anion. Carry out carefully all the experiments described below. Record all your observations and make appropriate inferences to identify the ions present in sample Z.

Test   Experiment   Observation   Inference
1.1   Appearance of solid sample Z   White crystalline solid   Colourless ionic salt
1.2   Place a spatulaful of Z in a dry test tube and heat   No gas evolved   No water of crystallization
1.3   To a little amount of sample Z in a test tube add concentrated H_2SO_4 and Cu turnings   Brown gas evolved (NO_2) NO_3^- confirmed
1.4   To a solution of Z add ammonia solution dropwise till no further change   Light blue precipitate, soluble in excess   Confirms Cu^{2+}
1.5   To another solution of Z add potassium ferrocyanide solution   Reddish-brown precipitate   Confirms Cu^{2+}
1.6   To another solution of Z add freshly prepared $FeSO_4$ followed by conc. H_2SO_4 No brown ring seen   Confirms absence of NO_3^- (already confirmed)
1.7   To a solution of Z add potassium thiocyanate solution   No red colour formed Absence of Fe^{3+}

Conclusion
Cation in sample Z is Cu^{2+}
Anion in sample Z is NO_3^-
The compound is $Cu(NO_3)_2$

3. Sample P is a simple salt containing ONE cation and ONE anion. Using systematic qualitative analysis procedures, carry out tests on sample P and make appropriate observations and inferences.

Test   Experiment   Observation   Inference
(a)   Observe the physical appearance of solid P   Blue crystalline solid Suggests presence of Cu^{2+}
(b)   Heat a little of solid P in a dry test tube   No water droplets or gas evolved No water of crystallization
(c)   Dissolve a spatula of P in distilled water and shake   Blue solution forms Confirms solubility and Cu^{2+}

(d) Add NaOH dropwise and then in excess to solution of P   Blue precipitate formed, insoluble in excess   Confirms Cu^{2+} as $Cu(OH)_2$

(e) Add aqueous NH_3 dropwise and then in excess   Deep blue solution formed Confirms Cu^{2+} as $[Cu(NH_3)_4]^{2+}$

(f) Add $AgNO_3$ to solution of P followed by dilute HNO_3 White precipitate formed, soluble in NH_3 Confirms Cl^- as AgCl

(g) Add $BaCl_2$ to solution of P followed by dilute HCl   No precipitate Absence of SO_4^{2-}

(h) Add $Pb(NO_3)_2$ to solution of P   No precipitate   Absence of CO_3^{2-}

(i) Perform flame test on solid P   No distinct flame colour Confirms non-alkali metal

(j) Add potassium chromate to solution of P   No precipitate Confirms absence of Ba^{2+}

Conclusion
The cation in sample P is Cu^{2+}
The anion in sample P is Cl^-