THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL

CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

NOVEMBER 1996

032/2

CHEMISTRY PAPER 2

ALTERNATIVE TO PRACTICAL

(For Both School and Private Candidates)

TIME: 3 Hours

INSTRUCTIONS

1. This paper consists of sections A, B and C.
2. Answer ALL questions in each section.
3. Wherever calculations are involved, show clearly all the steps required.
4. Remember to write your Examination Number on every page of your answer book provided.
5. The marks intended for each question are indicated in brackets.
6. For your calculations you may use the following:
   (i) Atomic masses: H = 1, O = 16, C = 12, Cl = 35.5, S = 32, Na = 23, Al = 27, Cu = 64
   (ii) 1 Faraday = 96,500 coulombs
   (iii) Gram-molecular volume (GMV) = 22.4 dm^4

This paper consists of 9 printed pages.

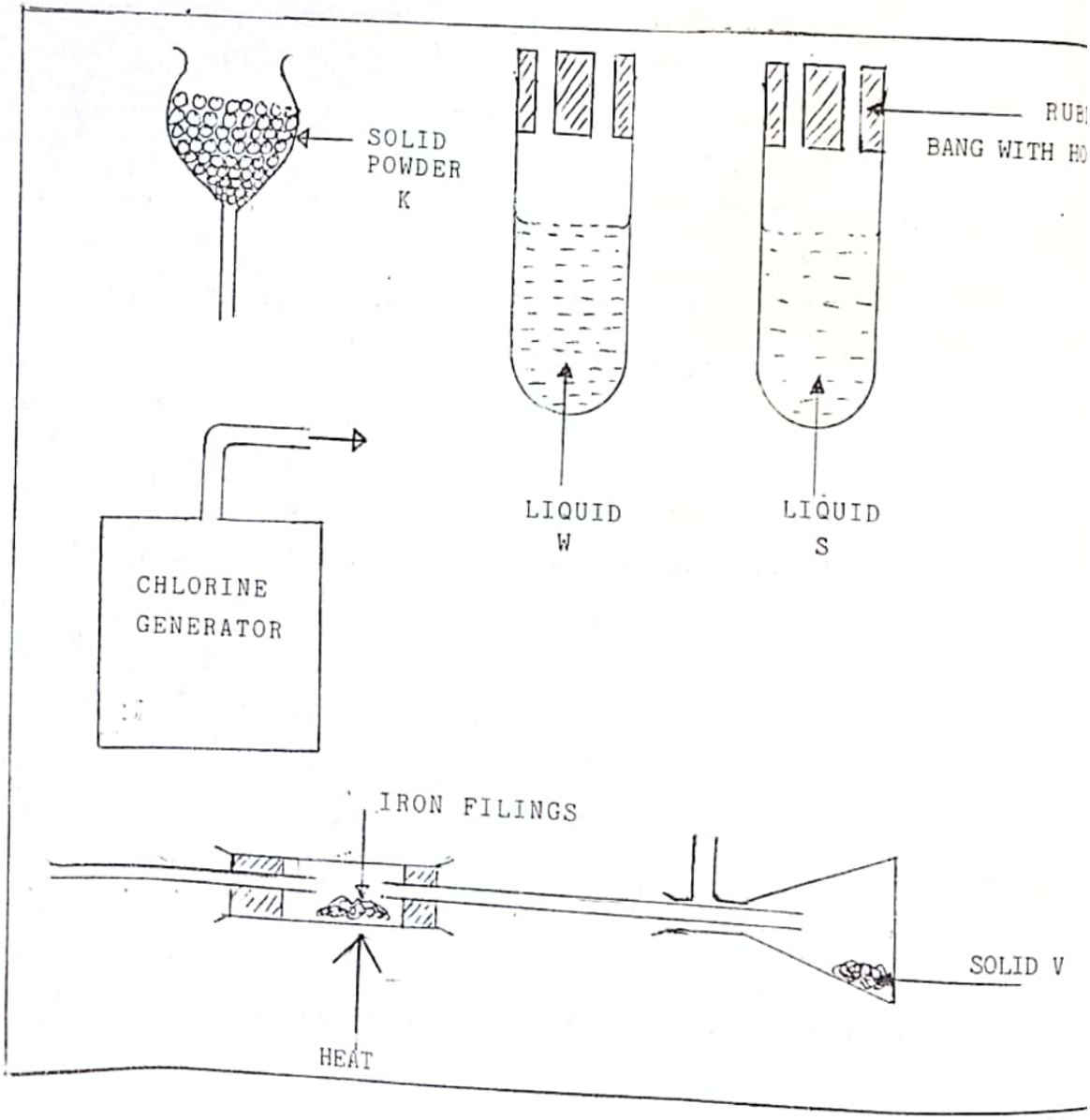
SECTION A

Answer ALL questions in this section.

1. Chlorine gas was produced in a gas generator in the laboratory by adding concentrated hydrochloric acid on potassium permanganate crystals. The chlorine gas contained two gaseous impurities C and D, which were removed by bubbling the gas through liquid W and liquid S respectively.

The pure chlorine gas was passed over red hot iron filings, which was oxidized to produce solid V. A solid powder K was used to prevent solid V from reacting with water vapour in the a

The main apparatus and materials which were used in this experiment are shown in the figure below.



(a) Draw a diagram which joins the pieces of apparatus together as they appear in the figure. Delivery tubes of any shape may be used.

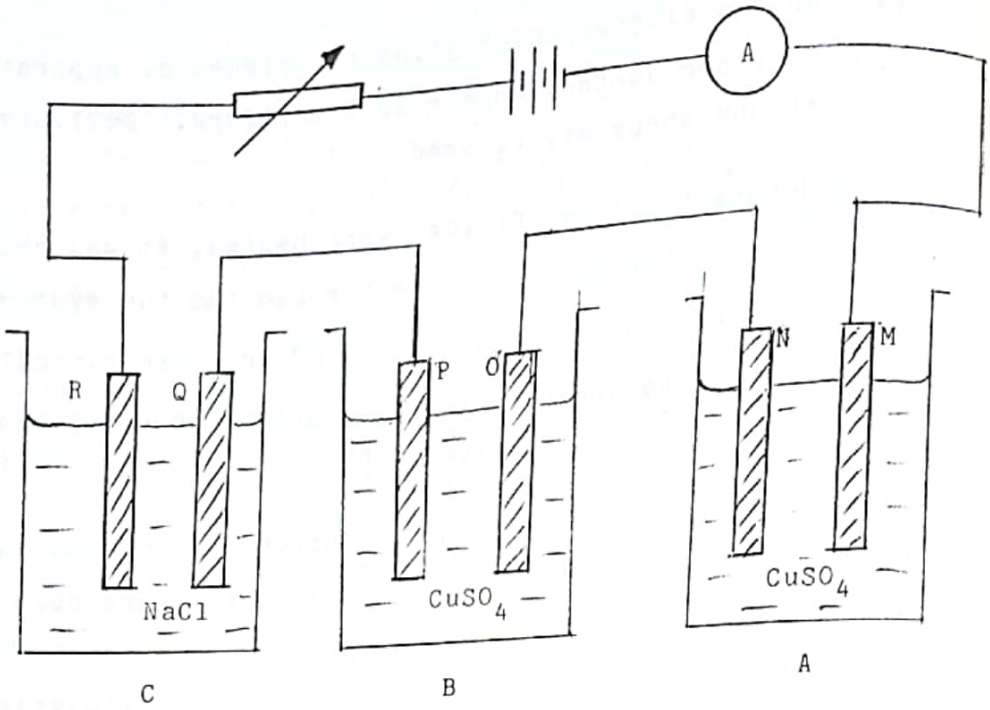
(b) Before the iron filings were heated, it was necessary to pass the pure chlorine through the the system. Why?

(c) What do you think is the aim of this experiment?

(d) Write a balanced chemical equation for the formation of solid V in this experiment. (13 marks)

2. In an electrolysis experiment, a current of 5A was passed through the electric circuit shown in the figure below for 45 minutes.

In the circuit diagram, A, B and C are electrolytic cells' (voltameters). The electrodes labelled P and O are made of copper, while those labelled R, Q, N and M are made of graphite. The cells A and B contain 0.25M aqueous copper (II) sulphate solution, while cell C contain 0.5M aqueous sodium chloride solution.



(a) State Faradays 2nd law of electrolysis.

(b) Write balanced electrochemical equations for the reactions which took place at the electrodes M, N, O, P, Q, and R.

(c) Calculate the number of coulombs of electricity supplied in this experiment.

(d) How many Faradays of electricity were passed through the circuit? (14 marks)

3. John wanted to find the quantity of one compound which would react completely with a specified quantity of another compound. He first prepared $250cm^3$ of a 0.1M solution of a trivalent metal sulphate of the formula, $M_2(SO_4)_3$. He then prepared $250cm^3$ of one molar barium chloride solution.
John arranged five test tubes of similar dimensions in a test tube rack and labelled them A, B, C, D and E. In each of these test tubes, John placed $20.0cm^3$ of the metal sulphate solution.

He then added different volumes of the chloride solution into each of the test tubes as the table below indicates. On each addition, white precipitates of barium sulphate were formed.
The test tubes were centrifuged, and the heights of the precipitates were measured using a ruler.

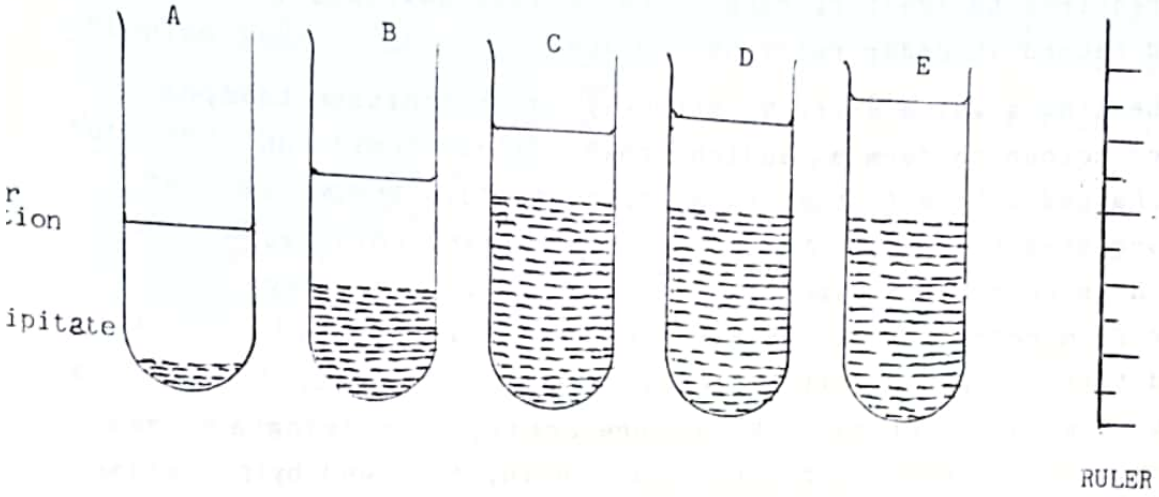


TABLE OF RESULTS

TEST TUBE	VOLUME OF THE METAL SULPHATE SOLUTION (cm^3)	VOLUME OF THE BARIUM CHLORIDE SOLUTION (cm^3)	HEIGHT OF THE BARIUM SULPHATE PRECIPITATE (mm)
A	20.0	2.0	9.0
B	20.0	4.0	11.0
C	20.0	6.0	16.0
D	20.0	8.0	16.0
E	20.0	10.0	16.0

(a) Write an ionic equation for the reaction involved.
The molecular equation is:

$$M_2(SO_4)_{3(aq)} + 3BaCl_{2(aq)} \longrightarrow 2MCl_{3(aq)} + 3BaSO_{4(5)}$$

(b) Plot a graph of the height of the precipitates (y-axis) against the volume of the barium chloride solution (x-axis).

(c) Briefly explain why at some point this graph becomes horizontal.

(d) If the molar mass of $BaCl_2$ and $M_2(SO_4)_3$ are 208 and 342 respectively, find the relative atomic mass of metal M.

(15 marks)

SECTION B

Answer ALL questions in this section.

4. The information given below was derived from a qualitative analysis experiment. Record this information in a tabular form under the heading: Experiment, Observations and Inferences. You are required to identify each piece of information given below and record it under relevant heading.

On heating a white salt N strongly in an ignition tube, it changed colour to form a reddish brown residue, which on cooling changed colour further to a yellow solid. The white colour suggested that salt N did not contain any coloured ions such as copper(II), iron(II) or iron(III). The change of colour from reddish brown when hot to yellow when cold suggested that N was a salt of lead.

A stock solution of salt N was prepared by dissolving a small sample of the salt in dilute nitric acid, followed by boiling, decanting and filtering while hot. The clear filtrate was divided into five portions and put into test tubes labelled: A, B, C, D and E. To portion A, sodium carbonate solution was added. White precipitates were formed suggesting the presence of lead, zinc or calcium ions.

To portion B, sodium hydroxide solution was added dropwise to excess. White precipitates which were readily soluble in the excess alkali were formed, suggesting the presence of either lead or zinc ions but not calcium ions, because calcium ions can not be precipitated by sodium hydroxide.

To portion C, dilute ammonia solution was added dropwise until excess. White precipitates were formed and were soluble in the excess alkali. This confirmed that the solution contained lead ions and not zinc ions, because while lead(II) hydroxide is soluble in excess ammonia solution, zinc hydroxide is not.

To portion D, potassium iodide solution was added. The yellow precipitates formed further confirmed the presence of lead ions.

To the last portion, E, silver nitrate solution was added. White precipitates were immediately formed, and these dissolved on adding dilute ammonia solution. This suggests that salt N contained chloride ions.

Concentrated sulphuric acid was added on a new solid sample of salt N in a test tube, and the contents were warmed. A colourless chocking gas was evolved. This gas was tested by hanging a drop of ammonia solution on the mouth of the test tube Dense smoky fumes were observed, suggesting that the chocking gas was actually hydrogen chloride. This confirmed the presence of chloride ions in salt N.

Another sample of solid salt N was placed in a clean test tube and distilled water was added with intermittent shaking. The salt did not dissolve appreciably. On boiling, the salt readily dissolved. This suggested that the salt N was lead(II) chloride because this compound is insoluble in cold water and soluble in hot water. (15 marks)

A series of qualitative analysis experiments were carried out on a sample M in order to identify one cation and one anion in the sample. The experiments and observations were recorded as shown in the table below. Complete the table by filling in the inferences column.

No.	EXPERIMENTS	OBSERVATIONS	INFERENCES
i	Apppearance of sample M	White amorphous powder	
ii	Solid sample M put in a test tube and distilled water added gradually with intermittent shaking.	Sample M was insoluble in water even after shaking strongly.	
iii	Solid sample M put in a dry test tube and heated first gently and then strongly. Gas evolved was tested.	The colourless gas evolved turned lime water milky. Solid residue remained which was yellow when hot but white when cold.	
iv	Solid sample M put 1/4 full in a test tube Dilute nitric acid was added, and the gas evolved was tested. The resulting solution was divided into four portions and labelled, U, V, W and X.	Solid sample M dissolved in dilute nitric acid. The colourless gas evolved turned lime water milky.	
v	To portion U, sodium hydroxide solution was added dropwise until excess	White gelatinous precipitate soluble in excess of the alkali.	

NO.	EXPERIMENTS	OBSERVATIONS	INFERENCES
vi	To portion V, dilute ammonia solution was added dropwise until excess.	White precipitate soluble in excess alkali.	
vii	To portion W, excess of ammonia solution is added and then hydrogen sulphide gas is bubbled.	The white precipitate which dissolved in the excess alkali re-appeared as the hydrogen sulphide gas was passed.	
viii	To portion X, potassium ferrocyanide solution was added.	White precipitates formed.	

CONCLUSION:

The Cation in sample M was .....

The anion in sample M was .....

The formula for sample M is ..... (14 marks)

SECTION C

Answer ALL questions in this section.

6. Lelo wanted to find out the amount of impurity contained in a solid sample of sodium carbonate which had been contaminated with some sodium chloride. He took 45g of the impure sample and dissolved it in enough pure water to make a litre of solution. Using a $25cm^3$ pipette, he took portions of the base and titrated against 0.75M hydrochloric acid. The titration results are tabulated below, but they contain some errors as a result of exceeding the end-point.

Volume of pipette used was $25cm^3$

Volume readings (cm^3)	Pilot	1	2	3	4
Final reading	33.30	50.00	27.30	26.40	46.80
Initial reading	7.00	24.20	1.60	0.50	20.10
Titre value					

(a) Which indicator do you think Lelo should have used?

(b) If Lelo used the indicator you have suggested, what colour changes would be observed at the end point?

(c) Complete the table above by filling in the titre values in each column.

(d) Inspect the titre values and identify the volume reading which had errors.

(e) Find the average volume of the acid used using the correct titre-values only.

(f) Write a balanced equation for the reaction which took place during the titration process.

(g) Find the mass of the impurity contained in the given sample.

(h) Calculate the percentage of the impurity in the given sample.

(14 marks)

7. Kida wanted to find out the number of the molecules of water of crystallization of oxalic acid (athanedioic acid, $H_2C_2O_4.XH_2O$) crystals. She prepared an acid solution by dissolving 2.25g of the hydrated oxalic acid crystals in enough pure water to make $250cm^3$ of solution, and labelled it as HT.

To prepare the base solution, Kida dissolved 0.855g of sodium hydroxide in enough pure water to make $250cm^3$ of base solution. This was labelled RP.

Kida used a $25cm^3$ pipette to transfer measured portions of the base solution RP into her titration flask. She then titrated solution RP against solution HT and obtained an average titre value of $15cm^3$. Phenolphthalein indicator was used to detect the end point.

The reaction equation is:

$$H_2C_2O_{4(aq)} + 2NaOH_{(a)} \longrightarrow Na_2C_2O_{4(aq)} + 2H_2O_{(l)}$$

Answer the following questions:

(a) Find the concentration of:

(i) the hydrated acid solution, HT, in g/dm^3.

(ii) the base solution, RP, in g/dm^3 and in moles per litre.

(b) Calculate the mass of the anhydrous acid that reacted with the base during the titration.

(c) Calculate the number of molecules of water of crystallization of oxalic acid.