**THE UNITED REPUBLIC OF TANZANIA**

**NATIONAL EXAMINATIONS COUNCIL OF TANZANIA**

**CERTIFICATE OF SECONDARY EDUCATION EXAMINATION**

**032/2** **CHEMISTRY 2**

**ALTERNATIVE TO PRACTICAL**

(For Both School and Private Candidates)

**Time: 3 Hours** **ANSWERS** **Year: 2000**

**Instructions**

1. This paper consists of five questions. Answer all questions.

2. Each question carries 10 marks

1. The following is a diagram of Kipp's apparatus.

(a) Name liquid A and solid B when the apparatus is being used to produce the following gases.

(i) Hydrogen
Liquid A - Dilute hydrochloric acid (HCl)
Solid B - Zinc (Zn)

(ii) Carbon dioxide
Liquid A - Dilute hydrochloric acid (HCl)
Solid B - Calcium carbonate ($CaCO_3$)

(b) Draw a labeled diagram of an apparatus which can be used in demonstrating the extreme solubility of ammonia in water.
A fountain experiment setup using an inverted flask containing ammonia gas with a jet that allows water to be drawn in due to pressure difference.

(c) Briefly explain how you would show that charcoal absorbs ammonia gas if you were only supplied with a small trough, a test tube, mercury, a small piece of charcoal, a source of dry ammonia gas, a test tube holder, and a stand fitted with a clamp.
Fill the test tube with mercury and invert it in a small trough containing mercury. Introduce dry ammonia gas into the test tube, then drop a small piece of charcoal into the test tube. The mercury level rises, indicating that charcoal absorbs the ammonia gas.

2. (a) Briefly explain how you would distinguish between the following solutions.

(i) Calcium hydroxide and sodium hydroxide solution
Add ammonium chloride; calcium hydroxide will give off ammonia gas upon heating, while sodium hydroxide will not.

(ii) Dilute sulphuric acid and dilute hydrochloric acid
Add barium chloride solution; a white precipitate forms in sulphuric acid due to the formation of barium sulfate, while no precipitate forms in hydrochloric acid.

(b) Calculate the volume of distilled water which must be added to 100 $cm^3$ of 0.4 M sodium hydroxide solution so as to obtain a solution which is exactly 0.05 M.
Using dilution formula $M_1V_1 = M_2V_2$
$0.4 \times 100 = 0.05 \times V_2$
$V_2 = 800\ cm^3$
Volume of distilled water to be added = $800 - 100 = 700\ cm^3$

(c) If 50 $cm^3$ of 0.1 M sulphuric acid were added to 50 $cm^3$ of 0.1 M sodium hydroxide solution, calculate the volume of a 0.2 M sodium hydroxide solution which is to be added to the mixture so as to complete the neutralization of the acid.
Moles of $H_2SO_4$ = 0.1 × 50 / 1000 = 0.005 moles
Moles of NaOH = 0.1 × 50 / 1000 = 0.005 moles
Since 1 mole of $H_2SO_4$ reacts with 2 moles of NaOH, an additional 0.005 moles of NaOH is required.
Volume of 0.2 M NaOH needed = 0.005 / 0.2 × 1000 = 25 $cm^3$

(d). 20 $cm^3$ portions of a certain potassium hydroxide solution were separately titrated against 0.1 M hydrochloric acid using methyl orange as an indicator. A copy of the burette readings was made but some of the readings and titre values were un-intentionally not copied.

| Titration number | trial | 1 | 2 | 3 |
|---|---|---|---|---|
| Final burette reading | 20.15 | 38.10 | 18.95 | 37.00 |
| Initial burette reading | 2.05 | 0.95 | 18.95 | 19.95 |
| Volume used | 18.10 | 17.95 | 18.05 | 17.05 |

(a) Complete the table above.
Final reading for trial 3 = 37.00
Initial reading for trial 3 = 19.95
Volume used = 37.00 - 19.95 = 17.05

(b) Calculate the average volume of the acid used.
(18.10 + 17.95 + 18.05 + 17.05) / 4 = 17.79 $cm^3$

(c) Calculate the concentration of the solution in moles per $dm^3$.
Moles of HCl used = 0.1 × 17.79 / 1000 = 0.001779
Since KOH reacts in a 1:1 ratio with HCl,
Moles of KOH = 0.001779
Concentration = moles / volume
= 0.001779 / (20/1000)
= 0.08895 mol/$dm^3$

(d) If the solution was made by dissolving 5.6 g of potassium hydroxide contaminated with sodium chloride in distilled water and then the solution was diluted to 1000 $cm^3$ with distilled water, calculate the percentage by mass of sodium chloride in the impure alkali.
Molar mass of KOH = 56 g/mol
Moles of KOH in 1000 $cm^3$ = 0.08895 × 1 = 0.08895
Mass of pure KOH = 0.08895 × 56 = 4.98 g
Mass of NaCl = 5.6 - 4.98 = 0.62 g

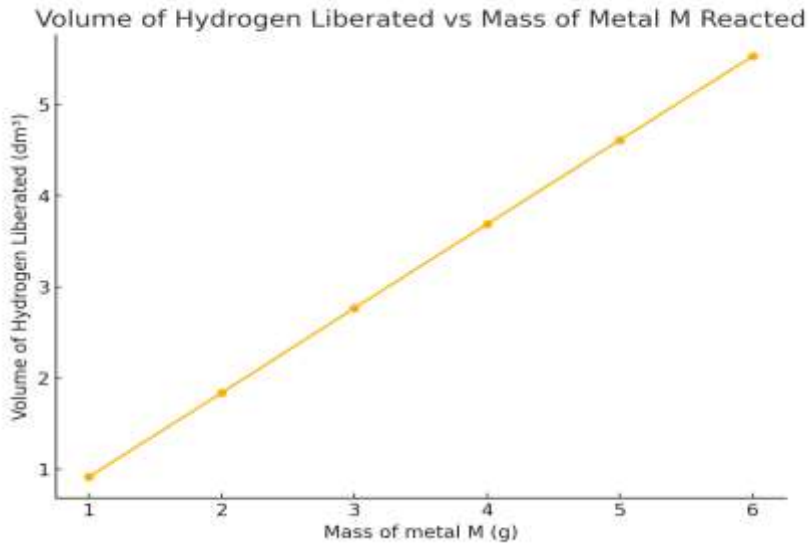
Percentage by mass = (0.62 / 5.6) × 100 = 11.07%

3. The reaction between element M and dilute sulphuric acid is as follows:
$M + H_2SO_4 \text{ ----> } MSO_4 + H_2$

In an experiment to determine the volume of hydrogen liberated by various masses of M, the following data was collected.

| Mass of metal reacted (g) | Volume of hydrogen liberated at S.T.P ($dm^3$) |
|---|---|
| 1 | 0.92 |
| 2 | 1.84 |
| 3 | 2.77 |
| 4 | 3.69 |
| 5 | 4.61 |
| 6 | 5.53 |

(a) Plot a graph of volume of hydrogen liberated against mass of element M reacted.




(b) Determine the slope of the graph in 3(a) above.
Slope = Change in volume / Change in mass
= (5.53 - 0.92) / (6 - 1)
= 4.61 / 5
= 0.922 $dm^3/g$

(c) What does the slope represent?
The slope represents the volume of hydrogen gas produced per gram of metal M.
(d) Use the slope in 3(b) to calculate the relative atomic mass of element M.

From the reaction equation, 1 mole of M produces 1 mole of $H_2$ gas (22.4 $dm^3$).
Mass of M per 22.4 $dm^3$ = 22.4 / 0.922
= 24.3 g/mol
Relative atomic mass of M = 24.3 (suggests M is Magnesium).

4. (a) State the color of the flame when each of the following substances burns in oxygen:

(i) Sulphur
Blue flame

(ii) Phosphorus
Yellow or white flame

(iii) Magnesium
Bright white flame

(iv) Sodium
Yellow flame

(b) Write balanced chemical equations and state the observations which would be made when each of the following compounds is strongly heated in a test tube.

(i) Iron(II) sulfate ($FeSO_4 \cdot 7H_2O$)
Equation:
$FeSO_4 \cdot 7H_2O$ ---> $FeSO_4 + 7H_2O$
$FeSO_4$ ----> $Fe_2O_3 + SO_2 + SO_3$

Observation:
The hydrated salt loses water and turns white. On further heating, it decomposes, releasing sulfur dioxide ($SO_2$) and sulfur trioxide ($SO_3$) gases, and a reddish-brown residue of iron(III) oxide ($Fe_2O_3$) remains.

(ii) Lead(IV) oxide ($PbO_2$)
Equation:
$2PbO_2$ --> $2PbO + O_2$

Observation:
The compound changes from brown to yellow, and oxygen gas is released.

(c) With the aid of chemical equations, briefly state how the following compounds can be prepared from the given solutions in a school chemistry laboratory.

(i) Zinc carbonate from zinc chloride solution
Equation:

$ZnCl_2 + Na_2CO_3$ ----> $ZnCO_3 + 2NaCl$

Procedure:
Add sodium carbonate solution to zinc chloride solution. A white precipitate of zinc carbonate ($ZnCO_3$) will form.

(ii) Iron(III) oxide from iron(III) chloride solution
Equation:
$2FeCl_3 + 3NaOH \rightarrow Fe_2O_3 + 3NaCl + 3H_2O$

Procedure:
Add sodium hydroxide to iron(III) chloride solution, then heat to remove water, leaving behind iron(III) oxide.

(d) Study the apparatus below very carefully and then answer the questions below.

(i) In what experiment is this apparatus used?
It is used to determine the percentage of oxygen in the air by reacting phosphorus with oxygen in a closed system.

(ii) What does the ratio (h - y) / h represent?
It represents the fraction of oxygen removed from the air due to its reaction with phosphorus.

(iii) What does the quantity [(h - y) / h] × 100 represent?
It represents the percentage of oxygen in the air.

5. (a) Sample SS was a simple salt containing one cation and one anion. The tests carried out on sample SS and the observations made were entered in the table shown below.

| Test | Observations | Inference |
|---|---|---|
| (i) Appearance | White deliquescent crystals | The salt is hygroscopic and highly soluble in water. |
| (ii) A little of solid SS was heated in a test tube | Light brown gas with a sweetish smell was evolved. A white residue was left. | Presence of a nitrate compound, as brown fumes of nitrogen dioxide ($NO_2$) were observed. |
| (iii) A solution of SS in distilled water was prepared. Sodium hydrogen carbonate solution was then added to the solution. | No reaction was observed. | The salt does not react with sodium hydrogen carbonate, suggesting the absence of a carbonate ion. |
| (iv) The mixture of solutions in (iii) above was gradually heated to boiling. | A white precipitate gradually formed, and effervescence of a colorless gas which turned lime water milky was seen. | Presence of sulfate or carbonate ions as the gas evolved could be carbon dioxide ($CO_2$). |
| (v) The precipitate formed in (iv) above was isolated, washed, and dried. The dry precipitate was then flame-tested. | A brick-red flame was observed. | Indicates the presence of calcium ions ($Ca^{2+}$). |

(b) (i) The cation was calcium ($Ca^{2+}$) and the anion was nitrate ($NO_3^-$).

(ii) Write down an equation for the reaction which took place when the mixture in (a)(iii) above was gradually heated to boiling.
$Ca(NO_3)_2$ ---> $CaO + 2NO_2 + ½O_2$

(iii) Write a confirmatory test for the anion present in sample SS.
Add freshly prepared iron(II) sulfate solution to a solution of SS, then carefully add concentrated sulfuric acid along the sides of the test tube. A brown ring at the interface confirms the presence of nitrate ions.

(iv) What would have happened if a little portion of sample SS was mixed with copper turnings and treated with cold moderately concentrated sulfuric acid?
Brown fumes of nitrogen dioxide ($NO_2$) would be evolved, and the solution would turn blue due to the formation of copper(II) nitrate.

Balanced equations:
$Cu + 4HNO_3$ ----> $Cu(NO_3)_2 + 2NO_2 + 2H_2O$
$2NO_2 + H_2O$ -------> $HNO_2 + HNO_3$