THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

032/1 **CHEMISTRY 1**

(For Both School and Private Candidates)

Time: 3 Hours **ANSWERS** **Year: 1995**

Instructions

1. This paper consists of sections A, B and C with total of thirteen questions

I. The most probable valency of an element whose atomic number is 12 is

A. 0
B. 1
C. 2
D. 3

An element with atomic number 12 is magnesium (Mg). Magnesium has an electronic configuration of 2, 8, 2, meaning it has two valence electrons in its outermost shell. It tends to lose these two electrons to achieve a stable noble gas configuration, making its valency 2.

The correct answer is C. 2.

II. A salt which on exposure to the air becomes covered with a liquid is

A. efflorescent
B. deliquescent
C. hygroscopic
D. hydrocyclic

A deliquescent substance absorbs moisture from the air and dissolves in the absorbed water, forming a liquid. Examples include sodium hydroxide (NaOH) and calcium chloride ($CaCl_2$).

The correct answer is B. deliquescent.

III. One disadvantage of hard water is that it

A. contains mineral salts which are harmful to the body
B. causes increased tooth decay
C. causes corrosion of water pipes
D. requires more soap for washing

Hard water contains dissolved calcium and magnesium salts, which react with soap to form insoluble scum, reducing its effectiveness. This means more soap is required to form lather.

The correct answer is D. requires more soap for washing.

IV. 30 cm^3 of nitrogen at 28°C and 710 mmHg are converted to standard temperature and pressure (STP). The new volume of nitrogen is

A. 31.3 cm^3
B. 29.6 cm^3
C. 28.2 cm^3

D. 25.5 cm^3

Using the combined gas law:

$(P_1V_1)/T_1 = (P_2V_2)/T_2$

where $P_1 = 710$ mmHg, $V_1 = 30$ cm^3, $T_1 = 28°C = 301K$,
$P_2 = 760$ mmHg, $T_2 = 273K$, $V_2 = ?$

$(710 \times 30) / 301 = (760 \times V_2) / 273$

$V_2 = (710 \times 30 \times 273) / (301 \times 760)$

$V_2 = 28.2$ cm^3

The correct answer is C. 28.2 cm^3.

V. One of the following substances is commonly used to determine the arrangement of metals in order of their reactivity

A. water
B. any salt
C. any non-metal
D. aluminium hydroxide

Water is commonly used in the reactivity series to determine how metals react. More reactive metals like sodium react violently with water, while less reactive metals like copper do not react.

The correct answer is A. water.

VI. A black powder, when heated alone, gave oxygen and a yellow residue. When heated with concentrated hydrochloric acid, chlorine gas was evolved. The black powder was

A. powdered charcoal
B. lead oxide
C. cupric oxide
D. manganese dioxide

Manganese dioxide (MnO_2) decomposes on heating to produce oxygen gas and manganese(III) oxide, which appears yellow. When MnO_2 reacts with concentrated HCl, chlorine gas (Cl_2) is released.

The correct answer is D. manganese dioxide.

VII. Before using a burette, it should be prepared by washing it with

A. dilute bench acid, then water
B. cold water only
C. hot, then cold water
D. water, then the solution to be used

A burette should be rinsed with the solution to be used in titration to prevent dilution or contamination from water.

The correct answer is D. water, then the solution to be used.

VIII. A standard solution of potassium hydroxide contains

A. 17 g of hydroxyl ions per given volume
B. one-equivalent of hydroxyl ions per litre
C. a known weight of alkali in a given volume
D. one molecular weight of alkali per litre

A standard solution is a solution with a precisely known concentration. It contains a known weight of alkali per given volume.

The correct answer is C. a known weight of alkali in a given volume.

IX. An example of a homologous series is found in the following

A. acetylene, ethylene, ethane
B. propane, butane, pentane
C. charcoal, graphite, diamond
D. glucose, fructose, sucrose

A homologous series is a group of organic compounds with the same functional group and general formula but differing by a CH_2 unit. Alkanes (propane, butane, pentane) are an example of a homologous series.

The correct answer is B. propane, butane, pentane.

X. A quantity of electricity is measured in

A. amperes
B. coulombs
C. volts
D. watts

Electric charge is measured in coulombs (C), while amperes measure current, volts measure potential difference, and watts measure power.

The correct answer is B. coulombs.

XI. An acid liquid when treated with copper gave a colorless gas which turned brown. When treated with marble chips, it gave carbon dioxide. The acidic liquid was

A. concentrated nitric acid
B. dilute sulphuric acid
C. concentrated sulphuric acid
D. dilute nitric acid

When dilute nitric acid reacts with copper, it produces nitrogen dioxide (NO_2), which is a brown gas. It also reacts with marble chips ($CaCO_3$) to produce carbon dioxide (CO_2).

The correct answer is D. dilute nitric acid.

XII. Substance B has a percentage composition of 54.6% carbon, 9.1% hydrogen, and 36.3% oxygen. The empirical formula of substance B is

A. CH_2O
B. CH_4O
C. C_2H_4O
D. C_2H_6O

To determine the empirical formula, the percentage composition is converted into moles:

- Carbon: 54.6 g / 12 = 4.55 moles
- Hydrogen: 9.1 g / 1 = 9.1 moles
- Oxygen: 36.3 g / 16 = 2.27 moles

Dividing all values by the smallest (2.27):

- Carbon: 4.55 / 2.27 = 2
- Hydrogen: 9.1 / 2.27 = 4
- Oxygen: 2.27 / 2.27 = 1

The empirical formula is C_2H_4O.

The correct answer is C. C_2H_4O.

XIII. Most salts have comparatively high melting points because they have

A. crystalline structure
B. low pressures
C. high specific heats
D. strong electronic attractions between ions

Ionic salts have high melting points because of strong electrostatic forces between positively and negatively charged ions, which require a large amount of energy to break.

The correct answer is D. strong electronic attractions between ions.

XIV. The balanced equation for the reaction $NH_3 + O_2 \rightarrow NO + H_2O$ is

A. $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$
B. $3NH_3 + 2O_2 \rightarrow 3NO_2 + 6H_2O$
C. $2NH_3 + 3O_2 \rightarrow 2NO + 6H_2O$
D. $NH_3 + 4O_2 \rightarrow NO + 6H_2O$

Balancing nitrogen and hydrogen atoms first, then oxygen:

- $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

The correct answer is A. $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$.

XV. A hen's eggshell contains calcium

A. sulphate
B. carbonate
C. chloride
D. nitrate

Eggshells are made of calcium carbonate ($CaCO_3$), which gives them strength and structure.

The correct answer is B. carbonate.

XVI. The most abundant metal in the Earth's crust is

A. iron
B. aluminium
C. calcium
D. sodium

Aluminium is the most abundant metal in the Earth's crust, making up about 8% of its composition.

The correct answer is B. aluminium.

XVII. The kinetic theory of gases attempts to explain the behaviour of gases on the basis of the
A. ionisation of their molecules
B. brownian movement
C. laws of Boyle, Charles, Gay-Lussac, and Avogadro
D. hydrogen displacement
The kinetic theory of gases is based on Boyle's, Charles's, Gay-Lussac's, and Avogadro's laws, which describe the relationship between pressure, volume, temperature, and the number of gas molecules.

The correct answer is C. laws of Boyle, Charles, Gay-Lussac, and Avogadro.

XVIII. In a classroom experiment, air was passed over heated copper turnings in order to obtain some relatively pure nitrogen. Which impurities would you expect to be present in the relatively pure nitrogen gas which was collected over water?

A. Argon, water vapour, and helium
B. Helium, carbon dioxide, and carbon monoxide
C. Oxygen, hydrogen, and rare gases
D. Rare gases, water vapour, and carbon dioxide

Air consists of nitrogen, oxygen, argon, and other gases. When oxygen reacts with heated copper, the remaining nitrogen still contains small amounts of argon, water vapour, and carbon dioxide.

The correct answer is D. Rare gases, water vapour, and carbon dioxide.

XIX. In which of the following reactions is a metal reduced but not oxidised?

A. $Zn + CuSO_4 \text{------>} Cu + ZnSO_4$
B. $H_2S + 2FeCl_3 \text{-----> } S + 2FeCl_2 + 2HCl$
C. $Fe + S \text{-------> } FeS$
D. $Fe_2O_3 + 2Al \text{--------> } Al_2O_3 + 2Fe$

Reduction is the gain of electrons, while oxidation is the loss of electrons. In reaction A, copper (Cu^{2+}) is reduced to copper metal, while zinc is oxidised.

The correct answer is A. $Zn + CuSO_4 \text{----> } Cu + ZnSO_4$.

XX. The concentration of acetic acid in vinegar was determined by titrating the vinegar with 1.0M sodium hydroxide solution using phenolphthalein as an indicator. It was found that 25 cm^3 of the sodium hydroxide solution required 42 cm^3 of vinegar for complete neutralisation. Therefore, the concentration of the acetic acid, in grams per litre, in the vinegar was

A. 4 g per litre
B. 3 g per litre
C. 2 g per litre
D. 1 g per litre

Using the formula:

$M_1V_1 = M_2V_2$
$(1.0 \times 25) = (M_2 \times 42)$
$M_2 = (1.0 \times 25) / 42 = 0.595$ M
Molar mass of acetic acid (CH_3COOH) = 60 g/mol
Mass concentration = $0.595 \times 60 = 3.57$ g/L
The closest answer is B. 3 g per litre.

2. (a) State the main raw material and the process involved in the manufacture of each of the following products.

(i) Wood charcoal
(ii) Coke
(iii) Lamp black
(iv) Animal charcoal

(i) Wood charcoal is produced from wood by carbonization, a process involving the heating of wood in the absence of oxygen to remove volatile components, leaving behind carbon.

(ii) Coke is made from coal by destructive distillation, which involves heating coal in the absence of air to remove volatile substances, leaving behind solid carbon.

(iii) Lamp black is produced from incomplete combustion of hydrocarbons, such as burning oils, which produce fine carbon particles used as a black pigment.

(iv) Animal charcoal is obtained from animal bones by destructive distillation, where bones are heated in the absence of air to remove organic materials, leaving a porous carbon residue.

(b) Give two uses for each of the following:

(i) Graphite
(ii) Diamond

Graphite:
1. Used as a lubricant in machinery due to its layered structure and slippery nature.
2. Used in the production of electrodes in electrolysis and batteries because it conducts electricity.

Diamond:
1. Used in cutting tools and drilling equipment due to its extreme hardness.
2. Used in jewelry because of its high refractive index and brilliance.

3. (a) Industrial sulphuric acid is usually labeled as containing 98% of the acid and having a density of 1.84 g/cm^3.

(i) Calculate the molarity of this industrial sulphuric acid.

Step 1: Calculate the mass of H_2SO_4 in 1 liter.
Mass = Density × Volume = 1.84 g/cm^3 × 1000 cm^3 = 1840 g

Step 2: Calculate the mass of pure H_2SO_4.
98% of 1840 g = (98/100) × 1840 = 1803.2 g

Step 3: Calculate the number of moles of H_2SO_4.
Moles = Mass / Molar mass = 1803.2 g / 98 g/mol = 18.4 moles

Thus, the molarity of the acid is 18.4 M.

(ii) Calculate the volume of this industrial sulphuric acid that will be required to prepare 2 dm^3 of 0.50 M sulphuric acid solution.

Using the dilution formula:

$M_1V_1 = M_2V_2$
$(18.4 \times V_1) = (0.50 \times 2)$
$V_1 = (0.50 \times 2) / 18.4 = 0.0543$ dm^3 or 54.3 cm^3

Thus, 54.3 cm^3 of concentrated sulphuric acid is required.

(b) Name the main product formed when:
(i) Hot concentrated sulphuric acid is added to cane sugar.

When hot concentrated sulphuric acid is added to cane sugar ($C_{12}H_{22}O_{11}$), dehydration occurs, removing water molecules and leaving behind carbon:

$C_{12}H_{22}O_{11}$ ---> $12C + 11H_2O$

The main product formed is carbon (black residue).

(ii) Hot concentrated sulphuric acid is added to ethanol.

When concentrated sulphuric acid reacts with ethanol, it acts as a dehydrating agent, removing water and forming ethylene (C_2H_4) gas.
C_2H_5OH ---------> $C_2H_4 + H_2O$

4. With the aid of an equation in each case, record what would be observed when:

(a) Chlorine gas is passed through potassium bromide solution in water.
Reaction:
$Cl_2 + 2KBr$ --------> $2KCl + Br_2$

Observation: The solution changes from colorless to brown due to the formation of bromine (Br_2).

(b) Chlorine gas is bubbled through a solution of iron (II) chloride.

Reaction:
$Cl_2 + 2FeCl_2$ -----> $2FeCl_3$

Observation: The pale green color of $FeCl_2$ solution changes to yellow as iron (II) is oxidized to iron (III) chloride.
(c) Ammonia gas is passed through a gas jar containing hydrogen chloride.
Reaction:
$NH_3 + HCl$ ---------> NH_4Cl

Observation: Dense white fumes of ammonium chloride form in the gas jar.
(d) A piece of sodium metal is dropped into a beaker of water containing some red litmus paper.
Reaction:
$2Na + 2H_2O$ -----> $2NaOH + H_2$

Observation:
- Effervescence due to hydrogen gas formation.
- Sodium melts and moves rapidly on the water surface due to the exothermic reaction.
- Red litmus paper turns blue, indicating the formation of an alkaline solution (NaOH).

5. (a) On heating, iron combines with sulphur to form iron (II) sulphide.

(i) Write a balanced chemical equation for this reaction.

Fe + S --------> FeS

(ii) Calculate the mass of iron that will combine with 70 g of sulphur.

Using mole concept:
Molar mass of Fe = 56 g/mol, S = 32 g/mol
From the equation, 56 g of Fe reacts with 32 g of S.
Mass of Fe required for 70 g S:
Fe required = (56/32) × 70 = 122.5 g

Thus, 122.5 g of iron will combine with 70 g of sulphur.

(b) Write the electronic configuration of atom A whose atomic number is 16.
Sulphur (atomic number 16): 2, 8, 6

(c) Use the electronic configuration of atom A in (b) above to predict its
(i) Valency
Sulphur has six valence electrons and needs two more to complete its octet. Thus, its valency is 2.
(ii) Period
Sulphur has three shells (2, 8, 6), meaning it belongs to period 3.
(iii) Group
Since sulphur has six valence electrons, it belongs to group 16.

(d) Predict the nature of bond formed (covalent or ionic) when atom A combines with
(i) Magnesium
Magnesium (Mg) has two valence electrons, while sulphur (S) needs two electrons. Mg donates its two electrons to S, forming an ionic bond.
The bond is ionic.
(ii) Oxygen
Both sulphur and oxygen are non-metals and have six valence electrons. They share electrons to form a covalent bond.
The bond is covalent.

VI. (a) Distinguish between a fertilizer and an organic manure.

A fertilizer is a chemical or natural substance added to soil to supply nutrients essential for plant growth, such as nitrogen, phosphorus, and potassium compounds. It is usually manufactured industrially.

Organic manure, on the other hand, is a natural material derived from plant or animal waste, such as compost or animal dung, which enriches the soil with organic matter and nutrients.

(b) List four steps that are required in the preparation of land ready for seed growing.

1. Clearing the land – Removing weeds, stones, and unwanted vegetation.
2. Ploughing – Turning over the soil to improve aeration and root penetration.

3. Harrowing – Breaking down large soil clumps to create a fine seedbed.
4. Leveling – Smoothing the surface to facilitate uniform planting and irrigation.

(c) Give at least four reasons why a fertile soil is not necessarily productive.

1. Poor soil structure – Even if soil has nutrients, it may be too compacted or loose, affecting root growth and water retention.
2. Lack of proper moisture – Fertile soil may not be productive if it does not receive adequate water for plant absorption.
3. Presence of soil pests and diseases – Harmful microorganisms and insects can damage crops, reducing productivity.
4. Poor farming practices – Overgrazing, continuous cropping, or lack of proper soil management can reduce yield despite soil fertility.

(d) Your school shamba soil requires 80 kg of nitrogen per hectare to fulfill plant requirements. Calculate in kg the quantity of ammonium sulphate $(NH_4)_2SO_4$ fertilizer required to meet this demand.

Molar mass of ammonium sulphate = (2 × 14) + (8 × 1) + (32) + (4 × 16) = 132 g/mol

Percentage of nitrogen in ammonium sulphate:
(28 / 132) × 100 = 21.2%

Quantity of fertilizer required:
80 kg / 0.212 = 377.36 kg

Thus, 377.36 kg of ammonium sulphate is required per hectare.

VII. (a) With the aid of balanced chemical equations wherever appropriate, briefly outline the extraction of zinc from zinc blende.

1. Roasting: Zinc blende (ZnS) is heated in the presence of oxygen to convert it into zinc oxide.
   $2ZnS + 3O_2$ --------> $2ZnO + 2SO_2$

2. Reduction: The zinc oxide is reduced using coke in a blast furnace to obtain metallic zinc.
   $ZnO + C$ --------> $Zn + CO$

3. Refining: The impure zinc is purified by electrolysis.

(b) Give three main uses of zinc.

1. Galvanization – Coating iron and steel to prevent rusting.
2. Alloy formation – Used in making brass (zinc and copper alloy).
3. Battery production – Used in dry cell batteries.

8. (a) Explain what is meant by:

(i) Cracking – A process in which large hydrocarbon molecules are broken down into smaller, more useful hydrocarbons, such as gasoline and alkenes, through heat and catalysts.

(ii) Unsaturated hydrocarbons – Organic compounds containing carbon-carbon double or triple bonds, such as alkenes (C=C) and alkynes (C≡C), which can undergo addition reactions.

(b) Give two examples of each of:

(i) A solid fuel – Coal, wood
(ii) A liquid fuel – Petrol, kerosene
(iii) A gaseous fuel – Methane, propane

(c) Name four characteristics of a good fuel.

1. High calorific value – Should produce a large amount of energy per unit mass.
2. Easy availability – Should be readily accessible and affordable.
3. Low pollution – Should produce minimal harmful emissions.
4. Safe handling – Should not be highly explosive or toxic.

(d) Complete and balance each of the following equations:

(i) $C_2O_4 + C_2$ -----> $2CO_2$
(ii) $CHCl_3 + Cl_2$ ------> $CCl_4 + HCl$
(iii) $C_2H_3OH + O_2$ -----> $2CO_2 + 3H_2O$
(iv) $CH_3COOH + C_2H_5OH$ ------> $CH_3COOC_2H_5 + H_2O$
(v) C_2H_5OH + Conc. H_2SO_4 ------> $C_2H_4 + H_2O$

9. (a) Define the term electroplating.

Electroplating is the process of coating an object with a thin layer of metal using electrolysis to improve appearance, prevent corrosion, or enhance conductivity.

(b) "During electrolysis, oxidation and reduction occur at the same time." Briefly explain the validity of this statement.

Electrolysis is a redox process where:
- Oxidation occurs at the anode (loss of electrons).
- Reduction occurs at the cathode (gain of electrons).

For example, in the electrolysis of copper sulfate:

- At the anode: Cu -------> $Cu^{2+} + 2e^-$ (oxidation)
- At the cathode: $Cu^{2+} + 2e^-$ -------> Cu (reduction)

This shows that oxidation and reduction occur simultaneously.

(c) In the electrolysis of copper sulphate, the reactions at the electrodes are:

Cathode: $Cu^{2+} + 2e^-$ ------> Cu
Anode: $2H_2O$ ------> $O_2(g) + 4H^+ + 4e^-$

(i) Draw a diagram showing the voltameter in this electrolysis.

(ii) What volume of oxygen measured at STP will be liberated at the anode in the time it will take to plate out 5.08 g of copper onto the cathode?

Step 1: Calculate moles of Cu deposited.
Moles of Cu = 5.08 g / 63.5 g/mol = 0.08 moles

Step 2: Using Faraday's law, 2 moles of Cu require 1 mole of O_2.
Oxygen moles = 0.08 / 2 = 0.04 moles

Step 3: Volume of oxygen at STP = $0.04 \times 22.4 = 0.896$ dm^3

Thus, 0.896 dm^3 of oxygen is liberated.

10. (a) Name one key element present in all organic compounds.

Carbon is present in all organic compounds.

(b) Giving at least one example in each case, briefly explain the meaning of:

(i) Addition reaction – A reaction where molecules add across a double or triple bond without loss of atoms.
Example:
$C_2H_4 + Br_2$ -------> $C_2H_4Br_2$

(ii) Substitution reaction – A reaction where one atom or group in a molecule is replaced by another.
Example:
$CH_4 + Cl_2$ --------> $CH_3Cl + HCl$

(c) Write a balanced chemical equation for each of the following reactions:

(i) Ethanol reacts with sodium metal
$2C_2H_5OH + 2Na$ ----------> $2C_2H_5ONa + H_2$

(ii) Propanol and acetic acid are warmed together in the presence of concentrated sulfuric acid

$C_3H_7OH + CH_3COOH$ --------> $CH_3COOC_3H_7 + H_2O$

(d) With the aid of an equation, in each step, briefly explain how you would carry out the following conversions:

(i) Ethene to Ethane

$C_2H_4 + H_2$ ------> C_2H_6 (hydrogenation using nickel catalyst)

(ii) Ethane to Ethanol

$C_2H_6 + Cl_2$ -------> $C_2H_5Cl + HCl$ (chlorination)

$C_2H_5Cl + NaOH$ ---------> $C_2H_5OH + NaCl$ (hydrolysis)