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: 1994**

Instructions

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

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I. When a metal atom becomes an ion it

A. loses electrons and becomes oxidised
B. loses electrons and becomes reduced
C. gains electrons and becomes oxidised
D. gains electrons and becomes reduced

A metal atom loses electrons to form a positively charged ion (cation). The loss of electrons is called oxidation.

The correct answer is A. loses electrons and becomes oxidised.

II. One of the following substances is used in the manufacture of lead pencils.

A. Lead
B. Coal
C. Charcoal
D. Graphite

Lead pencils are made using graphite, which is a form of carbon with a layered structure that allows it to leave marks on paper.

The correct answer is D. Graphite.

III. The ionic equation for the reaction between hydrochloric acid and sodium hydroxide is

A. $H^+ + Cl^- + Na^+ + OH^- \rightarrow NaOH + HCl$
B. $H_2O + NaCl \rightarrow 2H_2O$
C. $H^+ + OH^- \rightarrow H_2O$
D. $H^+ + Cl^- + Na^+ + OH^- \rightarrow HCl + NaOH$

The reaction between hydrochloric acid (HCl) and sodium hydroxide (NaOH) is a neutralization reaction where hydrogen ions (H^+) react with hydroxide ions (OH^-) to form water.

The correct answer is C. $H^+ + OH^- \rightarrow H_2O$.

IV. The extraction of iron in the blast furnace gives slag as one of the products. This slag consists of

A. molten sand
B. molten calcium silicate
C. iron pyrites
D. molten iron

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In the blast furnace, limestone (CaCO₃) is added to remove impurities, forming molten calcium silicate (slag).

The correct answer is B. molten calcium silicate.

V. The addition of ammonium sulphate to a soil corrects the deficiency of the following elements in that soil:

A. nitrogen and oxygen
B. sulphur and oxygen
C. nitrogen and hydrogen
D. sulphur and nitrogen

Ammonium sulphate ((NH_4)$_2SO_4$) provides nitrogen for plant growth and sulphur for protein synthesis.

The correct answer is D. sulphur and nitrogen.

VI. One of the following sets of laboratory apparatus contains direct measuring items.

A. Crucible, Kipp's apparatus, and volumetric flask
B. Test-tube, beaker, and gas jar
C. Thistle funnel, separating funnel, and beaker
D. Burette, pipette, and measuring cylinder

Direct measuring items are those used to determine precise volumes of liquids, such as burettes, pipettes, and measuring cylinders.

The correct answer is D. Burette, pipette, and measuring cylinder.

VII. A 5% by weight of a solution of sodium hydroxide has a molarity of

A. 5.00M
B. 1.25M
C. 0.05M
D. 0.25M

Step 1: Calculate mass of NaOH in 1 liter.
5% solution means 5 g of NaOH in 100 g of solution. Assuming density is 1 g/cm³, 1 liter of solution contains 50 g NaOH.

Step 2: Calculate moles of NaOH.
Molar mass of NaOH = 23 + 16 + 1 = 40 g/mol
Moles of NaOH = 50 / 40 = 1.25 moles

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Step 3: Determine molarity.
Molarity = Moles / Volume = 1.25 M

The correct answer is B. 1.25M.

VIII. A galvanised iron is one which is coated with

A. Tin
B. Zinc
C. Copper
D. Silver

Galvanization is the process of coating iron with zinc to prevent rusting.

The correct answer is B. Zinc.

IX. "When gases react with one another, they do so by volumes that are in the ratios of small whole numbers." This is the statement of

A. Charles' law
B. Avogadro's hypothesis
C. Gay-Lussac's law
D. Law of constant composition

Gay-Lussac's law states that gases react in simple whole-number volume ratios under constant temperature and pressure.

The correct answer is C. Gay-Lussac's law.

X. A reading of 0°C corresponds, on the Kelvin scale, to

A. -273
B. 0
C. 273
D. 373

Kelvin temperature (K) = Celsius temperature (°C) + 273.
0°C = 273 K.

The correct answer is C. 273.

XI. All elements in the periodic table are arranged in groups according to

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A. their order of discovery
B. the similarity in their chemical and physical properties
C. order of increasing number of electrons in their outermost shells
D. the atomic sizes starting with the element with the largest atomic size

Elements are arranged in groups based on similar chemical and physical properties due to having the same number of valence electrons.

The correct answer is B. the similarity in their chemical and physical properties.

XII. The raw materials for the manufacture of sodium carbonate in the solvay process are

A. Sodium sulphate, nitric acid, and noble gases
B. Water, sodium chloride, and ammonia
C. Carbon dioxide, saturated sodium chloride, and ammonia
D. Ammonia, water, and noble gases

In the Solvay process, sodium carbonate (Na_2CO_3) is manufactured using carbon dioxide (CO_2), ammonia (NH_3), and saturated sodium chloride ($NaCl$) solution.

The correct answer is C. Carbon dioxide, saturated sodium chloride, and ammonia.

XIII. The passage of an electric current through a solution in order to decompose it is known as

A. Oxidation
B. Ionisation
C. Neutralisation
D. Electrolysis

Electrolysis is the process where an electric current is passed through an electrolyte to cause a chemical decomposition.

The correct answer is D. Electrolysis.

XIV. The burning back of the Bunsen burner occurs when the

A. Air hole is closed
B. Air hole is open
C. Bunsen burner is too high
D. Bunsen burner is overheated

Burning back occurs when the Bunsen burner gets too hot and the flame moves back into the barrel, often caused by excessive heating or too much oxygen supply.

The correct answer is D. Bunsen burner is overheated.

XV. A substance that can be used to remove colouring matter in brown sugar is

A. Wood charcoal
B. Animal charcoal
C. Lamp black
D. Bleaching agent

Animal charcoal is used to remove impurities and decolorize sugar in the refining process.

The correct answer is B. Animal charcoal.

XVI. Which of the following processes reduces the amount of carbon dioxide in the air?

A. Breathing
B. Photosynthesis
C. Burning of petrol
D. The manufacture of quicklime

Photosynthesis is the natural process where green plants use carbon dioxide to produce oxygen and glucose.

The correct answer is B. Photosynthesis.

XVII. The quantity of electricity needed to deposit 1 mole of aluminium in the electrolysis of aluminium III sulphate is

A. 386000 coulombs
B. 289500 coulombs
C. 193000 coulombs
D. 96500 coulombs

From Faraday's laws of electrolysis, 3 moles of electrons are required to deposit 1 mole of aluminium. Since 1 Faraday = 96500 C, the total charge required is:

$3 \times 96500 = 289500$ C

The correct answer is B. 289500 coulombs.

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XVIII. Red hot carbon can remove oxygen from both copper oxide and zinc oxide but not from magnesium oxide. Zinc can remove oxygen from copper oxide. On this evidence, therefore, the order of reactivity of the three metals, putting the most reactive metal first, is

A. Magnesium, zinc, copper
B. Zinc, copper, magnesium
C. Copper, zinc, magnesium
D. Magnesium, copper, zinc

A more reactive metal displaces oxygen from the oxide of a less reactive metal. Since magnesium oxide is not reduced by carbon, magnesium is the most reactive. Zinc can remove oxygen from copper oxide, so zinc is more reactive than copper.

The correct answer is A. Magnesium, zinc, copper.

XIX. The expression "nitric acid is a strong acid" may best be explained as follows: It

A. Is very corrosive
B. Is highly ionised
C. Is a strong oxidizing agent
D. Dissolves most metals

A strong acid is one that completely ionizes in water, meaning all its molecules dissociate into H^+ and NO_3^- ions.

The correct answer is B. Is highly ionised.

XX. The empirical formula of a certain compound is CH_2. Its vapour density is 30. Therefore, its molecular formula is

A. CH_4
B. C_2H_4
C. C_3H_6
D. C_4H_8

Molecular formula = (empirical formula) × (molar mass / empirical mass).

Empirical mass of $CH_2 = 12 + (2 \times 1) = 14$ g/mol.
Molecular mass = 2 × Vapour density = 2 × 30 = 60 g/mol.
Molecular formula = $CH_2 \times (60/14) = C_4H_8$.

The correct answer is D. C_4H_8.

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XXI. The school blackboard chalk is made of calcium

A. Hydroxide
B. Carbonate
C. Bicarbonate
D. Sulphate

Blackboard chalk is mainly composed of calcium carbonate ($CaCO_3$).

The correct answer is B. Carbonate.

XXII. Carbon monoxide gas is poisonous because it

A. Combines with haemoglobin faster than oxygen
B. Paralyses the nervous system
C. Coagulates the blood
D. Blocks the lung's vessels

Carbon monoxide binds with haemoglobin in red blood cells more strongly than oxygen, reducing oxygen transport in the body.

The correct answer is A. Combines with haemoglobin faster than oxygen.

XXIII. Urban water supplies are treated with potash alum (a crystallised double salt of potassium sulphate and aluminium sulphate) in order to

A. Add mineral salts to the water
B. Soften the water
C. Prevent corrosion in water pipes
D. Remove bacteria from the water

Potash alum acts as a coagulant, helping to remove bacteria and suspended particles in water treatment.

The correct answer is D. Remove bacteria from the water.

XXIV. An increase in temperature causes an increase of pressure of a gas enclosed in a container of constant volume because it

A. Increases the mass of the molecules
B. Causes the molecules to combine together
C. Increases the average velocity of the molecules
D. Causes the molecules to break into atoms

According to the kinetic theory of gases, increasing temperature increases the kinetic energy of gas molecules, making them move faster and collide with greater force, leading to higher pressure.

The correct answer is C. Increases the average velocity of the molecules.

XXV. The process of refining crude oil consists mainly of

A. removal of gaseous products from crude oil
B. fractional distillation of crude oil
C. decomposition of crude oil
D. evaporation and condensation of crude oil

Crude oil is separated into different components based on boiling points using fractional distillation. This process allows hydrocarbons with different chain lengths to be collected at various levels of the fractionating column.

The correct answer is B. fractional distillation of crude oil.

XXVI. The apparatus which is most suitable for the separation of immiscible liquids is

A. filter funnel
B. filter paper
C. paper chromatography
D. separating funnel

A separating funnel is used to separate two immiscible liquids based on their different densities. The denser liquid settles at the bottom and can be drained off first.

The correct answer is D. separating funnel.

XXVII. A dative covalent bond is formed when one atom

A. loses electrons
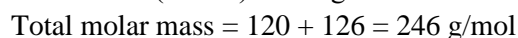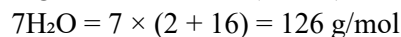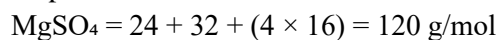B. gains electrons
C. shares electrons
D. donates electrons

A dative covalent bond (coordinate bond) is a type of covalent bond where both shared electrons come from the same atom. This happens when one atom donates a lone pair of electrons to another atom that lacks them.

The correct answer is D. donates electrons.

XXVIII. The percentage of water of crystallization in $MgSO_4 \cdot 7H_2O$ is

A. 51.22%
B. 49.21%
C. 40.32%
D. 47.32%

Step 1: Calculate molar masses
$MgSO_4 = 24 + 32 + (4 \times 16) = 120$ g/mol
$7H_2O = 7 \times (2 + 16) = 126$ g/mol
Total molar mass = 120 + 126 = 246 g/mol

Step 2: Calculate percentage of water
% water = $(126/246) \times 100 = 51.22\%$

The correct answer is A. 51.22%.

XXIX. When an egg shell is dropped into dilute hydrochloric acid, effervescence occurs because

A. carbon dioxide gas is evolved
B. hydrogen sulphide gas is evolved
C. oxygen gas is evolved
D. hydrogen gas is evolved

Eggshells contain calcium carbonate ($CaCO_3$), which reacts with hydrochloric acid to produce carbon dioxide gas (CO_2), causing effervescence (bubbling).

Reaction:
$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$
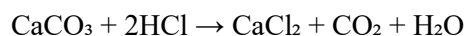
The correct answer is A. carbon dioxide gas is evolved.

XXX. Crystals of electrovalent compounds always possess

A. atoms held together by electrostatic forces
B. molecules held together by covalent forces
C. ions held together by electrostatic forces
D. molecules as their structural units

Electrovalent compounds (ionic compounds) are held together by electrostatic forces between positive and negative ions. These strong ionic bonds give them high melting points and characteristic crystalline structures.

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The correct answer is C. ions held together by electrostatic forces.

2. (a) Define each of the following:

(i) Catalyst – A substance that speeds up a chemical reaction without undergoing any permanent change.

(ii) Titration – A laboratory technique used to determine the concentration of a solution by reacting it with a solution of known concentration.
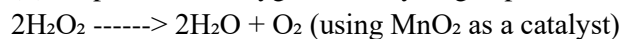
(iii) Ion – A charged particle formed when an atom gains or loses electrons.

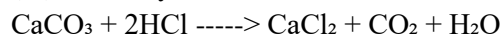(b) Write a balanced chemical equation for each of the following reactions:
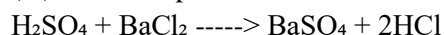
(i) Synthesis of water
$2H_2 + O_2 \text{-------} > 2H_2O$
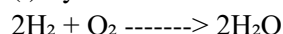
(ii) Preparation of oxygen from hydrogen peroxide
$2H_2O_2 \text{------} > 2H_2O + O_2$ (using MnO_2 as a catalyst)

(iii) Dilute hydrochloric acid and calcium carbonate
$CaCO_3 + 2HCl \text{-----} > CaCl_2 + CO_2 + H_2O$

(iv) Dilute sulphuric acid and barium chloride
$H_2SO_4 + BaCl_2 \text{-----} > BaSO_4 + 2HCl$

(v) Dilute hydrochloric acid and potassium permanganate
$2KMnO_4 + 16HCl \text{------} > 2MnCl_2 + 5Cl_2 + 8H_2O + 2KCl$

3. (a) Name one indicator you would choose for each of the following neutralization reactions:

(i) Hydrochloric acid against ammonium hydroxide – Methyl orange
(ii) Acetic (ethanoic) acid against sodium hydroxide – Phenolphthalein

(b) With the aid of a diagram, explain how you would prepare a standard solution of a named substance in the laboratory.

A standard solution is prepared by accurately weighing a solute, dissolving it in distilled water, and diluting it to a specific volume using a volumetric flask. The process includes:
1. Weighing the solute using an analytical balance
2. Dissolving it in distilled water in a beaker
3. Transferring the solution into a volumetric flask
4. Adding distilled water up to the calibration mark

(c) 20 cm³ of sulphuric acid required 25 cm³ of 0.1M potassium hydroxide for complete neutralization. Calculate:

(i) The molarity of the acid

Using the formula:
$M_1V_1 = M_2V_2$

$(20 \times M_1) = (0.1 \times 25)$
$M_1 = (0.1 \times 25) / 20 = 0.125$ M

(ii) The concentration in grams per litre of the acid

Mass concentration = Molarity × Molar mass
$= 0.125 \times 98$
$= 12.25$ g/L

4. Elements K, L, M, and R have atomic numbers 6, 8, 17, and 20 respectively.

(a) Write the electronic configuration of each element.
K (6) = 2, 4
L (8) = 2, 6
M (17) = 2, 8, 7
R (20) = 2, 8, 8, 2

(b) Write the normal valency of each element.
K = 4
L = 2
M = 1
R = 2

(c) Write the formula of the simplest compound and mention the type of bond formed when each of the following pairs of elements combine chemically.

(i) K with M – CCl_4 (covalent bond)
(ii) L with R – CaO (ionic bond)
(iii) K with R – CaC_2 (ionic bond)
(iv) M with M – Cl_2 (covalent bond)

5. (a) State Boyle's law.

Boyle's law states that the pressure of a fixed mass of gas is inversely proportional to its volume at constant temperature.

(b) A sample of gas X occupied a volume of 473 cm³ when measured at 740 mmHg and a temperature of 0°C. The gas was then expanded to a new volume of 570 cm³ at the same temperature. Calculate the new pressure of gas X.

Using Boyle's law:
$P_1V_1 = P_2V_2$

$(740 \times 473) = P_2 \times 570$

$P_2 = (740 \times 473) / 570$
$P_2 = 614.9$ mmHg

(c) Give the name of the type of reaction represented by each of the following reactions:

(i) $4Al + 3O_2 \text{------>} 2Al_2O_3$ – Combination reaction
(ii) $2Pb(NO_3)_2 \text{------>} 2PbO + 4NO_2 + O_2$ – Decomposition reaction
(iii) $AgNO_3 + NaCl \text{------->} AgCl + NaNO_3$ – Precipitation reaction

6. (a) What do you understand by the following terms?

(i) Soil erosion – The removal of the top layer of soil by natural forces such as wind, water, or human activity, leading to land degradation.

(ii) Mulching – A farming practice where a layer of material (such as straw, leaves, or plastic) is spread over the soil surface to retain moisture, reduce erosion, and suppress weeds.

(iii) Leaching – The process by which water carries dissolved nutrients or minerals away from the soil, often making it less fertile.

(iv) Soil fertility – The ability of soil to provide essential nutrients and support plant growth by maintaining an adequate supply of minerals, organic matter, and moisture.

(b) The weight of a fresh soil sample from your school's garden was 65 g. The soil sample, on drying in an oven at 140°C, cooling in a desiccator, and reweighing, had a constant weight of 36 g. What was the percentage of water in the soil sample?

Percentage of water = [(initial weight - final weight) / initial weight] $\times$ 100

= [(65 - 36) / 65] $\times$ 100
= (29 / 65) $\times$ 100
= 44.62%

Thus, the percentage of water in the soil sample is 44.62%.

(c) The Frasch process in the extraction of sulphur is essentially a physical process. With the aid of a diagram, briefly justify this statement.

The Frasch process involves drilling into underground sulphur deposits and injecting superheated steam to melt the sulphur, which is then forced to the surface using compressed air. No chemical changes occur; only a change in physical state takes place, making it a physical process.

(d) Mention three allotropes of sulphur.

1. Rhombic sulphur – The most stable form of sulphur at room temperature.
2. Monoclinic sulphur – A crystalline form that exists at higher temperatures.
3. Plastic sulphur – An amorphous form obtained by rapidly cooling molten sulphur.

(e) How and under what conditions does elemental sulphur react with each of the following?
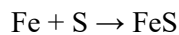
(i) Carbon – Sulphur reacts with carbon at high temperatures to form carbon disulphide (CS_2).
$C + 2S \rightarrow CS_2$
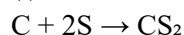
(ii) Iron – Sulphur reacts with iron when heated to form iron(II) sulphide (FeS).
$Fe + S \rightarrow FeS$
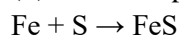
(iii) Iron filings – When mixed and heated, iron filings react with sulphur to form iron sulphide. The reaction is exothermic.

$Fe + S \rightarrow FeS$

8. (a) Define each of the following terms:

(i) Electrolyte – A substance that dissolves in water to produce ions, allowing the solution to conduct electricity. Examples include NaCl solution and H_2SO_4.

(ii) Anion – A negatively charged ion that moves toward the anode during electrolysis. Examples include Cl^- and SO_4^{2-}.

(iii) Cation – A positively charged ion that moves toward the cathode during electrolysis. Examples include Na^+ and Cu^{2+}.

(b) The diagram represents an experiment whose aim was to electroplate an iron fork with silver.

(i) What electrode was the cathode?

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The iron fork was the cathode, as electroplating occurs at the cathode where metal ions are reduced and deposited onto the object.

(ii) Was the process which took place at the anode reduction or oxidation?

Oxidation occurred at the anode, where silver atoms lost electrons to form silver ions ($Ag \rightarrow Ag^+ + e^-$).

(iii) If after passing a constant current for 300 minutes, the iron fork gained 2.16 g of silver, calculate the number of coulombs and the current which flowed during this experiment.

Step 1: Determine moles of silver deposited
Molar mass of Ag = 108 g/mol
Moles of Ag = 2.16 / 108 = 0.02 moles

Step 2: Find charge using Faraday's law
$Q = n \times F \times z$
$Q = 0.02 \times 96500 \times 1$
$Q = 1930$ C

Step 3: Calculate current
$I = Q / t$
$I = 1930$ C $/ (300 \times 60)$
$I = 0.107$ A

Thus, the charge is 1930 C, and the current is 0.107 A.

(iv) What is the importance of electroplating?

1. Prevents corrosion – Coating metals with a less reactive metal protects them from rusting (e.g., zinc coating on iron).
2. Improves appearance – Electroplating gives objects a shiny and decorative finish (e.g., silver-plated jewelry).
3. Enhances electrical conductivity – Copper electroplating is used in electrical circuits to improve conductivity.

9. (a) An organic compound D has a composition of 52.18% carbon, 11.04% hydrogen, and 36.78% oxygen and its molecular weight is 46. Determine its

(i) Empirical formula

Step 1: Convert percentages to moles
Carbon: 52.18 / 12 = 4.35

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Hydrogen: 11.04 / 1 = 11.04
Oxygen: 36.78 / 16 = 2.30

Step 2: Divide by the smallest ratio
C = 4.35 / 2.30 = 1.89 ≈ 2
H = 11.04 / 2.30 = 4.8 ≈ 5
O = 2.30 / 2.30 = 1

Empirical formula = C_2H_6O

(ii) Molecular formula

Empirical mass = $(2 \times 12) + (6 \times 1) + (1 \times 16) = 46$ g/mol
Since molecular mass = empirical mass, the molecular formula is also C_2H_6O.

(b) Write the possible structural formulae and their respective chemical names that can be derived from each of the following:
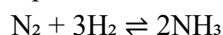
(i) C_2H_6O – Ethanol (CH_3CH_2OH) and Dimethyl ether (CH_3OCH_3)
(ii) C_6H_6 – Benzene (C_6H_6, an aromatic hydrocarbon)
(iii) C_4H_{10} – n-Butane ($CH_3CH_2CH_2CH_3$) and iso-Butane ($CH(CH_3)_3$)

10. (a) What do you understand by each of the following?

(i) Reversible reaction – A reaction that can proceed in both forward and backward directions under equilibrium conditions, such as Haber's process:
$N_2 + 3H_2 \rightleftharpoons 2NH_3$

(ii) Chemical equilibrium – A state in which the forward and reverse reactions occur at the same rate, leading to a constant concentration of reactants and products.

(b) What is the rate of a chemical reaction?

The rate of a chemical reaction is the measure of how quickly reactants are converted into products per unit time. It is affected by factors such as temperature, concentration, and catalysts.

(c) With the aid of an example in each case, explain briefly how each of the following affects the rate of a chemical reaction.

(i) Temperature – Increasing temperature provides more energy to molecules, increasing collision frequency and reaction rate. Example: The reaction of magnesium with hydrochloric acid is faster at higher temperatures.

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(ii) Concentration – Higher concentration increases the number of particles in a given volume, leading to more collisions and a faster reaction. Example: Increasing HCl concentration speeds up the reaction with calcium carbonate.

(iii) Physical state of reactants – Reactions occur faster when reactants are in states that allow better mixing. Example: Powdered zinc reacts faster with acid than zinc granules due to increased surface area.

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