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: 2005**

Instructions

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

1. For each of the items (i) - (x) choose the correct answer from among the given alternatives and write its letter beside the item number.

(i) Sodium metal is kept in oil because it

A. sinks in oil but floats in water
B. reacts vigorously with water
C. is very alkaline
D. forms a protective coat of sodium oxide with oil
E. forms a protective coat of sodium oxide with water

Sodium metal is highly reactive, especially with water, where it reacts violently, producing hydrogen gas and heat, which may cause an explosion. To prevent this reaction, sodium is stored in oil, which acts as a barrier to water and moisture.

Correct answer: B

(ii) A gas burned in air forms carbon dioxide and water only. From this experiment, the gas is likely to be

A. hydrogen
B. carbon monoxide
C. ethane
D. nitrogen
E. ozone

A gas that burns in air to produce only carbon dioxide and water must be a hydrocarbon. Ethane (C_2H_6) is a hydrocarbon that undergoes complete combustion in oxygen, forming carbon dioxide and water. Other gases listed do not fit this characteristic.

Correct answer: C

(iii) The molarity of a solution containing 26.5 g of anhydrous sodium carbonate in 5 dm^3 of the solution is

A. 0.05
B. 0.25
C. 1.25
D. 5.30
E. 0.025

Molar mass of sodium carbonate (Na_2CO_3) = (23 × 2) + 12 + (16 × 3) = 106 g/mol
Moles of Na_2CO_3 = 26.5 g / 106 g/mol = 0.25 mol
Molarity (M) = moles / volume (in dm^3)
= 0.25 mol / 5 dm^3

= 0.25 M

Correct answer: B

(iv) It was found that 3.27 g of zinc metal displaces 10.8 g of silver metal from an aqueous solution of silver nitrate. The correct equation for this reaction is

A. $Zn(aq) + Ag(s) \rightarrow Ag(aq) + Zn(s)$
B. $Zn(s) + Ag^{+}(s) \rightarrow Ag(s) + Zn^{+}(aq)$
C. $Zn(s) + 2Ag^{+}(aq) \rightarrow 2Ag(s) + Zn^{2+}(aq)$
D. $Zn(aq) + 2Ag^{+}(aq) \rightarrow 2Ag(s) + Zn(s)$
E. $Zn(s) + 2Ag^{+}(aq) \rightarrow Zn^{2+}(aq) + 2Ag(s)$

Zinc is more reactive than silver, meaning it can displace silver from its nitrate solution. In this reaction, zinc metal donates electrons to silver ions, reducing them to solid silver while zinc itself is oxidized to Zn^{2+}. The balanced chemical equation is:

$Zn(s) + 2Ag^{+}(aq) \rightarrow Zn^{2+}(aq) + 2Ag(s)$

Correct answer: E

(v) The pair of elements which is most likely to form a covalent bond when reacted together is

A. sodium and iodine
B. magnesium and oxygen
C. aluminium and oxygen
D. carbon and chlorine
E. calcium and carbon

A covalent bond forms between two nonmetals due to electron sharing. Carbon and chlorine are both nonmetals, meaning they will form a covalent bond when they react. The other options involve at least one metal, which leads to ionic bonding instead.

Correct answer: D

(vi) The method of collecting hydrogen chloride gas in a class experiment is known as

A. downward displacement of water
B. downward displacement of air
C. upward displacement of air
D. fountain
E. condensation

Hydrogen chloride (HCl) is heavier than air and highly soluble in water. Due to its higher density compared to air, it is collected using downward displacement of air rather than water.

Correct answer: B

(vii) Sea water contains various salts, which salt is present in the greatest proportion?

A. magnesium chloride
B. calcium sulphate
C. potassium chloride
D. sodium chloride
E. magnesium sulphate

Seawater is composed mainly of dissolved salts, with sodium chloride (NaCl) being the most abundant. It contributes to the salty taste of seawater. Other salts like magnesium chloride and potassium chloride exist in smaller amounts.

Correct answer: D

(viii) When dilute solutions of calcium chloride and sodium carbonate are mixed,

A. a white precipitate of sodium chloride is formed
B. carbon dioxide is evolved
C. a mixture of precipitates of sodium chloride and calcium carbonate is formed
D. a white precipitate of calcium carbonate is formed
E. a colourless solution of calcium carbonate and sodium chloride is formed

When calcium chloride ($CaCl_2$) is mixed with sodium carbonate (Na_2CO_3), an insoluble calcium carbonate ($CaCO_3$) precipitate forms, while sodium chloride remains in solution.

$CaCl_2(aq) + Na_2CO_3(aq) \rightarrow CaCO_3(s) + 2NaCl(aq)$

The white precipitate is calcium carbonate.

Correct answer: D

(ix) The atomic numbers of elements chlorine, argon, and potassium are 17, 18, and 19 respectively. Which statement best describes all three elements? These elements

A. have the same number of protons
B. have the same atomic mass
C. occur in the same period
D. have the same number of electrons

E. have octet stable electronic configuration

Elements with atomic numbers 17, 18, and 19 are in the same period of the periodic table (Period 3). This means they have the same number of electron shells, even though their properties differ.

Correct answer: C

(x) Three test tubes of the same volume separately contain nitrogen dioxide (NO_2), hydrogen (H_2), and carbon dioxide (CO_2) gases at room temperature and pressure. Then,

A. is the same number of atoms in each test tube
B. is the same number of molecules in each test tube
C. are more molecules of hydrogen gas than nitrogen dioxide and carbon dioxide molecules
D. is a 3 : 4 : 2 ratio for the number of molecules of carbon dioxide to nitrogen dioxide to hydrogen respectively
E. is a 2 : 4 : 3 ratio of the number of molecules of carbon dioxide to nitrogen dioxide to hydrogen respectively

According to Avogadro's law, equal volumes of gases at the same temperature and pressure contain the same number of molecules, regardless of their chemical identity. Therefore, the correct answer states that the number of molecules in each test tube is the same.

Correct answer: B

2. Match the terms in List A with the responses in List B by writing the letter of the correct response beside the item number.

List A
(i) Methane
(ii) Nitrogen
(iii) Zinc
(iv) Detergent
(v) Anion
(vi) Amphoteric oxide
(vii) Isotopes
(viii) Soap
(ix) Isomers
(x) Ammonia

List B
A. Crystallizes
B. Ethyl alcohol
C. Alkaline gas

D. Sublimes
E. $AlCl_3$
F. $40_{18}X$ and $39_{18}X$
G. Diamond and graphite
H. Rust
I. A gas present in natural gas
J. Used to coat iron metal
K. Turns lime water milky
L. An acidic gas
M. Compounds with the same molecular formula but different structural formula
N. Cl^-
O. The most abundant gas in air
P. Forms lather even with hard water
Q. Zinc oxide
R. The sodium salt of fatty acids
S. MgO
T. 16_8X and 16_8Y

Correct answers:
(i) Methane - I (A gas present in natural gas)
(ii) Nitrogen - O (The most abundant gas in air)
(iii) Zinc - J (Used to coat iron metal)
(iv) Detergent - P (Forms lather even with hard water)
(v) Anion - N (Cl^-)
(vi) Amphoteric oxide - Q (Zinc oxide)
(vii) Isotopes - F ($40_{18}X$ and $39_{18}X$)
(viii) Soap - R (The sodium salt of fatty acids)
(ix) Isomers - M (Compounds with the same molecular formula but different structural formula)
(x) Ammonia - C (Alkaline gas)

3. (a) Define the term fuel.
Fuel is any substance that is burned to produce heat or energy.

(b) State two examples in each of the following types of fuel:

(i) Liquid
- Petrol
- Kerosene

(ii) Solid
- Coal
- Wood

(iii) Gaseous
- Natural gas
- Hydrogen

(c)(i) What are two gaseous fuels used in industries? State the composition of each of the two gases.
- Natural gas (mainly composed of methane, CH_4)
- Hydrogen gas (composed of hydrogen, H_2)

(ii) List down three advantages of liquid fuels over solid fuels.
- Liquid fuels burn more efficiently and completely.
- They are easier to transport and store.
- They produce less residue or ash compared to solid fuels.

(iii) State five characteristics of a good fuel.
- High energy content per unit mass or volume
- Easily combustible and produces minimal smoke
- Readily available and cost-effective
- Safe to handle, store, and transport
- Produces minimal environmental pollution

4.(a)

(i) Write down the electronic configuration of elements F, G, L, M, and J.

- F (Atomic number 8): 2, 6
- G (Atomic number 9): 2, 7
- L (Atomic number 11): 2, 8, 1
- M (Atomic number 6): 2, 4
- J (Atomic number 18): 2, 8, 8

(ii) How many neutrons are present in element G?
Number of neutrons = Atomic mass - Atomic number
= 19 - 9
= 10 neutrons

(b) (i) What type of bond will exist in a compound formed when element F combines with M?
- Covalent bond (Both are nonmetals and share electrons)

(ii) What type of bond will exist in a compound formed when element G combines with L?
- Ionic bond (L is a metal and G is a nonmetal, so electron transfer occurs)

(c) (i) In what group and period in the periodic table does element J occupy?
- Group 18, Period 3

(ii) Which element is unreactive towards chemical reactions?
- J (because it is a noble gas with a full outer shell)

(d)(i) Define the term isotopes.
Isotopes are atoms of the same element that have the same number of protons but different numbers of neutrons.

(ii) Below is a list of isotopic atoms:

$^{18}_{8}X$, $^{18}_{8}Y$, $^{17}_{8}X$, $^{16}_{8}Y$, $^{19}_{9}Y$, $^{19}_{9}X$

Which isotopes form atoms of the same element?
- $^{18}_{8}X$, $^{18}_{8}Y$, $^{17}_{8}X$, $^{16}_{8}Y$ (all have atomic number 8, so they belong to oxygen)
- $^{19}_{9}Y$, $^{19}_{9}X$ (both have atomic number 9, so they belong to fluorine)

5.(a) Write a balanced chemical equation for the neutralization of the metal hydroxide XOH and hydrochloric acid.

$XOH + HCl \rightarrow XCl + H_2O$

(b) Calculate the concentration of the metal hydroxide XOH in moles per dm^3.

Given:
- Volume of XOH solution = 20 cm^3 = 0.020 dm^3
- Mass concentration of XOH = 7 g/dm^3
- Volume of HCl used = 25 cm^3 = 0.025 dm^3
- Molarity of HCl = 0.10 M

Step 1: Determine moles of HCl
Moles = concentration × volume
= 0.10 mol/dm^3 × 0.025 dm^3
= 0.0025 moles

Step 2: From the balanced equation, 1 mole of XOH reacts with 1 mole of HCl, so moles of XOH = 0.0025

Step 3: Calculate concentration of XOH
Concentration = moles/volume
= 0.0025 mol / 0.020 dm^3
= 0.125 M

(c) (i) Calculate the molar mass of XOH.

Mass concentration = molar mass × molarity
7 g/dm³ = molar mass × 0.125 mol/dm³
Molar mass = 7 g/dm³ ÷ 0.125 mol/dm³
= 56 g/mol

(ii) Identify element X.

XOH consists of a metal X, oxygen, and hydrogen. From the calculated molar mass (56 g/mol), the closest matching element is iron (Fe), as the molar mass of FeOH is approximately 56 g/mol.

Element X is iron (Fe).

6.(a)

(i) List down the three factors affecting the selection of ion discharge at the electrodes.

- Position of the ion in the electrochemical series (ions lower in the series discharge first)
- Concentration of the ion in solution (higher concentration ions discharge more readily)
- Type of electrode used (some electrodes influence ion discharge, e.g., platinum and graphite)

(ii) Define the term electrolyte.

An electrolyte is a substance that, when dissolved in water or molten, conducts electricity due to the presence of free-moving ions.

(b) A bluish copper sulphate aqueous solution was electrolyzed by using copper electrodes.

(i) Write ionic chemical equations for the reactions, which occurred at the cathode and anode.

At the cathode: $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$
At the anode: $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$

(ii) Explain what will happen to the blue colour of copper sulphate solution as electrolysis continues.

The blue colour of the copper sulphate solution remains unchanged because copper ions from the anode dissolve into the solution at the same rate that they are deposited at the cathode.

(c) How many moles of electrons are required to produce 27 g of Al during the electrolysis of molten Al_2O_3?

Given:
- Molar mass of Al = 27 g/mol

- From the equation: $2Al^{3+} + 6e^{-} \rightarrow 2Al$,
  2 moles of Al require 6 moles of electrons.

Step 1: Determine moles of Al
Moles of Al = 27 g / 27 g/mol = 1 mol

Step 2: Determine moles of electrons
From the equation, 2 moles of Al require 6 moles of electrons.
1 mole of Al will require (6/2) = 3 moles of electrons.

Moles of electrons required = 3 moles.

7.(a) What are the factors affecting the rate of chemical reaction?

- Temperature (higher temperature increases reaction rate)
- Concentration of reactants (higher concentration increases reaction rate)
- Surface area (smaller particles increase reaction rate)
- Presence of a catalyst (speeds up reaction without being consumed)
- Pressure (in gases, higher pressure increases reaction rate)

(b) One of the methods used for the preparation of oxygen is by the decomposition of hydrogen peroxide.

$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$

(i) What is the effect of MnO_2 on the rate of production of oxygen?

Manganese dioxide (MnO_2) acts as a catalyst, increasing the rate of oxygen production without being consumed in the reaction.

(ii) What will happen to the rate of production of oxygen if the concentration of hydrogen peroxide is increased?

Increasing the concentration of hydrogen peroxide increases the rate of oxygen production because more reactant molecules are available for decomposition.

(c) Calculate the volume of oxygen at standard temperature and pressure (s.t.p.) which theoretically could be obtained from 50 cm^3 of a solution of hydrogen peroxide containing 68 g/dm^3.

Given:
- 1 mole of H_2O_2 = 34 g
- 2 moles of H_2O_2 produce 1 mole of O_2
- Molar volume at s.t.p. = 22.4 dm^3

Step 1: Determine mass of H_2O_2 in 50 cm^3
Mass = (68 g/dm^3 × 50 cm^3) ÷ 1000
= 3.4 g

Step 2: Determine moles of H_2O_2
Moles = 3.4 g ÷ 34 g/mol
= 0.1 mol

Step 3: Determine moles of O_2 produced
From the reaction equation, 2 moles of H_2O_2 produce 1 mole of O_2.
So, 0.1 mol of H_2O_2 will produce (0.1 ÷ 2) = 0.05 mol of O_2.

Step 4: Calculate volume of O_2 at s.t.p.
Volume = moles × molar volume
= 0.05 × 22.4 dm^3
= 1.12 dm^3

Volume of oxygen = 1.12 dm^3 (or 1120 cm^3).

8.(a) Define the following terms:

(i) Homologous series.

A homologous series is a group of organic compounds with similar chemical properties, the same general formula, and a regular increase in molecular size by CH_2 units.

(ii) Isomerism.

Isomerism is the existence of two or more compounds with the same molecular formula but different structural arrangements and properties.

(b) Write down the expanded structural formulae of the following compounds:

(i) Chloroethane: CH_3CH_2Cl
(ii) 2-Methylbutane:
CH_3-$CH(CH_3)$-CH_2-CH_3
(iii) Ethanol: CH_3CH_2OH
(iv) 2,2-Dimethylpropane:
$(CH_3)_4C$

(c) Complete the following reactions:

(i) $CH_4 + O_2 \rightarrow CO_2 + H_2O$
(ii) $CaC_2 + 2H_2O \rightarrow C_2H_2 + Ca(OH)_2$
(iii) $CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$
(iv) $C_2H_5OH + O_2 \rightarrow CO_2 + H_2O$

9. (a)

(i) Write down the names of the substances represented by materials V, W, and X.

- V: Iron ore (Fe_2O_3)
- W: Coke (carbon)
- X: Limestone ($CaCO_3$)

(ii) Write down the names of the products Y and Z.

- Y: Iron (Fe)
- Z: Slag ($CaSiO_3$)

(b)

(i) Write a balanced chemical equation for the reaction between the iron ore, Fe_2O_3, and carbon monoxide.

$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

(ii) What is the function of carbon monoxide in its reaction with Fe_2O_3?

Carbon monoxide acts as a reducing agent, removing oxygen from iron ore (Fe_2O_3) to form iron metal (Fe) and carbon dioxide (CO_2).

(d) If 80 kg of iron ore, Fe_2O_3, were allowed to react with carbon monoxide during the extraction process, how many kilograms of iron (Fe) would be obtained?

Given:
- Molar mass of $Fe_2O_3 = (2 \times 56) + (3 \times 16) = 160$ g/mol
- Molar mass of Fe = 56 g/mol
- From the reaction equation: $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

Step 1: Determine moles of Fe_2O_3 in 80 kg
Moles = 80000 g / 160 g/mol = 500 moles

Step 2: Determine moles of Fe produced
From the equation, 1 mole of Fe_2O_3 produces 2 moles of Fe.
So, 500 moles of Fe_2O_3 will produce $2 \times 500 = 1000$ moles of Fe.

Step 3: Determine mass of Fe produced
Mass = moles × molar mass
= 1000 × 56 g
= 56000 g = 56 kg

Kilograms of iron obtained = 56 kg.

10.(a)

(i) Soil erosion.

Soil erosion is the removal of the top layer of soil by natural forces such as wind, water, or human activities.

(ii) Leaching.

Leaching is the process by which water dissolves and carries away nutrients and minerals from the soil, often leading to nutrient depletion.

(iii) Soil fertility.

Soil fertility refers to the ability of soil to provide essential nutrients and support plant growth. It depends on the presence of organic matter, minerals, and microorganisms.

(iv) Soil pH.

Soil pH is a measure of the acidity or alkalinity of the soil, which affects nutrient availability and microbial activity.

(b) The weight of a fresh soil sample collected from a farmer's field was 24 g. It was oven-dried at 106°C for 22 hours, cooled in a desiccator, and weighed. The oven-dry weight was 19.5 g. What was the percentage of moisture in the soil sample?

Moisture content = ((Initial weight - Dry weight) / Initial weight) × 100%
= ((24 - 19.5) / 24) × 100
= (4.5 / 24) × 100
= 18.75%

Percentage of moisture = 18.75%.

(c) Explain why a good farmer is advised to include leguminous plants in crop rotation.

Leguminous plants have root nodules containing nitrogen-fixing bacteria that convert atmospheric nitrogen into usable forms for plants, improving soil fertility and reducing the need for artificial fertilizers.

11.

(a) Complete and balance the following equations:

(i) $Ca(OH)_2(aq) + NH_4Cl(s) \rightarrow warm \rightarrow CaCl_2 + NH_3 + H_2O$

(ii) $AgNO_3(s) \rightarrow heat \rightarrow Ag + NO_2 + O_2$

(iii) $Cu(s) + 4HNO_3(aq) \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$

(iv) $Na_2CO_3(aq) + Ca(HCO_3)_2(aq) \rightarrow CaCO_3 + 2NaHCO_3$

(v) $Ca(OH)_2 + CO_2$ (excess) $+ H_2O \rightarrow Ca(HCO_3)_2$

(b) Explain with the help of a balanced equation, why a freshly prepared nitric acid changes from colourless to yellowish brown colour on standing.

Nitric acid decomposes over time to form nitrogen dioxide (NO_2), which dissolves in the acid, giving it a yellowish brown colour.

$4HNO_3 \rightarrow 2H_2O + 4NO_2 + O_2$

12.(a)

(i) Define the term pollution.

Pollution is the introduction of harmful substances or contaminants into the environment, causing adverse effects on living organisms and ecosystems.

(ii) List down the three main types of pollution.

- Air pollution
- Water pollution
- Soil pollution

(b)

(i) What is the importance of the ozone layer in the earth's atmosphere?

The ozone layer absorbs harmful ultraviolet (UV) radiation from the sun, preventing it from reaching the Earth's surface and protecting living organisms from its harmful effects.

(ii) Explain the effect of destroying the ozone layer.

The destruction of the ozone layer allows more UV radiation to reach the Earth, leading to increased skin cancer, cataracts, weakened immune systems, and damage to ecosystems and crops.

(iii) Which gases must not be produced in order to prevent the destruction of the ozone layer?

- Chlorofluorocarbons (CFCs)
- Hydrochlorofluorocarbons (HCFCs)
- Halons
- Carbon tetrachloride
- Methyl bromide