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: 2000**

Instructions

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

1. (i) A gas at 273°C under a pressure of 1600 mmHg occupies a volume of 190 cm^3. What is the volume of the gas at STP?

Solution: Use the combined gas law:

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

Given:
$P_1 = 1600$ mmHg, $V_1 = 190\ cm^3$, $T_1 = 273 + 273 = 546$ K
$P_2 = 760$ mmHg (STP), $T_2 = 273$ K

Solving for V_2:

$V_2 = (P_1V_1T_2) / (P_2T_1)$
$V_2 = (1600 \times 190 \times 273) / (760 \times 546)$
$V_2 = 450\ cm^3$

Answer: B. 450 cm^3

(ii) What volume of 0.2 M H_2SO_4 will be required to neutralize completely 25.0 cm^3 of 0.05 M KOH?

Solution:
Using the formula:
$M_1V_1 = M_2V_2$ (for monoprotic acids, but H_2SO_4 is diprotic, so $M_1V_1 = 2M_2V_2$)

$(0.2 \times V_1) = 2 \times (0.05 \times 25)$
$0.2V_1 = 2.5$
$V_1 = 12.5\ cm^3$

Answer: B. 6.125 cm^3

(iii) Which of the following statements does NOT support the fact that "water is a compound"?

A. The hydrogen and oxygen in water can not be separated by physical means.
B. The chemical and physical properties are quite different from the constituents.
C. Hydrogen can be separated from water at boiling point of water.
D. The formation of water is always accompanied by the production of heat, light, and sound.

Answer: C. Hydrogen can be separated from water at boiling point of water. (Incorrect because hydrogen can only be separated through electrolysis, not boiling.)

(iv) If element X is one of the elements found in the periodic table which are called "alkali earth metals," then element X is likely to be found in

A. group I
B. group II
C. group IV
D. group VI

Answer: B. group II

(v) Which of the following sets of compounds is NOT an example of a homologous series?

A. Ethene, ethane, and acetylene
B. Propene, butene, and ethene
C. Methanol, ethanol, and propanol
D. Formic acid, acetic acid, and propanoic acid

Answer: A. Ethene, ethane, and acetylene (They belong to different homologous series: alkenes, alkanes, and alkynes, respectively.)

(vi) Among the acids which are used to control excess stomach acidity are acetic, oxo, Andrews' acid, and sodium bicarbonate. Chemically, this drug contains a substance which neutralizes the acid; one of these substances is sodium hydrogen carbonate. Below is a balanced reaction equation for the action of the substance on hydrochloric acid.

A. $NaHCO_3 + 2HCl \rightarrow NaCl + CO_2 + H_2O$
B. $NaHCO_3 + HCl \rightarrow NaCl + CO_2 + H_2O$
C. $2NaHCO_3 + 2HCl \rightarrow Na_2Cl_2 + CO_2 + H_2O$
D. $2NaHCO_3 + 2HCl \rightarrow 3NaCl + 3CO_2 + 2H_2O$

Answer: B. $NaHCO_3 + HCl \rightarrow NaCl + CO_2 + H_2O$

(vii) Why is carbon dioxide used in fire extinguishers?

A. It is denser than air
B. It turns lime water milky
C. It does not support burning
D. It is colourless and odourless

Answer: C. It does not support burning

(viii) Cutting down trees without planting others is bad for animals because

A. it spoils nice shade
B. it makes the earth look ugly

C. the amount of carbon dioxide in air will become less
D. the amount of oxygen in air will become less

Answer: D. the amount of oxygen in air will become less

(ix) The discharge of cations during electrolysis is

A. oxidation
B. reduction
C. neither oxidation nor reduction
D. both oxidation and reduction

Answer: B. reduction (Cations gain electrons at the cathode.)

(x) Diamond and graphite differ because

A. graphite is an impure carbon
B. atoms in a different variety in the two forms
C. the atoms in diamond are larger than those in graphite
D. carbon atoms are differently arranged

Answer: D. carbon atoms are differently arranged

(xi) Which of the following lists of chemical species have the same number of electrons?

A. Na^{+}, Mg^{2+}, Be^{2+} and Li
B. O^{2-}, F^{-}, Ne, and Na
C. Cl^{-}, He, Be^{2+}, and O^{2-}
D. K^{+}, Ca^{2+}, Cl^{-} and Ar

Answer: D. K^{+}, Ca^{2+}, Cl^{-} and Ar (All have 18 electrons.)

(xii) If Ana wants to electroplate a spoon with copper by using copper sulphate solution, she should arrange the electrodes in the following way

A. Spoon as anode and copper as cathode
B. Spoon as cathode and copper as anode
C. Spoon as anode and carbon as cathode
D. Spoon as cathode and copper sulphate as anode

Answer: B. Spoon as cathode and copper as anode (The object to be plated is always the cathode.)

(xiii) Which of the following nitrites will not evolve nitrogen dioxide when heated?

A. Potassium nitrate
B. Silver nitrate
C. Mercury nitrate
D. Lead nitrate

Answer: A. Potassium nitrate (Alkali metal nitrates decompose to give nitrites and oxygen, not nitrogen dioxide.)

(xiv) The quantity of electricity needed to deposit 1 mole of aluminium in the electrolysis of aluminium sulphate is

A. 96500 coulombs
B. 289500 coulombs
C. 356000 coulombs
D. 193000 coulombs

Solution:
Since aluminium forms Al^{3+} ions, it requires 3 Faradays (3 × 96500 C) to deposit 1 mole:

Charge = 3 × 96500 = 289500 C

Answer: B. 289500 coulombs

(xv) The chemical equation $CH_4 + Cl_2$ -----> $CH_3Cl + HCl$ represents an example of

A. polymerization
B. addition reaction
C. substitution reaction
D. esterification

Answer: C. substitution reaction (Hydrogen is replaced by chlorine in methane.)

2. (a) State Avogadro's law

Avogadro's law states that equal volumes of all gases, at the same temperature and pressure, contain the same number of molecules.

(b) Define the term mole

A mole is the amount of a substance that contains exactly 6.022×10^{23} elementary particles (atoms, molecules, or ions). This number is known as Avogadro's constant.

(c) Solid calcium carbonate ($CaCO_3$) reacts with excess nitric acid (HNO_3) liberating carbon dioxide gas to form soluble calcium nitrate and water. Calculate the amount of nitric acid needed to dissolve 5 g of calcium carbonate.

Step 1: Write the balanced chemical equation

$CaCO_3 + 2HNO_3 \rightarrow Ca(NO_3)_2 + CO_2 + H_2O$

Step 2: Find the molar mass of calcium carbonate

Molar mass of $CaCO_3 = 40 + 12 + (16 \times 3) = 100$ g/mol

Step 3: Calculate the moles of calcium carbonate in 5 g

Moles = mass / molar mass
= 5 g / 100 g/mol
= 0.05 moles

Step 4: Use the mole ratio from the equation

1 mole of $CaCO_3$ reacts with 2 moles of HNO_3
So, 0.05 moles of $CaCO_3$ will react with $0.05 \times 2 = 0.10$ moles of HNO_3

Step 5: Find the mass of nitric acid required

Molar mass of $HNO_3 = 1 + 14 + (16 \times 3) = 63$ g/mol
Mass of $HNO_3 = 0.10 \times 63$
= 6.3 g

Amount of nitric acid needed is 6.3 g.

3. (a) State Faraday's laws of electrolysis

First law: The mass of a substance deposited or liberated during electrolysis is directly proportional to the quantity of electricity passed through the electrolyte.

Second law: When the same quantity of electricity is passed through different electrolytes, the masses of the substances deposited or liberated are proportional to their chemical equivalent weights.

(b) An element X has a relative atomic mass of 88. When a current of 0.5 amperes was passed through fused chloride of X for 32 minutes and 10 seconds, 0.44 g of X were deposited at the cathode.

(i) Calculate the number of Faradays needed to liberate one mole of X.

Charge (Q) = current × time
= 0.5 A × (32 × 60 + 10) s
= 0.5 × 1930
= 965 coulombs

Using Faraday's first law:
m = (Z × Q)

Electrochemical equivalent (Z) = mass deposited / charge
= 0.44 g / 965 C
= 0.000456 g/C

One mole of X (88 g) requires:
Faradays = 88 / (0.000456 × 96500)
= 2 Faradays

(ii) Write the formula of the X ion.

Since 2 Faradays are required, the charge on the X ion must be +2.
So, the formula of the ion is X^{2+}.

(iii) Write the formula of the hydroxide of X.

Since X has a valency of 2, the hydroxide will be $X(OH)_2$.

4. (a) Differentiate between saturated and unsaturated hydrocarbons.

Saturated hydrocarbons contain only single bonds between carbon atoms (alkanes), while unsaturated hydrocarbons contain one or more double or triple bonds (alkenes or alkynes).

(b) When a solution of sucrose is fermented by yeast, ethanol is formed. This ethanol can be isolated from the liquid by fractional distillation.

(i) Explain the meaning of the two terms bolded.

Fermentation is the process in which sugar is broken down by yeast in the absence of oxygen to produce ethanol and carbon dioxide.

Fractional distillation is the separation of liquids based on their boiling points. Ethanol is separated from the fermentation mixture because it has a lower boiling point than water.

(ii) What is the purpose of the yeast?

Yeast contains enzymes that break down sucrose into ethanol and carbon dioxide during fermentation.

(iii) Write down the structural formula of ethanol and give its name under the IUPAC system.

The structural formula of ethanol is:

CH_3CH_2OH

The IUPAC name of ethanol is ethanol.

(iv) Give the balanced chemical equations when

- Ethanol reacts with sodium metal.

$2C_2H_5OH + 2Na \rightarrow 2C_2H_5ONa + H_2$

- Ethanol reacts with concentrated sulphuric acid at 180°C.

$C_2H_5OH \rightarrow C_2H_4 + H_2O$

5. (a) The following list of elements is arranged in order of an activity series.

Na, Ca, Mg, Zn, Fe, H, Cu, Hg.

From these elements, name

(i) A metal which reacts with cold water

Sodium (Na).

(ii) A metal which burns in steam but does not react with cold water

Magnesium (Mg).

(iii) Any other element which reacts when heated in steam

Zinc (Zn).

(iv) An element which has oxide which decomposes on heating

Mercury (Hg).

(v) Those elements which do not displace hydrogen from dilute hydrochloric acid

Copper (Cu) and Mercury (Hg).

(b) Write balanced chemical equations when

(i) A named metal in (a)(i) above reacts with cold water.

$2Na + 2H_2O \rightarrow 2NaOH + H_2$

(ii) An oxide of the named element in (a)(iv) above is heated.

$2HgO \rightarrow 2Hg + O_2$

6. (a) Name four forms of organic manures which are commonly available in Tanzania.

1. Farmyard manure
2. Compost manure
3. Green manure
4. Poultry manure

(b) In what ways does the addition of organic manures affect the condition of the soil?

1. Improves soil structure and aeration
2. Increases the water-holding capacity of the soil
3. Supplies essential nutrients for plant growth
4. Enhances microbial activity in the soil
5. Reduces soil erosion
6. Increases organic matter content

(c) State three types of mineral fertilizers which are commonly used in Tanzania.

1. Nitrogen-based fertilizers (e.g., ammonium sulphate)
2. Phosphorus-based fertilizers (e.g., superphosphate)
3. Potassium-based fertilizers (e.g., potassium chloride)

(ii) Indicate the nutrient element provided by each of the mineral fertilizers stated in (c)(i) above.

1. Nitrogen-based fertilizers provide nitrogen (N).
2. Phosphorus-based fertilizers provide phosphorus (P).
3. Potassium-based fertilizers provide potassium (K).

7. (a) Define the following terms.

(i) Exothermic reaction

An exothermic reaction is a chemical reaction that releases heat energy to the surroundings.

(ii) Endothermic reaction

An endothermic reaction is a chemical reaction that absorbs heat energy from the surroundings.

(b) State Le Chatelier's principle.

Le Chatelier's principle states that if a system at equilibrium is subjected to a change in temperature, pressure, or concentration, the system will adjust to counteract the imposed change and restore a new equilibrium.

(c) The equation for the dissociation of calcium carbonate is

$CaCO_3 \rightleftharpoons CaO + CO_2 \quad \Delta H = +175.5\ kJmol^{-1}$

What will be the effect on the proportion of calcium carbonate in the equilibrium mixture if

(i) The temperature is increased?

The decomposition of $CaCO_3$ is endothermic, so increasing temperature shifts the equilibrium to the right, increasing the decomposition of $CaCO_3$.

(ii) The pressure is increased?

Increasing pressure shifts the equilibrium to the left, favoring calcium carbonate formation because fewer gas molecules are present on the left side.

What is the necessary condition for manufacturing calcium oxide from calcium carbonate on a large scale?

The reaction must be conducted at high temperatures in a lime kiln to ensure complete decomposition of calcium carbonate into calcium oxide and carbon dioxide.

10. (a) Name the apparatus.

The apparatus shown in the diagram is a blast furnace.

(b) What is the element obtained by using the apparatus in figure 1.

The element obtained using the blast furnace is iron (Fe).
(c) State what the letters A, B, C, D, E, F, and G represent.

A - Hot air blast inlet
B - Tuyeres (where the hot air enters the furnace)
C - Outlet for waste gases (carbon dioxide and nitrogen)
D - Molten iron outlet (tap hole)
E - Raw materials inlet (iron ore, coke, and limestone)
F - Slag outlet
G - Exit for waste gases

(d) Name the ore used in this process.

The ore used in this process is hematite (Fe_2O_3) or magnetite (Fe_3O_4).

(e) Is the element in (b) a metal or non-metal?

Iron (Fe) is a metal.