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: 2010**

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 among the given alternatives and write its letter beside the item number.

i. 1.4 g of potassium hydroxide is dissolved in water to form 250 cm^3 of solution. What is the molarity of this solution?

A 0.01 M
B 0.1 M
C 1.4 M
D 5.6 M
E 6.0 M

Solution:
- Molar mass of KOH = 39 + 16 + 1 = 56 g/mol
- Moles of KOH = mass / molar mass = 1.4 g / 56 g/mol = 0.025 moles
- Molarity (M) = moles / volume in liters
  = 0.025 moles / 0.250 L
  = 0.1 M

Correct answer: B

ii. In the blast furnace, carbon monoxide is prepared by passing carbon dioxide over a red-hot coke. Carbon dioxide is

A an accelerator
B an oxidizing agent
C a reducing agent
D a catalyst
E oxidized

Carbon dioxide is reduced to carbon monoxide, which then acts as a reducing agent in the blast furnace.

Correct answer: C

iii. A catalyst can be described as a substance

A that alters the rate of reaction
B that slows down the rate of reaction
C used in every reaction so as to speed up the rate of reaction
D that starts and speeds up the rate of reaction
E that terminates a chemical reaction

A catalyst increases the rate of reaction without being consumed.

Correct answer: A

iv. A covalent bond is formed when

A a metal combines with a non-metal
B potassium and oxygen combine
C ammonia is formed
D two metals combine
E an atom loses an electron
A covalent bond occurs when non-metals share electrons.
Correct answer: C

v. A solvent can be obtained from a solution by

A evaporation followed by decantation
B filtration and condensation
C evaporation and filtration
D evaporation and condensation
E crystallization followed by sublimation

Evaporation removes the solvent, and condensation recovers it.

Correct answer: D

vi. Aqueous sugar solution is a poor conductor of electricity because

A water and sugar are covalent compounds
B water is a non-electrolyte
C sugar is a non-electrolyte
D sugar is covalent when in liquid form
E sugar dissolves completely in water

Sugar does not ionize in solution, making it a non-electrolyte.

Correct answer: C

vii. The process of giving away water of crystallization to the atmosphere by a chemical substance is called

A efflorescence
B deliquescence
C hygroscopic
D sublimation
E vaporization

Efflorescence occurs when a hydrated salt loses its water of crystallization.

Correct answer: A

viii. Copper can be separated from a mixture of zinc and copper by adding to the mixture

A concentrated H_2SO_4
B dilute H_2SO_4
C aqueous solution of $ZnSO_4$
D concentrated HNO_3
E a catalyst

Dilute sulfuric acid reacts with zinc but not with copper, leaving copper behind.

Correct answer: B

ix. Among the factors that determine the ions to be discharged at electrodes when salt solutions are electrolyzed are their

A non-metallic nature
B relative concentrations in the solution
C relative ionic masses
D electronic configuration
E position in the periodic table

Higher concentration affects which ions are discharged in electrolysis.

Correct answer: B

x. The mass of sodium hydroxide contained in 25 cm^3 of 0.1 M NaOH is

A 0.5 gm
B 2.85 gm
C 250 gm
D 0.2 gm
E 25 gm

Solution:
- Molar mass of NaOH = 23 + 16 + 1 = 40 g/mol
- Moles of NaOH = Molarity × Volume in liters
  = 0.1 × 0.025
  = 0.0025 moles
- Mass = Moles × Molar mass

$= 0.0025 \times 40$
$= 0.1$ g

Correct answer: D

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

List A

i. Oxygen
ii. Sulfur dioxide
iii. Ammonia
iv. Hydrogen chloride
v. Carbon monoxide
vi. Nitrogen
vii. Hydrogen
viii. Chlorine
ix. Nitrogen dioxide
x. Carbon dioxide

List B

A. Green-yellow gas which rapidly bleaches damp litmus paper
B. Heats with cracking sound
C. It rekindles a glowing splint of wood
D. Colorless gas, extremely poisonous since it combines with hemoglobin in red blood cells
E. Brown-ring test
F. Produces a white precipitate of silver chloride in a drop of a solution of silver nitrate
G. It is the only alkaline gas
H. Substitution reaction
I. Explodes with air when flame applied
J. Sweet-aroma smell
K. It is a brown gas
L. It is very irritating and smells and decolorizes potassium manganate (VII) solution with no precipitation left
M. It turns lime water milky
N. Colorless, odorless, non-poisonous gas commonly used as a refrigerant
O. Characteristic yellow flame
P. Good solvent for fats and grease, non-poisonous
Q. Blackens lead (II) ethanoate paper
R. Turns brown on exposure to air

S. Freezes at 0°C and boils at 100°C
T. Rotten-egg smell

Answers

i. Oxygen - C
ii. Sulfur dioxide - L
iii. Ammonia - G
iv. Hydrogen chloride - F
v. Carbon monoxide - D
vi. Nitrogen - E
vii. Hydrogen - I
viii. Chlorine - A
ix. Nitrogen dioxide - K
x. Carbon dioxide - M

3. a. Asubuhi Njema's child was sick. When she took her to the hospital, she was prescribed some medicine, including a bottle of syrup. The bottle was written, Shake before you use. What does this statement signify?

The instruction Shake before you use means that the syrup is a suspension, meaning the active ingredients are not completely dissolved in the liquid. The solid particles tend to settle at the bottom over time, so shaking ensures that the medicine is evenly distributed before consumption to provide the correct dosage.

b. i. What is the first step to take when you want to identify the contents of a given salt containing one anion and one cation?

The first step in identifying the contents of a given salt is to perform a solubility test by dissolving the salt in water. If the salt dissolves, further tests such as flame tests, precipitation tests, or pH tests can be performed to determine the specific cation and anion present.

ii. In a solution of water, identify a solute and a solvent. Justify your answer.

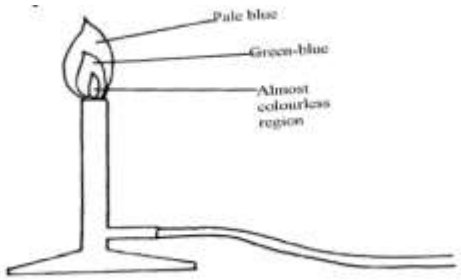
- Solvent: Water
- Solute: Any substance dissolved in water, such as sugar or salt.

Justification: A solvent is the substance that dissolves other materials, and since water is the universal solvent that dissolves many substances, it is the solvent in this solution. The solute is the substance that gets dissolved in the solvent, such as salt in saltwater.

iii. Sodium is a solid while chlorine is a gas at room temperature, although they are in the same period in the periodic table. What is the cause of this difference?

- Sodium is a metal with strong metallic bonds that hold its atoms together, giving it a high melting and boiling point.
- Chlorine is a non-metal with weak Van der Waals forces between its molecules, making it a gas at room temperature.
- The difference arises from the types of bonds present—sodium has metallic bonding, while chlorine has covalent bonding in simple molecular form.

4. (a) Draw a well-labeled diagram of a non-luminous Bunsen burner flame.



b. Explain the meaning of the following:

i. Malleable
- The ability of a material to be hammered or pressed into thin sheets without breaking.

ii. Ductile
- The property of a material that allows it to be stretched into a wire without breaking.

iii. Brittle
- A material that breaks easily under stress rather than deforming. Brittle materials lack elasticity and plasticity.

c. Give an account of the following:

i. Anhydrous copper (II) sulfate becomes colored when exposed to the air for a long time.

- Anhydrous copper (II) sulfate is white in color.
- When exposed to air, it absorbs moisture and forms hydrated copper (II) sulfate, which turns blue.
- The reaction is: $CuSO_4$ (s) + $5H_2O$ -------> $CuSO_4 \cdot 5H_2O$ (blue).

ii. Carbon dioxide can be collected by the downward delivery method.

- Carbon dioxide is denser than air and can be collected by downward displacement of air.
- It does not support combustion, making it easy to collect in an inverted container.

iii. Concentrated sulfuric acid is not used for drying hydrogen sulfide gas.

- Hydrogen sulfide (H_2S) is a reducing agent and reacts with concentrated sulfuric acid, producing sulfur and water.
- The reaction is: $H_2S + H_2SO_4$ --------> $S + H_2O$.
- Due to this reaction, concentrated sulfuric acid is not suitable as a drying agent for H_2S.

iv. Sodium metal is kept in paraffin oil.

- Sodium is a highly reactive metal that reacts violently with water and oxygen in the air.
- To prevent unwanted reactions, it is stored in paraffin oil, which provides an air-tight barrier and prevents oxidation.

5. a. Classify the following reactions into oxidation and reduction reactions.

i. $S_8 + O_2(g)$ ------> $SO_2(g)$

- Oxidation: Sulfur (S) is oxidized to SO_2.

ii. $N_2(g) + 3H_2(g)$ --------> $2NH_3(g)$

- Reduction: Nitrogen gas (N_2) is reduced to ammonia (NH_3).

iii. $Fe^{2+}(aq)$ ----> e^- ----> $Fe^{3+}(aq)$

- Oxidation: Fe^{2+} loses an electron to form Fe^{3+}.

iv. $Fe^{3+}(aq) + e^-$ ----> $Fe^{2+}(aq)$

- Reduction: Fe^{3+} gains an electron to form Fe^{2+}.

b. What is the oxidation number of iron in iron (III) chloride?

- In $FeCl_3$, the oxidation number of chlorine is -1.
- Since there are three chloride ions, their total charge is -3.
- Let the oxidation number of iron be x.
- x + (-3) = 0
- x = +3

The oxidation number of iron in iron (III) chloride is +3.
c. In the following reaction, name a reducing agent substance and an oxidizing agent.

$CuO(s) + H_2(g) \text{ ----> } Cu(s) + H_2O(g)$

- Reducing agent: Hydrogen (H_2) (It donates electrons and gets oxidized to H_2O).
- Oxidizing agent: Copper(II) oxide (CuO) (It accepts electrons and gets reduced to Cu).

6.

a. Which homologous series of organic compounds can be represented by the following general formula?

i. C_nH_{2n+2}
ii. C_nH_{2n}
iii. $C_nH_{2n+1}OH$

- The first formula, C_nH_{2n+2}, represents alkanes, which are saturated hydrocarbons.
- The second formula, C_nH_{2n}, represents alkenes, which contain at least one double bond.
- The third formula, $C_nH_{2n+1}OH$, represents alcohols, which contain a hydroxyl (-OH) functional group.

b. Give the name of the first compound in each series.

- Alkanes: Methane (CH_4)
- Alkenes: Ethene (C_2H_4)
- Alcohols: Methanol (CH_3OH)

c.

i. Describe a reaction by which a named compound of series (i) can be converted to a compound of series (ii).

- Alkanes can be converted to alkenes through cracking.
- Example: Ethane (C_2H_6) → Ethene (C_2H_4) + Hydrogen (H_2)
- This reaction occurs under high temperature and pressure, often with a catalyst.

ii. How can a compound of series (a) (iii) be converted to a compound of series in (a) (ii)?

- Alcohols can be converted to alkenes through dehydration using a strong acid like concentrated H_2SO_4 (sulfuric acid).
- Example: Ethanol (C_2H_5OH) → Ethene (C_2H_4) + H_2O

7.

a. Differentiate empirical formula from molecular formula.

- Empirical formula represents the simplest whole-number ratio of atoms in a compound.
- Molecular formula shows the actual number of atoms of each element in a molecule.

Example: The empirical formula of glucose is CH_2O, while its molecular formula is $C_6H_{12}O_6$.

b. Calculate the percentage composition by mass of water in a hydrated magnesium chloride, $MgCl_2 \cdot 6H_2O$.

- Molar mass of $MgCl_2 \cdot 6H_2O = (24.3) + (2 \times 35.5) + (6 \times 18)$
  $= 24.3 + 71 + 108$
  $= 203.3$ g/mol
- Mass of water = 108 g
- Percentage of water = $(108/203.3) \times 100 = 53.1\%$

c. Calculate the empirical formula for a compound with the following composition:

- Lead = 8.32 g, Sulfur = 1.28 g, Oxygen = 2.56 g
- Relative atomic masses: Pb = 207, S = 32, O = 16

Step 1: Find moles of each element
- Moles of Pb = 8.32 / 207 = 0.0402
- Moles of S = 1.28 / 32 = 0.0400
- Moles of O = 2.56 / 16 = 0.160

Step 2: Divide by the smallest value (0.0400)
- Pb: 0.0402 / 0.0400 = 1
- S: 0.0400 / 0.0400 = 1
- O: 0.160 / 0.0400 = 4

Empirical formula: $PbSO_4$

8. a. Ammonia gas can be prepared by heating an ammonium salt with an alkali.

i. Name the most common pair of reagents suitable for this reaction.

- Ammonium chloride (NH_4Cl) and sodium hydroxide (NaOH).

ii. Write the equation for the reaction.

$NH_4Cl + NaOH \rightarrow NH_3 + H_2O + NaCl$

b. Ammonia is very soluble in water and less dense than air. How does each of these properties determine the way in which ammonia is collected in a gas jar?

- Solubility in water: Since ammonia dissolves in water easily, it cannot be collected over water.
- Density: Ammonia is lighter than air, so it is collected by downward displacement of air.

c. i. Solution of chlorine in water is acidic.

- Chlorine reacts with water to form hydrochloric acid (HCl) and hypochlorous acid (HClO), both of which are acidic.
- Equation: $Cl_2 + H_2O \rightarrow HCl + HClO$

ii. Yellow phosphorus is stored under water.

- Yellow phosphorus is highly reactive and spontaneously ignites in air.
- It is stored under water to prevent contact with oxygen and stop combustion.

9. (a) (i) What are the natural causes of soil acidity?
- Decomposition of organic matter
- Leaching of basic ions (Ca^{2+}, Mg^{2+})
- Acid rain (from sulfur and nitrogen oxides)
- Respiration of soil microorganisms releasing CO_2

ii. What cations prevail in acidic soils?

- Hydrogen ions (H^+)
- Aluminum ions (Al^{3+})

b. i. On treatment with calcium hydroxide the soil pH was raised from 5 to 7. What can you say about the properties of calcium hydroxide?

- Calcium hydroxide is a basic compound used to neutralize acidic soil, making it suitable for plant growth.

ii. What effects can the alkalinity of a soil have on the availability of nutrients?

- Reduces availability of essential nutrients like iron (Fe), zinc (Zn), and phosphorus (P).
- Can cause nutrient lock-up, leading to plant deficiencies.

iii. Is it sensible to add lime to a field that has received an application of ammonium sulfate fertilizer? Explain.

- No, because ammonium sulfate is acidic, and adding lime ($CaCO_3$) can neutralize its effect, releasing ammonia gas and reducing nitrogen availability.

c. List the main properties of the following fertilizers:

i. Ammonium sulfate
- Acidic
- Soluble in water
- Supplies nitrogen

ii. Super phosphate
- Acidic
- Provides phosphorus
- Less soluble than ammonium sulfate

iii. Urea
- Neutral
- High nitrogen content
- Easily converted to ammonia in soil

10. (a) i. State Avogadro's law of gaseous volume.

- Equal volumes of all gases, at the same temperature and pressure, contain the same number of molecules.

ii. Find the volume of oxygen gas required to burn completely 1 dm^3 of methane.

$CH_4 + 2O_2$ --------> $CO_2 + 2H_2O$

- 1 mole of CH_4 requires 2 moles of O_2
- 1 dm^3 of CH_4 requires 2 dm^3 of O_2

iii. What is the volume of carbon dioxide formed in the reaction at (ii)?

- 1 mole of CH_4 forms 1 mole of CO_2
- 1 dm^3 of CH_4 forms 1 dm^3 of CO_2

b. Define the following terms:

i. Mole
- The amount of substance containing Avogadro's number of particles (6.022×10^{23} molecules or atoms).

ii. Molecular weight
- The sum of atomic masses of all atoms in a molecule.

c. Calculate the total number of

i. Molecules in 0.18 g of water

- Moles of H_2O = 0.18 / 18 = 0.01 moles
- Number of molecules = $0.01 \times 6.022 \times 10^{23} = 6.022 \times 10^{21}$ molecules

ii. Electrons present in 0.0001 moles of pure magnesium metal

- 1 atom of Mg has 12 electrons
- Electrons in 0.0001 moles = $0.0001 \times 6.022 \times 10^{23} \times 12$
- = 7.226×10^{19} electrons

11.a. Elements A, B, C, and D have atomic numbers 6, 8, 17, and 20, respectively. Write electronic structures of these elements.

- A (Carbon, atomic number 6) = 2,4
- B (Oxygen, atomic number 8) = 2,6
- C (Chlorine, atomic number 17) = 2,8,7
- D (Calcium, atomic number 20) = 2,8,8,2

b. Write down the formulae of the simplest compounds you would expect when

i. A and B combine chemically

- Carbon (A) and Oxygen (B) form carbon dioxide (CO_2)

ii. C and D combine chemically

- Chlorine (C) and Calcium (D) form calcium chloride ($CaCl_2$)

c. i. What types of bonding would you expect to occur in each of the compounds formed in (b)?

- CO_2 (carbon dioxide) → Covalent bonding (since both carbon and oxygen are non-metals)
- $CaCl_2$ (calcium chloride) → Ionic bonding (since calcium is a metal and chlorine is a non-metal)

ii. List three differences in properties you would expect to find between the compounds in (i) as a result of their difference in types of bonding.

- Covalent compounds (CO_2) have low melting and boiling points, while ionic compounds ($CaCl_2$) have high melting and boiling points.
- Covalent compounds (CO_2) are poor conductors of electricity, while ionic compounds ($CaCl_2$) conduct electricity in molten or dissolved states.
- Covalent compounds (CO_2) are often gases or liquids, while ionic compounds ($CaCl_2$) are usually crystalline solids.

12.

Read the following information carefully then answer questions that follow: 25 cm^3 of potassium hydroxide were placed in a flask and a few drops of phenolphthalein indicator were added. Dilute hydrochloric acid was added until the indicator changed color. It was found that 21 cm^3 of acid were used.

a.

i. What piece of apparatus should be used to measure out accurately 25 cm^3 of sodium hydroxide solution?

- A pipette should be used to accurately measure the sodium hydroxide solution.

ii. What color was the solution in the flask at the start of the titration?

- Since phenolphthalein was used, the solution was pink, indicating the presence of an alkali.

iii. What color did it turn when the alkali had been neutralized?

- The solution turned colorless when neutralized.

b.

i. Was the acid more concentrated or less concentrated than the alkali? Give reasons for your answer.

- The acid was more concentrated than the alkali because a smaller volume (21 cm^3) of acid neutralized a larger volume (25 cm^3) of alkali. This suggests that the acid contained more hydrogen ions per unit volume than the hydroxide ions in the alkali.

ii. Name the salt formed in the neutralization.

- The salt formed is potassium chloride (KCl).

iii. Write an equation for the reaction.

$KOH + HCl$ ----- >$KCl + H_2O$

c. Utilizing the given information describe how you can obtain pure crystals of the salt.

- Step 1: Perform the neutralization reaction by adding exact amounts of potassium hydroxide and hydrochloric acid.
- Step 2: Heat the neutralized solution gently to evaporate some of the water, forming a concentrated salt solution.
- Step 3: Allow the solution to cool slowly so that potassium chloride crystals form.
- Step 4: Filter the crystals from the remaining solution and dry them using filter paper or in a warm place.