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: 2008**

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 in the answer booklet(s) provided.

(i) Which of the following is not among the instruments and chemicals used for First Aid?
A Pair of scissors
B Assorted bandages
C Sterilized cotton wool
D Mosquito spray
E Iodine tincture

First Aid involves the immediate treatment given to an injured or sick person before professional medical help is available. The essential tools and chemicals used in First Aid include bandages, scissors, sterilized cotton wool, antiseptics like iodine tincture, and adhesive plasters. However, mosquito spray is not used in First Aid as it is primarily meant to repel or kill mosquitoes rather than treat injuries or infections.

Correct answer: D Mosquito spray

(ii) If 0.9 g of calcium metal is burnt in air, the mass of powder formed is

A 1.14 g
B 1.18 g
C 1.12 g
D 1.08 g
E 1.26 g

Calcium reacts with oxygen in air to form calcium oxide according to the reaction:

$2Ca + O_2$ ----------> 2CaO

To determine the mass of the product:
- Atomic mass of Ca = 40
- Atomic mass of O = 16
- Molar mass of CaO = 40 + 16 = 56

If 40 g of calcium forms 56 g of calcium oxide, then:

For 0.9 g of Ca, the mass of CaO formed is:
(0.9 g × 56 g) ÷ 40 g = 1.26 g

Correct answer: E 1.26 g

(iii) Domestic utensils made of iron do rust as a result of the presence of

A air and fire
B air and water
C water and oil
D oil and fire
E air and oil

Rusting of iron is a redox reaction that occurs when iron is exposed to both oxygen (from air) and moisture (water). The reaction forms iron(III) oxide hydrated, commonly called rust.

$4Fe + 3O_2 + 6H_2O$ ------> $4Fe(OH)_3$ --------> $Fe_2O_3 \cdot xH_2O$ (rust)

Since air and water are the necessary conditions for rusting, the correct answer is:

Correct answer: B air and water

(iv) Which of the following statements about the hardness of water is not true?

A Soft water readily forms lather with soap
B Hard water does not readily form lather with soap
C Permanent hardness of water is due to sulphates of calcium and magnesium
D Permanent hard water becomes soft on boiling
E Calcium and magnesium hydrogen carbonates decompose on boiling

- Soft water forms lather easily with soap.
- Hard water contains dissolved calcium and magnesium salts, which react with soap to form scum instead of lather.
- Permanent hardness is caused by calcium and magnesium sulphates, which cannot be removed by boiling.
- Temporary hardness, caused by calcium and magnesium hydrogen carbonates, can be removed by boiling.

The incorrect statement is:

Correct answer: D Permanent hard water becomes soft on boiling

(v) Elements lose or gain electrons to form

A isotopes
B radicals
C molecules
D ions
E allotropes

- Isotopes are atoms of the same element with different neutron numbers.
- Radicals are groups of atoms with an unpaired electron.

- Molecules are two or more atoms bonded together.
- Allotropes are different structural forms of the same element.
- Ions are formed when atoms lose or gain electrons.

Since elements form ions by losing or gaining electrons, the correct answer is:

Correct answer: D ions

(vi) An aqueous solution with pH 6 is

A slightly acidic
B strongly alkaline
C strongly neutral
D strongly acidic
E slightly alkaline

- The pH scale ranges from 0 to 14, where:
  - pH < 7 is acidic.
  - pH = 7 is neutral.
  - pH > 7 is alkaline.
- A solution with pH 6 is slightly acidic because it is close to neutral.

Correct answer: A slightly acidic

(vii) The atmospheric effect of burning fuel such as wood and petrol oils is to

A reduce oxygen gas
B produce clouds
C add carbon dioxide gas
D increase water vapour
E produce energy

Burning fuel releases carbon dioxide (CO_2) into the atmosphere, which contributes to the greenhouse effect and global warming. Oxygen is consumed in the process, but the most notable effect is the addition of CO_2.

Correct answer: C add carbon dioxide gas

(viii) A mixture of 50 cm^3 of ethanol and 50 cm^3 of pure water can be separated by

A solvent extraction
B fractional distillation
C simple distillation
D filtration

E decantation

Ethanol and water form a miscible liquid mixture and require fractional distillation for separation due to their close boiling points.

Correct answer: B fractional distillation

(ix) The oxidation state of chlorine in sodium chlorate ($NaClO_3$) is

A -1
B +2
C +5
D +3
E -3

For $NaClO_3$:
- Sodium (Na) has a +1 oxidation state.
- Oxygen (O) has -2 oxidation state.
- Let chlorine's oxidation state be x.

Using the oxidation sum rule:
$(+1) + x + 3(-2) = 0$
$1 + x - 6 = 0$
$x = +5$

Correct answer: C +5

(x) When ethane (C_2H_6) burns in air with a bright smoky flame, the product(s) formed will be

A carbon dioxide gas
B carbon dioxide gas and water
C water
D water and oxygen gas
E oxygen gas

Complete combustion of ethane occurs in excess oxygen, producing carbon dioxide and water:

$C_2H_6 + 3.5O_2 \text{ -----> } 2CO_2 + 3H_2O$

Correct answer: B carbon dioxide gas and water

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) Alkane
(ii) Isomers
(iii) Polymerisation
(iv) Ethene
(v) Ethanoic acid
(vi) Alcohol
(vii) Lubricating oils
(viii) Homologous series
(ix) Polyethene
(x) Petroleum products

LIST B
A Poisonous gas
B Polymer
C Existence of a substance which can crystallize in more than one form
D Poisonous gas
E Form ions in solutions
F Dehydrated to alkynes and CO_2
G A group of compounds which can be represented by the same molecular formula
H Water, liquid, and gas
I Fermentation product of carbohydrates
J Existence of an element in more than one form
K Unsaturated hydrocarbon
L Compounds with the same chemical formula but different structural formulae
M A preservative and flavoring
N Is obtained from methane
O A group of compounds which can be represented by a general molecular formula
P Methane, propane, and butane
Q Saturated hydrocarbon
R Paraffin wax, petroleum jelly, and grease
S Joining together of ethyne to form one single long chain
T Mineral acid

(i) Alkane - Q Saturated hydrocarbon
(ii) Isomers - L Compounds with the same chemical formula but different structural formulae
(iii) Polymerisation - S Joining together of ethyne to form one single long chain
(iv) Ethene - K Unsaturated hydrocarbon
(v) Ethanoic acid - M A preservative and flavoring
(vi) Alcohol - I Fermentation product of carbohydrates

(vii) Lubricating oils - R Paraffin wax, petroleum jelly, and grease
(viii) Homologous series - O A group of compounds which can be represented by a general molecular formula
(ix) Polyethene - B Polymer
(x) Petroleum products - P Methane, propane, and butane

3. Study the information in Table 1 and answer the questions that follow. (The letters are not the actual symbols of the elements).

Element	Atomic Number
P	11
Q	13
R	16
S	18
T	19

(a) Select the elements which belong to the same

(i) group

Elements in the same group have the same number of valence electrons, meaning they exhibit similar chemical properties.

P has an atomic number of 11, which corresponds to sodium (Na), and T has an atomic number of 19, which corresponds to potassium (K). Both sodium and potassium belong to Group 1 of the periodic table because they have one valence electron in their outermost shell.

The elements that belong to the same group are P and T.

(ii) period

Elements in the same period have the same number of electron shells.

P (11), Q (13), R (16), S (18), and T (19) all belong to Period 3 because they have three electron shells.

The elements that belong to the same period are P, Q, R, S, and T.

(b) (i) Write the formula for the nitrate of element Q.

Element Q has an atomic number of 13, which corresponds to aluminum (Al). The nitrate of aluminum is formed by combining Al^{3+} ions with NO_3^- ions. Since the aluminum ion has a +3 charge and the nitrate ion has a -1 charge, three nitrate ions are needed to balance the charge.

The correct formula is $Al(NO_3)_3$.

(ii) Give the equation for the reaction between P and R.

P has an atomic number of 11, which corresponds to sodium (Na), and R has an atomic number of 16, which corresponds to sulfur (S). When sodium reacts with sulfur, it forms sodium sulfide (Na_2S).

The balanced chemical equation is:

$2Na + S \rightarrow Na_2S$

(c) (i) Identify the element which is in gaseous state at room temperature.

Elements that exist as gases at room temperature are typically noble gases or non-metals like oxygen and nitrogen.

S has an atomic number of 18, which corresponds to argon (Ar), a noble gas that exists in a gaseous state at room temperature.

The element in a gaseous state is S (argon, Ar).

(ii) State the element which does not form an oxide.

Noble gases do not react easily with other elements because they have a full outer electron shell, making them chemically inert.

Since S (argon, Ar) is a noble gas, it does not form oxides.

The element that does not form an oxide is S (argon, Ar).

4. (a) Give the I.U.P.A.C. name of the following compounds:

(i) $Cu(NO_3)_2$

$Cu(NO_3)_2$ consists of Cu^{2+} (copper ion) and NO_3^- (nitrate ion). Since copper can have multiple oxidation states, the oxidation number must be indicated in Roman numerals. In this case, copper is in the +2 oxidation state.

The name is copper(II) nitrate.

(ii) NH_4Cl

NH_4^+ is ammonium, and Cl^- is chloride. Since ammonium has a fixed charge, no Roman numerals are needed.

The name of NH_4Cl is ammonium chloride.

(b) Name the ions present in

(i) $Cu(NO_3)_2$

The compound $Cu(NO_3)_2$ dissociates into Cu^{2+} (copper(II) ion) and NO_3^- (nitrate ion) in solution.

(ii) NH_4Cl

The compound NH_4Cl dissociates into NH_4^+ (ammonium ion) and Cl^- (chloride ion) in solution.

(c) Find the oxidation number of

(i) Cu in $Cu(NO_3)_2$

Let the oxidation number of Cu be x. Since nitrate (NO_3^-) has a charge of -1, and there are two nitrate ions, the total charge from nitrate is -2. The compound is neutral, so:

$x + 2(-1) = 0$
$x - 2 = 0$
$x = +2$

The oxidation number of Cu in $Cu(NO_3)_2$ is +2.

(ii) Cl in NH_4Cl

NH_4^+ (ammonium) has a charge of +1. Cl^- (chloride) has a charge of -1. Since ammonium chloride is neutral, the oxidation state of Cl is -1.

5. (a) Explain the meaning of

(i) a chemical equation

A chemical equation is a symbolic representation of a chemical reaction, showing reactants and products along with their quantities.

For example:

$H_2 + Cl_2$ ------> 2HCl represents the reaction of hydrogen and chlorine to form hydrogen chloride.

(ii) an ionic equation

An ionic equation represents only the ions that actively participate in a reaction, omitting spectator ions.

For example:

$Ag^+(aq) + Cl^-(aq)$ --------> AgCl(s) shows the formation of silver chloride precipitate.

(b) Given that dilute hydrochloric acid reacts with calcium carbonate to form different products, write a balanced

(i) chemical equation for the reaction

$CaCO_3 + 2HCl$ ------> $CaCl_2 + CO_2 + H_2O$

(ii) ionic equation for the reaction

$CaCO_3(s) + 2H^+(aq)$ --------> $Ca^{2+}(aq) + CO_2(g) + H_2O(l)$

(c) Calculate the number of moles of

(i) calcium carbonate needed by each mole of hydrochloric acid used in 5(b)

From $CaCO_3 + 2HCl$ -----> $CaCl_2 + CO_2 + H_2O$,
1 mole of $CaCO_3$ reacts with 2 moles of HCl.

For 1 mole of HCl, the moles of $CaCO_3$ needed:
$1 \div 2 = 0.5$ moles.

(ii) carbon dioxide evolved by each mole of calcium carbonate used in 5(b).

From the equation, 1 mole of $CaCO_3$ produces 1 mole of CO_2.

So, 1 mole of $CaCO_3$ evolves 1 mole of CO_2.

6. (a) Give two examples for each of the following:

(i) Strong acid

Hydrochloric acid (HCl)

Sulfuric acid (H_2SO_4)

(ii) Strong alkali

Sodium hydroxide (NaOH)
Potassium hydroxide (KOH)

(b) Identify the products formed when a strong acid reacts with

(i) CuO(s)

Copper(II) oxide reacts with acid to form a salt and water.

$CuO + 2HCl$ -----> $CuCl_2 + H_2O$

The products are copper(II) chloride ($CuCl_2$) and water (H_2O).

(ii) NaOH(aq)

An acid reacts with a base to form a salt and water (neutralization reaction).

$HCl + NaOH$ ---> $NaCl + H_2O$

The products are sodium chloride (NaCl) and water (H_2O).

(c) Explain the meaning of the following and give two examples in each case.

(i) pH scale of an acid

The pH scale measures the acidity or alkalinity of a solution. Acids have pH less than 7.

Examples: pH of HCl = 1, pH of vinegar = 3.

(ii) Organic acid

An organic acid contains carbon and hydrogen, often found in living organisms.

Examples: Ethanoic acid (CH_3COOH), Citric acid (found in citrus fruits).

7. (a) With the help of one example, give the meaning of the following.

(i) An electrolyte

An electrolyte is a substance that, when dissolved in water or melted, conducts electricity due to the movement of free ions. Electrolytes undergo electrolysis, where ions migrate towards opposite electrodes under an electric field.

Example: Sodium chloride (NaCl) in water dissociates into Na^+ and Cl^- ions, which conduct electricity.

(ii) A non-electrolyte

A non-electrolyte is a substance that does not conduct electricity when dissolved in water because it does not produce free ions in solution.

Example: Sugar ($C_{12}H_{22}O_{11}$) dissolves in water but does not ionize, so it does not conduct electricity.

(b) Decomposition of an electrolyte by an electric current is called electrolysis. Name the ions that move to the

(i) negative electrode (cathode) during electrolysis

At the cathode, positively charged ions (cations) migrate to gain electrons (reduction occurs).

Example: Cu^{2+}, Na^+, H^+ ions move to the cathode.

(ii) positive electrode (anode) during electrolysis

At the anode, negatively charged ions (anions) migrate to lose electrons (oxidation occurs).

Example: Cl^-, OH^-, SO_4^{2-} ions move to the anode.

(c) A solution of 1 M copper(II) chloride was electrolyzed using graphite electrodes. Write the reaction which took place at the

(i) anode

At the anode, chloride ions (Cl^-) lose electrons to form chlorine gas.

$2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$

(ii) cathode

At the cathode, copper ions (Cu^{2+}) gain electrons to form solid copper.

$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

8. (a) Give reason(s) for the use of carbon dioxide

(i) as a fire extinguisher

Carbon dioxide does not support combustion and is heavier than air, allowing it to displace oxygen and smother flames. It is commonly used in fire extinguishers for electrical and flammable liquid fires.

(ii) as a refrigerant

Carbon dioxide exists as dry ice at low temperatures and does not leave residue when it sublimates. This makes it useful for preserving perishable food and medical supplies.

(iii) in baking

Carbon dioxide is released from baking powder (sodium bicarbonate + acid) when heated, creating bubbles that make dough rise, giving baked goods a light and fluffy texture.

(b) Explain what will happen when carbon monoxide reacts with

(i) oxygen

Carbon monoxide (CO) is a toxic, colorless gas that reacts with oxygen to form carbon dioxide (CO_2).

$2CO + O_2 \rightarrow 2CO_2$

(ii) concentrated sodium hydroxide

CO reacts with NaOH under pressure to form sodium formate (HCOONa).

$CO + NaOH \rightarrow HCOONa$

(iii) copper oxide

CO acts as a reducing agent, removing oxygen from metal oxides.

$CuO + CO \rightarrow Cu + CO_2$

(c) (i) Outline the steps in the procedure for the preparation of charcoal.

1. Collection of wood – Dry wood is used as raw material.
2. Heating in limited oxygen – The wood is burned in a controlled environment with insufficient oxygen.
3. Carbonization – Volatile substances (e.g., water, tar) evaporate, leaving behind charcoal.
4. Cooling and collection – The charcoal is cooled and stored.

(ii) Provide two chemical properties of charcoal.

1. Combustibility – Charcoal burns in oxygen to produce carbon dioxide.

$C + O_2 \rightarrow CO_2$

2. Adsorption – Charcoal absorbs gases and impurities, making it useful in air purification and water filtration.

9. (a) List down four common stages in the extraction of less reactive metals like zinc and copper.

1. Concentration of ore – Removing unwanted impurities (e.g., sand) using gravity separation or froth flotation.
2. Roasting or Calcination – Heating the ore in limited or excess oxygen to remove volatile impurities.
3. Reduction – The metal oxide is reduced using a reducing agent (e.g., carbon or carbon monoxide).
4. Purification – The extracted metal is refined by electrolysis or other chemical methods.

(b) Name the ore commonly used in the extraction of iron metal.

The main ore of iron is hematite (Fe_2O_3).

(c) The following are series of chemical reactions which occur in the blast furnace during the process of extraction of iron metal.

$C(s) + O_2 \rightarrow CO_2 + \text{heat}$ (1)
$CO_2 + C \rightarrow 2CO$ (2)
$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$ (3)
$Fe_2O_3 + CO \rightarrow 2Fe + 3CO_2$ (4)

(i) Indicate the two reducing agents in the blast furnace.

- Carbon monoxide (CO)
- Carbon (C)

(ii) Explain the importance of steps (1) to (3).

- Step (1): Carbon burns in oxygen to produce carbon dioxide and heat.
- Step (2): Carbon dioxide reacts with carbon to form carbon monoxide, which is a reducing agent.

- Step (3): Carbon monoxide reduces iron ore to iron metal.

(iii) In this process, a compound “L” which produces a chemical substance that removes impurities as slag is added. Give the name of the substance.

- The compound "L" is calcium carbonate ($CaCO_3$).
- It decomposes to form calcium oxide (CaO), which removes impurities.

(iv) Write the complete chemical reactions that compound “L” undergoes to form slag.

$CaCO_3 \rightarrow CaO + CO_2$
$CaO + SiO_2 \rightarrow CaSiO_3$ (slag)

10. (a) Define the following terms:

(i) Soil

Soil is a mixture of minerals, organic matter, water, and air that supports plant life.

(ii) Soil profile

A soil profile is a vertical section of soil layers, showing horizons with different compositions.

(iii) Micronutrients

Micronutrients are essential nutrients required in small amounts by plants and animals, such as iron (Fe) and zinc (Zn).

(b) Explain why a fertile soil is not necessarily productive.

A soil can be fertile (rich in nutrients) but unproductive due to:

1. Poor drainage – Excess water prevents root respiration.
2. Soil erosion – Loss of topsoil removes nutrients.
3. Lack of organic matter – Reduces water retention.
4. Pests and diseases – Destroy crops despite nutrient availability.

(c) Soil erosion is one of the problems facing many farming areas in Tanzania leading to poor harvest. As a chemist give four advices to help farmers to overcome soil erosion.

1. Plant cover crops – Protects soil from wind and water erosion.
2. Use contour farming – Reduces water runoff.
3. Mulching – Retains moisture and prevents soil loss.

4. Terracing on slopes – Slows down water flow and prevents erosion.

11. (a) Mention three natural resources that should be protected from pollution.

1. Water resources (rivers, lakes, oceans)
2. Forests and vegetation
3. Air (atmosphere)

(b) Name two pollutants in each of the following:

(i) Land

1. Plastics
2. Pesticides

(ii) Water

1. Industrial waste
2. Sewage

(iii) Air

1. Carbon monoxide (CO)
2. Sulfur dioxide (SO_2)

(c) (i) Explain the effect of carbon monoxide to the human body.

Carbon monoxide binds to hemoglobin in red blood cells, preventing oxygen transport, leading to suffocation, dizziness, and even death.

(ii) Give three examples of gases which cause greenhouse effect.

1. Carbon dioxide (CO_2)
2. Methane (CH_4)
3. Nitrous oxide (N_2O)

12. (a) Give the meaning of the following terms:

(i) Decomposition reaction

A decomposition reaction is a chemical reaction in which a single compound breaks down into two or more simpler substances. This type of reaction often requires heat, light, or electricity to occur.

Example:
$2H_2O$ ------> $2H_2 + O_2$ (Electrolysis of water into hydrogen and oxygen gas)

(ii) Substitution reaction

A substitution reaction is a chemical reaction in which one atom or a group of atoms in a compound is replaced by another atom or group of atoms. This type of reaction is common in organic chemistry.

Example:
$CH_4 + Cl_2$ -----> $CH_3Cl + HCl$ (Methane reacts with chlorine in sunlight to form chloromethane)

(iii) Hydrogenation

Hydrogenation is a chemical reaction in which hydrogen (H_2) is added to an unsaturated compound, usually in the presence of a catalyst such as nickel or platinum. This reaction is commonly used in the food industry to convert liquid oils into solid fats.

Example:
$C_2H_4 + H_2$ -----> C_2H_6 (Ethene reacts with hydrogen to form ethane)

(iv) Esterification

Esterification is a chemical reaction between a carboxylic acid and an alcohol to form an ester and water. It is an important reaction in the production of perfumes and flavoring agents.

Example:
$CH_3COOH + C_2H_5OH$ ------> $CH_3COOC_2H_5 + H_2O$ (Ethanoic acid reacts with ethanol to form ethyl ethanoate)

(b) Sulfur is one of the elements which exhibit allotropy.

(i) Explain the term allotropy.

Allotropy is the existence of an element in two or more different physical forms in the same state. These different forms, called allotropes, have different structures and properties due to variations in atomic arrangement.

(ii) List down all allotropes of sulfur.

Sulfur has two main allotropes:

1. Rhombic sulfur – The most stable form at room temperature, consisting of octahedral crystals.
2. Monoclinic sulfur – A needle-shaped form that exists at temperatures between 96°C and 119°C.

(c) Write a balanced chemical reaction equation for the following observations:

(i) When copper(II) nitrate is heated, a brown gas which rekindles a glowing splint is given off.

When copper(II) nitrate ($Cu(NO_3)_2$) is heated, it decomposes into copper(II) oxide (CuO), nitrogen dioxide (NO_2, a brown gas), and oxygen (O_2, which rekindles a glowing splint).

$2Cu(NO_3)_2$ -----> $2CuO + 4NO_2 + O_2$

(ii) When common salt reacts with concentrated sulfuric acid, a gas which turns damp blue litmus red is evolved.

When sodium chloride (NaCl) reacts with concentrated sulfuric acid (H_2SO_4), it produces hydrogen chloride (HCl) gas, which turns damp blue litmus red due to its acidic nature.

$NaCl + H_2SO_4$ ----> $NaHSO_4 + HCl$