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: 2007**

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) A mixture of water and alcohol was carefully distilled. Which property of the first drops of the liquid distillate collected is not correct? The first drops

A have the same boiling point as water
B mix easily with water
C burn in air
D are colourless
E will boil at a temperature less than the boiling point of water
Distillation separates liquids based on their boiling points. Alcohol has a lower boiling point than water, so it will evaporate first and condense as the first drops. The correct properties of these drops include being colourless, mixing with water, and boiling at a lower temperature than water. However, the incorrect statement is that they have the same boiling point as water.
Correct answer: A have the same boiling point as water

(ii) Which oxides are gaseous at room temperature?

A Carbon dioxide and copper oxide
B Sulphur dioxide and copper oxide
C Carbon dioxide and sulphur dioxide
D Copper oxide and iron oxide
E Iron oxide and carbon dioxide
Gaseous oxides at room temperature are generally small molecules with low boiling points. Carbon dioxide (CO_2) and sulphur dioxide (SO_2) are gases at room temperature, while copper oxide (CuO) and iron oxide (Fe_2O_3) are solids.
Correct answer: C Carbon dioxide and sulphur dioxide
(iii) If 0.5 g of hydrogen gas are exploded in air, the mass of water formed is

A 1.8 g
B 4.5 g
C 0.75 g
D 40 g
E 18 g

Hydrogen reacts with oxygen in a 2:1 ratio to form water according to the reaction:

$2H_2 + O_2$ -----> $2H_2O$

The molar mass of hydrogen (H_2) is 2 g, and the molar mass of water (H_2O) is 18 g. Since 2 g of hydrogen forms 18 g of water, 0.5 g of hydrogen will form:

$(0.5\ g \times 18\ g) \div 2\ g = 4.5\ g$

Correct answer: B 4.5 g

(iv) A and B are atoms of elements in the same period of the periodic table. A is in group II and B is in group III. Which of the following statements is not true?

A B has one more proton than A in its nucleus
B The atomic number of B is one unit greater than that of A
C A has one electron less than B in its valence shell
D A contains one more electron than B in its valence shell
E A and B have the same number of shells
Since elements in the same period have the same number of electron shells, option E is true. In moving from Group II to Group III, the atomic number increases by one, and an extra electron is added to the valence shell, making A have one electron less than B in its valence shell. However, the incorrect statement is that A contains one more electron than B in its valence shell.
Correct answer: D A contains one more electron than B in its valence shell

(v) Which of the following statements is true. The Avogadro's constant is the number of

A electrons in one mole of a solid substance
B atoms in one mole of any gas at s.t.p.
C atoms in one mole of a metal
D electrons needed to liberate one gram of a univalent metal
E electrons released when one mole of any element is discharged at the anode

Avogadro's constant is the number of atoms, molecules, or ions in one mole of a substance, which is approximately 6.02×10^{23}. It specifically refers to the number of atoms in one mole of a gas at standard temperature and pressure (s.t.p.).

Correct answer: B atoms in one mole of any gas at s.t.p.

(vi) Which, among the given list of metals arranged in order of decreasing reactivity with steam from left to right, is correct?

A Calcium, magnesium, zinc, copper
B Magnesium, calcium, copper, zinc
C Calcium, zinc, magnesium, copper
D Zinc, magnesium, copper, calcium
E Calcium, magnesium, copper, zinc

Metals react with steam based on their position in the reactivity series. The correct decreasing order is:

Calcium > Magnesium > Zinc > Copper

Copper does not react with steam, while zinc reacts slowly, and magnesium and calcium react more readily.

Correct answer: A Calcium, magnesium, zinc, copper

(vii) Scum tends to be formed when washing clothes with hard water due to the reaction between

A hard water and soap
B calcium ions, magnesium ions and sodium stearate
C the dissolved calcium and magnesium salts with detergents
D hydrogen carbonate ions and soap
E hydrogen carbonate ions and clothes

Scum is formed when hard water, containing calcium and magnesium ions, reacts with soap to form insoluble precipitates. The reaction occurs between calcium/magnesium ions and sodium stearate (a component of soap).

Correct answer: B calcium ions, magnesium ions and sodium stearate

(viii) An organic compound of structural formula

belongs to the homologous series of

A alkenes
B esters
C alcohols
D alkanes
E acids

The functional group present in the compound determines the homologous series. Alcohols contain the hydroxyl (-OH) group. The compound given belongs to the alcohols.

Correct answer: C alcohols

(ix) A steady current of 4 amperes was passed through an aqueous solution of copper sulphate for 1800 seconds. The mass of copper deposited is

A 63.5 g
B 31.75 g
C 1.185 g
D 2.37 g

E 11.85 g

Using Faraday's law of electrolysis,

Mass deposited (m) = (It × M) / (nF)

Where:
I = 4 A, t = 1800 s, M (Cu) = 63.5 g/mol, n = 2 ($Cu^{2+} \rightarrow Cu$), F = 96500 C

m = (4 × 1800 × 63.5) / (2 × 96500)
m = (457200) / (193000)
m ≈ 2.37 g

Correct answer: D 2.37 g

(x) The particles M_{178} and M_{158} are

A isomers
B allotropes
C molecules
D radicals
E isotopes

Isotopes are atoms of the same element with different mass numbers due to a different number of neutrons. Since both particles have the same atomic number (8), they are oxygen isotopes (O-17 and O-15).

Correct answer: E isotopes

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.

(i) Double bond - E Bonding in a molecule of oxygen
(ii) Functional group of alkynes - Q Triple bond
(iii) Chlorine - N One of the products of electrolysis of molten sodium chloride
(iv) Empirical formula - I Simplest formula which expresses the composition of a compound by mass
(v) $Pb(NO_3)_2(aq) + Na_2CO_3(aq)$ -----> $PbCO_3(s) + 2NaNO_3(aq)$ - B Double decomposition reaction
(vi) Lead(II) chloride and silver chloride - J Common insoluble chlorides
(vii) Elements in the soil needed by plants in large amount - P Macronutrients
(viii) Presence of Al^{3+} and H^+ ions in the soil - G Soil acidity
(ix) Hypothesis - M A tentative statement for the observed phenomenon

3. (a) (i) What is an ionic bond?

An ionic bond is a type of chemical bond formed between two atoms when one atom donates an electron(s) to another, resulting in the formation of positively and negatively charged ions. These oppositely charged ions are held together by electrostatic forces of attraction.

Example: Sodium (Na) donates one electron to chlorine (Cl) to form sodium chloride (NaCl).
$Na \rightarrow Na^+ + e^-$
$Cl + e^- \rightarrow Cl^-$
$Na^+ + Cl^- \rightarrow NaCl$

(ii) Define a radical

A radical is a group of atoms that behave as a single unit in a chemical reaction and carry a charge, either positive or negative. Radicals do not exist freely but form compounds.

Examples: Sulphate (SO_4^{2-}), Nitrate (NO_3^-), Ammonium (NH_4^+).

(iii) Draw an electronic diagram to show the covalent bonding between hydrogen and chlorine in a hydrogen chloride gas molecule.

Hydrogen chloride (HCl) is formed by a covalent bond where hydrogen (H) shares one electron with chlorine (Cl).

H (1 electron) + Cl (7 electrons) → H-Cl (Covalent bond)

Diagram:
H : Cl (Each dot represents one electron)

(iv) Explain why covalent compounds do not conduct electricity.

Covalent compounds do not conduct electricity because they consist of neutral molecules without free-moving charged particles (ions). Since electrical conductivity requires free electrons or ions to move through the substance, covalent compounds are generally insulators in both solid and liquid states.

Examples of non-conducting covalent compounds: Water (H_2O), Methane (CH_4).

(b) What is the oxidation state of Fe in a $FeCl_3$ molecule?

Oxidation state is the charge an atom would have if all bonds in a molecule were ionic.

Let x be the oxidation state of Fe in $FeCl_3$.
Since chlorine has an oxidation state of -1 and there are three chlorine atoms, their total charge is -3.

$x + (3 \times -1) = 0$
$x - 3 = 0$
$x = +3$

The oxidation state of Fe in $FeCl_3$ is +3.

(c) Study carefully the electronic configuration of elements Q, R, and S given below then answer the questions that follow.

Q———2:7
R———2:8:1
S———2:6

(i) What type of bond will exist in a compound formed when Q combines with R?

Q has an electronic configuration of 2:7, meaning it has 7 valence electrons (Group VII - a non-metal).
R has an electronic configuration of 2:8:1, meaning it has 1 valence electron (Group I - a metal).

Since a metal (R) reacts with a non-metal (Q), an ionic bond will form. The metal loses an electron to the non-metal, forming a positively charged ion and a negatively charged ion, which attract each other electrostatically.

Example: NaCl formation follows the same principle.

(ii) In what group and period in the periodic table does element S occupy?

S has an electronic configuration of 2:6, meaning it has 6 valence electrons, placing it in Group VI.
Since it has two electron shells, it is in Period 2.

(iii) What is the valency of element Q?

Valency is the number of electrons an atom gains, loses, or shares to achieve a stable configuration.

Q has 7 valence electrons and needs 1 more electron to complete its octet.
Its valency is 1.

(iv) Write a molecular formula of a compound formed when element R combines with S.

R has 1 valence electron, and S has 6 valence electrons.
For stability, two atoms of R are needed to donate electrons to one atom of S.

The molecular formula of the compound formed is R_2S.

4. (a) Define the term molecular formula.

A molecular formula shows the exact number of each type of atom in a molecule of a compound. Unlike an empirical formula, it represents the actual composition of the molecule.

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

(b) An oxide of iron, 4.5 g by mass, was completely reduced by heating it in a certain reducing agent and 3.15 g of iron was produced. Calculate the empirical formula of the compound.

Step 1: Determine the mass of oxygen in the compound.
Mass of oxygen = Total mass - Mass of iron
= 4.5 g - 3.15 g
= 1.35 g

Step 2: Convert mass to moles.
Moles of Fe = 3.15 g / 56 g/mol = 0.05625 mol
Moles of O = 1.35 g / 16 g/mol = 0.0844 mol

Step 3: Find the simplest ratio.
Fe:O = 0.05625 : 0.0844
Dividing by the smallest value:
Fe:O = 1:1.5

Multiplying by 2 to get whole numbers, the ratio becomes 2:3, so the empirical formula is Fe_2O_3.

(c) When a salt of copper nitrate is heated it undergoes a chemical change as shown in equation 1 below.

$Zn(NO_3)_2(s) \rightarrow ZnO(s) + NO_2(g) + O_2(g)$

(i) Balance equation (1).

$2Zn(NO_3)_2 \rightarrow 2ZnO + 4NO_2 + O_2$

(ii) What is the type of chemical reaction represented by equation (1)?

This is a thermal decomposition reaction, where a compound breaks down into simpler substances when heated.

5. (a) Identify method A, B, and C.

- Method A: Downward displacement of water (used for collecting gases that are insoluble in water, e.g., hydrogen and oxygen).
- Method B: Downward delivery (for gases denser than air, e.g., chlorine, carbon dioxide).
- Method C: Upward delivery (for gases lighter than air, e.g., ammonia).

(b) Which method is used in the laboratory gas preparation of

(i) ammonia?

Method C, as ammonia is lighter than air and is collected by upward delivery.

(ii) chlorine?

Method B, as chlorine is denser than air and is collected by downward delivery.

(iii) hydrogen?

Method A, as hydrogen is insoluble in water and is collected over water.

(c) What will happen when
(i) yellow flowers are introduced into a gas jar containing chlorine gas?
They will turn white because chlorine is a strong bleaching agent.
(ii) a burning splint is introduced into a gas jar containing hydrogen gas?
A pop sound will be heard as hydrogen burns in oxygen, forming water.
(iii) a glass rod which was dipped in concentrated hydrochloric acid is introduced into a gas jar containing ammonia gas?
Dense white fumes of ammonium chloride (NH_4Cl) will form.
(iv) sulphur dioxide gas is bubbled through a yellow acidified potassium dichromate solution?
The solution will turn from yellow to green because SO_2 is a reducing agent that reduces Cr_6^+ to Cr^{3+}.

7. (a) (i) What is a reversible reaction?

A reversible reaction is a chemical reaction that can proceed in both the forward and backward directions under suitable conditions. This means that the reactants form products, and the products can react to form the original reactants again.

Example:
$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

In this reaction, nitrogen and hydrogen react to form ammonia, but ammonia can also decompose back into nitrogen and hydrogen under certain conditions.

(ii) List down three factors which affect the position of equilibrium in a reversible chemical reaction.

1. Temperature – Increasing or decreasing temperature shifts equilibrium depending on whether the reaction is exothermic or endothermic.
2. Pressure – Affects reactions involving gases; increasing pressure favors the side with fewer gas molecules.
3. Concentration – Changing the concentration of reactants or products shifts equilibrium to oppose the change.

(b) The industrial preparation of ammonia in the Haber process is represented by the following equation:

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ $\Delta H = -46.2kJ/mol$

Study the equation carefully then answer the questions that follow.

(i) What will happen to the position of equilibrium if the temperature of the equilibrium mixture is increased?

Since the reaction is exothermic (releases heat), increasing temperature will shift equilibrium to the left (toward reactants), decreasing ammonia production.

(ii) What will happen if more nitrogen gas is added to the equilibrium mixture?

Adding more nitrogen will shift equilibrium to the right to form more ammonia, according to Le Chatelier's principle.

(iii) What will happen if the formed ammonia gas is removed from the equilibrium mixture?

Removing ammonia shifts equilibrium to the right to replace the lost ammonia, increasing its production.

(c) (i) Why are catalysts used in chemical reactions?

Catalysts speed up chemical reactions by lowering activation energy, allowing reactants to convert into products faster without being consumed in the reaction.

(ii) What is the meaning of the negative sign against the value of heat change, -46.2 kJ/mol in the chemical equation given in 7(b) above?

The negative sign indicates that the reaction is exothermic, meaning it releases heat to the surroundings.

(iii) Sketch an energy level diagram of energy against reaction path for the reaction in 7(b) above.

The diagram should show:
- Reactants at a higher energy level
- Products at a lower energy level
- A downward arrow indicating heat release (exothermic)

8. (a) Classify the following compounds as alkanes, alkenes, and alkynes:

- C_7H_{12} - Alkyne (C_nH_{2n-2} formula)
- C_4H_{10} - Alkane (C_nH_{2n+2} formula)
- C_5H_{10} - Alkene (C_nH_{2n} formula)
- C_3H_4 - Alkyne (C_nH_{2n-2} formula)
- C_2H_4 - Alkene (C_nH_{2n} formula)
- C_6H_{12} - Alkene (C_nH_{2n} formula)

(b) Complete and balance the following chemical equations:

(i) $CH{\equiv}CH + O_2$ ------> $CO_2 + H_2O$
Balanced: $2C_2H_2 + 5O_2$ ------> $4CO_2 + 2H_2O$

(ii) $CH_3CH_2OH + Na$ --------> $CH_3CH_2ONa + H_2$

(iii) $CH_3COOH + KOH$ -------> $CH_3COOK + H_2O$

(iv) $CH_2{=}CH_2 + Cl_2$ --------> $CH_2Cl\text{-}CH_2Cl$

(c) Write down the condensed structural isomers of alcohols of molecular formula C_4H_9OH.

1. Butan-1-ol ($CH_3CH_2CH_2CH_2OH$)
2. Butan-2-ol ($CH_3CH_2CHOHCH_3$)
3. 2-Methylpropan-1-ol ($CH_3CH(CH_3)CH_2OH$)
4. 2-Methylpropan-2-ol ($C(CH_3)_3OH$)
9. (a) (i) Define the term fertilizer.

A fertilizer is a natural or synthetic substance applied to soil or plants to supply essential nutrients that promote plant growth. Fertilizers contain nutrients like nitrogen, phosphorus, and potassium.

(ii) What are the three effects of excessive nitrogen to plants?

1. Causes excessive vegetative growth at the expense of fruit and seed formation.

2. Weakens plant stems, making them more susceptible to lodging.
3. Can lead to soil acidification, reducing soil fertility over time.

(b) (i) State four methods of application of fertilizers.

1. Broadcasting – Evenly spreading fertilizer over the soil surface.
2. Side dressing – Placing fertilizer in rows near growing plants.
3. Foliar application – Spraying fertilizer solution directly on leaves.
4. Fertigation – Applying fertilizers through irrigation systems.

(ii) What are the four advantages of using manures in the farms?

1. Improves soil structure by increasing organic matter.
2. Increases water retention capacity of the soil.
3. Supplies a variety of nutrients in a slow-releasing form.
4. Encourages beneficial microbial activity in the soil.

(iii) Calculate the percentage composition of nitrogen in ammonium sulphate fertilizer, $(NH_4)_2SO_4$.

Step 1: Find the molar mass of $(NH_4)_2SO_4$.

N = 14 × 2 = 28
H = 1 × 8 = 8
S = 32 × 1 = 32
O = 16 × 4 = 64

Total molar mass = 132 g/mol

Step 2: Calculate percentage composition of nitrogen.

(28 g / 132 g) × 100 = 21.2%

The percentage composition of nitrogen in ammonium sulphate is 21.2%.

10. (a) Name the ore commonly used in the extraction of copper metal.

The main ore used in the extraction of copper is chalcopyrite ($CuFeS_2$). Other ores include malachite ($CuCO_3 \cdot Cu(OH)_2$) and copper(II) oxide (CuO).

(b) Steps (i) to (iv) below are used during the extraction of copper metal from its ore. Write a balanced chemical equation for each step.

(i) Roasting of the concentrated ore ($CuFeS_2$) in air.

During roasting, the ore is heated in excess oxygen to convert sulfides into oxides.

$2CuFeS_2 + 5O_2$ ------> $2CuO + 2FeO + 4SO_2$

(ii) Heating the roasted ore with silica in the absence of air.

Iron(II) oxide reacts with silica (SiO_2) to form slag (iron(II) silicate), which is removed.

$FeO + SiO_2$ -----> $FeSiO_3$ (slag)

(iii) Burning copper sulfide ore (CuS) in a regulated supply of air.

Copper(I) sulfide reacts with oxygen to form copper metal and sulfur dioxide.

$2Cu_2S + 3O_2$ -----> $4Cu + 2SO_2$

(iv) Purification of copper by electrolysis using copper sulfate solution electrolyte, pure copper cathode, and impure copper anode.

At the anode (impure copper):
Cu -----> $Cu^{2+} + 2e^-$

At the cathode (pure copper):
$Cu^{2+} + 2e^-$ -----> Cu

(c) With the help of chemical equations explain what will happen to

(i) an iron earring dropped into a container of copper sulfate solution.

Iron is more reactive than copper, so it displaces copper from the solution. The iron earring will get coated with copper.

$Fe + CuSO_4$ -------> $FeSO_4 + Cu$

(ii) a copper knife dipped into zinc nitrate solution.

Copper is less reactive than zinc and cannot displace zinc from its solution. No reaction will take place.

(iii) copper turnings dropped into a container of dilute hydrochloric acid.

Copper is below hydrogen in the reactivity series and does not react with dilute acids like HCl. No reaction occurs.

11. (a) (i) What does the term terrestrial pollution mean?

Terrestrial pollution refers to the contamination of land and soil by harmful substances such as industrial waste, pesticides, and plastics, which negatively impact the environment.

(ii) Mention three causes of terrestrial pollution.

1. Deforestation – Cutting down trees without replanting reduces soil fertility and leads to erosion.
2. Improper waste disposal – Dumping plastics, chemicals, and industrial waste pollutes land.
3. Use of pesticides and fertilizers – Excess chemicals harm soil and organisms.

(iii) Explain four methods of preventing terrestrial pollution.

1. Proper waste disposal – Recycling and proper disposal of hazardous waste can reduce land pollution.
2. Reforestation – Planting trees helps restore soil fertility and prevent erosion.
3. Use of organic farming methods – Avoiding excessive fertilizers and pesticides keeps soil healthy.
4. Legislation and policies – Governments should enforce laws to prevent industrial waste dumping.

(b) What is the effect of ultraviolet radiations on living organisms?

Ultraviolet (UV) radiation can cause:

- Skin cancer and premature aging due to DNA damage.
- Cataracts and eye damage, leading to vision problems.
- Weakening of the immune system, reducing the body's ability to fight diseases.

(c) (i) What is the function of the ozone layer in the atmosphere?

The ozone layer absorbs harmful ultraviolet (UV) radiation from the sun, protecting living organisms from its damaging effects.

(ii) What control measures should be taken to prevent the destruction of the ozone layer?

1. Reduce the use of chlorofluorocarbons (CFCs) found in aerosol sprays and refrigeration.
2. Promote alternatives to ozone-depleting substances, such as hydrofluorocarbons (HFCs).
3. Support international agreements like the Montreal Protocol to phase out harmful chemicals.
4. Encourage planting of trees to help absorb carbon dioxide and reduce global warming effects.

12. (a) (i) What are the factors affecting the selective discharge of ions at the electrodes?

1. Position in the electrochemical series – Ions lower in the reactivity series are discharged preferentially.
2. Concentration of ions – Higher concentration ions are more likely to be discharged.
3. Type of electrode used – Some electrodes, like platinum and graphite, do not react, while others influence discharge.

(ii) Define the term electrochemical equivalent.

Electrochemical equivalent (E.C.E) is the mass of a substance deposited or liberated at an electrode when one coulomb of electricity passes through an electrolyte. It is measured in grams per coulomb (g/C).

(b) The apparatus shown in figure 2 below was used in an experiment of electroplating an iron knife with silver.

(i) Which electrode is the cathode?

The iron knife is the cathode because it is the object being coated with silver.

(ii) Write ionic equations to represent the reactions taking place at the electrodes.

At the anode (silver electrode):
$Ag \text{ -----> } Ag^+ + e^-$

At the cathode (iron knife):
$Ag^+ + e^- \text{ -----> } Ag$ (silver is deposited on the knife)

(iii) At which electrode was reduction taking place?

Reduction takes place at the cathode because silver ions gain electrons to form solid silver metal.

(c) A sample of impure silver of mass 3.45 g was used as the anode in an electrolysis purifying process. The cathode was made up of pure gold of mass 6.45 g. After the electrolysis, the cathode was found to weigh 9.66 g.
(i) Calculate the number of coulombs of electricity passed.

Step 1: Find the mass of silver deposited.
Mass of silver deposited = Final mass of cathode - Initial mass of cathode
= 9.66 g - 6.45 g
= 3.21 g

Step 2: Find the moles of silver deposited.
Molar mass of Ag = 108 g/mol
Moles of Ag = 3.21 g / 108 g/mol

= 0.0297 mol

Step 3: Find the charge passed using Faraday's law.
1 mole of Ag requires 96500 C (1 Faraday).

Charge (Q) = 0.0297 × 96500
= 2868.05 C

Number of coulombs of electricity passed = 2868 C (rounded).

(ii) What is the percentage purity of the impure silver?

Step 1: Find the mass of silver removed from the anode.
Mass removed = 3.21 g (same as deposited on cathode).

Step 2: Calculate percentage purity.
Percentage purity = (Mass of pure silver / Mass of impure silver) × 100
= (3.21 g / 3.45 g) × 100
= 93.04%

The percentage purity of the impure silver is 93.04%.

.