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: 2002**

Instructions

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

1.

(i) Separation of the constituents of a mixture by fractional distillation is possible because the constituents in the mixture differ in their

A. vaporizing points
B. freezing points
C. melting points
D. boiling points
E. sublimation points

Fractional distillation is based on differences in the boiling points of components in a mixture. The component with the lower boiling point evaporates first and can be separated.

Correct answer: D

(ii) If element M of Group I combines with element X of Group VII, the formula of the compound formed is

A. MX
B. MX_2
C. MX_3
D. X_2M
E. M_2X

Group I elements have a valency of 1, and Group VII elements also have a valency of 1. When they combine, they form a compound in a 1:1 ratio, giving the formula MX.

Correct answer: A

(iii) In an industrial process, ethene may be made from ethane. Ethane is fed into pre-heated furnaces and mixed with steam at 800°C. The type of reaction involved in the process of converting ethane to ethene is called

A. cracking
B. double decomposition
C. solution
D. distillation
E. chain decomposition

The process of converting larger hydrocarbons into smaller, more useful ones by breaking carbon-carbon bonds at high temperatures is called cracking.

Correct answer: A

(iv) During chemical reactions, bonds are broken and others are formed. If the total energy required to break the bonds is higher than the energy required to form the new bonds, the reaction will be

A. exothermic
B. endothermic
C. polymerisation
D. hydrogenation
E. neutralisation

If more energy is required to break bonds than is released in forming new bonds, the reaction absorbs heat, making it endothermic.

Correct answer: B

(v) One disadvantage of hard water is that it

A. causes the corrosion of water pipes
B. causes increased tooth decay
C. requires more soap for washing
D. contains minerals which are harmful
E. boils below 300°C

Hard water contains dissolved calcium and magnesium ions, which react with soap to form scum, requiring more soap to produce lather.

Correct answer: C

(vi) An example of a salt which is insoluble in water but can dissolve by warming is

A. sodium chloride
B. lead chloride
C. calcium carbonate
D. silver chloride
E. copper carbonate

Lead chloride is slightly soluble in cold water but dissolves readily when warmed.

Correct answer: B

(vii) Ammonia is manufactured by

A. Le Blanc process
B. Hess process
C. Contact process
D. Kuhlman process
E. Haber's process

The Haber process is used to synthesize ammonia by reacting nitrogen with hydrogen under high temperature and pressure.

Correct answer: E

(viii) Equivalent weight of an element is the mass liberated by

A. 1 coulomb of electricity
B. 96500 coulombs of electricity
C. 2 Faradays
D. 9650 coulombs of electricity
E. electrolytic process

One equivalent weight of an element is deposited by 96500 coulombs of electricity, which corresponds to one Faraday.

Correct answer: B

(ix) In the periodic table, ionization energy

A. decreases towards the right-hand side
B. increases down the group
C. increases towards the right-hand side
D. decreases down the group
E. follows the diagonal relationship

Ionization energy increases across a period (right-hand side) due to increasing nuclear charge and decreases down a group due to increasing atomic radius and shielding effect.

Correct answer: C

(x) The loss in mass when 100 g of calcium carbonate is strongly heated to constant mass is

A. 100 g
B. 56 g
C. 54 g
D. 48 g

E. 44 g

The decomposition of calcium carbonate follows the reaction:

$CaCO_3 \rightarrow CaO + CO_2$

The molar mass of $CaCO_3$ is 100 g, and upon decomposition, it loses CO_2 with a molar mass of 44 g.

Correct answer: E

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

List A

i. Hygroscopic substance
ii. Oxygen
iii. Nickel
iv. Basicity of an acid
v. O_2
vi. Solvent
vii. Mercury
viii. Air
ix. A coordinate bond
x. Dehydration

List B

A. a liquid non-metal
B. sublimes
C. one atom donates a pair of electrons to be shared in a chemical bond
D. a dissolved substance
E. a gaseous mixture
F. a substance which dissolves a solute
G. mainly used in the hydrogenation of oils
H. concentrated sulphuric acid
I. relights a glowing wooden splint
J. a compound
K. a liquid metal
L. removal of water from a compound

Correct answers

i. H
ii. I
iii. G
iv. Q
v. O
vi. F
vii. K
viii. E
ix. C
x. L

3. Diamond and graphite are two allotropes of carbon.

(a)(i) State two similarities and four differences of these allotropes.

Similarities:
- Both diamond and graphite are made of carbon atoms.
- Both are solid at room temperature.

Differences:
- Diamond has a three-dimensional tetrahedral structure, while graphite has a layered hexagonal structure.
- Diamond is the hardest known natural material, whereas graphite is soft and slippery.
- Diamond does not conduct electricity as it has no free electrons, whereas graphite conducts electricity due to the presence of free-moving electrons in its layers.
- Diamond is transparent and highly refractive, while graphite is opaque and black.

(ii) How can we experimentally prove that diamond and graphite are the allotropic forms of carbon?

- Both diamond and graphite can be burned in excess oxygen to produce carbon dioxide (CO_2), which confirms that they are composed of carbon.
- Their mass before and after burning can be measured, and the mass loss should correspond to the amount of carbon dioxide formed.

(b) 200 cm^3 of ethene were mixed with 60 cm^3 of oxygen gas and the mixture was exploded to complete reaction.

Write the balanced equation to represent the reaction.

$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$

(c) If excess ethene was exploded in only 60 cm^3 of oxygen, what volume of CO_2 measured at STP would be formed? What volume of ethene would be consumed?

From the balanced equation:
1 mole (1 volume) of C_2H_4 reacts with 3 moles (3 volumes) of O_2 to form 2 volumes of CO_2.

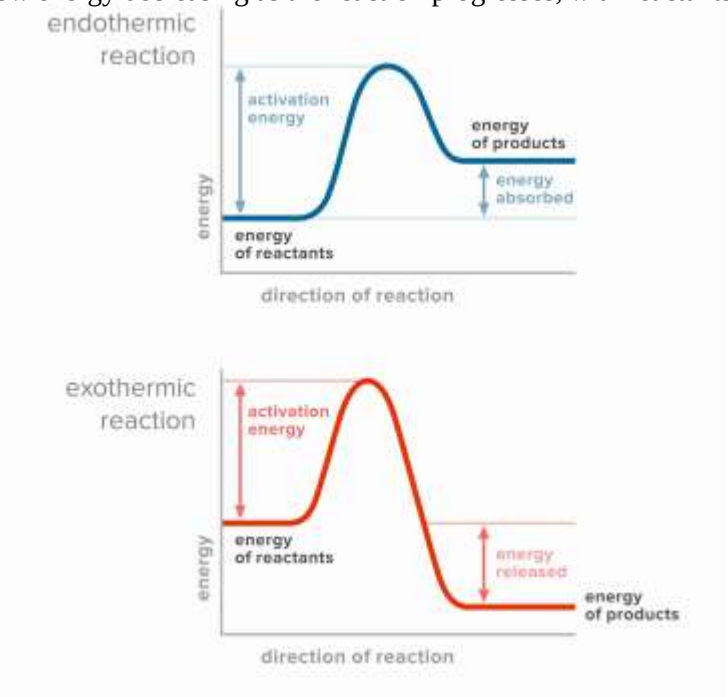
Using the given volume of oxygen:
- Oxygen available = 60 cm^3
- Required volume ratio: 3 parts O_2 reacts with 1 part C_2H_4
- Ethene consumed = (60 cm^3 O_2 × 1 volume C_2H_4) ÷ 3 volumes O_2 = 20 cm^3
- CO_2 produced = (60 cm^3 O_2 × 2 volumes CO_2) ÷ 3 volumes O_2 = 40 cm^3

Thus, 40 cm^3 of CO_2 is produced, and 20 cm^3 of ethene is consumed.

4.(a) Distinguish between an endothermic and an exothermic reaction.
- An endothermic reaction absorbs heat from the surroundings, resulting in a temperature drop. Examples include photosynthesis and thermal decomposition.
- An exothermic reaction releases heat, increasing the temperature of the surroundings. Examples include combustion and neutralization reactions.

(b) (i) Draw a simple straight-line graph of the energy profile diagram for an endothermic reaction.
- The graph should show energy increasing as reactants absorb heat, with products having higher energy than reactants.
(ii) Draw a similar graph of an exothermic reaction.

- The graph should show energy decreasing as the reaction progresses, with reactants having higher energy than products.



(c) Name the types of reaction represented by each of the following chemical phenomena:

(i) $2KClO_3$ --------> $2KCl + 3O_2$ (using MnO_2 as a catalyst)
- This is a thermal decomposition reaction, as potassium chlorate breaks down into potassium chloride and oxygen upon heating.

(ii) Fe + S -------> FeS
- This is a combination reaction, as iron and sulfur combine to form iron sulfide.

(iii) $AgNO_3 + NaCl$ ----------> $AgCl + NaNO_3$
- This is a precipitation reaction, as silver chloride forms as an insoluble solid in solution.

(iv) NH_4Cl --------> $NH_3 + HCl$
- This is a thermal decomposition reaction, as ammonium chloride decomposes upon heating.

5. (a) Define the following terms:

(i) Electrolyte
An electrolyte is a substance that conducts electricity in its molten state or in solution by allowing the movement of ions. Examples include sodium chloride solution and sulfuric acid.

(ii) Cation
A cation is a positively charged ion formed when an atom loses one or more electrons. Examples include Na^+ and Ca^{2+}.

(b) What is meant by isotropy?
Isotropy refers to a material's property of having identical values of a physical quantity, such as strength or refractive index, in all directions. An example is the uniform expansion of gases in all directions.

(c) Give four differences between electrovalent compounds and covalent compounds.

1. Electrovalent compounds (ionic compounds) are formed by the transfer of electrons, whereas covalent compounds are formed by the sharing of electrons.
2. Electrovalent compounds usually have high melting and boiling points, while covalent compounds have lower melting and boiling points.
3. Electrovalent compounds conduct electricity in molten or aqueous states due to the movement of ions, whereas covalent compounds do not conduct electricity.
4. Electrovalent compounds are generally soluble in water but insoluble in organic solvents, whereas covalent compounds are usually soluble in organic solvents but less soluble in water.

6. Study the part of the periodic table below and then answer the questions that follow.

(a) Name and write the chemical symbols for elements with the letters U, V, W, X, Y, and Z.

- U ---> Carbon (C)
- V ----> Nitrogen (N)
- W ----> Oxygen (O)
- X ------> Fluorine (F)
- Y -------> Chlorine (Cl)
- Z -------> Sulfur (S)

7.

(a) Differentiate between the following, giving an example in each case:

(i) Solute and solvent
- A solute is a substance that dissolves in a solvent to form a solution. Example: Salt in water.
- A solvent is a substance that dissolves a solute to form a solution. Example: Water dissolving salt.

(ii) Deliquescence and efflorescence
- Deliquescence is the property of a substance absorbing moisture from the air and dissolving in it to form a solution. Example: Sodium hydroxide (NaOH) pellets.
- Efflorescence is the process where a hydrated salt loses its water of crystallization when exposed to air. Example: Washing soda ($Na_2CO_3 \cdot 10H_2O$).

(iii) Miscible liquids and immiscible liquids
- Miscible liquids mix completely with each other in any proportion without separating. Example: Water and ethanol.
- Immiscible liquids do not mix and form separate layers. Example: Oil and water.

(iv) An element and a molecule
- An element is a pure substance consisting of only one type of atom. Example: Oxygen (O_2).
- A molecule is a combination of two or more atoms chemically bonded together. Example: Water (H_2O).

(b) Study carefully the flow chart below and then answer the questions which follow:

(i) Name processes 1 and 2.
- Process 1: Fermentation
- Process 2: Distillation

(ii) Identify gas X and solution Y.
- Gas X: Carbon dioxide (CO_2)
- Solution Y: Ethanol (C_2H_5OH)

(iii) A newspaper article wrote about "drivers of the future fuelling their cars with sugar beet instead of petrol". What do you think was meant by the article?
The article refers to the use of bioethanol, which is produced from sugar beet through fermentation, as an alternative fuel to petrol. Bioethanol is a renewable energy source that reduces carbon emissions and dependence on fossil fuels.

(c) The following experiments were carried out on metals A, B, C, and D.

Metals B, C, and D reacted with dilute acid. Oxides of B and C were reduced on heating with carbon. When B and C were made at the electrodes in a voltaic cell, electricity flowed from B → C.

(i) What does the experiment tell you about the reactivities of the metals?
- Since metals B, C, and D reacted with acid, they are more reactive than hydrogen.
- Since the oxides of B and C were reduced using carbon, carbon is more reactive than these metals.
- Since electricity flowed from B to C in the voltaic cell, B is more reactive than C.

(ii) Arrange the metals in the order of decreasing reactivity.
B > C > D > A

(iii) What is the position of carbon and hydrogen in this series?
- Carbon is more reactive than B and C but less reactive than A.
- Hydrogen is less reactive than B, C, and D but more reactive than A.

8.(a) Define the following terms:

(i) Empirical formula
The empirical formula of a compound is the simplest whole-number ratio of atoms of each element in the compound. Example: The empirical formula of glucose ($C_6H_{12}O_6$) is CH_2O.

(ii) Molecular formula
The molecular formula represents the actual number of atoms of each element in a molecule of the compound. Example: The molecular formula of water is H_2O.
(b) Determine the empirical formula of a substance that has the following composition by mass: 49.5 % Manganese and 50.5 % oxygen.

Step 1: Convert mass percentages to moles.
- Moles of Mn = 49.5 ÷ 54.9 = 0.902
- Moles of O = 50.5 ÷ 16 = 3.156

Step 2: Divide by the smallest number of moles.
- Mn = 0.902 ÷ 0.902 = 1
- O = 3.156 ÷ 0.902 = 3.5

Step 3: Multiply by 2 to get whole numbers.
- Mn = 1 × 2 = 2
- O = 3.5 × 2 = 7

Empirical formula = Mn_2O_7

(c) Complete and balance the following equations:
(i) $Mg_3N_2 + 6H_2O$ --------> $3Mg(OH)_2 + 2NH_3$

(ii) $2NH_3 + CuO$ ---------> $Cu + N_2 + 3H_2O$
(iii) $NH_3 + Cl_2$ -------> $N_2 + 3HCl$

(iv) $4NH_3 + 3O_2$ -------> $2N_2 + 6H_2O$

(v) $MgCl_2(aq) + 2AgNO_3(aq)$ ----> $Mg(NO_3)_2 + 2AgCl$
9.(a) 25 cm^3 of impure sulphuric acid containing 5.2 g/dm^3 reacted with 25 cm^3 of sodium hydroxide solution made by dissolving 4.0 g NaOH in distilled water to make 1.0 litre solution. Calculate the percentage of

(i) purity of the acid
(ii) impurity of the acid

Step 1: Calculate the moles of sodium hydroxide
Molar mass of NaOH = 23 + 16 + 1 = 40 g/mol
Moles of NaOH in 1.0 litre = 4.0 g / 40 g/mol = 0.1 moles

Step 2: Calculate the moles of NaOH in 25 cm^3
Since 1 litre contains 0.1 moles,
Moles in 25 cm^3 = (25/1000) × 0.1 = 0.0025 moles

Step 3: Write the balanced reaction equation
$H_2SO_4 + 2NaOH$ ---------> $Na_2SO_4 + 2H_2O$

From the equation, 1 mole of H_2SO_4 reacts with 2 moles of NaOH,
Moles of H_2SO_4 = 0.0025 ÷ 2 = 0.00125 moles

Step 4: Calculate the mass of pure H_2SO_4
Molar mass of H_2SO_4 = 98 g/mol
Mass = 0.00125 × 98 = 0.1225 g

Step 5: Calculate the percentage purity
Mass of impure H_2SO_4 in 25 cm^3 = (5.2 g/dm^3 × 25 cm^3) / 1000 = 0.13 g

Percentage purity = (0.1225 / 0.13) × 100 = 94.23%

Step 6: Calculate percentage impurity
Percentage impurity = 100 - 94.23 = 5.77%

(b) The following reaction can take place in living organisms:

$X + O_2$ ------> $CO_2 + H_2O$

(i) What name is given to this reaction?
This reaction is called cellular respiration.

(ii) Why is this reaction important to animals?
Cellular respiration is essential for animals because it provides energy in the form of ATP, which is required for various metabolic activities and maintaining bodily functions.

(c) The following is a table of electron arrangements:

ELEMENT	ELECTRON ARRANGEMENT
A	2:8:5
B	2:8:8
C	2:2
D	2:8:8:1
E	2:7

(i) What kind of bonding is there between the atoms in each of these elements?
- A (2:8:5) - Covalent bonding
- B (2:8:8) - No bonding (Noble gas)
- C (2:2) - Covalent bonding
- D (2:8:8:1) - Metallic bonding
- E (2:7) - Covalent bonding

(ii) What type of bonding exists between atoms of A and E?
Atoms of A (2:8:5) and E (2:7) will form covalent bonding as they share electrons to complete their outer shells.

(iii) What type of bonding occurs when an atom of hydrogen combines with bromine and with an atom of sodium?
- Hydrogen and bromine form covalent bonding by sharing an electron.
- Hydrogen and sodium form ionic bonding where sodium donates an electron to hydrogen.

(iv) Sketch the appearance of the resulting molecules in 9(c)(iii) above.

- H—Br (covalent bond)
- $Na^+ H^-$ (ionic bond)

10.(a) Write down the balanced equations for the manufacture of sulphur dioxide (SO_2) from

(i) sulphur
$S + O_2$ ----------> SO_2

(ii) hydrogen sulphide
$2H_2S + 3O_2$ ---------> $2SO_2 + 2H_2O$

(iii) a sulphide ore
$4FeS_2 + 11O_2$ ------> $2Fe_2O_3 + 8SO_2$

(b) Write down a balanced chemical equation for the combustion of sulphur dioxide.
$SO_2 + ½O_2$ -------> SO_3

(c) State two important commercial uses of sulphuric acid.
- Used in the manufacture of fertilizers like ammonium sulphate.
- Used in car batteries as an electrolyte.

11. (a) What do you understand by soil fertility?
Soil fertility is the ability of soil to provide essential nutrients in sufficient quantities to support plant growth and yield healthy crops.

(b) Give reasons why a fertile soil is not necessarily productive.
- Lack of proper water supply can limit plant growth even if the soil is fertile.
- Poor farming practices like overgrazing or erosion can degrade soil structure and reduce productivity.

(c) List four nitrogenous straight fertilizers and describe the properties of two of them.

1. Ammonium nitrate (NH_4NO_3)
2. Urea ($CO(NH_2)_2$)
3. Ammonium sulphate ($(NH_4)_2SO_4$)
4. Calcium ammonium nitrate ($Ca(NO_3)_2 \cdot NH_4NO_3$)

Properties:
- Ammonium nitrate is highly soluble in water and provides nitrogen in an immediately available form for plant uptake.
- Urea contains a high nitrogen content (46%) and must be hydrolyzed in soil to release nitrogen for plant absorption.

12.(a) With the aid of an equation/equations show how each of the following conversions can be brought about:

Calcium oxide ------> calcium hydroxide -----> calcium nitrate ------> calcium carbonate.

Step 1: Formation of calcium hydroxide
$CaO + H_2O$ ------> $Ca(OH)_2$

Step 2: Formation of calcium nitrate
$Ca(OH)_2 + 2HNO_3$ ---------> $Ca(NO_3)_2 + 2H_2O$

Step 3: Formation of calcium carbonate
$Ca(NO_3)_2 + Na_2CO_3$ -------> $CaCO_3 + 2NaNO_3$

(b) The reaction cycle for malachite ($CuCO_3$) is shown below.

(i) How would step 1 be brought about?
Step 1 is brought about by heating copper carbonate, which decomposes to form copper(II) oxide and carbon dioxide.

(ii) Name reagent A in step 2.
Reagent A is hydrochloric acid (HCl).

(iii) What kind of reaction is involved in step 2?
Step 2 is a neutralization reaction where an acid reacts with a base to form a salt and water.

(iv) Write down a balanced equation for step 1 and step 2.

Step 1:
$CuCO_3$ -------> $CuO + CO_2$

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

(c) A pupil set up the cell shown in the drawing below.
(i) What does X represent?
X represents the salt bridge.
(ii) What is the function of X?
The salt bridge completes the circuit by allowing the movement of ions, maintaining electrical neutrality between the solutions in the two half-cells.

(iii) What is the direction of flow of electricity in the circuit?
Electrons flow from the zinc electrode (anode) to the lead electrode (cathode) through the external circuit.