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: 2001**

Instructions

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

1. (i) The following are methods of separating mixtures of liquid substances which are miscible:

A Chromatography, filtration and fractional distillation
B Chromatography, fractional distillation, sorting
C Chromatography, fractional distillation, condensation
D Chromatography, fractional distillation, fractional crystallization
E Chromatography, filtration, condensation

Correct answer: D
Fractional distillation separates miscible liquids based on their boiling points, and fractional crystallization further purifies them.

(ii) The total number of protons and neutrons in the nucleus of an atom is called

A valency number
B atomic number
C molecular number
D mass number
E hybrid orbital

Correct answer: D
The mass number is the sum of protons and neutrons in an atom's nucleus.

(iii) Which of the following solutions will turn pink when phenolphthalein indicator is added to it?

A Orange juice
B Drinking water
C Deionised water
D Caustic soda
E Sulphuric acid

Correct answer: D
Caustic soda (NaOH) is a strong base, and phenolphthalein turns pink in basic solutions.

(iv) A chemist is a person who investigates and collects data on the changes of chemical substances before making any conclusions. Which important qualities must this person have?

A Mastery of the periodic table of elements
B Skills in writing reports in English language
C Keen in the use of most of the sense organs
D Interest in the use of computers
E Familiar with other science subjects

Correct answer: C
A chemist must use their sense organs carefully for observation, measurement, and experimentation.

(v) An element having atomic number 35 is likely to be a

A non-metal having one electron in the outer shell
B metal of valency one
C non-metal of group VI
D non-metal having seven electrons in the outer shell
E metal of group II

Correct answer: D
The element with atomic number 35 is bromine, which is a halogen (group VII) with seven valence electrons.

(vi)

The above illustration presents … reaction.

A an activation
B an endothermic
C an exothermic
D a heat
E a neutralisation

Correct answer: B
The graph shows energy absorption as reactants move to products, indicating an endothermic reaction.

(vii) Substance L has a percentage composition of 54.6 % carbon, 9.1 % hydrogen and the rest is oxygen. The empirical formula of substance L is

A C_2H_4O
B CH_4
C CH_2O
D C_3H_6O
E $C_2H_6O_2$

Correct answer: C

Step 1: Convert mass percentages to moles.
- Carbon: 54.6 ÷ 12 = 4.55
- Hydrogen: 9.1 ÷ 1 = 9.1
- Oxygen: (100 - 54.6 - 9.1) ÷ 16 = 3.41

Step 2: Divide by the smallest number of moles.
- C: 4.55 ÷ 3.41 = 1.33
- H: 9.1 ÷ 3.41 = 2.67
- O: 3.41 ÷ 3.41 = 1

Step 3: Multiply by 3 to get whole numbers.
- C: 1.33 × 3 = 4
- H: 2.67 × 3 = 8
- O: 1 × 3 = 3

Empirical formula = CH_2O

(viii) Substances P and Q exist in different structural forms yet they belong to one element.

The existence of these substances in different forms is known as

A isotopy
B anisotropy
C allotropy
D isomerism
E radioactivity

Correct answer: C
Allotropy is when an element exists in different structural forms with different physical properties, like diamond and graphite.

(ix) The effect of surface area of reactants on the rate of chemical reaction can be studied in the laboratory using dilute sodium hydroxide solution and aluminium foil or powdered aluminium. The chemical equation for this reaction will be

A $2Al(s) + NaHCO_3(aq) + NaOH(aq) \rightarrow 2NaAl(OH)_4(aq) + CO_2(g) + 2H_2O(l)$
B $2Al(s) + Na^+(aq) \rightarrow 2NaAl(s)$
C $Al(s) + NaOH(aq) + H_2SO_4(aq) \rightarrow AlSO_4(aq) + NaHSO_4(aq) + H_2(g)$
D $Al(s) + NaOH(aq) + H_2O(l) \rightarrow NaAlO_2 + AlH_3O_3 + H_2O(l)$
E $2Al(s) + 2NaOH(aq) + 6H_2O(l) \rightarrow 2NaAl(OH)_4(aq) + 3H_2(g)$

Correct answer: E
The reaction between aluminum and sodium hydroxide forms sodium aluminate and releases hydrogen gas.

(x) Electroplating of a wedding ring was carried out in the laboratory using copper sulphate solution as shown in the diagram below.

What reaction took place at the carbon electrode?

A Oxidation reaction with discharge of OH^- ions
B Oxidation reaction with discharge of $H_2(g)$
C Reduction reaction with discharge of OH^- ions
D Oxidation reaction with discharge of Cu^{2+} ions
E Redox reaction with discharge of Cu^{2+} and H^+ ions

Correct answer: D
At the carbon electrode (anode), oxidation occurs, where Cu^{2+} ions go into solution as Cu^{2+} from the copper sulphate electrolyte.

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) Flocculation
(ii) Bonding in a molecule of nitrogen
(iii) Ammonia in water
(iv) Chemical equations
(v) Identification of hydrogen
(vi) Acid-base reaction
(vii) Mass number
(viii) Used to remove colouring matter in brown sugar
(ix) Empirical formula
(x) Existence of element in more than one form without changing its state

List B

A Graphite
B Isomer
C Triple bonds
D Binding together of soil particles
E Catenation
F pH greater than 7
G Pop sound
H Lime water change to milky colour
I Representation of reactants and products in a chemical reaction
J Neutralisation reaction
K Allotropy
L Total number of protons and neutrons in the nucleus
M Animal charcoal
N Bleaching

O Simplest formula that expresses its composition by mass
P Kipp's apparatus
Q To precipitate soil materials
R One which expresses the actual number of each kind of atom present in its molecule
S Method of separating solid mixtures
T Chromatographic techniques

Correct matching:

(i) Flocculation - D
(ii) Bonding in a molecule of nitrogen - C
(iii) Ammonia in water - F
(iv) Chemical equations - I
(v) Identification of hydrogen - G
(vi) Acid-base reaction - J
(vii) Mass number - L
(viii) Used to remove colouring matter in brown sugar - M
(ix) Empirical formula - O
(x) Existence of element in more than one form without changing its state - K

3. (a) Differentiate between

(i) isotopes and allotropes

Isotopes are atoms of the same element that have the same number of protons but different numbers of neutrons. This means they have the same atomic number but different mass numbers. For example, carbon has isotopes such as carbon-12 and carbon-14.

Allotropes, on the other hand, are different structural forms of the same element in the same physical state. These forms arise due to variations in the arrangement of atoms. For example, carbon has allotropes such as diamond, graphite, and graphene.

(ii) protons and neutrons

Protons are positively charged subatomic particles found in the nucleus of an atom. The number of protons in an atom determines the atomic number of an element, which defines the element's identity.

Neutrons are neutral subatomic particles also located in the nucleus. They contribute to the atomic mass but do not affect the element's chemical properties. The number of neutrons can vary among atoms of the same element, leading to the formation of isotopes.

(b) Dalton's atomic theory contains assumptions concerning the manner in which elements combine with one another. State these assumptions.

Dalton proposed the following assumptions about atoms and their behavior in chemical reactions:

1. All matter is composed of tiny, indivisible particles called atoms, which cannot be created or destroyed in a chemical reaction.
2. Atoms of the same element are identical in mass and properties, but atoms of different elements have different masses and properties.
3. Atoms combine in simple whole-number ratios to form compounds.
4. A chemical reaction involves the rearrangement of atoms without their creation or destruction.
5. Atoms of different elements combine in fixed proportions to form compounds.

(c) A mass of 4.133 g of sodium carbonate crystal ($Na_2CO_3 \cdot xH_2O$), was heated gently and 3.533 g of the anhydrous compound remained. Calculate the value of x.

Given:
- Mass of hydrated sodium carbonate = 4.133 g
- Mass of anhydrous sodium carbonate = 3.533 g

Step 1: Determine the mass of water lost.
Mass of water = 4.133 g - 3.533 g = 0.600 g

Step 2: Find the molar masses of sodium carbonate (Na_2CO_3) and water (H_2O).
- Molar mass of Na_2CO_3 = 23(2) + 12 + 16(3) = 105 g/mol
- Molar mass of H_2O = 18 g/mol

Step 3: Calculate the number of moles of anhydrous Na_2CO_3.
Moles of Na_2CO_3 = 3.533 g / 105 g/mol = 0.03365 mol

Step 4: Calculate the number of moles of water.
Moles of H_2O = 0.600 g / 18 g/mol = 0.03333 mol

Step 5: Find the value of x.
x = Moles of H_2O / Moles of Na_2CO_3
x = 0.03333 / 0.03365
$x \approx 10$

Thus, the value of x is 10, meaning the compound is $Na_2CO_3 \cdot 10H_2O$.

4. (a) What do you understand by the following terms?

(i) A base

A base is a substance that neutralizes acids to form salt and water. Bases are usually metal oxides or hydroxides. For example, sodium hydroxide (NaOH) and calcium hydroxide ($Ca(OH)_2$) are bases.

(ii) An alkali

An alkali is a base that dissolves in water to release hydroxide ions (OH^-). All alkalis are bases, but not all bases are alkalis. Examples of alkalis include sodium hydroxide (NaOH) and potassium hydroxide (KOH).

(iii) A salt

A salt is a compound formed when the hydrogen ions (H^+) in an acid are replaced by metal ions or ammonium ions. Salts are neutral and can be formed through neutralization reactions. For example, sodium chloride (NaCl) is a salt formed from hydrochloric acid (HCl) and sodium hydroxide (NaOH).

(iv) A weak acid

A weak acid is an acid that partially ionizes in solution, meaning it does not completely dissociate into hydrogen ions (H^+). As a result, it has a lower concentration of H^+ ions in solution. Examples of weak acids include acetic acid (CH_3COOH) and carbonic acid (H_2CO_3).

(b) When zinc granules and dilute sulphuric acid are reacted together, a gas M is produced. The gas produced is collected by downward displacement of water. Use this information to answer the questions below:

(i) Name the gas M produced.

The gas produced is hydrogen gas (H_2).

(ii) How is the gas tested?

Hydrogen gas is tested by bringing a burning splint near it. If hydrogen is present, it burns with a 'pop' sound.

(iii) Why is the gas collected by downward displacement of water?

Hydrogen gas is collected by downward displacement of water because it is insoluble in water and lighter than air. This allows it to be effectively collected without dissolving in the water.

(iv) List all the apparatuses used in the preparation of gas M.

- Conical flask
- Delivery tube
- Test tube
- Dilute sulphuric acid
- Zinc granules
- Water trough

(v) Write one use of gas M.
Hydrogen gas is used in fuel cells to generate electricity as a clean energy source.

(c) Give reasons for the following chemical phenomena:
(i) Hydrochloric acid is added in a test-tube containing a carbonate.
When hydrochloric acid reacts with a carbonate, it produces carbon dioxide gas (CO_2), which can be tested by bubbling it through limewater. The reaction is:
$CaCO_3 + 2HCl$ ------> $CaCl_2 + CO_2 + H_2O$
(ii) Ammonium sulphate crystals are warmed together with sodium hydroxide solution.
Ammonium salts react with sodium hydroxide to release ammonia gas (NH_3), which has a characteristic pungent smell. The reaction is:
$(NH_4)_2SO_4 + 2NaOH$ --------> $Na_2SO_4 + 2NH_3 + 2H_2O$

(iii) Lead nitrate is heated in a test-tube.
When lead nitrate is heated, it decomposes to produce lead(II) oxide, nitrogen dioxide, and oxygen gas. The reaction is:
$2Pb(NO_3)_2$ -------> $2PbO + 4NO_2 + O_2$
The brown fumes observed are due to nitrogen dioxide (NO_2) gas.

5. (a) Identify the substances revealed by the following information:
(i) A pale green solution which becomes yellowish-brown on exposure to air
This substance is iron(II) sulfate ($FeSO_4$). When exposed to air, it oxidizes to iron(III) sulfate.

(ii) A colourless liquid, immiscible with water, which dissolves sulphur
This substance is carbon disulfide (CS_2).

(iii) A heavy liquid metal
This substance is mercury (Hg).

6. (a) Study the following elements:
$^{32}_{16}S$, $^{35}_{17}Cl$, $^{40}_{18}Ar$, $^{20}_{18}Ca$ and $^{39}_{19}K$.

Atoms and ions which have the same number of electrons are said to be iso-electronic. From the elements given above, write the formula of three ions which are iso-electronic and draw their electronic structures.
Solution:

Isoelectronic species have the same number of electrons despite being different elements or ions. The electronic configurations of the given elements and their possible ions are:

- Sulfur (S): 2, 8, 6 -----> S^{2-} (2, 8, 8)
- Chlorine (Cl): 2, 8, 7 ------> Cl^- (2, 8, 8)
- Argon (Ar): 2, 8, 8 (Noble gas, does not form ions)
- Calcium (Ca): 2, 8, 8, 2 --------> Ca^{2+} (2, 8, 8)

- Potassium (K): 2, 8, 8, 1 ------> K^+ (2, 8, 8)

From this, the three ions that are iso-electronic (having the same electronic configuration of 2, 8, 8) are: S^{2-}, Cl^-, and Ca^{2+}.

Their electronic structures would show the same number of electrons distributed across shells, similar to argon.

(b) Calcium oxide (quicklime) is manufactured by heating limestone in a stream of air.
(i) Write the equation for the reaction and explain why it is necessary to heat the limestone in a stream of air.

Solution:
The decomposition of limestone ($CaCO_3$) to form calcium oxide (CaO) occurs as follows:
$CaCO_3$ (s) ------> CaO (s) + CO_2 (g)

It is necessary to heat the limestone in a stream of air to ensure complete decomposition and removal of carbon dioxide gas. The continuous supply of air helps to remove CO_2 from the reaction site, shifting the equilibrium to favor the production of more CaO.
(ii) State how calcium oxide is converted to calcium hydroxide and indicate one point of interest concerning the reaction that takes place.

Solution:
Calcium oxide reacts with water to form calcium hydroxide in an exothermic reaction:

CaO + H_2O -----> $Ca(OH)_2$

One point of interest in this reaction is that it releases a significant amount of heat, making it an exothermic process. This heat release is useful in construction, where slaked lime ($Ca(OH)_2$) is used in mortar and plaster.

I see the issue, and I'll correct it. I'll ensure that chemical elements are properly capitalized while keeping the format you prefer. Here's the corrected version:

6. (c)(i) Explain one laboratory use and one large-scale use of calcium hydroxide.

Laboratory use: Calcium hydroxide ($Ca(OH)_2$), also known as slaked lime, is used in the laboratory to test for the presence of carbon dioxide gas. When CO_2 is bubbled through limewater (a dilute solution of calcium hydroxide), it forms a white precipitate of calcium carbonate, indicating the presence of carbon dioxide:

$Ca(OH)_2$ + CO_2 ----> $CaCO_3$ + H_2O

Large-scale use: Calcium hydroxide is widely used in the treatment of acidic soil in agriculture. It neutralizes excess acidity in the soil, improving plant growth and increasing crop yield. This process is known as liming.

(ii) Give the reaction that takes place when a mixture of coke and calcium oxide is heated in an electric furnace.

When coke (carbon) is heated with calcium oxide in an electric furnace, it produces calcium carbide (CaC_2), which is used to manufacture acetylene gas. The reaction is as follows:

$CaO + 3C \text{ ---> } CaC_2 + CO$

This reaction is carried out in an industrial electric arc furnace at high temperatures.

7.The diagram represents the laboratory preparation of oxygen.

(a)(i) Label the parts indicated with letters A, B, C, D in the diagram.

- A: Dropping funnel
- B: Conical flask
- C: Delivery tube
- D: Gas jar

(ii) Does oxygen burn? Why?

Oxygen itself does not burn because it is not a fuel, but it supports combustion by helping other substances to burn more rapidly.

(b) The formula of Manganese (IV) Oxide is MnO_2 and that of Hydrogen Peroxide is H_2O_2. Which compound produces oxygen?

Hydrogen Peroxide (H_2O_2) decomposes to produce oxygen gas when a catalyst like Manganese (IV) Oxide is added:

$2H_2O_2 \text{ ----> } 2H_2O + O_2$

Thus, Hydrogen Peroxide (H_2O_2) is the compound that produces oxygen.

(c) (i) What is the name of the method of collecting the gas?

Oxygen is collected by the downward displacement of water (or over water method) because it is insoluble in water.

(ii) Explain the meaning of a catalyst.

A catalyst is a substance that speeds up the rate of a chemical reaction without being consumed or permanently changed in the process. For example, Manganese (IV) Oxide (MnO_2) acts as a catalyst in the decomposition of Hydrogen Peroxide to produce oxygen.

(iii) How can you test for oxygen?

Oxygen gas is tested by inserting a glowing splint into the gas jar. If oxygen is present, the splint will relight or burst into flames due to the gas's ability to support combustion.

8.(a)(i) Define the term mole.

A mole is the amount of a substance that contains exactly 6.022×10^{23} particles (atoms, molecules, or ions). This number is known as Avogadro's constant. One mole of any substance has a mass equal to its relative atomic or molecular mass in grams.
(ii) How many hydrogen atoms are there in 2.57×10^{-6} g of hydrogen?

Step 1: Find the molar mass of Hydrogen atoms (H). The atomic mass of Hydrogen is 1 g/mol.

Step 2: Calculate the number of moles of Hydrogen atoms in the given mass:

Moles of Hydrogen = mass / molar mass
$= (2.57 \times 10^{-6}\ g) / (1\ g/mol)$
$= 2.57 \times 10^{-6}$ moles

Step 3: Use Avogadro's constant to find the number of Hydrogen atoms:

Number of atoms = moles × Avogadro's number
$= (2.57 \times 10^{-6}) \times (6.022 \times 10^{23})$
$= 1.548 \times 10^{18}$ atoms

Thus, there are 1.548×10^{18} Hydrogen atoms.

(b) Suggest the suitable indicators for the following titrations:

(i) Strong acid against strong base – Methyl Orange or Phenolphthalein

(ii) Strong base against weak acid – Phenolphthalein

(iii) Weak base against strong acid – Methyl Orange
(iv) Weak acid against weak base – No suitable indicator (a pH meter is preferred)

(c) (i) Ammonium Sulphate combines with Sodium Hydroxide solution to produce Sodium Sulphate. With the aid of a balanced chemical equation, calculate the mass of Sodium Hydroxide that would combine with 52 g of Ammonium Sulphate.

Balanced chemical equation:

$(NH_4)_2SO_4 + 2NaOH \text{ -----> } Na_2SO_4 + 2NH_3 + 2H_2O$

Step 1: Find the molar masses of the reactants.
- Ammonium Sulphate $(NH_4)_2SO_4 = (14 \times 2) + (1 \times 8) + (32) + (16 \times 4) = 132$ g/mol
- Sodium Hydroxide (NaOH) = (23 + 16 + 1) = 40 g/mol

Step 2: Find the moles of Ammonium Sulphate in 52 g.

Moles of $(NH_4)_2SO_4$ = 52 g / 132 g/mol = 0.394 mol

Step 3: Use the reaction equation to find the required moles of NaOH.

From the equation, 1 mole of $(NH_4)_2SO_4$ reacts with 2 moles of NaOH.

Moles of NaOH needed = 0.394 × 2 = 0.788 moles

Step 4: Convert moles of NaOH to mass.

Mass of NaOH = 0.788 mol × 40 g/mol = 31.52 g

Thus, 31.52 g of NaOH is required to react with 52 g of Ammonium Sulphate.

(ii) 25 cm^3 of a solution containing 0.196 g of a metal hydroxide, XOH, were neutralized by 35 cm^3 of 0.1 M Hydrochloric Acid solution.

Write down the balanced chemical equation for the reaction.

$XOH + HCl \text{ -----> } XCl + H_2O$

This equation shows that one mole of the metal hydroxide reacts with one mole of Hydrochloric Acid to form a salt and water.

9. (a) The diagram below represents the process of extraction of aluminium metal from bauxite. Label parts A, B, C, D, E, F, G and H.

Solution:
- A: Electrolytic cell

- B: Carbon cathode
- C: Molten aluminium
- D: Carbon anodes
- E: Power source (positive terminal)
- F: Electrolyte (molten cryolite and aluminium oxide)
- G: Outlet for molten aluminium
- H: Waste electrolyte/sludge

(b) (i) Explain briefly how aluminium is obtained from its oxide.

Aluminium is extracted from its oxide (Al_2O_3) using electrolysis. The aluminium oxide is dissolved in molten cryolite to lower its melting point and is then electrolyzed. At the cathode, aluminium ions gain electrons and get reduced to aluminium metal, which collects at the bottom. The reaction is:

$Al^{3+} + 3e^- \text{------>} Al$ (reduction at the cathode)

(ii) Explain how aluminium chloride is formed.

Aluminium chloride ($AlCl_3$) is formed by the direct reaction of aluminium metal with chlorine gas at high temperatures:

$2Al + 3Cl_2 \text{----->} 2AlCl_3$

(iii) What will happen if aluminium chloride reacts with water?

When aluminium chloride reacts with water, it undergoes hydrolysis to form aluminium hydroxide and hydrogen chloride gas:

$AlCl_3 + 3H_2O \text{----->} Al(OH)_3 + 3HCl$

(c) With the help of a balanced chemical equation, explain why aluminium containers can be used to store concentrated nitric acid and not concentrated sulphuric acid.

Aluminium containers can store concentrated nitric acid because aluminium reacts with nitric acid to form a protective oxide layer (Al_2O_3), which prevents further reaction:

$Al + 6HNO_3 \text{----->} Al(NO_3)_3 + 3H_2$

However, concentrated sulphuric acid reacts aggressively with aluminium, breaking down the protective oxide layer and leading to further corrosion:

$2Al + 6H_2SO_4 \text{----->} Al_2(SO_4)_3 + 3H_2$

Thus, aluminium is resistant to nitric acid but not to sulphuric acid.

10. (a) What do you understand by the following terms?

(i) Isomerism

Isomerism is the phenomenon where compounds have the same molecular formula but different structural arrangements, resulting in different physical and chemical properties. For example, butane (C_4H_{10}) has structural isomers: n-butane and isobutane.

(ii) Homologous series

A homologous series is a group of organic compounds with the same general formula, similar chemical properties, and a gradual change in physical properties due to an increasing molecular size. For example, alkanes (CnH_{2n+2}) form a homologous series.

(iii) Substitution reaction

A substitution reaction is a chemical reaction where one atom or group of atoms in a molecule is replaced by another atom or group. For example, when methane reacts with chlorine under UV light, a hydrogen atom is substituted by a chlorine atom:

$CH_4 + Cl_2$ -----> $CH_3Cl + HCl$

(b) Explain how the following conversions take place. Give the necessary conditions.

(i) Methane is converted to tetrachloromethane

Methane reacts with excess chlorine in the presence of ultraviolet (UV) light, undergoing multiple substitution reactions until all hydrogen atoms are replaced by chlorine atoms:

$CH_4 + 4Cl_2$ ----> $CCl_4 + 4HCl$

(ii) Ethanol is converted to acetaldehyde

Ethanol is oxidized to acetaldehyde (ethanal) using an oxidizing agent like acidified potassium dichromate ($K_2Cr_2O_7$) or potassium permanganate ($KMnO_4$) under controlled conditions:

$C_2H_5OH + [O]$ ----> $CH_3CHO + H_2O$

(iii) Alcohol is converted to ethene

Ethanol is dehydrated to ethene using concentrated sulphuric acid (H_2SO_4) as a catalyst at about 170°C:

$C_2H_5OH \rightarrow C_2H_4 + H_2O$

(c) (i) Name the compound in natural gas.

The main component of natural gas is methane (CH_4).

(ii) Give the general formula for the homologous series to which it belongs.

Methane belongs to the alkane series, which follows the general formula:

CnH_{2n+2}

For example:
- Methane (CH_4)
- Ethane (C_2H_6)
- Propane (C_3H_8)

11. (a) Explain briefly the following terms.

(i) Soil formation

Soil formation is the process of breaking down rocks into finer particles through weathering (physical, chemical, and biological) and mixing with organic matter to form soil over time.

(ii) Denitrification

Denitrification is the process where bacteria convert nitrates (NO_3^-) in the soil into nitrogen gas (N_2), which is released into the atmosphere. This process reduces soil fertility.

(iii) Symbiotic bacteria

Symbiotic bacteria are bacteria that live in mutual association with plants or other organisms, providing benefits such as nitrogen fixation in exchange for nutrients. An example is Rhizobium in legume root nodules.

(iv) Mulching

Mulching is the practice of covering the soil surface with organic or inorganic materials (such as straw, grass, or plastic) to retain moisture, reduce erosion, and suppress weeds.

(b) (i) What is manure?

Manure is organic material derived from decomposed plant and animal waste, used to improve soil fertility by adding essential nutrients.

(ii) Name five types of organic manures.

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

(iii) Give three advantages and three disadvantages of manures.

Advantages:
1. Improves soil structure and aeration
2. Provides essential nutrients for plant growth
3. Enhances soil microbial activity

Disadvantages:
1. Nutrient content varies and may be imbalanced
2. Requires large quantities for significant impact
3. May introduce weeds and pathogens into the soil

(c)(i) Give four reasons why a fertile soil is not necessarily productive.
1. Lack of sufficient water, leading to drought stress.
2. Poor soil drainage, causing waterlogging and root rot.
3. Presence of pests and diseases that damage crops.
4. Poor farming practices such as overcultivation or erosion.

(ii) Asha's school shamba soil requires 80 kg of nitrogen per hectare so as to fulfill plant requirements of nitrogen. Calculate the quantity (in kg) of ammonium sulphate [$(NH_4)_2SO_4$] fertilizer required to meet this demand.

Step 1: Find the percentage of nitrogen in ammonium sulphate [$(NH_4)_2SO_4$].

Molar mass of $(NH_4)_2SO_4 = (14 \times 2) + (1 \times 8) + (32) + (16 \times 4) = 132$ g/mol
Total nitrogen from $(NH_4)_2 = 14 \times 2 = 28$ g
Percentage of nitrogen = $(28/132) \times 100 = 21.2\%$

Step 2: Use the percentage to determine the required mass.

If ammonium sulphate contains 21.2% nitrogen, then:

Mass of $(NH_4)_2SO_4$ needed = (80 × 100) / 21.2 = 377.36 kg

Thus, approximately 377.4 kg of ammonium sulphate is needed per hectare.

12. (a) Define the following terms:

(i) Electrolyte

An electrolyte is a substance that conducts electricity when dissolved in water or molten state due to the presence of free ions. It undergoes chemical decomposition during electrolysis. Examples include sodium chloride (NaCl) solution and sulfuric acid (H_2SO_4).

(ii) Electrochemical equivalent

Electrochemical equivalent (ECE) is the mass of a substance deposited or liberated at an electrode by passing one coulomb of electric charge through an electrolyte. It is given by the formula:

ECE = Mass of substance deposited / Total charge passed

(iii) What is the mass of copper deposited when a current of 2 amperes flows in an electrolyte for one hour?

Solution:

Using Faraday's first law of electrolysis:

Mass (m) = (Z × I × t)

Where:
- Z = Electrochemical equivalent of copper (0.000329 g/C)
- I = Current (2 A)
- t = Time in seconds (1 hour = 3600 s)

m = (0.000329 × 2 × 3600)
m = 2.37 g

Thus, the mass of copper deposited is 2.37 g.

(b) (i) State first Faraday's law of electrolysis.

Faraday's first law of electrolysis states that the mass of a substance deposited or liberated at an electrode is directly proportional to the quantity of electric charge passed through the electrolyte.

Mathematically, it is given as:

$m = Z \times Q$
Where:
- m = Mass of substance deposited
- Z = Electrochemical equivalent
- Q = Total charge passed ($Q = I \times t$)

(ii) How many faradays of electricity are required to liberate one mole of zinc by electrolysis?

Solution:

The electrochemical reaction for the liberation of zinc (Zn) is:

$Zn^{2+} + 2e^{-}$ ---->Zn

From the reaction, 2 moles of electrons (2 Faradays) are required to deposit 1 mole of zinc.

Thus, 2 Faradays are required to liberate one mole of zinc.

(iii) Explain three factors which affect electrolysis.

1. Nature of the electrolyte
   - The type of electrolyte affects the products of electrolysis. Strong electrolytes ionize completely, while weak electrolytes ionize partially, affecting ion movement and deposition.

2. Current strength
   - A higher current increases the number of ions discharged at the electrodes, leading to a greater mass of the deposited substance.

3. Type of electrode
   - The nature of the electrode can influence the electrolysis process. Inert electrodes (such as platinum) do not react, while active electrodes (such as copper or silver) can dissolve into the electrolyte and affect deposition.

(c)(i) What is meant by electroplating?

Electroplating is the process of coating an object with a thin layer of a metal using electrolysis. It is commonly used for decorative purposes or to prevent corrosion. For example, iron objects can be electroplated with chromium to prevent rusting.

(ii) What does the amount of element liberated in electrolysis depend upon?

The amount of element liberated in electrolysis depends on:
1. The amount of electric charge ($Q = I \times t$) passed through the electrolyte

2. The electrochemical equivalent (Z) of the element
3. The valency of the ion being deposited

(iii) Given the following solution

$KAg(CN)_2(aq) \rightleftharpoons K^+(aq) + Ag^+(aq) + 2CN^-(aq)$

What happens when direct current passes through this solution using a pure silver anode?

Solution:

When direct current passes through the solution:

1. At the cathode (negative electrode):
   - Silver ions (Ag^+) gain electrons and are deposited as solid silver:
     $Ag^+ + e^- \rightarrow Ag$ (silver metal deposited)

2. At the anode (positive electrode):
   - The pure silver anode dissolves by releasing silver ions into the solution:
     $Ag \rightarrow Ag^+ + e^-$

3. Overall process:
   - There is no net loss of silver ions in the solution since silver dissolves at the anode and deposits at the cathode. This ensures a continuous supply of silver ions in the electrolyte.

This process is commonly used in silver electroplating.