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: 2003**

Instructions

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

1. (i) The molarity of 5.3 g of Na_2CO_3 in 100 ml of solution is

A. 0.20 M
B. 0.50 M
C. 0.05 M
D. 0.005 M
E. 0.01 M

Molarity (M) = moles of solute / volume in dm^3

Molar mass of Na_2CO_3 = (23 × 2) + 12 + (16 × 3) = 106 g/mol
Moles of Na_2CO_3 = 5.3 g / 106 g/mol = 0.05 mol
Volume of solution = 100 ml = 0.1 dm^3

M = 0.05 mol / 0.1 dm^3
= 0.50 M

Correct answer: B

(ii) Two faradays (2 F) were required to deposit one mole of a metallic element M from an aqueous solution of its salt. If element M has no variable valency, the empirical formula of its phosphate is

A. $M(PO_4)_3$
B. MPO_4
C. $M_3(PO_4)_2$
D. $M_2(PO_4)_3$
E. $M_3(PO_4)$

Since 2 Faradays deposit 1 mole of the element, it means the charge of M is +2. The phosphate ion is PO_4^{3-}, so balancing charges, we get $M_3(PO_4)_2$.

Correct answer: C

(iii) Nitrogen, which constitutes about 79% by volume of the gases in the atmosphere, is a gas which is inert at

A. ordinary conditions, colourless, and has no any positive test
B. all conditions, colourless and has no positive test
C. ordinary conditions, colourless and burns with a blue flame
D. all conditions, colourless and burns with a yellow flame

Nitrogen is an inert gas under ordinary conditions, meaning it does not react easily. It is also colourless and does not have a positive test.

Correct answer: A

(iv) The problem of acid rains is now a reality in industrialized countries. The gases which come from industries into the atmosphere and cause acid rains include

A. nitrogen, carbon dioxide and chlorine
B. nitrogen, carbon monoxide and ammonia
C. chlorine, nitrogen dioxide and sulphur dioxide
D. nitrogen monoxide, carbon dioxide and sulphur dioxide
E. sulphur dioxide, nitrogen and nitrogen monoxide

Acid rain is caused mainly by sulphur dioxide (SO_2) and nitrogen oxides (NO, NO_2), which react with water in the atmosphere to form acidic compounds.

Correct answer: C

(v) Dilute acids when in solution with metals to produce hydrogen except

A. CH_3COOH
B. HCl
C. H_2SO_4
D. H_2CO_3
E. HNO_3

Acetic acid (CH_3COOH) is a weak acid and does not readily react with metals to produce hydrogen gas compared to strong acids like HCl and H_2SO_4.

Correct answer: A

(vi) Which of the following substances increase the biological oxygen demand (BOD) of river water?

A. Heavy metals
B. Radioactive wastes
C. Industrial effluents
D. Nitrogenous fertilizers
E. Polymers

Biological oxygen demand (BOD) increases due to organic pollutants, particularly from industrial effluents, which encourage microbial growth, depleting oxygen in the water.

Correct answer: C

(vii) An iron spoon can be electroplated with copper if the spoon is

A. the anode, platinum the cathode and copper (II) sulphate solution the electrolyte
B. the anode, pure the cathode and copper (II) sulphate solution the electrolyte
C. the anode, copper the cathode and copper (II) sulphate the electrolyte
D. the anode, iron the cathode and copper (II) sulphate solution the electrolyte

In electroplating, the object to be plated (iron spoon) is made the cathode, and the metal (copper) to be deposited is the anode, with a solution of its salt as the electrolyte.

Correct answer: D

(viii) Which of the following warning signs stand for flammable chemicals?

The correct symbol is the flame symbol, which is **B** in the given diagram.

Correct answer: B

(ix) The IUPAC name of H_2SO_4 is

A. sulphuric (IV) acid
B. sulphuric acid
C. sulphuric (V) acid
D. sulphurous acid
E. sulphuric (VI) acid

Sulphuric acid has a +6 oxidation state for sulphur, making its IUPAC name **sulphuric (VI) acid**.

Correct answer: E

(x) The correct chemical equation for the combustion of ethanol is

A. $CH_3CH_2OH + VO_2 \rightarrow CH_3CHO + H_2O$
B. $CH_3CH_2OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$
C. $CH_3CH_3OH + O_2 \rightarrow CH_3COOH + H_2O$
D. $2CO + 3H_2O \rightarrow CO_2 + H_2$
E. $CH_3CH_2OH + 2O_2 \rightarrow 2CO_2 + H_2O + H_2$

The complete combustion of ethanol produces carbon dioxide and water.

Correct answer: B

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

List A

(i) Solvent extraction
(ii) Electrochemical oxidation reaction F
(iii) Producer gas
(iv) Exothermic reaction
(v) Deliquescent substances
(vi) Viscosity
(vii) Graphite
(viii) Biodegradable material
(ix) $KMnO_4$
(x) Dry ice

List B

A. Keeps substances constantly dry
B. Substances which decay easily
C. Substances which conduct electricity
D. Substances which do not decay easily e.g., plastics
E. Bags to absorb liquid oil from groundnuts
F. Esterification
G. Heat absorbed by temperature
H. Favoured by low temperature
I. Used to extract substances from unsaturated solvents
J. NaOH, KOH
K. Use of carbon dioxide gas
L. A method to separate two solvents
M. Neutralization reaction
N. Mixture of carbon monoxide and hydrogen gas
O. Mixture of nitrogen dioxide and nitrogen gas
P. Evaporated liquid carbon dioxide
Q. Nanom
R. $Ca(NO_3)_2$
S. Hydrogenation
T. Nitrogen fixation process

Correct answers

(i) L
(ii) M

(iii) N
(iv) H
(v) A
(vi) E
(vii) C
(viii) B
(ix) R
(x) P

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

(i) Temporary hardness of water
Temporary hardness of water is caused by the presence of dissolved bicarbonate salts, mainly calcium bicarbonate ($Ca(HCO_3)_2$) and magnesium bicarbonate ($Mg(HCO_3)_2$), which can be removed by boiling the water. When boiled, these compounds decompose to form insoluble carbonates.

(ii) Permanent hardness of water
Permanent hardness is caused by the presence of dissolved salts such as calcium sulfate ($CaSO_4$) or magnesium sulfate ($MgSO_4$), which cannot be removed by boiling and require chemical treatment to be removed.

(b) Name a substance which when dissolved in water causes:

(i) Temporary hardness of water
Calcium bicarbonate ($Ca(HCO_3)_2$) causes temporary hardness of water.

(ii) Permanent hardness of water
Calcium sulfate ($CaSO_4$) causes permanent hardness of water.

(c) Explain with the help of one chemical equation in each case how:

(i) Temporary hardness of water can be removed by boiling
When water containing calcium bicarbonate ($Ca(HCO_3)_2$) is boiled, it decomposes to form calcium carbonate ($CaCO_3$), which precipitates out, removing the hardness. The chemical equation is:

$Ca(HCO_3)_2$ (aq) ----> $CaCO_3$ (s) + CO_2 (g) + H_2O (l)
(ii) Permanent hardness of water can be removed by chemical means
Permanent hardness can be removed by adding a substance such as washing soda (sodium carbonate, Na_2CO_3), which precipitates the calcium or magnesium ions as carbonates. The chemical equation is:

$CaSO_4$ (aq) + Na_2CO_3 (aq) ------> $CaCO_3$ (s) + Na_2SO_4 (aq)

(b) (i) Carbon can be used to convert copper (II) oxide to copper as shown in the equation below:

$C + 2CuO \text{ ----> } 2Cu (s) + CO_2 (g)$

What is the function of carbon in this equation?
In this reaction, carbon acts as a reducing agent. It reduces copper (II) oxide (CuO) to copper metal (Cu) by removing oxygen from it. The carbon is oxidized to carbon dioxide (CO_2) in the process.

(ii) Calculate the mass of CuO which can react with 12 g of carbon in the equation given in 5. b (i) above.

From the balanced equation:
$C + 2CuO \text{ -----> } 2Cu + CO_2$

The molar mass of carbon (C) = 12 g/mol
The molar mass of copper (II) oxide (CuO) = 63.5 g/mol (Cu) + 16 g/mol (O) = 79.5 g/mol

From the equation, 1 mole of carbon reacts with 2 moles of CuO. The molar ratio is 1:2, so for 12 g of carbon, the moles of carbon = 12 g / 12 g/mol = 1 mole. Therefore, moles of CuO = 2 × 1 = 2 moles.

Mass of CuO = 2 moles × 79.5 g/mol = 159 g

Therefore, 159 g of CuO will react with 12 g of carbon.

(iii) What is the effect of carbon monoxide in the blood?
Carbon monoxide (CO) binds to hemoglobin in the blood more strongly than oxygen, forming carboxyhemoglobin (COHb). This prevents oxygen from binding to hemoglobin, leading to reduced oxygen transport in the body. Prolonged exposure can cause poisoning, symptoms include dizziness, confusion, headaches, and in extreme cases, death.

4. (a) Use the graph above to answer the following questions:

(i) Which experiment gave the fastest reaction?
Experiment 1 gave the fastest reaction. This is evident from the graph as curve 1 shows the steepest initial increase in the volume of carbon dioxide produced, indicating a higher rate of reaction.

(ii) In which experiment did the pupil use the largest size marble chips?
The largest marble chips were used in experiment 3. Larger marble chips have a smaller surface area, leading to a slower reaction. This is supported by curve 3, which has the slowest rate of increase in carbon dioxide production.

(iii) At what time did experiment 2 produce the largest volume of carbon dioxide?
From the graph, experiment 2 (curve 2) produced the largest volume of carbon dioxide at around 100 seconds. This is the point where the curve levels off, indicating the completion of the reaction.

(iv) What was the volume of carbon dioxide produced at the 30th second in experiment 1?
From the graph, at the 30th second, the volume of carbon dioxide produced in experiment 1 is approximately 30 cm^3.

(v) Why did the volume of carbon dioxide not increase any further after 130 seconds in experiment 3?
The volume of carbon dioxide stopped increasing after 130 seconds in experiment 3 because all the marble chips (calcium carbonate) had reacted completely with the hydrochloric acid. At this point, the limiting reactant had been used up, meaning no more carbon dioxide could be produced.

(b) Answer the following questions, using the above graph or otherwise:

(i) Write a balanced chemical equation for the reaction which took place between marble chips and dilute hydrochloric acid in the three experiments.

$CaCO_3$ (s) + 2HCl (aq) → $CaCl_2$ (aq) + H_2O (l) + CO_2 (g)

(ii) Calculate the mass of marble chips used to produce 50 cm^3 of carbon dioxide in experiment 1.

Step 1: Use the molar volume of gas at standard temperature and pressure (STP), which is 24 dm^3 (24,000 cm^3) per mole.
Step 2: Calculate moles of CO_2 produced.

Moles of CO_2 = volume of CO_2 / molar volume
Moles of CO_2 = 50 cm^3 / 24,000 cm^3
Moles of CO_2 = 0.00208 moles

Step 3: Calculate the mass of $CaCO_3$ used.
Molar mass of $CaCO_3$ = 40 (Ca) + 12 (C) + (16 × 3) (O) = 100 g/mol

Mass = moles × molar mass
Mass of $CaCO_3$ = 0.00208 × 100
Mass of $CaCO_3$ = 0.208 g

(iii) What will happen to the rate of production of carbon dioxide in experiments 1, 2, and 3 if excess 3.00 M hydrochloric acid is used instead of excess 2.00 M hydrochloric acid?

If 3.00 M hydrochloric acid is used instead of 2.00 M hydrochloric acid, the rate of reaction will increase in all three experiments. This is because a higher concentration of acid provides more H^+ ions, leading to a greater frequency of collisions between the acid and the marble chips.

- Experiment 1 (with the smallest marble chips) will experience the most significant increase in reaction rate, as the greater surface area allows for faster reactions.

- Experiment 2 will also see an increase in reaction rate, but not as much as experiment 1.
- Experiment 3 will experience the slowest increase in reaction rate because the larger marble chips limit the available surface area for reaction.

However, the total volume of carbon dioxide produced will remain the same since the amount of marble chips remains unchanged. The only difference will be the speed at which the reaction reaches completion.

5. (a)(i) What is the name given to the different forms of the element which exists in the same physical state?
The different forms of an element that exist in the same physical state are called allotropes. Allotropy occurs when an element can exist in more than one structural form, each with distinct physical and chemical properties.

(ii) Carbon exists in two different forms of the same physical state and one of those carbon forms is represented by structure X below. Give the name of the carbon form with structure X.
Structure X represents diamond, one of the crystalline allotropes of carbon. Diamond has a tetrahedral structure where each carbon atom is bonded to four other carbon atoms in a three-dimensional lattice, making it the hardest known natural material.

(iii) Name the second form of carbon.
The second form of carbon is graphite. Graphite consists of layers of hexagonally arranged carbon atoms, with weak forces between the layers, allowing it to be used as a lubricant and in pencil leads.

(iv) State one property and one use which depends on the property you have stated for each form of carbon.

- Diamond
  - Property: Extremely hard due to its strong covalent bonds in a three-dimensional network.
  - Use: Used in cutting tools, drills, and jewelry.

- Graphite
  - Property: Good conductor of electricity due to the presence of free-moving electrons within its layers.
  - Use: Used in making electrodes, batteries, and lubricants.

(b)(i) Carbon can be used to convert copper (II) oxide to copper as shown in the equation below:

$C(s) + 2CuO(s) \text{----> } 2Cu(s) + CO_2(g)$

What is the function of carbon in this equation?
Carbon acts as a reducing agent in this reaction. It removes oxygen from copper (II) oxide (CuO), reducing it to copper metal (Cu), while itself being oxidized to carbon dioxide (CO_2).

(ii) Calculate the mass of CuO which can react with 12 g of carbon in the equation given in 5. b (i) above.

Step 1: Find the molar masses
- Molar mass of carbon (C) = 12 g/mol
- Molar mass of copper (II) oxide (CuO) = 63.5 (Cu) + 16 (O) = 79.5 g/mol

Step 2: Use the balanced equation
From the equation:
$C + 2CuO \longrightarrow 2Cu + CO_2$

This means 1 mole of carbon (12 g) reacts with 2 moles of CuO (2×79.5 g = 159 g).

Thus, 12 g of carbon reacts with 159 g of CuO.

(iii) What is the effect of carbon monoxide in the blood?
Carbon monoxide (CO) is highly toxic because it binds to hemoglobin in the blood more strongly than oxygen, forming carboxyhemoglobin (COHb). This reduces the ability of hemoglobin to transport oxygen, leading to oxygen deprivation in body tissues. Prolonged exposure can cause dizziness, confusion, difficulty breathing, unconsciousness, and even death in severe cases.

6. (a) (i) Define isomerism.
Isomerism is the phenomenon where two or more compounds have the same molecular formula but different structural arrangements, resulting in different properties.

(ii) Write down the molecular structures and IUPAC names of the isomers whose molecular formula is C_4H_{10}.

- Isomer 1: Butane (n-butane)
  Molecular structure: $CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_3$
  IUPAC name: Butane

- Isomer 2: Isobutane (2-methylpropane)
  Molecular structure: $CH_3\text{-}CH(CH_3)\text{-}CH_3$
  IUPAC name: 2-Methylpropane

(b) Name the homologous series of organic compounds which are represented by the molecular formulae:

(i) C_nH_{2n+2}
Alkanes (saturated hydrocarbons)

(ii) C_nH_{2n}
Alkenes (unsaturated hydrocarbons with one double bond)

(iii) $C_nH_{2n+2}O$
Alcohols (compounds with a hydroxyl group, -OH)

(c) Complete the following equations of chemical reactions and give the IUPAC names of each organic compound which appears in each equation.

(i) $CH_4 + O_2$ -----> $CO_2 + 2H_2O$
This is the complete combustion of methane, forming carbon dioxide and water.
IUPAC name of CH_4: Methane

(ii) $C_2H_4 + Cl_2$ -----> $C_2H_4Cl_2$
This is the addition reaction of ethene (C_2H_4) with chlorine (Cl_2), forming 1,2-dichloroethane.
IUPAC name of C_2H_4: Ethene

(iii) $CaC_2 + 2H_2O$ -----> $C_2H_2 + Ca(OH)_2$
This is the reaction of calcium carbide (CaC_2) with water to produce acetylene (C_2H_2) and calcium hydroxide ($Ca(OH)_2$).
IUPAC name of C_2H_2: Acetylene
7. (a) Identify the substances by using the following information:

(i) A solid is yellow when hot and white when cold
Sulfur (S)

(ii) When water is added to a white powder heat is evolved and the white powder changes to blue crystals
Copper (II) sulfate ($CuSO_4$)

(iii) An aqueous solution of a greenish crystalline sulfate forms a pale-green precipitate with sodium hydroxide solution which turns to brown on standing and when exposed to air
Iron (II) sulfate ($FeSO_4$)

(iv) A colourless gas turns yellow the acidified potassium dichromate paper green
Sulfur dioxide (SO_2)

(v) A colourless gas becomes brown on exposure to air
Nitric oxide (NO)

(b) With the help of chemical equations explain what happens to the following compounds of ammonia when heated in separate test tubes:

(i) A mixture of ammonium chloride and sodium hydroxide solution
Ammonium chloride reacts with sodium hydroxide to form ammonia gas and water.
$NH_4Cl + NaOH$ ----> NH_3 (gas) + H_2O

(ii) Ammonium chloride crystals
Upon heating, ammonium chloride sublimes directly into ammonia gas and hydrogen chloride gas.
NH_4Cl (s) ---> NH_3 (g) + HCl (g)

(iii) Ammonium nitrate crystals
Upon heating, ammonium nitrate decomposes explosively into nitrogen oxide (NO_2), oxygen, and water.
$2NH_4NO_3$ ---> $2N_2 + 4H_2O + O_2$

(iv) Ammonium sulphate crystals
When heated with a base, ammonium sulphate decomposes to form ammonia gas and water.
$(NH_4)_2SO_4 + 2NaOH$ -----> $2NH_3 + Na_2SO_4 + 2H_2O$

(v) Ammonium nitrite crystals
Ammonium nitrite decomposes when heated to release nitrogen gas and water.
NH_4NO_2 -----> $N_2 + 2H_2O$

8. (a) Define the following terms:

(i) Valency
Valency is the measure of the combining capacity of an element, which is determined by the number of electrons an atom of the element can donate, accept, or share to form a chemical bond.

(ii) Molar solution
A molar solution is a solution that contains one mole of solute in one liter (1 dm^3) of solvent.

(b) Metal M has variable valences of values 2 and 3. Write down the formulae of its oxides when its valency is

(i) 2
When the valency of metal M is 2, it forms an oxide with the formula MO. This is because oxygen has a valency of 2, so to balance the charges, we need one M^{2+} ion for every O^{2-} ion.

(ii) 3
When the valency of metal M is 3, it forms an oxide with the formula M_2O_3. This is because oxygen has a valency of 2, so two M^{3+} ions will balance with three O^{2-} ions.

(c) 8.48 g of sodium carbonate crystals were made up to 250 cm^3 of solution. 25 cm^3 of this solution neutralized 30 cm^3 of 0.20 M hydrochloric acid. Calculate the number of moles of water of crystallization in sodium carbonate crystals.

Step 1: Write the neutralization equation for sodium carbonate and hydrochloric acid:

$Na_2CO_3 + 2HCl$ ----> $2NaCl + H_2O + CO_2$

Step 2: Calculate moles of HCl used in neutralization.

Moles of HCl = concentration × volume in liters
Moles of HCl = 0.20 mol/dm³ × (30 cm³ / 1000)
Moles of HCl = 0.20 × 0.030
Moles of HCl = 0.006 mol

Step 3: Calculate moles of Na_2CO_3 required to neutralize the acid.

From the equation, 1 mole of Na_2CO_3 reacts with 2 moles of HCl.
Moles of Na_2CO_3 = 0.006 mol / 2
Moles of Na_2CO_3 = 0.003 mol

Step 4: Calculate the molar mass of Na_2CO_3.

The molar mass of Na_2CO_3 = (2 × 23) + 12 + (3 × 16) = 106 g/mol

Step 5: Calculate the moles of Na_2CO_3 in the original 8.48 g of sodium carbonate.

Moles of Na_2CO_3 = mass / molar mass
Moles of Na_2CO_3 = 8.48 g / 106 g/mol
Moles of Na_2CO_3 = 0.08 mol

Step 6: Calculate the mass of Na_2CO_3 required for 0.003 mol.

Mass of Na_2CO_3 = moles × molar mass
Mass of Na_2CO_3 = 0.003 mol × 106 g/mol
Mass of Na_2CO_3 = 0.318 g

Step 7: Calculate the number of moles of water of crystallization in the sodium carbonate crystals.
Assuming the sodium carbonate crystals contain water of crystallization, we subtract the mass of Na_2CO_3 from the total mass of the crystals (8.48 g). This gives us the mass of the water of crystallization:

Mass of water = 8.48 g - 0.318 g = 8.162 g

Moles of water = mass / molar mass of water
Moles of water = 8.162 g / 18 g/mol
Moles of water = 0.453 mol

Therefore, the number of moles of water of crystallization in sodium carbonate crystals is 0.453 mol.

9. (a) What do letters A, B, C, D, and E represent?

- A: Thistle funnel – used to add acid into the reaction vessel
- B: Delivery tube – transports the chlorine gas to the collection jar

- C: Manganese dioxide or concentrated hydrochloric acid – reactants for the preparation of chlorine gas
- D: Gas jar – used to collect the chlorine gas
- E: Water trough – used to hold the gas jar in position

(b)(i) Why is the gas prepared in the fume-chamber?
Chlorine gas is toxic and has a strong choking smell. It can cause respiratory issues and irritation to the eyes and skin. Therefore, it is prepared in a fume chamber to prevent exposure to harmful fumes and ensure proper ventilation.

(ii) Can the gas be collected over water? Why?
No, chlorine gas cannot be collected over water because it is highly soluble in water. When chlorine gas comes into contact with water, it dissolves and forms hydrochloric acid (HCl) and hypochlorous acid (HClO), making water an unsuitable medium for collection.

(iii) What will happen to a damp blue litmus paper if it is introduced into a gas jar full of chlorine gas?
A damp blue litmus paper will turn red and then get bleached white when exposed to chlorine gas. This happens because chlorine gas dissolves in water to form hydrochloric acid, which turns the litmus paper red. The bleaching effect occurs due to the oxidation properties of chlorine, which breaks down the color pigments in the litmus paper.

(iv) What will happen if a gas jar of hydrogen sulphide is inverted over a gas jar of chlorine such that the two gases get mixed? Write a balanced equation for the reaction which will take place between hydrogen sulphide gas and chlorine gas.
When hydrogen sulphide (H_2S) and chlorine gas (Cl_2) mix, a redox reaction occurs where chlorine oxidizes hydrogen sulphide to form sulfur (S) and hydrochloric acid (HCl). The reaction produces a yellow precipitate of sulfur and acidic fumes of hydrochloric acid.

Balanced chemical equation:

$H_2S + Cl_2 \text{ ---> } 2HCl + S$

(c)(i) List down two uses of chlorine gas.
- Chlorine is used in water treatment to disinfect and kill bacteria, making water safe for drinking.
- It is used in the production of household bleach and disinfectants for cleaning and sanitation purposes.

(ii) Give a balanced chemical equation for the method of preparation of chlorine used in this question.
The preparation of chlorine gas in this setup involves the reaction of manganese dioxide (MnO_2) with concentrated hydrochloric acid (HCl).

Balanced chemical equation:

$MnO_2 + 4HCl \text{ ------> } MnCl_2 + Cl_2 + 2H_2O$

10. (a) Which of the following are isotopes of the same element?

To determine isotopes of the same element, we need to identify atoms that have the same atomic number (proton number) but different mass numbers.

From the given options:

- $^{31}_{16}U$
- $^{30}_{14}V$
- $^{32}_{16}W$
- $^{32}_{17}Y$
- $^{33}_{16}X$
- $^{32}_{15}Z$

The atomic number is the subscript (bottom number), and the mass number is the superscript (top number).

Isotopes are atoms of the same element with the same atomic number but different mass numbers.

Identifying elements with the same atomic number:
- $^{31}_{16}U$, $^{32}_{16}W$, and $^{33}_{16}X$ all have atomic number 16, meaning they belong to the same element (sulfur, S).

Thus, $^{31}_{16}U$, $^{32}_{16}W$, and $^{33}_{16}X$ are isotopes of the same element.

(b) Element Q has 17 electrons and 18 neutrons.
(i) What is the atomic number of element Q?
The atomic number is determined by the number of protons in an atom, and since the number of electrons in a neutral atom is equal to the number of protons, the atomic number of element Q is 17.

(ii) What is the mass number of element Q?
The mass number is the sum of the number of protons and neutrons in the nucleus. Given that element Q has 17 protons and 18 neutrons, the mass number is:
Mass number = protons + neutrons
Mass number = 17 + 18 = 35

(iii) Write down the electronic configuration of element Q.
Since element Q has an atomic number of 17, it is chlorine (Cl). The electronic configuration of chlorine is:
2:8:7
This shows that chlorine has 2 electrons in the first shell, 8 in the second, and 7 in the third shell.

(iv) Which group and period in the periodic table does element Q occupy?
Element Q, chlorine (Cl), has an atomic number of 17.
- Group: Chlorine is in Group 17, which is the halogens group.
- Period: Chlorine is in Period 3, since it is the third element in its period.
11. (a) Give the meaning of the following terms:

(i) Soil pH
Soil pH refers to the measure of how acidic or alkaline the soil is. It is crucial for determining nutrient availability in the soil, as some nutrients are more available in acidic or alkaline conditions. A pH of 7 is neutral, below 7 indicates acidic soil, and above 7 indicates alkaline soil. Soil pH affects microbial activity and influences plant growth. For example, plants such as blueberries thrive in acidic soil, while others like cabbage prefer alkaline soil.

(ii) Liming
Liming is the process of adding lime (such as calcium carbonate or calcium hydroxide) to acidic soils. This helps to neutralize the acidity by raising the soil pH. By reducing the acidity, liming improves the availability of essential nutrients, such as nitrogen, phosphorus, and potassium, making them more accessible to plants. It also encourages beneficial soil microorganisms and improves the overall fertility of the soil.

(iii) Macronutrients
Macronutrients are essential elements required by plants in large quantities for their growth and development. These nutrients include nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S). Each of these plays a specific role in plant health. For example, nitrogen is vital for leaf and stem growth, phosphorus supports root development and flowering, and potassium helps with overall plant vigor and resistance to disease.

(b)(i) Define soil erosion.
Soil erosion is the process where the topsoil, which is rich in nutrients, is removed by wind, water, or human activity. This leads to a loss of fertile land, which can affect agricultural productivity and cause desertification. It also disrupts the water cycle, as eroded soil can clog rivers and lakes, leading to poor water quality. The most common types of erosion are water and wind erosion.

(ii) List down four main causes of soil erosion.
- Deforestation: When trees are removed for timber or agriculture, the soil becomes more vulnerable to erosion because plant roots no longer anchor the soil.
- Overgrazing: When livestock graze too heavily, they remove vegetation that protects the soil from erosion. This is particularly a problem in arid regions.
- Agriculture practices: Tillage, or plowing the soil for planting, can break down the structure of the soil and increase susceptibility to erosion.
- Heavy rainfall or water runoff: Intense rainfall can cause water to flow over the surface, picking up soil particles and washing them away, especially on steep slopes.

(c) List down four advantages of organic manure over artificial fertilizers.
- Organic manure improves the structure of the soil, increasing its ability to retain water and nutrients. This is particularly important in sandy soils, where water retention is poor.
- It increases the organic matter content of the soil, which supports the growth of beneficial soil organisms like earthworms, improving soil health.
- Organic manure provides nutrients slowly, reducing the risk of nutrient leaching or over-fertilization. This leads to more consistent plant growth and reduced environmental pollution.
- It enhances soil fertility over the long term, as the breakdown of organic matter contributes to the formation of humus, which provides essential nutrients for plants.
(d)(i) What is meant by the term "nitrogen fixation"?
Nitrogen fixation is the process by which nitrogen gas (N_2) from the atmosphere is converted into a form that plants can use, such as ammonia (NH_3). This process is carried out by certain bacteria, such as Rhizobium, which live in the root nodules of leguminous plants like peas and beans. These bacteria can "fix" nitrogen by converting atmospheric nitrogen into ammonia, which plants can then absorb and use for growth.
(ii) State two major processes by which atmospheric nitrogen is converted to usable form in the soil.
- Biological nitrogen fixation: This process is carried out by nitrogen-fixing bacteria, which convert nitrogen gas from the atmosphere into ammonia, a form that plants can absorb.
- Industrial nitrogen fixation: The Haber process is an industrial method used to convert atmospheric nitrogen into ammonia, which is then used to make fertilizers.

12. (a) Define the following terms:

(i) Pollution
Pollution is the introduction of harmful substances or contaminants into the environment, which leads to adverse effects on ecosystems, human health, and the planet's resources. Pollution can take many forms, including air pollution, water pollution, soil contamination, and noise pollution. It results from human activities such as industrial emissions, waste disposal, and deforestation.

(ii) Pollutant
A pollutant is any substance or material that causes pollution. Pollutants can be natural, such as volcanic ash, or man-made, such as industrial chemicals or plastic waste. Pollutants can be in the form of solids, liquids, or gases, and their presence in the environment can cause harm to living organisms or disrupt ecological balance.

(b) List down the three main types of pollution.
- Air pollution: The contamination of the air by harmful gases, particulate matter, and toxins from sources like vehicles, industries, and agriculture.
- Water pollution: The contamination of water bodies (rivers, lakes, oceans) by pollutants such as chemicals, sewage, and plastics, which negatively affects aquatic life and water quality.
- Soil pollution: The presence of toxic substances in the soil, often from chemicals, pesticides, or waste disposal, which can harm plant and animal life and degrade the quality of the land.

(c)(i) Define "greenhouse effect"
The greenhouse effect is the process by which certain gases in the Earth's atmosphere trap heat from the sun, preventing it from escaping back into space. This natural process helps to keep the Earth's temperature within a range suitable for life. The gases involved, known as greenhouse gases, include carbon dioxide (CO_2), methane (CH_4), and water vapor (H_2O).

(ii) Why does the increase of the concentration of carbon dioxide gas in the atmosphere result in a large increase in the earth's surface temperature?
An increase in carbon dioxide (CO_2) in the atmosphere enhances the greenhouse effect. CO_2 absorbs and traps more heat radiated from the Earth's surface, preventing it from escaping into space. This trapped heat leads to an overall warming of the Earth's surface, a phenomenon known as global warming.

(iii) What is the function of the ozone layer at the top of the Earth's atmosphere?
The ozone layer serves as a protective shield in the Earth's stratosphere, absorbing and blocking most of the sun's harmful ultraviolet (UV) radiation. This protects living organisms, including humans, from skin cancer, cataracts, and other harmful effects of UV radiation. The ozone layer also helps to regulate the Earth's temperature by controlling the amount of solar radiation that reaches the surface.

(iv) List down any two gases produced by industries that destroy the ozone layer.
- Chlorofluorocarbons (CFCs)
- Halons

Both of these gases contain chlorine or bromine atoms, which break down the ozone molecules in the stratosphere, leading to ozone depletion.