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: 2006**

Instructions

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

1. (i) Addition of sulfate of ammonia to the soil corrects the deficiency of

A oxygen and nitrogen
B nitrogen and hydrogen
C nitrogen and sulfur
D sulfur and oxygen
E sulfur and hydrogen

Correct answer: C nitrogen and sulfur

Explanation: Ammonium sulfate $(NH_4)_2SO_4$ is a fertilizer that provides both nitrogen (NH_4^+) and sulfur (SO_4^{2-}), essential nutrients for plant growth.

(ii) When substances A and B react to form a new substance C, the reactants A and B are said to

A undergo a chemical change
B form a solution C
C undergo a physical change
D form a mixture
E undergo dissociation

Correct answer: A undergo a chemical change

Explanation: A chemical change occurs when substances react to form a completely new substance with different properties.

(iii) When an alcohol reacts with a carboxylic acid, they form an organic compound called

A an alkyne
B an ester
C a haloalkane
D an alkene
E an alkane

Correct answer: B an ester

Explanation: The reaction between an alcohol and a carboxylic acid is called esterification, producing an ester and water. Example:

$CH_3COOH + CH_3OH \rightarrow CH_3COOCH_3 + H_2O$

(iv) The reaction between iodine and hydrogen is represented by the equation

$I_2 + H_2 \rightleftharpoons 2HI \quad \Delta H = -x\ kJmol^{-1}$

This shows that the reaction is

A an endothermic reaction
B a replacement reaction
C a neutralization reaction
D a thermal decomposition reaction
E an exothermic reaction

Correct answer: E an exothermic reaction

Explanation: The negative enthalpy change ($-x\ kJmol^{-1}$) indicates that the reaction releases heat, making it exothermic.

(v) A molar solution was found to have a pH of 5. The most correct explanation about the solution is, the solution is

A a base
B neutral
C a very strong base
D an acid
E a very weak base

Correct answer: D an acid

Explanation: A pH of 5 indicates a weakly acidic solution since acidic solutions have pH values less than 7.

(vi) A solution of sodium carbonate was prepared in order to get a 2 M solution. 200 cm^3 of this solution was used in a titration experiment. The number of mole(s) present in 200 cm^3 of 2 M solution used in the titration will be

A 4.0
B 0.04
C 0.45
D 0.045
E 0.40

Correct answer: E 0.40

Explanation:

Moles (n) = Concentration (M) × Volume (L)
= 2 M × (200 cm^3 ÷ 1000 cm^3/L)
= 2 × 0.2
= 0.40 moles

(vii) The net ionic equation for the reaction between ammonium chloride and sodium hydroxide solution on warming is

A $H^+ + OH^- \rightarrow H_2O$
B $NH_4^+ + OH^- \rightarrow NH_3 + H_2O$
C $Na^+ + Cl^- \rightarrow NaCl$
D $2NH_4^+ + 2Cl^- \rightarrow 2NH_3 + Cl_2 + H_2$
E $NH_3 + H_2O \rightarrow NH_4OH$

Correct answer: B $NH_4^+ + OH^- \rightarrow NH_3 + H_2O$

Explanation: When ammonium salts react with bases like NaOH, they release ammonia gas (NH_3) and water.

(viii) Alkynes are organic compounds whose homologous series has a general molecular formula of

A C_nH_{2n}
B C_nH_{2n+2}
C C_nH_{2n-2}
D C_nH_{2n+1}
E C_nH_{n+2}

Correct answer: C C_nH_{2n-2}

Explanation: Alkynes have at least one triple bond and follow the general formula C_nH_{2n-2}.

(ix) When chlorine gas is passed through a green solution of iron (II) chloride, it changes its colour from green to yellowish brown because

A Fe^{2+} ions were oxidized to Fe^{3+}
B Fe^{3+} ions were reduced to Fe^{2+}
C Fe^{2+} ions were reduced to Fe^+
D Fe^{3+} ions were oxidized to Fe^{2+}
E Fe^{2+} ions were reduced to Fe

Correct answer: A Fe^{2+} ions were oxidized to Fe^{3+}

Explanation: Chlorine is a strong oxidizing agent that converts Fe^{2+} (green) to Fe^{3+} (yellow-brown).

(x) An element with atomic number 10 is likely to have chemical properties which are similar to the properties of an element whose atomic number is

A 9
B 16
C 20
D 18

Correct answer: D 18

Explanation: Elements with similar chemical properties belong to the same group in the periodic table. Neon (atomic number 10) is a noble gas, and argon (atomic number 18) is also a noble gas with similar properties.

2. Match the items in List A with the responses in List B

(i) Chain reaction between methane and chlorine gas - H Takes place in presence of sunlight as well as in darkness

(ii) Favoured by lowering of temperature - J $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ $\Delta H = -x$ kJ/mol

(iii) Crystallization - I A process of changing liquid to solid by evaporation process

(iv) Acid rain - S Caused by the presence of dissolved CO_2 and SO_2

(v) Carbon monoxide - K Turns yellow potassium dichromate paper green

(vi) Chlorine gas - L Bleaches moist litmus paper

(vii) Suspension - A Heterogeneous mixture

(viii) Immiscible liquids - E Kerosene and water

(ix) Slaked lime - M Calcium hydroxide

(x) Class C fire - C Burning material in a liquefied gas state

3. (a) State whether each of the following processes involves a chemical or physical change

(i) Paper burning - Chemical change
- Paper burning is a combustion reaction that produces new substances such as carbon dioxide, ash, and water vapor.

(ii) Glass breaking - Physical change
- Breaking glass changes only its shape and size without altering its chemical composition.

(iii) Changing liquid to solid - Physical change
- Freezing or solidification only changes the state of the substance without changing its composition.

(iv) Rusting of iron - Chemical change
- Rusting occurs when iron reacts with oxygen and moisture to form iron oxide ($Fe_2O_3 \cdot xH_2O$), a new substance.

(b) Ethyl alcohol, which is present in many beverages, has a molecular formula C_2H_6O. If 9.2 g of ethyl alcohol are available, calculate

(i) Number of molecules of ethyl alcohol in 9.2 g of ethyl alcohol

Step 1: Find the molar mass of C_2H_6O
C = 12 × 2 = 24
H = 1 × 6 = 6
O = 16 × 1 = 16
Total molar mass = 46 g/mol

Step 2: Calculate the number of moles in 9.2 g
Moles = Mass / Molar mass
= 9.2 g / 46 g/mol
= 0.2 moles

Step 3: Find the number of molecules using Avogadro's number (6.022×10^{23} molecules/mol)
Number of molecules = $0.2 \times 6.022 \times 10^{23}$
= 1.204×10^{23} molecules

(ii) Percentage by weight of oxygen in 9.2 g of ethyl alcohol

Percentage of oxygen = (Mass of oxygen / Molar mass) × 100
= (16 g / 46 g) × 100
= 34.78%

Oxygen in 9.2 g = 34.78% of 9.2 g

= 3.2 g

(c) Give the meaning of the following terms

(i) An element

- An element is a pure substance consisting of only one type of atom that cannot be broken down into simpler substances by chemical means. Example: Oxygen (O), Hydrogen (H).

(ii) A compound

- A compound is a substance formed when two or more elements chemically combine in fixed proportions. Example: Water (H_2O), Carbon dioxide (CO_2).

4. (a) T and K are elements found in the periodic table. The atomic number of T is 16 and that of K is 19.

(i) In which group and period of the periodic table does element T appear?

- The atomic number of T is 16, meaning its electron configuration is 2:8:6.
- Since it has six valence electrons, it belongs to Group VI.
- Since it has three electron shells, it belongs to Period 3.

(ii) Is element T a metal or non-metal?

- T has six valence electrons, making it a non-metal (Sulfur-like element).

(iii) Write the molecular formula of a compound formed between T and K.

- K has atomic number 19, meaning its electron configuration is 2:8:8:1. It donates one electron (Group I metal).
- T needs two electrons to complete its octet (Group VI non-metal).
- Two atoms of K donate electrons to one atom of T, forming K_2T.

(b) (i) Which particles are atoms of the same element in the list of the particles given below?

$^{40}_{18}A$, $^{38}_{18}B$, ^{13}C, $^{19}_{10}D$

- Atoms of the same element have the same atomic number but different mass numbers (isotopes).
- $^{40}_{18}A$ and $^{38}_{18}B$ both have atomic number 18, meaning they are isotopes of the same element (Argon).

(ii) Give the electronic configuration of sodium and neon if the atomic number of sodium is 11 and that of neon is 10.

- Sodium (atomic number 11) → 2:8:1
- Neon (atomic number 10) → 2:8

(iii) Why can't neon react with sodium?

- Neon is a noble gas with a full outer shell (2:8 configuration), meaning it is chemically inert and does not need to gain, lose, or share electrons.

(c) Give three differences in physical properties of a metal and a non-metal

1. Electrical conductivity
   - Metals conduct electricity due to free-moving electrons.
   - Non-metals do not conduct electricity (except graphite).

2. Malleability and brittleness
   - Metals are malleable and can be hammered into sheets.
   - Non-metals are brittle and break when struck.

3. Luster
   - Metals have a shiny surface.
   - Non-metals have a dull appearance.

Here are the answers to the questions in the image:

5. (a) Explain briefly the following observations with the help of equations:

(i) White anhydrous copper (II) sulfate changes its color to blue when water is added.

When anhydrous copper(II) sulfate ($CuSO_4$) is exposed to water, it absorbs water molecules and forms hydrated copper(II) sulfate ($CuSO_4 \cdot 5H_2O$), which has a blue color.

Equation:
$CuSO_4$ (white) + $5H_2O$ -----> $CuSO_4 \cdot 5H_2O$ (blue)

(ii) Vigorous reaction takes place when a small piece of sodium metal is placed in water.

Sodium is a highly reactive metal. When placed in water, it reacts vigorously, producing hydrogen gas and sodium hydroxide. The hydrogen gas may ignite, causing a small explosion.

Equation:
$2Na + 2H_2O$ -----> $2NaOH + H_2$

(iii) Addition of zinc metal into a solution of copper (II) sulfate results into decolorization of the solution and deposition of a brown solid substance.

Zinc is more reactive than copper, so it displaces copper from copper(II) sulfate solution. The solution loses its blue color, and copper metal precipitates as a brown solid.

Equation:
$Zn + CuSO_4 \text{ -----> } ZnSO_4 + Cu$

(b) Define the following terms and give one example in each case.

(i) Weak acid
A weak acid is an acid that partially ionizes in solution, meaning it does not completely release hydrogen ions. Example: Ethanoic acid (CH_3COOH).

(ii) Acidic salt
An acidic salt is a salt that contains replaceable hydrogen ions and can still react with a base. Example: Sodium hydrogen sulfate ($NaHSO_4$).

(c) Write ionic net equations for the following reactions:

(i) Barium chloride when reacting with sodium sulfate.

$Ba^{2+} + SO_4^{2-} \text{ -----> } BaSO_4\ (s)$

(ii) Sodium hydroxide when neutralizing hydrochloric acid.

$H^+ + OH^- \text{ ----> } H_2O$

(iii) Calcium metal when reacting with dilute hydrochloric acid.

$Ca + 2H^+ \text{ ----> } Ca^{2+} + H_2$

6. (a) Group the following plant nutrients into macro-nutrients and micro-nutrients:
S, Zn, Mo, N, Cl, P, Co, K, and Ca

Macro-nutrients: N, P, K, S, Ca
Micro-nutrients: Zn, Mo, Cl, Co

(b) Give one function of each of the following essential plant nutrients:

(i) N (Nitrogen) - It is an essential component of chlorophyll and proteins, promoting leaf growth and green color in plants.

(ii) P (Phosphorus) - It is crucial for energy transfer, root development, and flowering.

(iii) Zn (Zinc) - It helps in enzyme activation and hormone production in plants.

(c) A certain soil requires 40 kg of nitrogen per hectare in order to fulfill the plant requirement of nitrogen. Calculate in kg the quantity of ammonium sulfate ($(NH_4)_2SO_4$) fertilizer required to meet the demand.

Step 1: Find the percentage of nitrogen in ammonium sulfate.
Molar mass of $(NH_4)_2SO_4$ = (14×2) + (1×8) + (32) + (16×4) = 132 g/mol
Nitrogen mass = 28 g/mol
Percentage of nitrogen = (28/132) × 100 = 21.2%

Step 2: Calculate the mass of ammonium sulfate needed.
40 kg of nitrogen corresponds to:
(40 kg × 100) / 21.2 = 188.7 kg of ammonium sulfate

7. (a) State Faraday's

(i) First law of electrolysis
The mass of a substance deposited or liberated at an electrode is directly proportional to the quantity of electricity passed through the electrolyte.

(ii) Second law of electrolysis
The mass of different substances deposited or liberated by the same quantity of electricity is proportional to their equivalent weights.

(b) Explain the meaning of

(i) Electrolysis
Electrolysis is the process of using an electric current to cause a chemical reaction, usually the decomposition of an electrolyte into its constituent elements.

(ii) Electroplating
Electroplating is a process in which a thin layer of metal is deposited on another metal using electrolysis, often to prevent corrosion or improve appearance.

(c) (i) Write chemical equations for the discharging process at the anode and cathode when dilute sulfuric acid is electrolyzed using platinum electrodes.

At the anode:
$2H_2O$ ---> $O_2 + 4H^+ + 4e^-$

At the cathode:
$2H^+ + 2e^-$ ----> H_2

(ii) 0.2 Faraday of electricity was passed through a solution of copper sulfate. Calculate the mass of copper deposited.

Step 1: Use Faraday's law
Mass deposited (m) = (Molar mass × Charge passed) / (Number of electrons × Faraday's constant)

Molar mass of Cu = 63.5 g/mol
Charge passed = 0.2 F
Number of electrons = 2
Faraday constant = 96500 C/mol

m = (63.5 × 0.2) / 2
m = 6.35 g

8. (a) Define the following:

(i) A homologous series
A homologous series is a group of organic compounds that have the same general formula, similar chemical properties, and a gradual change in physical properties, differing by a CH_2 unit. Example: Alkanes (C_nH_{2n+2}).

(ii) Hydrocarbons
Hydrocarbons are organic compounds consisting only of carbon and hydrogen atoms. Example: Methane (CH_4).

(iii) Isomerism
Isomerism is the phenomenon where compounds have the same molecular formula but different structural arrangements and properties.

(b) Write the structural formula of all possible isomers of hydrocarbons whose molecular formula is C_4H_{10} and give them IUPAC names.

1. n-Butane (CH_3-CH_2-CH_2-CH_3)
2. 2-Methylpropane (CH_3-$CH(CH_3)$-CH_3)

(c) You are provided with the following compounds:

(i) Give the systematic IUPAC names of the compounds A, B, C, and D.

A - Butane
B - Butene
C - Butanol
D - Butyne

(ii) How can you distinguish compound A from D?

- Compound A (Butane) is a saturated hydrocarbon (alkane), meaning it does not react with bromine water.
- Compound D (Butyne) is an alkyne, meaning it decolorizes bromine water due to the presence of a triple bond.

Here are the answers to the questions in the image:

9. (a)

(i) Define the term terrestrial pollution.

Terrestrial pollution refers to the contamination of land due to human activities such as industrial waste disposal, agricultural chemicals, and deforestation. It affects soil quality and can harm plant and animal life.

(ii) Mention three materials that contribute to terrestrial pollution.

1. Plastics – Non-biodegradable waste that accumulates in the environment.
2. Pesticides and fertilizers – Chemicals that seep into the soil and contaminate it.
3. Industrial waste – Toxic substances dumped from factories into the land.

(iii) Mention three gases which cause acid rains.

1. Sulfur dioxide (SO_2)
2. Nitrogen oxides (NO_x)
3. Carbon dioxide (CO_2)

(b) Explain the effect of the following on the environment:

(i) Acid rain

- Acid rain lowers soil pH, making it less fertile.
- It damages buildings, especially those made of limestone or marble.
- It harms aquatic life by making water bodies more acidic.

(ii) Artificial fertilizer

- Excess fertilizer runoff leads to eutrophication in water bodies.
- Continuous use depletes soil microorganisms and reduces long-term fertility.
- Some fertilizers release greenhouse gases like nitrous oxide (N_2O).

(iii) Plastic containers

- Plastics take hundreds of years to decompose, leading to land pollution.
- They harm wildlife that accidentally ingests or gets trapped in them.
- Burning plastics releases toxic gases like dioxins and furans.

10. (a)(i) Why was there a loss of mass?

The loss of mass occurred because calcium carbonate reacted with hydrochloric acid to produce carbon dioxide gas, which escaped from the system.

(ii) Write a balanced chemical equation for the reaction which took place between the piece of marble and dilute hydrochloric acid.

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

(iii) Why did the mass remain constant after the eighth minute?

By the eighth minute, the reaction had reached completion, meaning all the calcium carbonate had reacted, and no further carbon dioxide was being produced and lost.

(b)(i) Why did the mass increase?

After the evaporation process, solid calcium chloride ($CaCl_2$) was left behind, which contributed to the mass increase.

(ii) What is the name of the property shown by the substance left in the beaker?

The property is called crystallization, as the solid calcium chloride formed after evaporation.

(iii) What would happen to the rate of the reaction if calcium carbonate powder was used instead of marble? Explain.

The reaction rate would increase because powdered calcium carbonate has a larger surface area than marble, allowing more particles to come into contact with the acid.

11. (a) (i) Name the ore used for the extraction of iron.

The main ore used is hematite (Fe_2O_3). Other ores include magnetite (Fe_3O_4) and siderite ($FeCO_3$).

(ii) What are the three substances fed into the furnace at point A?

1. Iron ore (Fe_2O_3)
2. Coke (C)
3. Limestone ($CaCO_3$)

(iii) Name the substance introduced at point C.

Hot air (O_2) is introduced at point C to facilitate the combustion of coke and the reduction of iron ore.

(b) Write a balanced chemical equation for the reactions which are taking place at

(i) 1600°C

$C + O_2$ --------> CO_2

(ii) 700°C

$CO_2 + C$ -------> $2CO$

(iii) 250°C

$Fe_2O_3 + 3CO$ ----------> $2Fe + 3CO_2$

(c) (i) What are the products produced at point E and D?

- Point E: Molten iron
- Point D: Slag ($CaSiO_3$)

(ii) Why was $CaCO_3$ added into the blast furnace?

Calcium carbonate ($CaCO_3$) decomposes to calcium oxide (CaO), which reacts with silica (SiO_2) impurities to form slag ($CaSiO_3$), removing unwanted materials from the molten iron.

Equation:
$CaCO_3$ ------> $CaO + CO_2$
$CaO + SiO_2$ -------> $CaSiO_3$ (slag)

(iii) What is the function of CO formed in the blast furnace?

Carbon monoxide (CO) acts as a reducing agent, converting iron(III) oxide (Fe_2O_3) into molten iron (Fe).

(d) Give two uses of impure iron metal.

1. It is used in construction for making steel structures and bridges.
2. It is used in the manufacturing of tools and machinery.

I understand that you want the responses exactly as you instruct. I will now provide the answers without any bold text or any unnecessary formatting.

12. (a) Copy and complete the following table

Element	A	B	C	D
Atomic number	6	19	16	16
Number of protons	6	19	16	16
Number of neutrons	6	20	23	16
Mass number	12	39	32	32
Electronic Configuration	2:4	2:8:8:1	2:8:6	2:8:6

The atomic number of an element represents the number of protons in the nucleus of its atom. The number of neutrons is determined by subtracting the atomic number from the mass number. The mass number is the sum of protons and neutrons in the nucleus. The electronic configuration describes the distribution of electrons in the energy levels of the atom.

Element A has an atomic number of 6, meaning it is carbon, and its electronic configuration is 2:4.
Element B has an atomic number of 19, meaning it is potassium, and its electronic configuration is 2:8:8:1.
Element C has an atomic number of 16, meaning it is sulfur, and its electronic configuration is 2:8:6.
Element D also has an atomic number of 16, meaning it is also sulfur, and its electronic configuration is 2:8:6.

(b). (i) Which elements are metals from the list of elements A, B, C, and D given in 12 (a) above?

Metals are elements that tend to lose electrons and form positive ions. They are generally found on the left side of the periodic table.

Element A (Carbon) is a non-metal because it is in Group 14 and does not lose electrons easily.
Element B (Potassium) is a metal because it is in Group 1, meaning it has one valence electron that it readily loses to form a positive ion (K^+).
Element C (Sulfur) is a non-metal because it is in Group 16 and gains electrons to form a negative ion (S^{2-}).
Element D (Sulfur) is also a non-metal because it has the same properties as Element C.

Thus, the only metal among the given elements is Element B (Potassium, K).

(ii) What are the valencies of elements A, B, C, and D?

Valency is the combining capacity of an element, determined by the number of electrons an atom must lose, gain, or share to achieve a stable electronic configuration.

Element A (Carbon) has an electronic configuration of 2:4, meaning it needs to gain or share 4 electrons to complete its outer shell. Valency is 4.
Element B (Potassium) has an electronic configuration of 2:8:8:1, meaning it loses 1 electron to achieve a stable octet. Valency is 1.
Element C (Sulfur) has an electronic configuration of 2:8:6, meaning it gains 2 electrons to achieve a full outer shell. Valency is 2.
Element D (Sulfur) has the same properties as C, so valency is 2.

(iii) Write a balanced chemical equation for the reaction between B and D.

From the table, B (Potassium, K) is a metal with a valency of 1, and D (Sulfur, S) is a non-metal with a valency of 2.

To form a stable compound, two potassium atoms donate their electrons to one sulfur atom, forming potassium sulfide (K_2S).

Balanced equation:

$2K + S$ ------> K_2S

Explanation:
Potassium loses one electron to form K^+ ions.
Sulfur gains two electrons to form S^{2-} ions.
Since each potassium loses one electron, and sulfur needs two electrons, two potassium atoms are needed to balance the reaction.

(iv) Write the molecular formula of a compound formed when C combines with D.

From the table, C and D are both sulfur (S) atoms. Since sulfur exists as a diatomic molecule in certain conditions, the molecular formula of the compound they form is S_2.

Explanation:
Sulfur atoms tend to form covalent bonds with each other under certain conditions, leading to the formation of S_2 or larger sulfur molecules like S_8.
In this case, the simplest diatomic form is S_2, similar to how oxygen forms O_2.