

Some Basic Concepts of Chemistry — Assignment 2

Class 11 Chemistry · Higher-difficulty challenge set + integrated problems · Answer key included · Narayan Gurukul Academy

Instructions: (1) Attempt all questions; start with the topic-wise challenge set, then attempt the integrated (multi-topic) problems.
(2) Give all answers with correct SI units. $g = 10 \text{ m/s}^2$ unless stated.
(3) A final answer key is provided at the end — try the full set before checking it.

Part A — Topic-wise challenge questions

Laws of Chemical Combination

1. State the law of multiple proportions and illustrate it with an example.
2. State Gay-Lussac's law of gaseous volumes with an example.
3. State the law of definite proportions.

Atomic and Molecular Mass, Avogadro's Number

1. Define atomic mass, molecular mass and molar mass.
2. Calculate the number of moles in 22 g of CO_2 .
3. State the relation between the mole and Avogadro's number.

Stoichiometry and the Mole

1. Define mole and state the molar volume of a gas at STP.
2. Calculate the number of moles in 5.6 L of nitrogen at STP.
3. Calculate the number of molecules in 100 g of water.

Percentage Composition, Empirical and Molecular Formulas

1. Calculate the percentage composition of carbon dioxide.
2. A compound has empirical formula CH_2O and molar mass 180 g/mol. Find its molecular formula.
3. Determine the empirical formula of a compound with 40% C, 6.7% H and 53.3% O.

Stoichiometric Calculations and Limiting Reagent

1. Define limiting reagent and give an example.
2. Calculate the mass of water formed when 4 g of H_2 reacts with excess O_2 .
3. In $\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$, find the limiting reagent when 28 g N_2 reacts with 6 g H_2 .

Concentration Terms

1. Define molarity and molality and state how they differ.
2. Calculate the molarity of a solution containing 5.85 g NaCl in 500 mL.
3. Calculate the mole fraction of ethanol and water in 46 g ethanol + 180 g water.

Part B — Integrated problems (multi-topic)

1. Calculate the number of moles and molecules in 22 g of carbon dioxide.
2. A compound contains 40% carbon, 6.7% hydrogen and 53.3% oxygen by mass. Determine its empirical formula.
3. Calculate the mass of sodium carbonate required to prepare 250 mL of a 0.1 M solution. (Molar mass of $\text{Na}_2\text{CO}_3 = 106 \text{ g/mol}$)
4. In the reaction $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$, 6 g of H_2 reacts with 32 g of O_2 . Identify the limiting reagent and calculate the mass of water formed.
5. Calculate the molarity of a solution prepared by dissolving 4 g of NaOH in enough water to make 250 mL of solution.

Answer Key**Laws of Chemical Combination**

Law of multiple proportions: masses of one element combining with a fixed mass of another are in small whole-number ratios (e.g. CO and CO_2). Gay-Lussac: gases react in simple whole-number volume ratios. Law of definite proportions: a compound has fixed composition by mass.

Atomic and Molecular Mass, Avogadro's Number

$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$; molar mass = mass of 1 mole. Moles = mass/molar mass. $22 \text{ g CO}_2 = 0.5 \text{ mol}$.

Stoichiometry and the Mole

1 mole = 6.022×10^{23} particles = molar mass = 22.4 L gas at STP. $5.6 \text{ L N}_2 = 0.25 \text{ mol}$; $100 \text{ g water} = 5.56 \text{ mol} = 3.34 \times 10^{24}$ molecules.

Percentage Composition, Empirical and Molecular Formulas

Percentage = (mass of element / molar mass) $\times 100$. CO_2 : 27.27% C, 72.73% O. CH_2O with $M = 180$ gives $\text{C}_6\text{H}_{12}\text{O}_6$. 40:6.7:53.3 gives CH_2O .

Stoichiometric Calculations and Limiting Reagent

Limiting reagent is completely consumed and decides product mass. 4 g H_2 gives 36 g H_2O . In $\text{N}_2 + 3\text{H}_2$: H_2 is limiting, giving 34 g NH_3 .

Concentration Terms

Molarity = moles/litre of solution; molality = moles/kg solvent; mass% per 100 g solution; mole fraction = moles/total moles. 5.85 g NaCl in 500 mL = 0.2 M.

Integrated problems

1: $22/44 = 0.5 \text{ mol}$; 3.011×10^{23} molecules. 2: moles C:H:O = $40/12 : 6.7/1 : 53.3/16 = 3.33:6.7:3.33 = 1:2:1$, so CH_2O . 3: $250 \text{ mL} \times 0.1 \text{ M} = 0.025 \text{ mol} \times 106 = 2.65 \text{ g}$. 4: H_2 (3 mol) needs 1.5 mol O_2 but 1 mol O_2 given, so O_2 is limiting; 2 mol $\text{H}_2\text{O} = 36 \text{ g}$. 5: $4/40 = 0.1 \text{ mol}$ in 0.25 L = 0.4 M.