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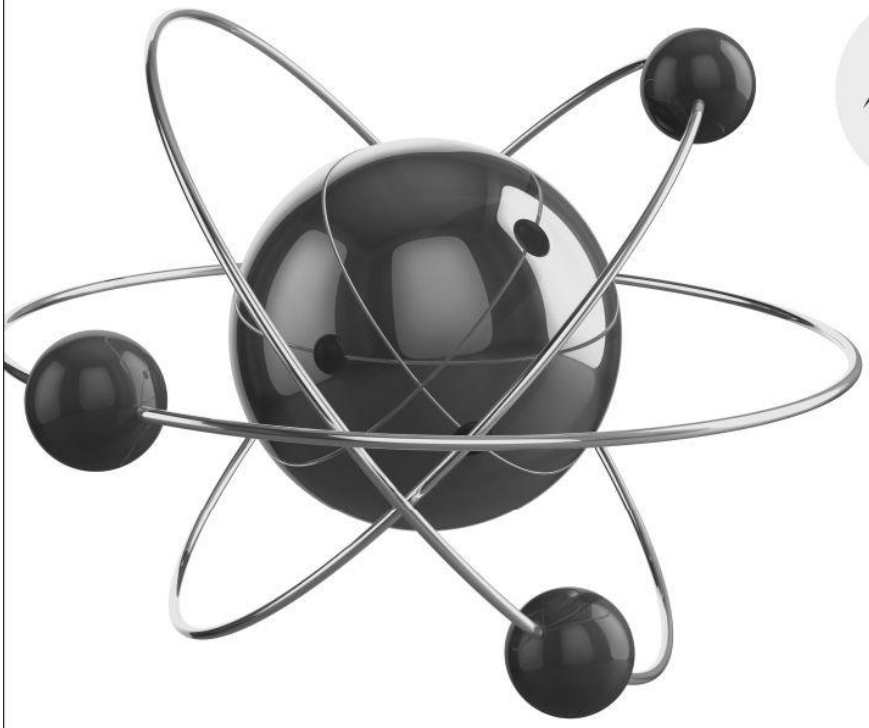

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Contents

CHAPTER 1

SOME BASIC CONCEPTS OF CHEMISTRY

KEY CONCEPTS

1. **Significant Figure :** Significant figures are total number of digits in any number including the last digits whose value is uncertain.

Rules for Determining Significant Figure :

(i) All non-zero digits are significant.

(ii) Zeros to the left of the first non-zero digit in the number are not significant.

(iii) Zeros between non-zero digits are significant.

(iv) Zeros to the right of the decimal point are significant.

(v) If a number ends in zeros that are not to right of a decimal, the zeros may or may not be significant.

Rounding off :

(i) If the digit to be retained is less than five, the last digit is left unchanged.

(ii) If the digit following the last digit to be retained is more than five, the last digit retained is increased by one.

(iii) If the digit following the last digit to be retained is equal to five, the last digit is left unchanged if it is even and is increased by one if it is odd.

2. **Laws of Chemical Combination**

(i) **The law of conservation of mass (Lavoiser) :** This law states that "matter can neither be created nor destroyed, or in a chemical reaction, the mass of the reactants is equal to the mass of the products".

(ii) **The law of constant composition or definite proportion (Proust):**
This law states that "All pure samples of the same chemical compound contain the same elements combined in the same proportion by mass".

(iii) **The law of multiple proportion (John Dalton) :**
This law states that "When two elements A and B combine together to form more than one compound, then several masses of A which separately combine with a fixed mass of B, are in a simple ratio."

(iv) **The law of Reciprocal Proportions (Richter) :**
This law states that "When two elements combines separately with third element and form different types of molecules, their combining ratio is directly reciproated if they combine directly".

(v) **The Law of Gaseous Volume (Gaylussac) :**
This law states that "Whenever gases react together, the volumes of the reacting gases as well as the products if they are gases, bear a simple whole number ratio, provided all the volumes are measured under similar conditions of temperature & pressure.

3. **Avogadro Hypothesis :** Equal volumes of all gases under similar conditions of temperature and pressure contain equal number of molecules.

4. **Dalton's Atomic Theory :** Proposed by **John Dalton** in 1808. Main points are :

(i) Matter is made up, by indivisible particles called atoms.

(ii) Atoms of same elements are identical in physical and chemical properties.

(iii) Atoms of different substances are different in every respect.

(iv) Atoms always combine in whole numbers to form compounds.

(v) Atoms of resultant compounds possess similar properties.

5. **Atomic and Molecular Masses**

Atomic Mass : It is the number of times an atom of an element, which is heavier than 1/12 th of an atom of C–12.

Atomic weight of an element

$$= \frac{\text{Weight of 1 atom of element}}{1/12 \times \text{Weight of 1 atom of C-12}}$$

Molecular weight : It is the number of times a molecule of any compound is heavier than 1/12th of an atom of C–12.

Molecular weight

$$= \frac{\text{Weight of one molecule}}{1/12 \times \text{Weight of one C-12 atom}}$$

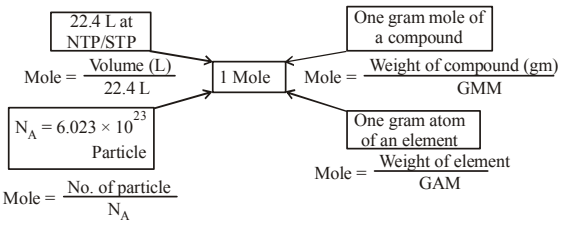
6. Chemical Formula : It is of two types :

(i) Molecular formulae : Chemical formulae that indicate the actual number and type of atoms in a molecule is called molecular formulae.

(ii) Empirical formulae : Chemical formulae that indicate only the relative number of atoms of each type in a molecule is called empirical formulae.

7. Mole concept

Mole : Mole is a unit which represent 6.023×10^{23} particles of same nature.



8. Chemical reaction & mole concept : The ratio between reactant and product molecules is same to the ratio of their moles and volumes (gaseous substance) at NTP in a balanced chemical equation.

9. Limiting Reagent : It may be defined as the reactant which is completely consumed during the reaction is called limiting reagent.

10. Equivalent weight

(i) Equivalent weight of element

$$= \frac{\text{Atomic weight of element}}{\text{Valency of element}}$$

(ii) Eq. wt of an acid/base

$$= \frac{\text{Molecular mass}}{\text{Basicity of acid} \mid \text{Acidity of base}}$$

(iii) Eq. wt of salts

$$= \frac{\text{Formula mass}}{(\text{Valency of cation})(\text{No. of cations})}$$

11. Expression of Strength /Concentration of Solution

(i) Mass percent $= \frac{\text{Weight of solute (gm)}}{\text{Weight of solution (gm)}} \times 100$

(ii) Normality

$$= \frac{\text{Number of gram equivalents of solute}}{\text{Volume of solution (lit.)}}$$

(iii) Molarity $= \frac{\text{Number of gram moles of solute}}{\text{volume of solution (lit.)}}$

(iv) Molality $= \frac{\text{Gram moles of solute}}{\text{Weight of solvent (kg)}}$

(v) Mole fraction :

Mole fraction of solute $= X_A$

$$= \frac{n_A}{n_A + n_B}$$

Mole fraction of solvent $= X_B = \frac{n_B}{n_A + n_B}$

$$X_A + X_B = 1$$

12. Chemical Stoichiometry

The method described for determining atomic and molecular masses constitute the beginning of a general approach to chemical calculations and quantitative methods called chemical stoichiometry.

Stoichiometry calculations. The following steps are generally followed for carrying out such calculations :

(i) Write the balanced chemical equation.

(ii) Write the molar relationship from the equation between the given and the required species.

(iii) Convert these moles into the desired parameters such as mass, volume, etc.

(iv) Apply unitary method to calculate the result.

TEXTBOOK SOLUTIONS

1.1 Calculate the molecular mass of the following : (i) H_2O (ii) CO_2 (iii) CH_4

Ans. (i) Molecular mass of H_2O =
$2(1.008 \text{ amu}) + 16.00 \text{ amu}$
$= 18.016 \text{ amu.}$

(ii) Molecular mass of CO_2 =
$12.01 \text{ amu} + 2 \times 16.00 \text{ amu}$
$= 44.01 \text{ amu.}$

(iii) Molecular mass of CH_4 =
$12.01 \text{ amu} + 4\ (1.008 \text{ amu})$
$= 16.042 \text{ amu.}$

1.2 Calculate the mass per cent of different elements present in sodium sulphate (Na_2SO_4).

Ans. Mass % of an element

$$= \frac{\text{Mass of that element in the compound}}{\text{Molar mass of the compound}} \times 100$$

Now, molar mass of
$Na_2SO_4 = 2(23.0) + 32.0 + 4 \times 16.0 = 142 \text{ g mol}^{-1}$

$$\text{Mass percent of sodium} = \frac{46}{142} \times 100 = 32.39\%$$

$$\text{Mass percent of sulphur} = \frac{32}{142} \times 100 = 22.54\%$$

$$\text{Mass percent of oxygen} = \frac{64}{142} \times 100 = 45.07\%$$

1.3 Determine the empirical formula of an oxide of iron which has 69.9% iron and 30.1% dioxygen by mass.

Ans.

Element	Symbol	% by mass	Atomic mass	Moles of the element	Simplest molar ratio	Simplest whole number molar ratio
Iron	Fe	69.9	55.85	$\frac{69.9}{55.85} = 1.25$	$\frac{1.25}{1.25} = 1$	2
Oxygen	O	30.1	16.0	$\frac{30.1}{16.0} = 1.88$	$\frac{1.88}{1.25} = 1.5$	3

$\therefore$ Empirical formula $= Fe_2O_3$.

1.4 Calculate the amount of carbon dioxide that could be produced when

(i) 1 mole of carbon is burnt in air.

(ii) 1 mole of carbon is burnt in 16 g of dioxygen.

(iii) 2 moles of carbon are burnt in 16 g of dioxygen.

Ans. The balanced equation for the combustion of carbon in dioxygen/air is

$$C(s) + O_2(g) \longrightarrow CO_2(g)$$

1 mole (12 g) + 1 mole (32 g) → 1 mole (44 g)

(i) In air, combustion is complete. Therefore, CO_2 produced from the combustion of 1 mole of carbon = 44g.

(ii) As only 16 g of dioxygen is available, it can combine only with 0.5 mole of carbon, i.e., dioxygen is the limiting reactant. Hence, CO_2 produced = 22 g.

(iii) Here again, dioxygen is the limiting reactant. 16 g of dioxygen can combine only with 0.5 mole of carbon. CO_2 produced again is equal to 22 g.

1.5 Calculate the mass of sodium acetate (CH_3COONa) required to make 500 mL of 0.375 molar aqueous solution. Molar mass of sodium acetate is 82.0245 g mol^{-1}.

Ans. 0.375 M aqueous solution means that 1000 mL of solution contain sodium acetate = 0.375 mole.

500 mL of the solution should contain sodium acetate = 0.375/2 mole

Molar mass of sodium acetate = 82.0245 g mol^{-1}

Mass of sodium acetate required = 0.375/2 mole × 82.0245 g mol^{-1} = 15.380 g.

1.6 Calculate the concentration of nitric acid in moles per litre in a sample which has a density, 1.41 g mL^{-1} and the mass per cent of nitric acid in it being 69%.

Ans. Mass percent of 69% means that 100 g of nitric acid solution contain 69 g of nitric acid by mass.

Molar mass of nitric acid (HNO_3) = 1 + 14 + 48 = 63 g mol^{-1}

Moles in 69g of HNO_3 = 69/63 = 1.095 mole

Volume of 100 g nitric acid solution =100/1.41 = 70.92 mL = 0.07092 L

Conc. of HNO_3 in moles per litre

= 1.095 / 0.0792 L = 13.83 M

1.7 How much copper can be obtained from 100 g of copper sulphate ($CuSO_4$) ?

Ans. One mole of $CuSO_4$ contains 1 mole (1 g atom) of Cu Molar mass of $CuSO_4$ = 63.5 + 32 + 4×16 = 159.5 g mol^{-1}.

Thus, Cu that can be obtained from 159.5 g of $CuSO_4$ = 63.5 g

Cu that can be obtained from 100 g of $CuSO_4$

$$= \frac{63.5}{159.5} \times 100\text{ g} = 39.81\text{ g}$$

1.8 Determine the molecular formula of an oxide of iron in which the mass per cent of iron and oxygen are 69.9 and 30.1 respectively.

Ans. Calculation of Empirical Formula. See Q. 3.

Empirical formula mass of Fe_2O_3

$= 2 \times 55.85 + 3 \times 16.00 = 159.7\text{ g mol}^{-1}$

$$n = \frac{\text{Molar mass}}{\text{Empirical formula mass}} = \frac{159.8}{159.7} = 1$$

Hence, molecular formula is same as empirical formula, viz., Fe_2O_3.

1.9 Calculate the atomic mass (average) of chlorine using the following data :

	% Natural Abundance	Molar Mass
^{35}Cl	75.77	34.9689
^{37}Cl	24.23	36.9659

Ans. Fractional abundance of ^{35}Cl = 0.7577,

Molar mass = 34.9689

Fractional abundance of ^{37}Cl = 0.2423,

Molar mass = 36.9659

Average atomic mass

= (0.7577) (34.9689 amu) + (0.2423) (36.9659 amu)

= 26.4959 + 8.9568 = 35.4527

1.10 In three moles of ethane (C_2H_6), calculate the following :

(i) Number of moles of carbon atoms.

(ii) Number of moles of hydrogen atoms.

(iii) Number of molecules of ethane.

Ans. (i) 1 mole of C_2H_6 contains 2 moles of carbon atoms. Hence 3 moles of C_2H_6 will contain C–atoms = 6 moles.

(ii) 1 mole of C_2H_6 contains 6 moles of hydrogen atoms. Hence 3 moles of C_2H_6 will contain H–atoms = 18 moles.

(iii) 1 mole of C_2H_6 contains 6.02×10^{23} molecules. Hence 3 moles of C_2H_6 will contain ethane molecules = $3 \times 6.02 \times 10^{23}$ = 18.06×10^{23} molecules.

1.11 What is the concentration of sugar ($C_{12}H_{22}O_{11}$) in mol L^{-1} if its 20 g are dissolved in enough water to make a final volume up to 2L?

Ans. Molar mass of sugar ($C_{12}H_{22}O_{11}$)

= 12×12 + 22 × 1 + 11 × 16 = 342 g mol^{-1}

No. of moles in 20 g of sugar

$$= \frac{20\text{g}}{342\text{g mol}^{-1}} = 0.0585\text{ mole}$$

Molar concentration

$$= \frac{\text{Moles of solute}}{\text{Volume of solution}} = \frac{0.0585}{2} = 0.0293\text{ M}$$

1.12 If the density of methanol is 0.793 kg L^{-1}, what is its volume needed for making 2.5 L of its 0.25 M solution?

Ans. Molar mass of methanol (CH_3OH) = 32 g mol^{-1}

= 0.032 kg mol^{-1}

As Molarity = $\frac{\text{mass of solute}}{\text{molar mass of solute} \times \text{volume of solution}}$

We can write molarity = $\frac{\text{density of solution}}{\text{molar mass of solute}}$

Thus the molarity of the given solution will be

$$\frac{0.793\,\text{kg L}^{-1}}{0.032\,\text{kg mol}^{-1}} = 24.78\,\text{mol L}^{-1}$$

Applying $\underset{\text{(Given solution)}}{M_1} \times V_1 = \underset{\text{(Solution to be prepared)}}{M_2} \times V_2$

$24.78 \times V_1 = 0.25 \times 2.5\,\text{L}$

or $V_1 = 0.02522\,\text{L} = 25.22\text{mL}$

1.13 Pressure is determined as force per unit area of the surface. The SI unit of pressure, pascal is as shown below :

1Pa = 1N m^{-2}

If mass of air at sea level is 1034 g cm^{-2}, calculate the pressure in pascal.

Ans. Pressure is the force (i.e., weight) acting per unit area

But weight = mg

Pressure = Weight per unit area

$= 1034\,\text{g} \times 9.8\,\text{ms}^{-2}/\text{cm}^2$

$$= \frac{1034\text{g} \times 9.8\text{ms}^{-2}}{\text{cm}^2} \times \frac{1\text{kg} \times 100\text{cm} \times 100\text{cm}}{1000\text{g}}$$

$$\times \frac{1\text{N}}{1\text{m} \times 1\text{m}} \times \frac{1\text{Pa}}{\text{kg m s}^{-2}} = 1.01332 \times 10^5\,\text{Nm}^{-2}$$

$= 1.01332 \times 10^5$ Pa

1.14 What is the SI unit of mass? How is it defined?

Ans. S.I. unit of mass is kilogram (kg). It is equal to the mass of the international prototype of the kilogram. It is defined as the mass of platinum–iridium cylinder that is stored in air–tight jar at International Bureau of Weights and Measures in France.

1.15 Match the following prefixes with their multiples:

	Prefixes	Multiples
(i)	micro	10^6
(ii)	deca	10^9
(iii)	mega	10^{-6}
(iv)	giga	10^{-15}
(v)	femto	10

Ans. micro = 10^{-6}, deca = 10, mega = 10^6, giga = 10^9, femto = 10^{-15}.

1.16 What do you mean by significant figures?

Ans. The total number of digits in a number including the last digit whose value is uncertain is called the number of significant figures.

1.17 A sample of drinking water was found to be severely contaminated with chloroform, $CHCl_3$, supposed to be carcinogenic in nature. The level of contamination was 15 ppm (by mass).

(i) Express this in percent by mass.

(ii) Determine the molality of chloroform in the water sample.

Ans. (i) 15 ppm means 15 parts in million (10^6) parts,.

% by mass $\frac{15}{10^6} \times 100$

$= 15 \times 10^{-4} = 1.5 \times 10^{-3}\%$

(ii) Molar mass of chloroform

$(CHCl_3) = 12 + 1 + 3 \times 35.5 = 119.5\,\text{g mol}^{-1}$

100 g of the sample contain chloroform $= 1.5 \times 10^{-3}$ g

$\therefore$ 1000 g (1 kg) of the sample will contain chloroform $= 1.5 \times 10^{-2}$ g

Now molality

$$= \frac{1.5 \times 10^{-2}}{119.5} = 1.255 \times 10^{-4}\,\text{m}$$

$\therefore$ Molality $= 1.255 \times 10^{-4}$ m.

1.18 Express the following in the scientific notation:

(i)	**0.0048**	**(ii)**	**234,000**
(iii)	**8008**	**(iv)**	**500.0**
(v)	**6.0012**		

Ans. (i) 4.8×10^{-3} (ii) 2.34×10^5

(iii) 8.008×10^3 (iv) 5.000×10^2

(v) 6.0012×10^0

1.19 How many significant figures are present in the following?

(i)	**0.0025**	**(ii)**	**208**
(iii)	**5005**	**(iv)**	**126,000**
(v)	**500.0**	**(vi)**	**2.0034**

Ans. (i) 2 (ii) 3

(iiii) 4 (iv) 3

(v) 4 (vi) 5

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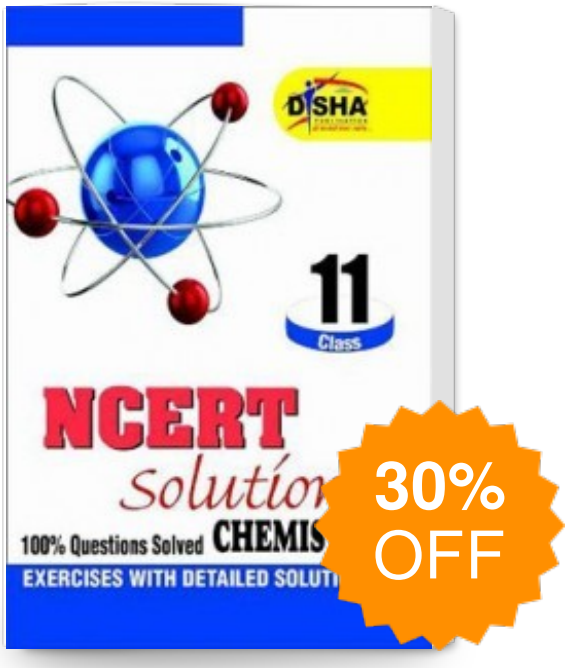

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