

5. STOICHIOMETRY

STUDY NOTES

[1VSAQ & 1SAQ]

STOICHIOMETRY means **MEASURE** of **ELEMENTS**.

In Stoichiometry, we learn the following:

- (I) Understanding the concepts of **five Laws of Chemical combination**.
- (II) Solving simple problems on **mole concepts, GMW, Molar Mass**.
- (III) Finding **Equivalent weights** of Elements, Acids, Bases, Salts, Oxidants,....
- (IV) Finding **Empirical formula** of a given unknown compound.
- (V) Solving simple problems on concentration methods like **mass %, Molarity, Normality,...**
- (VI) Finding **Oxidation number** of Elements in a Compound
- (VII) Balancing an unbalanced **Redox equation**

1) FIVE LAWS OF CHEMICAL COMBINATION:

1) Law of conservation of mass (Lavoisier):

In a chemical reaction, the total mass of reactants is equal to the total mass of products.

[We use this law in the **balancing of Redox equations**]

2) Law of definite (or) constant proportion (Joseph Proust) :

Elements always combine in a 'definite fixed composition' in 'the ratio of their masses'.

A given chemical compound 'always contains the same elements' in a 'fixed ratio by mass'.

[We use this law in the final Steps of **finding Empirical Formula** of given unknown compound]

3) Law of Multiple proportion (Dalton):

If an element forms two or more compounds with another element then the 'weights of that element' 'maintain a simple whole number ratio' with a fixed weight of the other element.

Nitrogen and Oxygen form N_2O , NO , N_2O_3 , NO_2 , N_2O_5 .

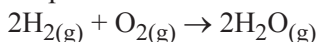
Here, the weights of O with respect to 28 g of N are

16, 32, 48, 64, 80 which are in the ratio 1:2:3:4:5

[We use this law in the final steps of **balancing Redox equations**]

4) Gay - Lussac's gaseous law of combining volumes:

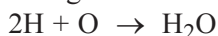
Gases combine in 'simple whole number ratio of their volumes'.



Ratio of volumes of H, O, H_2O is 2:1:2.

5) Avogadro's law :

Equal volumes of 'different gases contain equal number of molecules'.



2 vol of H gas + 1 vol of O \rightarrow 2 vol of water vapour

2n molecules + n molecules \rightarrow 2n molecules

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Lower Class Maths లో మీరు Ratio & Proportion Rules ఉపయోగించి చేసిన చిన్న చిన్న లెక్కల వంటివే....

ఇప్పుడు Stoichiometry లో ఉన్నాయి చూడండి. [Page No. 81/ 29,30,31]

III) EQUIVALENT WEIGHTS

Equivalent weight is the 'combining capacity' of Elements, Acids, Bases, Salts, Oxidants,....

$$\text{Equivalent weight of element/ acid / salt} = \frac{\text{Atomic weight / GMW / GMM}}{\text{Valency / Basicity / total positive charge}}$$

IV) EMPIRICAL FORMULA AND MOLECULAR FORMULA OF COMPOUNDS**1) Empirical formula**

Empirical formula just denotes the ratio of elements in the Molecule.

Ex: Empirical formula of C_2H_4 is CH_2 ; Empirical formula of C_2H_6 is CH_3 .

2) Molecular formula

Molecular formula 'exactly specifies' the actual number of elements in the Molecule.

Ex: Molecular Formula of ethane is C_2H_4 .

3) Relation between Empirical formula and Molecular formula :

Molecular formula = (Empirical formula)_n, n is a simple integer multiplier.

$$n = \frac{\text{Molecular formula weight}}{\text{Empirical formula weight}}$$

Molecular weight = n × (Empirical formula weight)

Note: Molecular weight = 2 × Vapour density

V) VARIOUS CONCENTRATION METHODS OF SOLUTE IN A SOLUTION

[Mass percent, Weight percent, Molarity, Mole fraction, Molality, Normality]

1) Mass Percent (%):

Mass % of element is the Mass of element present in 100 grams of the sample of a compound.

$$\text{Formula: Mass \% of an element} = \frac{\text{mass of the element}}{\text{Molar mass}} \times 100$$

2) Molarity (M)

Molarity of a solution is the number of 'moles of solute' dissolved in **one litre of solution** .

$$\text{Formula: Molarity } M = \frac{\text{No. of moles of solute}}{\text{Volume of solution per litre}}; M = \frac{w}{\text{GMW}} \times \frac{1000}{V(\text{mL})}$$

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DUMB CHARADES vs EMPIRICAL FORMULA

Dumb Charades అనే Mime Game లో ఎలాగైతే ఒక వస్తువును చూడకుండానే దాని లక్షణాలను వర్ణించడం బట్టి ఆ వస్తువు పేరు కనుగొంటారో అలాగే ఒక unknown Chemical compound ఇచ్చినప్పుడు అందులో ఉండే Components 'composition % by weight' ద్వారా 3 లేదా 4 Steps లలో చివరికి

ఆ Chemical compound formula ను కనుగొనవచ్చు!

See Model Problems on **Page No. 76/20, 21 & Page No. 77/ 22,23**

3) MOLALITY(m)

Molality of a solvent is the number of 'moles of solute' present in **one kilogram of solvent**.

$$\text{Formula: Molality } m = \frac{\text{No. of moles of solute}}{\text{Mass of solvent in kg}}; m = \frac{w}{\text{GMW}} \times \frac{1000}{W(\text{g})}$$

4) MOLE FRACTION(χ)

Mole fraction of a component is the ratio of the number of 'moles of the component' to the 'total number of moles of all the components' present in the solution.

$$\text{Mole Fraction } \chi_A = \frac{\text{No. of moles of component A}}{\text{Total no. of moles of all the components}} = \frac{n_A}{n_A + n_B}$$

5) NORMALITY(N)

Normality is the number of gram equivalents of solute present in one litre of solution [AP 22]

$$\text{Formula: Normality } N = \frac{W}{\text{GEW}} \times \frac{1000}{V(\text{mL})}$$

For Neutralization: $V_1N_1=V_2N_2$.

VI) OXIDATION NUMBER:

- 1) Oxidation number it is the total number of electrons that an atom /ion gains(-) or loses (+) in order to form a chemical bond with another atom / ion.
- 2) Oxidation number of a monoatomic ion = Charge of the ion.
- 3) Oxidation number of a free atom = zero
- 4) Oxidation number = Number of electrons, Oxygens, Hydrogens gained/lost.
- 5) Sum of oxidation states for all atoms of a neutral molecule is zero.
- 6) O.N. of H is usually +1 in regular compounds but it is -1 in alkaline compounds LiH, NaH.
- 7) O.N. of O is usually -2 in regular compounds but it is -1 in Peroxides like H_2O_2 .

BULLET MASTER'S**CHEM BEATS!****CONCENTRATION vs INTELLIGENCE**

మీ కాలేజీలో మొత్తం 1000 మంది Students ఉన్నారనుకొందాం. ఆ 1000 మందిలో **Intelligence** లో మీ స్థానాన్ని కొలిచే విధానాలు సరిగ్గా Solution లో Solute యొక్క **concentration** లను కొలిచే మాదిరిగానే ఉంటుంది.

- 1) Mass % = $\frac{\text{mass}}{\text{Molar mass}} \times 100$ **Verses** Intelligence Quotient (IQ) = $\frac{\text{Mental age}}{\text{Chronological age}} \times 100$
- 2) Weight % వలె 10th classలో మీ Marks % ని బట్టి మీ Academic Intelligence ను అంచనా వేయచ్చు.
- 3) Molarity వలె Interలో 1000కి ఏ Subject లో ఎన్ని మార్కులు వచ్చాయో దానిని బట్టి మీ Subject Intelligence ను అంచనా వేయచ్చు.
- 4) Molality వలె, JEE-Mains Percentile మాదిరిగా 1000 మందిలో మీ తెలివితేటలను అంచనా వేయచ్చు.
- 5) Mole Fraction వలె, 1000 మందిలో మీ Rank ను బట్టి మీ తెలివితేటలను అంచనా వేయచ్చు.
- 6) Normality వలె, మీ Academic Intelligence+Scholastic Achievements ద్వారా మీ Overall ప్రతిభను అంచనా వేయవచ్చు.

Imp. IPE Formulae

Formula 1: Number of moles $n = \frac{\text{g}(\text{weight of substance in grams})}{M(\text{GMW in g})}$ [☞ Page No. 73/2]

Formula 2: Weight of substance = $n \times \text{GMW}$ [☞ Page No. 73/4]

Formula 3: Number of molecules = $\frac{(\text{weight of substance in grams}) \times N_A}{M(\text{GMW in g})} = n \times N_A$ [☞ P. No. 73/3]

Formula 4: Number of molecules = No. of moles \times Avagadro Number.

Formula 5: Equivalent weight of element/ acid / salt = $\frac{\text{Atomic weight / GMW / GMM}}{\text{Valency / Basicity / total positive charge}}$ [☞ P. No. 73/7]

Formula 6: Molecular Formula = (Empirical formula)_n. [☞ Page No. 77/ 22,23]

Formula 7: $n = \frac{\text{Molecular formula weight}}{\text{Empirical formula weight}}$ [☞ Page No. 77/ 22,23]

Formula 8: Mass % of A = $\frac{\text{mass of A}}{\text{mass of solution}} \times 100$ [☞ P. No. 74/8]

Formula 9: Molarity $M = \frac{w}{\text{GMW}} \times \frac{1000}{V(\text{mL})}$ [☞ P. No. 74/9]

Formula 10: Molality $m = \frac{w}{\text{GMW}} \times \frac{1000}{W(\text{g})}$ [☞ P. No. 74/10]

Formula 11: Normality (N) = $\frac{w}{\text{GEW}} \times \frac{1000}{V(\text{mL})}$ [☞ P. No. 74/11]

Formula 12: For Neutralization: $V_1 N_1 = V_2 N_2$. [☞ P. No. 74/12]

STEPS IN THE BALANCING OF REDOX EQUATION IN ACIDIC MEDIUM

STEP 1: Write the given skeletal ionic equation.

STEP 2: Write Oxidation half reaction and reduction half reaction.

STEP 3: Balance atoms other O and H.

STEP 4: Balance Oxygen atoms.

STEP 5: Balance Hydrogen atoms.

STEP 6: Balance charges.

STEP 7: Equalise electrons.

STEP 8: Apply Crisscross rule if required.

STEP 9: Add the two Half reactions.

STEP 10: Write the Balanced Equation.