CHAPTER NO 02

CHEMICAL COMBINATION

Q1. Write down the names of different laws of chemical combination. Define and prove all the laws with with example.

There are four laws of chemical combinations these laws were given by different scientists.

i. Law of conversation of mass.

ii. Law of definite Proportion.

iii. Law of multiple proportion.

iv. Law of reciprocal proportions.

LAW OF CONVERSATION OF MASS:

INTRODUCTION:

It is presented by Lavoiser in 1785.

STATEMENT:

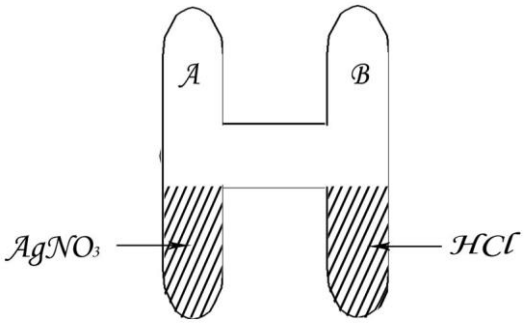
"In any chemical reaction the initial weight of a reacting substance is equal to the final weight of product."

OR

"Mass is neither created nor destroyed during chemical reaction."

PRACTICAL VARIFICATION (LANDOLT EXPERIMENT):

This law was verified by a German Chemist H. Landolt by an experiment. He took H-shaped tube and filled the two limbs, limb A with $AgNO_3$ and limb B with HCl. The tube was sealed so that the material could not escape out side. The tube was weighted in vertical position to avoid mixing. Then reactants were mixed by inverting and shaking the tube. The tube was weighted after the mixing (on the formation of white precipitate of AgCl). He observed that weight remains same.



Reaction:

$$AgNO_3 + HCl \longrightarrow AgCl + HNO_3$$
$$(aq) \quad (aq) \qquad (s) \quad (aq)$$

CONCLUSION:

Thus total mass of the substance before the reaction is equal to the total mass of the substance to after the reaction.

2. LAW OF CONSTANT COMPOSITION OR

LAW OF DEFINITE PROPORTION:

INTRODUCTION:

It is presented by a French Chemist Louis Proust in 1799.

STATEMENT:

"Every pure sample of a particular chemical compound contains the same element combine in the same fined proportion."

PRACTICAL VERIFICATION (BERZELLIUS EXPERIMENT):

J.J Berzellius proved the law of definite proportion.

10gm of lead (Pb) was heated with various amount of Sulphur (S) to give 11.56gm of Lead Sulphide (PbS).

$$\underset{(10g)}{Pb} + \underset{(?)}{S} \longrightarrow \underset{(11.56)}{PbS}$$

Again this experiment was repeated by heating 18gm of lead and 1.56gm of Sulphur then 11.56gm of PbS was prepared and 8gm of Pb remained unused.

$$\underset{(18g)}{Pb} + \underset{(1.56)}{S} \longrightarrow \underset{(11.56g)}{PbS} + \underset{(8.0g)}{Pb}$$

CONCLUSION:

It means that "Pb" and "S" always combine in the fixed ratio by mass.

3. LAW OF MULTIPLE PROPORTION:

INTRODUCTION:

This law was given by an English scientist Johan Dalton 1803.

STATEMENT:

"If two elements combine to form more than one compounds the mass of one element that combines with a fixed masses of the other element is in the ratio of small whole numbers or simple multiple of it."

Example 01:

Carbon forms two stable compounds with Oxygen (O), Carbon monoxide (CO) and Carbondioxide (CO_2)

S.no	Compound	Mass of C	Moss of O	Ratio of O
1	CO	1x12 = 12	1x16 = 16	1
2	CO_2	1x12 = 12	2x16 = 32	2

It means that the different masses of Oxygen are 16, 32 which combine with the fixed mass of Carbon which is 12g, the ratio of oxygen is 1:2 which is simple whole number ratio.

Example 02:

Hydrogen and oxygen combine to form two stable compounds, (H_2O) water and (H_2O_2) hydrogen peroxide.

S.no	Compounds	Mass of H	Mass of O	Ratio of O
1	H_2O	1x2 = 2	16x1 = 16	1
2	H_2O_2	1x2 = 2	16x2 = 32	2

It means that different masses oxygen are 16, 32 combine with the fixed mass of hydrogen which is 2, the ratio of oxygen is 1:2 which is simple whole number ratio.

4. LAW OF RECIPROCAL PROPORTION:

INTRODUCTION:

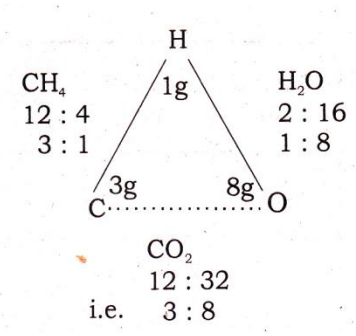
This law was given by Ritcher in 1792-1794

STATEMENT:

"When two different elements separately combine with the fixed mass of third element. The proportions in which they combine with one another shall be either in the simple ratio or some multiple of it"

Example:

When two elements Carbon (C) and Oxygen (O) separately combine with hydrogen (H) to form methane (CH_4) and water (H_2O). It is very clear, that the methane 3g of Carbon combines with 1g of hydrogen and in water, 8gm of oxygen combine with the fixed mass of hydrogen.



Now when carbon and oxygen combine with each other to form carbondioxide (CO_2) they do in same proportions 3:8 parts by mass.

Q2. Define the following terms:

i. Atomic Number **ii. Atomic Mass** **iii. Molecular Formula**
iv. Empirical Formula **v. Molecular Mass** **vi. Formula Mass**
vii. Mole **viii. Molar Mass** **ix. Avogadro's Number**

1. ATOMIC NUMBER (Z):

"The number of protons present in the nucleus of an atom is called atomic number. It is denoted by "Z".

Example:

Atomic number of Sodium (Na) = 11

Atomic number of Chlorine (Cl) = 17

2. ATOMIC MASS:

"The sum of number of protons and neutrons present in the nucleus of an atom is called Atomic Mass. It is denoted by "A" and unit is a.m.u."

Example:

Atomic mass of Sodium (Na) = 23 a.m.u

Atomic mass of Oxygen (O) = 16 a.m.u

3. MOLECULAR FORMULA:

"Molecular formula indicates the actual number and types of atoms present in a molecule."

Example:

Molecular formula of Glucose is $C_6H_{12}O_6$

Molecular formula of Copper Sulphate is $CuSO_4$

Molecular formula of Benzene is C_6H_6

4. EMPIRICAL FORMULA OR SIMPLEST FORMULA:

"The formula which represent the simple ratio between the number of atoms present in a molecule is called Empirical formula."

Example:

Empirical formula of Glucose is CH_2O

Empirical formula of Benzene is CH

5. MOLECULAR MASS:

"The molecular mass of a substance is the sum of atomic masses of all atoms present in a molecule"

Example:

Molecular mass of CO_2 = 12+16x2

= 12+32

= 44 a.m.u

6. MOLAR MASS:

"The mass of one mole of any substance (element / compound) which is expressed in grams is called molar mass of a substance

Example:

1 mole of NH_3 = 17gm

Molar mass of NH_3 = 17gm

1 mole of CO_2 = 44gm

Molar mass of CO_2 = 44gm

7. AVOGADRO'S NUMBER (N_A):

"The number of particles (atom or molecules) present in one mole of any substance is called avogadro's number. The number is constant which is $6.02x10^{23}$."

Example:

1 mole of C = $6.02x10^{23}$ atoms

1 mole of O_2 = $6.02x10^{23}$ molecules

1 mole of NaCl = $6.02x10^{23}$ particles

8. FORMULA MASS:

" The sum of atomic masses of all atoms of a substance in a formula unit is called formula mass."

Some compounds are not available in molecular form for example: NaCl is available in ionic form Na^+Cl^- so we can consider its formula mass not a molecular mass.

9. MOLE:

"The molecular mass, atomic mass and formula mass of any substance expressed in grams is known as mole."

Mathematically:

$$\text{Mole (n)} = \frac{\text{mass in gm}}{\text{Atomic mass / Formula mass}}$$

Example:

1 mole of CO_2 = 44gm

1 mole of Na= 23gm

1 mole of $CaCO_3$ = 100gm

Q3. Define chemical reaction. How many types of chemical reaction? Explain each type with examples.

CHEMICAL REACTION:

"Such a process during the change takes place in the matter such as one substance converted into another substance is called chemical reaction."

OR

"A chemical change in which reactants are converted into products is called chemical reaction."

Example 01:

When limestone ($CaCO_3$) is heated, quick lime (CaO) and carbondioxide (CO_2) are formed.

$$CaCO_3 \xrightarrow{\Delta H} CaO + CO_2$$

Example 02:

When acid (HCl) reacts with base (NaOH) then salt and water are formed.

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

TYPES OF CHEMICAL REACTION:

Chemical reaction can be divided into five different types.

i. Decomposition Reaction

ii. Synthesis/Addition/Combination Reaction

iii. Single Displacement Reaction

iv. Double Displacement Reaction

v. Oxidation/Combustion Reaction

1. DECOMPOSITION REACTION:

"The reaction in which a single compound breaks into two or more simplest substances is called decomposition reaction. They mostly required heat energy (ΔH)***."***

Example:

$$CaCO_3 \xrightarrow{\Delta H} CaO + CO_2$$

$$2KClO_3 \xrightarrow{\Delta H} 2KCl + 3O_2$$

2. SYNTHESIS / ADDITION / COMBINATION REACTION:

" When two different compounds or elements react together to give only one compound. This reaction is called Addition Reaction."

Example:

$$H_2 + Cl_2 \longrightarrow 2HCl$$

$$2Mg + O_2 \longrightarrow 2MgO$$

3. SINGLE DISPLACEMENT REACTION:

"The reaction in which an atom or a group of atoms is displaced (replaced) by another atom or a group of atoms of a compound is called Single Displacement Reaction."

Example:

$$Cu + ZnSO_4 \longrightarrow CuSO_4 + Zn$$

$$Mg + H_2SO_4 \longrightarrow MgSO_4 + H_2$$

4. DOUBLE DISPLACEMENT REACTION:

"The reaction in which reacting substances exchange their radicals or ions are called Double Displacement Reaction."

Example:

$$AgNO_3 + NaCl \longrightarrow AgCl + NaNO_3$$

$$CaCl_2 + Na_2CO_3 \longrightarrow 2NaCl + CaCO_3$$

5. OXIDATION / COMBUSTION REACTION:

"The reaction in which substances react with either free oxygen or oxygen of the air with the rapid release of heat and flame is called Combustion Reaction".

Example:

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O\ \Delta H \text{ (heat)}$$

$$C + O_2 \longrightarrow CO_2 + \Delta H \text{ (heat)}$$

Q4. Define neutralization and hydrolysis reaction with examples.

NEUTRALIZATION REACTION:

"The chemical reaction in which acid reacts with base to form salt and water this reaction is called Neutralization Reaction."

Example:

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

(acid) (base) (Salt) (water)

$$H_2SO_4 + 2KOH \longrightarrow K_2SO_4 + 2H_2O$$

(acid) (base) (salt) (water)

HYDROLYSIS REACTION:

"The chemical reaction in which water reacts with salt to form acid and base, this reaction is called Hydrolysis Reaction."

Example:

$FeCl + 2H\text{-}OH \longrightarrow Fe(OH)_2 + 2HCl$

(salt) (water) (base) (acid)

$MgCl_2 + 2H\text{-}OH \longrightarrow Mg(OH)_2 + 2HCl$

(salt) (water) (base) (acid)

Q5. Calculate molecular masses or formula masses of the following compounds.

i. H_2SO_4 **ii. $AgNO_3$**

1. H_2SO_4.

H =1, S =32, O =16

1x2 + 1x1 + 16x4

2 + 32 + 64

98 a.m.u

2. $AgNO_3$.

Ag =108, N =14, O =16

1x108 + 1x14 + 3x16

108 + 14 + 48

170 a.m.u

ASSIGNMENT:

iii. Na_2CO_3 **iv. MnO_2** **v. $C_6H_{12}O_6$** **vi. CCl_4**

vii. $NaNO_3$ **viii. PbI_2** **ix. NH_4Cl** **x. $CaCO_3$**

Q6. Numericals