Some Basic Concepts of Chemistry
MOLE CONCEPT AND MOLAR MASSES

❖ MOLE CONCEPT

For the counting of articles, the unit dozen or unit gross is commonly used irrespective of their nature. For example, one dozen pencils mean 12 pencils or one dozen apples means 12 apples or one gross book means 144 books or one gross orange means 144 oranges. In a similar way, for counting of atoms, molecules, ions, etc., chemists use the unit mole. The term mole was introduced by Ostwald in 1896. This is the Latin word 'moles' meaning heap or pile. A mole (mol) is defined as the number of atoms in 12.00 g of carbon-12. The number of atoms in 12 g of arbon-12 has been found experimentally to be $6.02xl0^{23}$, this number is also known as Avogadro's number named in honors of Amedeo Avogadro (1776 - 1856).

Thus, a mole contains $6.02xl0^{23}$ units. These units can be atoms, molecules, ions, electrons or anything else.

1 mole of hydrogen atoms means $6.02xl0^{23}$ hydrogen atoms.1 mole of hydrogen molecules means $6.02xl0^{23}$ hydrogen molecules. 1 mole of potassiiun ions means $6.02xl0^{23}$ potassium ions. 1 mole of electrons means $6.02xl0^{23}$ electrons. The type of entity must be specified when the mole designation is used. A mole of oxygen atoms contains $6.02xl0^{23}$ oxygen atoms. and a mole of oxygen molecules contains $6.02xl0^{23}$ oxygen molecules. Therefore, a mole of oxygen molecules is equal to two moles of oxygen' atoms, i. e., 2 x $6.02xl0^{23}$ oxygen atoms.

How much does one mole weigh? That depends on the nature of particles (units). The mass of one mole atoms of any element is exactly equal to the atomic mass in grams (gram-atomic mass or gram atom) of that element. For example, the atomic mass of aluminum is 27 amu. One amu is equal to 1.6{i x 10^{-24} g. One mole of aluminum contains $6.02xl0^{23}$ alJlll1inium atoms.

$$\text{Mass of one atom aluminum} = 27 \times 1.66 \times 10^{-24}\ \text{g}$$

$$\text{Mass of one mole aluminum} = 27 \times 1.66 \times 10^{-24} \times 6.02xl0^{23}$$

$$= 27\text{g}$$

This is the atomic mass of aluminum in grams or it is one-gram atomic mass or one gram atom of aluminum. Similarly, the mass of $6.02xl0^{23}$ molecules (1 mole) of a substance is equal to its molecular mass in grams c.r gram-molecular mass or gram molecule. For example, molecular mass of water is 18 amu. Thus, mass of one mole of water will be 18 x 1.66 x 10^{-24} x $6.02xl0^{23}$, i. e., 18 g.

This is the molecular mass of water in grams or one gram-molecular mass or one gram molecule. Mole concept is also applicable to ionic compounds which do not contain molecules. In such cases, the fonnula of an ionic compound represents the ratio between constituent ions. The mass of 6.02xl0^{23} fonnula units represents one mole of an ionic compound.

One mole of BaC12

$$= 6.02xl0^{23} BaCl2 \text{ units}$$

$$= 208.2g \text{ } BaCl2$$

Molecular mass (formula mass) of BaCl2

:::: 6.02xl0^{23} Ba 2+ ions + 2 x 6.02xl0^{23}CI- ions

$$= 137.2 + 71.0 = 208.2g$$

One mole of a substance will have mass equal to formula mass of that substance expressed in grams.

❖ MOLE

A mole is the amount of a substance that contains as many entities (atoms, molecules or other particles) as there are atoms exactly in 0.012 kg (or 12 g) of the carbon - 12 isotope.

From mass spectrometer we found that there are 6.023×10^{23} atoms are present in 12 g of C-12 isotope.

The number of entities in 1 mol is so important that it is given a separate name and symbol known as Avogadro constant denoted by N_A.

i.e., on the whole we can say that 1 mole is the collection of 6.02×10^{23} entities. Here entities may represent atoms, ions, molecules or even pens, chair, paper etc.

1 mole of atom is also termed as 1 g – atom

1 mole of ions is also termed as 1 g – ion

1 mole of molecule is also termed as 1 g – molecule

Methods of Calculations of Mole

(a) If no. of some species is given,

$$\text{then no. of moles} = \frac{\text{Given no.}}{N_A}$$

(b) If weight of a given species is given,

$$\text{then no. of moles} = \frac{\text{Given wt.}}{\text{Atomic wt.}} \quad \text{(for atoms)},$$

or $$\frac{\text{Given wt.}}{\text{Molecular wt.}} = \text{ (for molecules)}$$

(c) If volume of a gas is given along with its temperature (T) and pressure (P).

$$\text{use n } \frac{PV}{RT} =$$

where R = 0.0821 lit-atm/mol-K

(When P is in atmosphere and V is in liters)

1 mole of any gas at STP occupies 22.4 litter.

Ex. Chlorophyll the green colouring material of plants contains 3.68 % of magnesium by mass. Calculate the number of magnesium atom in 5.00 g of the complex.

Sol. Mass of magnesium in 5.0 g of complex $= \frac{3.68}{100} \times 5.00 = 0.184$ g

Atomic mass of magnesium $= 24$

24 g of magnesium contain $= 6.023 \times 10^{23}$ atoms

$\therefore$ 0.184 g of magnesium would contain $= \frac{6.023 \times 10^{23}}{24} \times 0.184 = 4.617 \times 10^{21}$ atom

Therefore, 5.00 g of the given complex would contain 4.617×10^{21} atoms of magnesium.