

Unit: 1 MOLE CONCEPT

Introduction to Mole Concept

→ Atoms and molecules are regarded as fundamental chemical unit which are whose quantitative explanation is relatively unfavourable in practical life. Thus the concept of mole concept was introduced for measuring fundamental chemical unit.

→ According to Atomic theory, "equal number of fundamental particles are present in one gram atomic/molecular wt. of any element/compound."

One-Mole:

The amount of substance present in one mole of a system which contains as many elementary entities as there are in exactly 12 gm of C^{12} isotope is called one mole.

Avogadro's Number

The number of carbon atoms present in exactly 12 gm of C^{12} isotope is called Avogadro's number.

$$N_A = 6.022 \times 10^{23} \text{ particles.}$$

According to Avogadro's number,
a mole is defined as the amount of
substance that contains 6.022×10^{23} particles.

Also, 1 mole of substance = equivalent mass in grams.

Eg: i) 1 mole of $H_2O \approx 18 \text{ gm of } H_2O \approx 1 \text{ gm mol. wt of } H_2O$
 $\approx 6.022 \times 10^{23} \text{ } H_2O \text{ molecules.}$

ii) 1 mole of $O \approx 16 \text{ gm of } O \approx 1 \text{ gm atomic wt of } O$
 $\approx 6.022 \times 10^{23} \text{ } O \text{ atoms.}$

Formulae Related to Mole:

$$(i) \text{ No. of mole (atom) } = \frac{\text{wt. in gm}}{\text{Atomic wt}}$$

$$(ii) \text{ No. of mole (molecule) } = \frac{\text{wt. in gm}}{\text{molecular wt.}}$$

$$(iii) \text{ No. of mole (particles) } = \frac{\text{given no. of particles}}{\text{Avogadro's number}}$$

$$(iv) \text{ No. of mole (volume) } = \frac{\text{given volume at STP}}{22.4 \text{ litres.}}$$

(*) Note: (i) $1 \text{ cc} = 1 \text{ ml}$

(ii) $1 \text{ litre} = 1000 \text{ cc}$

Date _____ No. _____

Q.1: Calculate the weight of one atom oxygen.

Soln:

1 mole of O contains 6.023×10^{23} particles and weights 16 gms.

So,
to 6.023×10^{23} atoms of O weights 16 gm

$$\therefore 1 \text{ atom of O weights } \frac{16}{6.023 \times 10^{23}} \text{ gm} \\ = 2.656 \times 10^{-23} \text{ gms.}$$

Q.2 Calculate the weight of one atomic mass unit.

Soln:

Here,

One atomic mass unit (amu) means $\frac{1}{12}$ th part of the mass of one atom of C^{12} isotope.

Now,

1 mole of C^{12} weights 12 gm
So, 6.022×10^{23} atoms of C^{12} weights 12 gm
 \therefore 1 atom of C^{12} weights $\frac{12}{6.023 \times 10^{23}}$ gm

$$\therefore \text{weight of one amu} = \frac{1}{12} \times \frac{12}{6.023 \times 10^{23}} = 1.66 \times 10^{-24} \text{ gm.}$$

Q.3: How many oxygen atoms are there in 8 gm of oxygen atoms?

Solⁿ:

Given, wt =

wt of oxygen = 8 gm

We know,

$$\text{No. of moles} = \frac{\text{wt. in gm}}{\text{Atomic wt}} = \frac{8 \text{ gm}}{16 \text{ gm}} = 0.5 \text{ moles.}$$

Now,

$$\begin{aligned} \text{No. of atoms} &= \text{No. of moles} \times \text{Avogadro's no.} \\ &= 0.5 \times 6.022 \times 10^{23} \end{aligned}$$

$$\therefore \text{No. of atoms in 8 gm oxygen atoms} = 3.011 \times 10^{23} \text{ atoms.}$$

Q.4: Calculate the weight of one molecule of MgSO_4 .

Solⁿ:

for molecular wt. of MgSO_4 ,

$$= 24 \times 1 + 32 + 4 \times 16 = 120$$

So, 1 mole of MgSO_4 weighs 120 gm

i.e. ~~6.023~~ 6.022×10^{23} molecules of MgSO_4 weighs 120 gm

$$\therefore 1 \text{ molecule of } \text{MgSO}_4 \text{ weighs } \frac{120}{6.022 \times 10^{23}} \text{ gm}$$

$$= 1.992 \times 10^{-22} \text{ gm.}$$

Q.5: find the weight of 100 ml of CO_2 gas at NTP.
Solⁿ.

Given,

volume of CO_2 gas = 100 ml.

Now,

$$\begin{aligned}\text{No. of moles} &= \frac{\text{Given volume at STP}}{22.4 \text{ litres}} \\ &= \frac{100 \text{ ml}}{22400 \text{ ml.}} = 4.464 \times 10^{-3} \text{ mole.}\end{aligned}$$

Sol,

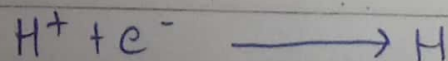
$$\begin{aligned}\text{weight of 100 ml of } \text{CO}_2 \text{ gas} &= \text{No. of mole} \times \text{Molecular wt} \\ &= 4.464 \times 10^{-3} \times 44 \\ &= 0.196 \text{ gm.}\end{aligned}$$

Q.6: On electrolysis of dil. acid solution, hydrogen gas ions are discharged at cathode according to reaction $\text{H}^+ + \text{e}^- \rightarrow \text{H}$. Then, find the number of mole of electrons required to discharge 5 moles of H^+ ions.

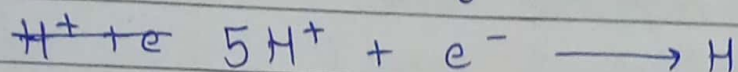
Also, calculate total charge gained by H^+ ions in the process.

Solⁿ:

Here, given reaction,



To discharge 5 moles of H^+ ,
i.e.,



Balancing the equation presented above,
 $5H^+ + 5e^- \rightarrow 5H$

Here, we require 5 moles of electron.

So,

$$\begin{aligned} \text{No. of electrons} &= \text{No. of moles of electron} \times \text{Avogadro's No.} \\ &= 5 \times 6.022 \times 10^{23} \end{aligned}$$

$$\text{Charge of one electron} = 1.6 \times 10^{-19} \text{ C.}$$

So,

$$\begin{aligned} \text{Charge of 5 mole electron} &= 5 \times 6.022 \times 10^{23} \times 1.6 \times 10^{-19} \\ &= 481760 \text{ C.} \end{aligned}$$

Chemical Equations

The representation of a chemical change using symbols and molecular formula is called chemical equation.

- Qualitative aspect:
- i) types of species present in reactant and product side
 - ii) symbols and molecular formula of the elements / compounds involved.

Quantitative Aspect: (i): Amount of species present in the respective side of reactant and product.

Stoichiometric Coefficients

→ The numbers that are placed before atoms / molecules in a balanced chemical equation is called stoichiometric coefficients.

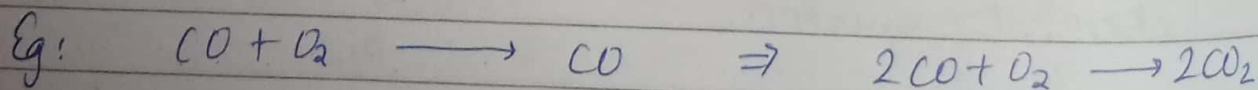
→ Express the quantitative aspect of a chemical reaction.

i.e; These stoichiometric coefficients also represents the relative number of atoms / molecules involved in chemical reaction which corresponds to relative number of moles for that reaction.

Principle of Atom Conservation:

Principle of Atom Conservation states that, "the number of ~~elements~~ atoms of each element is always constant or conserved."

This principle is the basis for balancing chemical equations.



Principle of Charge Conservation:

Principle of Charge Conservation states that, "the net electrical charge is neither created nor destroyed during chemical reactions."

This principle is the basis for balancing redox equations.

Stoichiometric relationship:

for reaction of type;



The stoichiometric relationship betⁿ chemicals,

$$\frac{\text{moles of A}}{a} = \frac{\text{moles of B}}{b} = \frac{\text{moles of C}}{c} = \frac{\text{moles of D}}{d}$$

% composition of an element by Mass

The ratio of total weight of one element to the molecular weight in terms of % gives % composition of element in compound.

Mathematically,

$$\begin{aligned} \text{\% composition of element} &= n \times \frac{\text{molar mass of element}}{\text{molar mass of compound}} \times 100\% \\ &= \frac{\text{weight of element in compound}}{\text{molar mass of compound}} \times 100\% \end{aligned}$$

Empirical Formula and Molecular Formula

Empirical formula is the simplest whole number ratio of atoms present in a compound.

Molecular formula is a chemical formula that gives the total number of atoms of each element in each molecule of substance.

Ex 7: How to find Empirical formula if from given % mass

Ans:

Steps:

(i): The atomic mass of each atom involved must be known.

(ii): The total mass is supposed to be 100 gm to find the amount of each element present.

(iii): The no. of moles of each element present in the compound is calculated.

(iv): The ratio of number of moles of each element is taken and is divided by the smallest value of number of mole.

(v): The ratio is change into simple whole number ratio ie, integer form.

(vi): This gives Empirical formula.

Also,
$$n = \frac{\text{Molecular wt}}{\text{Empirical wt}}$$

$$\therefore \text{Molecular formula} = (\text{Empirical formula}) \times n$$

[Numericals included in assignment part]