Date No.

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 ~~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 12gm of C^{12} isotope is called one mole.

Avogadro's Number

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

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

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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 gm of $H_2O \approx$ 1 gm mol. wt of H_2O
$\approx 6.022 \times 10^{23}$ H_2O molecules.

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

Formulae Related to Mole:

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

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

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

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

(*) ! Note: (i) 1 cc = 1 ml
(ii) 1 litre = 1000 cc

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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, 6.022×10^{23} atoms of O ~~particles~~ weights 16 gm

$\therefore$ 1 atoms of O weights $\frac{16}{6.022 \times 10^{23}}$ gm

$= 2.656 \times 10^{-23}$ gms.

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

Soln:

Here,

One atomic mass unit (amu) means $1/12^{th}$ 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.

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

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

Soln:

Given, ~~wt o~~

wt of oxygen = 8 gm

We know,

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

Now,

No. of atoms = No. of moles x Avogadro's no.

$= 0.5 \times 6.022 \times 10^{23}$

$\therefore$ No. of atoms in 8 gm oxygen atoms $= 3.011 \times 10^{23}$ 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 $MgSO_4$ weights 120 gm

i.e., ~~6.023 of~~ 6.022×10^{23} ~~parti~~ molecules of $MgSO_4$ weights 120gm

$\therefore$ 1 molecule of $MgSO_4$ weighs $\dfrac{120}{6.022 \times 10^{23}}$ gm

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

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

Soln.

Given,

volume of CO_2 gas = 100 ml.

Now,

No. of moles = $\dfrac{\text{Given volume at STP}}{22.4 \text{ litres}}$

$= \dfrac{100 \text{ ml}}{22400 \text{ ml}} = 4.464 \times 10^{-3}$ mole

So,

weight of 100 ml of CO_2 gas = No. of mole × Molecular wt

$= 4.464 \times 10^{-3} \times 44$

$= 0.196$ gm.

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

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

Soln:

Here, given reaction,

$$H^+ + e^- \longrightarrow H$$

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To ~~re~~ discharge 5 moles of H^+.
ie,

~~$H^+ + e$~~ $5H^+ + e^- \longrightarrow H$

Balancing the equation ~~of~~ presented above,

$5H^+ + 5e^- \longrightarrow 5H$

Here, we require 5 moles of electron.

So,

~~5 m~~ No. of electrons = No. of moles of electron × Avogadro's No.

$= 5 \times 6.022 \times 10^{23}$

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

So,

Charge of 5 mole electron $= 5 \times 6.022 \times 10^{23} \times 1.6 \times 10^{-19}$

$= 481760$ C.

Chemical Equations

The representation of a chemical change using symbols and molecular ~~form~~ 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.

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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 ~~coeffici~~ 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.

Eg: $CO + O_2 \longrightarrow CO \Rightarrow 2CO + O_2 \longrightarrow 2CO_2$

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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;

$$aA + bB \longrightarrow cC + dD$$

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,

$$\%\text{ composition of element} = \frac{n \times \text{molar mass of element}}{\text{molar mass of compound}} \times 100\%.$$

$$= \frac{\text{weight of element in compound}}{\text{molar mass of compound}} \times 100\%.$$

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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.

(*): 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, $n = \dfrac{\text{Molecular wt}}{\text{Empirical wt}}$

$\therefore$ Molecular formula = (Empirical formula) × n

[∵ Numericals included in assignment part]

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