ToppersNotes

THE IIT-JEE SECRET

PHYSICAL CHEMISTRY VOL.-I

Sierra Innovations Pvt. Ltd.

Contents

Mole concept-I

Atomic structure

Gaseous state

Mole concept-II

Redox reaction

Acid & Bases

Chemical equilibrium

Le-chateliers principle

Mole Concept - 1

Classification of matter (having mass & occupies space)

- Physical classification (i.e physical appearance)
  - Solid → having strong intermolecular forces of attraction
  - Liquid
  - Gas
  - Plasma → matter in ionic form under extreme high temp. condition
- Chemical classn.
  - Pure substances (fixed composition)
    - Elements (consisting of only one type of atom) Eg: O_2, P_4, S_8
    - Compound (Made up of two or more than two types of atom) Eg:- CH_4, CO_2
    - ← chemical Methods
  - Mixtures (variable composition)
    - Homogenous → uniform composition Eg:- gaseous mix, sugar sol^n.
    - Heterogen → non-uniform composit Eg:- s in wa

In mixtures :-
Components can be separated by physical methods
Eg:- Filtration, crystallisation, centrifugation, etc

→ Air is an example of nearly homogenous mixtures

→ Distillation - (based on difference b/w boiling points)

→ Crystallisation - (based on difference b/w freezing points)

→ Filtration - (due to the different physical state)

→ Centrifugation - (due to difference in densities)

Note :- Compounds → Properties of its constituent elements are lost

Mixtures → it retains the individual properties of components.

Compounds

Covalent comp. | Ionic comp.

SOME GENERAL TERMS :-

* Relative atomic mass or (Relative atomic weight) = $\frac{\text{Mass of one atom of element}}{1/12 \times \text{mass of 1 atom of C-12 isotope}}$

$= \frac{\text{Mass of one atom of element}}{1 \text{ amu}}$

1 amu = 1 atomic mass unit = $1/12 \times$ mass of 1 atom of C-12 isotope.

$= 1.66 \times 10^{-24}$ g (determined by mass spectrometry)

→ it is unitless

Ques :- At one time there was a chemical atomic weight scale based on the assignment of the value 16.0000 to naturally occuring oxygen. What could have been the atomic weight on such a table of Ag, if the atomic wt. of Oxygen & Ag on the present table based on C-12 reference are 15.9994 & 107.868?

Say atomic weight on older scale of O-16 = $\frac{107.868 \times 16}{15.9994}$

Ratio of the mass of the element on old scale is equal to the Ratio of the mass of that element on new scale

★) Atomic mass (or atomic weight) = It is the mass of 1 atom of an element expressed in a.m.u.

H → 1 amu

S → 32 amu

O → 16 amu

Definition of mole :- 1 mole is the amount of sub. which contains no. of entities (atoms/molecules/ions) equal to the no. of atom present in 12 g of C-12 isotope.

1 mole = No. of atoms in 12 g of C-12 isotope

= 6.022×10^{23}

= Avagadro's No (N_A)

★) Gram atomic mass → Mass of 1 mole of atom of an element expressed in gm.

Eg GAM of Sulphur = Mass of 1 atm of S × N_A

= 32 amu × N_A

= $32 \times 1.66 \times 10^{-24} \times 6.022 \times 10$

= 32 g.

ToppersNotes

*) Relative molecular mass

*) Molecular mass

*) Gram molecular mass (Molar mass)

Calculation of no. of mole :-

1.) If no. of particles are known, then

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

2.) If mass of substance is known, then

$$\text{no. of moles} = \frac{\text{mass of substance (in g)}}{\text{molar mass (GAM or GMM)}}$$

3.) When volume of gas is given under STP or NTP

$$\text{no. of moles of gas} = \frac{\text{Volume of gas (in l) at STP}}{\text{molar vol. of gas (in l) at STP}}$$

*) for ideal gases $= \frac{\text{Vol. of gas at S.T.P (in l)}}{22.4\ l}$

*) If gas is present at condition other than STP, then apply ideal gas equation, $PV = nRT$, for calculation of no. of moles

P → pressure of gas
- 1 atm = 1.01325×10^5 Pa
- 1 bar = 1.013 atm
- 1 atm = 760 mm of Hg = 76 cm of Hg
- 1 torr = 1 mm of Hg

T → temprature in Kelvin $\{K = °C + 273.15\}$

V → volume in l

n → no. of moles of gas

R → universal gas constant, $R = 8.314$ J/mol K

or 0.0821 litre atm/mol k

or 1.987 ($\simeq 2$) cal/mol K

Note:- *) Earlier S.T.P conditions – 1 atm pressure & 0°c Temp and accordingly molar volume of gas, under S.T.P conditions was 22.4 Litres.

*) with recent modification by IUPAC, S.T.P is now modified as 1 bar pressure and 0°c temp. and accordingly molar volume of gas at newer S.T.P. is 22.7 Litres. For solving numericals, we usually use molar volume of gas at S.T.P = 22.4 Lit.

Ques:- Calculate no. of moles in following cases:-

1.) no. of moles of electron in 1.6 g of methane
2.) no. of moles of O_2 having filled in 0.5 l container, with 3 atm pressure & 0°c temp
3.) no. of moles of protons, electrons & neutrons in 1.8 gm of $C_6H_{12}O_6$

Sol:- a) moles of CH_4 = $\frac{1.6}{16}$ = $\frac{1}{10}$ moles.

molecules of CH_4 = $\frac{1}{10} \times N_A$

∴ No. of electrons = $\frac{1}{10} \times N_A \times 10$ = N_A electrons
= 1 mole e^-

b.) $PV = nRT$

$3 \times 0.5 = n \times 0.0821 \times 273$

$\Rightarrow n = \frac{1.5}{0.0821 \times 273} = \frac{6}{91}$

c.) moles of $C_6H_{12}O_6$ = $\frac{1.8}{180}$ = $\frac{1}{100}$ mole.

moles of e^- = $\frac{1}{100} \times 96 = 0.96$

moles of p^+ = $\frac{1}{100} \times 96 = 0.96$

moles of neutron = $\frac{1}{100} \times 84 = 0.84$

Average Atomic Mass or Average Isotopic mass

Average molar mass = $\frac{\text{Total mass of all isotopes}}{\text{Total no. of moles}}$.

or Average atomic mass = $\frac{\text{Total mass of all atoms}}{\text{Total no. of atoms}}$.

If fractional abundance of various isotope is known, then we can evaluate average isotopic mass -

a.) when % by mol of various isotope is given :-

A + B

x% ↙ ↘ $(100-x)$% (Assume total 100 moles)

$$\text{Average isotopic mass} = \frac{M_A \times x + M_B \times (100-x)}{\text{Total moles}}$$

$$= \frac{M_A \times x + M_B \times (100-x)}{100}$$

⇒ where M_A = mass of 1 mole of A,
M_B = mass of 1 mole of B

In general, Average wt = $\frac{M_1 x_1 + M_2 x_2 + M_3 x_3 + \cdots}{100}$

⇒ where x_1, x_2, x_3 are % by wt of various isotopes

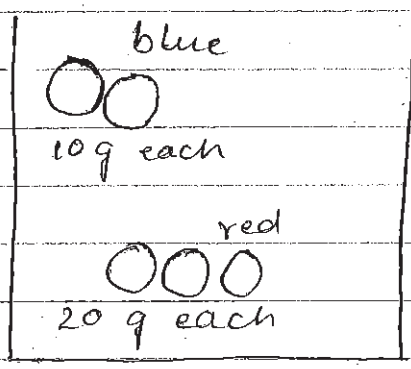
b.) when molar ratio of various isotopes or components are given :-

$A + B$ where $A : B = m : n$

$$M_{ave} = \frac{m \times M_A + n \times M_B}{m+n}$$

In general, $$M_{ave} = \frac{m_1 M_1 + m_2 M_2 + m_3 M_3 + \cdots}{m_1 + m_2 + m_3 + \cdots}$$

Understanding % by mole & % by mass



Suppose there are 2 blue & 3 red balls.

% by mol (by number) of blue balls

$$= \frac{\text{no. of blue ball}}{\text{total no. of ball}} \times 100$$

$$= \frac{2}{5} \times 100 = 40\%$$

% by mass of blue balls

$$= \frac{\text{mass of blue balls}}{\text{mass of (red + blue) ball}} \times 100$$

$$= \frac{20}{80} \times 100$$

$$= 25\%$$

Relation b/w % by mol & % by mass

GAM = M_A — A + B — GAM = M_B

n % by mol — (100 − n) % by mol

$$M_{av}\ (\text{by mol}) = \frac{n \times M_A + (100-n) M_B}{100}$$

$$\%\ \text{by mass of A} = \frac{\text{mass of A}}{\text{total mass}} \times 100$$

(Assume total moles = 100, mol of A = n, mol of B = 100 − n)

$$= \frac{M_A \times n}{n \times M_A + (100-n) M_B} \times 100$$

$$= \frac{M_A \times n}{\left(\frac{n \times M_A + (100-n) \times M_B}{100}\right)} = \frac{M_A \times n}{M_{av}\ (\text{by mol})}$$

$$\boxed{\%\ \text{by mass of A} = \frac{\%\ \text{by mol of A} \times M_A}{M_{av}\ (\text{by mol})}}$$

Ques Chlorine sample has isotopic composition
, Cl^{35} → 75 % by wt
& Cl^{37} → 25 % by wt. , find M_{av}

Sol

$$M_{av} = \frac{35 \times 75 + 37 \times 25}{100}$$

$$= 35.5$$

↳ ave. atomic mass = 35.5 amu

↳ ave. molar mass = 35.5 g/mol