SOME BASIC CONCEPTS IN CHEMISTRY

C1 In this chapter we will discuss the calculations based on chemical equations. It has been classified into two parts :

1. Mole Concept
2. Equivalent Concept

C2 **MOLE CONCEPT :**

In mole concept we deal with different types of relations like weight-weight, weight-volume, or volume-volume relationship between reactants or products of the reaction.

Mole concept is based on balanced chemical chemical reaction. Some basic definitions used in mole concept are as follows :

Limiting Reagent : A reagent which is consumed completely during the chemical reaction.

$$\textbf{Number of moles of a substance(n)} = \frac{\textbf{weight of substance}}{\textbf{atomic or molecular weight}}$$

Also, $$\textbf{Number of moles of a substance(n)} = \frac{\textbf{Given number of molecules}}{\textbf{Avogadro number}}$$

In gas phase reaction number of moles of a gas **(n)** = $\frac{PV}{RT}$,

At STP/NTP one mole of any gas contains 22.4 L i.e. at 273 K and 1 atm pressure.

In aq. solution **n = MV [M - molarity, V - volume of solution]**

Practice Problems :

1. **Chlorine can be produced by reacting H_2SO_4 acid with a mixture of MnO_2 and NaCl. The reactions follows the equation : $2NaCl + MnO_2 + 3H_2SO_4 \rightarrow 2NaHSO_4 + MnSO_4 + Cl_2 + H_2O$ what volume of chlorine at STP can be produced from 100 g of NaCl ? (At. wt. Na = 23, Cl = 35.5)**

(a) **19.15 lt** **(b)** **30 lt** **(c)** **29 lt** **(d)** **5 lt**

2. **A solution contains 5 g of KOH was poured into a solution containing 6.8 g of $AlCl_3$, find the mass of precipitate formed [At. wt. : H-1, Al-27, Cl-35.5, K-39]**

(a) **2.3 g** **(b)** **23 g** **(c)** **32 g** **(d)** **0.32 g**

[Answers : (1) a (2) a]

C3 **EQUIVALENT CONCEPT :**

Volumetric Analysis is based on acid base titration and redox titration mainly.

Important Definitions :

$$\textbf{Molarity(M)} = \frac{\textbf{No. of moles of solute}}{\textbf{Vol. of solution in L}}$$

$$\textbf{Normality (N)} = \frac{\textbf{No. of gramequivalents of solute}}{\textbf{Vol. of solution in L}}$$

$$\textbf{No. of gram equivalents of solute}(n_{eq}) = \frac{\textbf{Weight of solute}}{\textbf{Equivalent weight}}$$

$$\textbf{Equivalent weight} = \frac{\textbf{Molecular weight (or) Atomic weight (or) Ionic weight}}{\textbf{n factor}}$$

$n_{eq} = n_{mol} \times$ n-factor

n_{eq} = Normality × Volume (L)

Number of moles(n_{mol}) = Molarity × Volume (L)

Normality = Molarity × n-factor

Calculation of 'n' Factor for Different Class of Compounds

1. Acids : n = basicity
   H_3PO_4 n = 3
   H_3PO_3 n = 2
   H_3PO_2 n = 1
2. Bases : n = acidity
   e.g. Ammonia and all amines are monoacidic bases
3. Salt : (Which does not undergo redox reactions)
   n factor = Total cationic or anionic charge
4. Oxidizing Agents or Reducing Agents : 'n' factor = change in oxidation number Or number of electron lost or gained from one mole of the compound.

Note : In a balance equation n factor ratio of two compounds is reverse of their molar ratio.

Practice Problems :

1. $[Na^+]$ in a solution prepared by mixing 30.00 mL of 0.12 M NaCl with 70 mL of 0.15 M Na_2SO_4 is

(a) 0.135 M (b) 0.141 M (c) 0.210 M (d) 0.246 M

2. The equivalent mass of $MnSO_4$ is half of its molar mass when it is converted to

(a) Mn_2O_3 (b) MnO_2 (c) MnO_4^- (d) MnO_4^{2-}

3. The anion nitrate can be converted into ammonium ion. The equivalent mass of NO_3^- ion in this reaction would be

(a) 6.20 g (b) 7.75 g (c) 10.5 g (d) 21.0 g

4. When BrO_3^- ion reacts with Br^- ion in acid solution Br_2 is liberated. The equivalent weight of $KBrO_3$ in this reaction is

(a) M/8 (b) M/3 (c) M/5 (d) M/6

5. The number of moles of $KMnO_4$ that will be needed to react completely with one mole of ferrous oxalate in acidic solution is

(a) 3/5 (b) 2/5 (c) 4/5 (d) 1

[Answers : (1) d (2) b (3) b (4) c (5) a]

C4 **LAW OF CHEMICAL EQUIVALENTS :** In a chemical reaction the equivalents of all the species (reactants or products) are equal to each other provided none of these compounds is in excess.

$N_1V_1 = N_2V_2$ (when normalities and volumes are given)

Relation between percentage weight by weight (x), density (d) and strength in gm / litre (s) S = 10 xd

C5 **BACK TITRATION**

This is a method in which a substance is taken in excess and some part of its has to react with another substance and the remaining part has to be titrated against standard reagent.

C6 **BASIC PRINCIPLE OF TITRATIONS :**

In voltmetric analysis, a given amount (weight or volume) of an unknown substance is allowed to react with a known volume of a standard solution slowly. A chemical reaction takes place between the solute of an unknown substance and the solute of the standard solution. The completion of the reaction is indicated by the end point of the reaction, which is observed by the colour change either due to the indicator or due to the solute itself. Whether the reactions during the analysis are either between an acid and or base or between O.A. and R.A., the law of equivalence is used at end point.

Following are the different important points regarding this process :

(i) In case of acid base titration at the equivalence point
   (n_{eq})acid = (n_{eq})base

(ii) In case of redox titration
   (n_{eq})oxidant = (n_{eq})reductant

(iii) If a given volume of solution is diluted then number of moles or number of equivalence of solute remains same but molarity or normality of the solution decreases.

(iv) If a mixture contains more than one acids and is allowed to react completely with the base then at the equivalence point, (n_{eq}) acid$_1$ + (neq) acid$_2$ + ... = (n_{eq}) base

(v) Similarly if a mixture contains more than one oxidising agents then at equivalence point,

(n_{eq}) O.A_1 + (n_{eq}) O.A_2 +... = (n_{eq}) reducing agent.

(vi) If it is a difficute to solve the problem through equivalence concept then use the mole concept.

Practice Problems :

1. **5 ml of N-HCl, 20 ml of N/2-H_2SO_4 and 30 ml of N/3 – HNO_3 are mixed together and the volume made to 1 litre.**

(i) The normality of the resulting solution is

(a) N/5 (b) N/10 (c) N/20 (d) N/40

(d)

(ii) The wt. of pure NaOH required to neutralize the above solution is

(a) 10 g (b) 2 g (c) 1 g (d) 2.5 g

2. **0.7 g of a sample of $Na_2CO_3.xH_2O$ were dissolved in water and the volume was made to 100 ml, 20 ml of this solution required 19.8 ml of N/10 HCl for complete neutralization. The value of x is**

(a) 7 (b) 3 (c) 2 (d) 5

3. **100 mL of 1 M $KMnO_4$ oxidised 100 mL of H_2O_2 in acidic medium (when MnO_4^- is reduced to Mn^{2+}); volume of same $KMnO_4$ required to oxidise 100 mL of H_2O_2 in basic medium (when MnO_4^-. is reduced to MnO_2) will be**

(a) $\frac{100}{3}$ mL **(b)** $\frac{500}{3}$ mL **(c)** $\frac{300}{3}$ mL **(d) 100 mL**

4. **100 mL of a mixture of NaOH and Na_2SO_4 is neutralised by 100 mL of 0.5 M H_2SO_4. Hence amount of NaOH in 100 mL mixture is**

(a) 0.2 g (b) 0.4 g (c) 0.6 g (d) 1.0 g

5. **3 mol of a mixture of $FeSO_4$ and $Fe_2(SO_4)_3$ required 100 mL of 2 M $KMnO_4$ solution is acidic medium. Hence mol fraction of $FeSO_4$ in the mixture is**

(a) $\frac{1}{3}$ **(b)** $\frac{2}{3}$ **(c)** $\frac{2}{5}$ **(d)** $\frac{3}{5}$

6. **5.3 g of M_2CO_3 is dissolved in 150 mL of 1 N HCl. Unused acid required 100 mL of 0.5 N NaOH. Hence equivalent weight of M is**

(a) 23 (b) 12 (c) 24 (d) 13

[Answers : (1) c (2) c (3) b (4) b (5) a (6) a]