

IV. Molality (m): It is number of moles of solute in kilogram of solvent.
Or no. of millimoles of solute in (g) of solvent.

$$m = \frac{W \times 1000}{M.wt. \times W \text{ solvent kg}}$$

In dilute aqueous solution:

$$M = m$$

Weight of solution = Weight of solvent = Volume of solution

Molar Fraction (X):

It's the ratio between numbers of solute moles to number of moles of all solution contains.

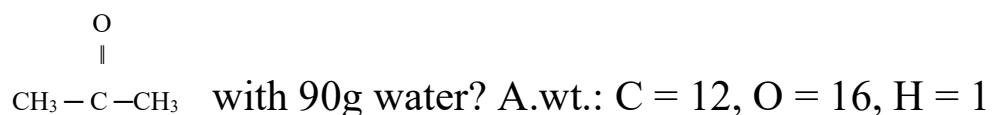
$$\text{Mole of Fraction of Solute}(X) = \frac{\text{no. moles of (solute)}}{\text{no. moles of (solution)}}$$

$$\text{no. of moles of solution} = \text{no. of solute moles} + \text{no. of solvent moles}$$

$$\text{Mole of Fraction of solvent}(X) = \frac{\text{no. moles of (solvent)}}{\text{no. moles of (solution)}}$$

$$X \text{ solute} + X \text{ solvent} = 1$$

Ex.: Calculate the mole fraction of 5.8g acetone solution



$$\text{Mole of Fraction of Solute}_{\text{Acetone}}(X) = \frac{\text{no.moles of(solute)}}{\text{no.moles of (solution)}}$$

$$\begin{aligned} \text{Moles (solute)} &= \frac{\text{Wt.}}{\text{M.wt.}} \\ &= \frac{5.8 \text{ g}}{(3 \times 12) + (1 \times 16) + (6 \times 1) = 58 \text{ g/mol}} \end{aligned}$$

$$\text{Mole}_{(\text{solute})} = 0.1 \text{ mole}$$

$$\text{Mole}_{(\text{solvent})} = \frac{90}{18} = 5 \text{ mole}$$

$$\text{no.of solution moles} = 5.0 + 0.1 = 5.1 \text{ mole}$$

$$\text{Mole Fraction of Solute} = \frac{\text{no.moles of(solute)}}{\text{no.moles of (solution)}}$$

$$X_{\text{solute}} = \frac{0.1}{5.1}$$

$$X = 0.0196$$

$$\text{Mole Fraction of Solvent} = \frac{5.0}{5.1}$$

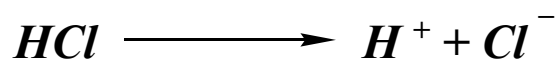
$$X = 0.9804$$

$$\begin{aligned} \text{Total Mole Fraction} &= 0.9804 + 0.0196 \\ &= 1.0 \end{aligned}$$

Aqueous Solution and Chemical Equilibria

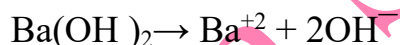
Electrolysis: are solutes which are ionized in solution to produce an electrically conducting medium. There are two types of electrolytes.

Strong electrolytes: the compounds which are completely ionized or dissociate in solution.



Example of Strong electrolytes

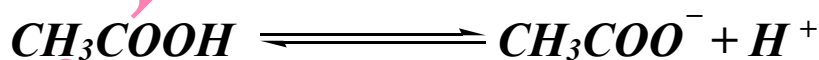
1. Many inorganic acids: Hydrochloric acid HCl, nitric acid HNO₃, perchloric acid HClO₄, sulfuric acid H₂SO₄.
2. Alkali and alkaline-earth hydroxides: Sodium hydroxide NaOH , Potassium hydroxide KOH , Calcium hydroxide Ca(OH)₂ , Barium hydroxide Ba(OH)₂ .



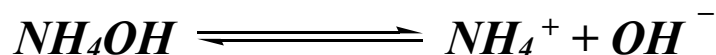
3. Most salts:
Sodium chloride NaCl, Sodium fluoride NaF , Potassium fluoride KF
Sodium nitrate NaNO₃



Weak electrolytes: the compounds which are partially ionized or dissociate in solution to produce an electrically conducting medium.

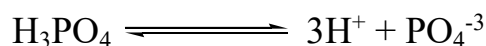
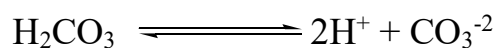


The dissociation of weak electrolyte undergoes in to two directions.

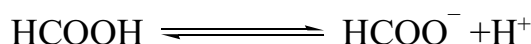


Example of Weak electrolytes

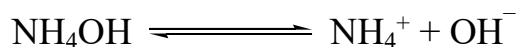
1. Some inorganic acid: Carbonic acid H₂CO₃, Boric acid H₃BO₃, Phosphoric acid H₃PO₄, Hydrogen sulfide H₂S



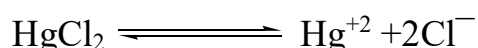
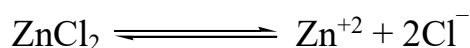
2. Most organic acid :(Acetic acid CH_3COOH), Formic acid HCOOH).



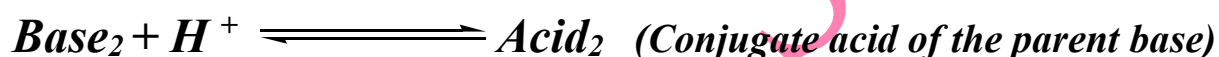
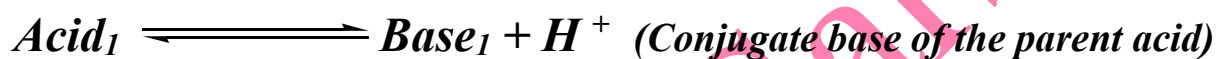
3. Many organic bases and ammonia, $\text{H}_2\text{N}-\text{CH}_2-\text{CH}_2-\text{NH}_2$



4. Halides (chloride Cl^- , bromide Br^- , fluoride F^- , iodide I^-), Cyanides (CN^-) and thiocyanate (SCN^-) of Hg, Zn and Cd.



Conjugate Acids and Bases

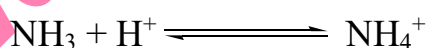


The result in an acid /base or neutralization reaction:



e.g.

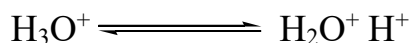
A conjugate acid: is formed when a base accepts a proton H^+ .



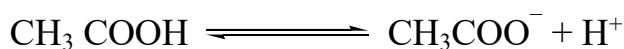
NH_4^+ is a conjugate acid of ammonia

A conjugate base: is formed when an acid loss a proton H^+ .

e.g.

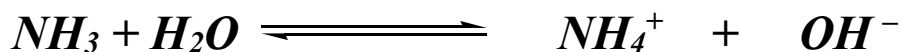
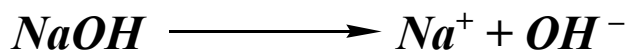
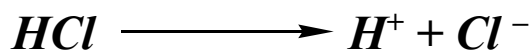
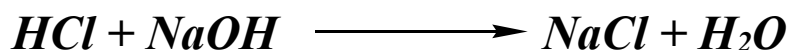


H_2O is a conjugate base of H_3O^+



CH_3COO^- is a conjugate base of acetic acid

Neutralization Reaction:

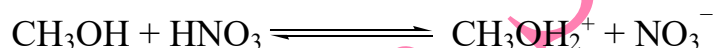
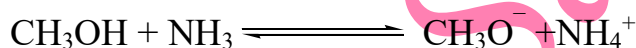


Conjugated of NH_3

Conjugated base of H_2O

NH_3 , NH_4^+ are conjugate pair.

Amphiprotic compounds: -These compounds act as an acid in the presence of base and as base in the presence of an acid



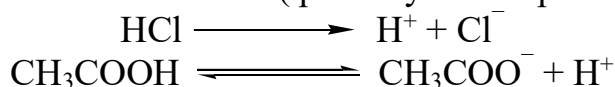
Amphiprotic Solvents :- Solvents act as an acid in the presence of base and as base in the presence of an acid.



Acid Base Theories

1. Arrhenius theory (The theory of H^+ and OH^-)

Acid : is any compound which ionize (partially or completely) to give H^+



Base :- is any compound which ionize (partially or completely) to give OH^- .

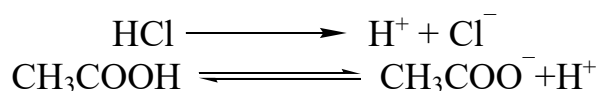


The disadvantage of Arrhenius theory

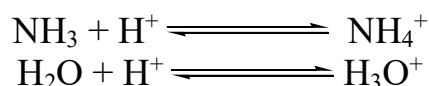
This theory applicable for aqueous media only and not applicable for organic media.

2. Bronsted – Lowry Theory (The theory of give and accept H^+)

Acid : is any compound which ionize (partially or completely) to give proton (H^+)



Base : is any compound which accept H^+



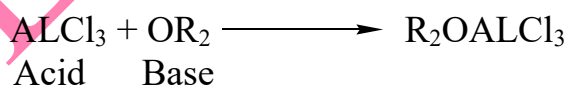
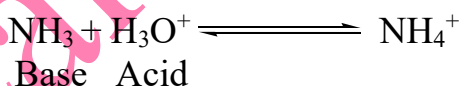
Disadvantage / Advantage

The theory is applicable for aqueous and organic solvent. But isn't applicable for non-ionized solvent dioxane, hexane, CCl_4 carbon tetra chloride.

3. Lewis Theory (The theory of give and accept electron pair)

Acid : any compound which accept electron pair.

Base : any compound which give electron pair.



(Aluminum chloride) ether R-O-R

Lewis Theory give an explanation for organic compound and the effect of solvent.

Chemical Equilibrium

Many reactions used in analytical Chemistry never result in complete conversion of reactants to products.

Instead, they proceed to a state of chemical equilibrium that describe the concentrations of reactants existing among reactants product is constant.

Equilibrium constant expressions are algebraic equation that describe the concentration relationships existing among reactants and products at equilibrium.

Equilibrium- Constant Expressions:

A generalized equation for a chemical equilibrium is:



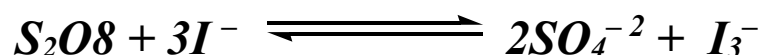
where the capital letters represent the formulas of participating chemical species and the lower case are the small whole numbers required to balance the equation.

a,b,c,d = mole of A,B,C,D.

The equilibrium –constant expression of the above reaction is :

$$K_{eq.} = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

Ex. 1. :



H.W

Ex.2

Calculate the concentration of each of A,B of equilibrium state of 0.1 M AB solution (AB: weak electrolyte). $K_{eq} = 3 \times 10^{-6}$.

Solubility Product Constant

Solubility: is the amount of solute can be dissolved in a volume of solvent.

When one substance (solute) dissolves in any solvent, it is said to be **soluble**. When one substance does not dissolve in another it is said to be **insoluble**. Solubility depends on type of solvent, temperature and acidity (pH) of media.

The solubility can be determined by solubility product constant (K_{SP}).

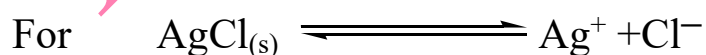
In saturated solution of A_xB_y salt.



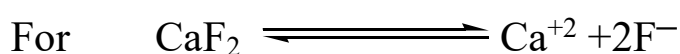
$$K = \frac{[A^+]^x [B^-]^y}{[A_xB_y]} \quad \text{at equilibrium state}$$

\therefore Conc. of solid compound is constant

$$\therefore K = [A^+]^x [B^-]^y$$



$$\therefore K_{sp} = [Ag^+] [Cl^-]$$



$$\therefore K_{sp} = [Ca^{+2}] [F^-]^2$$