ACID BASE CONCEPTS: TITRATIONS

Q. 1. Discuss various acid base concepts.

Ans. Following are the various concepts of acids and bases:

1. Arhenious concept of electrolytic dissociation given in 1887.
According to this theory, acids dissociates into H^+ and anions

$$HX \rightleftharpoons H^+ + X^-$$

$$HCl \rightleftharpoons H^+ + Cl^-$$

& Bases dissociates into Hydroxide ions and cation

Base: $BOH \rightleftharpoons OH^- + B^+$

$NaOH \rightleftharpoons Na^+ + OH^-$

2. Bronsted & Lowry Concept:
J.N. Bronsted and T.M. Lowry in "1923" gave acid base concept, which is applicable to all solvents.
According to this theory:
An acid is a substance which may be charged or uncharged species and is capable of donating a proton.
A Base is a substance which may be charged or uncharged species and is capable of accepting a proton.
In Bronsted and Lowry concept, acid may be cations such as NH_4^+ and $H_3O^+$and bases may be anions like HSO_4^- and CH_3COO^-, or Neutral molecules such as HCl and NH_3 respectively. Water (H_2O) can either act as base or an acid and is an amphiprotic molecule. Acid Base reactions occur when an acid reacts with a base to form new acid and base, since reactions involve transfer of a proton, Hence these are also known as protolytic reactions or protolysis.
Eg:- In reaction between HCl and H_2O

$$\underset{\text{acid1}}{HCl} + \underset{\text{Base2}}{H_2O} \rightarrow \underset{\text{Acid2}}{H_3O^+} + \underset{\text{Base1}}{Cl^-}$$

Acid $\overline{=}$ proton + conjugated Base

$HA \rightleftharpoons H^+ + A^-$ (Hypothetical scheme to define acid and base)

Stronger acid loses its H^+ more easily than weaker
Strength of strong acid → HCl, HBr, HI, HNO_3 and $HClO_4$
Reaction of weak acid or slightly ionized acid eg: ethanonic acid, propanoic acid proceeds only slightly to right in the equation:-

$$\underset{\text{Acid 1}}{CH_3COOH} + \underset{\text{Base 2}}{H_2O} \rightleftharpoons \underset{\text{Acid 2}}{H_3O^+} + \underset{\text{Base 1}}{CH_3COO^-}$$

Conjugate bases have strengths that vary inversely with strength of respective acid.
Basic ionization constant of conjugate base

$$K_{base} = \frac{Kw}{K_{A\ conj}} \qquad Kw = \text{ionic product of } H_2O$$

3. Lewis concept of Lewis electronic theory
Given by G.N. Lewis in 1938
According to this theory, acid is a molecule or ion that accepts an e^- pair to form a covalent bond.

Base is a substance that provides pair of unshared e- by which the base coordinates with an acid.

BF_3, Al_2Cl_3 though do not contain hydrogen and not serving as H^+ donors are acids under lewis concept.

Many substances that do not contain OH^- including amines, ethers and – COOH, anhydrides are bases under Lewis concept.

Eg:

It should be referred as form of electronic sharing rather than as acid base reaction.

Q. 2. Write a note on chemical equilibrium.

Ans. It may be defined as balance between two opposing forces or actions. It does not mean that the opposing reactions stops, rather a dynamic equality between the velocities of two exists. Chemical equilibrium maintains the concentration of reactants and products constant. Most chemical reactions proceed in both forward and backward direction, if products of reactions proceeds to completion such reactions are regarded as irreversible. Chemical equilibrium includes ionization or proteolysis of a weak electrolyte like CH_3COOH in H_2O.

$$\underset{\text{Acid1}}{HAC} + \underset{\text{Base 2}}{H_2O} \rightleftharpoons \underset{\text{Acid 2}}{H_3O^+} + \underset{\text{Base1}}{AC^-}$$

Arrows indicate forward and backward reaction, right and left side reactions respectively. According to law of mass action:

Rate/velocity of forward reaction α to concentration of reactants

$$R_f \propto [HAC]^1 [H_2O]^1$$

$$R_f = K_1 \times [HAC]^1 [H_2O]^1$$

Speed of reaction depends on decrease in concentration of either of reactants/ unit time.

Similarly for reverse reaction

$$R_r = K_2 \times [H_3O^+]^1 [AC^-]^1$$

K_1 & K_2 are proportionality constant for forward and backward reactions respectively.

If concentration is replaced by activities consider following reaction

$$aA + bB \rightleftharpoons cC + dD$$

Equilibrium constant k is written as

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

a g mole of substance A react with b g mole of substance B to produce C g mole of substance C and d g mole of subs D.

In term of activity

$$k = \frac{aC^c . aD^d}{aA^a . bB^b}$$

aC, aD, aA and aB activity of respective substance at equilibrium

Activity and concentration are related by equation

$a_i = c_i \times f_i$

a_i = activity c_i = Conc.

f_i = activity coefficient of any species

When concentration are low in dilute solution, Value of activity coeff.

is unity and activity = conc. (For all practical purposes, provided very dilute solutions are involved)

$$\therefore k = \frac{[C]^c [D]^d}{[A]^a [B]^b}$$