AQUEOUS SOLUTION OF ACIDS, BASES AND SALTS.

A substance which dissociates to produce hydrogen ions (H^+) is an acid.

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

A base dissociates to produce hydroxide ions (OH^-) in an aqueous solution.

$$NaOH \rightleftarrows Na^{+} + OH^{-}$$

Acids and bases that are completely dissociated in water are called strong acids or bases (strong electrolytes).

Example: . $HCl \rightleftarrows H^{+} + Cl^{-}$.

HCl is the strong acid, which is completely dissociated in aqueous solution to form H^{+} and Cl^{-}.

Names and Formulas of all the strong Acids and Bases

$HClO_4$ Perchloric acid	LiOH Lithium hydroxide
HNO_3 Nitric acid	NaOH Sodium hydroxide
H_2SO_4* Sulfuric acid	KOH Potassium hydroxide
HCl Hydrochloric acid	RbOH Rubidium hydroxide
HBr Hydrobromic acid	CsOH Cesium hydroxide
HI Hydroiodic acid	$Ca(OH)_2$ Calcium hydroxide
	$Sr(OH)_2$ Strontium hydroxide
	$Ba(OH)_2$ Barium hydroxide

Acids and bases that are partial dissociated in water are called weak acids or bases (weak electrolytes).

Example: $NH_4OH \rightleftarrows NH_4^+ + OH^-$.

NH_4OH is a weak base. When dissolved in water it produces OH^- ions, but the OH^- concentration is considerably less than the NH_4OH concentration.

For the weak acids and bases dissociation is reversible process and can be characterized by equilibrium constant.

In the case of weak acid, for example, acetic acid, CH_3COOH, the equilibrium constant is called the <u>acid dissociation constant</u> K_a, and for the dissociation reaction

$$CH_3COOH \rightleftarrows H^+ + CH_3COO^-$$

the equilibrium constant

expression is $K_a = \frac{[H^+]\cdot[CH_3COO^-]}{[CH_3COOH]}$.

The dissociation process for the weak base NH_4OH is written $NH_4OH \rightleftarrows NH_4^+ + OH^-$ and the equilibrium constant expression is

$$K_b = \frac{[NH_4^+] \cdot [OH^-]}{[NH_4OH]}.$$

The term K_b is called the base dissociation constant.

The values of K_a's and K_b's indicate the extents of dissociation of weak acids and bases. The larger the constants, the stronger the acids or bases. Dissociation constants must be determined by experiment.

CH_3COOH $K_a = 1.8 \cdot 10^{-5}$ greater than

HCN hydrocyanic $K_a = 4 \cdot 10^{-10}$ (HCN less acid than CH_3COOH)

CH_3COOH stronger than HCN

Salts are strong electrolytes. Salts are completely dissociated in water.

We may write: $NaCl \rightleftarrows Na^{+} + Cl^{-}$

$$Al_2(SO_4)_3 \rightleftarrows 2Al^{+3} + 3SO_4^{2-}$$

The reaction between acids and bases is called <u>neutralization reaction</u>.

Base + Acid = Salt + H_2O

Bases react with acid to produce salt and water.

Equations for acid – base neutralization reactions can be written in molecular, ionic and net ionic form.

Molecular: $NaOH + HCl = NaCl + H_2O$

Ionic: $Na^+ + OH^- + H^+ + Cl^- = Na^+ + Cl^- + H_2O$

Net ionic: $OH^- + H^+ = H_2O$

A neutralization reaction simply involves the combination of hydrogen and hydroxide ions to form water.

The pH scale

The equation of dissociation of H_2O is

$H_2O \rightleftarrows H^+ + OH^-$ in water solution H+ exists as hydronium ion H_3O^+.

$$H_2O + H_2O \rightleftarrows H_3O^+ + OH^-$$

in this process, an H_2O molecule transfers a proton to another H_2O molecule.

The equilibrium constant expression for this process is

$K_w = [H_3O^+] \cdot [OH^-]$ or $K_w = [H^+] \cdot [OH^-]$

This equilibrium constant also has a special name the ion-product of water, in pure water at $25^{o}C$: $[H^{+}] = [OH^{-}] = 1.0 \times 10^{-7}$

$K_{w} = [H^{+}] \cdot [OH^{-}] = 10^{-7} \cdot 10^{-7} = 1.0 \times 10^{-14}$

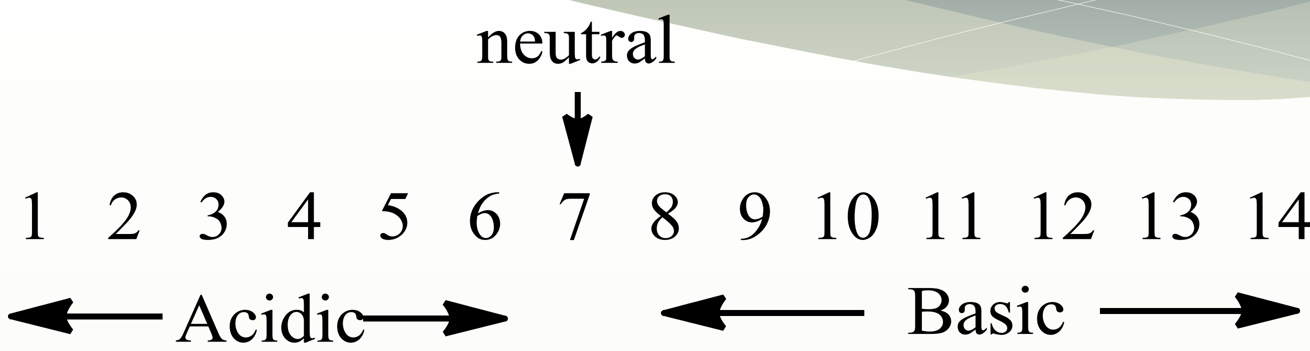
In 1909 the chemist Sorensen proposed pH scale.

If a solution has $[H^+] = 10^{-x}$, pH = x.

On this scale, a concentration of of $1 \times 10^{-7}\ mol$ H^+ per liter of solution becomes a pH of 7.

The pH is the negative of the logarithm of $[H^+]$

$$pH = -\log[H^+]$$



A pH of 7 represents a neutral solution.

The pH less than 7 the solution is acidic;

the pH greater than 7 indicates than the solution is basic.

The pOH is defined in an analogous fashion to pH

$$pOH = -\log[H^{-}] \text{ or } [OH^{-}] = 10^{-pOH}$$

We can write the equilibrium constant for water in a new way:

$$-\log K_w = -\log[H^+] - \log[OH^-] = -\log[1 \cdot 10^{-14}]$$

$$pK_w = pH + pOH = 14$$

$$pH + pOH = 14$$

Hydrolysis

This reaction, in which water reacts with an ionic species in solution, is called hydrolysis.

Salts of strong acids and strong bases

(for example, NaCl) do not hydrolyze: PH=7.

$$NaCl + H_2O = no\ reaction$$

Salts of weak acids and strong bases (for example, CH_3COONa) hydrolyze, producing a basic solution: pH>7.

$$CH_3COONa + H_2O \rightleftarrows CH_3COOH + NaOH$$

$$CH_3COO^- + Na^+ + HOH \rightleftarrows CH_3COOH + Na^+ + OH^-$$

$$Na^+ + HOH = \text{no reaction}$$

Water reacts with a CH_3COO^- to produce OH^-.

A solution of CH_3COONa has a pH>7.

Salts of strong acids and weak bases (for example, NH_4Cl) hydrolyze, producing a acidic solution: pH<7.

$$NH_4Cl \rightleftarrows NH_4^+ + Cl^-$$

$$Cl^- + H_2O \rightleftarrows no\ reaction$$

$$NH_4^+ + H_2O \rightleftarrows H^+ + NH_4OH$$

$$NH_4Cl + H_2O \rightleftarrows NH_4OH + HCl$$

Salts of weak acids and weak bases (for example, NH_4CH_3COO) hydrolyze, but whether the resulting solution is neutral, acidic, or basic depends on the relative values of K_a and K_b.