Buffer Solutions

A buffer solution is defined as a solution which resists any change in its pH value on addition of small amount of strong acid or strong base to it.

Types of Buffer Solutions

Acid Buffers = These solutions are the solution of weak acid and a salt of weak acid with strong base

Example - $CH_3COOH + CH_3COONa$
- $HCN + NaCN$
- $PhCOOH + PhCOONa$

Buffer action of Acidic Buffer

Consider acidic Buffer of CH_3COOH and CH_3COONa in aqueous solution

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

$$CH_3COONa \longrightarrow CH_3COO^- + Na^+$$

Due to common ion effect ionization of CH_3COOH is further suppressed →

— When small amount of strong acid (HCl) is added to the acidic Buffer solution Then H^+ ion of HCl combines with CH_3COO^- ion to form weakly ionized molecules CH_3COOH

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

Thus H^+ or H_3O^+ in aqeous solution or PH (which $-\log_{10} H^+$) remains constant. or negligible change occurs.

(Henderson - Hasselbalch) Equation for Acidic Buffer

for weak acid CH_3COOH in aq. solution $CH_3COOH \rightleftharpoons CH_3COO^- + H^+$

$$Ka = \frac{[CH_3COO^-][H^+]}{[CH_3COOH]}$$

Hence In presence of salt

$$\Rightarrow [H^+] = Ka \frac{[CH_3COOH]}{[CH_3COO^-]_{salt}}$$

Taking $-\log_{10}$ both sides

$$-\log [H^+] = -\log Ka - \log[CH_3COOH] + \log[CH_3COO^-]$$

$$PH = PKa + \log \frac{[CH_3COO^-]_{salt}}{[CH_3COOH]}$$

$$\boxed{PH = PKa + \log \frac{[salt]}{[Acid]}}$$

→ This Eqn. is known as Henderson Hasselbalch eqn.

Basic Buffer ⇒ Such Solutions are solutions of mixture of ~~strong~~ weak Base and its Salt with Strong Base.

Ex- $NH_4OH + NH_4Cl$

- $CH_3NH_2 + CH_3-NH_3^+Cl^-$

- $NH_4OH + NH_4ClO_4$

Buffer Action of Basic Buffer

Consider Basic Buffer of ($NH_4OH + NH_4Cl$) dissociates as

$NH_4OH \rightleftharpoons NH_4^+ + OH^-$

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

addition of strong base in small amount, OH^- of S.Base combines with NH_4^+ to give NH_4OH (weak base)

$NH_4^+ + OH^- \rightarrow NH_4OH$

Due to formation weakly dissociated NH_4OH, PH of solution does not change effectively hence PH is unchanged

When H^+ from S.Acid is added to Basic Buffer, H^+ of Acid combines →

with NH_4OH to give NH_4^+ + H_2O

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

Due to formation of NH_4^+ ion, PH of solution does not change effectively.

Henderson Equation for Basic Buffer

For Basic Buffer

$$NH_4OH \rightleftharpoons NH_4^+ + OH^-$$

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

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

In presence of common ion NH_4^+

$$[OH^-] = K_b \frac{[NH_4OH]}{[NH_4^+]_{salt}}$$

Taking $-\log_{10}$ both sides

$$-\log[OH^-] = -\log K_b - \log \frac{[NH_4OH]}{[NH_4^+]_{salt}}$$

$$POH = PK_b + \log \frac{[NH_4^+]_{salt}}{[NH_4OH]}$$

$$POH = PK_b + \log \frac{[Salt]}{[Base]}$$

Henderson Eqn.

$$PH = 14 - POH$$