15-07-20

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Deg-I (H) Physical (paper-II)
Chapter - Ionic Equilibrium
Topics — Buffer Solution
Henderson's equation

Buffer Solution — Those solution which resists its pH-value by the small addition of acids & bases.

The ability to resists its pH-value on addition of small amount of Acid & Base are called its Buffer-Action.

General Characteristics of a Buffer-solution

(1) It has definite pH. Its acidity & alkalinity must be preserved.
(2) Its pH does not change on standing for long-time.
(3) Its pH does not change upon dilution.
(4) Its pH slightly change by the addition

Of very small amount of an acid & bases.

Types of Buffer Solution:-

(1) Acidic Buffer:- By mixing a weak acid with salt of its strong base.

Example- (a) $CH_3COOH + CH_3COONa$

(b) Boric acid + Borax

(c) Phthalic Acid + potassium acid phthalate

(2) Basic Buffer:-

By mixing weak base & its salt with strong acid.

Example- (a) $NH_4OH + NH_4Cl$

(b) Glycine + Glycine hydrochloride.

(3) By a solution of amphoteric substance which show both an acid & base.

Example- protein & Amino acid

(4) By a mixture of an acid salt and a normal salt of a polybasic acid.

Example- $Na_2HPO_4 + Na_3PO_4$

or CH_3COONH_4

Buffer Action:- In case of acidic buffer acetic acid is feebly ionised but sodium acetate is almost completely ionised. A solution contains both CH_3COOH & CH_3COO^- along with H^+ & OH^-.

$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$ (feebly ionised)

$CH_3COONa \rightarrow Na^+ + CH_3COO^-$ (completely ionised)

$H_2O \rightleftharpoons H^+ + OH^-$ (very feebly ionised)

(a) by adding a drop of an acid or H^+

H^+ combines with CH_3COO^- ion to form CH_3COOH (feebly ionised)

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

Its ionisation is further suppressed due to common ion effect.

(b) by adding a drop of base or OH^-

OH^- combines with CH_3COOH to form CH_3COO^- & undissociated H_2O.

$OH^- + CH_3COOH \rightleftharpoons CH_3COO^- + H_2O$

Thus OH^- furnished by base are removed by CH_3COOH & its pH of the solution is practically unaltered.

Henderson Equation [pH of buffer eq]

In case of acidic-Buffer, it consist of a mixture of weak acid & its salt. It can be taken as HA (CH$_3$COOH)

HA ionises as

$$HA \rightleftharpoons H^+ + A^-$$

Applying law of mass action.

Diss. const. of acid. $\rightarrow K_a = \frac{[H^+][A^-]}{[HA]}$

$$\text{or } [H^+] = K_a \times \frac{[HA]}{[A^-]}$$

Taking log both sides.

$$\log [H^+] = \log K_a + \log \frac{[HA]}{[A^-]}$$

Taking -ve sign $\quad -\log [H^+] = -\log K_a + \log \frac{[A^-]}{[HA]}$

Hence $\quad \boxed{pH = pK_a + \log \frac{[Salt]}{[Acid]}}$

Similarly for basic-buffer

$$\boxed{p(OH) = pK_b + \log \frac{[Salt]}{[Base]}}$$

The above eqn. is called Henderson Eq.