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Class \Rightarrow B.Sc. Part-I Subsidiary
 Subject \Rightarrow Chemistry
 Chapter \Rightarrow Ionic Equilibrium
 Topic \Rightarrow Buffer Solutions

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Buffer Solution

A buffer solution is one which maintains its pH fairly constant even upon the addition of small amounts of an acid or a base.

In other words,

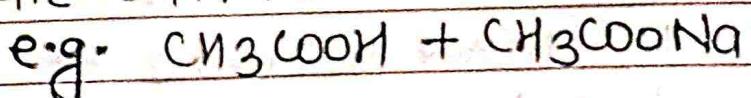
A buffer solution is one which can resist change in its pH on the addition of an acid or a base.

Types of Buffer solution

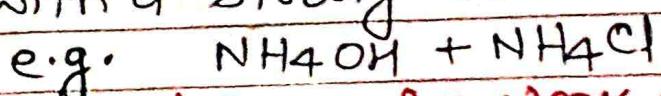
Two common types of Buffer solution

- (i) Acidic Buffers
- (ii) Basic Buffers

(i) Acidic Buffers \Rightarrow A weak acid together with a salt of the same acid with a strong base are called Acidic buffers.



(ii) Basic Buffers \Rightarrow A weak base and its salt with a strong acid are called Basic buffers.

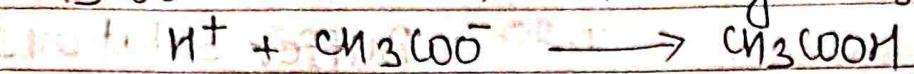


Buffer mixture of a weak acid and its salt

A common buffer is prepared by mixing equimolar aqueous solutions of Acetic acid and sodium acetate.

(2)

Suppose a strong acid is added to the mixture. The H^+ ions added will be taken up immediately by CH_3COO^- ions to form very slightly dissociated CH_3COOH .



feebly dissociated

Thus, the H^+ ions added are neutralised by the acetate ion present in the mixture. There is little change in the pH of the mixture.

If, on the other hand, a strong base is added, the OH^- ions added are neutralised by the acetic acid present in the mixture.



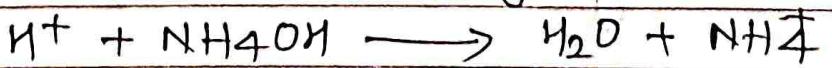
Thus, again, there is very little change in the pH of the mixture.

It should be clear from the above mechanism of buffer action that acidity of $CH_3COON - CH_3COO^-$ buffer is due to the presence of CH_3COOH and reserve alkalinity is due to the presence of CH_3COO^- ions.

Buffer mixture of a weak Base and its Salt

A mixture containing equimolar aqueous solutions of ammonium hydroxide and its salt ammonium chloride, constitutes another good buffer. The mixture contains undissociated NH_4OH as well as NH_4^+ and Cl^- ions.

If a strong acid is added, the H^+ ions added are neutralised by the base NH_4OH .



If a strong base is added, the OH^- added are neutralised by NH_4^+ ions forming very slightly undissociated NH_4OH .

The reserve acidity is due to the presence of NH_4^+ ions and reserve alkalinity is due to the presence of NH_4OH .

Calculation of pH of Buffer Mixtures

(1) Buffer Mixture of a Weak Acid and its Salt OR

Henderson - Hasselbach equation

Consider a buffer solution containing a weak acid HA and its highly dissociated salt NaA. The hydrogen ion concentration of such a solution is given by the equation:

$$[H^+] = K_a \frac{[\text{Acid}]}{[\text{salt}]}$$

Taking log and reversing the signs, we have

$$-\log[H^+] = -\log K_a + \log \frac{[\text{salt}]}{[\text{Acid}]}$$

$$\therefore \text{pH} = \text{p}K_a + \log \frac{[\text{salt}]}{[\text{Acid}]}$$

This equation is called Henderson - Hasselbatch equation.

This equation enables the calculation of pH of a buffer solution made by mixing known quantities of a weak acid and its salt. Alternatively, it enables calculation of the ratio in which acid and salt must be mixed in order to get a buffer solution of a definite pH.

(2) Buffer mixture of a weak base and its salt

If a buffer solution consists of a mixture of a weak base and its salt, it can be easily shown that

$$[\text{OH}^-] = K_b \frac{[\text{Base}]}{[\text{salt}]}$$

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$$pOH = pK_b + \log \frac{[\text{salt}]}{[\text{Base}]}$$

Knowing pOH , the pH can easily be calculated from the relation

$$pH + pOH = pK_w = 14$$

Buffer capacity

The capacity of a solution to resist alteration in its pH is called its Buffer capacity.

Buffer index

A quantitative measure of the buffer capacity is called Buffer index.

Van Slyke introduced the quantity buffer index. Buffer index is denoted by β .

$$\therefore \beta = \frac{dB}{d(pH)}$$

Where dB is the increment of a strong base added to a buffer solution and $d(pH)$ is the resulting increment in pH . β is always a positive quantity.