

**Buffers, Types of Buffer Solutions, Solutions  
of Single Substance, Solutions of Mixtures,  
Importance.**

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- There is often a need of having a solution whose pH does not change appreciably with a change in conditions.
- A study of such solutions is essential to understand their behavior.
- This will help in utilizing such buffer solutions to resist change in pH for maintaining product stability.

# DEFINITION

- Solutions with stable hydrogen ion concentration and therefore usually with no change in pH which is almost independent of dilution and changing very little with small additions of a strong acid or alkali are called buffers.
- In simple terms it can also be defined as a solution which resists any change of pH when a small amount of a strong acid or a strong base is added to it, is called a buffer solution or simply as a buffer.
- Such as, ammonium acetate, have a tendency to resist any change in its hydronium ion concentration or pH, whenever a small amount of a strong acid or a strong base is added to it.
- Buffer solutions usually consist of a mixture of a weak acid and its salt with a strong base e.g.,  $\text{CH}_3\text{COOH}$  and  $\text{CH}_3\text{COONa}$ , or that of a weak base and its salt with a strong acid e.g.,  $\text{NH}_4\text{OH}$  and  $\text{NH}_4\text{Cl}$ .
- The solution of any salt of a weak acid and a weak base e.g., ammonium acetate, also shows buffering property.

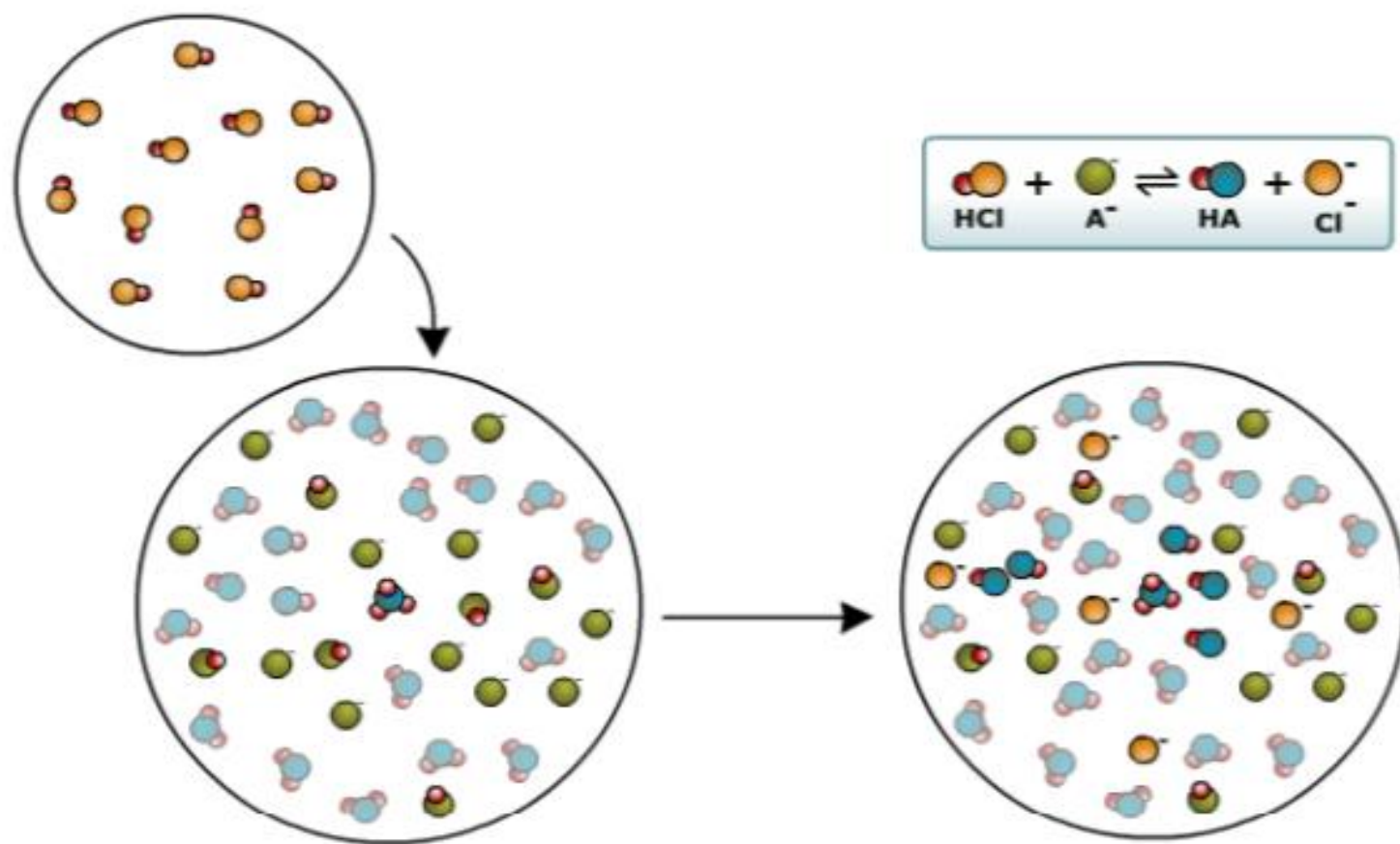
# TYPES OF BUFFERS

- There are two types of buffers, acid buffer and basic buffer.
- **Acid buffer:** A buffer solution containing large amounts of a weak acid, and its salt with a strong base, is termed as an acid buffer. Such buffer solutions have pH on the acidic side i.e., pH is less than 7 at 298 K. The pH of an acid buffer is given by the equation.  $\text{CH}_3\text{COOH}$  and  $\text{CH}_3\text{COONa}$

$$\text{pH} = \text{pK}_a + \ln \frac{[\text{salt}]}{[\text{acid}]}$$

Where  $K_a$  is the acid dissociation constant of the weak acid

Addition of a strong acid to the buffer solution



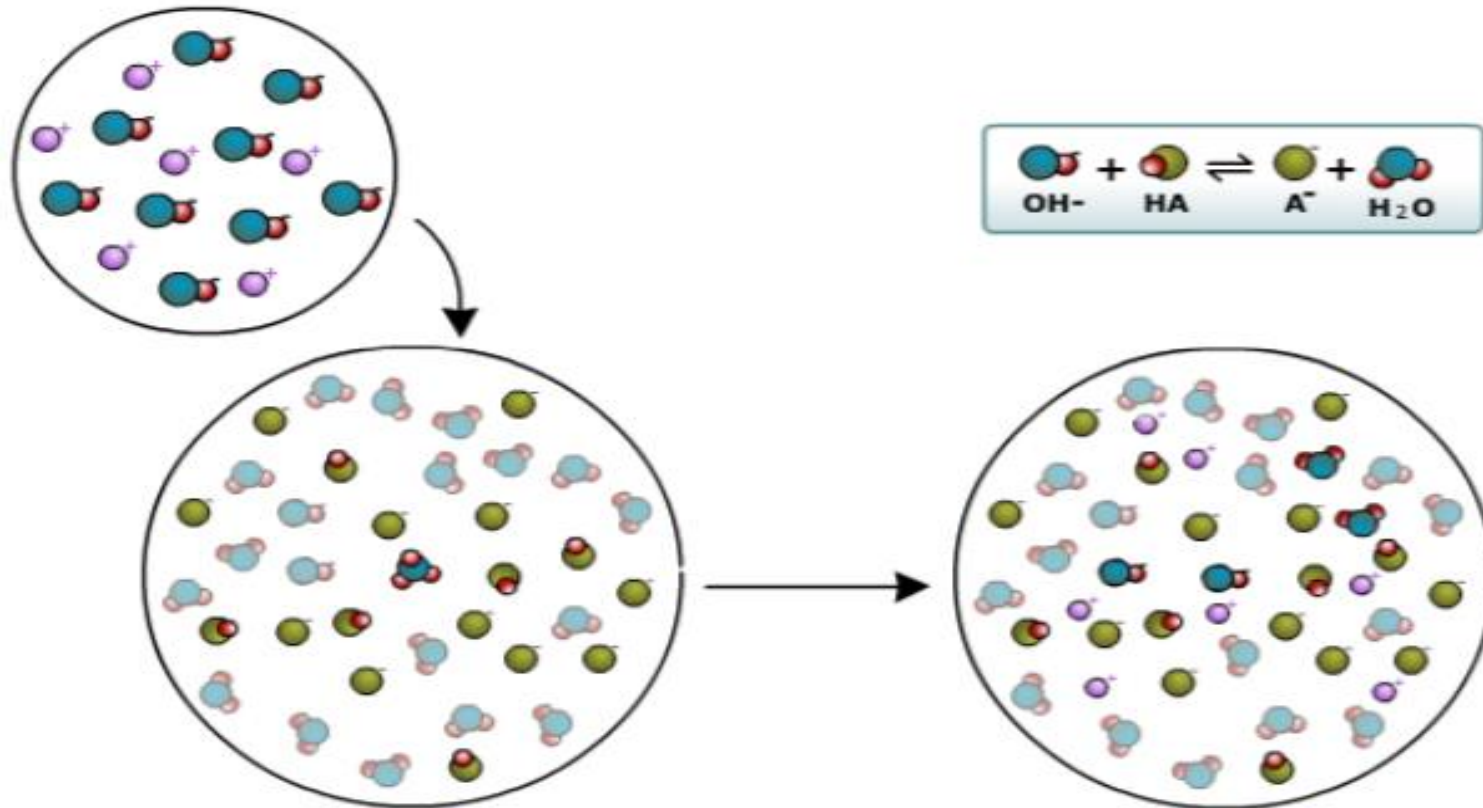
Acid Buffer

- **Basic Buffer:** A buffer solution containing relatively large amounts of a weak base and its salt with a strong acid is termed as a basic buffer. Such buffers have pH on the alkaline side i.e., pH is higher than 7 at 298 K. e.g.:  $\text{NH}_4\text{OH}$  and  $\text{NH}_4\text{Cl}$
- The pH of a basic buffer is given by the equation

$$\text{pOH} = \text{pK}_b + \ln \frac{[\text{salt}]}{[\text{acid}]}$$

Where  $K_b$  is the base dissociation constant of the weak base.

**Addition of a strong base to the buffer solution**



**Base Buffer**

# BUFFER-CAPACITY AND BUFFER-RANGE

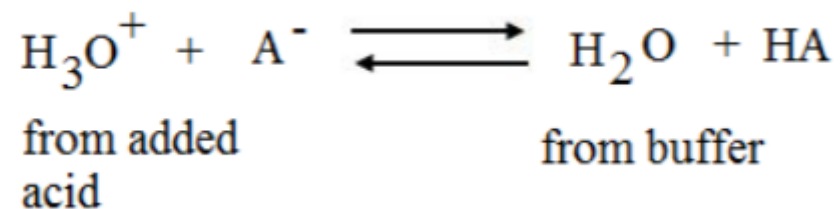
- The effectiveness of any buffer is described in terms of its **buffer capacity**.
- It is defined as, 'the number of equivalents of a strong acid (or a strong base) required to change the pH of one litre of a buffer solution by one unit, keeping the total amount of the acid and the salt in the buffer constant.'
- The buffer capacity of a buffer is maximum when acid to salt or base to salt ratio is equal to 1 i.e., it contains equal number of moles of acid (or base) and the salt.
- All buffer solutions remain effective over a small pH range: this pH-range is characteristic of the buffer and is termed as the **buffer-range**.



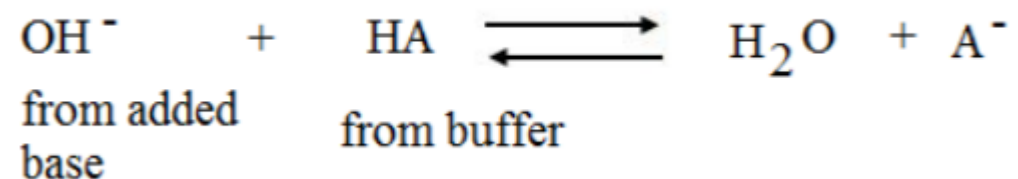
# MECHANISMS

## Action of an acid buffer:

- An acid buffer contains relatively large amounts of a weak acid (HA) and its salt with a strong base (say NaA).
- The buffer solution thus contains large concentration of HA and A<sup>-</sup> (due to the dissociation of the salt), apart from H<sub>3</sub>O<sup>+</sup> and OH<sup>-</sup>.
- An addition of small amount of a strong acid causes the reaction, to proceed in such a direction that an equivalent amount of A<sup>-</sup> combines with H<sub>3</sub>O<sup>+</sup> to give the same amount of undissociated weak acid, HA.
- Thus, the added acid is picked up by the anions (from the salt) present in large concentrations in the buffer. As long as the added strong acid is in smaller amounts, the changes in the concentrations of salt and that of the weak acid, (HA) are small.
- Therefore, the acid to salt ratio does not change appreciably by the addition of strong acid to the buffer solution. As a result, no noticeable change is seen in the pH value of the buffer.

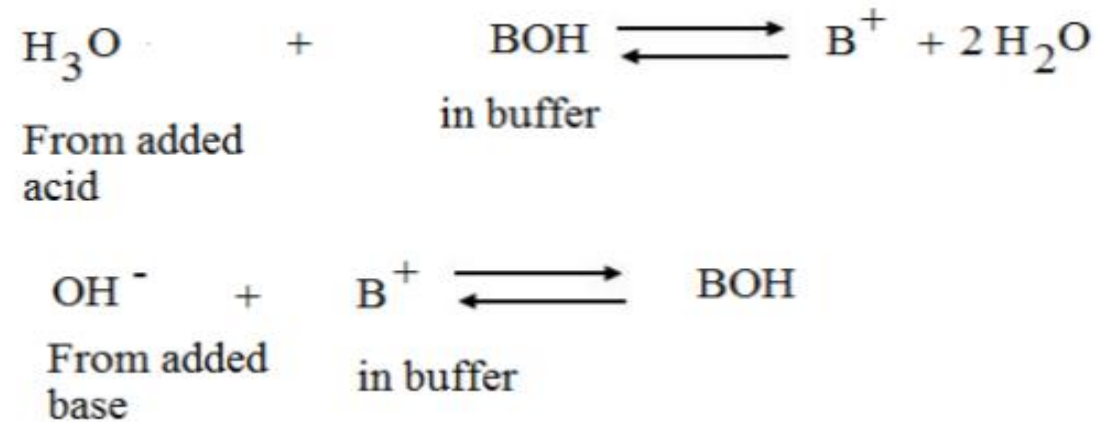


- Similarly addition of a strong base to an acid buffer on the other hand causes the reaction to proceed in the forward direction, resulting in the formation of an equivalent amount of the salt at the cost of the buffer acid.
- As long as the added base is in small amounts, the ratio of weak acid to salt remains virtually unchanged. As a result, no observable change in the pH value is seen.



# Action of basic buffer

- A basic buffer contains a weak base (BOH), and its salt with strong acid (BX). The buffer solution thus contains large amounts of the weak base BOH, and the cation B<sup>+</sup> (coming from the dissociation of the salt BX), in addition to H<sub>3</sub>O<sup>+</sup> and OH<sup>-</sup>. The addition of an acid or a base to the basic buffer causes the following reactions:



The reactions proceed in the forward direction. It is clear that the addition of an acid or a base to any buffer solution does cause a change in the concentrations of the buffer acid (or base) and the salt. But, because of the relatively much larger concentrations of these in the buffer solution, for all practical purposes, the ratio, [Salt] / [Acid] or [Salt] / [Base] remains constant. Hence, the pH does not change.

# IMPORTANCE OF BUFFERS

- Many chemical reactions are affected by the acidity of the solution in which they occur. In order for a particular reaction to occur or to occur at an appropriate rate, the pH of the reaction medium must be controlled.
- Such control is provided by buffer solutions, which are solutions that maintain a particular pH. Biochemical reactions are especially sensitive to pH.
- Most biological molecules contain groups of atoms that may be charged or neutral depending on pH, and whether these groups are charged or neutral has a significant effect on the biological activity of the molecule.
- In all multi cellular organisms, the fluid within the cell and the fluids surrounding the cells have a characteristic and nearly constant pH.
- This pH is maintained in a number of ways, and one of the most important is through buffer systems.