

# Buffers

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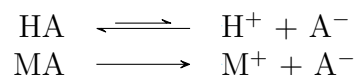
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## **1 Introduction**

Buffers are solutions that can resist a change in pH when small amounts of acid or base are added to them. They are required in many biological systems such as the circulatory systems.

## 2 Theory

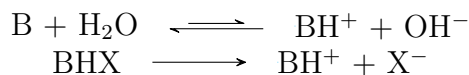
Acidic Buffers are made from a weak acid and its conjugate base:



Upon adding hydroxide ions ( $\text{OH}^-$ ), the concentration of hydroxonium ions ( $\text{H}^+$ ) reduces, by L.C.P, the equilibrium will move to the right to resist this change. Because most of the acid has not dissociated, plenty of molecules can still break down to supply hydroxonium ions ( $\text{H}^+$ ).

On adding hydroxonium ions ( $\text{H}^+$ ), by L.C.P, the position of the equilibrium wants to move to the left to use up the extra hydroxonium ions ( $\text{H}^+$ ). However we need the conjugate base ( $\text{A}^-$ ) to react with the extra hydroxonium ions ( $\text{H}^+$ ). The acid does not produce any conjugate base ( $\text{A}^-$ ) to react with the extra hydroxonium ions ( $\text{H}^+$ ) added. Therefore we need a secondary source of conjugate base ( $\text{A}^-$ ), which comes from the salt.

Basic Buffers are made from a weak base and its conjugate acid:



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On adding hydroxide ions ( $\text{OH}^-$ ), by L.C.P, the position of the equilibrium wants to move to the left to use up the extra hydroxide ions ( $\text{OH}^-$ ). However we need the conjugate acid ( $\text{BH}^+$ ) to react with the extra hydroxide ions ( $\text{OH}^-$ ). The acid does not produce any conjugate acid ( $\text{BH}^+$ ) to react with the extra hydroxide ions ( $\text{OH}^-$ ) added. Therefore we need a secondary source of conjugate acid ( $\text{BH}^+$ ), which comes from the salt.

The pH of Buffer Solutions:

$$K_a = \frac{[H^+][A^-]}{[HA]} \quad (1)$$

The value of  $K_a$  is a representation of how far the weak acid dissociates. With our knowledge of buffers, we can say that:

$$[HA]_{\text{equilibrium}} \simeq [HA]_{\text{initial}} \quad (2)$$

because very little of the acid dissociates. We can also say that:

$$[A^-]_{\text{equilibrium}} \simeq [A^-]_{\text{initial}} \quad (3)$$

because since there is a weak acid that does not dissociate significantly, only few extra conjugate base ( $A^-$ ) at equilibrium are added. We can now say that:

$$K_a = \frac{[H^+][\text{conc.base}]}{[\text{Acid}]} \quad (4)$$

$$K_a \cdot [\text{Acid}] = [H^+][\text{conc.base}] \quad (5)$$

$$K_a \cdot \frac{[\text{Acid}]}{[\text{Base}]} = [H^+] \quad (6)$$

$$-\log[H^+] = -\log\left(K_a \cdot \frac{[\text{Acid}]}{[\text{Base}]}\right) \quad (7)$$

$$pH = -\log(K_a) - \log\left(\frac{[\text{Acid}]}{[\text{Base}]}\right) \quad (8)$$

$$pH = pK_a - \log\frac{[\text{Acid}]}{[\text{Base}]} \quad (9)$$