Al-Mustaqbal University College
Department of Radiology Techniques

First Stage

# General Chemistry

## Fifth Lecture


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# BUFFER SOLUTIONS

**Buffer Solution:** is a solution that **resist** any **change in pH** (**maintain pH approximately constant**) when added amount of an acid or base.

**Buffer Solutions divided into two types:**

## Buffer Solutions

### Acidic Buffers

are made from a **weak acid and its salts.**

**Example:**
$CH_3COOH - CH_3COONa$

- $CH_3COOH$ (weak acid)
- $CH_3COONa$ (salt)

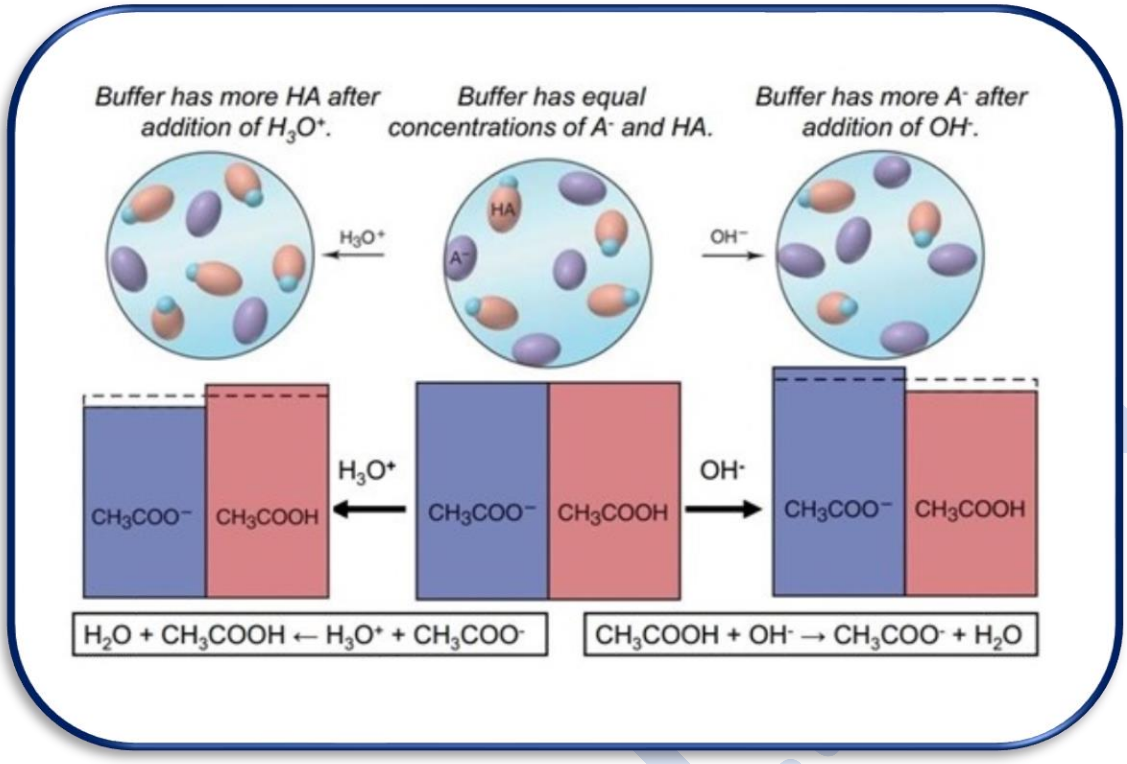
### Basic Buffers

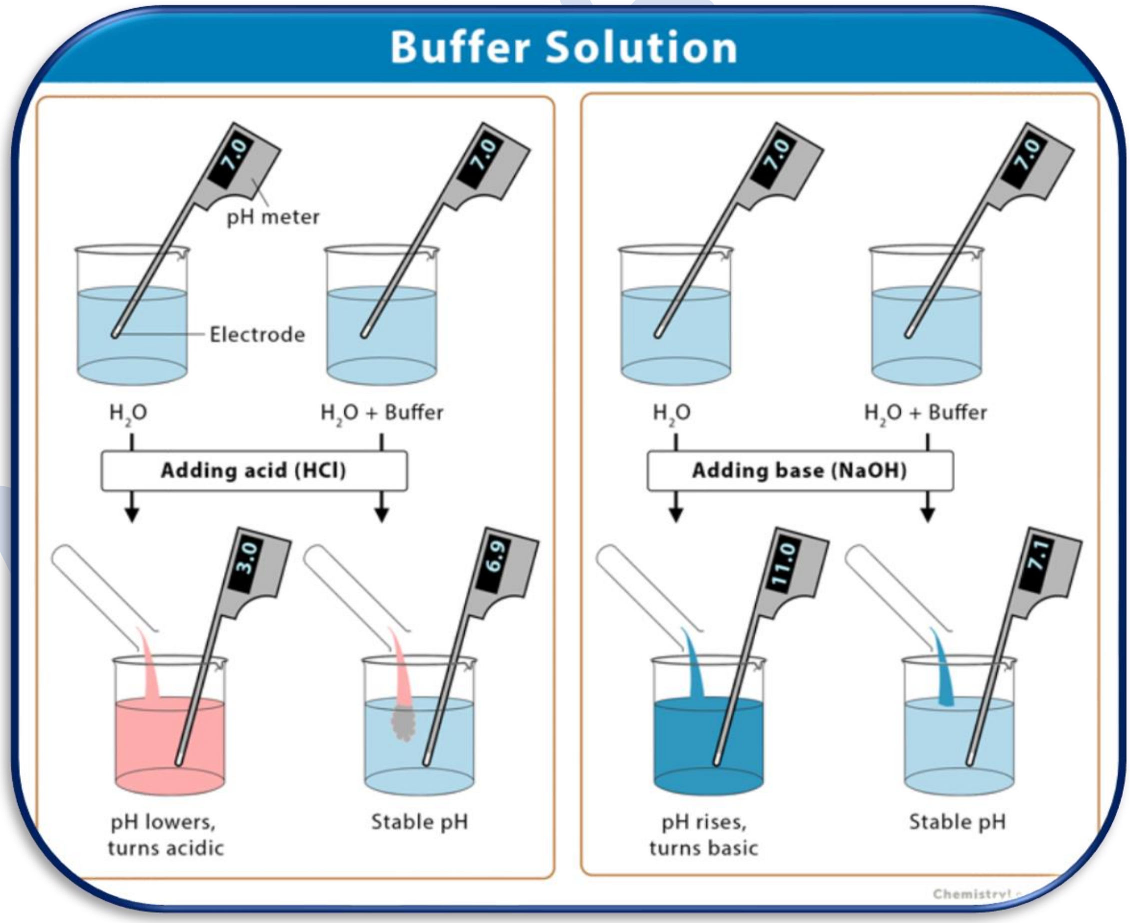
are made from a **weak base and its salts.**

**Example:**
$NH_3 - NH_4Cl$

- $NH_3$ (weak base)
- $NH_4Cl$ (salt)

***How a buffer works?***


Buffer has more HA after addition of $H_3O^+$.
Buffer has equal concentrations of $A^-$ and HA.
Buffer has more $A^-$ after addition of $OH^-$.
HA
$A^-$
$H_3O^+$
$OH^-$
$CH_3COO^-$
$CH_3COOH$
$H_3O^+$
$CH_3COO^-$
$CH_3COOH$
$OH^-$
$CH_3COO^-$
$CH_3COOH$
$H_2O + CH_3COOH \leftarrow H_3O^+ + CH_3COO^-$
$CH_3COOH + OH^- \rightarrow CH_3COO^- + H_2O$


Buffer Solution
7.0
pH meter
Electrode
$H_2O$
$H_2O$ + Buffer
Adding acid (HCl)
3.0
6.9
pH lowers, turns acidic
Stable pH
$H_2O$
$H_2O$ + Buffer
Adding base (NaOH)
11.0
7.1
pH rises, turns basic
Stable pH

**The Henderson-Hasselbalch equation is an equation that is often used to perform the calculations required in preparation of buffers for use in the laboratory.**

***Buffer solution that formed of weak acid and its salt:***

$$CH_3COOH + H_2O \rightleftarrows CH_3COO^- + H_3O^+$$

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

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

**Or**

$$[H^+] = K_a \times \frac{[HA]}{[A^-]} \quad \begin{matrix} \text{acid} \\ \text{salt} \end{matrix}$$

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

***Multiply by −1***

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

$$\therefore \quad pH = pK_a + \log\frac{[\text{salt}]}{[\text{acid}]}$$

## *Buffer solution formed of weak base and its salt:*

$$NH_3 + H_2O \rightleftharpoons NH^+_4 + OH^-$$

$$NH_4Cl \longrightarrow NH^+_4 + Cl^-$$

$$K_b = \frac{[NH_4^+][OH^-]}{[NH_3]}$$

**Or**

$$K_b x \frac{[NH_3]}{[NH_4^+]} = [OH^-]$$

$$\log[OH^-] = \log K_b + \log\frac{[base]}{[salt]}$$

***Multiply by −1***

$$-\log[OH^-] = -\log K_b + \log\frac{[salt]}{[base]}$$

$$\therefore \quad pOH = pK_b + \log\frac{[salt]}{[base]}$$

## Solved Problems

**Problem 1/ Calculate the pH of buffer of 0.3M $CH_3COONa$ in 0.09M $CH_3COOH$? $K_a = 1.8\times10^{-5}$**

**Solution:**

$$pH = pK_a + \log\frac{[salt]}{[acid]}$$

$$pH = -\log 1.8\times10^{-5} + \log (0.3 / 0.09)$$

$$pH = 4.74 + 0.522$$

$$pH = 5.262$$

**Problem 2/** **Calculate the pH of buffer of 0.28M $NH_4Cl$ in 0.07M $NH_3$? $K_b = 1.76\times10^{-5}$**

## Solution:

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

$$pOH = -\log 1.76\times10^{-5} + \log(0.28 / 0.07)$$

$$pOH = 4.75 + 0.602$$

$$pOH = 5.352$$

$$pH = 14 - 5.352$$

$$pH = 8.648$$