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# Buffer Solution

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# Objectives

- Introduction
- Buffer equation
- Drugs as buffer
- Buffer capacity
- Buffer and biological system.



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## Introduction

- Buffers are compounds or mixtures of compounds that, by their presence in solution, resist the changes in pH upon the addition of small quantities of acids or alkali.
- The resistance to a change in pH is known as **buffer action**.
- While if a small amount of a strong acid or base, is added to water or NaCl solution, the pH is altered considerably (there is no buffer action).

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- Example on buffer (w.a. + its conjugate base or salt) or (w.b. + its conjugate acid or salt).
- Then if 1 ml of 0.1N HCl solution is added to a pure water (100 ml), the pH changes from 7 to 3.
- But, if this acid is added to 0.01M solution containing equal quantities of acetic acid and sodium acetate, the pH changes only 0.09 unit.

Here, $[Ac^-]$ spp. Will reduce $[H_3O^+]$ spp. As in eq.

$$Ac^- + H_3O^+ \Leftrightarrow HAc + H_2O$$

while if a strong base like NaOH is added to the same buffer, acetic acid spp. will neutralize the $[OH^-]$ spp. As in:

$$HAc + OH^- \Leftrightarrow H_2O + Ac^-$$

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## The buffer equation

- Buffer equation is used for calculation of the pH of a buffer solution and the change in pH upon the addition of an acid or base.
- This expression is developed by considering the effect of a salt on the ionization of a weak acid when the salt and acid have an ion in common. **Ex. Sodium acetate is added to acetic acid solution.**

$$HAc + H_2O \Leftrightarrow H_3O^+ + \underline{Ac^-}$$

$$NaAc + H_2O \rightarrow Na^+ + \underline{Ac^-}$$

$$Ka = \frac{[H3O^+][Ac^-]}{[HAc]} \quad \text{or} \quad [H_3O^+] = Ka\,\frac{[HAc]}{[Ac^-]}$$

[HAc]= the total conc. of acid = [acid]

$[Ac^-]$= [salt] mainly obtained from salt where one mole salt give one mole $Ac^-$ ion.

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$$[H_3O^+] = Ka \frac{[Acid]}{[Salt} \quad \text{(multiplied by –Log)}$$

$$-\log [H_3O^+] = -\log \{Ka \frac{[Acid]}{[Salt}\}$$

$$-\log [H_3O^+] = -\log Ka - \log \frac{[Acid]}{[Salt}$$

$$pH = pKa + \log \frac{[Salt]}{[Acid]}$$

**Is the buffer equation used for weak acid and its salt (Handerson-Hasselbalch equation)**
**Where pKa represents the dissociation exponent**

**For weak base and its salt**
**Prove that????**
**Note: pKa+pKb=pKw=14**

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**Q. What is the molar ratio [Salt]/[Acid] required to prepare an acetate buffer at pH= 5 (pKa= 4.76)**

$$5.0 = 4.76 + \log \frac{[Salt]}{[Acid]}$$

$$\log \frac{[Salt]}{[Acid]} = 5.0 - 4.76 = 0.24$$

$$\frac{[Salt]}{[Acid]} = \text{antilog } 0.24 = 1.74$$

Therefore, the mole ratio of salt to acid is 1.74/1. Mole percent is mole fraction multiplied by 100. The mole fraction of salt in the salt–acid mixture is 1.74/(1 + 1.74) = 0.635, and in mole percent, the result is 63.5%.

**Q/ Why the buffer solutions are not ordinarily prepared from weak bases and their salts?**

**Because of:**

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# Factors affecting pH of buffer solutions

1) Addition of neutral salt, can change pH by altering the ------------------------
2) Dilution (water addition), can change pH by altering the ionic strength (depending on the dilution value), so we have positive dilution (↑ $pH$) and negative dilution (↓ pH).
3) Temperature, can affect the basic buffers more than acidic one by affecting Kw value.

**Acetate buffer pH increase with temp. while borate buffer pH decrease**

Note: **Dilution value**: is the change in pH on diluting the buffer solution to one half of its original strength.





# Drugs as Buffer

- Drugs solutions which are weak electrolytes can manifest buffer action. Like:

1) Salicylic acid solution in the soft glass bottles that contains sodium It expected to increase the alkalinity by formation of sodium salicylate ( ↑ pH).
2) Solution of ephedrine base has buffer action that can resist the pH changes. Also, addition of hydrochloric acid HCl, can form ephedrine HCl salt, the we have weak base and salt.

- **Note/ These actions are often weak (only one definite pH range) to contract the pH changes brought about by $CO_2$ of the air and the bottle alkalinity, so the buffers must be added.**