BRAC UNIVERSITY

Inspiring Excellence

Acid-Base Concept

Part-02

Course: CHE101: Introduction To Chemistry

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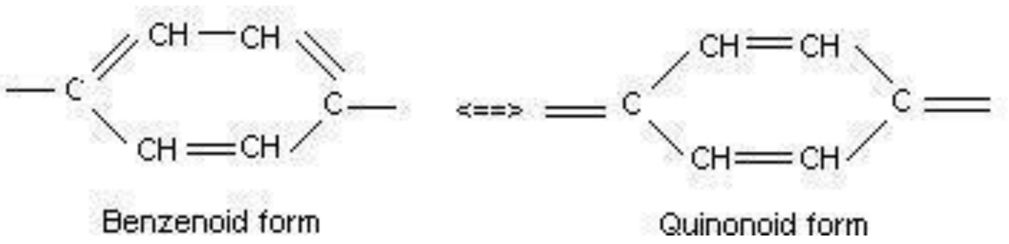
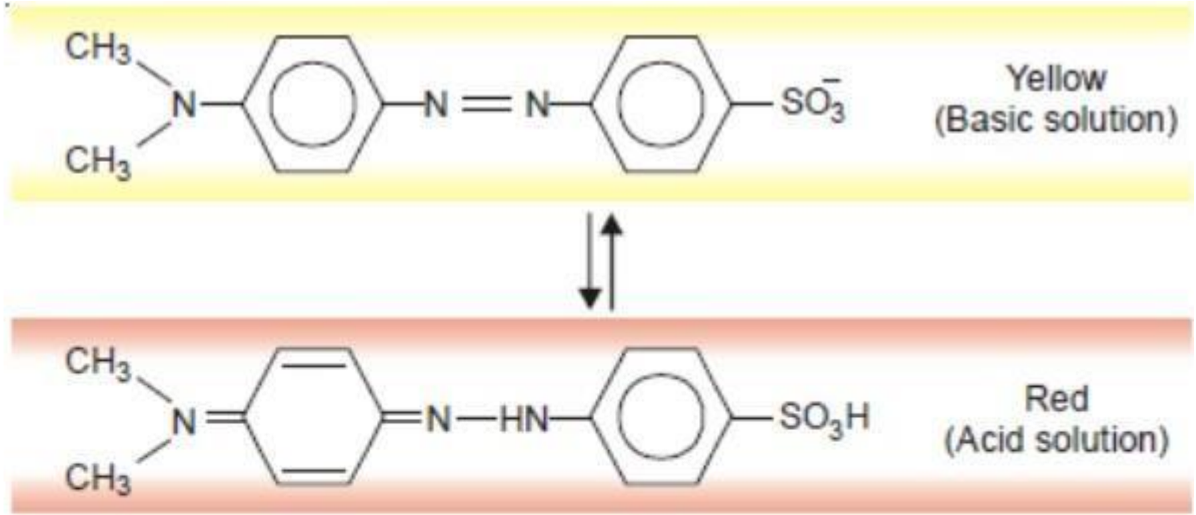
Quinonoid theory

a) The acid-base indicators exist in two tautomeric forms having different structures. Two forms are in equilibrium. One form is termed **benzenoid form** (light colour) and the other **quinonoid form** (deep colour).

b) The two forms have different colors. The color change in due to the interconversation of one tautomeric form into other

c) One form mainly exists in acidic medium and the other in alkaline medium.





Relative strength of acids

The strength of an acid is defined as the concentration of H+ ions in its aqueous solution at a given temperature.

The strength of an acid depends on its ability to transfer its proton (H+) to a base to form its conjugate base. When a monoprotic acid (HA) dissolves in water, it transfers its proton to water (a Bronsted base) to form hydronium ion (H3O+) and a conjugate base.

ACIDS AND BASES

$$HA + H_2O \rightleftharpoons H_3O^+ + \underset{\text{conjugate base}}{A^-}$$

For simplifying our discussion, we take

$$H_3O^+ = H^+$$

Thus we can write the equilibrium reaction (1) as

$$HA + H_2O \rightleftharpoons H^+ + A^-$$

This equation represents the dissociation of the acid HA into H^+ ion and A^- ion.

Applying the Law of Mass action to the acid dissociation equilibrium, we can write

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

Calculation of Relative strength of Weak acids from Ka

Since $[H^+]$ is a measure of acid strength and it depends on the degree of dissociation α, we can write

$$\frac{\text{Strength of acid 1}}{\text{Strength of acid 2}} = \sqrt{\frac{K_1}{K_2}}$$

Evidently, **the ratio $\sqrt{K_1/K_2}$ would give us the relative strengths of the two acids.**

SOLVED PROBLEM 1. The dissociation constants of formic acid and acetic acid are 21.4×10^{-5} and 1.81×10^{-5} respectively. Find the relative strengths of the acids.

SOLUTION

$$\frac{\text{Strength of HCOOH}}{\text{Strength of } CH_3COOH} = \sqrt{\frac{K_{HCOOH}}{K_{CH_3COOH}}}$$

$$= \sqrt{\frac{21.4 \times 10^{-5}}{1.81 \times 10^{-5}}}$$

$$= 3.438$$

Thus formic acid is **3.438** times stronger than acetic acid.

SOLVED PROBLEM 2. Two hypothetical acids HA and HB have the dissociation constants 1×10^{-3} and 1×10^{-5} respectively in water at 25°C. Calculate the strength of HA with respect to HB.

SOLUTION

$$\frac{\text{Strength of HA}}{\text{Strength of HB}} = \sqrt{\frac{K_{HA}}{K_{HB}}}$$

$$= \sqrt{\frac{1 \times 10^{-3}}{1 \times 10^{-5}}}$$

$$= \mathbf{10}$$

Thus HA is ten times stronger than HB.

Relative strength of bases

The strength of a base is defined as the concentration of OH– ions in its aqueous solution at a given temperature.

According to the Arrhenius concept, a base is a substance which produces OH^- ions in aqueous solution. The basic properties of such a substance are due to these hydroxyl ions. Let us consider a base BOH whose dissociation can be represented as

$$BOH \rightleftharpoons B^+ + OH^- \quad ...(1)$$

Applying the Law of Mass action to the above equilibrium we can write the equilibrium expression as

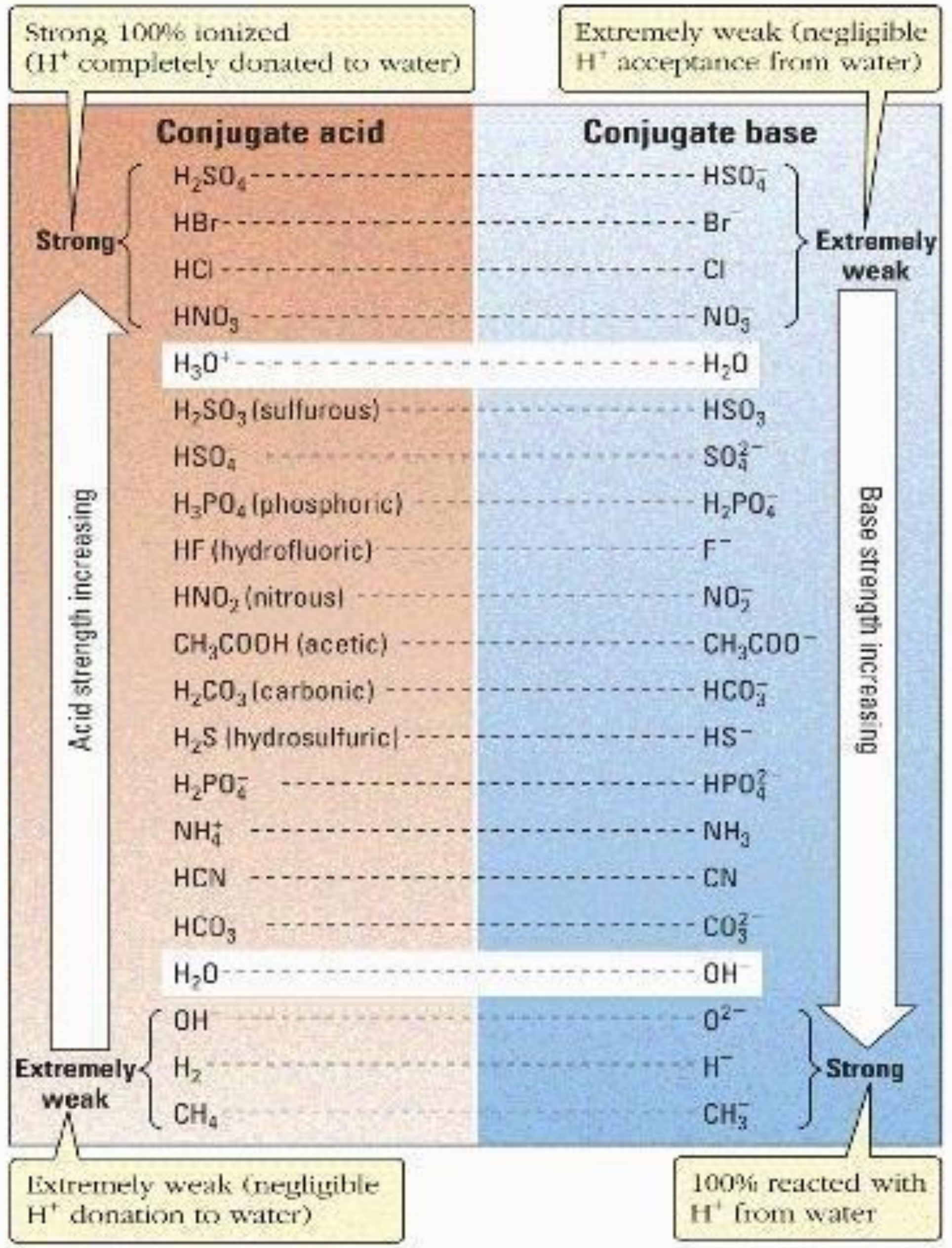
$$K_b = \frac{[B^+][OH^-]}{[BOH]} \quad ...(2)$$

From the equilibrium expression (2), it is evident that the concentration of OH^- ions, $[OH^-]$, depends on the value of K_b. Therefore, the value of K_b for a certain base is a measure of its base strength. In the aqueous solution of a strong base, practically all the original base is dissociated and the value of K_b is large. In the case of a weak base, it is dissociated in aqueous solution to a very small extent and the value of K_b is also small.

Relative Strengths of Acid and Bases

As acid strength decreases, base strength increases;
the weaker the acid, the stronger its conjugate base.

As base strength decreases, acid strength increases;
the weaker the base, the stronger its conjugate acid.



UA GenChem

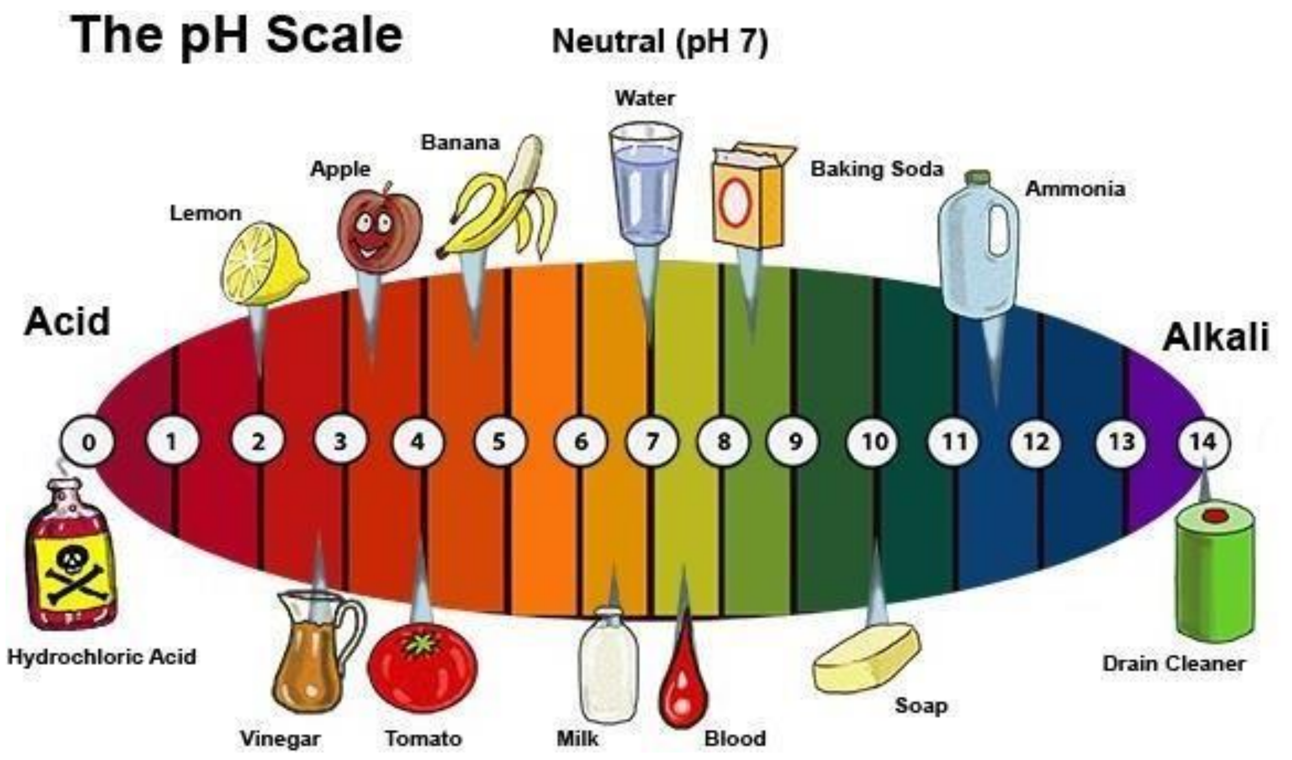
pH scale

The pH scale, (0 - 14), is the full set of pH numbers which indicate the concentration of H^+ and OH^- ions in water.

pH Scale Principle

- **H^+ ion concentration and pH relate inversely**
- **OH^- ion concentration and pH relate directly.**

a. Increasing pH means the H^+ ions are decreasing.
b. Decreasing pH means H^+ ions are increasing.
c. Increasing pH means OH^- ions are……………….....?
d. Decreasing pH means OH^- ions are……………….?



Buffer solution

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

- We can add a small amount of an acid or base to a buffer solution and the pH will change very little.

- a weak acid together with a salt of the same acid with a strong base. These are called Acid buffers e.g., $CH_3COOH + CH_3COONa$.

- a weak base and its salt with a strong acid. These are called Basic buffers. e.g., $NH_4OH + NH_4Cl$.

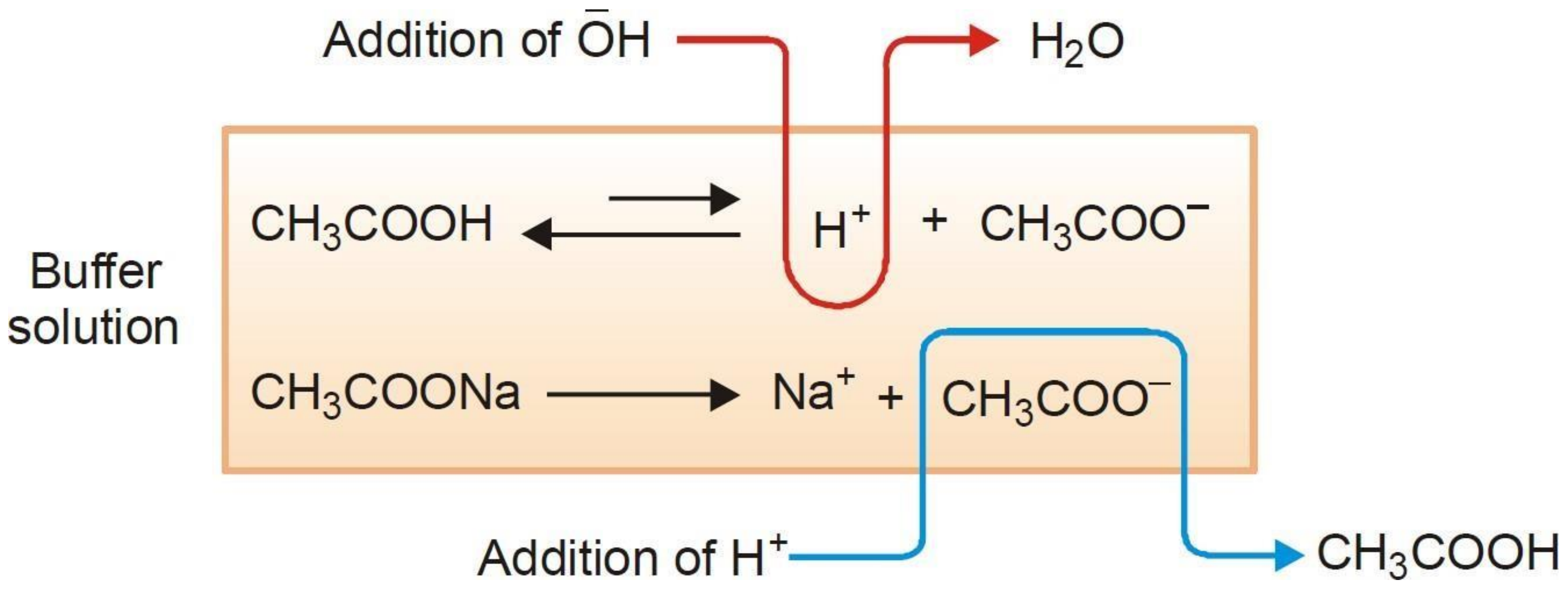
- **Acid Buffer= Weak acid + Its salt**
- **Base Buffer= Weak Base + Its salt**

How a buffer operates:

For acid buffer

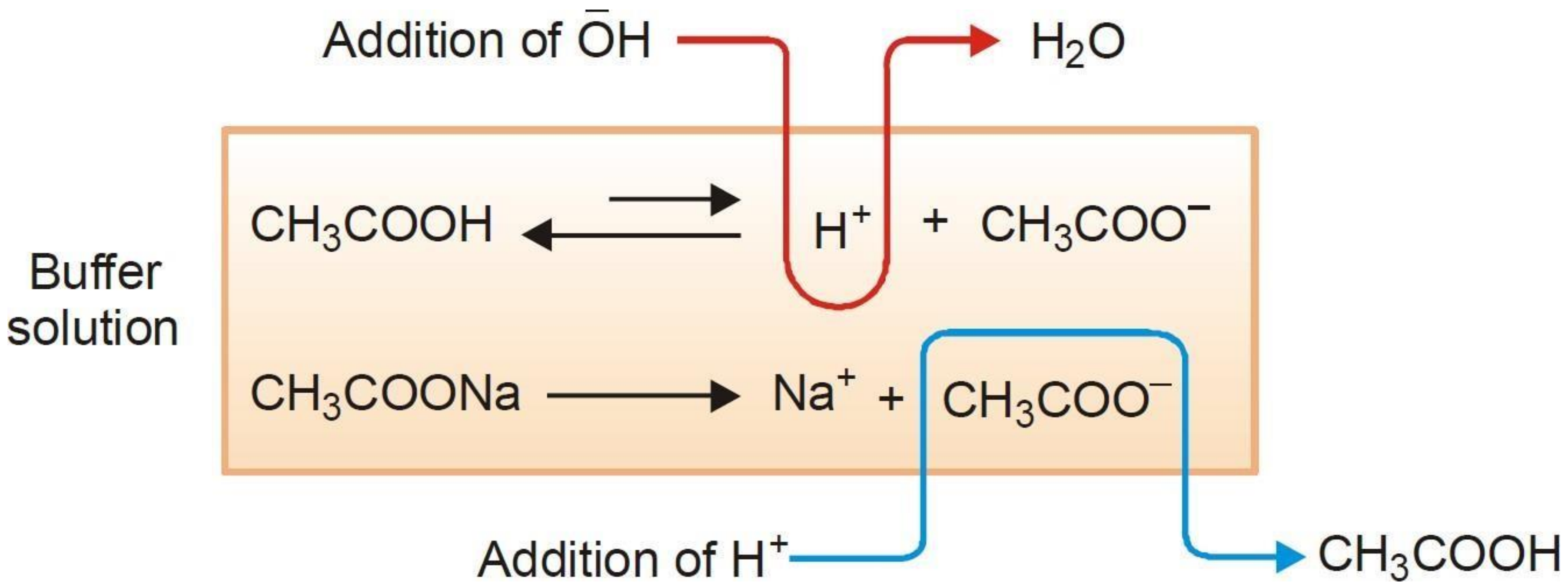
Addition of H+

H+	OH-	Mechanism
1	0	Normal State
2	0	Addition of H+ (transition state)
1	0	Formation of CH_3COOH



Addition of OH-

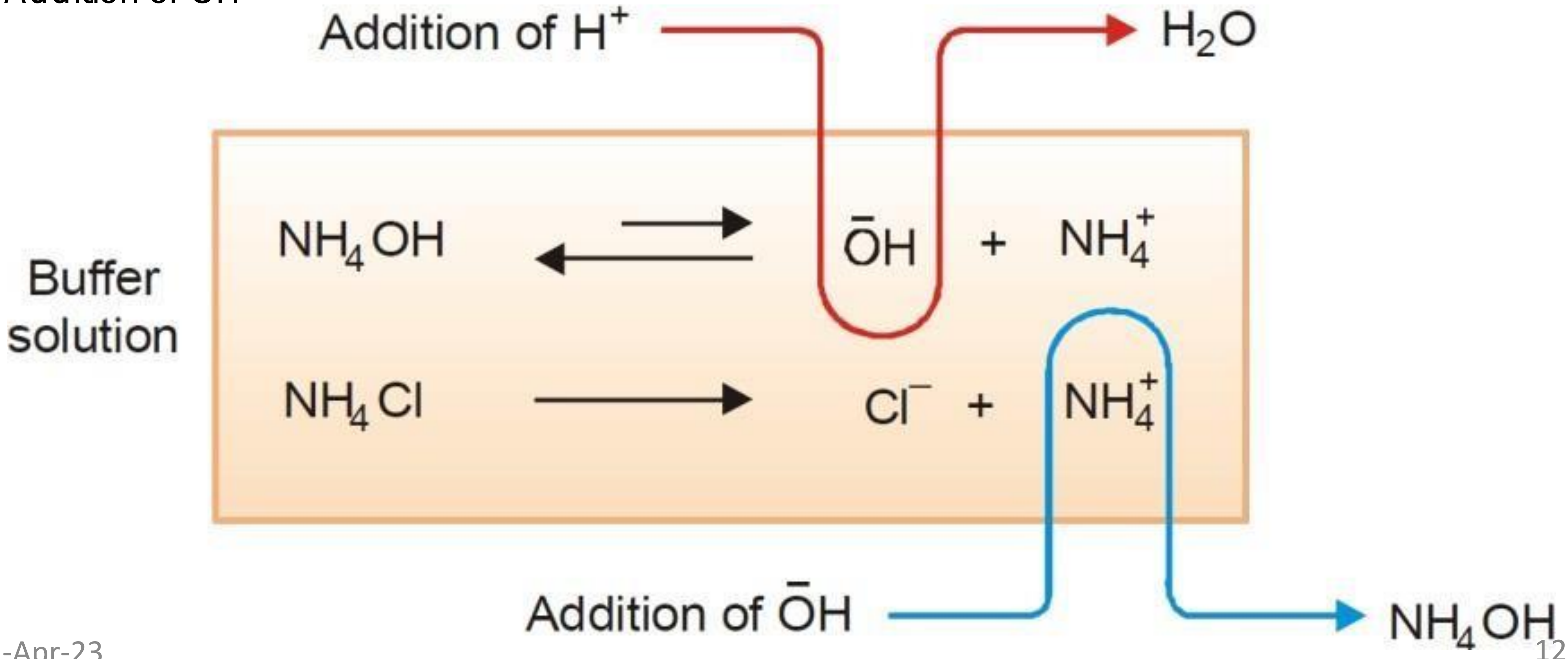
H+	OH-	Mechanism
1	0	Normal State
1	1	Addition of OH- (transition state)
0	0	Formation of H_2O (transition state)
1	0	Formation of H+ & CH_3COO^- from old CH_3COOH



How a buffer operates:

For base buffer

1. Addition of H+
2. Addition of OH-



Color of METHYL ORANGE is ______in highly acidic pH.

a. Red
b. Yellow
c. Orange

a. Red

Increasing pH means OH- ions are……………………....

a. Decreasing
b. Increasing
c. Unchanged

b. Increasing

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

a. True
b. False

a. True

T H A N K S