

**Objective:** Prepare buffer solutions using acetic acid and sodium acetate in the entire compositional range and determine the pH of the given unknown solution by colour matching.

**Requirements:** NaOH solution, Acetic acid solution, Sodium acetate, indicators etc.

**Theory:** Buffer solutions are those solutions, which reserve their acidity and alkalinity on addition of acid or alkali.

In this experiment, a series of buffer solutions are prepared by mixing different volumes of equimolar solutions of acetic acid and sodium acetate. Acetic acid is slightly dissociated while sodium acetate being a salt is almost completely dissociated. Thus, the mixture contains  $\text{CH}_3\text{COOH}$ ,  $\text{CH}_3\text{COO}^-$  and  $\text{Na}^+$  ions.

The  $\text{H}^+$  ion concentration or pH of the prepared buffer can be calculated by Henderson Equation as follows:

If the weak acid is HA and its salt is BA, then



$$\text{Hence, } k_a = \frac{[\text{H}_3\text{O}^+][\text{A}^-]}{[\text{HA}]} \quad (k_a = \text{dissociation constant of weak acid, HA})$$

$$\text{i.e., } [\text{H}_3\text{O}^+] = k_a \frac{[\text{HA}]}{[\text{A}^-]}$$

Since,  $[\text{A}^-] = [\text{BA}]$  (due to ionization of salt BA, the dissociation of weak acid, HA is further suppressed, a common ion effect),

$$[\text{H}_3\text{O}^+] = k_a \frac{[\text{HA}]}{[\text{BA}]} = k_a \frac{[\text{acid}]}{[\text{salt}]}$$

$$-\log[\text{H}_3\text{O}^+] = -\log k_a - \log \frac{[\text{acid}]}{[\text{salt}]}$$

$$\text{pH} = \text{p}k_a + \log \frac{[\text{salt}]}{[\text{acid}]} \quad (\text{This equation is known as Henderson Equation.})$$

( $\text{pH} = -\log[\text{H}_3\text{O}^+]$ ). The pH of a solution is the negative logarithm (to base 10) of the concentration of hydrogen ions (in moles per liter) that it contains.)

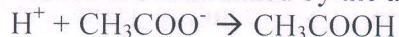
Since, we have prepared equimolar solution of salt (sodium acetate) and acid (acetic acid), the above equation can be written as

$$\text{pH} = \text{p}k_a + \log \frac{[\text{vol. of salt solution}]}{[\text{vol. of acid solution}]} \quad [k_a = 1.8 \times 10^{-5} \text{ for acetic acid, hence, } \text{p}k_a = 4.75]$$

Using this equation, the pH of the prepared buffer solution can be determined.

Action of the prepared buffer on addition of acid and base:

i) the  $\text{H}^+$  added are neutralized by the acetate ions present in the mixture



ii) the  $\text{OH}^-$  ions added are neutralized by acetic acid present in the mixture

