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 CH_3COOH, CH_3COO^- and Na^+ ions.

The 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

$HA + H_2O \leftrightarrow H_3O^+ + A^-$

$BA \rightarrow B^+ + A^-$

Hence, $k_a = \frac{[H_3O^+][A^-]}{[HA]}$ (k_a=dissociation constant of weak acid, HA)

i.e., $[H_3O^+] = k_a \frac{[HA]}{[A^-]}$

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

$[H_3O^+] = k_a \frac{[HA]}{[BA]} = k_a \frac{[acid]}{[salt]}$

$-\log[H_3O^+] = -\log k_a - \log \frac{[acid]}{[salt]}$

$pH = pk_a + \log \frac{[salt]}{[acid]}$ (This equation is known as *Henderson Equation.*)

(pH= $-\log[H_3O^+]$,.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

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

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 H^+ added are neutralized by the acetate ions present in the mixture

$H^+ + CH_3COO^- \rightarrow CH_3COOH$

ii) the OH^- ions added are neutralized by acetic acid present in the mixture

$OH^- + CH_3COOH \rightarrow CH3COO^- + H_2O$

Procedure:

1. Standardization of NaOH (given ~0.4-0.5N) and acetic acid (give ~0.4-0.5N) by standard oxalic acid solution (to be prepared by the students, 1.2600gm in 100ml→ 0.2N. Use phenolphthalene indicator for the acid base titration.)
2. Prepare 'exact' 100ml of 0.4N NaOH solution and 100ml of 0.4N acetic acid solution.
3. Prepare 100ml 0.2N sodium acetate (by mixing 50ml of 0.4N NaOH solution and 50ml of 0.4N acetic acid solution.
4. Prepare 100ml 0.2N acetic acid solution (by mixing 50ml of distilled water in 50ml of 0.4N acetic acid solution.
5. Prepare the following buffer solutions:

Test Tube	1	2	3	4	5	6	7	8	9
Vol. of sod. acetate solution	9	8	7	6	5	4	3	2	1
Vol. of acetic acid solution	1	2	3	4	5	6	7	8	9
pH (cal.)	5.70	5.35	5.12	4.93	4.75	4.56	4.38	4.15	3.79

6. Add two drops of methyl red indicator in each test tube.
7. Take unknown buffer solution and add two drops of methyl red indicator.
8. Compare the colour and report the pH of the unknown buffer solution.

Calculation:
Calculate the pH of the solution of each test tube and then enter in the above table.

Observation: The colour of the test tube number 10 (unknow pH buffer solution) closely matches with that of test tube number X.

Result: The pH of the supplied buffer solution was found to be .....

Extra information (various buffers solution and their pH ranges):

pH range	Components
1-2	HCl + KCl
3	Na_2HPO_4 + Citric acid
4-6	Acetic acid+ Sodium acetate
7-9	Borax + (H_3BO_3 + NaCl)
10	$NaHCO_3$ + Na_2CO_3 (equal part)

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