

Experiment No. 4

To prepare standard buffer solutions using acetic acid and sodium acetate, and to measure the pH of the given unknown solution using universal indicator .

Apparatus required:

- (1) Pipette, (2) Burette, (3) Conical flask, (4) Beaker,
- (5) Test tubes (6) Stand

Chemicals required:

1. Standard NaOH solution
2. Acetic acid solution
3. Sodium acetate solution
4. Phenolphthalein indicator
5. Universal indicator

Theory :

The solution which has a constant pH and resist change in pH even on addition of small amount of acid or base is known as buffer solution. Buffer solution is a mixture of weak acid or base with it's strong salt. Hence, buffer solutions are two types:

- 1) Acidic buffer
- 2) Basic buffer

Acidic buffer: It consists of weak acid with a salt of acid like aqueous solution of acetic acid and sodium acetate.

Basic buffer: It consists of weak base with a salt of base like aqueous solution of ammonium hydroxide and ammonium chloride.

In the laboratory, buffers are mainly used to prepare the solution of known stable pH. Buffer solutions are also used in many industrial processes like dyeing, fermentation process, food industry, pharmaceuticals etc.

The pH of a buffer consisting of a weak acid and its salt can be calculated by using the Henderson equation

$$\text{pH} = \text{pK}_a + \log_{10} \frac{[\text{salt}]}{[\text{acid}]} \dots\dots\dots (1)$$

Where, $\text{pK}_a = -\log \text{K}_a$ of weak acid

$[\text{salt}]$ = molar concentration of the salt

$[\text{acid}]$ = molar concentration of the weak acid

In the indicator method, a series of the standard buffer solutions are prepared and the universal indicator is added to each of them. Then the same amounts of the universal indicator is added to the equal volumes of the unknown solution pH is determined by matching the color against the standard solutions. Solutions having the same pH have the same color.

Procedure:

1. Prepare 100 ml of an acetic acid solution of approximately 0.4 M strength in a beaker. Standardize it against a standard 0.4 M NaOH solution using phenolphthalein as the indicator. From this acetic acid, prepare 100 ml. of exactly 0.2M acetic acid by taking the required volume of acid from the burette and making up to the mark by the addition of water.
2. 100 ml. of exactly 0.2 M sodium acetate is supplied.
3. Prepare a series of standard buffer solutions by mixing different volumes of 0.2 M acetic acid and 0.2M sodium acetate as given in the following Table and calculate the value of each by using the Henderson equation (1) given above.
4. Mark the test tubes as 1, 2, 3,9 and place them in a test tube stand serially.
5. Put 5 drops of the universal indicator in each of them.
6. Now take 10 ml of the given unknown solution in another test tube and add 5 drops of the universal indicator in it.

Determine the pH of the unknown solution by matching the color against the standards.

Observation Table :

pKa of acetic acid = 4.74

Test tube No.	Vol. of 0.2 M acetic acid (ml)	Vol. of 0.2 M sodium acetate (ml)	$\text{pH} = \text{pKa} + \log \frac{[\text{salt}]}{[\text{acid}]}$	pH of the unknown solution
1	9	1		
2	8	2		
3	7	3		
4	6	4		
5	5	5		
6	4	6		
7	3	7		
8	2	8		
9	1	9		

Calculations :

For buffer no. 1

$$\text{pH} = 4.74 + \log 1/9 = 4.74 + (- 0.95) = 3.78$$

For buffer no. 2,

$$\text{pH} = 4.74 + \log 2/8 =$$

For buffer no. 3,

$$\text{pH} = 4.74 + \log 3/7 =$$

For buffer no. 4

$$\text{pH} = 4.74 + \log 4/6 =$$

For buffer no. 5

$$\text{pH} = 4.74 + \log 5/5 =$$

and so on.

Results :