Unit-5

Physical Pharmaceutics

pH, buffers and Isotonic solutions:

Sorensen's pH scale, pH determination (electrometric and calorimetric), applications of buffers, buffer equation, buffer capacity, buffers in pharmaceutical and biological systems, buffered isotonic solutions.

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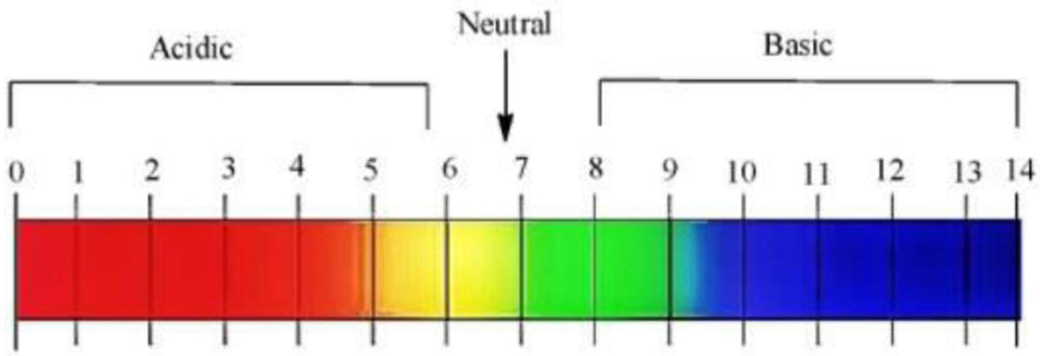
Sorensen's pH scale:

- The pH scale was defined because the enormous range of hydrogen ion concentrations found in aqueous solution make using H+ Molarity.
- It was given by Danish biochemist Soren Sorense in 1909 developed the pH scale and introduced pH definition as minus (-) logarithm of (H+) to the base 10.
- pH defined as negative logarithm of the hydrogen ion concentration.

$$pH = -\log (H^+)$$

- The concentration of the hydrogen ion is a measure of its acidity or basicity of a aqueous solution at a specific solution.

- Acidic solution have a higher relative number of H^+ ion.
- pH scale help to measure the acidity and basicity of any solution.



The pH Scale

- The pH scale range from 0 to 14.
- The scale start with a zero pH indicates that the solution is strongly acidic, and end with 14 indicates that the solution is strongly alkaline (basic).
- The central point Ph in the scale is 7 indicates that the solution is neutral (neither acidic or basic).

Determination of pH:

There are several methods of pH determination.

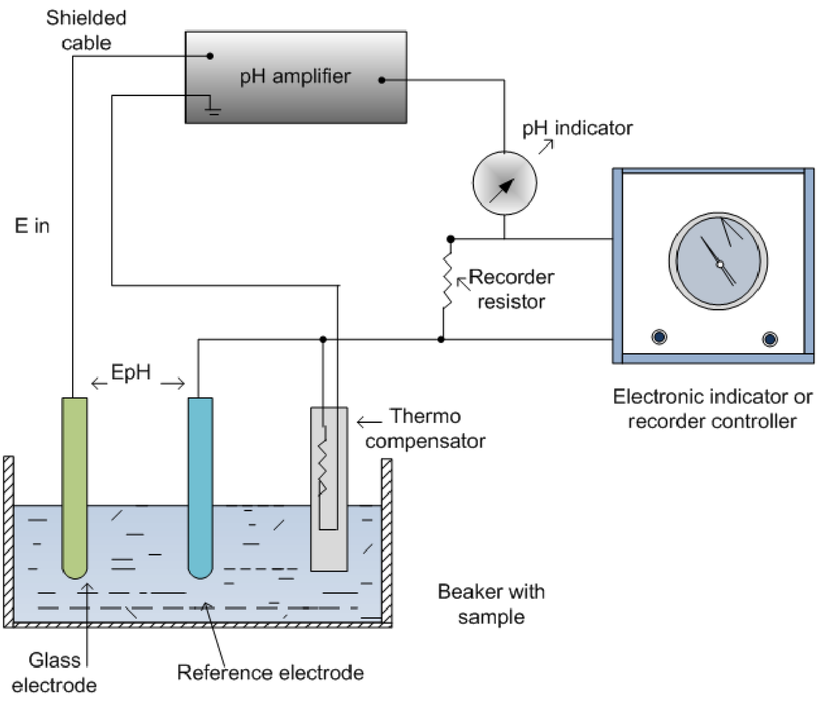
1. Electrometric
2. Calorimetric
3. pH Paper

1. Electrometric Method:

Principle:

- The magnitude in the potential difference between glass and a solution containing hydrogen ion varies with concentration of H+ concentration.
- Hence the pH of the solutions are determined by means of the electrodes.

- Hydrogen electrode and glass electrodes are used for this purpose. However glass electrodes are commonly used.



Circuit for electronic pH measurement

Method:

- Step-1: At first the instrument temperature is set to that of the solution temperature.
- Step-2: The electrode is immersed into a standard buffer solution of pH 7.0. The potential control knob is adjusted till the pH reading in digital meter becomes 7.0.
- Step-3: Then the instrument is calibrated using standard buffers of pH 4.0 (M/20 potassium hydrogen phthalate) or/and pH 9.14.
- Step-4: The electrode is now rinsed with distilled water properly and re-immersed into the test solution. The pH value is obtained from the digital meter.

The pH of the test solution can be changed by the addition of slight amount acid or base solution (depending upon the desired direction of change) and the procedure is followed till the desired pH is obtained.

2. Calorimetric method:

- Take a Calorimetric paper and dip into sample solution (which we have to determine the pH)
- Then obtained colour is computed with the standard table of colorimetric colour
- According to pH value we determined that the solution is acidic or basic or neutral.

3. pH Paper:

- On a white tile place a clean pH paper strip.
- Drop of the sample on the pH paper using a clean dropper.
- Observe the change in the colour of the pH paper.
- Now compare the colour obtained on the pH paper with the colour shades on the standard pH chart.
- Make a note of the pH value obtained.

Buffer Solution:

- A solution whose pH is not altered to any great extent by the addition of small quantities of either an acid or base is called buffer solution.
- Buffer is also defined as the solution of reserve acidity or alkalinity which resists change of pH upon the addition of a small amount of acid or alkali.
- If Buffer Solution is added in any solution then it resist the change in pH of that solution, whether we add small amount of acid or alkali/base in that solution.

Types of Buffer Solution:
(a) Acidic Buffer:

- It is formed by the mixture of weak acid and its salt with a strong base.
- Examples: (i) $CH_3COOH + CH_3COONa$, (ii) HCN + NaCN, (iii) Boric acid + Borax etc.

(b) Basic Buffer:

- It is formed by the mixture of a weak base and its salt with strong acid.
- Examples: (i) $NH_4OH + NH_4Cl$, (ii) $NH_4OH + NH_4NO3$, (iii) Glycine + Glycine hydrochloride

(c) Simple Buffer:

- It is formed by a mixture of acid salt and normal salt of a polybasic acid,
- example $Na_2HPO_4 + Na_3PO_4$

Applications of buffers:

- Buffers are used in industrial processes such as manufacture of paper, dyes, inks, paints, drugs, etc.
- Buffers are also employed in agriculture, dairy products and preservation of various types of foods and fruits.
- It is used to determine the pH with the help of indicators.
- Blood is the natural buffer, it maintenance of pH is essential to sustain life because enzyme catalysis is pH sensitive process. The normal pH of blood plasma is 7.4.

Buffer Equation:
It is used to calculate the pH of a buffer solution and the change in pH with the addition of an acid/base.

Acidic buffer (Weak acid & its salts)
The pH of acidic buffer can be calculated from the dissociation constant (ka) of weak acid and the concentration of the acid and the concentration of the acid and salt used.
Henderson-Hasselbalch equation:
The Henderson-Hasselbalch equation is a mathematical equation that can be used to calculate the pH of a buffer solution. The equation is as follows:

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

where:

- pH is the pH of the buffer solution
- pKa is the negative logarithm of the acid dissociation constant of the weak acid

The Henderson-Hasselbalch equation can be used to calculate the pH of a buffer solution, or to determine the ratio of the conjugate base to the weak acid in the buffer solution. The equation is also useful for understanding how buffers work.

Basic buffer (Weak base and its salts)
In similar way buffer equation for a basic buffer can be written as

$$pOH = pKb + \log\frac{[Salt]}{[Base]}$$

Buffer capacity:

The amount of acid/base required to produce a unit change in pH in a solution is called buffer capacity.

It helps to know the effectiveness of a buffer on a quantitative basic.

$$\mathrm{B}B = \frac{\Delta B}{\Delta pH}$$

Where,

B = Buffer Capacity

ΔB = Amount of Acid/Base

ΔpH = Change in pH

Buffers in pharmaceutical and biological systems

Pharmaceutical system:

The buffer play an important role in pharmaceutical preparation to ensure pH condition for the medicinally active compound:

- **Parenteral products (injections):** Buffers are used to maintain the pH of injectable products within a range that is safe and comfortable for patients. Common buffers used in parenteral products include acetate, phosphate, citrate, and glutamate.
- **Solubility:** Solubility of compounds can be frequently controlled by providing a medium of suitable pH, and required pH is adjusted by buffers.
- **Ophthalmic products (eye drops and ointments):** Buffers are used to maintain the pH of ophthalmic products within a range that is compatible with the tears and the surface of the eye. Common buffers used in ophthalmic products include phosphate and borate.
- **Oral dosage forms (tablets and capsules):** Buffers are used to maintain the pH of oral dosage forms within a range that promotes dissolution and absorption of the drug in the gastrointestinal tract. Common buffers used in oral dosage forms include phosphate, citrate, and bicarbonate.
- **Improve solubility:** Buffers can help to improve the solubility of drugs in solution, which can lead to better absorption and bioavailability.
- **Reduce irritation:** Buffers can help to reduce irritation at the site of administration, such as the eyes or the gastrointestinal tract.

Biological System:

- Body fluids in biological system (Body) are having balance quantity of acid or base (pH).
- The biochemical reaction that takes place in living system are having balance quantity of acid or base (pH).
- The biochemical reaction that takes place in living system in pH (acidity or basicity).
- So the maintenance of the normal pH range within the body fluids become essential.
- The pH value of some body fluids with their buffer system to maintain pH in body:

BODY FLUIDS	PH VALUE	BUFFER SYSTEM
BLOOD	7.4-7.5	Bicarbonate
URINE	4.5-8.0	Phosphate
INTERSTITIAL FLUIDS	7.2-7.4	Bicarbonate
INTRACELLULAR FLUIDS	6.5-6.9	Protein and Phosphate

Buffered isotonic Solution:

Pharmaceutical buffer solution that are meant for applications of body should be adjusted to same osmotic pressure as that of the body fluids.

Eg: Blood : 0.9% W/V Nacl solution.

There are three types of solutions:-

- Isotonic: A buffer solution have same osmotic pressure as body fluid (0.9% Nacl)
- Hypotonic: A buffer solution have less concentration of solute (osmotic pressure) than 0.9% Nacl.
- Hypertonic: A buffer solution have high concentration of solute (osmotic pressure) than 0.9% Nacl.

We have to make buffer isotonic solution which have some osmotic pressure as body fluids or same concentration of solute as 0.9% w/V Nacl.

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