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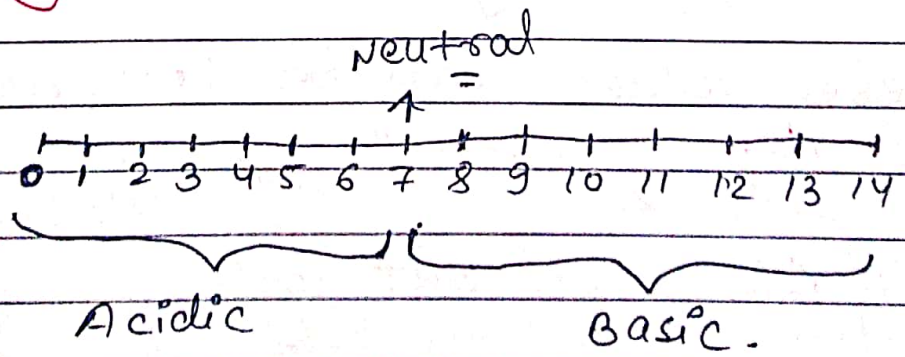
pH, buffer and Isotonic solution

Sorensen's pH scale :

- The p in pH denotes "power" and H stand for Hydrogen.
- Sorensen defined pH of the solution as the 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.
- Acidic solutions have a higher relative number of H^+ ions, while alkaline or basic solutions have a higher number of OH^- ions.



Sorensen's pH scale

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- The pH scale range from 0 to 14. The scale starts with a zero pH indicates that the solution is strongly Acidic.

- At, the other end of the scale, pH is 14 indicates that the solution is strongly alkaline/Basic.

- The central point pH in the scale is 7.0 (neutral).

- The region with pH below 7 is designated as a acidic and above pH 7 is designated as basic.

Measurement of pH :

- The pH value is measured by following methods :-

1) pH paper
2) Electrometric Method
3) Calorimetric Method

1) pH paper :

- In this Method, pH of a solution is determined with pH paper. A piece of pH paper is partially dipped into the sample then compare the change of colour with the colour chart and record the range of pH.

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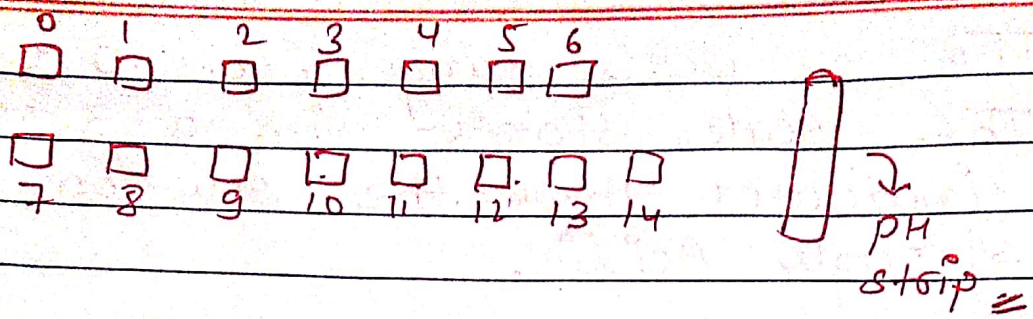

2) Electrometric Method :

- Electrometric method is the most accurate of the method. It measures accurately to 0.1 to 0.001 pH.

→ Principle :

- The basic principle of the electrometric pH measurement is determination of the activity of the hydrogen ion by potentiometric measurement using a standard hydrogen electrode and a reference electrode.

→ Procedure :

- Before use, calibrate the instrument with standard buffer solution (KCl solution of pH 7.0)

- Dip the electrode in the sample whose pH has to be measured.

- Stir the sample to ~~ensure homo~~ minimize CO_2 entrainment.

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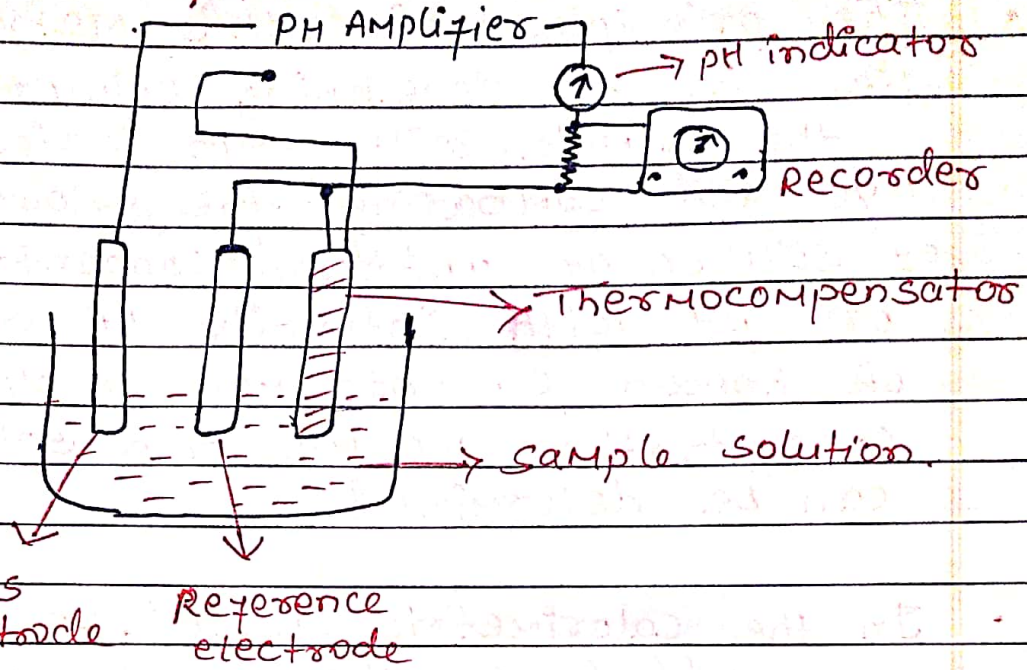
- Note down the reading (pH) from the pH meter/potentiometer.



→ Advantages:

- Electrometric method is more precise/accurate than calorimetric method.
- Results can be easily read.
- Reading are not fluctuated by the natural colour.

→ Disadvantage:

- Expensive equipment.
- chances of damaging the electrode, proper care of electrode should not be done.

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3) Calorimetric Method :

- The principle behind this method lies in the developing colour in the sample with an indicator dye and comparing the colour of solution of unknown concentration or pH with intensity of solution of known concentration or pH. Concentration of unknown solution can be determined.

- In the calorimetric method, chemicals are added to the sample and those chemicals produce a colour change. The colour indicates the pH of the sample.

- The colour can be measured visually or electronically.

a) Visual Method for Estimation :

- Different kits are available to determine pH. After adding reagent, the colour of unknown solution in test tube is compared with standard to determine pH.

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b) Electronic Method of estimation:

- It is also use to determine pH.
- Take the sample in two square shape test tubes upto the same level.
- Put 2-3 drops of indicator in one tube and put in the right hand side compartment.
- Place the blank (tube without indicator) in left hand side compartment.
- Rotate the disc till the colour developed in the right hand side sample coincides with the disc colour.
- Note the corresponding pH & recorded.

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pH, buffer and Isotonic solutions:

Buffer:

- Buffers are compounds or mixtures of compounds which resist change in pH after adding Acid or base/alkaline.

- The resistance to a change in pH is known as buffer action.

- The solution whose pH is not much altered by the addition of small amounts of strong acid (H^+ ions) or a strong base (OH^- ions) is called buffer solution.

- A combination of a weak acid and its conjugate base or a weak base and its conjugated Acid act as buffers.

- Acidic buffer solution: [pH<7]

CH_3COOH + CH_3COONa
Acetic Acid Sodium Acetate

- Alkaline buffer solution:

Ammonia + Ammonium chloride.

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Buffer Equation:

- This equation is used to calculate the pH of a buffer solution and the change in pH with the addition of an acid or base.

→ Buffer Equation for weak Acid and its salt:

- An Acid is considered as proton donor. The pH of the Acid buffer can be calculated from the dissociation constant (Ka) of weak acid and the concentration of the Acid and salt used.

$$HA \rightleftharpoons H^+ + A^-$$
(weak Acid)

$$BA \longrightarrow B^+ + A^-$$
(salt) (Strong Electrolyte) ⇒ completely

[Note: Due to the common ion effect of A^- ion, the conc. of H^+ & A^- ion decreases and rxn goes backward]

→ By Applying law of Mass Action:

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

⇒ HA = Acid or A^- ⇒ salt.

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=> Taking log both side.

=> $-\log [H^+] = -\log \left[\frac{ka \cdot [HA]}{[A^-]} \right]$

=> $PH = -\log ka - \log \frac{[HA]}{[A^-]}$

=> $\boxed{PH = PKa + \log \frac{[salt]}{[Acid]}}$

=> Handerson - Hasselbatch equation for weak Acid.

[pH determine for weak Acid after adding small amount of acid/base in a soln.]

→ Buffer Equation for weak base and its salts:

- A base is considered as proton acceptor. The pH of the basic buffer can be calculated from the dissociation constant (ka) of the weak base and the concentration of the ~~Acid~~ base and salt used.

weak base ← $BOH \rightleftharpoons B^+ + OH^-$

salt ← $BA \longrightarrow B^+ + A^-$

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Note: Due to the common ion effect of B^+ ion, the dissociation of B^+ & OH^- ion decrease and the rxn shifts backward.

By Applying law of mass action:

$$K_b = \frac{[B^+][OH^-]}{[BOH]}$$

$[BOH]$ = Base
$[B^+]$ = salt.

$$[OH^-] = k_b \cdot \frac{[BOH]}{[B^+]}$$

Taking log both side,

$$-\log[OH^-] = -\log\left(k_b \cdot \frac{[BOH]}{[B^+]}\right)$$

$$pOH = -\log k_b - \log\frac{[BOH]}{[B^+]}$$

$$pOH = pK_b + \log\frac{[B^+]}{[BOH]}$$

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

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Buffer capacity:

- The buffer capacity of a solution is a measure of its magnitude of its resistance to change in pH, in the addition of an acid or a base.

It can be represented as:

$$\boxed{\beta = \frac{\Delta A \text{ or } \Delta B}{\Delta pH}}$$

where,

ΔP_H = small variation in pH:

ΔA or ΔB = small amount of Acid/base added to buffer to change pH.

Application of Buffer:

1) Maintainance of life:

- Most biochemical processes work within a relatively small pH range.

- The body uses buffers solution to maintain a constant pH.

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2) In shampoos:

- Many shampoos use a citric acid / sodium citrate in shampoo to maintain a slightly acidic pH.

3) In textile industry:

- Many dyeing process use buffer to maintain the correct pH for various dyes.

4) In baby lotion:

- Baby lotion are buffered at a pH of About 6.

- This help to protect from bacteria growth and helps to prevent diaper rash.

5) In food industry:

- Buffers are used in food industry to maintain the acidity of food in order to preserve the flavour, appearance, physical, chemical and chemical stability of food.

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II Buffers in Pharmaceutical and biological System

→ Biological Buffer system:

1> Blood –

- The blood is maintained at a pH of about 7.4.
- The plasma contains carbonic acid/ bicarbonate and acidic/alkaline sodium salts of phosphoric acid act as buffer.

2> Lacrimal fluid: (Tears)

- The pH of tears is about 7.4, with range of 7 to 8.

3> urine:

- The urine of a normal adult has a pH of about 6.0.
- when the pH range of the urine is below normal value, hydrogen ions are excreted by the kidneys to maintain pH.

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→ Pharmaceutical buffer :

- Buffer solutions are used particularly in the formation of opthalmic solution

i) when we mix boric acid and monohydrate sodium carbonate they yield buffer soln with pH range 5 to 9.

ii) Sorenson's proposed mixture of salt of sodium phosphate for buffer of pH 6 to 8.

iii) Mixture of boric acid, sodium borate and NaCl are used for opthalmic solution with pH range 7 to 9.

Buffer Isotonic Solution :

- The isotonic solutions do not cause swelling or contraction of the tissues and do not produce discomfort when injected into eyes, nasal tract or blood.

- The movement of water molecules across a semi-permeable membrane from region of low concentration of solute to high concentration of solute is known as osmosis.

- The pressure applied to prevent this movement is called osmotic pressure.

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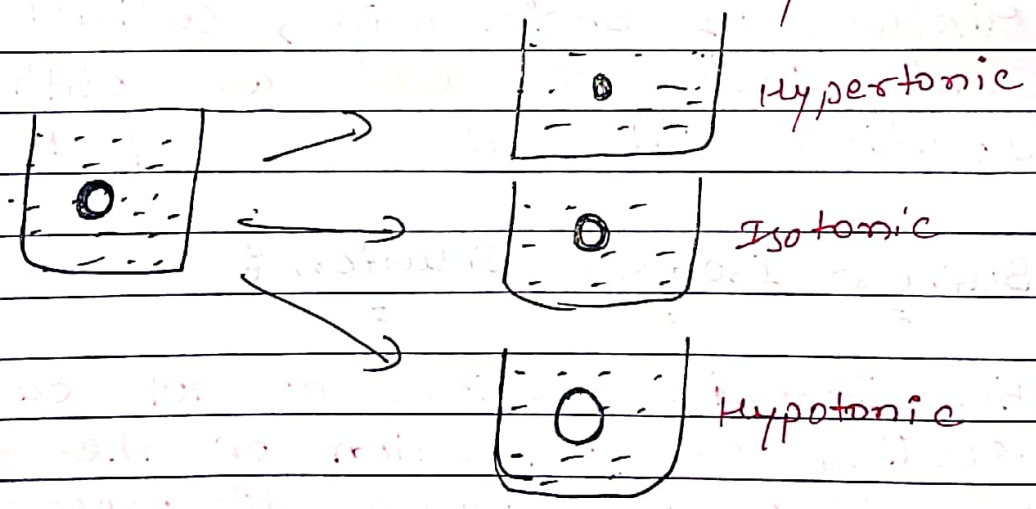
- Isoosmotic soln and Isotonic soln are the soln have same osmotic pressure.

- Hypertonic soln are the soln have an osmotic pressure greater than 0.9% w/v NaCl, In this situation cells to shrink and become wrinkled.

- Hypotonic soln are the soln have an osmotic pressure less than 0.9% w/v NaCl, In this situation, cells to swell and finally burst



→ **Tonicity :**

- It is the measure of the osmotic pressure gradient between two solutions separated by a semi-permeable membrane.

- Measured in mol/l.

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→ Measurement of Tonicity

i) Haemolytic Method:

- In this method, RBCs suspended in numerous solution and check weather the RBC swell, shrink or remained as such.

- In Hypertonic solⁿ, the cell shrink due to the movement of fluid outside the cell.

- In Hypotonic solⁿ, the cell swells due to the fluid movement into the cell.

- In isotonic solⁿ, the cell don't modified their shape, it remained same due to the movement of fluid is equal in inside and outside the cell.

ii) Colligative Method:

- The solⁿ having same tonicity exhibit similar behaviour with respect to their colligative properties such as lowering of vapour pressure, depression of freezing point, etc. Hence, the tonicity of a solution may be determined by measuring its colligative properties.

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II Methods of Adjusting Tonicity :

Class I Method

- cryoscopic Method
- Nacl equivalent Method

Class II Method

- sprowls Method
- white-vincent Method.

→ Class I Method :

- In this Method, Nacl is added to drug soln to adjust tonicity.

It includes :

i) Cryoscopic Method –

- This Method is used to calculate how much salt is needed to obtain isotonic preparation from hypotonic preparation.

$$\boxed{w\% = \frac{0.52 - a}{b}}$$

w = Amount of adjusting substances.

a = freezing point of 1% soln of un-adjusted soln.

b = freezing point of 1% soln of adjusting substances.

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b) Nacl Equivalent Method :

- Defined as the amount of Nacl (in grams) that is equivalent to 1 gm of that drug.

$$E = \frac{17\ L_{iso}}{M}$$

→ const. for diff Materials diff values.

M = Molecular weight of drug
E = Nacl Equivalent

→ class II Method :

- In this Method, water is added to the drug in a sufficient amount to form an isotonic soln.

It includes :

i) White - vincent Method -

- This Method involves the addition of water to the given amount of drug to make isotonic solution.

$$V = w \cdot E \cdot 111.1$$

V = vol. of isotonic soln prepared by adding water in drug.
w = weight of drug in grams
E = Equivalent weight of drug.
111.1 = const.

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ii) Sprowl's Method :-

- It is the modification of white vincent method.

- Here, we use weight of drug (w)

$w = 0.3$

$V = 0.3 \cdot F \cdot 111.1$

$$\boxed{V = 33.33\,F}$$

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