Name - Rajamul Haque

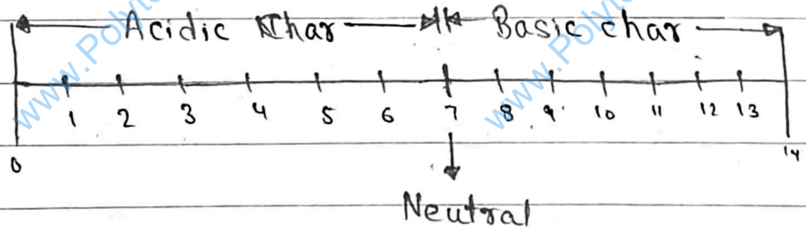
Electrochemistry

★ **Electrochemistry :-** Electrochemistry is the branch of chemistry which deals with the study of relationship between electrical energy and chemical energy.

In electrochemistry, electrical energy is converted into chemical energy or vice-versa.

i.e. Electrical Energy ⇌ Chemical Energy

★ **pH Scale :** pH scale is defined as the logarithm scale from which we can identify that solution is acid, basic (alkali) or neutral.



- Pure water should have a pH value 7.0.
- Solutions with a pH value less than 7.0 (i.e. 0 to 7.0) are termed as acidic.
- Solutions with a pH value greater than 7.0 (i.e. 7.0 to 14.0) are termed as basic.

✩ Electrolytic Conduction :-

Those substance that conduct electricity with decomposition of substance into its ion. such substance are called electrolytic conductor. The conduction of electricity by the movements of ions is called electrolytic conduction.

* Factors that effect electrolytic conduction :-

(a) Nature of electrolyte :- Strong electrolyte have more ionic conduction than weak electrolyte.

(b) Size of ion :-

$$\text{Ionic conduction} \propto \frac{1}{\text{size}}$$

(c) Viscosity :-

$$\text{I.C. Viscosity} \propto \frac{1}{\text{Viscosity}}$$

(d) Concentration of soln :-

$$\text{Ionic conduction} \propto \frac{1}{\text{concentration of soln}}$$

(e) Temperature :-

$$\text{Ionic conduction} \propto \text{Temperature}$$

✫ Variation of Specific Conductance with concentration :-

- The conductivity of an electrolytic sol^n is directly proportional to the concentration.

  i.e. Conductivity ∝ concentration

- On dilution, the degree of dissociation increases, number of ions increases, but actually number of ions per unit volume decrease. Hence conductivity decreases.

- As strong electrolyte are completely ionized in the sol^n with increases in concentration, the number of ions per unit volume increases, Hence conductivity increases.

- In weak electrolytes due to partial dissociation, increase in number of ions per unit volume with concentration is comparatively small, therefore, conductivity doesn't increase rapidly as in strong electrolytes.

☆ Variation of molar conductance with concentration :-

- The molar conductivity is the conductance of all the ions produced by one mole of electrolyte.
- On dilution, the total number of ions increases due to increase in the degree of dissociation.
- Hence, the molar conductivity of both strong and weak electrolytes increases with dilution.

☆ Variation of equivalent conductance with concentration :-

Equivalent conductance increases with dilution, because it is the product of specific conductivity and the volume V, containing one mole of electrolyte.

☆ Summary :- Effect of dilution are as follows :-

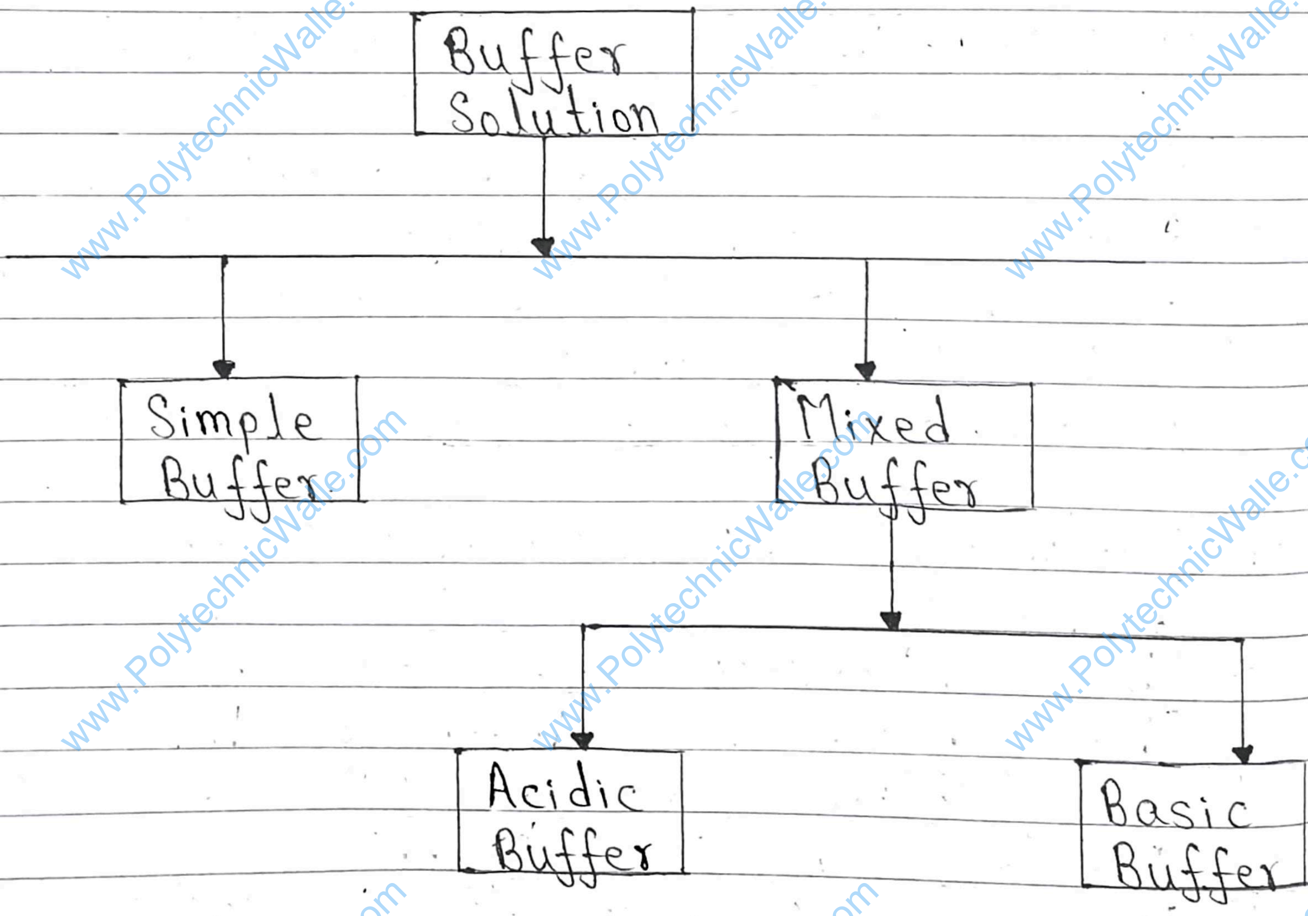
i) ~~The conductivity of sol^n increases~~
ii) The specific conductivity decreases on dilution (as number of ions decreases w.r.t. to volume)
iii) The Λ_e & Λ_m increases with dilution.

★ Buffer Solution :-

A solution which has a definite pH value on addition of a small amount of acid or base and which resists the sudden changes in its pH value is known as buffer solution.

Ex :- (i) CH_3COONH_4 ;
(ii) $CH_3COOH + CH_3COONa$;
(iii) $NH_4OH + NH_4Cl$ solutions.

Types of buffer solution :-



* Properties of Buffer Solution :-

1. The pH of buffer sol^n is constant.
2. The pH of buffer sol^n doesn't change on dilution.
3. The pH of buffer sol^n doesn't change in addition of acids or bases.
4. It is useful in number of chemical reactions.
5. It should contain definite pH range.

* Applications of Buffer Solution :-

1. In bread, milk, flour and other chemical products.
2. Buffer solutions are also used in the food industries.
3. Buffer solutions can be used in electroplating.
4. Buffers solutions are used during printing to ensure the
5. Buffer solutions are used in manufacture of glue (गोंद).
6. To maintain the desired pH value of blood.

✪ Application of pH :-

1. **Pharmaceutical Industries :-** In a large number of pharmaceutical industries like preparation of drugs, antibiotics. etc. and soft drink industries, the pH control is necessary.

2. **Physiological Application :-** The pH of public water supply should be maintained between 6 to 8. Lower values of pH may cause corrosion while higher values indicate certain physiological effects.

3. **City Water Supply :-** In city water supply and treatment of sewage by coagulation process, the pH control is necessary.

4. **Food Processing Industries :-** The wastes from food processing industries mostly contain organic matter which is putrecible. Hence, in the receiving water, the oxyzen is reduced. In such industries also pH control is essential.

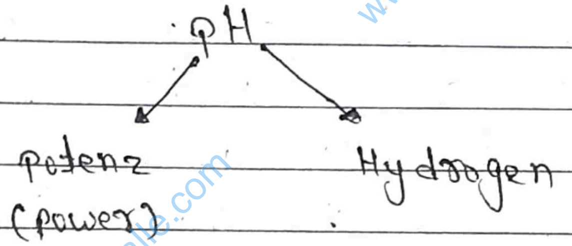
✫ pH (Hydrogen Ion Concentration):

The pH of a solution is defined as the negative logarithm to the base 10 of hydrogen ion concentration.

It is expressed as:

$$\boxed{pH = -\log_{10} [H^+]} \Rightarrow \boxed{pH = -\log \frac{1}{[H^+]}}$$

where, H^+ = Hydronium ion



pH was discovered by Sorenson in 1909.

✫ pOH (Hydroxide Ion Concentration):

The pOH of a solution is defined as the negative logarithm to the base 10 of hydroxide ion concentration.

It is expressed as:

$$\boxed{pOH = -\log_{10} [OH^-]}$$

or, $$\boxed{pOH = -\log \frac{1}{[OH^-]}}$$

☆ Ohm's Law:

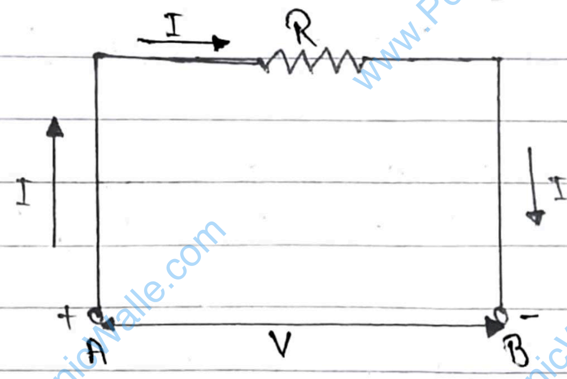
Ohm's law states that at a constant temperature the potential difference across a conductor is directly proportional to the current flowing through the conductor.

i.e. $V \propto I$

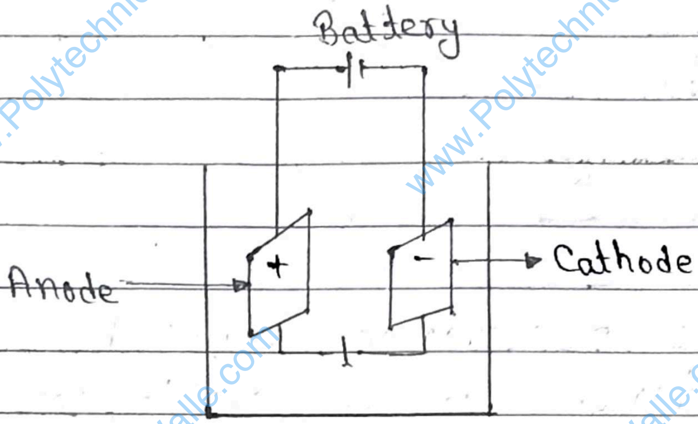
$\Rightarrow \quad V = IR$

$\Rightarrow \quad \boxed{\frac{V}{I} = R}$

where, V = potential difference across a conductor (in volts),
I = current flowing through the conductor (in amperes),
R = constant of proportionality called resistance (in ohm's)



✯ Specific Resistance or Resistivity (ρ):



The resistance of a conductor is;

i) directly proportional to its length

i.e. $R \propto l$ ——— (i)

ii) inversely proportional to its area of cross-section.

i.e. $R \propto \frac{1}{A}$ ——— (ii)

From eq^n (i) and (ii),

$$R \propto \frac{l}{A}$$

$$\Rightarrow R = \rho \frac{l}{A}$$

$$\Rightarrow \rho = \frac{RA}{l}$$ ——— (iii)

where, ρ = constant of proportionality called specific resistance

If $l = 1\ m$ & $A = 1\ m^2$

Then eqn (iii) becomes,

$$\boxed{\rho = R}$$

Hence, specific resistance may be defined as the resistance of a conductor having a length of 1 m and area of cross-section equal to $1\ m^2$.

<u>Unit</u> : Ωm or ohm meter

☆ <u>Conductance (G)</u> :

The measure of the ease of flow of conductor current through a conductor is known as conductance.

or,

Conductance is defined as the reciprocal of resistance of a conductor.

$$\therefore \quad \boxed{G = \frac{1}{R}}$$

where, G = conductance of a conductor
R = resistance of a conductor

<u>Unit</u> : Ω^{-1} or ohm^{-1} or mho or siemens (S)

☆ Specific Conductance (K) :

The reciprocal of specific resistance is known as specific conductance.

It is also called specific conductivity or conductivity.

It is represented by a Greek letter K (kappa).

i.e. $$K = \frac{1}{\rho}$$

$$\Rightarrow K = \frac{1}{\frac{RA}{l}} \qquad \left\{ \because \rho = \frac{RA}{l} \right\}$$

$$\Rightarrow K = \frac{1}{R} \cdot \frac{l}{A}$$

If $l = 1\ m$ and $A = 1\ m^2$

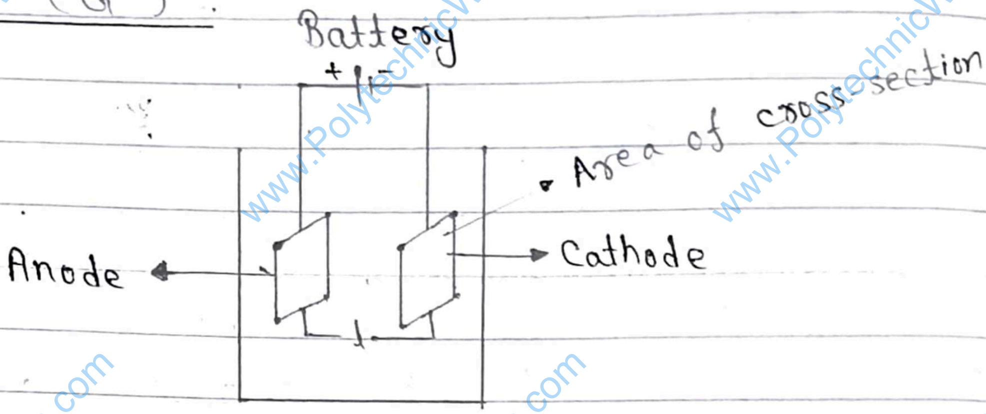
$$\Rightarrow K = \frac{1}{R}$$

$$\Rightarrow K = G \qquad \left\{ \because G = \frac{1}{R} \right\}$$

Hence, specific conductance may be defined as the conductance of a conductor having a length of 1 m and area of cross-section equal to $1\ m^2$.

Unit : $\Omega^{-1} m^{-1}$ or $ohm^{-1}\ meter^{-1}$ or $S\ m^{-1}$

Cell Constant (G^*) :



The ratio of length between two electrodes to the area of cross-section of the electrode is known as cell constant.
It is denoted by G^*.

$\therefore$ Cell Constant = $\dfrac{\text{length between two electrodes}}{\text{area of cross-section of electrode}}$

$$\Rightarrow \boxed{G^* = \frac{l}{A}}$$

Unit : m^{-1} or cm^{-1}

Note :
Conductivity = conductance × cell constant

☆ Equivalent Conductivity [Λ_e] :

The conductivity of all the ions are produced when 1 gram equivalent of an electrolyte is dissolved in $V_{in\ ml}$ of solution is known as equivalent conductivity.

It is represented by Λ_e.

It may be represented as :

$$\Lambda_e = K \times V_{in\ ml}$$

$$\Rightarrow \quad \boxed{\Lambda_e = K \times \frac{1000}{C_{eq}}}$$

$$\text{or} \quad \boxed{\Lambda_e = K \times \frac{1000}{N}}$$

where, Λ_e = equivalent conductivity
K = specific conductance
$V_{in\ ml}$ = volume having 1 g of equivalent of electrolyte
C_{eq} = concentration in eq/litre.
N = normality.

Unit : $\Omega^{-1} m^2 eq^{-1}$ or $S m^2 eq^{-1}$

★ Molar Conductivity [Λ_m] :

The conductivity of all the ions are produced when 1 mole of an electrolyte is dissolved in $V_{in\ ml}$ of solution is known as molar conductivity.
It is represented by Λ_m.

It may be expressed as :

$$\Lambda_m = \kappa \times V_{in\ ml}$$

$$\Rightarrow \boxed{\Lambda_m = \kappa \times \frac{1000}{C_M}}$$

or

$$\boxed{\Lambda_m = \kappa \times \frac{1000}{M}}$$

where,
Λ_m = molar conductivity,
κ = specific conductance,
$V_{in\ ml}$ = volume having 1 mole of electrolyte,
C_M = concentration in mol / litre
M = molarity

Unit : $\Omega^{-1} m^2 mol^{-1}$ or $S m^2 mol^{-1}$

☆ Relation between Λ_e and Λ_m

i) $$\boxed{\Lambda_e = \left(\frac{1}{n^+ \cdot z^+}\right) \cdot \Lambda_M}$$

where, n^+ = number of cation
z^+ = charge on cation

ii) $$\boxed{\Lambda_M = \Lambda_e \times \text{charge on cation}}$$

Ex : $CuSO_4 \longrightarrow Cu^{2+} + SO_4^{2-}$

i) $\Lambda_e = \left(\frac{1}{1\times 2}\right) \Lambda_M$

$\Rightarrow \Lambda_e = \frac{1}{2}\Lambda_M$

$\Rightarrow \boxed{2\Lambda_e = \Lambda_M}$

ii) $\Lambda_M = \Lambda_e \times 2$

$\Rightarrow \boxed{\Lambda_M = 2\Lambda_e}$

☆ Variation of specific, molar and equivalent conductance with ~~conductance~~ dilution :

- Specific conductance decreases on dilution (as number of ions decreases w.r.t. to volume).
- Molar conductance increases on dilution.
- Equivalent conductance increases on dilution.