

UNIT -I

COLLOIDAL DISPERSION

POINTS TO BE COVERED IN THIS TOPIC

INTRODUCTION

CLASSIFICATION OF DISPERSED SYSTEM, SIZE & SHAPE OF COLLOIDAL PARTICLE

CLASSIFICATION OF COLLOIDS

PROPERTIES OF COLLOIDS

EFFECT OF ELECTROLYTES

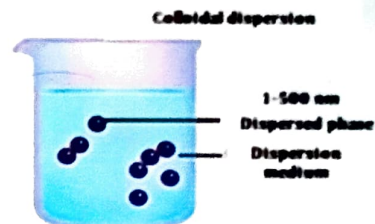
COAGULATION

PEPTIZATION

PROTECTIVE COLLOID ACTION

INTRODUCTION

- A colloidal dispersion is **composed of solid, liquid, or gas particles dispersed in a continuous phase** (solid, liquid, or gas). Strictly speaking, colloidal refers to particles with at least one dimension ranging from **1 nm to 1 μm** .
- Dispersed systems consist of particulate matter (known as the dispersed phase), distributed throughout a continuous phase (known as dispersion medium).



CLASSIFICATION OF DISPERSED SYSTEM

- On the basis of mean particle diameter of the dispersed material, three types of dispersed systems are generally considered:

- Molecular dispersions**
- Colloidal dispersions**
- Coarse dispersions**

i. Molecular dispersions

- Molecular dispersions are the **true solutions of absolute phase** in a **solvent**. The solute is in the form of **separate molecules homogeneously** distributed throughout the solvent.

✓ **Example: Aqueous solution of salts, glucose**

ii. Colloidal dispersions

- Colloidal dispersions are **micro-heterogeneous** dispersed systems.
- The dispersed phases **cannot be separated** under gravity or centrifugal or other forces. The particles **do not mix or settle down**.

✓ **Example: Aqueous dispersion of natural polymer, colloidal silver sols, jelly**

iii. Coarse dispersions

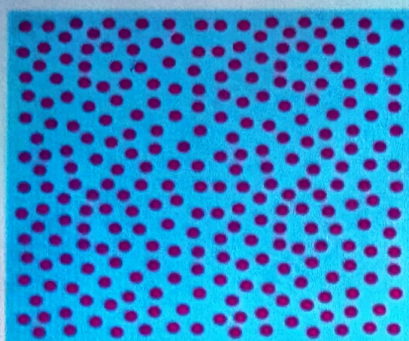
- Coarse dispersions are heterogeneous dispersed systems in which the dispersed phase particles are **larger than 0.5 μm** .

• The concentration of **dispersed phase may exceed 20%**.

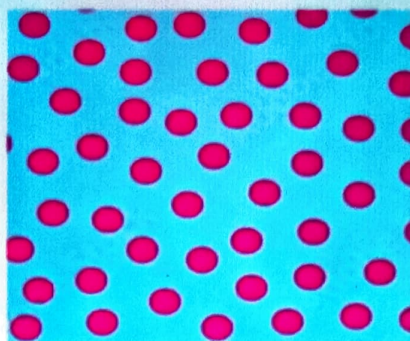
✓ **Example: Pharmaceutical emulsions and suspensions**

DISPERSION SYSTEM

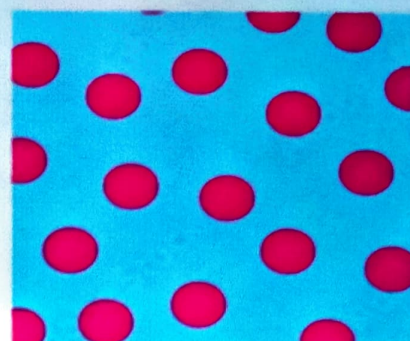
MOLECULAR DISPERSION



COLLOIDAL DISPERSION



COARSE DISPERSION

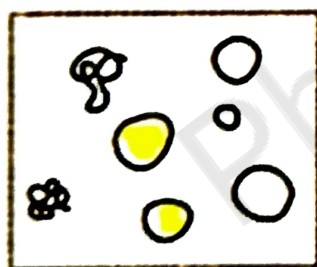


❖ COMPARISON OF CHARACTERISTICS THREE DISPERSED

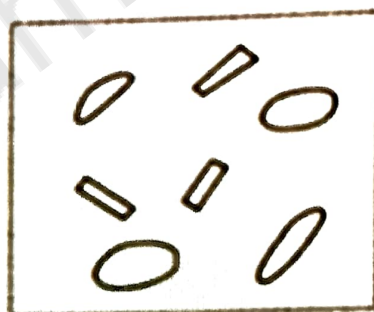
	MOLECULAR DISPERSIONS	COLLOIDAL DISPERSIONS	COARSE DISPERSIONS
Particle size	<1 nm	1 nm to 0.5 μm	>0.5 μm
Appearance	Clear, transparent	Opalescent	Frequently opaque
Visibility	Invisible in electron microscope	Visible in electron microscope	Visible under optical microscope or naked eye
Separation	Pass through semipermeable membrane, filter paper	Pass through filter paper but do not pass through semipermeable membrane	Do not pass through normal filter paper and semipermeable membrane
Diffusion	Undergo rapid diffusion	Diffuse very slowly	Do not diffuse
Sedimentation	No question of settling Example :- glucose in water	Do not settle down Example :- jelly, butter, milk	Fast sedimentation of dispersed phase by gravity or other forces Example :- calamine, fine sand in water, red blood cells

❖ SHAPE OF COLLOIDAL PARTICLES

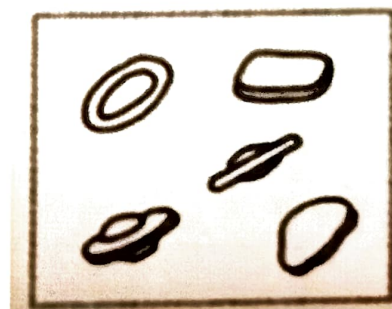
- The shapes of particles in a dispersion depend on methods of preparation and affinity of the **particles to the dispersion medium**.
- Shape also influence the **colour of the dispersion**.
- It is believed that **spherical particles of gold** is indicated by **red colour**, while **disc like particles of gold** gives **blue colour** .
- The more extended the particle the greater its specific surface the greater the **attractive force between the particles of the dispersed phase and the dispersion medium**.
- **Flow, sedimentation and osmotic pressure of the colloidal system** affected by the **shape of colloidal particles**.
- Particle shape may also influence the **pharmacological action**.
- The shape of the **dispersed phase** influences the viscosity of the dispersion.
- **Spherical particles produce dispersion of low viscosity** while **linear particles generally produce more viscous dispersion**.
- These effects are reflected by the degree of salvation. Good solvent (vehicle) produce particles with maximum surface.



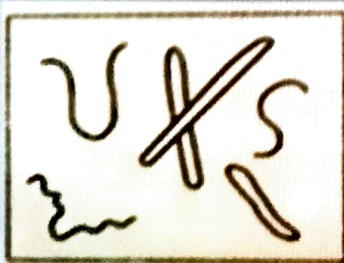
Spheres and globules-
surfactants,
poliovirus



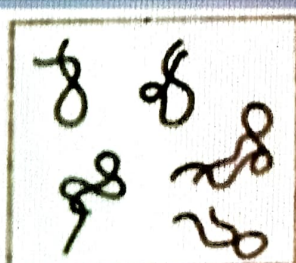
Short rods and prolate
ellipsoids-serum
albumin, microcrystalline



Oblate ellipsoids flakes-
bentonite , kaolin



Long rods and threads
attapulgite



Loosely coiled
threads



Branched threads
cellulose asbestos

- **The shapes that can be assumed by colloidal particles are:**
 - i. **Spheres and globules**
 - ii. **Short rods and prolate ellipsoids (rugby ball-shaped/elongated)**
 - iii. **Oblate ellipsoids (discus-shaped/flattened) and flakes**
 - iv. **Long rods and threads**
 - v. **Loosely coiled threads branched threads**
- **The following properties are affected by changes in the shape of colloidal particles:**
 - i. **Flow-ability**
 - ii. **Sedimentation**
 - iii. **Osmotic pressure Pharmacological action.**

CLASSIFICATION OF COLLOIDS

- On the basis of nature of interaction between dispersed phase and dispersion medium.

[A]. Lyophilic colloids (solvent attracting) (solvent loving)

[B]. Lyophobic (solvent repelling) (solvent hating)

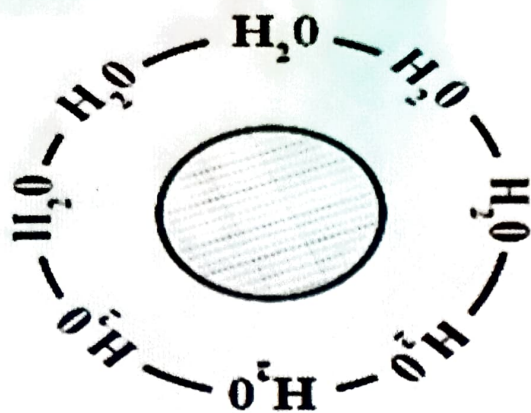
[C]. Association/ Amphiphilic colloids

[A]. LYOPHILIC COLLOIDS (SOLVENT ATTRACTING) (SOLVENT LOVING)

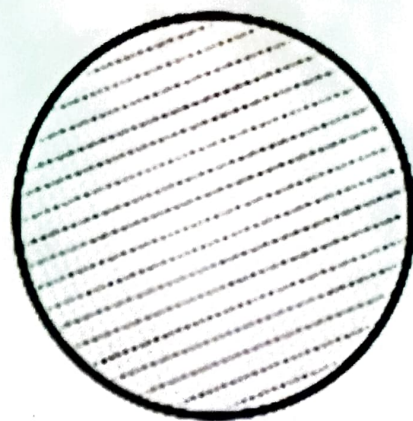
- The particles in a lyophilic system have a **great affinity** for the solvent. **dispersed particle and dispersion medium interact** to a great extent.
- If water is the **dispersing medium**, it is often known as **hydrophilic colloids**.
- ✓ E.g:- **Gelatin, acacia and albumin in water Rubber and polystyrene** form **lyophilic colloids** in **non aqueous organic solvents** such as benzene and thus known as **lipophilic colloids**.

[B]. LYOPHOBIC (SOLVENT REPELLING) (SOLVENT HATING)

- The particles **resist solvation and dispersion in the solvent**. Very little attraction between **dispersed particle and dispersion medium**.
- When **dispersion medium** in these colloids is water they are known as **hydrophobic colloids**.
- ✓ E.g. **Gold and silver in water**. These are **thermodynamically unstable**.



Lyophilic colloid

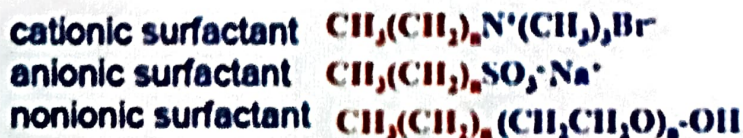
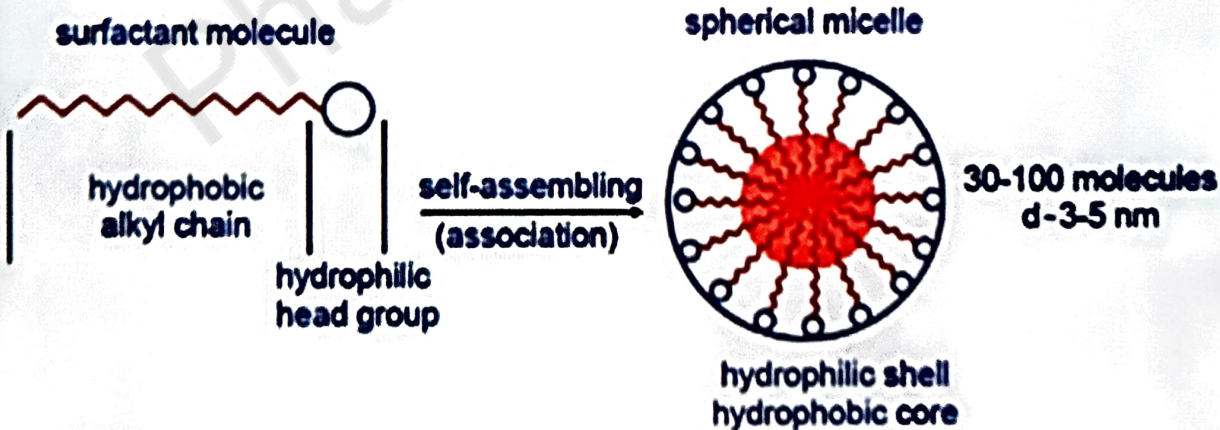


Lyophobic colloid

[C]. ASSOCIATION/ AMPHIPHILIC COLLOIDS

- Certain molecules termed **Amphiphilic or surface active agents**, characterized by **two regions of opposing solution affinities** within the same molecule.
- **At low concentration:** Amphiphilic exist - separately (sub colloidal size).
- **At high concentration:** Form aggregates or micelles (50 or more monomers) (colloidal size)

SURFACTANT MICELLES



orientation \rightarrow energy minimum
Hardy-Harkins principle

➤ **Difference between Lyophilic colloids and Lyophobic colloids**

LYOPHILIC COLLOIDS	LYOPHOBIC COLLOIDS
Colloidal particles have greater affinity for the dispersion medium	Colloidal particles have little affinity for the dispersion medium
Owing to their affinity for the dispersion medium the molecules disperse spontaneously to form colloidal solution	Material does not disperse spontaneously , and hence lyophobic sols are prepared by dispersion or condensation methods
These colloids form " reversible sols "	These colloids form " irreversible sols "
Viscosity of the dispersion medium is not greatly increased by the presence of lyophilic colloidal particles	Viscosity of the dispersion medium is increased greatly by the presence of the lyophobic colloidal particles
Dispersions are stable generally in the presence of electrolytes; they may be salted out by high concentrations of very soluble electrolytes	Lyophobic dispersions are unstable in the presence of even small concentrations of electrolytes
Dispersed phase consists generally of large organic molecules such as gelatin, acacia lying within colloidal size range	Dispersed phase ordinarily consists of inorganic particles , such as gold or silver

✓ **Preparation of Lyophilic Colloids**

- This simple dispersion of lyophilic material in a solvent leads to the formation of lyophilic colloids.

✓ **Preparation of Lyophobic Colloids**

- The lyophobic colloids may prepared by

(a) Dispersion method (b) Condensation method

(a) Dispersion methods

- This method involves the **breakdown of larger particles** into particles of **colloidal dimensions**.
- The breakdown of coarse material may be effected by the use of the **Colloid mills, Ultrasonic** treatment in presence of stabilizing agent such as a **surface active agent**.

(b) Condensation method

- In this method, the **colloidal particles** are formed by the **aggregation of smaller particles** such as molecules.
- These involve a **high degree of initial** super saturation followed by the **formation and growth of nuclei**.
- **Super saturation can be brought about by**

(i) Change in solvent

- For example, if **sulfur is dissolved in alcohol** and the concentrated solution is then poured into an excess of water, many **small nuclei** form in the **supersaturated solution**.
- These grow rapidly to form a colloidal sol. If a **saturated solution of sulphur** in acetone is poured slowly into **hot water** the **acetone vaporizes**, leaving a colloidal dispersion of **sulphur**.

(ii) Chemical reaction

- For example, **colloidal silver iodide** may be obtained by reacting together dilute solutions of **silver nitrate and potassium iodide**.
- If a **solution of ferric chloride** is boiled with an excess of water produces red sol of **hydrated ferric oxide by hydrolysis**

✓ Purification of Colloids

- When a colloidal solution is prepared, it often contains certain electrolytes which tend to destabilize it.
- The following methods are used for purification of colloids:

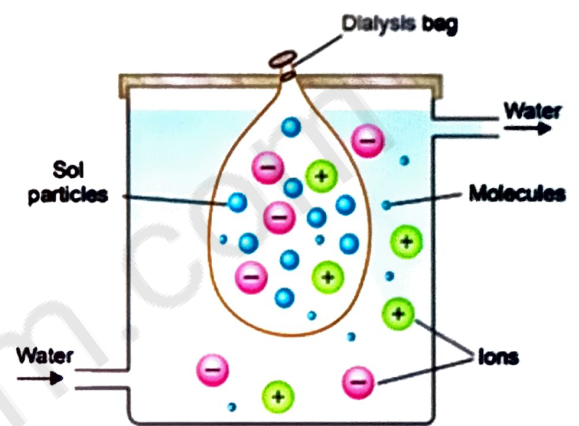
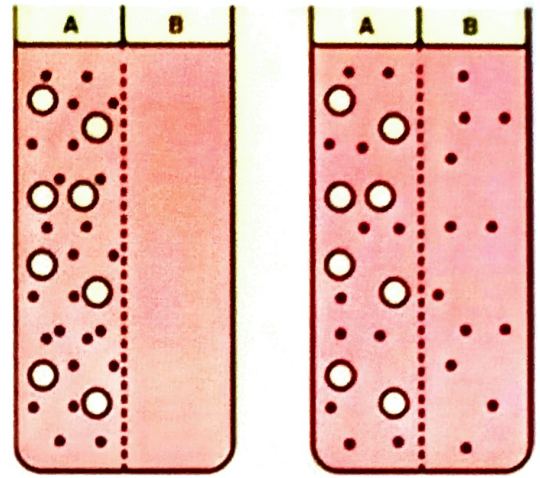
(a) Dialysis

(b) Ultrafiltration

(c) Electro dialysis

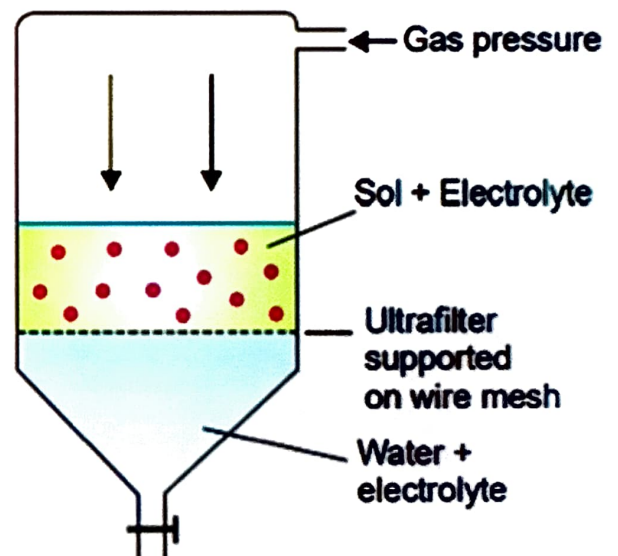
(a) Dialysis

- At equilibrium, the colloidal material is retained in **compartment A**, whereas the sub-colloidal material is distributed equally on **both sides of the membrane**.
- By continually removing the liquid in **compartment-B**, it is possible to obtain colloidal material in **compartment-A** which is free from **sub-colloidal contaminants**.
- The process of dialysis may be hastened by stirring, so as to maintain a **high concentration gradient of diffusible molecules across the membrane** and by renewing the outer liquid from time to time.



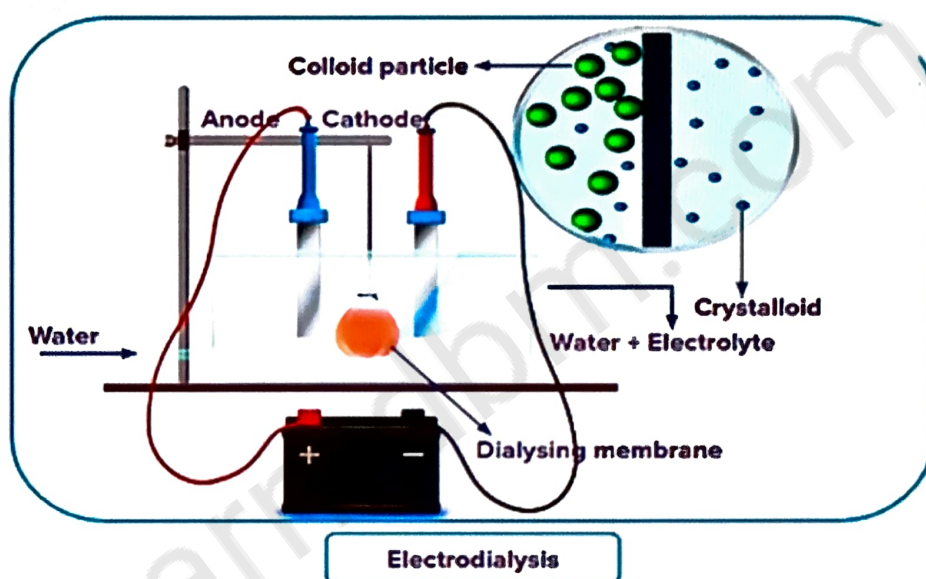
(b) Ultrafiltration

- Colloidal dispersion can pass through an **ordinary filter**, because the **pore size of the filter is large**.
- If this filter paper is **impregnated with collodion** (syrupy solution of nitrocellulose), the **pore size reduces**.
- Such **modified filter papers** are called **ultra filters**.
- By applying **pressure (or suction)** the **solvent and small particles** may be **forced across a membrane** but the **larger colloidal particles** are retained. This process is referred to as **ultrafiltration**.



(c) Electro-dialysis

- In the dialysis unit, the **movement of ions across the membrane** can be **speeded up** by applying an **electric current through electrodes** induced in **solution**.
- The electric potential **increases the rate of movement of ionic impurities** through a **dialysing membrane** and so provide a more rapid means of **purification**.
- The dialysis membrane allows **small particles (ions)** to pass through but the **colloidal size particles (hemoglobin)** do not pass **through the membrane**.



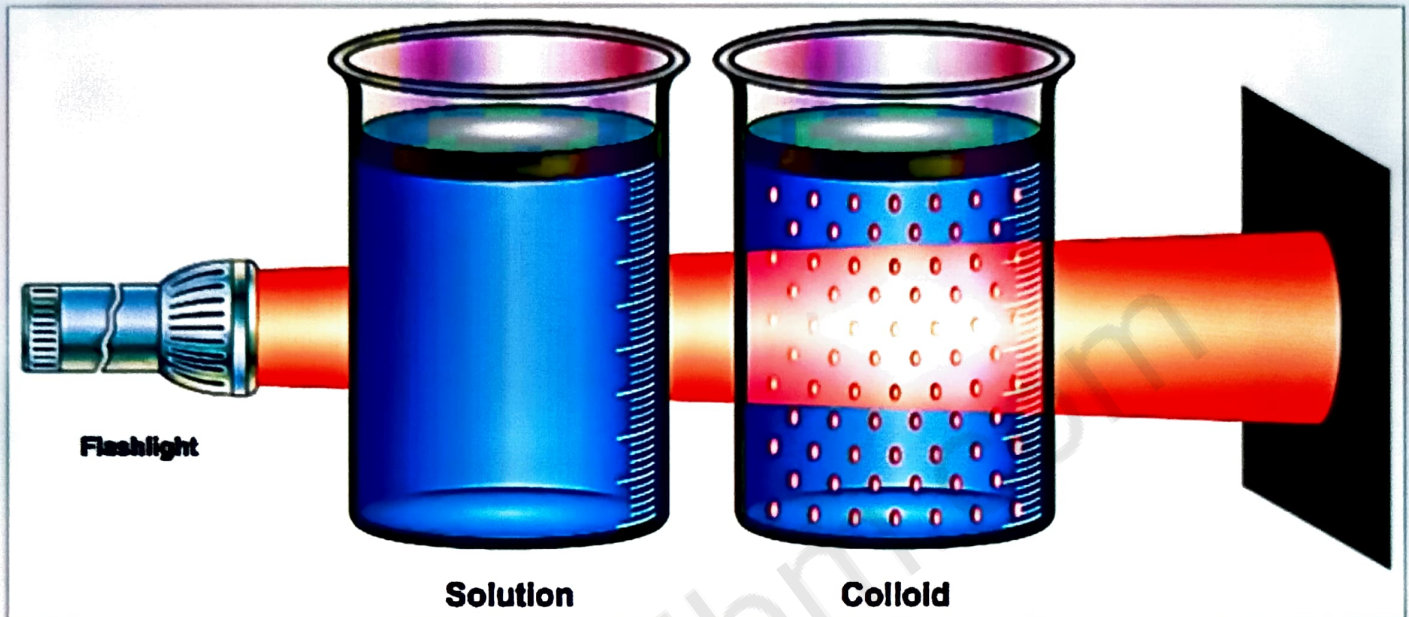
PROPERTIES OF COLLOIDS

❖ OPTICAL PROPERTIES OF COLLOIDS

TYNDALL EFFECT

- When a strong beam of light is passed perpendicularly through **two solutions (1) true solution and (2) colloidal solution** place against a dark background:
 1. The path of light beam is **not visible** in case of **true solution**.
 2. The path of light beam is **visible (scattered)** in case of **colloidal solution** and further it is **forming a shadow (beam or cone)** at the **dark background**.
- This phenomenon of **scattering of light** by the colloidal particles is called **Tyndall effect**.

- The illuminated beam or cone formed by the solution particles is called **Tyndall beam or Tyndall cone**.
- The Tyndall effect is due to the fact that **colloidal particles scatter light in all directions in space**.
- The scattering of light illuminates the **path of beam in the colloidal dispersion**.

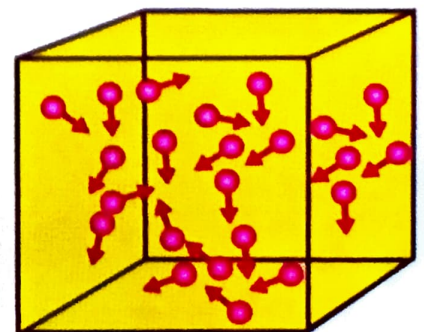


❖ KINETIC PROPERTIES OF COLLOIDS

- Kinetic properties of colloidal systems relate to the **motion of particles with respect to the dispersion medium**.
- The kinetic properties are:
 1. **Brownian motion**
 2. **Diffusion**
 3. **Osmotic pressure**
 4. **Sedimentation**
 5. **Viscosity**

1. Brownian motion

- Colloidal particles undergo random collisions with the molecules of the dispersion medium and follow an **irregular and complicated zigzag path**.
- If the particles up to about **0.5 μm diameter** are observed under a microscope or the light scattered by colloidal particles is viewed using an ultra-microscope, an erratic motion is seen.



- This movement is referred to as **Brownian motion**.

2. Diffusion

- As a result of Brownian motion colloidal particles spontaneously diffuse from a region of **higher concentration to one of lower concentration**.
- The rate of diffusion is expressed by **Fick's first law**:

$$\frac{dM}{dt} = -DS \frac{dc}{dx}$$

- According to the law, the amount, **dM** of substance diffusing in time, **dt** across a plane of area **(S)** is directly proportional to the change of concentration, **dc**, with distance traveled, **dx**.
- **D is diffusion coefficient** and has dimension of area per unit time, **dc/dx is concentration gradient**.
- The minus sign denotes that the diffusion takes place in the direction of decreasing concentration.
- The diffusion coefficient of a dispersed material is given by **Stokes-Einstein equation**

$$D = \frac{RT}{6\pi\eta rN}$$

Where

N=Avogadro's number (6.023×10²³ molecules per mole)

R=molar gas constant

r = Radius of spherical particle.

The analysis of above equations allows us to formulate three main rules of diffusion:

- (i) The velocity of molecules **increase with reduction of particle size**
- (ii) The velocity of molecules **increase with increasing temperature**
- (iii) The velocity of molecules **decrease with increasing viscosity of the medium.**

3. Osmotic Pressure

- Osmosis is the spontaneous net movement of solvent molecules through **semipermeable membrane** into a region of **higher solute concentration** in the direction that tends to equalize the solute concentration on the **two sides**.
- The external pressure required to be applied so that there is **no net movement** of solvent across the membrane is **called osmotic pressure**.
- The osmotic pressure, π of a dilute colloidal solution is described by the Van't Hoff equation:

$$\pi = cRT$$

Where

c = molar concentration of solute.

- This equation can be used to calculate the molecular weight of a colloid in a dilute solution.
- Replacing **c** with C_g/M in above equation, in which **c_g** is the grams of solute per liter of solution **M** is the molecular weight. We obtain

$$\pi = \frac{C_g}{M} RT$$

$$\frac{\pi}{C_g} = \frac{RT}{M}$$

- The above equation is true when the concentration of colloids is low (ideal system).
- For **linear lyophilic molecules** or high molecular weight polymers (real system), the following equation is valid.

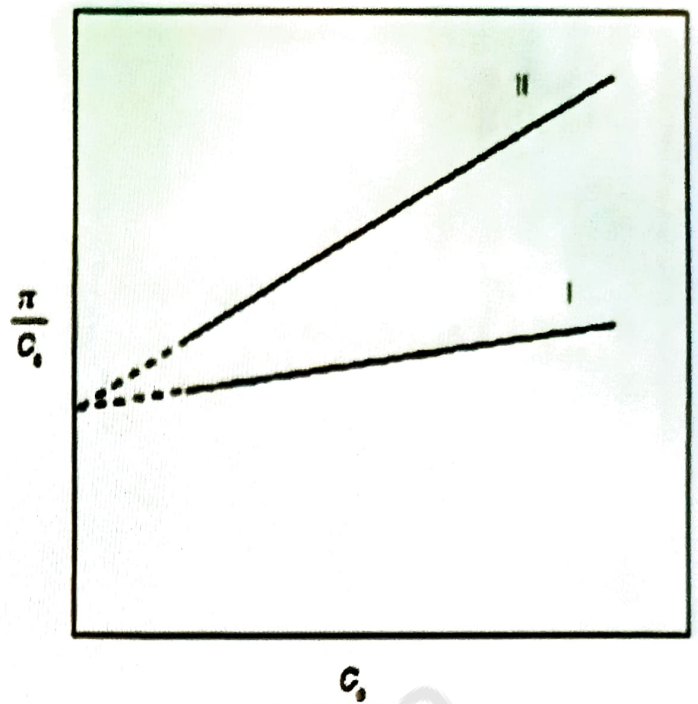
$$\frac{\pi}{C_g} = RT \left(\frac{1}{M} + BC_g \right)$$

- where **B** is an interaction constant for any particular solvent/solute system. A plot of $\frac{\pi}{C_g} \text{ vs } C_g$ is linear.
- The extrapolation of line to the vertical axis where **C_g=0** gives **RT/M** and if the **temperature** at which the **determination** was carried out is known, the **molecular weight of solute** can be **determined**.

- From the slope of the line the value of **interaction constant (B)** can be **determined**.

- Line II is typical of a linear colloid in a solvent having a high affinity for the dispersed particles.

- Type I line is observed for the same colloid if it is present in a relatively poor solvent having a reduced affinity for the dispersed material.



- However, the extrapolated intercept on y-axis is identical for lines I and II. This indicates that the calculated molecular weight is independent of the solvent used.

4. Sedimentation

- The velocity, v , of sedimentation of spherical particles having a density ρ , in a medium of density ρ_0 and a viscosity η_0 is given by Stoke's law:

$$v = \frac{2r^2(\rho - \rho_0)g}{9\eta_0}$$

where

- g is the acceleration due to gravity. If the particles are subjected only to the force of gravity, then the lower size limit of particles obeying Stokes's equation is about $0.5 \mu\text{m}$.

- A high speed centrifuge (ultracentrifuge), can produce a force of about 10^6g .

- In a centrifuge, g is replaced by ω^2x ,

- ω =angular velocity or angular acceleration= 2π times the speed of rotor in revolution per second,

- x = the distance of particle from the centre of rotation

$$v = \frac{dx}{dt} = \frac{2r^2(\rho - \rho_0)\omega^2x}{9\eta_0}$$

5. Viscosity

- Einstein equation of flow for the colloidal dispersions of spherical particles is given by:

$$\eta = \eta_0(1 + 2.5\phi)$$

- η_0 is the viscosity of dispersion medium, η is the viscosity of dispersion when volume fraction of colloid particles is ϕ .
- The volume fraction is defined as the volume of the particles divided by the total volume of the dispersion.

✓ Relative viscosity (η_{rel})

$$\eta_{(rel)} = \frac{\eta}{\eta_0} = 1 + 2.5\phi$$

✓ Specific viscosity (η_{sp})

$$\eta_{(sp)} = \frac{\eta}{\eta_0} - 1 = 2.5\phi$$

$$\frac{\eta_{sp}}{\eta_0} = 2.5\phi$$

- By determining η at various concentration and knowing η_0 the specific viscosity can be calculated.
- Because the volume fraction is directly related to concentration, we can write,

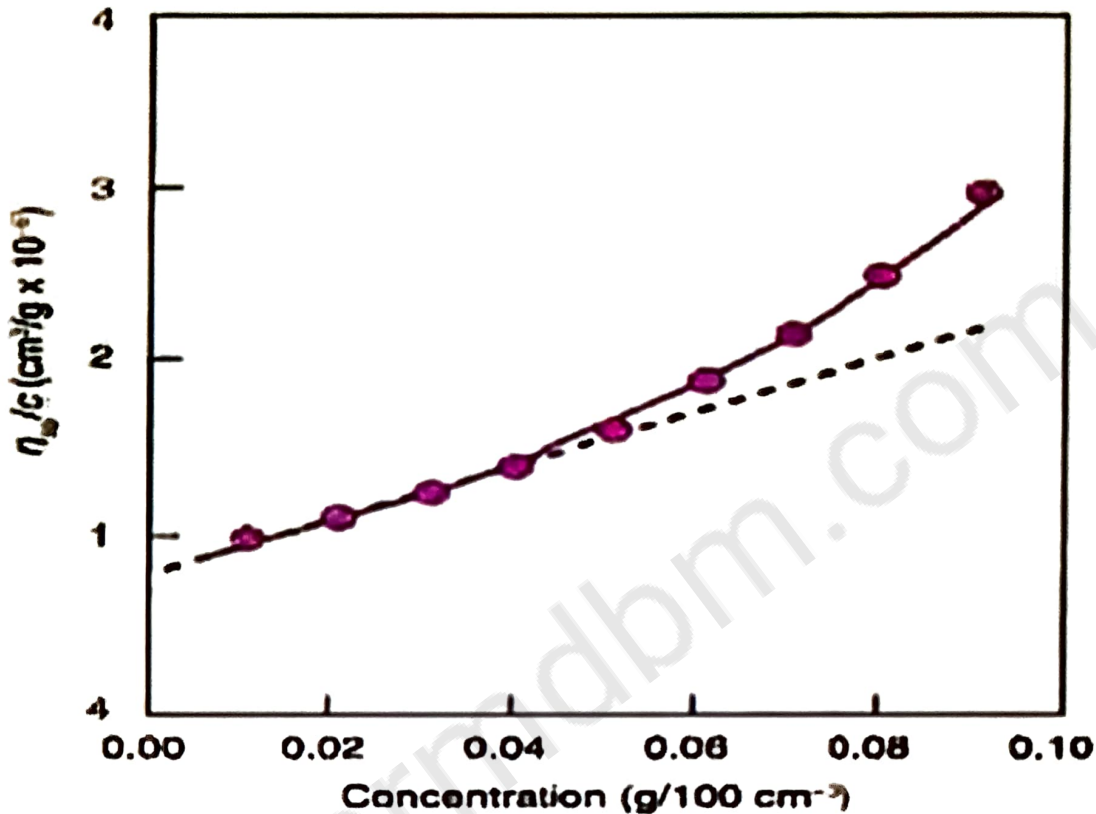
$$\frac{\eta_{sp}}{C} = K$$

Where

- C = gm of colloid particles per 100ml.**
- For highly polymeric materials, **Huggin's equation** is used.
- Specific viscosity expresses incremental viscosity due to presence of polymer in solution.
- Intrinsic viscosity is a measure of solute's contribution to the viscosity of a solution or limiting value of specific viscosity/concentration ratio at zero concentration.

$$\frac{\eta_{sp}}{C} = \eta_i + k\eta_i^2 C$$

- If η_{sp}/C is plotted against C and the line extrapolated to infinite dilution, the intercept is intrinsic viscosity (η_i).



- This constant, commonly known as the intrinsic viscosity η_i and is used to calculate the approximate molecular weights of polymers. According to the so-called **Mark-Houwink equation**

$$\eta_i = kM^a$$

Where

- k and a are constants, characteristics of a particular polymer-solvent system and are virtually independent of molecular weight.

$$\log \eta_i = \log k + a \log M$$

- These constants are obtained initially by determining η_i experimentally for polymer fractions whose molecular weights have been determined by other methods such as **light scattering, osmotic pressure, or sedimentation.**

- Then the specific viscosity for each fraction is determined and then intrinsic viscosity can be obtained.
- If we plot $\log \eta_i$ vs. $\log M$ then the slope will give ' α ' value and the intercept will give ' k ' value.
- Then, the molecular weight (M) of unknown fraction of the polymer can be obtained from **Mark-Houwink equation**.

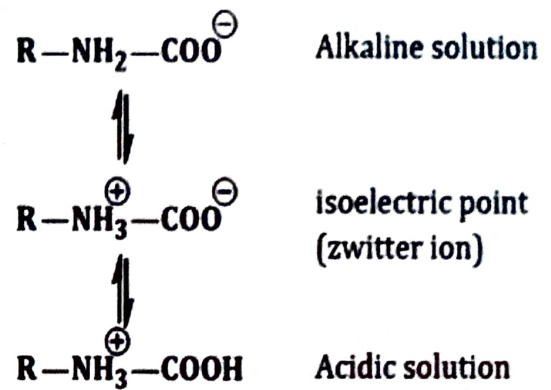
❖ ELECTRICAL PROPERTIES OF COLLOID

- The **colloidal particles** acquire a **surface electric charge** when brought into **contact with an aqueous medium**.
- The **movement of colloidal particles** towards a particular electrode under the **influence of an electric field**.
- The **colloidal particle** with a **positive charge moves towards the cathode** under the influence of the **electric field** and the colloidal particle with a **negative charge moves towards the anode**.
- The principal charging mechanisms are discussed below.

1. Surface Ionization

- The charge is controlled by the **ionization of surface groupings**.
- For example, **carboxymethyl cellulose** frequently has **carboxylic acid groupings** at the surface which **ionize to give negatively charged particles**.
- **Amino acids and proteins** acquire their charge mainly through the **ionization of carboxyl and amino groups to give $-\text{COO}^-$ and NH_3^+ ions**.
- The ionization of these groups and hence the **net molecular charge depends on the pH of the system**.
- At a pH below the pK_a of the COO^- group the protein will be positively charged because of the protonation of this group, $-\text{COO}^- \rightarrow \text{COOH}$, and the ionization of the **amino group $-\text{NH}_2 \rightarrow -\text{NH}_3^+$** , which has a much higher pK_a , whereas at higher pH, where the **amino group is no longer ionized**.

- The net charge on the molecule is now **negative** because of the **ionization of the carboxyl group**.
- At a certain definite pH, specific for each individual protein, the total number of positive charges will equal the total number of negative charges and the net charge will be zero.
- This **pH** is termed the **isoelectric point of the protein** and the protein exists as its **zwitterion**.
- This may be represented as follows:

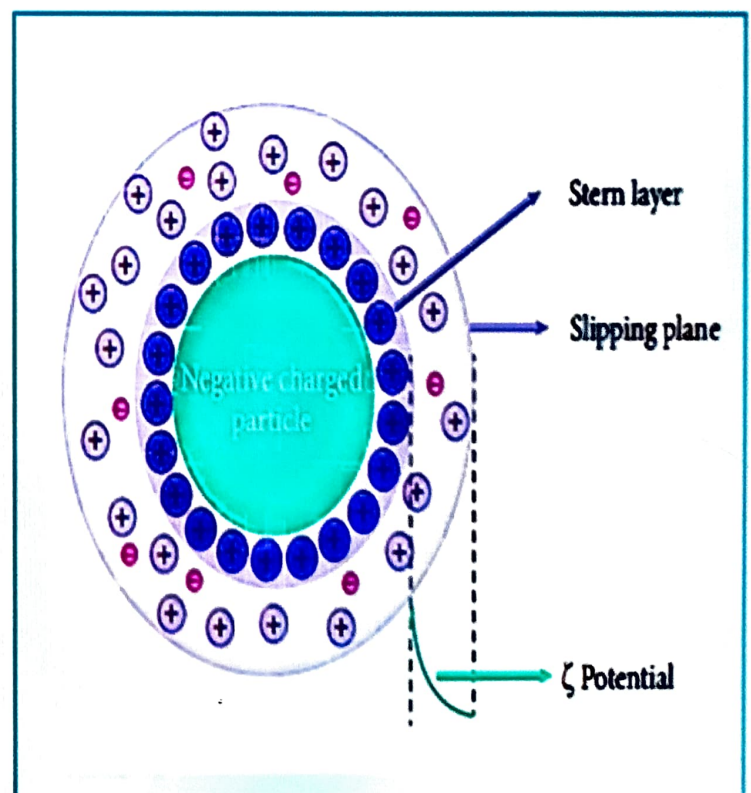


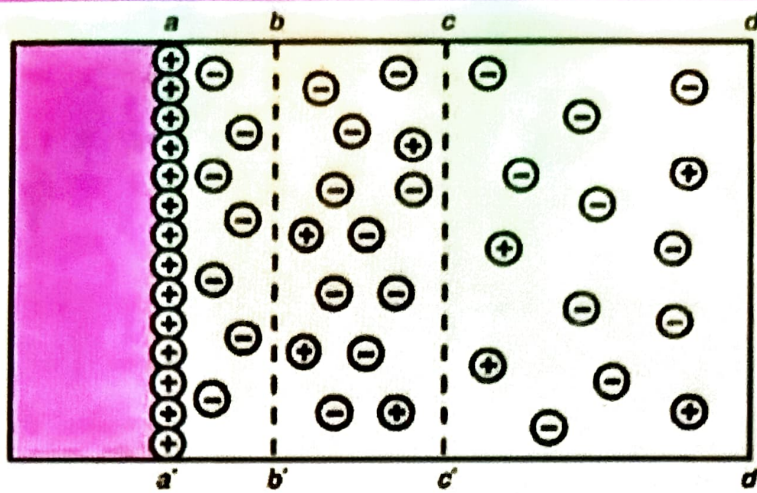
2. Ion Adsorption

- Surfaces in water are more often **negatively charged** than **positively charged**, because cations are generally **more hydrated than anions**.
- Consequently, the former have the greater tendency to reside in the bulk aqueous medium, whereas the **smaller, less hydrated and more polarizing anions** have a greater tendency to reside at the particle surface, **Surface-active agents** are strongly adsorbed and have a pronounced influence on the **surface charge**, imparting either a **positive** or **negative charge** depending on their **ionic character**.

3. Electrical double layer

- The **theory of the electric double layer** deals with this distribution of ions and hence with the **magnitude of the electric potentials** that occur in the locality of the **charged surface**.
- Consider a **solid charged surface** in contact with an **aqueous solution of electrolyte**.





- The cations are adsorbed onto the solid surface (aa') giving it a positive charge and these are called potential determining ions.
- Then the counter anions are attracted to the **positively charged surface** by **electric forces** and forms a region called **tightly bound layer**.
- In this layer there are fewer anions than cations adsorbed onto the solid surface and hence the potential at bb' is still positive.
- In addition to these **electrical forces**, the thermal motion tends to produce an equal distribution of all the ions in solution.
- The system as a whole is electrically neutral even though there are regions of **unequal distributions of anions and cations**.
- The region bounded by **bb' and cc'** is called diffuse second layer where an **excess anions** are present.
- Beyond cc', the distribution of ions is uniform and an electrically neutral region exists.
- The potential at the solid surface is called **NERNST POTENTIAL** and is defined as the difference in potential between **actual solid surface** and the **electrically neutral region of the solution**.
- The potential at **plane bb'** is called **ZETA POTENTIAL** and is defined as the difference in potential between surface of tightly bound layer and the electrically neutral region of the solution.
- If **zeta potential** falls below a particular value (+30mV or -30mV), **the attractive force exceed the repulsive force** and results in aggregation of colloidal particles.

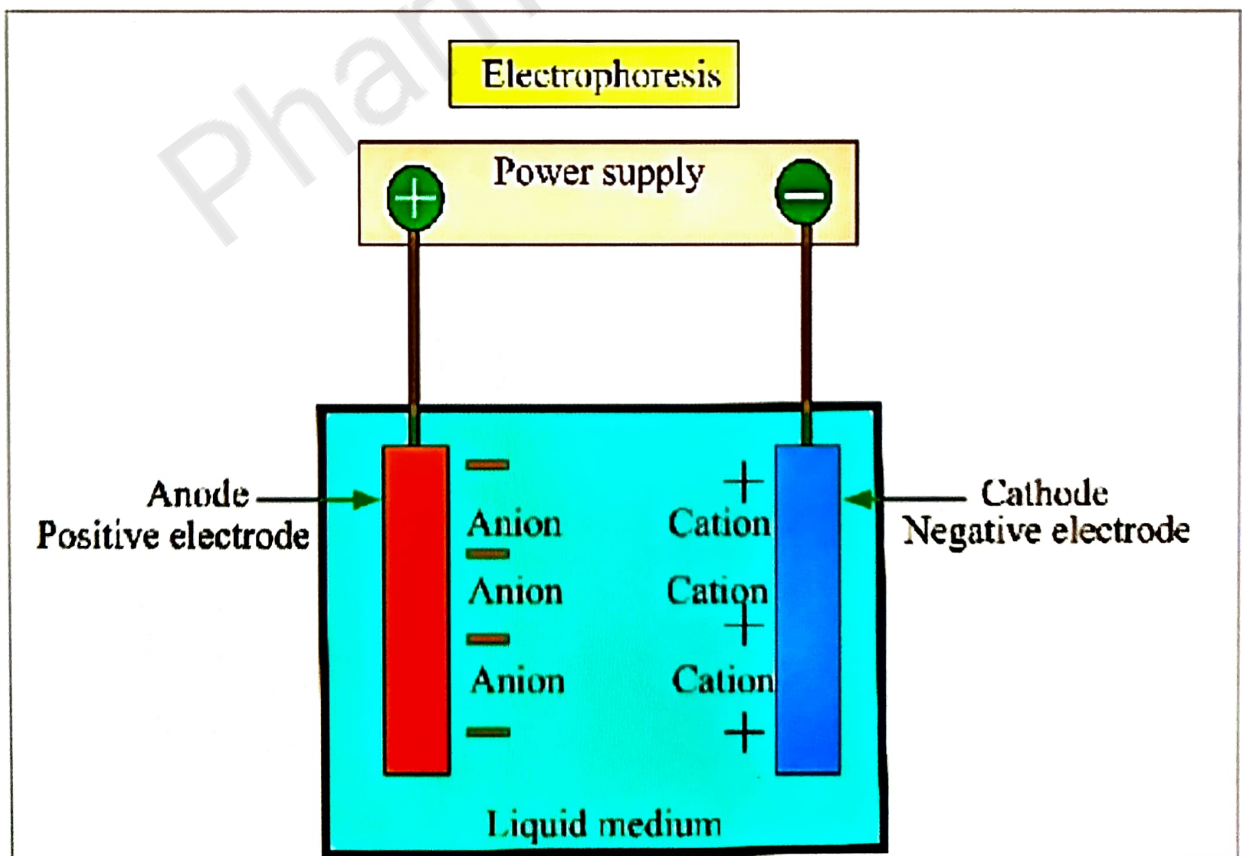
- The stability of colloidal particles is evaluated based on **zeta potential value**.
- Zeta potential **decreases more rapidly** when the concentration of electrolytes is increased or the **valency of counter ions is higher**.

❖ **ELECTROPHORESIS**

- The movement of a charged particle which is relative to liquid it is suspended under influence of an applied electric field is called as **Electrophoresis**.
- Used to **measurement of zeta potential**.
- It is **electro kinetic phenomenon**.
- If an **electric potential** is applied to a **colloid**, the charged colloidal particles move towards the **oppositely charged electrode**.
- The charge on the **particle determined** and gives **sign of zeta potential** and **rate of migration** of function of charge on particles.
- Velocity or rate of migration increases with **increasing potential gradients**.

$$V = \xi \times E$$

- where, ξ = **zeta potential**.



❖ ELECTRO-OSMOSIS

- Electro-osmosis is opposite principle to that **electrophoresis**.
- The atmosphere of counter ions around the particle confers a charge on the dispersion medium. **+ve and - ve** particle are present in liquid medium, they are move opposite pole.
- This flow of liquid medium under the influence of electric field is known as **electro-osmosis**, and pressure is called **electro-osmotic pressure**.

❖ STREAMING POTENTIAL

- This is opposite of **electro-osmosis**.
- If the electrodes in the **electro-osmosis apparatus** are replaced by **galvanometer in the circuit**, **no current** will be detected when the liquid is stationary.
- If the liquid is forced through tube the **galvanometer measure current**.
- Streaming potential due to displacement of the charges equilibrated in the double layer around the solid.
- This technique can be used to measure the zeta potential of relatively coarse solids which would sediment rapidly on electrophoresis cell.

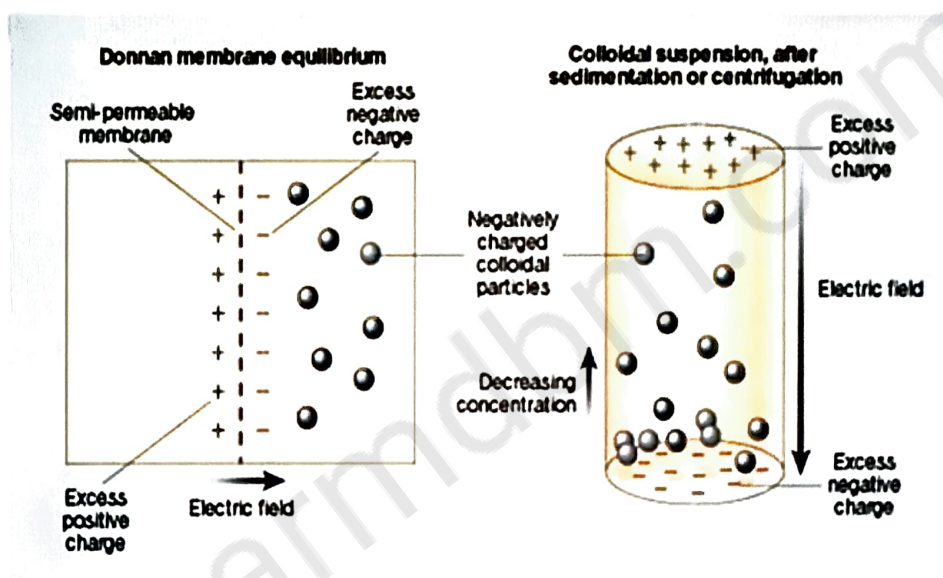
❖ SEDIMENTATION POTENTIAL/ DONNAN MEMBRANE EQUILIBRIUM

- This is the potential difference set up between **top and bottom** of a **suspension of solid particles** in a liquid when the particles settle under the influence of **gravity**.

✓ Principle:

- A solution of **NaCl** is placed on one side of the **semipermeable membrane**.
- On the other side a solution of **negatively charged colloids** together with its counterion is placed.
- The **volume of solution** on the **two side of membrane** are considered to be **equal**.

- Na^+ and Cl^- ion move freely across the semipermeable membrane, but colloidal particles, colloidal particles (R^-) are not diffusible soon equilibrium is attained.
- Apply the condition of **electro neutrality**.
- The **+ve and - ve charge** on either side of the membrane must be balanced.
- At equilibrium, the **osmotic pressure of two solutions** will be different and if **two reference electrodes** such as **calomel electrodes** are put into the two solutions then a difference of **potential** will be set up.
- This type of equilibrium is known as **DONNAN**.



EFFECT OF ELECTROLYTES

- The instability in colloidal solution is characterised either by coagulation or precipitation.
- The reasons for instability of colloids are addition and **removal of electrolytes, coacervation and sensitization**.
- **Addition of electrolytes**
- In **lyophobic colloids** trace amount of electrolyte addition is required for providing charge to colloidal particle which overcome the **attraction forces between particles**.
- Addition of **excess amount of electrolyte** leads to **coagulation** because it **provides both the charges**.

- Under this condition, **repulsive forces** are diminished with dominance of **attractive forces and colloids gets coagulated.**
- In lyophobic colloids accumulation of opposite charge particle changes the zeta potential which leads to coagulation.
- **Removal of electrolytes**
 - **Coagulation of colloid** is observed when electrolyte is **completely removed from the sol.**
 - This happen due to **repulsive forces.**
- **Addition of non-solvent**
 - Addition of **less polar solvent** like **alcohol or acetone** causes the **dehydration of colloidal particles of lyophilic sols.**
 - If electrolyte is added in such situation it **leads to precipitation of colloids.**

COACERVATION

- When **oppositely charged hydrophilic colloids** are mixed, a colloidal rich layer separates which is called as **Coacervate.**
- This phenomenon in which **separation** take place on mixing two dispersions on mixing is called **Coacervation.**
- E.g **Gelatin is positively charged** and **acacia** having **negatively charged** particle.
- When two are mixed together **two layers** are formed , the **upper layer** of **low viscosity** having a **poor concentration** of colloidal material and a **lower layer of higher viscosity** containing **high concentration** of colloidal material.

PEPTIZATION

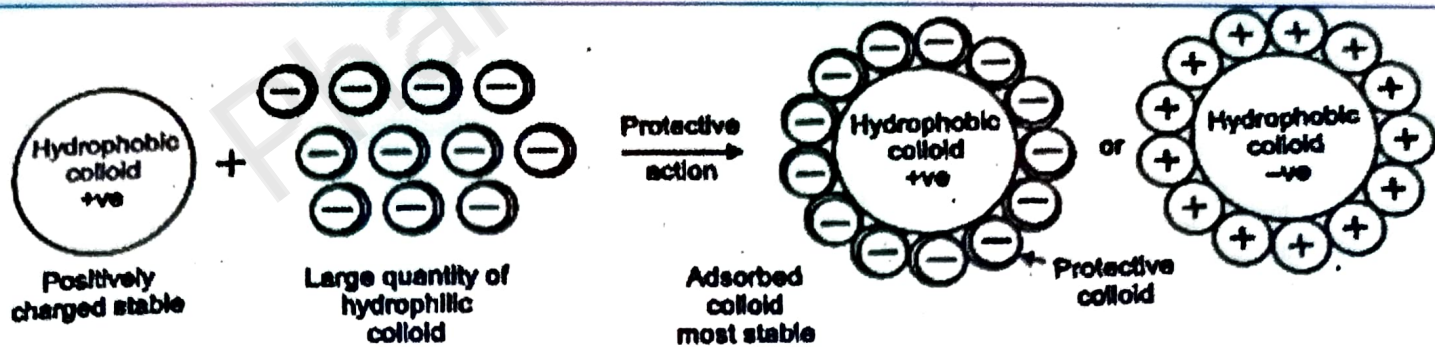
- **The conversion of precipitate into colloidal solution by adding a suitable electrolyte** is called **peptization.**
- The electrolyte is a stabilizing agent and basically called a **peptizing agent.**

➤ Example

- When the ferric chloride (FeCl_3) solution is added to the precipitate of ferric hydroxide ($\text{Fe}(\text{OH})_3$), the hydroxide is dispersed into the colloidal solution by **absorbing ferric ions**.
- The ions of the electrolyte are **adsorbed** on the **ions of the precipitate**.
- They repel and hit each other breaking the particles of the **precipitate into colloidal size**.

PROTECTIVE COLLOID ACTION

- When a **large amount of hydrophilic colloid** carrying **opposite charge** is added to **hydrophobic colloids**, these gets adsorbed on the hydrophobic particles and form a **protective layer around it**.
 - This adsorbed layer prevents the precipitating ions reaching the sol particles. Therefore, **coagulation is prevented** and the system becomes stabilized. The entire colloid behaves like a **hydrophilic colloid**.
 - The colloid that helps to stabilize the other colloid is known as **protective colloid**.
 - The protective property is expressed most frequently in terms of the **gold number**.
 - The gold number is the **minimum weight in milligrams** of the protective colloid (dry weight of dispersed phase) required to prevent a color change from red to violet in 10 mL of a cold sol on the addition of **1 mL of a 10% solution of sodium chloride**.
- The gold numbers for some common protective colloids are:
- ✓ **Gelatin (gold number 0.005-0.01)**
 - ✓ **Albumin (gold number 0.1) Acacia (gold number 0.1-0.2)**.
- Basically gold sol is a hydrophobic colloid and has **red color**.
 - When an electrolyte like **NaCl** is added **coagulation of colloid** is observed indicating **violet color**.
 - When protective colloids are added, these stabilize the gold solution and **prevent the change to violet color**.
 - Lower the gold number, **greater the protective action**



PROTECTIVE COLLOIDS	GOLD NUMBER
Albumin	0.1
Acacia	0.1-0.2
Tragacanth	2
Gelatin	0.005-0.01

