Unit-I Colloidal Dispersions

Colloidal dispersions – are defined as those polyphasic system (heterogenous), where at least one dimension of the dispersed phase measure b/w one nm and one micrometer.

↳ Colloid ⇒ glue-like (in Greek) substances.
eg – Glue, gelatin, starch.

→ Heterogenous
→ but not visible

Classification of dispersed System

① Classification According to physical State of two phases:

S.No.	Dispersed phase	Dispersion medium	Name system	Examples
1.	Solid	Solid	Solid solution	Colloidal gold
2.	Liquid	Solid	Gels	wax, gels
3.	Gas	Solid	Solid foam	foam, rubber
4.	Solid	liquid	sols	moist paints, proteins.
5.	Liquid	Liquid	~~foam~~ emulsion	milk
6.	Gas	liquid	foam (liquid)	Soap lather Sodawater
7.	Solid	Gas	Aerosal of solid	smoke dust storm
8.	Liquid	Gas	Aerosal of liquid	Fogs, Clouds

(2) Classification According to particle diameter –

(1) Molecular dispersions	(2) Colloidal dispersions	(3) Coarse dispersion –
↳ dispersed particles range ~~from~~ less than 1 nm	↳ Range from ⇒ 1 nm to 1 um	⇒ more than 1 um
↳ invisible in electron microscope	↳ visible in only electron-microscope (not ordinary microscope)	↳ visible under ordinary micro-scope.
↳ pass through semi-permeable membranes	↳ pass through filter paper but not pass through semi-permeable membrane	↳ Do not pass ~~semi~~ filter paper, retained on the filter paper.
eg - oxygen gas, glucose etc.	↳ eg - Colloidal silver sols, natural & synthetic polymers	eg - Emulsions, suspensions, RBCs.
↳ Rapid diffusion	↳ very slow diffusion	↳ not diffusion
↳ not settle	↳ under centrifugation settle down	↳ under gravity settle down
↳ Homogeneous	→ Heterogeneous	→ Heterogeneous.
→ Tyndall effect Don't show	→ show	→ show
→ Brownian motion Negligible	→ show (occured)	→ may be / may not
→ Separation not possible	→ separate through semipermeable membrane	→ separate through filter paper.

⇒

Size and shape of Colloidal particles

Particle Size:- Particle size influences the colour of a dispersion. The wavelength of light absorbed by a particles is approximately related to its ~~density~~ radius.

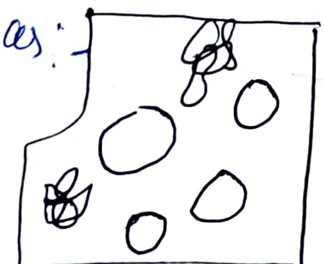
→ the larger the particle, the shorter the wavelength of light transmitted, i.e. the colour Colour approaches the violet end of the spectrum.

eg. Colloidal gold has red colour (650 to 750 nm) while intermediate size is in violet colour.

Particle shape:-

The shape of particles of colloidal is depends upon method by which they are prepared and the type of interaction between dispersed phase with dispersion medium.

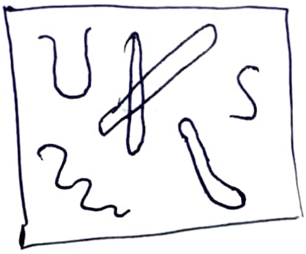
- They may be exists in cubical, ~~Shex~~ spherical, spiral thread, cylindrical, disc & rod shaped.
- It visible in electron microscope and look like as:-



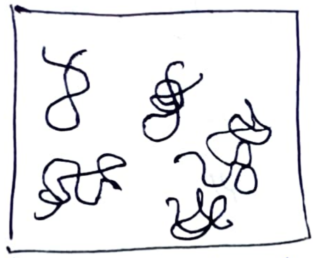
Spheres and globules
surfactants, poliomyelitres

· Short rods and prolate ellipsoids

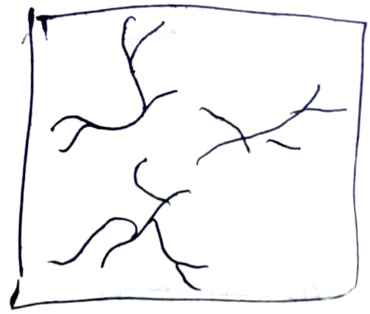
· oblate ellipsoids and flakes



• Long rods & threads



• Loosely coiled threads



• Branched thread.

⇒ It also influence the ~~colour~~ & viscosity of particles.

eg- Spherical particles dispersion of low viscosity while linear particles generally produce more viscous dispersion.

⇒ Classification of Colloids:-

• Based on nature of interaction (affinity) between dispersed phase and dispersion medium

three types-

1. Lypophilic Colloids
2. Lyophobic Colloids
3. Association colloid

① Lypophilic Colloids: Lyo → Solvent, philic → loving -

- Also called as solvent loving colloids.

• These are those solution, in which the dispersed phase has great attraction for the dispersion medium.

Types

Hydrophilic

- When dispersion medium is water

eg- Acacia, ~~Alb~~ Albumin & gelatin in H_2O

Lipophilic

→ When dispersion medium is oil (other than water)

eg- Rubber, Polystyrene in non-aqueous (Benzene)

- ⇒ these are thermodynamically stable.
- ⇒ Viscosity of these solution generally increase on addition of dispersed phase.

② **Lyophobic Colloids**:- lyo → Solvent, phobic → Hating.

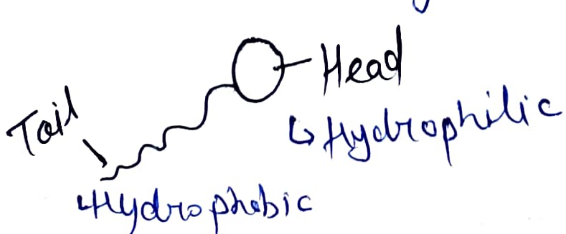
- → Also termed as Solvent hating colloids.
- → In which the dispersed phase has very less interaction [no affinity] for the dispersion medium.
- → They are thermodynamically unstable (low stability).
- ⇒ Viscosity of these solution does not increase on addition of dispersed phase.
- If the dispersion medium is water then they also called as Hydrophobic colloids.

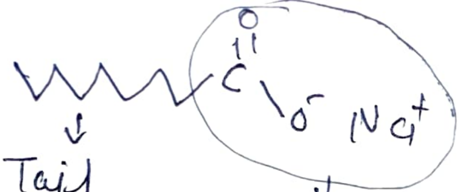
eg. metal such as Gold, Silver in water.

③ **Association Colloids**:

↳ Also called as Amphiphilic colloids.

- Molecules / Ions have both polar and non-polar group.
- They exists separately at low concentration.
- They associate at CMC (Critical miscelle concentration) to form micelle of colloidal size.
- ⇒ they are also thermodynamically stable.



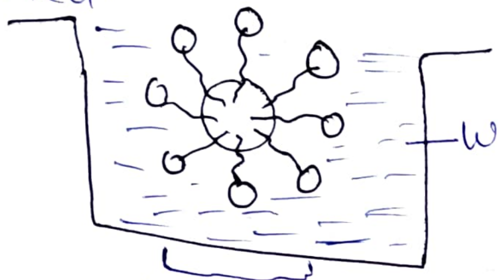


Tail
(hydrophobic
- Non-polar

Head
- Hydrophilic
→ polar

CMC ⇒ [Critical Micelle Concentration]

The ~~ma~~ minimum concentration at which micelle are formed.



water (as a dispersion medium)

↳ Micelle (Associated Colloids)

⇒ these amphiphiles also known as Surfactants -

- Viscosity increases with addition of amphiphiles.

⇒ Comparative account of their general properties

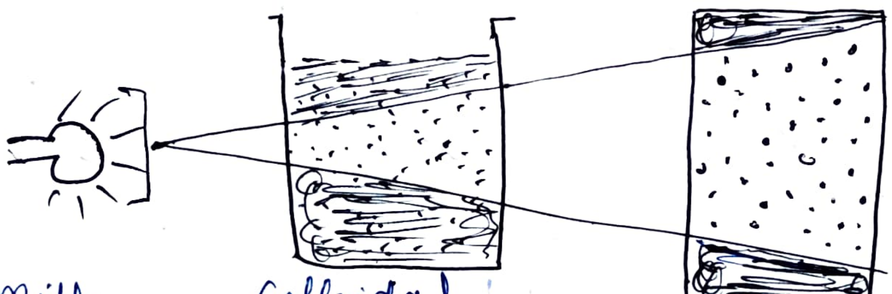
Characteristic features/properties	Lyophilic colloids	Lyophobic colloids	Association colloids
1. Nature of Interaction	Strong, high affinity	Little affinity (very low)	Depend on type of dispersion medium
2. Dispersed phase	mostly organic molecules	mostly inorganic molecules	Aggretion of surfactants -
3. Size	Small	large	small
4. Viscosity	Increased	Same as dispersion m.	increases
5. Reversibility profil.	Reversible	Irrersible	Reversible
6. Stability	Stable high	Less stable	stable
7. Method of preparation	Simple & Easy	special method required	Depends on CMC

Optical, Kinetic & Electrical properties

① Optical properties of Colloids –

These help to known about size, shape, structure ~~of~~ & molecular weight of colloids.
* There are following –
(i) ~~T~~ Tyndall Effect (Light scattering)
(ii) Ultramicroscopy
(iii) Electron microscopy
(iv) Turbidity.

① **Tyndall Effect :–** When a beam of light is passed through a colloidal solution (dispersion) kept in dark, the path of the beam get illuminated with blue colour.
This phenomena is known as tyndall effect and the path is known as tyndall cone.
⇒ The ~~tynd~~ tyndall effect is due to the scattering of light by colloidal particles.



eg- Milk.

Colloidal dispersion

Dark background

• True (Homogeneous) solution does not show this, they have small particle size.

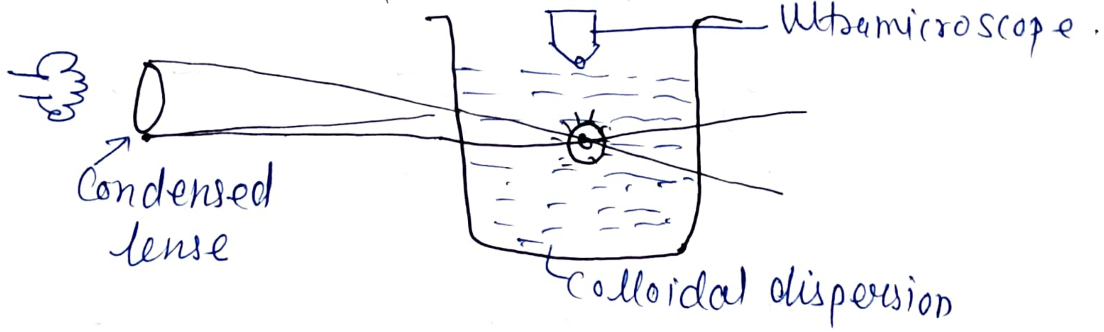
→ Heterogeneous (colloidal) dispersion show this.-
Lyophobic → show more
Lyophilic → show less (no effect)

(ii) Ultramicroscope :-

Ultramicroscope has been used to observe the dyndall beam.

When a intense light beam is passed through the solution (colloidal dispersion) against a dark background at right angles to the plane of observation.

→ The particles will appear as the bright spot which can be observed and counted.



(iii) Electron Microscope :-

It give the actual picture of the colloidal particles.

- High energy electron beam are passed, it used to observe the size, shape and structure of colloidal particles.
- Useful ~~of~~ in lyophilic.

(iv) Turbidity :-

All colloidal dispersion show turbidity according to molecular weight of colloids particles, spectrophotometer are used to check this.

Turbidity ∝ molecular weight

(2) Kinetic Properties of Colloids :-

These properties helps to known about the motion of colloidal particles in colloidal dispersion.

(i) Brownian Motion
(ii) Diffusion
(iii) Sedimentation
(iv) Viscosity

(i) Brownian Motion :-

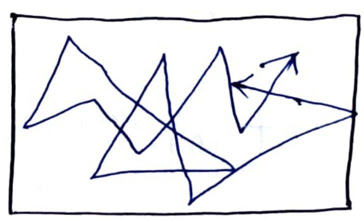
It is the zig-zag motion of colloidal particles in colloidal dispersion in continuosly random manner.

→ It is given by scientist Robert Brown.

→ Particles continous strike to each other and to the wall of container.

→ Velocity ↑ → particle size ↓

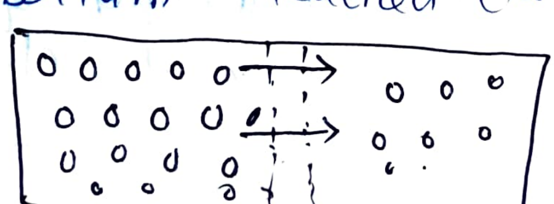
→ Brownian movement ↑ → Stability ↑



(ii) Diffusion :-

It is the movement of particles from an area of higher concentration to the area of lower concentration.

→ It is based on Fick's first law, that particles diffuse spontaneously (continously) until the diffusion equlibrium reached. (is attained).



(iii) Sedimentation :-

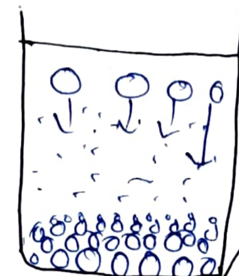
It is the settling down of dispersed phase particles into dispersion medium due to gravity.

⇒ It is depends upon molecular weight of colloidal particles (mol. weight ↑ = sedimentation ↑).

⇒ It is also depends upon the density difference of dispersed phase to the dispersion medium.

⇒ Brownian motion ↑
⇓
Sedimentation ↓

⇒ Sedimentation ↑
⇓
stability ↓



→ Stoke's law used to determine sedimentation.

→ $\eta = \eta_0 (1 + 2.5 \phi)$

where, η = viscosity of dispersion, Pa.s.
η_0 = viscosity of dispersion medium, Pa.s
ϕ = volume fraction of particles

(iv) Viscosity :-

It is the resistance to fluid to flow under an applied stress.

⇒ It is depend upon -
- shape, size, molecular weight
- interaction between dispers phase and dispersion medium.

⇒ Molecular weight ∝ viscosity.

• Einstein describe on equation of flow to dilute colloidal dispersions of spherical particles -

⇒ $$\eta = \eta_0 (1 + 2.5 \phi).$$

③ Electrical Properties of Calloids-

These properties helps to known about the charge on calloidal particles in dispersion (calloidal dispersion).

ⓘ Electrophoresis

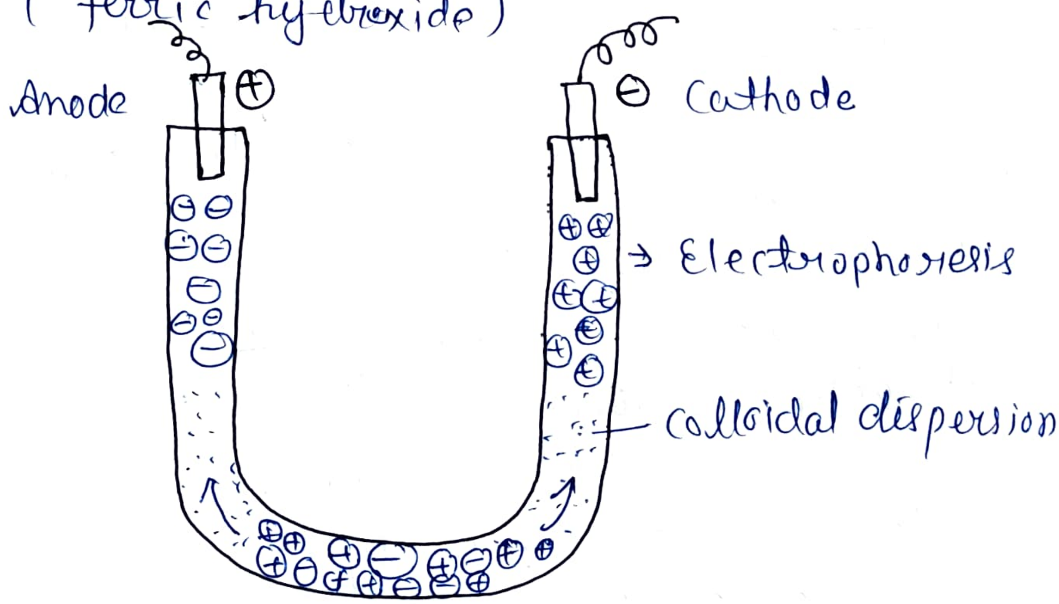
ⓘⓘ Electrical double layer

ⓘ Electrophoresis :-

When an electric field is applied on calloidal dispersion, then the particles carrying charged move towards opposite charge electrod. i.e-

⇒ Negative charged particle move towards anode (kaoline, sulphar).

⇒ Positive (+ve) charged particle move towards cathode - (ferric hydroxide)

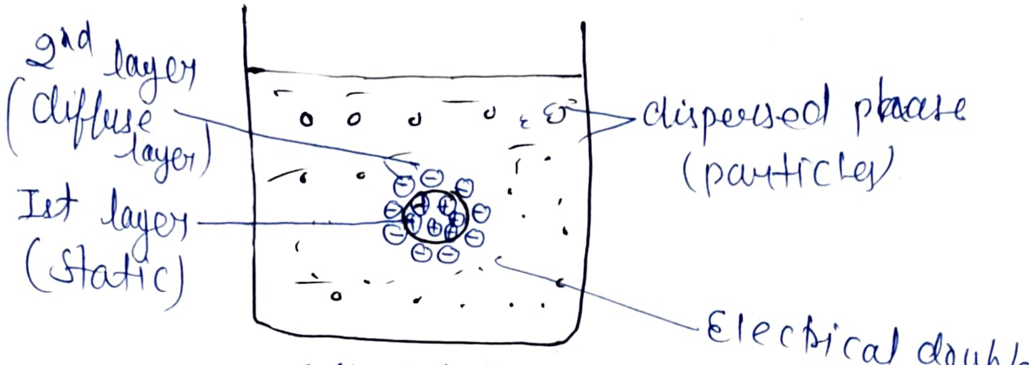


ⓘⓘ Electrical double layer :-

Helmhotz explain it in 1879.

⇒ In this theory, at the first layer charge is imparted to the surface of particles which is immovable also known as static layer (or helmhotz layer) and the second layer consists of diffused mobile ions (according to first layer).

- The charge develop (present) on both the layer are equal



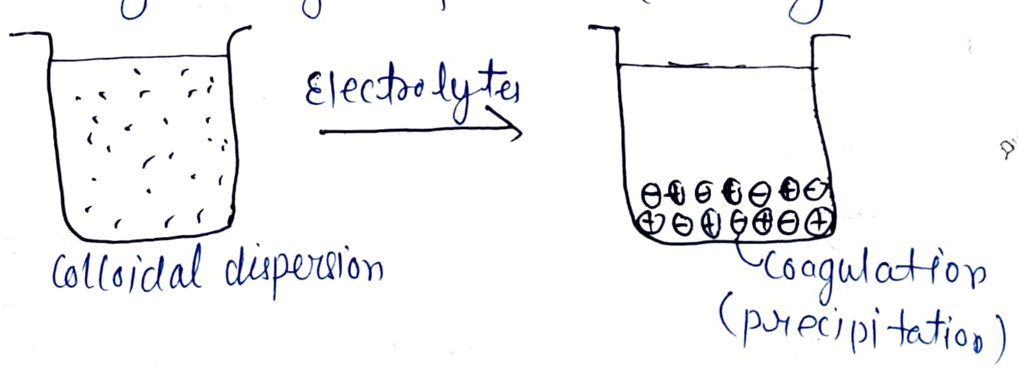
Colloidal dispersion

⇒ The potential difference between two layer i.e. Static and diffuse layer is called as <u>Zeta potential</u> or Electrokinetic potential.

⇒ Effect of Electrolytes :-

On addition or removal of electrolyte in colloidal dispersion may affect the stability of colloids.

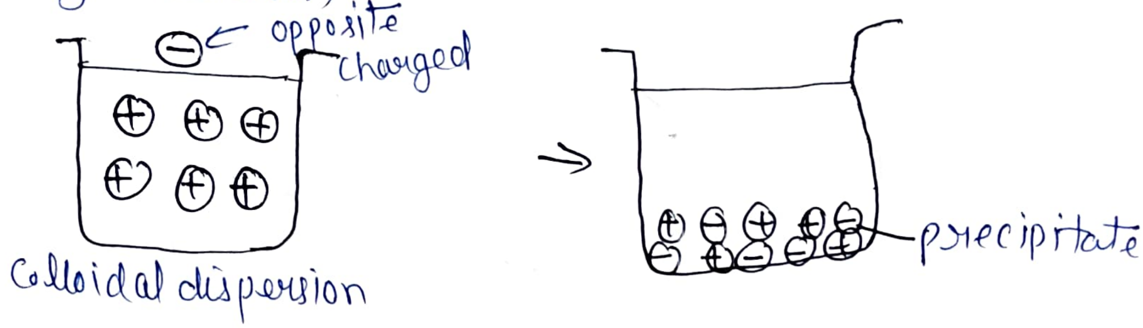
- On addition of excess of electrolytes, particles of colloidal dispersion precipitate due to accumulation of oppositely charged particles (stability decreases)



Hardy Schulze law (rule):-

The phenomenon of deposition of colloid particles when oppositively charged electrolyte on it. (Stability decreases)

eg.



⇒ Charge on Cation/Anion ∝ Coagulation/precipitation.

eg - $Al^{+3} > Mg^{+2} > Na^{+}$

$PO_4^{-3} > SO_4^{-2} > Cl^{-}$

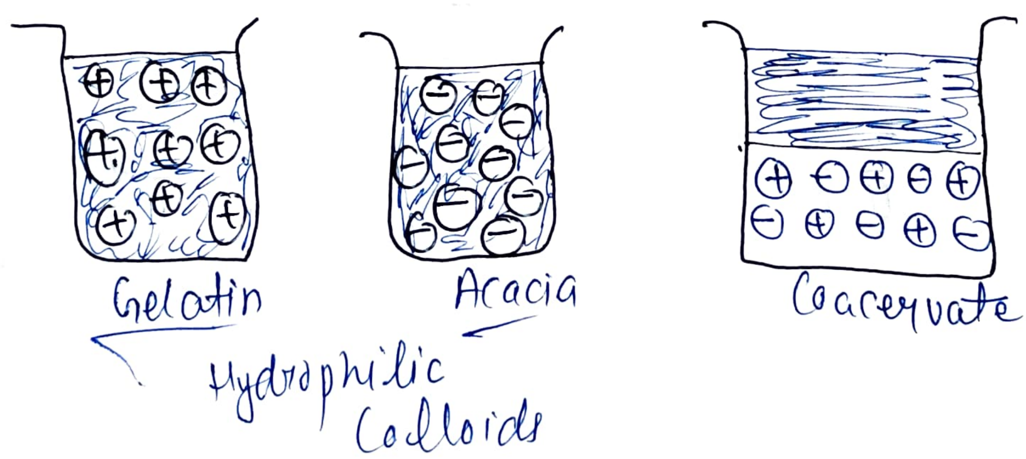
⇒ But if we add same charged particles then particles and electrolytes repel each other and increase stability of colloidal dispersion.

⇒ Coacervation:-

When two opposite charged hydrophilic colloids are mixed then there will be separation of the colloid rich layer.

⇒ The colloid-rich layer is known as coacervate. The phenomenon is called as Coacervation.

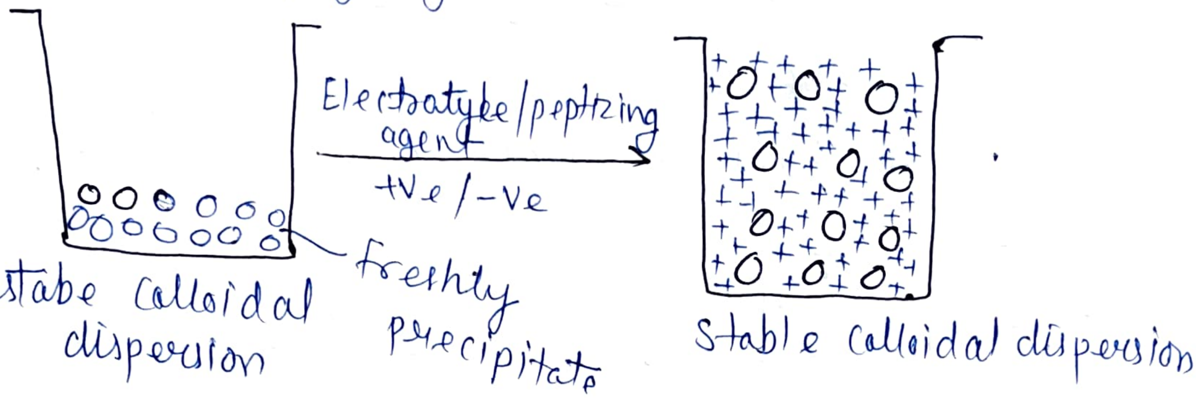
eg.



⇒ Peptization :-

It is used for the formation of stable colloidal dispersion.

"It is the process of converting a precipitate into colloidal dispersion by shaking it with dispersion medium in the presence of small amount of electrolyte/ peptizing agent."



eg. - $Fe(OH)_3 + Fe^{3+} \longrightarrow$ $^{+}_{+}Fe(OH)_3{}^{+}_{+}\ Fe(OH)_3{}^{+}_{+}$

Precipitate Electrolyte

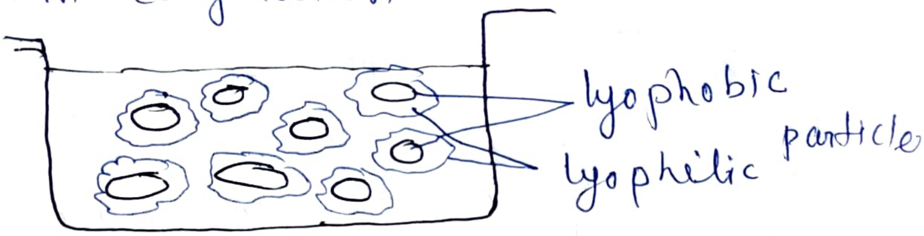
⇒ Protective Action :-

The addition of lyophilic colloidal solution into a lyophobic colloidal solution prevents a lyophobic sol form coagulation.

- This phenomenon is known as protective action and the lyophilic colloid used for this purpose is known as protective colloids.

mechanism - when lyophilic colloid added to a lyophobic colloid, the particles of lyophilic cover the surface of lyophobic particle and behave as protective colloids - and the particles of lyophobic behave as lyophilic colloids and

and prevents from coagulation.

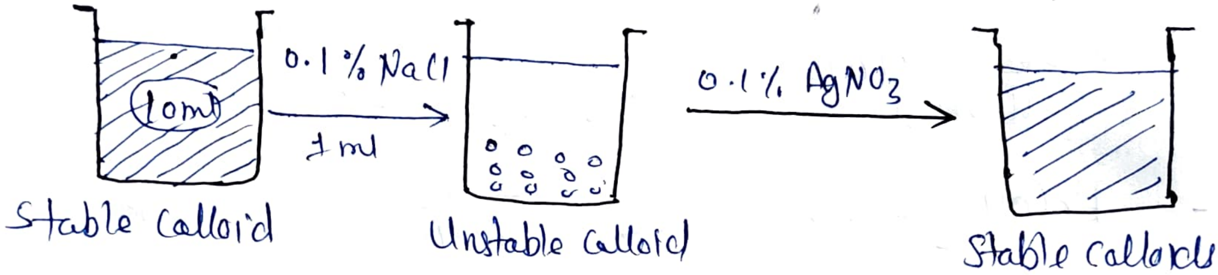


Colloidal dispersion

Gold number -

The amount of protective colloids in mg. which prevents the coagulation of gold solution (10 ml) when 1 ml of NaCl added to it.

eg:-



→ Amount of 0.1% $AgNO_3$ to make it stable.