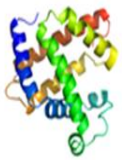
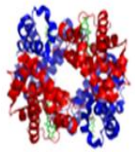
COLLOIDAL STATE

Biocolloids

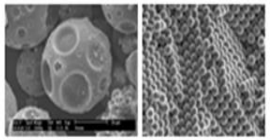


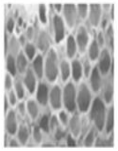
myoglobin



haemoglobin

Nano "golf balls"





Megaspore wall
from a fossil of *Salvinia cerebrata*.

Multiple Colloids

16

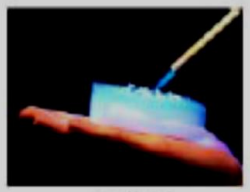
Examples of colloidal systems from daily life

Foams

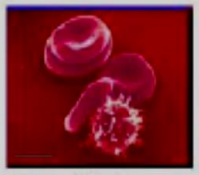
Milk

Fog, smoke

Detergents



Aerogel



Blood

Paints

Cosmetics

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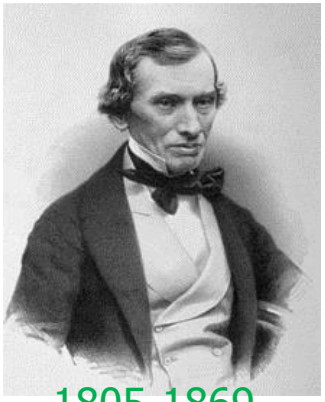
Better things for better living through chemistry.

Introduction

Thomas Graham (1861) *…English scientist.(founder of colloidal state…)*

Crystalline substances-

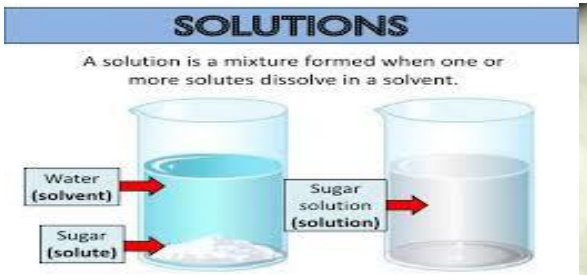
- eg. Solution of Sugar,urea,common salt passes through membrane but others like gelatin, glue did not……



1805-1869

solution of sugar, urea and common salt------clear like water

but…..gelatin,glue ------thicker than water…



- Grahams statement:- materials like sugars ,urea be called as crystalloids..and gelatin,glue be called as collides……This is due to particle size……
- Any substance can be convertible to collides…..
- Grahams-.. Every substance irrespective its nature can be crystalloid or a colloid under suitable conditions…..
- eg….1) Nacl is crystalloid in water but colloidal in benzene…

  2) soap is collidal in water but crystalloid in benzene….

Solutions

1) -contain small particles (ions or molecules).

2) - are transparent.

3)- do not separate.

4) - cannot be filtered.

5)-do not scatter light.(Tyandell effect)

6) Solute particles dispersed in solvent as single molecules or ions.

7) particle size (diameter) 10^{-7} to 10^{-8}cm.....

Ex..salt,sugar,oxalic acid,etc...solution..

Suspension

1) have very large particles.10^{-2} to 10-7cm

2) settle out and can be filtered.

4) must be stirred to stay suspended..

5) Insoluble particles remains suspended in liquid or gas...

Ex..coffee/tea with milk,blood platelets, muddy water,Calamine lotion,oil,vinegar dressing,milo drink...

Colloidal state

1)- have medium size particles.10^{-4} to 10^{-7} cm. Intermediate betn. true soln .and suspension…

2) -cannot be filtered.

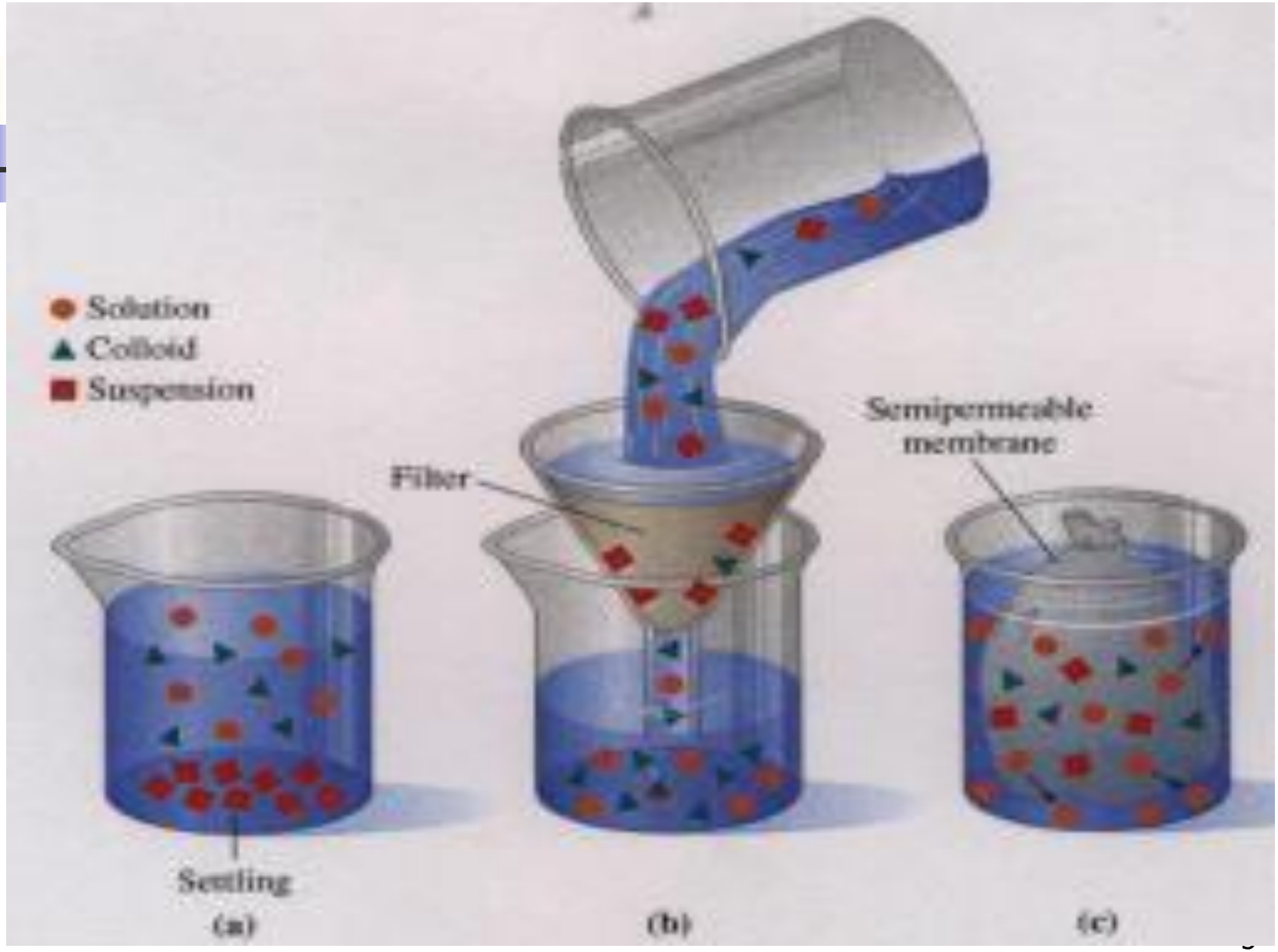
3) -can be separated by semipermeable membranes.

4)- scatter light (Tyndall effect – in which the path of a beam of light through the colloid is visible due to scatter light).

5)- Usally corpuscular(Grain like) but may be rod,disc shaped,thin films or long filament.

5) Ex…Fog,Whipped cream,Milk,Cheese,Blood plasma,Pearls etc…..

Solutions, Colloids, and Suspensions

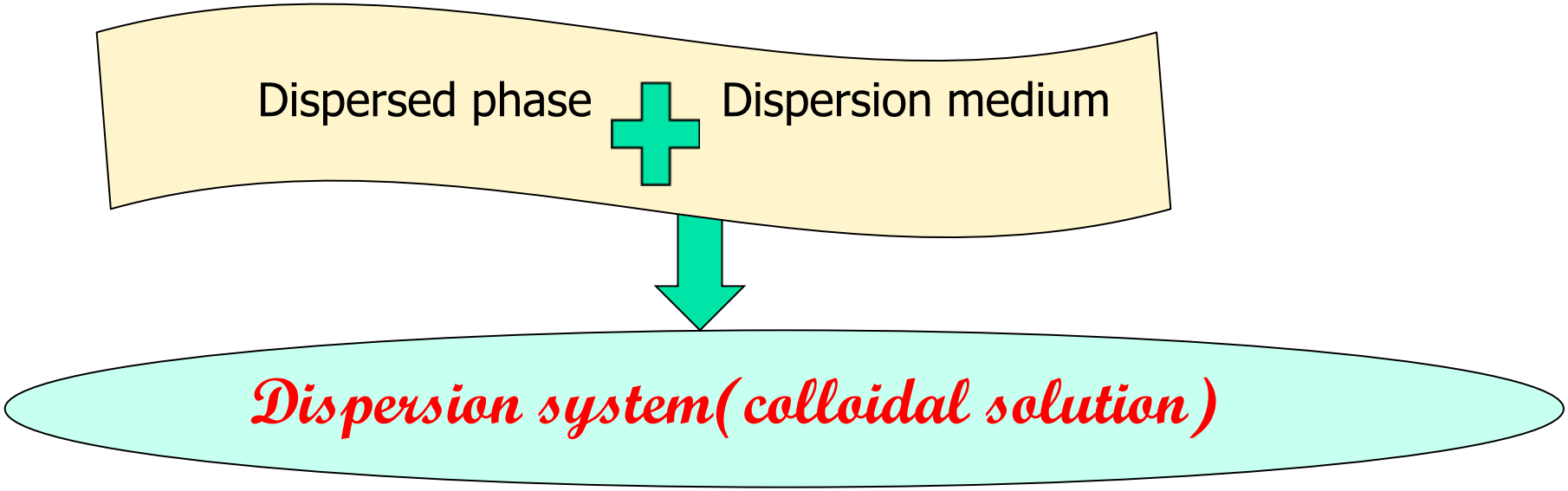


Property	True solution	Suspension	Colloidal solution
Nature	Homogeneous	Heterogeneous	Appears to be homogenous but actually heterogeneous
Particle size	< 10^{-3} Å (1 nm)	> 1000 Å (100 nm)	Between 10 Å (1 nm) to 1000 Å (100 nm)
Sedimentation	Do not settle	Settle on standing	Do not settle
Diffusion	Diffuse quickly	Unable to diffuse	Diffuse slowly
Visibility	Particles invisible	Particles visible by naked eye or under microscope	Particles scatter light and can be observed under ultramicroscope
Filterability	Pass easily through animal membrane and filter paper	Unable to pass through animal membrane or filter paper	Pass through filter paper but not through animal membrane
Appearance	Clear and transparent	Opaque	Translucent

Components of colloids

- Colloid solution is heterogeneous system consists of following three components…..
- 1) A dispersed phase- substance distributed as collidal particles…
- 2) Dispersed medium- medium in which the collidal particles are dispersed….
- Ex..As_2S_3(Arsenic sulphide) is dispersed phase and water as dispersion medium…

3) Stabilizing agent(adding agent)- agent added in colloidal solution for to keep colloidal particles in a pair..



Classification of colloids:- Table -I

Sr. No.	Dispersed phase	Dispersion medium	Type/Name	Examples
1	Gas	Liquid	Foam	Shaving cream,soaplather,wipped cream, froth on beer…
2	Gas	Solid	Solid soal	Cake,foam rubber,bread,lava,pumice stone……
3	Liquid	Gas	Aerosol	Fog,mist,cloud,smoke,dust,Insecticide sprays……
4	Liquid	Liquid	Emulsion	Milk,oil in water,hair cream,butter……
5	Liquid	Solid	Gel	Cheese,jelliees,curds,pudding…….
6	Solid	Gas	Smoke	Dust,soot in air, smoke…
7	Solid	Liquid	Sol	Paint,ink,white of egg,mud,cell fluid…
8	Solid	solid	Solid sol	Ruby glass,gem stones,coloured glass,alloys……

❖ Sols(solids in liquids) :-

- Sols are colloidal solutions in which solid is dispersed in liquid…
- When water is dispersion medium-----called as hydrosol or aquasol..
- When medium is alcohol……..called as alcosols..
- When benzene is medium…..called as benzosols…
- Two types of sols- (depends on interaction of two phases)..
- ***1) Lyophilic sols(solvent loving)-***

-The particles in a lyophilic system have a great affinity for the solvent.

- readily solvated (combined chemically or physically, with the solvent) and dispersed, even at high concentrations.

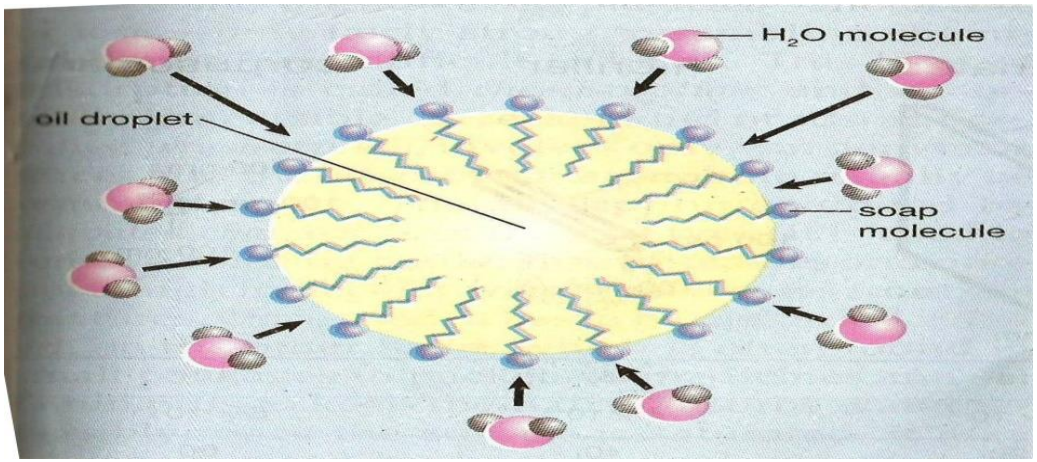
- Due to high degree of solvation it has high viscosity and surface tension is lower than the medium..

Ex…. sols of gum, gelatin, starch, proteins and certain polymers (rubber) in organic solvents.

-the dispersed phase does not precipitate easily.

-Process of precipitation called coagulation. Stabilized agent are added to prevent coagulation…

- the sols are quite stable as the solute particle surrounded by two stability factors: a- negative or positive charge b- layer of solvent.



2) lyophobic (solvent repelling) (solvent hating) –

- The particles resist solvation and dispersion in the solvent.

-slight interaction between suspended particles and medium.

-The concentration of particles is usually relatively low.

- Less viscid.

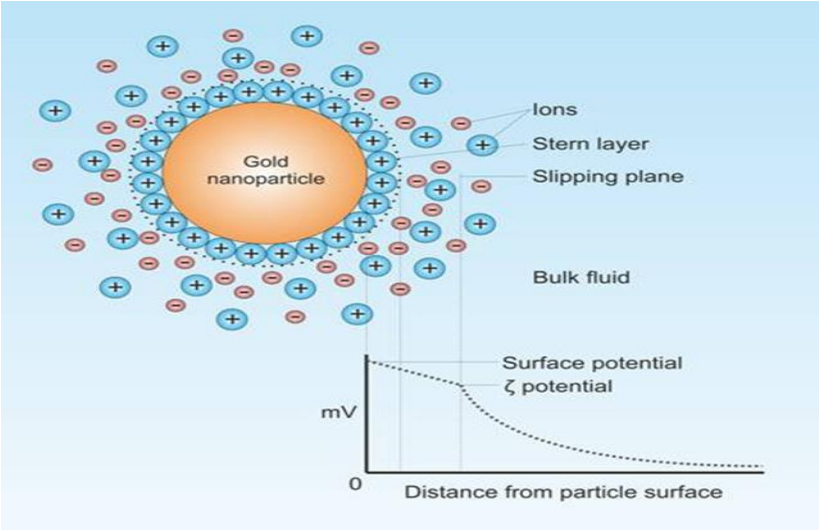
-These colloids are easily precipitated on the addition of small amounts of electrolytes, by heating or by shaking

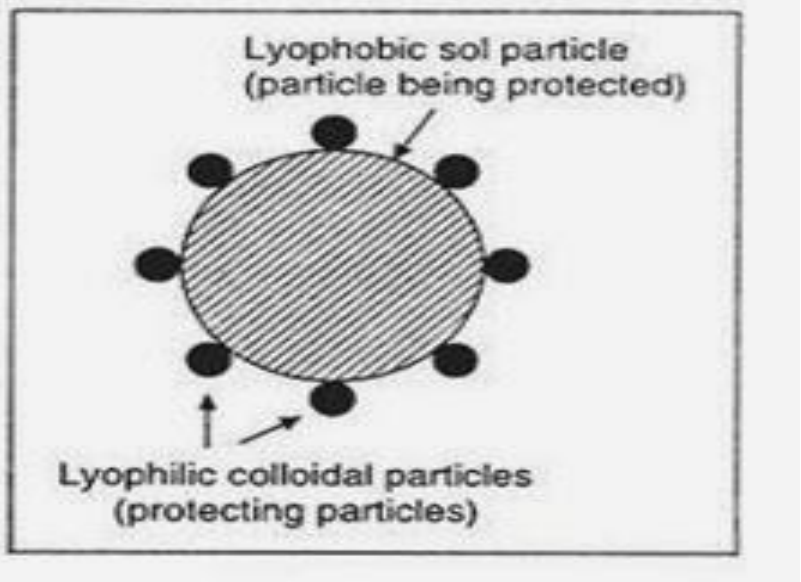
-Less stable as the particles surrounded only with a layer of + or -.

-Once precipitated, it is not easy to reconstitute the sol by simple mixing with the dispersion medium. Hence, these sols are called irreversible sols.

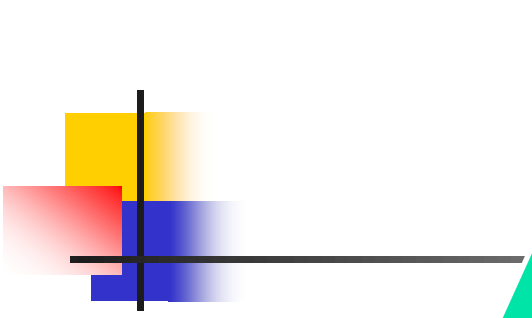
-Ex… sols of metals and their insoluble compounds like sulphides and oxides.

e.g. 1) gold in water(As_2S_3) 2) iron(II) hydroxide and sulphur in water.





Classification of colloids



Depends on nature of dispersed phase and medium.(Table-I)

Depends on appearance of colloids.
Eg..sol ,gel..

Depends on interaction of two phases

On the basis of electrical charge on dispersed phase eg.+ ve & - ve colloids

On the basis of structure of colloid particles..

Based on particle shape

Depending upon chemical composition…

2) Depends on appearance of colloids.

Sol:- collidal solution appears as fluid…sols are named after dispersion medium…..
Eg.. When medium is water---- called hydrosol
When medium is alcohol-----called alcosols.
Gel:- colloid has solid like appearance…..Rigidity varies from substance to substance
..... SOME SUBSTANCES OCCUR AS BOTH.....
Gelatin-----at high temp.& low concentration ----as hdrosol
Gelatin-----at loe temp.& high concentration-----as gel..(water as phase and gelatin particles as medium..

3) Interaction of two phases…1) Lyophobic 2) Lyophilic sols…
4) Depending on electrical charge

Positive colloids:-
Phase carries + ve charge
.eg..Fe(OH)3 sol in water,methylene blue,Tio2 sols…

Negative colloids;-
- Phase carries -ve charge
eg..As2S3 sol in water,copper or gold sols..,dyestuffs like eosin and congo red..

5) Depending on structure of colloid particles--

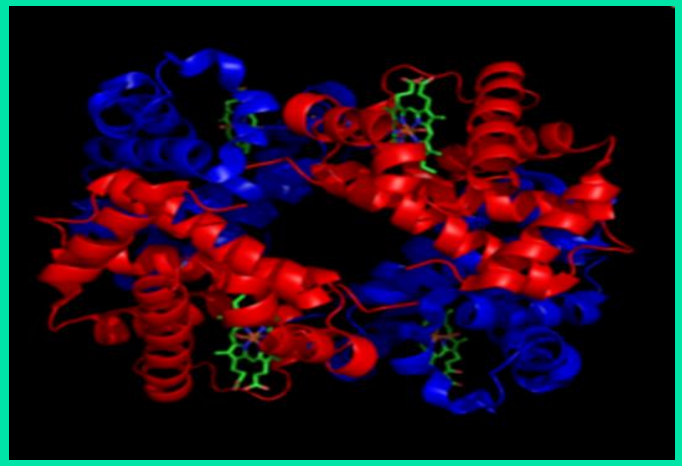
Molecular- single macromolecules and structure is similar to small molecules…
eg…albumin,silicones,rubber…

Micellar- particles are aggregates of many molecules or groups…
-- helded by cohesive or vanderwaals force..
Eg..sulphur,gold,soap,detergents…

6)Based on particle shape:-

1) Spherocolloids –composed of more or less compact globular particles…eg.native albumin.

2) Linear collids- consists of long fibrous units eg..denaturated albumin..



7) Depend on chemical composition:- Organic collids….
includes organic molecules….eg 1) rubber in benzene
2) hydroxy salt like starch
3) heteropolarsols like proteins,soap in water..

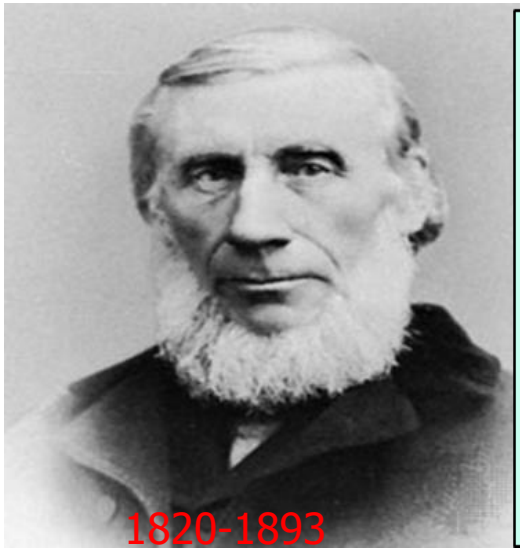
Properties of colloids:-

1) Physical property….Lyophilic and lyophobic

2) Colligative property;-(V.P.,elevation in B.P.,lowering of freezing pt.,osmotic pressure)

These are very much smaller than that of true solution..(except effect in osmatic press.)

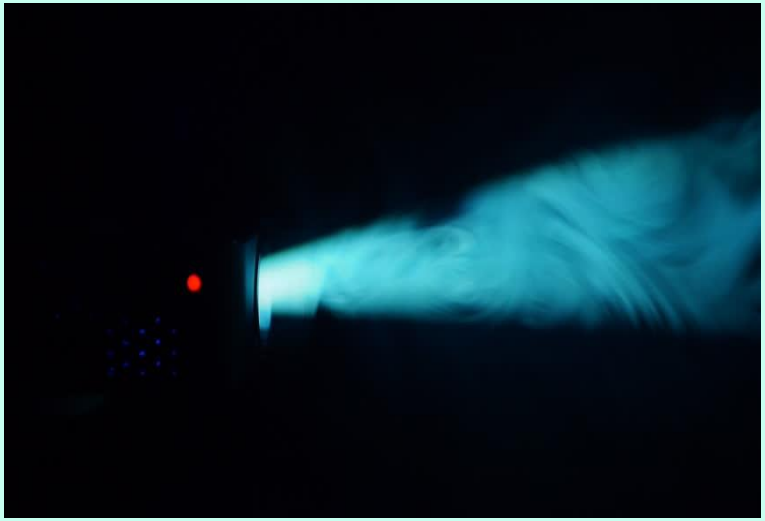
3) Optical property;- (Tyndall effect Colloidal particles scatters light. Discovered by Tyndall,known as Tyndall effect…



…..Similar examples to that of Tyndall effect in everyday experience…

1)Head light of car on dusty road…..

2) Light beam of film projector in smoke filled theatre…3) light beam coming through roof in a dust filled huts…..

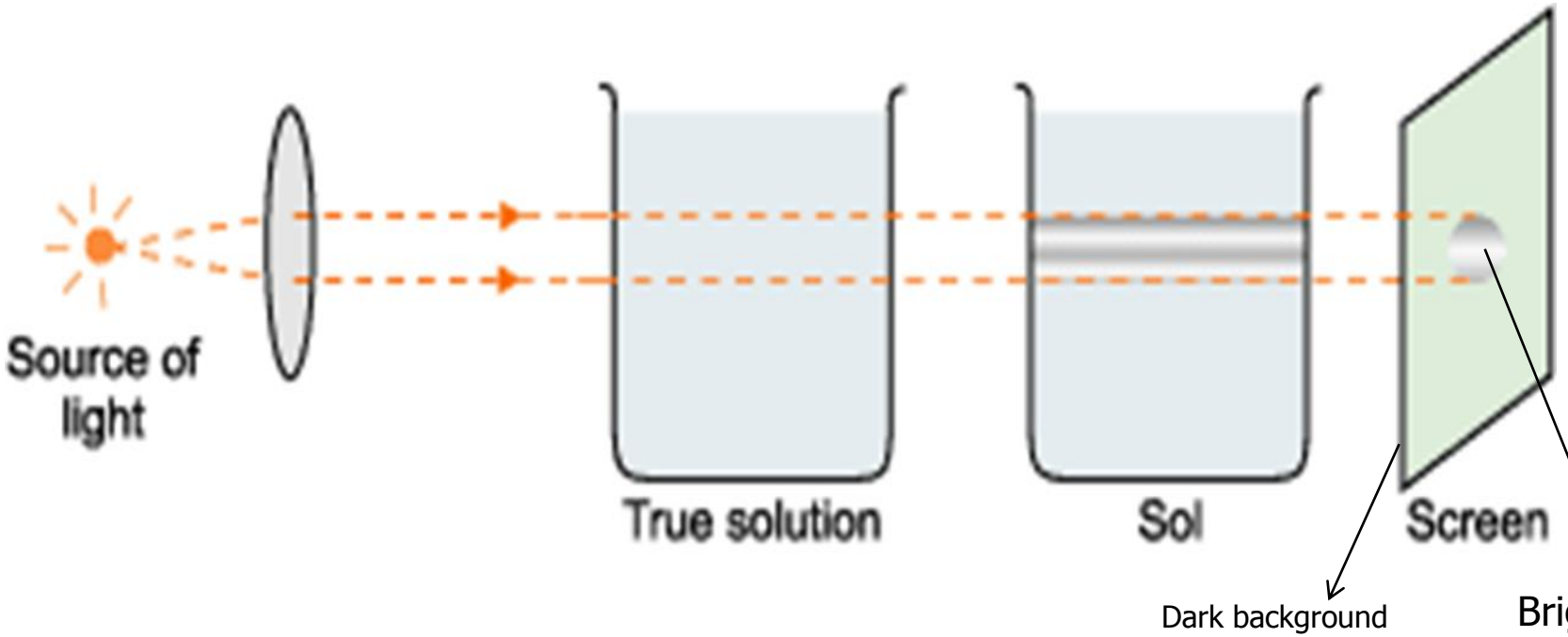


- When a strong beam of light passed through a sol and is viewed at right angles, the path of light shows up as a heavy beam or cone.

  The scattering of light as it is called as illuminates the path of the beam in the colloidal dispersion.(Shining a beam of light through a colloid)

  The cone formed by scattering of light by sol particles is often called as Tyndall beam or Tyndall cone.

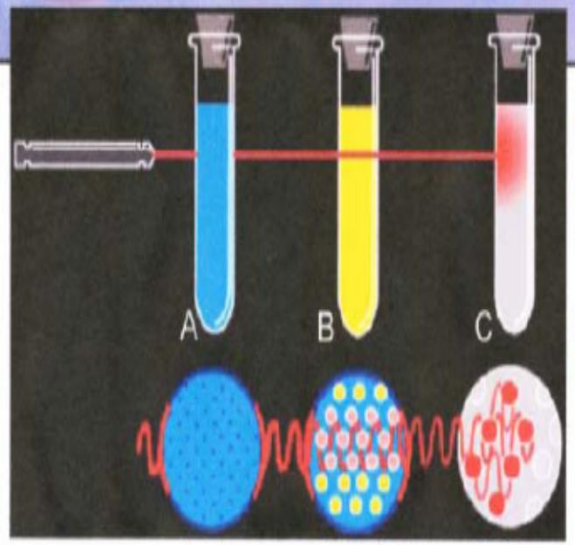
- It is a positive sign to detect colloidal particles.
- True solution never shows this effect due to too much smaller ions ,can't scatter light.
- Intensity of scattered light depends on the diff.between the R.I.of phase and medium.
- Extent of scattering depends on the size of solute, in very dilute soln.it is small.
- In this effect no difference between the wavelength of incident and scattered light.



The Faraday-Tyndall effect

Conditions:- 1) λ of light not larger than diameter of size of particle of phase.
2) R.I.of phase and medium should have considerable difference.

Tyndall Effect: Laser Pointer traveling through a solution (right) and through a colloidal suspension (left).



A: Solution

B: Colloidal Suspension Transparent

C: Colloidal Suspension completely absorbing light

- Lyophobic collides-----R.I.is appreciable---- effect is well defined….
- Lyophilic collides—high solvation-R.I. diff.is small----weak tyndall effect…

- 4) Kinetic properties of sol:-Robert brown (Botanist) 1827

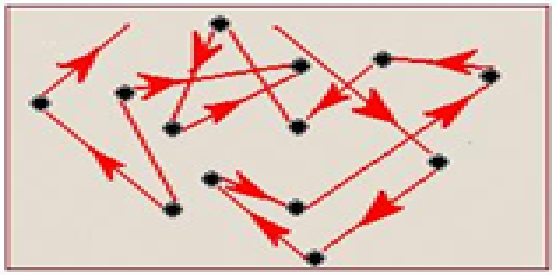
A) Diffusion:- Colloidal particle diffuse much more slowly than solutes in true solutions.

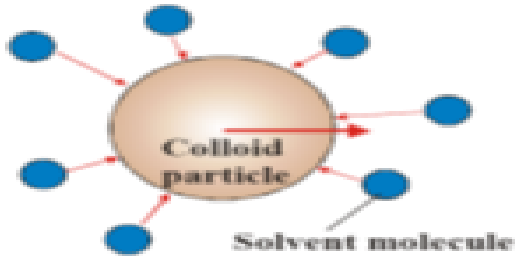
B) Brownian motion;- Brown showed that pollen grains when suspended in water shows continuous rapid and random motion in all directions.(Zig-zag motion in straight line path seen under ultra microscope)

The constant pushing of colloidal particles by the molecules of the medium does not permit to settle.

1-Brownian motion

- The zig-zag movement of colloidal particles continuously and randomly.
- This brownian motion arises due to the uneven distribution of the collisions between colloid particle and the solvent molecules.
- Brownian movement was more rapid for smaller particles.
- It decrease with increase the viscosity of the medium.

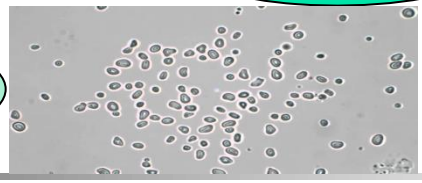




Examples of Brownian motion:-

1) Glittering ,tumbling motion of small dust particles……

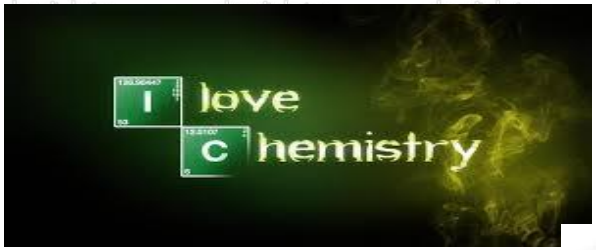
2) Pollen grains in water……



3) Tea diffusing in water…..

4) Ink drops added in water…….

5) Burning incense stick(Agarbatti) in air……



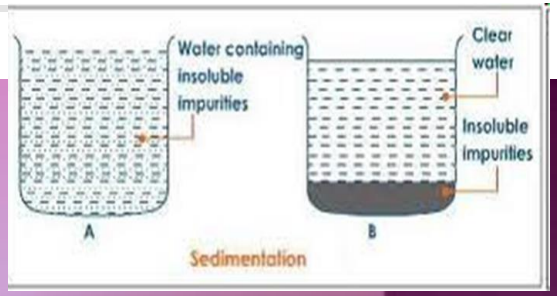
7) Heavy drunker….. walking randomly……

Yahhhh… ….I am in heaven… I am great…

6) Milk fat jiggles in water…..

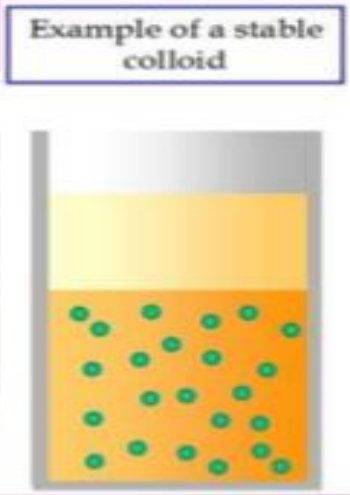
c) Sedimentation;-

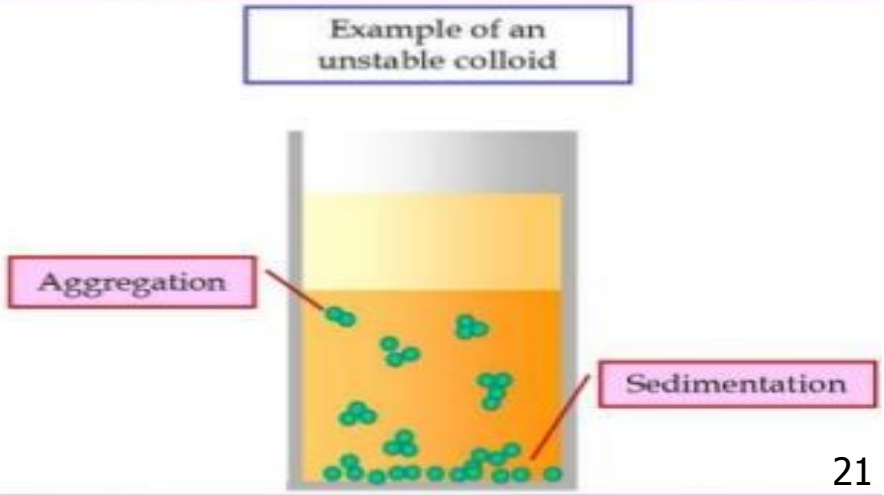
- Under influence of gravity on prolonged standing colloids gets settles very slowly……
- We can calculate dimensions and masses of particles…
- By knowing density and viscosity of phase and medium and time of sedimentation..
- Sedimentation can be carried out by ultracentrifugation….(high speed cetrifuge machine) which creates high centrifugal force…



SEDIMENTATION

- At small particle size (less than 0.5 um) Brownian motion is significant & tend to prevent sedimentation due to gravity & promote mixing instead.
- So, we use an **ultracentrifuge** which provide stronger force so promote sedimentation in a measurable manner.





05) Electrical properties.:-

As colloidal particles carries an electric charge, when they placed in electric field ,certain effects are observes….which are known as electrokinetic effects… these are of four types…

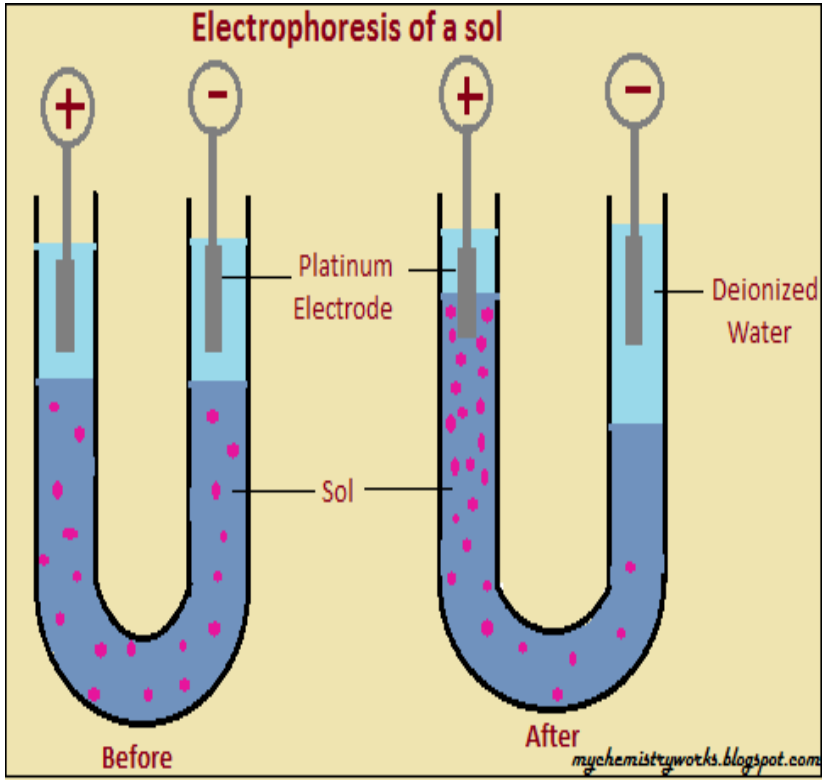
01) Electrophresis or cataphoresis..

02) Electrosmosis or Electroendosmosis..

03) Streaming potential

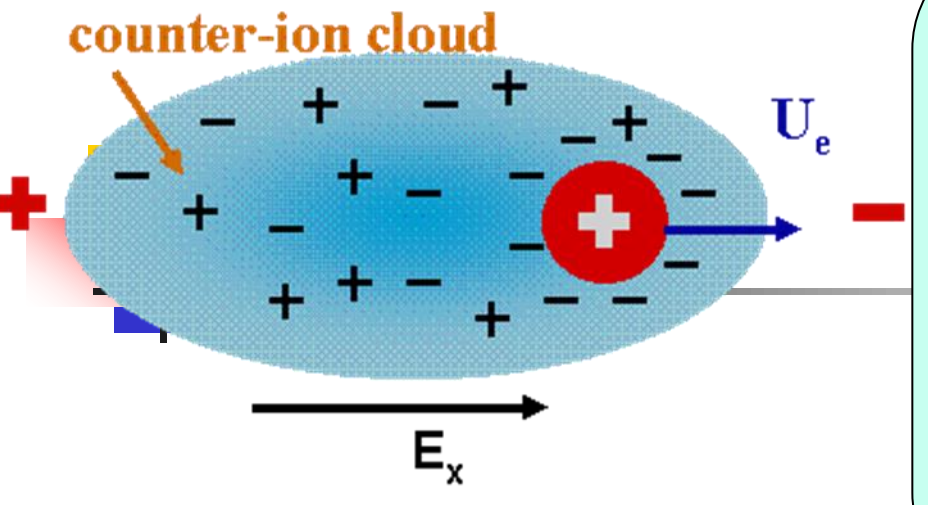
04) Sedimentation potential or Dorn effect.

1) Electrophresis or cataphoresis..;-



Electrophoresis refers to the motion of charged particles related to the fluid under the influence of an applied electric field.

If an electric potential is applied to a colloid, the charged colloidal particles move toward the oppositely charged electrode.



Applications…..

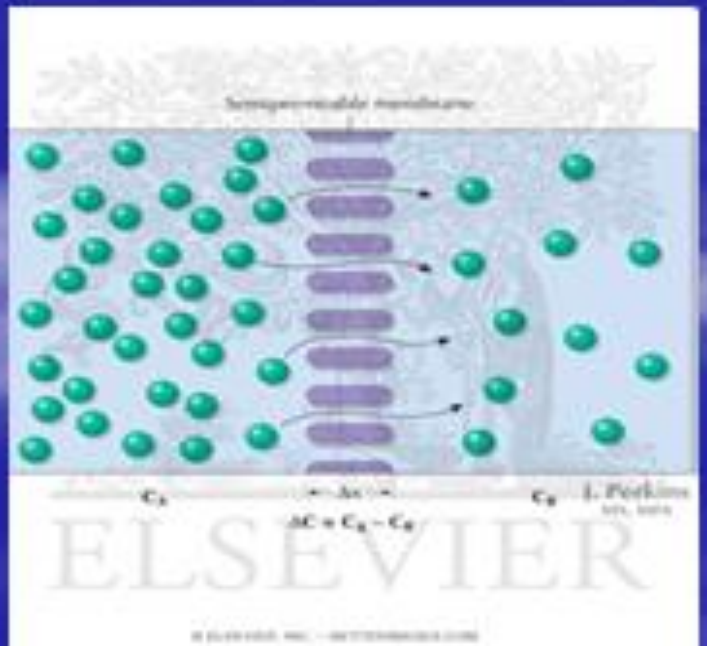
1) Rate of migration of colloids under influence of electric field..
2) for preparative separations of colloids…
3) used to detect charge of colloids..
4) to separate proteins ,DNA, RNA, polysaccharides……
5) coagulation of carbon from colloidal smoke of industry chimney and removed on cathode…
6) electroplating of rubber on metal surfaces….
7) paintings of metal parts of cars from colloidal pigments…..

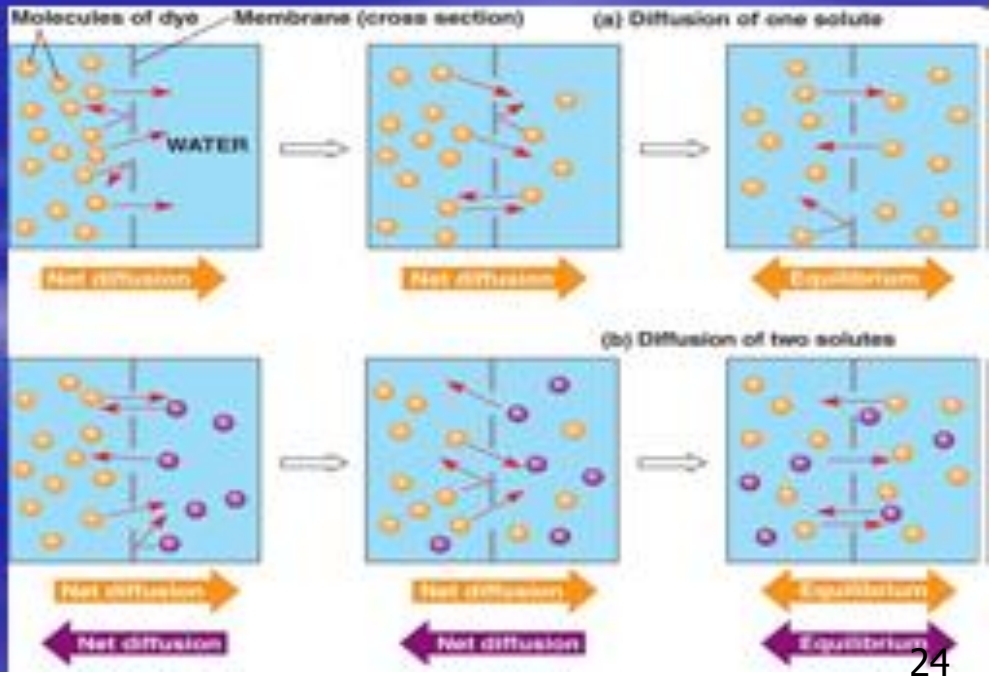
02) Electrosmosis:-

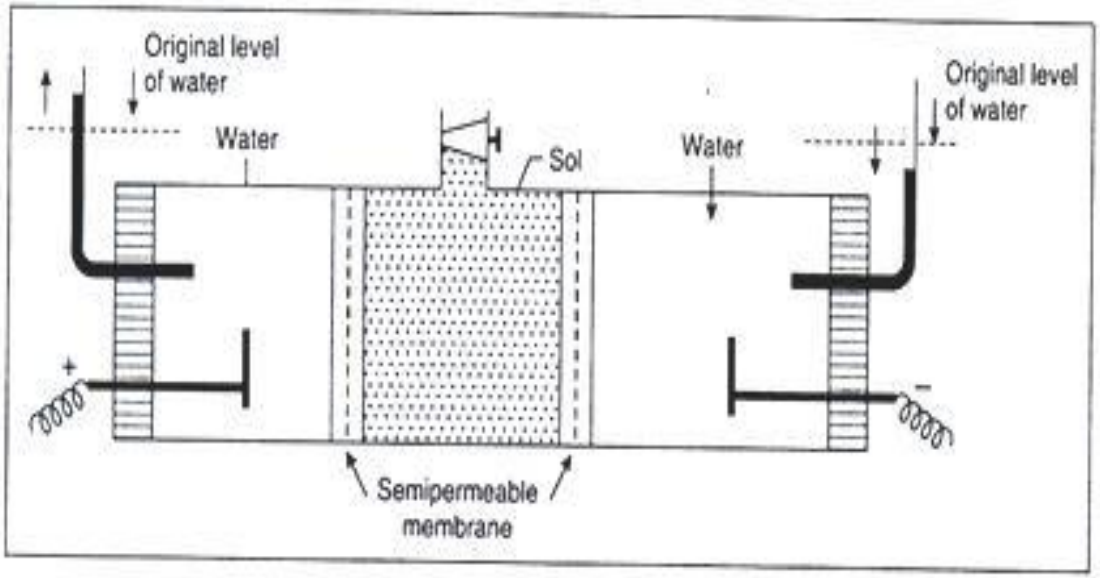
- It is the opposite in principal to that of electrophoresis.
- It is migration of ions in a solvent through the capillaries of membrane under the influence of an applied electric field…
- When electrodes are placed across a clay mass and a direct current is applied, water in the clay pore space is transported to the cathodically charged electrode by electro-osmosis.
- Electro-osmotic transport of water through a clay is a result of diffuse double layer cations in the clay pores being attracted to a negatively charged electrode or cathode. As these cations move toward the cathode, they bring with them water molecules that clump around the cations as a consequence of their dipolar nature

Diffusion

is the tendency for molecules to migrate from a region of high concentration to a region of lower concentration and is a direct result of Brownian motion.



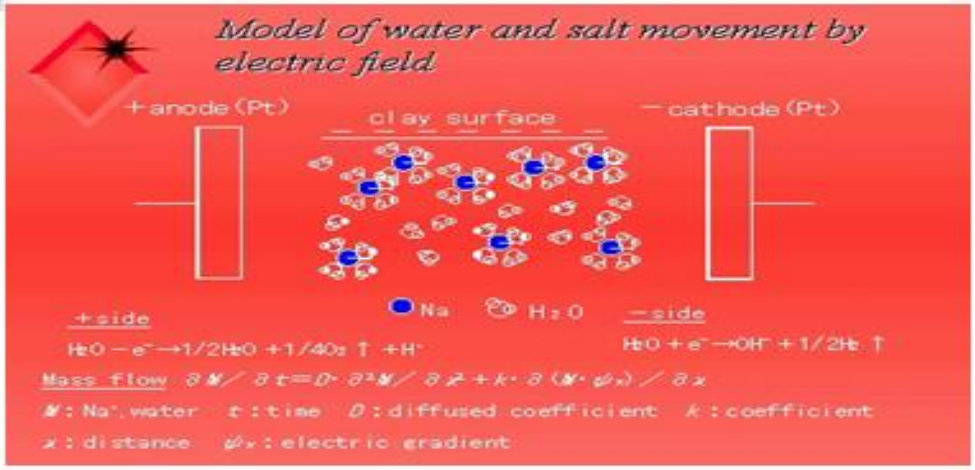




Applications:-

1) To prepare pure colloids….
2) technique used in drying of peat and clay…
3) In the tanning of hides…
4) in manufacture of gelation for photographic emulsions and high grade glue….

Electro-osmosis



Stability of colloids;-

Stability of lyophobic sols;-

stability due to presence of electric charge on it.. to precipitate a colloidal solution or sol , the particles must coalesce so as to form aggregates.

Such type of agglomeration is avoided by presence of electric charges of same sign

For eg. AgBr sol (if there is presence of excess of $AgNO_3$) contains positively charged Br particles, on account of adsorption of Ag+ ions on the surface of particles.

Stability of lyophilic sols;-

Stability due to electric charges of same sign

Solvation:- tendency to bind with solvent…. The layer of molecules of solvent form and envelop which prevents aggregation.

Lyophobic colloids readily coagulated by removing the electric charge while lyophilic colloids, the charge removal may decrease stability but does not lead to coagulation..

Isoelectric point;-

The concentration at which the colloidal particles have no charge…….

(the con. Of H^+ can be increased by addn.of acid and OH^- by addn.of NaOH.

Hardy's opinion is that,at isoelectric pt.colloidal particles are electrophoretically inert..Most of the colloids coagulate at this pt….if they don't,they are least stable….they can be readily coagulated with alcohol…..

Eg….Gelatin has isoelectric pt.at PH 4.7 indicates it has no motion at this PH.
At a PH below 4.7 it moves towards the cathode…..
while at PH above moves towards the anode….

Hardy-Schulze law:-

- Due to repulsive force lyophobic sols do not allow them to settle..they would be settle if the charge is removed…
- Particle can no longer remain apart, they would then aggregate and settle down under gravity…this settle down called as flocculation or coagulation…
- Greater is the valences of the oppositely charged ion of the electrolyte being added, the faster is the coagulation. That is greater the charge ,greater the coagulating capacity….
- The idea behind this is the attractive electrostatic forces between ions of opposite charges…
- precipitation of As_2S_3(negative surface) the precipitating power as an order….

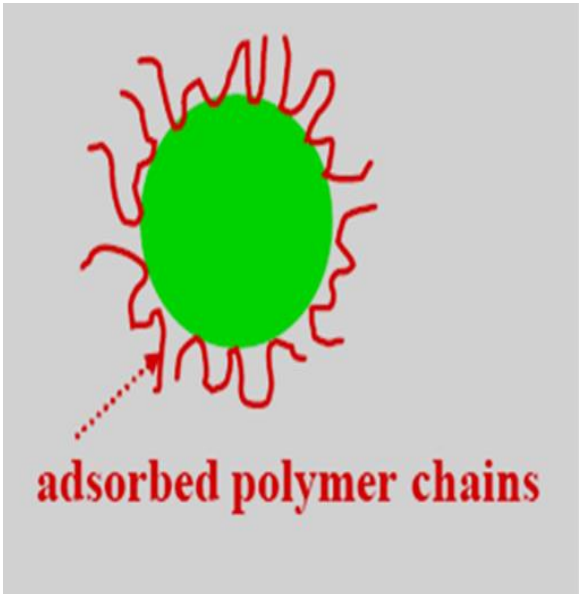
$Al^{+3} > Ba^{+2} > Na+$

similarly pptation of Fe(OH)3 sol (+ ve surface) the pptation power of anions is,….

$[Fe(CN)6]3- > SO4^{-2} > Cl^-$

Protective action:-

- Process of addition of lyophilic sols by which the lyophobic sols are protected from precipitation on adding an electrolyte is known as protection ….
- The lyophilic colloid added as the protective colloid…..and lyophobic sols achieve extra stability…
- This may be due to:-
- The hydrophile is adsorbed as a monomolecular layer on the hydrophobic particles.
- For eg… hydrophilic colloids such as gelatin,starch etc.act as protective colloids for the gold sol and prevents their pption..by addn.of limited amount of NaCl..



Eg……1) soluble $Ca_3(PO_4)_2$ are held as colloids in blood due to protective action of protein in blood……

2) To prevent clogging in pen; superior pen inks contains some protective colloids…

3) Protargol and Argyrol powders are protected forms of the colloidal silver…

Liquid in liquid (Emulsions):-

Types of

Emulsions

Oil in water(O/W)

Oil is dispersed in water medium.

Eg. milk emulsion

Water in Oil (W/O)

Water is dispersed in oil.

Eg.. Codliver oil.

Term oil is used to designate any liquid which is immiscible with water and capable of forming an emulsion with water…

Emulsion particles can be observes by microscope or sometimes magnifying lens, due to dia. Of droplets are in range of 0.1 micron and having small stability.

Experimental methods for identification of emulsions….

01) conductivity method

02) fluorescence method or dilution method..

Emulsifiers:-

Oil + water---shake it vigorously---becomes colloidal emulsions (but not stable and tends to separate on standing.)

To get stable emulsions---- small quantity of third substance is added ----called emulsifying agent or emulsifier

What it does

It reduces the surface tension…

eg. of emulsifier…. 1) Soaps or detergents….

2) Gelatin,egg albumin,gum ie lyophilic colloids can used which forms protective coating around small drops

Preparation of emulsion:-

Emulsion Preparation

1) By shaking or stirring the two phases..ie dispersion phase and medium in presence of liquid emulsifier…….

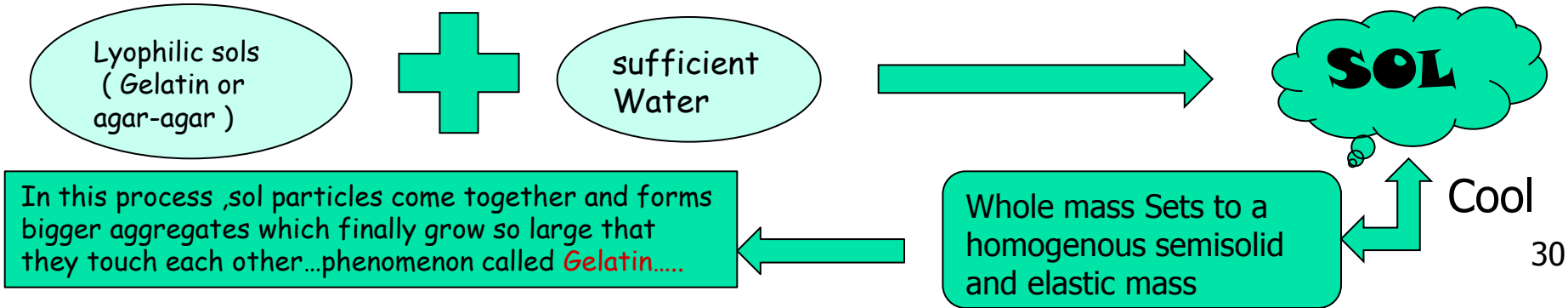
2) By adding a solution in excess to another solvent…

Which quickly dissolves the solvent of the added solution but keeps liquid solute dissolved…

3) Emulsions can also prepared by using ultrasonic waves….

Gels:-(Liquid in solid)

A colloidal solution in which liquid is dispersed in solid is called Gel….



Eg. Of Gel. .1) When alcohol is added to sat. soln. of calcium carbonate in water initially produces a colloid which coagulates to a semisolid mass of $CaCo_3$ in which alcohol is trapped.

This gel of alcohol in $CaCO_3$called solid alcohol, is used as solid fuel in picnic stoves ,military camp etc…

2) silicic acid gel in water,sodium oleate gel in water or gelatin in water,curdled milk,piece of meat(complex gel)

Types or classification of gels;-

1)On the basis of dispersion medium;-----If medium is benzene---called benzogel… Alcohol---alcogel ,Water---hydrogel..

2)On the basis of particle size:----A) colloidal --- bog size and B) coarse--- small size..

3) On basis of chemical composition:- A) Inorganic gels B) organic gels…

4) On the basis of their property;- A)rigid gels B) elastic gels C) nonelastic gellies D) Thixo-tropic gels…

5) Elastic or reversible gels:- substance + warm water--cooled till it sets--dehydration----converts into elastic semisolid form……..this may be regenerated by adding water…….eg..gelatin,agar-agar

6) Non elastic or irreversible gels:- dry solid + water----further dried---loses their acidity and becomes glassy….rigidity increases with time….their is no deformation on applying force…eg..silica gel,ferric oxide gel…

Methods of preparation of gels:-

1) By coagulation or decrease in solubility:-many colloids transformed into gel by this method..this transformation is characterized by,
A) shape of particle. B) conc,of sol C) degree of solvation..
Eg..1) sol of pectin sets on addition of alcoholor sugar..
2) sol of Al/Fe hydroxide sets on addition of aluminium salt and ammonium hydroxide…

2) By chemical reaction:-A) Barium thiocynate + manganeous sulphate $\longrightarrow$ $BaSO_4$ gel

B) Aluminium salt soln.+ ammonium hydroxide $\longrightarrow$ Aluminium hydroxide

3) By cooling colloidal soln.;- agar-agar,gelatin,soap etc.when heated in hot solvent they are soluble when they cooled they forms a gel…..gelation depend on…
1) Temp.of gelation.
2) time of gelation.
3) Viscosity of medium.
4) minimum concentration of colloid.

4) By exchange of solvents:- exchange of solvent in which the sol is insoluble..
Eg..calcium acetate gel, pure alcohol can be added to aq. soln .of calcium acetate, thus whole calcium acetate goes to alcohol which then sets in the form of a gel having the liquid….

Properties of Gels:-

1) Electrical conductivity:- (Kistler 1931)

There is no change of electrical conductivity when sol converts into a gel..

It is simply the change of state during this conversion…

2) Optical properties;-

1) Gels shows double refraction due to some property starts in gels or fprmed due to internal tension..

2) Gels shows property of polarised light….thus we can measure R.I.of diff.gelatin gels..

3) Elastic properties:-

gels shows compressibility, flexibility, tensile strength etc… properties…

4) Swelling or imbibition of gels;-

Hydrophilic or plastic gels having property of adsorbing definite amount of water or other liquid causes increase in volumeof gels…it depends on…….

A)Temp. of system B) PH of soln .C) nature of gel…

5) Syneresis;-

Continuous liberation of liquid from a gel…

Elastic and non elastic gels both shrink when they kept standing.

Eg…1) perspiring of cheese…

2) suitable electrolyte added in silicic acid sol to form jelly and shrinks in size…

Syneresis is reversal of swelling… it depend on temp.,pressure of electrolyte,medium and state of gel..

It is imp. Phenomenon in biological problems…

General applications of colloids:-

- Colloid plays vital role in our daily life .Human body itself as a colloid.
- Protoplasm, the building material of plant cells and animal tissues and blood flows through our veins are colloidal in nature.
- Fats pass through our intestines in the form of emulsions…
- Foods:- 1) milk is emulsions of butter fat in water protected by a protein.
  2)fruit jellies, whipped cream…
  3) Ice-cream is dispersion of ice in cream
  4) Bread is dispersion of air in a baked dough..

Medicines:-many colloidal solutions used in medicine as they are easily assimilated into body

1) codliveroil,sharkliveroil are emulsions..
2) Argorol an eye lotion is colloidal soln. of silver protected by gelatin.
3) colloidal gold used in tuberculosis.
4)Milk of magnesia is a popular emulsions.
5) many ointments are emulsions..
6) sulphur colloids are sprayed on plants to kill germs..

- Smoke is colloidal soln. particulate matter from smoke is removed by applying voltage..
- kidney removes urea and unwanted electrolyte from colloidal blood by dialysis. This is useful for kidney failure patients..
- Muddy water is purified by adding potash alum $Al^{+3}.Al(OH)_3 + 4H_2O$
- Cleaning action of soap is due to formation of oil in water type emulsions. $\longrightarrow Al(OH)_3(H_2O)^{4+}$
- A)Solid alcohol are used as a fuels B) bleeding of blood can be stopped by Al^{+3} salts like alum.

Any Question ???