SURFACE CHEMISTRY & COLLOIDAL STATE

Preface

In this chapter your will know about different types of colloids and their classification based on different facts. You will know about difference between true solution, colloidal solution and suspension. After successful completion of the topic you will be able to know about : Difference between lyophiic and lyphobic sols, preparation of colloidal solutions, purification of colloidal solutions, Brownian movement, mutual coagulation.

This book consists of theoretical & practical explanations of all the concepts involved in the chapter. Each article followed by a ladder of illustration. At the end of the theory part, there are miscellaneous solved examples which involve the application of multiple concepts of this chapter.

Students are advised to go through all these solved examples in order to develope better understanding of the chapter and to have better grasping level in the class.

Total No.of questions in **Surface chemistry & Calloidal state** are -

In chapter Examples 02

Solved Examples 10

Total No. of questions 12

1. ADSORPTION

If we consider a liquid or a solid substance then we find that a molecule which is present in the bulk or interior of the substance is being attracted uniformly from all sides by the neighbouring molecules and hence there is no net force acting on the molecule.

On the other hand , if we consider a molecule that is present near the surface , we find that such a molecule is not bonded to other molecules from all sides but has some unutilized valencies because there are no neighbouring molecules above the surface to which it can be bonded.

As a result of these unbalanced forces the molecules present at the solid or liquid surface tend to satisfy their residual forces by attracting or retaining on their surface the molecule of other species when brought in contact with them. This result in increase in concentration of the substance near the surface compared with the bulk phases.

1.1 Adsorbed : A substance which has different concentration at the surface than in the bulk or interior phase is said to be adsorbed and the existance of a substance at a surface in a different concentration than in the adjoining bulk phases is called adsorption.

1.2 Adsorbent : The material upon whose surface the adsorption takes place is called adsorbent while the molecular species used to get adsorbed are called adsorbate.

1.3 Desorption : The process of removal of an adsorbed substance from the surface on which it is adsorbed is called desorption. It is reverse of adsorption and can be brought about by heating or by reducing the pressure

1.4 Difference between adsorption and absorption

ADSORPTION	ABSORPTION
1. It is a surface phenomenon.	1. It concerns with the whole mass of the absorbent.
2. In it, the substance is only retained on the surface and does not go into the bulk or interior of the solid or liquid.	2. It implies that a is substance is uniformly distributed,through the body of the solid or liquid
3 In it the concentration of the adsorbed molecules is always greater in the free phase.	3 In it the concentration is low.
4 It is rapid in the beginning and slows down near the equilibrium.	4 It occurs at the uniform rate
5. Examples -	5 Examples
(a) Water vapours adsorbed by silica gel.	(a) Water vapours absorbed by anhy. $CaCl_2$.
(b) NH_3 is adsorbed by charcoal.	(b) NH_3 is absorbed in water forming NH_4OH.
(c) N_2 is adsorbed on mica.	
(d) O_2 is adsorbed on tungsten surface	
(e) Declourisation of sugar solution by activated or animal charcoal.	
(f) Ink is adsorbed by bloting paper.	

1.5 Common adsorbents :

(a) Charcoals (Both vegetable and Animal).

(b) Silica gel (prepared by heating a mixture of sodium silicate and 10% HCl at 50^0C).

2. REVERSIBLE AND IRREVERSIBLE ADSORPTION

The adsorption is reversible , if the adsorbate can be easily removed from the surface of the adsorbent by physical methods . It is called irreversible adsorption , if the adsorbate cannot be easily removed from the surface of the adsorbent.

Example :

Reversible : A gas adsorbed on a solid surface can be completely removed in vacuum.

Irrveresible : Adsorption of O_2 on tungusten adsorbent.

2.1 Characteristics of adsorption :

(1) Adsorption refers to the existence of a higher concentration of any particular component at the surface of a liquid or a solid phase

(2) Adsorption is accompanied by decrease in the free energy of the system. When $\Delta G=0$ adsorption equilibrium is said to be established.

(3) In adsorption there is a decrease in the entropy of the system. Since both ΔG and ΔS decrease in adsorption, the value of ΔH also decreases so there appears a heat means adsorption process is always exothermic. $\boxed{\Delta H = \Delta G - T\Delta S}$

2.2 Types of Adsorption :

(1) Depending upon the concentration : In adsorption the concentration of one substance is different at the surface of the other substance as compared to adjoining bulk or interior phase

(A) **Positive adsorption :** If the concentration of adsorbate is more at the surface as compared to its concentration in the bulk phase then it is called positive adsorption

(B) **Negative adsorption :** If concentration of adsorbate is less in the surface layer than in the bulk phase then it is called negative adsorption.

Example : Generally in solutions

(2) Depending upon the nature of forces existing between adsorbate molecule and adsorbent -

(A) **Physical adsorption :** If the forces of attraction existing between adsorbate and adsorbent are vander waal's forces, the adsorption is called physical adsorption. This type of adsorption is also known as physisorption or Vander waal's adsorption. It can be easily reversed by heating or decreasing the pressure

(B) **Chemical adsorption :** If the forces of attraction existing between adsorbate particles and adsorbent are almost of the same strength as chemical bonds, the adsorption is called chemical adsorption. This type of adsorption is also called chemisorption. This type of adsorption cannot be easily reversed.

Comparision between physisorption and chemisorption

Physisorption	Chemisorption
1. Low heat of adsorption usually in range of 20-40 KJ/mol	1. High heat of adsorption in the range of 40-400 KJ/mol
2. Forces of attraction are vanderwaal's forces	2. Forces of attraction are chemical bond forces
3. It is reversible	3. It is irreversible
4. It usually takes place at low temperature and decreases with increasing temperature	4. It takes place at high temperature
5. It is related to the case of liquefaction of the gas	5. It is not related
6. It forms multimolecular layers	6. It forms monomolecular layers
7. It does not require any activation energy	7. It requires activation energy
8. It is not very specific	8. It is highly specific

2.3 Adsorption of gases on solids :

The extent of adsorption of a gas on a solid adsorbent is affected by the following factors -

(i) Nature of the gas : Physical adsorption is non specific in nature. Every gas will get adsorbed on the surface of any solid to a lesser or greater extent.

Example : NH_3 , HCl , CO_2 (easily liquefiable gases) are adsorbed to a greater extent than the permanent gases such as H_2, O_2, N_2 etc. While chemisorption is specific in nature. In it , a gas gets adsorbed on the solid only if it forms chemical bond with it.

(ii) Effect of nature of adsorbent : Activated charcoal is the most common adsorbent for the gases which are easily liquefied. Poisonous gases such as methane belong to this type and charcoal is commonly used in gas masks.

(iii) Specific area of the solid : Specific area of an adsorbing solid is the surface area available for adsorption per gram of the adsorbent. Greater the specific area of the solid, greater would be its adsorbent power. That's why porous form of adsorbent adsorbs strongly

(iv) Effect of pressure of the gas : The adsorption causes a net decrease in pressure as the gas gets adsorbed and thus the increase in pressure favours the process of adsorption in accordance with Le-chatelier's principle.

Adsorption isotherm : - Graph betweeen extent of the adsorption $\left(\frac{x}{m}\right)$ & pressure (P) at a given temperature is called adsorption isotherm. There are two types of adsorption isotherms -

(i) Freundlich Adsorption isotherm :

(a) At low pressure : $\frac{x}{m} \propto P \Rightarrow \frac{x}{m} = kP$

(b) At high pressure : $\frac{x}{m}$ = constant (almost)

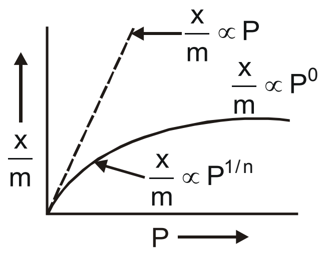
$$\Rightarrow \frac{x}{m} \propto P^0$$

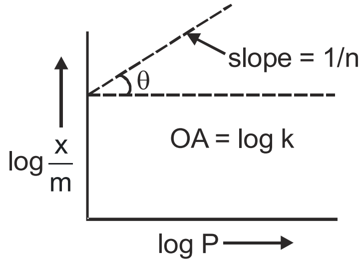
$$\Rightarrow \frac{x}{m} = kP^0$$

(c) At intermediate pressure : $\frac{x}{m} \propto kP^{1/n}$, where $n \geq 1$

Hence $\boxed{\frac{x}{m} = kP^{1/n}}$ (Freundlich's Equation)

$$\Rightarrow \boxed{\log\frac{x}{m} = \log k + \frac{1}{n}\log p}$$





Note :

(i) Freundlich equation is valid for physical adsorption only.

(ii) Freundlich's equation is valid only in the lower pressure range

(ii) Langmuir Adsorption isotherm :

Freundlich adsorption isotherm fails at high pressure and hence langmuir adsoption isotherm is of importance which is based on kinetic consideration.

According to Langmuir —

(a) There is adsoption of gas molecules on the surface of the solid.

(b) There is desorption of the adsorbed molecules from the surface of the solid.

(c) There is formation of unimolecular layer and thus it is chemisorption

(e) A dynamic equilibrium is attained when rate of adsorption = rate of desorption.

(f) Based on the above facts, langmuir adsorption isotherm is represented as

$$\boxed{\frac{x}{m} = \frac{ap}{1+bp}}$$

Where a & b Langmuir parameters.

Case-I At very high pressure

bp >>> 1, hence 1 + bp ≈ bp

$$\therefore \ \frac{x}{m} = \frac{ap}{bp} = \frac{a}{b} = \text{constant}$$

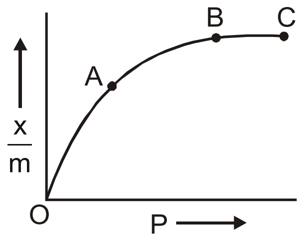
This shows saturation point as shown along BC.

<u>Case-II</u> At very low pressure

$bp <<< 1 \ \therefore \ 1 + bp \approx 1$

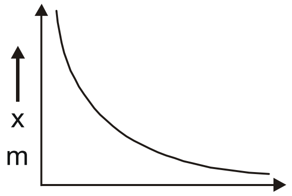
$$\therefore \ \frac{x}{m} = ap \qquad \Rightarrow \frac{x}{m} \propto p$$

This is shown along OA

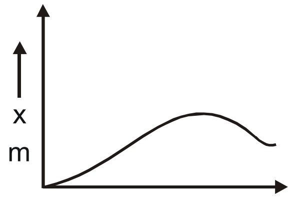


(iv) Effect of temperature :

As adsorption is accompanied by evolution of heat , so in accordance with the Le-chatelier's principle, the magnitude of adsorption should decrease with rise in temperature.



(a) Physical adsorption T →



(b) Chemisorption T →

[adsorption isobar]

A physical adsorption isobar shows a decrease in x/m as the temperature rises. The isobar of chemisorption shows an increase in the beginning and then decrease as the temperature rises.

(v) Activation of adsorbent : Activation of an adsorbent means increasing the adsorbing power of the adsorbent. This can be achieved by increasing the specific area of the adsorbent. This can be done either by making the surface of adsorbent rough or by breaking it into small pieces.

2.4 Application of adsorption :

(1) Activated charcoal is used in gas masks to remove poisonous gases such as CH_4, CO etc.

(2) Animal charcoal is used as decolorizer in manufacture of sugar.

(3) Silica is used for removing moisture and controlling humidity.

(4) A number of industrial processes take place in the presence of catalysts which are based upon adsorption.

(5) Chromatographic purification of compounds is based upon phenomenon of adsorption.

(6) The ion exchange resins used for removing hardness of water are also based upon adsorption.

Thomas Graham classified substances into two categories on the basis of their rates of diffusion-

1. CRYSTALLOIDS ⁚

The one having higher rate of diffusion & diffused from parchment papers

2. COLLOIDS ⁚

The one having slower rate of diffusion and cannot diffuse from parchment paper.

Example : Starch, Haemoglobin etc.

2.1 Characteristics of colloidal state :

(1) It is the state in which rate of diffusion through parchment membrane is slow

(2) It is heterogeneous state i.e. No. of phases$\geq$ 2

(3) Colloidal state must have at least two phases. The one phase dispersed in other is known as dispersed phase. Whereas the other in which dispersion are made is known as dispersion medium.

Colloidal solution = Dispersed phase + Dispersed medium -

(4) It is an intermediate state in between true solution and suspension state.

(5) Colloidal particles do not settle down under the force of gravity even on long keeping

(6) The surface area of colloidal particle is very large in comparision to suspension state

(7) Colloidal particle always carry charge positive or negative on dispersed phase particles.

2.2 Distinction between true solution, colloidal solution and suspension :

Name of property	True solution	Colloidal solution	suspension
1. Particle size	$< 10^{-7}$ cm	10^{-7} to 10^{-5} cm	$> 10^{-5}$ cm
2. Visibility	Not visible with any of the optical means	Images are visible under ultra microscope	visible with naked eye
3. Separation with filter paper	Not possible	Not possible	Possible
4. Diffusion	Diffuses readily	Diffuse very slowly	Does not diffuse
5. Nature	Homogeneous	Heterogeneous	Heterogeneous
6. Setting	Does not settle	Settle under centrifuge	Settles under influence of gravity
7. Tyndall effect	Does not show	Shows	May or may not show
8. Brownian movement	Does not show	Shows	May show

2.3 Phases of colloidal solution : It consists of at least two phases

(1) Dispersed phase : One phase dispersed in other is known as dispersed phase. In which the small particles of solute is diffused in solvent

(2) Dispersion medium : The other in which dispersion are made is known as disperse medium. It means that solvent in which the particle of solute are diffused

Example

Dispersion medium		Name of colloids
1. Water	:	Hydrosols
2. Alcohol	:	Alcosols
3. Gases	:	Aerosols

S.No.	Dispersed phase	Dispersed Medium	Common Name	Examples
1.	Solid	Solid	Solid sol	Coloured Glass, Gems
2.	Solid	Liquid	Sol	Starch , Gold sol, Muddy water
3.	Solid	Gas	Aerosol	Smoke, Dust storm
4.	Liquid	Solid	Gels	Cheese , Boot polish
5.	Liquid	Liquid	Emulsion	Milk, Cod river oil
6.	Liquid	Gas	Liquid aerosol	Mist, Fog , Cloud
7.	Gas	Solid	Solid foam	Rubber
8.	Gas	Liquid	Foam	Soap and detergent foam
9.	Gas	Gas	Do not form	—

2.4 Classification of colloids :

(a) Based on size :

Multimolecular colloid

Colloidal particle - It is made up by aggregation of atoms or small molecules with molecular size < 1 $m\mu$

Examples - Gold atoms , sulphur molecules

Macromolecular colloid

Colloidal particle - Particles are of bigger size equal to that of colloidal dimension

Examples : Gelatin , starch , protein

Associated collodial (Colloidal electrolyte)

Collodial particle - Soap moleucles (sodium stearate etc.) at higher concentration associate together to form micelle of collodial size

Examples - Soaps, detergents

(b) According to nature of colloidal particles :

(A) **Lyophilic sols :** If there is attraction between disperse phase and disperse medium's particle then it is called lyophilic sols. In this type of colloidal solutions, the disperse phase has great affinity for the dispersion medium.

Example : Starch, Rubber's solution, Sols of gum, gelatine etc.

(B) **Lyophobic sols :** If there is no attraction between the particles of disperse medium and disperse phase. It means in this type of sols, disperse phase has little affinity for the dispersion medium.

Difference between Lyophilic and Lyophobic sols

S.No. Property	Lyophilic sols	Lyophobic sols
1. Nature	More affinity between disperse phase & disperse medium	Less affinity between disperse phase & disperse medium
2. Preparation	As soon as disperse phase comes in contact with disperse medium, sols are formed	Special methods are required
3. Conc. of sol	More conc. of disperse phase in sol.	Less conc. of sol.
4. Stability	More stable	Less stable
5. Size of sol particle	More	Less
6. Viscosity	More viscous than disperse medium	Same as of disperse medium
7. Surface tension	Much less than disperse medium	Same as of disperse medium
8. Reversibility	Reversible with temperature.	Irreversible
9. Tyndall effect	Do not show	Show
10. Charge	The charge of sol particles depends upon pH of medium. Generally they are chargeless	Independent of pH. They show +ve or -ve charge
11. Solvation	High degree of solvation	Low degree of solvation
12. General examples	Mostly of organic nature	Mostly of inorganic nature

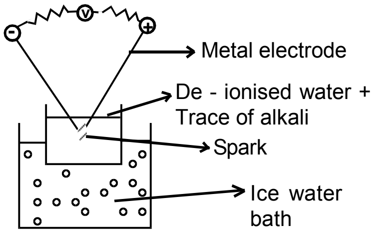
2.5 Preparation of colloidal solutions :

(A) Dispersion methods

(1) **By mechanical disintregation :** In it both pieces of colloidal mill rotate with a speed of 7000 r.p.m. in opposite direction. In it suspension can convert into colloidal phase.

Example : Manufacture of Buttermilk(Lassy) by curd.

(2) **Bredig's arc method :** If an electric arc is struck between two electrodes of a metal in water having traces of an alkali, the metal is found to be converted into colloidal solution. Alkali acts as a stabiliser. By Arc, metal is vaporised but due to coldness of ice this metal retains into colloidal sols.



Example : Sols of gold, silver, copper etc.

(3) **Peptisation :** The process of converting a precipitate into colloidal particles by adding suitable electrolyte is known as peptisation and the electrolyte as peptizing agent.

Important peptizing agents : Sugar, Gum, Gelatin & Electrolytes.

Example

(1) Freshly prepared ferric hydroxide can be converted into colloidal state by shaking it with water containing Fe^{+3} or OH^{-} or $FeCl_3$

$Fe(OH)_3 \quad + \quad xFe^{+3} \longrightarrow Fe(OH)_3 . xFe^{+3}$

Precipitate   Peptizing

agent   colloid

(2) Gelatin stabilises the colloidal state of ice-cream

(3) Lamp black is peptised by gums to form Indian ink

(4) AgCl precipitate is peptized by adding $AgNO_3$ or KCl

(5) A stable sol of stannic oxide is obtained by adding small amount of dil HCl to SnO_2 precipitate

(6) When a precipitate of CuS or $BaSO_4$ or AgCl is continuously washed with water. After sometime the precipitate is converted into colloidal state which passes through the filter paper.

(B) Condensation methods

(1) **By oxidation :**

Example : A colloidal solution of sulphur can be obtained by bubbling oxygen through a hydrogen sulphide in water

$2H_2S + O_2 \rightarrow 2H_2O + 2S$

(colloidal sulphur)

(2) **By reduction :** A colloidal solution of a metal like. Ag, Au & Pt can be prepared by reducing its salt solution with a suitable reducing agent (Stannous chloride, Hydrazene, Formaldehyde)

Example :

$2AuCl_3 + 3SnCl_2 \rightarrow 3SnCl_4 + 2Au$

(Gold sol)

(3) **By hydrolysis :** Many salt solutions are rapidly hydrolysed by boiling dilute solution of their salts.

Example :

$FeCl_3 + 3H_2O \rightarrow Fe(OH)_3 + 3HCl$

(sols)

(4) **Double decomposition :**

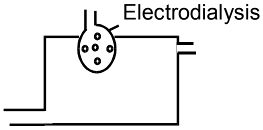
Example :

$As_2O_3 + 3H_2S \rightarrow As_2S_3 + 3H_2O$

Arsenic oxide   Sol of arsenic sulphide

2.6 Purification of colloidal solutions :

(1) Dialysis : Dialysis may be defined as the process of separating a crystalloid from a colloid by diffusion or filtration through a fine membrane. The process of dialysis can be quickened by using hot water (hot dialysis) or by applying an electric field (electrodialysis)



(2) Ultrafiltration : Sol particles directly pass through ordinary filter paper because their pores are larger than the size of sol particles. But if the pores of the ordinary filter paper are made smaller by soaking the filter paper in a solution of gelatin, the treated filter paper may retain colloidal particles and allows the true solution particle to escape. Such filter is known as ultrafilter and process is known as ultrafiltration.

(3) Ultracentrifugation : In this method, the colloidal solution is placed in a high speed centrifugal machine. On centrifuging, the colloidal particles settle down. The impurities remain in centrifugate and are removed. The settled colloidal particles are mixed with water to form the colloidal solution again.

2.7 Properties of colloidal solutions :

(i) Heterogeneous nature : They consist of two phases viz. dispersed phase and dispersed medium

(ii) Non setting : Colloidal solutions are stable systems

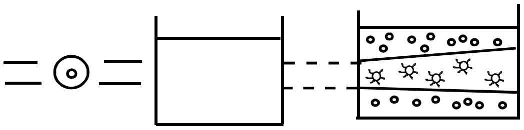
(iii) Diffusibility : Sol particles have slow rate of diffusion through parchment membrane.

(iv) Filtrability : Colloidal particles readily pass through ordinary filter paper. They can be retained by special filters known as ultrafilters

(v) Visibility : Owing to very small size the colloidal particles are not visible even under a most powerful microscope.

(vi) Colour : Colour of a colloidal solution depends upon the size and shape of particle. Due to their different size and shape, they acquire different colours, because the nature of light to get adsorbed and transmitted out depends upon size and shape of particles.

(vii)Tyndall effect : When a beam of light is passed through a true solution, it cannot be seen unless the eye is placed directly in its path. On the other hand when the same beam of light is passed through a colloidal suspension it becomes visible as a bright streak. This phenomenon is called Tyndall effect.



True solution Colloidal solution

Cause : The Tyndal effect is owing to the scattering of light from the surface of colloidal particles

Example :

(A) Appearance of dust particles in a semidarkened room

(B) Light thrown from a projector in cinema hall.

(viii) Brownian movement (Robert brown) : When colloidal solutions were examined under the ultramicroscope , it was found that the particles in these solutions were also in constant random motion, transversing no definite set paths, but travelling in Zig - Zag directions. This movement of colloidal particles is called brownian movement.

Cause : It is due to the bombardment of colloidal particles by the molecules of dispersion medium which are in constant motion like molecules in a gas.

Advantages

(ai) Confirmation of kinetic theory. It is direct demonstration of ceaseless motion of molecules as pictured by kinetic theory.

(b) Determination of Avogadro's number. With the help of ultramicroscope the number of particles in a given mass of the gas can be counted and the Avogadro's number i.e. the number of molecules in the one gm. mol. of gas can be calculated

(c) In stabilising colloidal solution. The zig-zig motion prevents the setting of colloidal particles by gravity and thus helps in stabilisng colloidal solutions to some extent

(d) Determination of the size of the colloidal particles we have the formula

$$\frac{RT}{N_0} \ln \frac{n_1}{n_2} = \frac{4}{3} \pi r^3 (h_2 - h_1) (p-p')$$

where, N_0 = Avogadro's number

R = Gas constant

T = Temperature (K) n_1 and n_2 = Number of particles at depths h_1 and h_2 respectively.

p and p' = densities of colloidal particles dispersion medium respectively

∴ 'r' radius of the particle can be calculated

(ix) Electrical property : All particles of a colloidal system carry the same charge while the dispersion medium has an equal but opposite charge with the result the system as a whole is electrically neutral. When an electric current is passed through a colloidal solution the solid particles and liquid medium being oppositely charged move in opposite direction.

In case the experiment is so arranged that only the particle can move (no liquid medium), the phenomenon is known as cataphoresis or electrophoresis. On other hand , when only the medium is allowed to migrate and not the particle the phenomenon is called electrosmosis .

(x) Electrophoresis or Cataphoresis

The movement of electrically charged collodial particles towards either of the oppositely charged electrode under the influence of an electrical potential is called **Electrophoresis or Cataphoresis**

Advantages

(i) It establishes the fact that colloidal particles are charged

(ii) The direction of migration of collodial particles indicates the type of charge present on the particles

Example :

$As_2S_3|S^{-2}$ (negative sol particles move towards anode)

Some common sols with type of charge

	Positively charged sol		**Negatively charged sol.**
(i)	Oxides : TiO_2 Sol	(i)	Metals : Cu, Au, Ag sols
(ii)	Metallic hydroxides : $Cr(OH)_3$, $Al(OH)_3$, $Fe(OH)_3$	(ii)	Metallic sulphides As_2S_3, CdS and Sb_2S_3 sols.
(iii)	Basic dye - stuffs (methylene blue)	(iii)	Acid dye stuffs : eosin, congored
(iv)	Haemoglobin	(iv)	Sols. obtained from starch , charcoal , gum

$Fe(OH)_3|Fe^{+3}$ (Positive sol particles move towards cathode)

(xi) Coagulation :

(1) Stability of the colloidal state is due to the existence of electrical charge on the particles. If the charge is lowered to a certain critical value or neutralised, the particles approach close enough to form bigger particles of the suspension range. This phenomenon of change of colloidal state to suspension state is known as coagulation of colloidal solutions.It means that destabilization of sols may also be made by artificial means and the phenomenon is known as coagulation.

(2) Following methods are used for coagulation -

(A) **Mutual coagulation :** When the two oppositely charged sols are mixed in approximately equal proportions, the charge on one sol is neutralised by the opposite charge on the other sol.

Example : $Fe(OH)_3$ and As_2S_3

(B) **General methods :**

(1) By heating : Coagulation of butter

(2) By cooling : Coagulation of milk

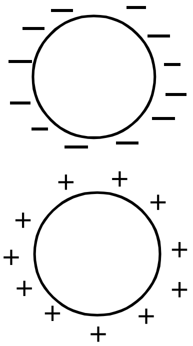
(3) By mechanical agitation

(C) **Cataphoresis :** Sols particles during migration under cataphoresis towards opposite electrodes get adhered there and lose their charge

(D) Addition of electrolyte : It has been dealt in terms of Schulze - Hardy rule

(1) One of the ions furnished by an electrolyte carrying charge opposite to that of sol particles is responsible for coagulation of sol and is known as effective ion.

(2) Greater is the valencey of effective ion, more is coagulating power.



Example :

(a) $Na^+ < Mg^{+2} < Al^{+3}$

To neutralise a negative colloid Al^{+3} will show highest coagulating power

(b) $Cl^- < SO_4^{-2} < PO_4^{-3}$

(3) More is the coagulating power, lesser is coagulation value

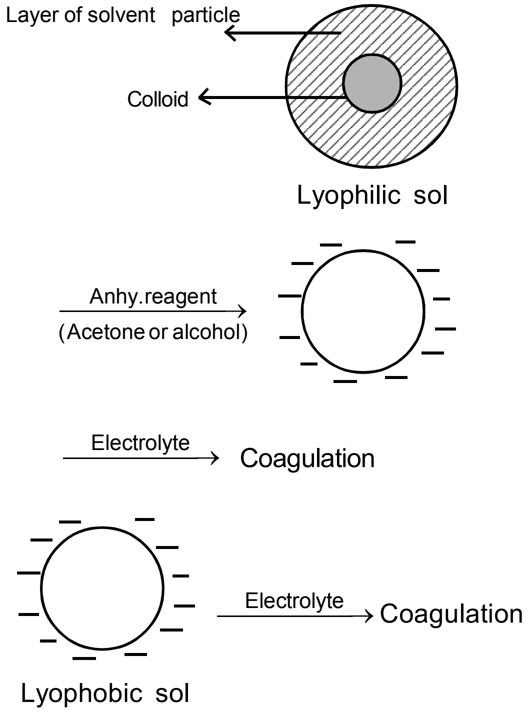
Example :

Positive sol :

Coagulation value - $KNO_3 > K_2SO_4 > K_3PO_4$

Coagulation power - $KNO_3 < K_2SO_4 < K_3PO_4$

(4) **Mechanism of coagulation :**



(xii)Origin of charge : Many views have been reported regarding the origin of charge on colloidal particles. A few of them are

(a) It is due to friction between the particles of dispersed phase and the particles of dispersion medium

(b) It is due to the difference in dielectric constant of dispersed phase and dispersion medium

(c) It is due to the electron capture during electro dispersion of metals

Modern views : Above views have been discarded. According to the modern view it is due to the preferential adsorption of ions by the colloidal particles. In most cases colloidal particles are formed in media containing electrolytes of same kind, and if the particles are capable of adsorbing predominantly or exclusively ions of one type i..e either cations or anions, they acquire the charge of those ions. Of course, charged colloidal particles can exist in solution only if the latter contains at the same time ions of the opposite charge. Thus , an electrical double layer is formed on the surface of the particles. i.e. one due to adsorbed ions and the other due to oppositely charged ions forming a diffuse layer which is randomly distributed

(a) A sol of $Fe(OH)_3$ prepared from ferric chloride is positively charged due to the preferential adsorption of Fe^{+++} ions on the surface with the -vely charged Cl^- ions in the diffused layer and can be represented as :

$[Fe(OH)_3]Fe^{+++}$, $3Cl^-$ [double layer]

(b) A solution of As_2S_3 prepared by the action of H_2S on As_2O_3 is -vely charged due to the preferential adsorption of S^{2-} ions on the surface with the +vely charged H+ ions in the diffuse layer as :

$[AS_2S_3^{-}]S^{--}$: $2H^+$ (double layer)

(c) A gold sol. prepared by dispersing metallic gold (Bredign's method) in water contains -vely charged particles due to the adsorption of OH^- ions from the water as

$[Au]_n$ x OH^-

As a general rule electrovalent compounds have a preference for adsorbing ions which are common to them

(A) SIGNIFICANCE OF THE CHARGE

(i) **Stability of Sols.** Lyophobic colloids are stable due to the charge on the colloidal particles. On account of similar charge colloidal particles are repelled by electrostatic forces and resist the tendency to combine. Lyophilic colloids are stable due to their charge and extensive solvation.

In Industrial applicaiton. This knowledge of the charge on colloidal particles is used in many industries. It is used in electro deposition of rubber, leather tanning, purification of water and removal of carbon from smoke.

(b) Colligative properties : Colligative properties, such as osmotic pressure , elevation in B.P. depression in F.P. which depend on the number particles present in solution, are usually very small for colloidal solutions.

(xiii) Protection : Lyophobic sols are relatively less stable than lyophilic sols. Their stability may be increased on addition of lyophilic sols. This phenomenon of stabilizing lyophobic sols by the addition of lyophilic colloids is known as protection . The lyophilic used for this purpose are known as particles colloids.

Gold Number : The protective character of various lyophilic substances has been expressed in terms of gold numbers. It was used first of all by Zigmondy.

Weight in milligrams of a protective colloid which stops the coagulation of lyophobic colloid known as gold number

Definition : The minimum amount of lyophilic in milligrams which prevents the coagulation of 10ml gold sol against 1ml of 10% NaCl solution

Protective colloid		**Gold number**
Geltain	:	0.005
Haemoglobin	:	0.03
Albumin	:	0.15
Starch	:	2.5

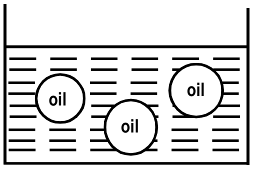
More is gold number less is the protective power of lyophilic colloid

(xiv) Emulsions :

(1) A dispersion of liquid droplets in another liquid (the two liquid should be immiscible) is known as emulsion .

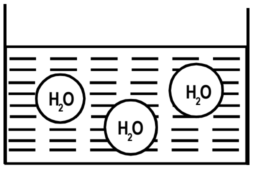
(2) Emulsions are of two types

(a) **Oil in water :** Dispersed phase is oil, dispersed medium is water.



Example : Milk , Vanishing cream etc.

(b) **Water in oil :** Dispersed phase is water, dispersed medium is oil.



Example : Butter, Cold cream etc.

(c) Interconversion of phases in emulsion is known as phase conversion.

Example : Creaming of milk.

(d) Emulsions are prepared by vigorous shaking of the relevant liquids.

(e) Emulsion, like other colloidal systems are unstable and are stabilized by the adition of third component known as emulsifiers or emulsifying agents. In the absence of emulsifying agent two liquids are separated into separate layers.

(xv) Reversible colloids : Substances like gelatin, gum, arabic, starch, etc. have great affinity for the dispersion medium. Such substances easily form colloidal solution by merely bringing in contact with the dispersion medium. They will easily revert to the colloidal state after coagulation, on adding the dispersion medium. They are known as lyophilic or reversible colloids.

(xvi) Irreversible colloids : Lyophobic colloids once coagulated can not be reverted to sol by shaking with dispersion medium as such they are called irreversible collids.

(xvii) Isoelectric point of the colloid : The hydrogen ion concentration at which the colloidal particles are neither positively charged nor negatively charged [neutral] is known as isoelectric point of the colloid. At this point, the lyophilic colloid is expected to have minimum stability because at this point particles have no charge or equal quantum of positve and negative charge.

Example : Isoelctric point of gelatin is 4.7. This indicates.

- At pH 4.7 gelatin has no electrophoretic motion.
- At pH < 4.7, gelatin moves towards cathode.
- At pH > 4.7, gelatin moves towards anode.

(xviii) Applicaiton of Colloid Chemistry

(a) **Blue colour of sky and Tail of commets (Tyndalleffect) :** The blue colour of the sky and the tails of the comets, are due to scattering of light by the collodial particles of dust in air

(b) **Purificaton of water by alum (coagulation) :** Alum which yield Al^{+3} ions, is added to water to coagulate the negatively charged clay particles

(c) **In rubber and Tanning Industry [Coagulation and mutual coagulation]** : Latex is colloidal suspension of rubber particles in water. This on boiling or addition of electrolytes gets coagulated and forms rubber

Hides and skins are colloidal in nature containing proteins. The positively charged colloidal particles of hides are coagulated by adding negatively charged tannin sol and thus mutual coagulation occur

(d) **Artificial rains (coagulation) :** Silver halide layer is used in ballons i.e. silver halide is sprinkeled over clouds.

(e) **Cleansing action of soap (Micelle formation)**: Soap solution is colloidal in natue. It emulsifies greasy and oily materials sticking to the surface of clothes or body

(f) **Smoke precipitaiton (coagulaiton) :** Smoke is a -ve sol consisting of C- particles dispersed in air. Thus, these particles are removed by passing through a chamber provided with highly +vely charged metallic knob.

(g) **Removal of dirt from sewage (coagulation) :** The sewage contains dirt particles suspended in water forming a -ve sol. The -vely charged particles coagulate on anode.

(h) **Formation of deltas (coagulation) :** River water consists of negatiely charged clay particles of colloidal dimension. When the river false into the sea, the clay particles are coagulated by the positive Na^+, K^+, Mg^{+2} ions etc. present in sea water and newlands called deltas are formed.

(i) **Stop bleeding from a cut (coagulation) :** Blood is negatiely charged sol. and is coagulated by the positive aluminium or ferric ions to a clot which closes the wound.

(j) **Colloidal medcine :** Argyrol and protargyrol are colloidal solutions of silver and are used as eye lotions. Colloidal sulphur is used as disinfectant. Colloidal gold, calcium and iron are used as tonics.

(k) **Photographic plate.** Gelatin is protective colloid in AgBr amulsion used to prepare photographic plate.

(xix) Typical examples :

(a) Examples of hompolar, heteropolar and hydroxy sols,

- Homopolar sol. ...... ruber in benzene
- Heteropolar sol. ....Starch
- Hydroxy sol. $Fe(OH)_3$Sol.

(b) Examples of hydrophobic colloid is

$Fe(OH)_3$ sol. As_2S_3 sol., AuSo.

(c) Example of emulsion is

Milk , cod liver oil

(d) Starch , albuminm, rubber , silicons colloids can be classified as

Molecular colloids

(e) $Fe(OH)_3$. $Fe^{+3}|3Cl^-$ is a positively charged sol.

(f) Colloids represent a ...... of matter and not a class of substance

state

(g) Blood is a .... charged sol

Negatively

Examples based on Colloidal state

Ex.1 'Purple of cassius' is a -

(A) Colloidal solution of gold
(B) Collidal solution of silver
(C) Colloidal solution of platinum
(D) Colloidal solution of Tin

Sol. Collodial solution of gold is called "purple of cassius'

(Ans. A)

Ex.2 The process of making colloidal solution from the precipitate is called -

(A) Coagulation (B) Vulcanization
(C) Peptization (D) Flocculation

Sol. The conversion of precipitate into colloidal solution is called peptization.

(Ans. C)

SOLVED EXAMPLES

Ex.1 The charge on the colloidal particle of soap in its solution developed -

(A) By prefrential adsorption of ions

(B) The effective ion of soap micelle carries negative charge

(C) The effective ion of soap micelle carries positive charge

(D) None of the above

Sol. $RCOONa \rightarrow RCOO^{-} + Na^{+}$

The active species of soap is negatively charged.

(Ans. B)

Ex.2 In order to coagulate the impurities present in water. Which is the most effective ion present in the 'alum' -

(A) K^{+} (B) SO_4^{2-}

(C) Al^{3+} (D) None of these

Sol. The impurities carry negative charge hence Al^{3+} will exhibit maximum coagulating power.

(Ans. C)

Ex.3 Which is not the property of the hydrophilic sols -

(A) High concentration of dispered phase can be easily attained

(B) Coagulation is reversible

(C) The charge of the particle depends upon the pH values of the dispersion medium. It may be positive or negative

(D) Viscosity and that surface tension are about the same as of dispersion medium.

Sol. Viscosity of hydrophilic sol is much higher than dispersion medium while surface tension of the sol is much lesser than water. This is attributed to the higher concentration of the sol itself.

(Ans. D)

Ex.4 If water is chosen as dispersion medium, then the sol formed will be called -

(A) Alcohosol (B) Benzosol

(C) Hydrosol (D) Aerosol

Sol. If water is chosen as dispersion medium then the colloidal system will be called hydrosol.

(Ans. C)

Ex.5 Colloids and crystalloids can be separated by animal membrane using the technique -

(A) Electro-osmosis (B) Filteration

(C) Dialysis (D) Electrophoresis

Sol. Crystalloids can be separated from the colloids by dialysis method.

(Ans. C)

Ex.6 Maximum hydrophobic character will be shown by -

(A) Glycine (B) Stearic acid

(C) Glucose (D) Adenine

Sol. Adenine exhibits maximum hydrophobic character.

(Ans. D)

Ex.7 $Fe(OH)_3$ sol obtained by peptization when subjected to 'electrophoretic effect' -

(A) Colloidal particles will migrate towards anode

(B) Colloidal particles will migrate towards cathode

(C) Colloidal particles remain stationary

(D) Colloidal particles migrate towards both the electrode

Sol. Ferric hydroxide is a positive sol $Fe(OH)_3/Fe^{3+}$, it will migrate towards cathode.

(Ans. B)]

Ex.8 Which of the following solution is positively charged -

(A) As_2S_3 (B) $Fe(OH)_3$

(C) Au (D) Starch

Sol. $Fe(OH)_3/Fe^{3+}$ is a positively sol particle.

(Ans. B)

Ex.9 Dispersion of AgCl in water is called -

(A) Hydrophilic sol

(B) Emulsion

(C) Benzosol

(D)Hydrophobic colloid

Sol. Colloidal system AgCl is called, hydrophobic colloid.

(Ans. D)

Ex.10 The stability of lyophilic colloid is due to -

(A) Charge on the solution particles

(B) Layer of dispersion medium over the solution paricles

(C) Smaller size of solution particles

(D) Bigger size of solution particles

Sol. Lyophilic colloids are of bigger size and this accounts for their stability.

(Ans. D)