CHAPTER -

Adsorption is the phenomenon of accumulation of molecular species at the surface rather than in the bulk of a solid or liquid

1. Difference between adsorption and absorption

	Absorption	Adsorption
1.	Phenomenon in which the particles of gas or liquid get uniformly distributed through the body.	Phenomenon in which concentration of particles is higher at the surface than in bulk.
2.	Concentration is same throughout the material.	Concentration is higher at surface than in bulk.
3.	Occurs at uniform rate.	Rate is fast higher than decreases gradually.

Sorption is the process in which both adsorption and absorption take place simultaneously.

During adsorption ΔH is always negative and ΔS is negative.
At equilibrium $T\Delta S = \Delta H$

2. Difference between physisorption and chemisorption?

	Physisorption	Chemisorption
1.	Arises due to weak van der Waal forces.	2. Formed by chemical bonds

2.	Low enthalpy of adsorption	High enthalpy of adsorption
3.	The reaction is reversible.	It is irreversible.
4.	It is not specific	It is highly specific.
5	Low temperature is favourable for adsorption.	High temperature is favourable for adsorption.
6.	No appreciable amount of activation energy is required.	High activation energy is needed.

Both physisorption and chemisorption increases with increase in surface area.

3. Why 1g of activated charcoal (More critical temperature) adsorbs more SO_2 than CH_4? (less CT)

Ans Physisorption is more for easily liquefiable gases (i.e high critical temperature) are readily adsorb as Van der Waal forces are stronger near critical temperature

Promoters are the substance that enhance the activity of a catalyst.
Poisons are the substance that decrease the activity of a catalyst.

4. Phenomenon of adsorption applicable in homogenous catalysis?
When reactants and catalyst are in the same phase
Application
1. Hydrolysis of methyl acetate catalysed by H^+ ions furnished by HCl.

$CH_3COOCH_3(l) + H_2O(l) \xrightarrow{HCl(l)} CH_3COOH + CH_3OH$

ii) Hydrolysis of sugar is catalysed by H^+ ions furnished by sulphuric acid.

$C_{12}H_{22}O_{11}(aq) + H_2O(l) \xrightarrow{H_2SO_4(l)} C_6H_{12}O_6 + C_6H_{12}O_6$

5. Application of adsorption in heterogenous catalysis

i) In Haber's process when N_2 combines with H_2 to form ammonia in presence of iron.

$N_2(g) + 3H_2(g) \xrightarrow{Fe(s)} 2NH_3$

ii) Hydrogenation of vegetable oils in the presence of finely divided nickel as catalyst.

Vegetable oils(l) + $H_2(g) \xrightarrow{Ni(s)}$ Vegetable ghee.

Activity of a catalyst - Strength for chemisorption.
Selectivity of a catalyst - Ability to direct a reaction to yield a particular product.

6. What are shape-selective catalysis? Why zeolites are good-shape selective catalysts?

Ans Catalystic reaction that depends upon the pore ~~substance~~ structure of the catalyst and size of reactant and product molecules is called shape selective catalysis.

Zeolites are good shape-selective catalyst because of their honeycomb-like structure.

- Zeolites are aluminosilicates structure.
ZSM-5 (used in petrochemical industries) converts alcohol into gasoline.

- Characteristics of enzymes -
i) Highly specific
ii) Highly active under optimum temperature
iii) Highly active under optimum pH.
iv) Highly efficient.

- Colloid is a heterogenous system in which one substance is dispersed as very fine particles in another substance called dispersion medium.

On the basis of physical state of dispersed phase and dispersion medium.

D.P	D.M	Types of colloid	EXAMPLES
Solid	Gas	Aerosol	Smoke, dust
Solid	Liquid	Sol	Paints, cell fluids
Solid	Solid	Solid sol	Coloured glasses & gem stone
Liquid	Gas	Aerosol	Fog, mist, cloud, insecticide spray
Liquid	Liquid	Emulsion	Milk, hair cream
Liquid	Solid	Gel	Jellies, butter, cheese
Gas	Liquid	Foam	Froth, whipped cream, soap lather
Gas	Solid	Solid sol	Pumice stone, foam rubber

Gas - Gas do not form colloid. because it is a homogenous mixture.
If dispersion medium is water - sol is aquasol / hydrosol
If dispersion medium is alcohol - sol is alcosol.

On the basis of interaction between DP and DM

Lyophilic colloids	Lyophobic colloids
1. Easily prepared	1. Prepared with difficulty
2. Particles are not easily visible.	2. Particles are easily visible.
3. More stable than lyophobic.	3. Less stable than lyophilic.
4. On addition of electrolytes they are not easily coagulated.	4. Easily coagulated on addition of electrolyte.
5. They are reversible sols	5. They are irreversible sol.
6. Ex - Gum, gelatin, starch, rubber.	6. Ex - Metals and their sulphides

On the basis of type of particle of dispersed phase.

i) Multimolecular colloid - When on dissolution atoms or smaller molecules aggregate together having diameter less than 1nm to form colloidal sol thus multimolecular
Ex - Gold sol, sulphur sol.

ii) Macromolecular colloid - Substances having big size molecules called macromolecules which on dissolution form solution in which dispersed phase particles have size in colloidal ranges
Ex - Starch, cellulose, proteins, enzymes, polyethene, nylon, polystereme, synthetic rubber.

iii) Associated colloid - Substances on dissolution behave as normal electrolyte at low concentration and colloidal particle at higher concentration due to formation of aggregate particles.
Ex- Soaps and synthetic detergents

- Formation of micelles takes place above a particular concentration called Critical micelle concentration (CMC) and above a partiular temperature called Krafft Temperature (T_K)
For soaps CMC is 10^{-4} to 10^{-3} mol L^{-1}.

- Aggregate particles are called micelles / associated colloids

Preparation of colloids

i) Chemical method - By double decomposition, oxidation, reduction or hydrolysis.

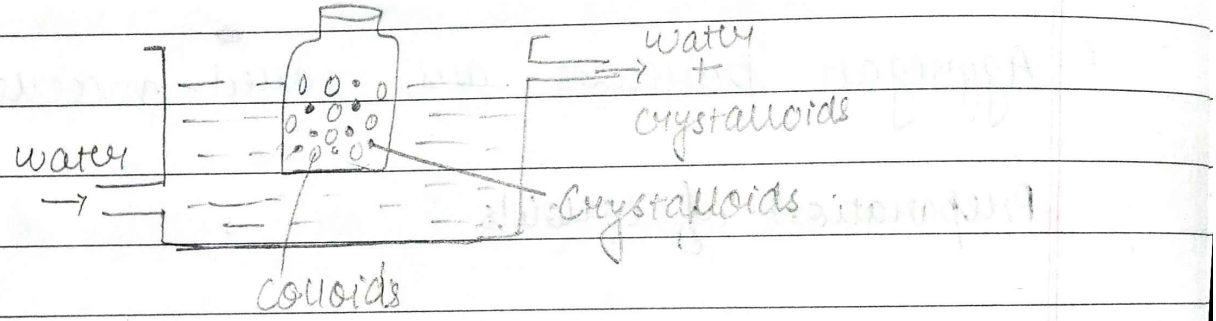
$$As_2O_3 + 3H_2S \longrightarrow As_2S_3 + 3H_2O$$
$$SO_2 + 2H_2S \longrightarrow 3S + 2H_2O$$
$$2AuCl_3 + 3HCHO + 3H_2O \longrightarrow 2Au + 3HCOOH + 6HCl$$
$$FeCl_3 + 3H_2O \longrightarrow Fe(OH)_3 + 3HCl$$

ii) Electrical disintegration / Bredig's arc method -
a) Involves both dispersion and condensation
b) Used for preparation of Gold, silver, platinum etc.
c) Electric arc struck between electrode produces intense heat and metal vaporises which then condenses to form particle of colloid.

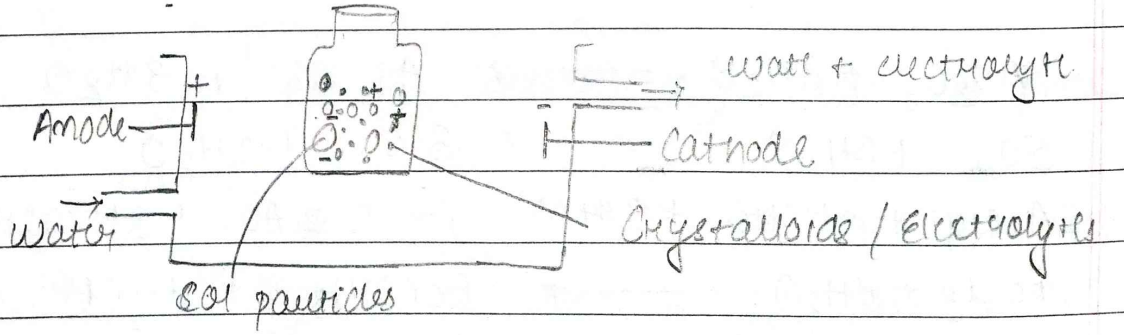
iii) Peptization - Process of conversion of freshly prepared precipitate into colloidal solution by addition of small amount of electrolyte.
Leads to formation of charge over precipitate which break upto form smaller colloids.

Methods of purification-

1. Dialysis - Process of separating the particles of colloids from those of crystalloids by means of suitable membrane (animal bladder, cellophane).



2. Electrodialysis - It is used if impure colloidal solution is only electrolyte.



3) Ultrafiltration - Process of separating colloids from soluble solvent by passing it through specially prepared filter paper (Filter paper $\xrightarrow{\text{soaking}}$ collodion soln (4% soln of nitro-cellulose + mixture of alcohol & ether) + formaldehyde)

Properties of colloids

i) Colligative property - Being big molecular aggregate the number of particles is relatively low than true solution. so it have low colligative property as compared to true solution.

ii) Tyndall effect - Colloidal solution - when ~~viewed in~~ a beam of light passes through colloidal solution -

a) In direction of light appears clear.

b) At right angle to beam of light, path is illuminated by a bluish light.

Tyndall effect is due to scattering of light in all direction in space.

Conditions for Tyndall effect -

i) Diameter of DP is not much smaller than the wavelength of the light used.

ii) Refractive index of DP and DM differs greatly.

iii) Colour - Depends on the wavelength of light scattered by dispersed particle.

iv) Brownian motion - Colloidals particles are in a zig-zag motion all over the field. This motion is called Brownian motion.

Depends on size of particle and viscosity of the solution. The cause of the Brownian motion is due to the unbalanced bombardment of the particles by the particles of dispersion medium.

(v) Electrophoresis - The phenomenon of movement of colloidal particles under an applied electric field is called electrophoresis.

vi) Electroosmosis - The phenomenon of movement of the molecules of dispersion medium under the influence of electric field.

vii) Coagulation or precipitation -
The phenomenon of precipitation of a colloidal solution by the addition of excess of an electrolytes is called coagulation or flocculation.

o Lyophobic sols are stable due to presence of charge which repel each other and if charge is removed the particles will come nearer to each other to form aggregate and settle down.

Ways of coagulating lyophobic sols -

i) By electrophoresis - Colloidal particles move towards oppositely charged electrodes, get precipitated.

ii) By mixing two oppositely charged sol - When equimolar amount of oppositely charged sols are added they neutralize each other and get coagulated.

iii) By boiling - Adsorbed layer is disturbed due to increased collisions with molecules of DM.

iv) By persistent dialysis - On prolonged dialysis whole of electrolyte is removed, colloid become unstable and ultimately coagulate.

v) By addition of electrolyte - When excess of electrolyte is added the colloids interact with ions carrying charge opposite to that present on themselves.

Hardy-Schulze's rule - Greater the valency of the coagulating ion, greater will be its coagulating power.

For example to coagulate negative sol, the order is

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

To coagulate positive sol, the order is

$[Fe(CN)_6]^{4-} > PO_4^{3-} > SO_4^{2-} > Cl^-$

Coagulating value - Minimum amount of an electrolyte which is required to cause the coagulation of one litre of sol.

Smaller is the coagulating value of an electrolyte, greater is its coagulation power.

Ways of coagulation of lyophilic sols -

o Stability of lyophilic sols is due to charge and the solvation of the colloidal particle.

i) By addition of electrolyte.

ii) By addition of suitable solvent - It causes dehydration of dispersed phase. On addition small electrolyte it gets coagulated

Emulsions

Colloidal solution in which both the dispersed phase and dispersion medium are liquids.

Emulsifying agents are the stabilizers which reduce the interfacial tension between two liquids forming emulsions.

Types of emulsions

i) Oil-in-water (O/W type) -

a) Oil act as DP and water act as DM.

b) Ex - Milk, vanishing cream etc

c) They are called aqueous emulsions., Emulsifying agent - protein, gum, soaps

ii) Water-in-oil (W/O type) -

a) Water act as DP and oil act as DM

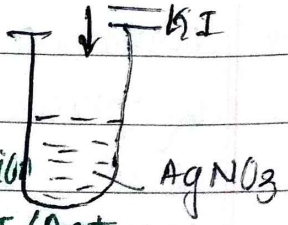
b) Ex - butter, cold cream

c) They are called oily emulsions. Emulsifying agent - lampblack, long chain alcohols

- Can be interchanged by adjusting the ratio

- Test for identification
  If on adding water emulsion gets dilute - O/W type
  if not then W/O type.

6. A colloidal sol is prepared by the method given in the given figure. What is the charge of AgI colloidal particles formed in the test tube? How is the sol represented?



When KI solution is added to $AgNO_3$ a positively charged sol results due to absorption of Ag^+ ions from dispersion medium - AgI/Ag^+

- Charge on colloidal sol is due to the adsorption of the common ion of the dispersion medium.

- If $FeCl_3$ is added to excess of hot water - +ve charge sol of hydrated ferric oxide is formed.
$FeCl_3$ is added to NaOH - -ve charge sol is formed

$Fe_2O_3 \cdot xH_2O / Fe^{3+}$ — Positively charged

$Fe_2O_3 \cdot xH_2O / OH^-$ — Negatively charged

7. Define electrokinetic potential or zeta potential.
The potential difference between the fixed layer and the diffused layer of opposite charges is called electrokinetic potential or zeta potential.

8. A delta is formed at the meeting point of sea water and river water why?
River water is a colloidal solution of clay. Sea water contains a number of electrolyte. When river water meets the sea water, the electrolytes present in sea water coagulate the colloidal solution of clay resulting in its deposition with the formation of delta.

9. Why colloidal medicines are more effective?
Colloidal medicines are more effective because they have large surface area and are therefore easily assimilated.

10. Leather gets hardened after tanning. Animal skin is colloidal in nature and has positively charged colloidal particles. When a hide is soaked in tanning, mutual coagulation takes place and as a result, leather get hardened.

11. It is necessary to remove CO when ammonia is prepared by Haber's process. Because in this process the CO acts as a poison and adversely affects the activity of iron catalyst, used in the process

12. Why is chemisorption referred to as activated adsorption?

Chemisorption referred to as activated adsorption as it involves chemical bond formation between reactant and adsorbent molecule. Formation of chemical bond requires high activation energy. So, it is activated on increasing temperature.

13. What happens when gelatin is mixed with gold sol?

Gold sol is a solvent repelling sol i.e a lyophobic sol and unstable in nature. Addition of gelatin stabilises the gold sol because gelatin forms lyophilic sol and act as protective colloid.

14. Gelatin which is a peptide is added in ice-creams.

Emulsifying agent is added to emulsion to stabilise the emulsion. Emulsyfying agent form a layer between suspended particles and the medium and hence stabilises the emulsion. Ice creasm is stabilised by emulsifying agent like gelatin.

15. Why do we add alum to purify water?

We add alum to purify water as alum coagulates the colloidal impurities present in water so that these impurities get settle down and remove by decantation or filteration.

16. Why does bleeding stop by rubbing moist alum?
Blood is a colloidal sol. When we rub the injured part with moist alum then coagulation of blood takes place and hence the bleeding stops.

17. Why does the white precipitate of silver halide become coloured in the presence of dye eosin?
White coloured precipitate of silver halide becomes coloured in the presence of dye eosin because dye eosin gets adsorbed on the surface of silver halide precipitate.

18. What is the role of activated charcoal in gas mask used in coal mines?
Activated charcoal adsorbs various poisonous gases on its surface present in coal mines.

19. How does the precipitation of colloidal smoke take place in Cottrell precipitation?
In Cottrell precipitation, smoke particles are passed through a chamber containing plates with charge opposite to the smoke particles, smoke particles lose their charge on the plates and gets precipitated.