

# Class 12th Chemistry Chapter 5 Surface Chemistry Revision Notes & Important Question (www.free-education.in)

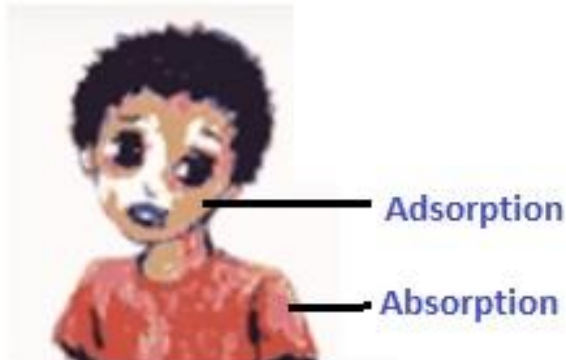
## Introduction

Surface Chemistry deals with the study of physical and chemical phenomena occurring at the boundary (interface) separating two bulk phases.

- The bulk phase can be a pure compound or a solution.
- The bulk phases may be solid – liquid, solid – gas, solid – vacuum, liquid – gas etc.

Let us consider a simple example of a dirty shirt. The dirt stays in the surface of the fabric and the study of phenomena occurring at the interface between the fabric and the dirt is surface chemistry, in simple words.

## Adsorption and Absorption



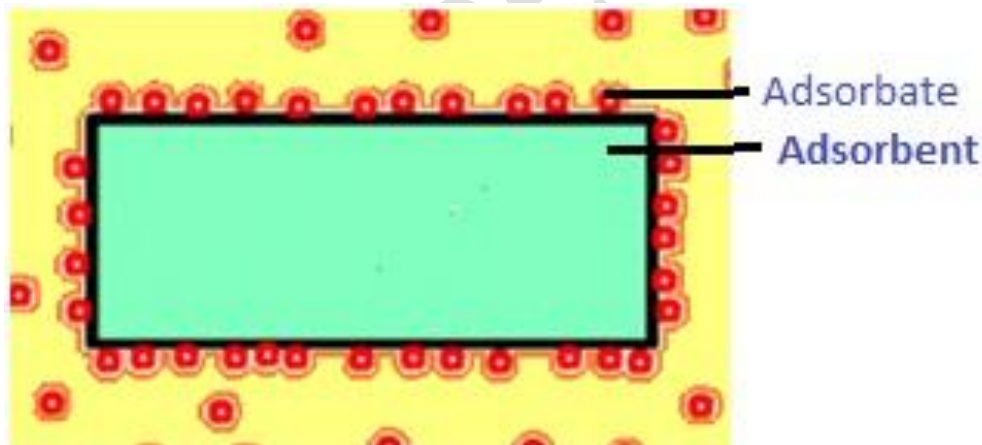
The dirt staying on the surface of the skin as a layer is termed as adsorption.

Now consider applying soap solution to the shirt containing dirt. The soap solution is absorbed by the fabric and does not stay on the fabric as a layer. This is called absorption.

## Adsorption

Adsorption is the phenomenon of attracting and retaining molecules of a substance on the surface of a solid (or liquid) resulting as a higher concentration of molecules only on the surface.

- Adsorbent- the surface on which adsorption takes place
- Adsorbate- the substance which is adsorbed



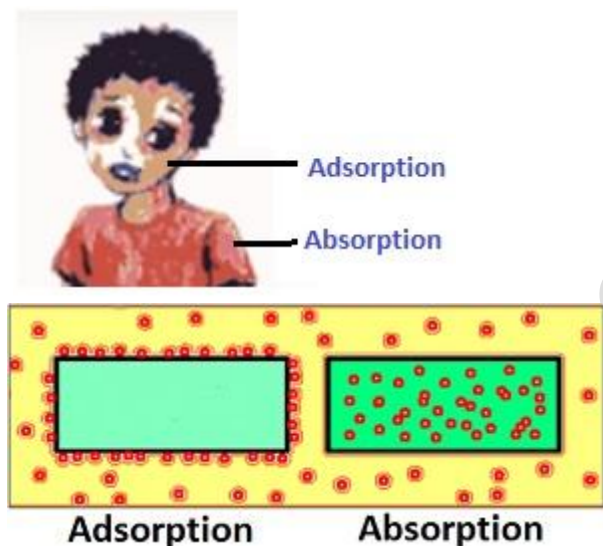
Example- Water vapour adsorbed by silica gel

- Adsorbent- Silica gel
- Adsorbate- Water vapour

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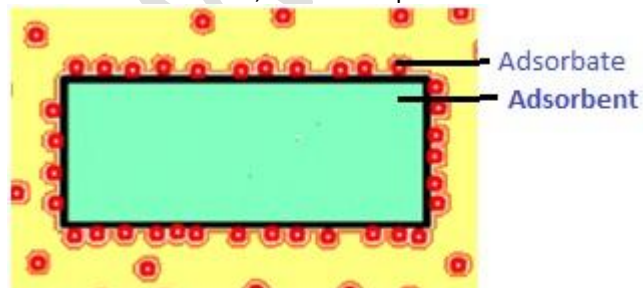
### Differences between Adsorption and Absorption

ADSORPTION	ABSORPTION
Surface phenomenon- concentration of the adsorbate increases only on the surface	Bulk phenomenon- concentration is uniform throughout the solid
Exothermic process- heat is released	Endothermic process- heat is absorbed
It is favoured by low temperature	It is not affected by temperature
Eg- Chalk stick dipped in ink adsorbs the colour of the ink but when you break the piece of chalk, its core still remains white	Eg- When anhydrous $\text{CaCl}_2$ absorbs water vapour, it becomes wet and pasty



### Mechanism of Adsorption

- Adsorption occurs because the particle on the surface and the particle in the bulk of the adsorbent are not in the same environment. That is, the net force acting on them is not the same.
- The particle on the surface has unbalanced forces acting on it which are also called residual attractive forces
- Due to these forces, the surface particles of the adsorbent attract the adsorbate particles



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- During adsorption, there is always a decrease in the residual attractive forces of the surface. That is, the energy of the surface decreases and this appears as heat. This is called the heat of adsorption
- The amount of heat evolved when one mole of adsorbate is adsorbed on the adsorbent surface is called enthalpy of adsorption
- Adsorption is always exothermic and the enthalpy change,  $\Delta H$  is always negative
- When the adsorbate molecules are adsorbed on the surface of the adsorbent, their freedom of movement becomes restricted and hence  $\Delta S$  the entropy decreases
- We know that Gibbs free energy,  $\Delta G = \Delta H - T\Delta S$ .

For adsorption to be spontaneous,  $\Delta G$  must be negative. This can happen if  $\Delta H$  has a significantly high negative value as  $-T\Delta S$  is positive.

- As the adsorption continues,  $\Delta H$  becomes less and less negative till it becomes equal to  $T\Delta S$  and  $\Delta G$  becomes zero. At this point, equilibrium is attained.

### Factors affecting adsorption of Gases by Solids

- Nature and Surface area of adsorbent:
  - The same gas is adsorbed by different solids at different extents even at the same temperature.
  - Greater the surface area, greater is the volume of gases adsorbed.
- Nature of the gas being adsorbed:
  - Different gases are adsorbed to different extents even by the same solid.
  - As the critical temperature of a gas increases, it is easier to liquefy and it is also more readily adsorbed.
  - Reason- Higher the critical temperature, the easier it is to liquefy the gas as greater are the intermolecular forces of attraction between the molecules of the gas. For such a gas, the intermolecular forces of attraction are greater on the surface of the adsorbent and thus, the adsorption will be more.
- Temperature: As temperature increases, adsorption decreases
- Pressure: At constant temperature, the adsorption of a gas increases with increase in pressure.
- Activation of the solid adsorbent: It means increasing the adsorbing power of the adsorbent.

It can be done by-

1. Making the surface of the adsorbent rough- It can be done by rubbing the surface or chemical action or by depositing fine metal particles on the surface by electroplating
2. By dividing the adsorbent into small pieces or grains- It increases the surface area but this method has a practical limitation. If the particles are too fine like powder, the adsorption of the gas will become difficult.
3. By removing the already adsorbed gases

### Types of Adsorption

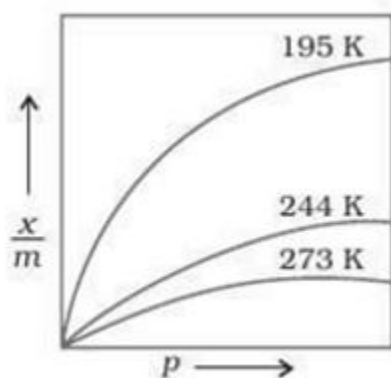
Physisorption	Chemisorption
Occurs due van der Waals forces	Caused by chemical bond formation
Not specific in nature that is all gases are adsorbed on the surface to an extent	Highly specific in nature
Reversible	Irreversible
More easily liquefiable gases are adsorbed more readily	Gases which can react with the adsorbent show chemisorption
Enthalpy of adsorption is low(20-40 kJ)	Enthalpy of adsorption is high (80-240 kJ)

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It decreases with increase in temperature. Favours low temperature	It increases with increase in temperature. Favours high temperature
It does not need any activation energy	It does require activation energy.
It results into multimolecular layers on adsorbent surface under high pressure	It results into a unimolecular layer.

### Adsorption isotherms

The variation in the amount of gas adsorbed by the adsorbent at constant temperature with change in pressure is shown by a curve called adsorption isotherm.



Freundlich adsorption Isotherm:

- Freundlich proposed this relation to show a relation between the extent of adsorption and pressure.

$$\frac{x}{m} = k(p)^{1/n} \quad \dots 1$$

$$\log\left(\frac{x}{m}\right) = \log k + \frac{1}{n} \log p \quad \dots 2$$

If there are solutions involved, the above equations become

$$\frac{x}{m} = k (C)^{1/n}$$

$$\log \frac{x}{m} = \log k + \frac{1}{n} \log C$$

Where x → amount of adsorbate

m → mass of adsorbent

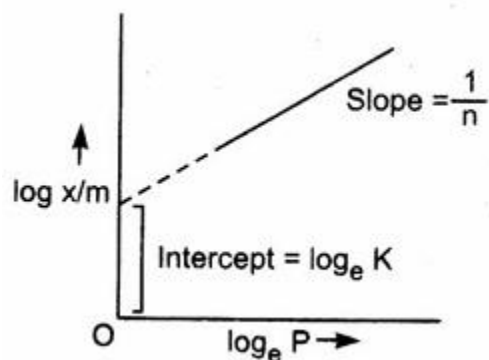
p → pressure

C → concentration of adsorbate

K and n → constants, n > 1 always

Looking at equation 2, as we plot log x/m versus log p on a graph, we get a straight line with slope = 1/n and y-intercept = log k.

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### Applications of adsorption

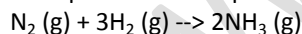
1. **Production of high vacuum**- Remaining traces of air in a vessel already evacuated by vacuum pump can be adsorbed by charcoal to create high vacuum
2. **Control humidity** - Silica and aluminium gels can adsorb moisture and remove humidity
3. **Gas masks**- Gas masks consist of activated charcoal or mixture of adsorbents and are used to breathe in coal mines
4. **Removing coloured substances from solutions**- This is used in chromatographic analysis.
5. **Separation of inert gases**- Different inert gases are adsorbed to different extents on coconut charcoal
6. **Heterogeneous catalysis**- When gaseous reactants are adsorbed on the surface of a solid catalyst, the concentration of the reactants on the surface increases and thus, the rate of reaction also increases( adsorption theory). Eg- Using finely divided Nickel in the hydrogenation of vegetable oils
7. **Adsorption indicators**- Many dyes have become useful due to adsorption. These dyes have been introduced as indicators especially in precipitation titrations. Eg- KBr is easily titrated with  $\text{AgNO}_3$  using eosin as the indicator
8. **Froth floatation process**- When sulphide ore is shaken with pine oil and water, the ore particles are adsorbed on the froth that floats and the gangue particles ( like silica, mud) settle down in the tank. This process is used in the concentration of sulphide ores
9. **Chromatographic analysis**- The selective adsorption of some substances by a solution helps us separate components of a mixture. Example- All the dyes in ink
10. **Curing Diseases**- Some drugs can adsorb the germs on them and hence, kill them saving us from diseases

### Catalysis

Substances which alter the rate of a chemical reaction and themselves remain chemically and quantitatively unchanged after the reaction are called catalysts.

- **Promoters**- Substances which enhance the activity of the catalyst
- **Poisons**- Substances which decrease the activity of the catalyst

Example- In Haber's process for manufacturing ammonia, molybdenum acts as promoter for the catalyst- iron



### Homogenous and Heterogeneous Catalysis

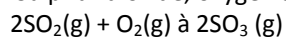
Catalysis can be classified into 2 types.

#### 1. Homogenous catalysis:

The reactants and the catalyst are in the same phase (that is liquid or gas).

Example- In Oxidation of sulphur dioxide,

Sulphur dioxide, oxygen and the catalyst nitrogen oxide are all gases



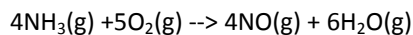
#### 2. Heterogeneous catalysis:

The reactants and the catalyst are in different phases

Example- In Oxidation of ammonia,

Ammonia and oxygen are gases but the catalyst Platinum is solid

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Adsorption theory of Heterogeneous catalysis:

- This theory explains the mechanism of heterogeneous catalysis.
- It is combination of the intermediate compound formation theory and the old adsorption theory. The Intermediate Compound Formation Theory is in the chapter of the Chemical Kinetics
- Old Adsorption theory- The reactants (gases or in solutions) are adsorbed on the surface of the solid catalyst. The increase in concentration of the reactant on the surface also increases the rate of reaction. The heat of adsorption( adsorption is exothermic) also increases the rate of reaction.

## Mechanism of Catalytic Activity

1. Diffusion of reactants towards the surface of the catalyst
2. Adsorption of reactant molecules on the surface of the catalyst
3. Occurrence of a chemical reaction between the reactants and the catalyst which forms an intermediate
4. Desorption of product molecule from the surface because of the lack of its affinity to the catalyst's surface by which the surface is now available for the adsorption of new reactant molecules
5. Diffusion of product molecules away from the surface of the catalyst

Advantages of This Theory:

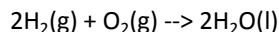
- Only a small quantity of the catalyst is required as it is regenerated again and again
- The catalyst does not take part in the reaction but its mass and composition remain unchanged at the end of the reaction
- If catalytic poisons are present they preferentially get adsorbed onto the surface of the catalyst. This hinders the adsorption of the reactant molecules

Note- This theory does not satisfactorily explain the action of catalytic promoters

## Important Features of Solid Catalysts

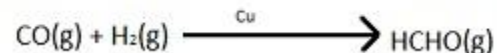
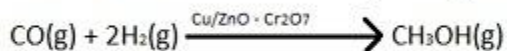
### Activity

- Activity of a catalyst refers to the capacity of the catalyst to increase the speed of the chemical reaction. The activity depends upon the extent of chemisorption.
- The adsorption should be reasonably strong but not so strong that the adsorbed molecules become immobile and there is no place for other reactants to get adsorbed. Example- Combination of  $\text{H}_2$  and  $\text{O}_2$  in the presence of Platinum(catalyst) to form water is an explosive reaction.
- But in the absence of catalyst,  $\text{H}_2$  and  $\text{O}_2$  do not react and can be stored like that for a very long period of time.



### Selectivity

- Selectivity of a catalyst refers to its ability to direct the reaction to form particular products excluding others.
- Example- CO and  $\text{H}_2$  form different products in the presence of different catalysts



Note- Catalysts are very specific and selective in their action. So a substance which acts as a catalyst in one reaction may fail to catalyse another reaction

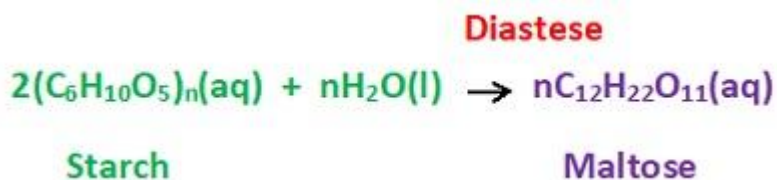
### Shape selective catalysis-Zeolites

- The reactions taking place in zeolites depend on-
- They are good shape selective catalysts due to their honey-comb like structures
- They are three dimensional network of silicates where some silicon atoms are replaced by aluminium atoms forming a Al-O-Si network.
- Zeolites are microporous aluminosilicates.
- The catalytic reaction which depends upon the pore structure of the catalyst and the size of the reactant and product molecules is called shape-selective catalysis



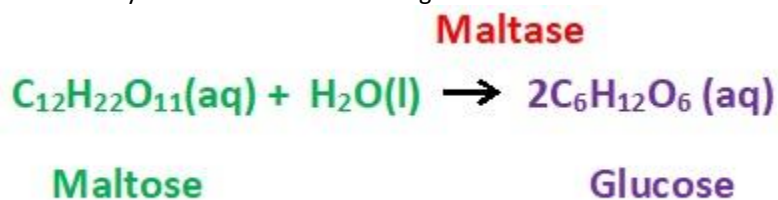
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Diastase enzyme converts starch to maltose



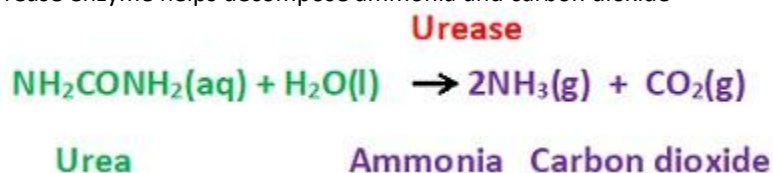
4. Conversion of maltose into glucose

Maltase enzyme converts maltose into glucose



5. Decomposition of Urea into Ammonia and Carbon Dioxide

Urease enzyme helps decompose ammonia and carbon dioxide



6. In stomach and intestine :

In **stomach- Pepsin** enzyme converts **Proteins to Peptides**

In the **intestine- Pancreatic Trypsin** converts **Proteins to Amino acids** by hydrolysis

7. Conversion of milk into curd : The **Lacto bacilli enzyme** present in **curd** helps convert **Milk to Curd**

### Characteristics of Enzyme catalysis

Highly Efficient

- One molecule of an enzyme may transform one million reactant molecules per minute

Highly Specific in Nature

- Catalysts are highly specific

Example- Urease enzyme catalyses the hydrolysis of urea only and not the hydrolysis of any other amide

Highly active at Optimum temperature

- The temperature at which the rate of an enzyme catalysed reaction is maximum is called Optimum temperature. On either side this temperature, enzyme activity decreases

Example- Human body temperature(310K) is suitable for enzyme-catalysed reactions

Highly active at Optimum pH

- The rate of an enzyme-catalysed reaction is maximum at a particular pH called the Optimum pH

Activity Increases in presence of Activators and Co-enzymes-

- The enzymatic activity increases considerably in the presence of certain other substances called co-enzymes.

Example- When a certain non-protein(vitamin) is present along with the enzyme, catalytic activity is enhanced

Influence of inhibitors and Poisons-



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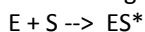
- Like ordinary catalysts, enzymes are also inhibited by the presence of certain substances (inhibitors or poisons).
- These substances interact with the active functional groups on the surface of the enzyme and usually reduce or completely destroy the catalytic activity of the enzymes

Example- Many of the drugs we use is related to their action as enzyme inhibitors in our body

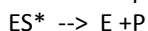
### Mechanism of enzyme catalysis

Enzyme-catalysed reactions usually proceed in 2 steps-

1. Binding of the enzyme to the substrate to form an activated complex

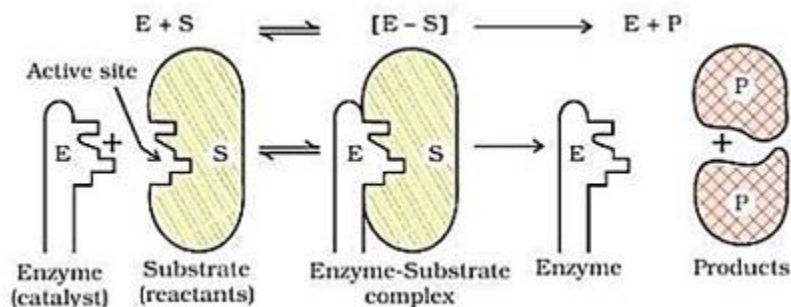


2. Decomposition of activated complex



where E- Enzyme, S- Substrate, ES\*- Activated complex, P- Product

Lock and Key Mechanism- There are many cavities present on the surface of the enzyme. These cavities have a characteristic shape and active groups like  $-NH_2$ ,  $COOH$ ,  $-SH$ ,  $-OH$  etc. These are actually the active centres on the surface of the enzyme. The reactant molecules which have a complementary shape can fit into these cavities a lot like a key fitting into a lock. Due to the active centres (groups) present an activated complex also called enzyme-substrate complex is formed. This complex decomposes to give products and the enzyme.



### Catalysts in the industry-

1. Haber's process to manufacture ammonia

**Finely divided Fe, Mb(promoter)**

Or

**FeO, K<sub>2</sub>O, alumina(nowadays)**

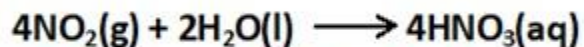


**200 bar, 723-773 K**

2. Ostwald's process to manufacture Nitric acid

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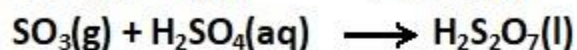
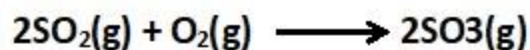
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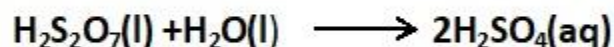
**Catalyst used: Platinised asbestos**

**Temp: 573K**

3. Contact process to manufacture Sulphuric acid



Oleum



**Catalyst: Platinised asbestos or vanadium oxide ( $\text{V}_2\text{O}_5$ )**

**Temp: 673- 723K**

**Colloids:**



Colloidal solutions are mixtures in which the particle size is between 1-1000nm such that they can pass through filter paper but not animal or plant membranes. These particles also don't settle upon standing for sometime.

They involve 2 substances called the dispersed phase and the dispersed medium

The dispersed phase- The substance that is dispersed in another medium to form a colloid. Usually lesser in quantity

Dispersed medium- The substance inside which the dispersed phase is dispersed

### **Classification of colloids**

Colloids are classified in 2 different ways

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Based on the physical state of the dispersed phase and dispersed medium:

S.No	Dispersed Phase	Dispersed Medium	Name of Colloid	Examples
1.	Solid	Solid	Solid sol	Gem stones
2.	Solid	Liquid	Sol	Muddy water, Paint, cell fluids
3.	Solid	Gas	Aerosol	Smoke, dust
4.	Liquid	Solid	Gel	Cheese, butter, jelly
5.	Liquid	Liquid	Emulsion	Milk, Hair cream
6.	Liquid	Gas	Aerosol	Fog, mist, cloud
7.	Gas	Solid	Solid Foam	Pumice Stone
8.	Gas	Liquid	Foam	Froth, soap lather

Based on nature of Interaction Between Dispersed Phase and Dispersed Medium

### Lyophilic Colloids(liquid loving)-

- Some substances which can form colloids directly on mixing them with a suitable liquid (dispersion medium). These colloids are called lyophilic colloids. Examples of these substances are gum, gelatine, starch, rubber.
- They are also called Reversible sols as in these sols (colloids) when the dispersion phase is separated from the dispersion medium (by say evaporation), the sol can be formed again by just mixing the dispersion phase and medium again.
- They are also very stable and cannot be coagulated

### Lyophobic colloids(liquid hating)

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- Some substances cannot form colloid just by directly mixing them with a liquid. Their colloidal sols are prepared by special methods and are called lyophobic colloids. Examples of these substances are metals, metal sulphides.
- They are also called Irreversible colloids as on precipitation, they don't give back the colloid on simply mixing the dispersed phase and the dispersed medium.
- They are unstable and coagulate easily by heating shaking or adding electrolytes. Stabilising agents are used to preserve them

### *Based on the Types of Particles of the Dispersed Phase-*

- **Multimolecular Colloids:** Many particles(atoms or small molecules) of the dispersed phase aggregate together to form species having the size of a colloidal particle( 1-1000nm). These colloids are called multimolecular colloids. Example-gold sol, Sulphur sol
- **Macromolecular colloids:** Substances with large molecules (macromolecules) in suitable solvents form solutions but these macromolecules might be in the colloidal range. These solutions are called macromolecular colloids and resemble true solutions in many ways. Example- Starch, Cellulose, Proteins are natural macromolecules. Nylon, polythene, polystyrene are man-made macromolecules
- **Associated Colloids:** Some substances at high concentrations act as colloids due to the formation of aggregates. But at low concentrations they behave like normal strong electrolytes. These aggregates formed are called micelles. Such colloids are called associated colloids.

**Kraft Temperature-** The formation of micelles takes place only above a particular temperature called Kraft's temperature

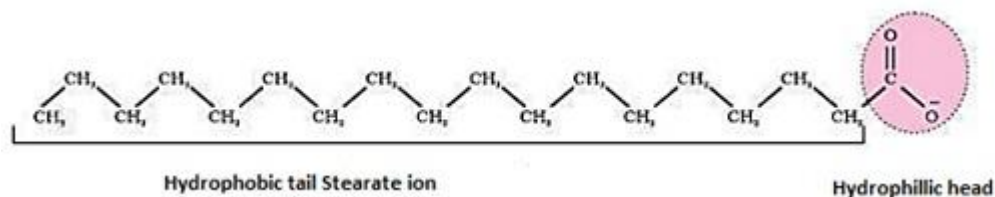
**Critical Micelle Concentration(CMC)** – The concentration above which micelle formation takes place

Example- Soaps, synthetic detergents

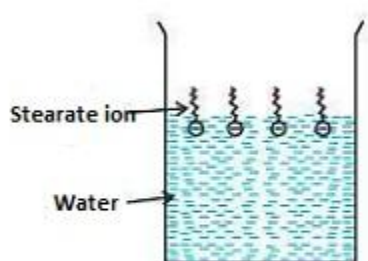
### **Mechanism Of Micelle Formation-**

- Soap is the sodium or potassium salt of fatty acid and may be represented as  $\text{RCOO}^- \text{Na}^+$  (e.g. sodium stearate,  $(\text{CH}_3(\text{CH}_2)_{16}\text{COO}^- \text{Na}^+)$ ). When dissolved into water, it dissociates into  $\text{RCOO}^-$  and  $\text{Na}^+$  ions
- The  $\text{RCOO}^-$  ion consists of two parts – long hydrocarbon chain (also called non – polar tail) which is hydrophobic (water repelling) and a polar group  $\text{COO}^-$  (polar head) which is hydrophilic (water loving)

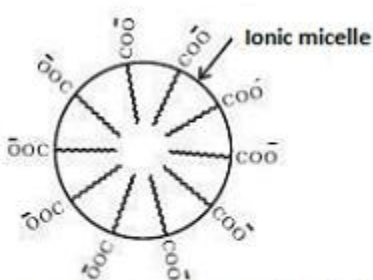
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- At higher concentrations(CMC)  $\text{RCOO}^-$  ions form an aggregate of spherical shape with the hydrocarbon chains pointing towards the centre and the  $\text{COO}^-$  part facing outward on the surface of the sphere. This aggregate is called ionic micelle. It may have as many as 100 ions



Arrangement of stearate ions on the surface of water at low concentrations of soap

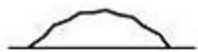


Arrangement of stearate ions inside the bulk of water (ionic micelle) at critical micelle concentrations of soap

### Cleansing Action of Soaps

The cleansing action of soap is due to the formation of micelle by the soap molecules in such a way that the hydrophobic part is in the oil droplet(dirt) and the hydrophilic part projects out. Since the polar groups interact with water surrounded by soap ions is pulled from the surface and pulled into water.

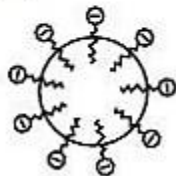
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(i) Grease on cloth



(ii) Stearate ions arranging around the grease droplet

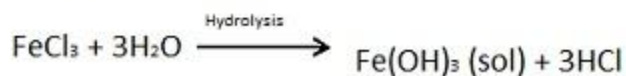
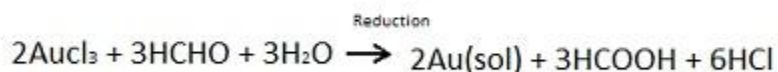
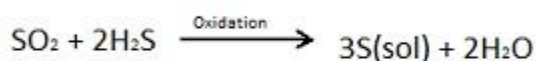
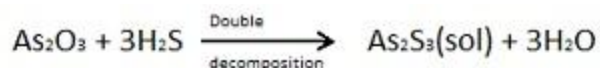


(iii) Grease droplet surrounded by stearate ions (micelle formed)

### Preparation of Colloids

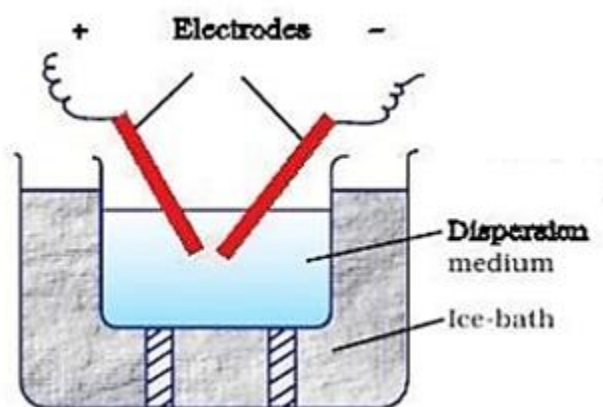
A few ways to prepare colloids are given below

- Chemical method : Colloids can be prepared by chemical reactions leading to formation of molecules by double decomposition, oxidation, reduction or hydrolysis. These molecules then aggregate to form sols



- Electrical Disintegration/ Bredig's arc Method: This is applied to obtain colloidal sols of metals like gold, silver and platinum. An electric arc is stuck between the electrodes of the metal immersed in the dispersion medium. The intense heat produced vapourises the metal, which then condenses to form particles of colloidal size.

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- Peptization- It is the process of converting a precipitate into colloidal sol by shaking it with dispersion medium in the presence of a small amount of electrolyte. The electrolyte used for this is called peptizing agent. During peptization the precipitate absorbs the one of the ions of the electrolyte on its surface. This causes +ve or -ve charge to develop on the precipitate, which ultimately break up into small particles of the size of a colloid.

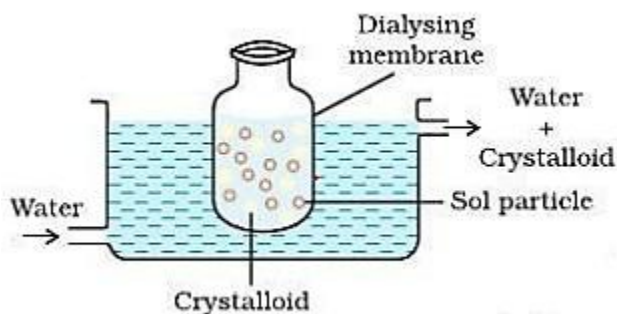
### Purification of Colloids

The process used for reducing the amount of impurities to a required minimum is called purification of colloids.

Some of processes used to do so are-

Dialysis- The process of separating the particles of a colloid by diffusion through a suitable membrane .

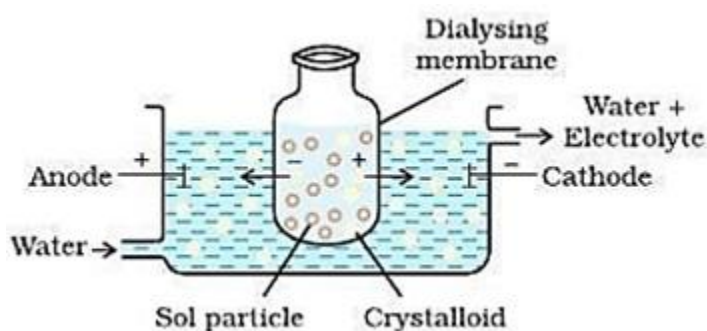
Process – An apparatus called dialyser is used. A bag with a suitable membrane containing the colloid is suspended in a vessel through which fresh water flows continuously. The impurities diffuse through the membrane into the water leaving behind the colloid



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Here Crystalloid-Impurities

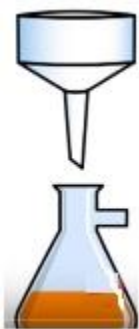
Electro-dialysis- Dialysis is a slow method. It is made faster by this method. In this method, an electric field is applied using metal electrodes. These ions present in the colloidal solution migrate out to the oppositely charged electrodes. It is possible only if the dissolved substance in the impure colloid is an electrolyte.



### Ultrafiltration-

This is the process of separating colloidal particles from the soluble solutes (impurities) using specially prepared filters, which are permeable to all substances except the colloid.

Colloidal particles can usually pass through filter papers as the pores are too large. An ultrafilter paper can be made by soaking the filter paper in a colloidal solution, hardening by formaldehyde and then finally drying it. As this is a slow process, pressure or suction is applied to speed it up. The colloidal particles left on the ultra-filter paper are stirred with fresh dispersion medium (solvent) to form a pure colloid.



### Properties of Colloids

Colligative Properties-



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The particles in colloids are bigger aggregates than those in a true solution. So, the number of particles in a colloid is lesser than a true solution of the same concentration. The values of colligative properties (osmotic pressure, lowering of vapour pressure, depression in freezing point, elevation in boiling point) are of small order as compared to values shown by true solution at same concentration.

**Tyndall effect-**

Tyndall effect is the scattering of the light by the particles present in the colloidal solution when viewed at right angles to the passage of light.

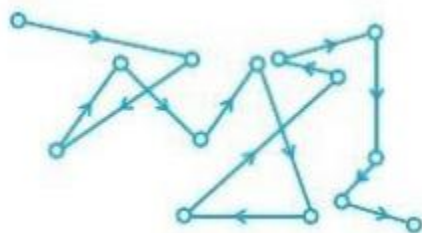
It is observed only when-

- The diameter of the dispersed particles is not much smaller than the wavelength of light used
- The refractive indices of the dispersed phase and dispersed medium have a large difference
- This effect was used to make an ultramicroscope and differentiate between true solution and colloids.

**Colour-**

The colour of the colloidal solution depends on the wavelength of the light scatter by the dispersed particles, size and nature of the dispersed particles and the manner in which it is viewed. Example- Finest gold sol is red in colour and as the size of the particle keeps increasing its colour changes to blue, then purple and finally gold.

**Brownian Movement-**



Brownian movement may be defined as continuous zigzag movement of the colloidal particles in a colloidal solution. It depends on the size of the particles and the viscosity of the colloid. Smaller the size of the particle and lesser its viscosity, faster is its motion. This movement is responsible for the stability of sols

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### Charge on Colloids-

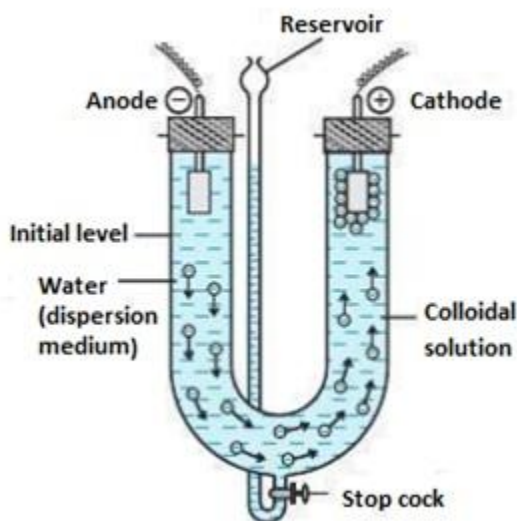
Colloidal particles always have an electric charge. The nature of this charge is the same on all the particles in a given colloidal solution and maybe either +ve or -ve.

#### Positively charged sols-

- Haemoglobin
- Oxides- $\text{TiO}_2$  solution
- Hydrated Metal oxides like  $\text{Al}_2\text{O}_3 \cdot x\text{H}_2\text{O}$  ,  $\text{Fe}_2\text{O}_3 \cdot x\text{H}_2\text{O}$
- Dyes-methylene blue sols

#### Negatively charged sols-

- Metals- Cu, Ag, Au sols
- Metallic sulphides- $\text{As}_2\text{S}_3$ , CdS
- Acid dye stuffs- Eosin
- Sols of starch, gelatin
- **Electrophoresis-**



- 
- The movement of colloidal particles under the influence of an electric field is called electrophoresis. Negatively charged particles move towards the cathode and Positively charged particles moves towards anode.
- When the movement of particles is prevented, it is observed that the dispersion medium starts to move in the electric field. This is called electroosmosis.

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### Coagulation-

It is process of settling of colloidal particles. Also called precipitation of sol

### COAGULATION OF LYOPHOBIC SOLS-

Coagulation of lyophobic sols can be done by the following methods:

- By electrophoresis - The colloidal particles move towards oppositely charged electrodes get discharged and precipitate.
- By mixing two oppositely charged sols - Oppositely charged sols when mixed together in almost equal proportion, neutralise their charges and get partially or completely precipitated.
- By Boiling- When a sol is boiled the adsorbed layer is disturbed due to increased number of collisions with the molecules of the dispersion medium. This reduces the charge on the particles and they ultimately settle down in the form of a precipitate.
- By Persistent dialysis - On prolonged dialysis, traces of the electrolyte present in the sol are removed almost completely. Colloids become unstable and coagulate.
- By addition of electrolyte - When excess of electrolyte is added, colloidal particles precipitate as colloids interact with ions carrying charge opposite to that present on themselves. This causes neutralisation leading to their coagulation.
- Example- A negatively charged ion when added to a positively charged sol causes coagulation. The negatively charged ion is called coagulating ion/flocculative ion as it neutralises the colloid to cause coagulation.

- 
- COAGULATION OF LYOPHILIC SOLS-
- Lyophilic sols are stable because of charge and solvation of colloidal particles. So we remove these two factors to coagulate them. This is done by
- Addition of an electrolyte
- Addition of a suitable solvent

- 
- PROTECTION OF COLLOIDS -
- Lyophilic sols are more stable than lyophobic sols
- Lyophilic colloids have a unique ability to protect lyophobic colloids from electrolytes
- When a lyophilic sol is added to lyophobic sol, the lyophilic particles (colloids) form a layer around the particles of lyophobic sol
- Lyophilic colloids are also called protective colloids

- 
- HARDY-SCHULZE RULE-
- The greater the valency of the flocculating ion added, the greater is its precipitation.
- For negative sols, when positive ions are added
- $Al^{3+} > Ba^{2+} > Na^{+}$  is the order in terms of flocculating power
- For positive sols, when negative ions are added
- $[Fe(CN)_6]^{4-} > PO_4^{3-} > SO_4^{2-} > Cl^{-}$  is the order in terms of flocculating power

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### Emulsions

- Emulsions are colloids where both the dispersion phase and dispersion medium are liquids. These two liquids are immiscible or partially miscible. Generally one of the liquids is water.
- There are two types of emulsions

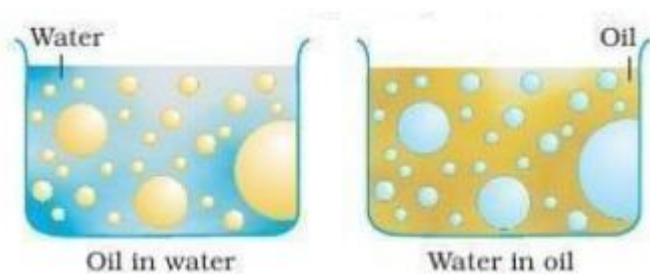
1. Oil dispersed in water (o/w type)- Water acts as dispersion medium

Example –Milk, vanishing cream

2. Water dispersed in oil (w/o type)- Oil acts as dispersion medium

Example- Butter, Cream

- Emulsions like water and oil separate into two layers and make the emulsion unstable. So emulsions are stabilised by stabilising agents.



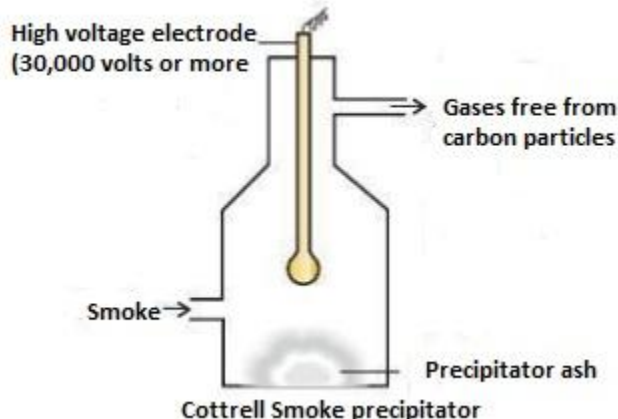
- o/w emulsions are stabilised by proteins, gum, natural and synthetic soaps
- w/o emulsions are stabilised by metal salts of fatty acids, long chain alcohols

### Applications of Colloids

1. Electro precipitation of smoke – The smoke is led through a chamber containing plates having a charged opposite to that carried by smoke particles. The particles on coming in contact with these plates lose their charge and get precipitated. The particles settle down on the floor of the chamber. The precipitator is called Cottrell precipitator.

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2. Purification drinking water – Alum is added to impure water to coagulate the suspended impurities and make water fit for drinking.
3. Medicines – Most of the medicines are colloidal in nature. Colloidal medicines are more effective because they have a larger surface area and are more easily absorbed by the body. Eg- Argyrol is a silver sol used as an eye lotion, milk of magnesia is used to cure stomach disorders
4. Tanning – Animal hides are colloidal in nature. When a hide that has positively charged particles is soaked in tannin/chromium salts, which contains negatively charged particles, mutual coagulation takes place. This results in the hardening of leather. This process is termed as tanning.
5. Cleansing action of soaps- already explained
6. Photographic plates and films – Photographic plates and films are prepared by coating an emulsion of the light sensitive silver bromide in gelatin over glass plates or celluloid films.
7. Rubber industry- Latex is a colloidal solution of rubber particles which are negatively charged. Rubber is obtained by coagulation of latex.
8. Industrial products- Paints inks, synthetic plastics, rubber, cement, graphite lubricants are all colloids