

## CHAPTER - SURFACE CHEMISTRY

### NCERT BOOK-1

#### GUIDELINES-

Dear students,

- Read the chapter from NCERT book.
- Refer to the following notes of this chapter.
- Notes will help you to understand the chapter and complete the assignment that follows.
- Attempt MCQ QUESTIONS of Section A online on the link given below.

<https://forms.gle/NjTBa7kNkJPsS7bj7>

- Watch the complete chapter video shiksha house, follow the following link

<https://youtu.be/2cCiOvm44q4>

<https://youtu.be/-YtNNph4qIM>

- For NCERT textbook and exercise solution click the link below :-  
[https://drive.google.com/file/d/1IOKW-RdlkKGASzom\\_0QiZTL2Hm2oEJ24/view](https://drive.google.com/file/d/1IOKW-RdlkKGASzom_0QiZTL2Hm2oEJ24/view)

### Adsorption

The accumulation of molecular species on the surface rather than in the bulk of the solid or liquid is called adsorption.

### Reversible and irreversible adsorption

The adsorption is **reversible**, if the adsorbent can be easily removed from the surface of the adsorbent by physical methods. It is called **irreversible**

**adsorption**, if the adsorbate cannot be removed from the surface of the adsorbent.

A gas adsorbed on a solid surface can be completely removed in vacuum. It is, therefore, reversible adsorption. Examples of irreversible adsorption are adsorption of oxygen on tungsten adsorbate and adsorption of CO on tungsten surface

### **Adsorbent, Adsorbate , Interface and desorption**

- The substances upon whose surface adsorption occurs, is called **adsorbent**.
- The molecular species or substance which accumulates on the surface is called **adsorbate**.
- The common surface between the two phases where the adsorbed molecules concentrate is called the **interface**.
- The process of removing an adsorbed substance from the surface is called **desorption**.

### **Thermodynamics of adsorption**

Gibbs energy change during adsorption: During adsorption, there is always decrease in residual force ie there is a decrease in surface energy, which appears as heat. Therefore adsorption is an exothermic process i.e.  $\Delta H = -ve$  . Also movement of the particles are restricted in this process as molecules of gas gets adsorbed Therefore  $\Delta S = -ve$  According to Gibbs Helmholtz equation :  $\Delta G = \Delta H - T\Delta S$ , or  $\Delta G = (-\Delta H) - T(-\Delta S)$

for adsorption to occur.  $\Delta G$  must be negative which is possible only when  $\Delta H > T\Delta S$

## Types of Adsorption: physical and chemical adsorption

<b>Physisorption</b>	<b>Chemisorption</b>
<b>1. In this type of adsorption, the adsorbate is attached to the surface of the adsorbent with weak van der Waal's forces of attraction.</b>	<b>In this type adsorption, strong chemical bonds are formed between the adsorbate and the surface of the adsorbent.</b>
<b>2. No new compounds is formed in the process.</b>	<b>New compounds are formed at the surface of the adsorbent.</b>
<b>3 Rate of adsorption depends on ease of liquefaction of gases. Easy liquefiable gases have great extent of adsorption</b>	<b>Rate of adsorption does not depend on liquefaction of gases.</b>
<b>4. It is generally found to be reversible in nature.</b>	<b>It is usually irreversible in nature</b>
<b>5. Enthalpy of adsorption is low as weak van der Wall's forces of attraction are involved. The values lie in the range of 20-40 kJ mol<sup>-1</sup></b>	<b>Enthalpy of adsorption is high as chemical bonds are formed. The values lie in the range of 40-400 kJ mol<sup>-1</sup></b>

6. It is favoured by low temperature conditions.

7. It is an example of multi-layer adsorption.

It is favoured by high temperature conditions.

It is an example of mono-layer adsorption.

### Freundlich Isotherm:

$x$  = Mass of the gas adsorbed

$m$  = Mass of adsorbent

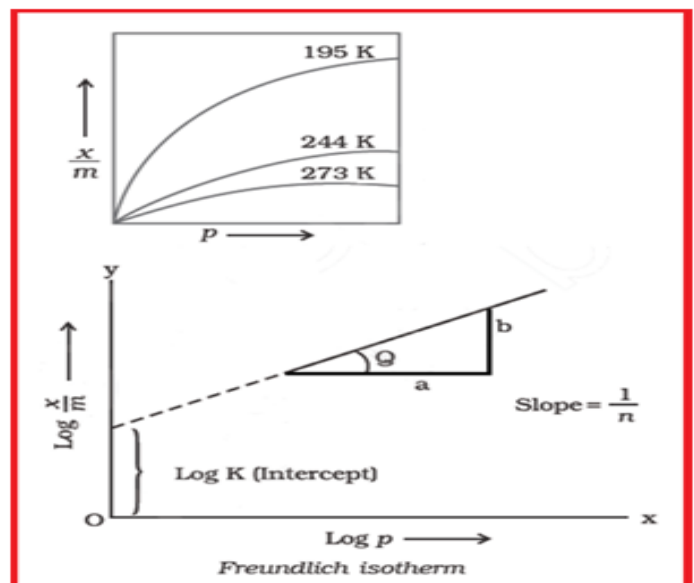
$p$  = Pressure

$K$  and  $n$  = constants

$$x/m = k \cdot p^{(1/n)} \quad [n > 1]$$

or

$$\log x/m = \log k + 1/n \log p$$



### Factors Affecting Adsorption:

- **Temperature:** An increase of temperature leads to a decrease in amount adsorbed and vice – versa.
- **Pressure or concentration:** It has been found that in most cases, the adsorption is reversible and an increased pressure of a gases vapour or an increase in concentration of a solute causes increased adsorption.
- **Nature of Adsorbate and Adsorbent:** The amount of the gas adsorbed depends upon the nature of adsorbent and the gas (adsorbate), which is to be adsorbed. It has been found that easily liquefiable gases such as  $\text{NH}_3$ ,  $\text{HCl}$ ,  $\text{Cl}_2$ ,  $\text{SO}_2$ ,  $\text{CO}_2$  etc. are more readily adsorbed than so the called permanent gases such as  $\text{O}_2$ ,  $\text{N}_2$ ,  $\text{H}_2$  etc. This is because that molecules of the former type of gases have greater Vander waal's or molecular force of attraction.

Gas	H <sub>2</sub>	N <sub>2</sub>	CO	CH <sub>4</sub>	CO <sub>2</sub>	HCl	NH <sub>3</sub>	SO <sub>2</sub>
Critical temp. (K)	33	126	134	190	304	324	406	430

**Adsorption from solutions** : In case of adsorption from *solution* phase.

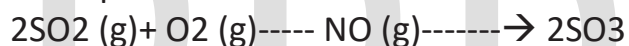
Extent of adsorption (  $x/m$  )  $\propto 1/T$ .

Extent of adsorption (  $x/m$  )  $\propto$  surface area of the adsorption.

Extent of adsorption (  $x/m$  )  $\propto$  concentration of the solute.

The extent of adsorption depends on the nature of adsorbent and the adsorbate unchanged after the reaction and the phenomenon is called catalysis.

**HOMOGENEOUS CATALYSIS**- When the reactants and the catalysts are in the same phase



**HETEROGENEOUS CATALYSIS**- The catalytic process in which the reactants and the catalysts are in different phases.

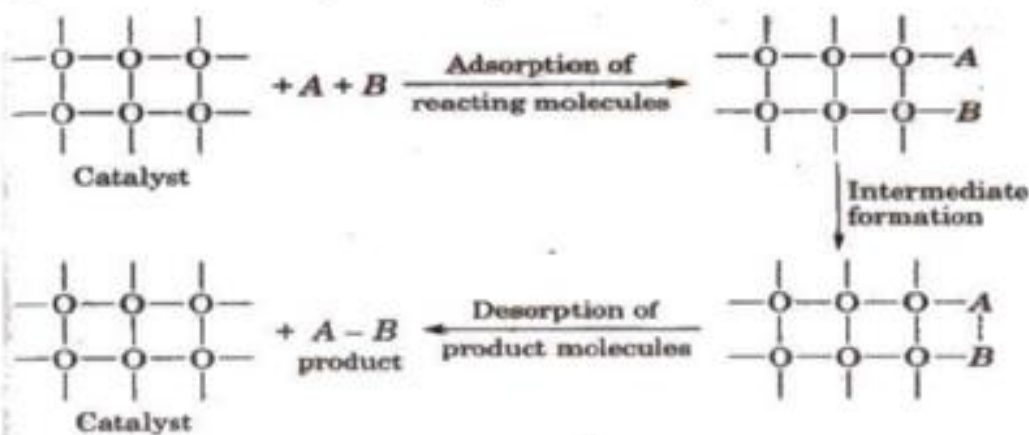


**AUTO CATALYSIS** – when one of the products increases the rate of reaction by acting as a catalysts

## Adsorption Theory of Heterogeneous Catalysis

The mechanism involves five steps:

- (i) Diffusion of reactants to the surface of the catalyst
- (ii) Adsorption of reactant molecules on the surface of the catalyst.
- (iii) Occurrence of chemical reaction on the catalyst's surface through formation of an intermediate.
- (iv) Desorption of reaction products from the catalyst surface.
- (v) Diffusion of reaction products away from the catalyst's surface

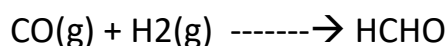
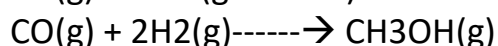
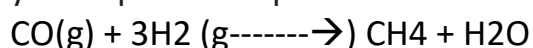


## FEATURES OF SOLID CATALYSTS

**1. ACTIVITY** –The activity of a catalysts depends upon the strength of chemisorption to a large extent. The reactants must get adsorbed reasonably strongly on to the catalyst to become active.



**2. SELECTIVITY** The selectivity of a catalyst is its ability to direct a reaction to yield a particular product.



**ZEOLITES** : are shape selective catalysts because of their honeycomb like structures. Chemically **microporous aluminosilicates**.

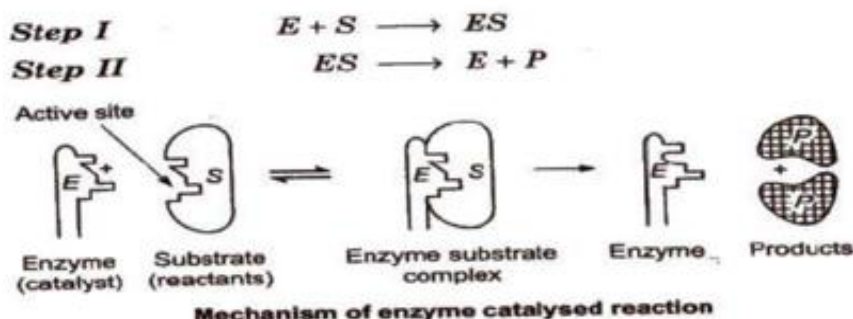
The reaction taking place in zeolites depend upon ---The size and shape of reactant and product molecules and pores and cavities of the zeolites. Zeolites widely used as catalysts in petrochemical industries for cracking of hydrocarbons zeolite catalysts used in petroleum industries. **ZSM-5**, converts alcohols directly into gasoline(petrol)

## Enzyme Catalysis

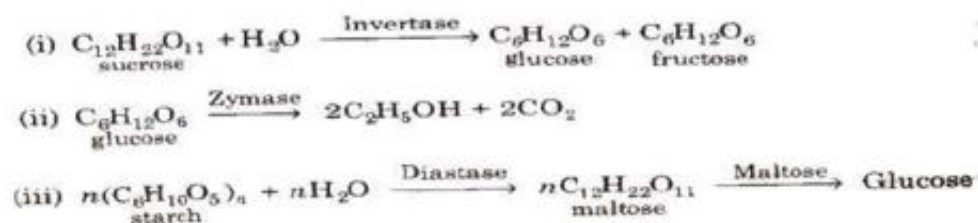
Enzymes are complex nitrogenous organic compounds which are Produced by living plants and animals. They are actually protein molecules of high molecular mass and form colloidal solutions in water.

They are also known as biochemical catalysis.

### Mechanism of Enzyme Catalysis



Some examples of enzyme catalysed reactions are:



## Characteristics of Enzyme Catalysis

- **High efficiency** One molecule of an enzyme may transform one million molecule of reactant per minute.
- **Highly specific nature** Each enzyme catalyst cannot catalyse more than one reaction.
- **Optimum temperature** Enzyme catalyst gives higher yield at optimum temperature i.e., at 298-310 K. Human body temperature, i.e., at being 310 K is suited for enzyme catalysed reactions.
- **Optimum pH** The rate of an enzyme catalysed reaction is maximum at optimum pH range 5 to 7.
- **Activators** Activators like ions such as  $Na^+$ ,  $Ca^{2+}$ ,  $Mn^{2+}$  help in the activation of enzymes which cannot act on their own strength.
- **Co-enzyme** Co-enzymes are the substance having nature similar to the enzyme and their presence increases the enzyme activity. Mostly vitamins act as co-enzymes.
- **Effect of Inhibitors** Inhibitors slow down the rate of enzymatic reaction. The use of many drugs is based on enzyme inhibition action of those drugs in the body

## Colloids

### Dispersed Phase:

The phase which is dispersed or scattered through the dispersion medium is called Dispersed phase or discontinuous phase.

### **Dispersion Medium:**

The phase in which the scattering is done is called the dispersion medium or continuous medium.

### **Lyophobic and Lyophilic Colloids:**

**Lyophobic (solvent hating colloids) :** These colloids cannot be prepared by simply mixing dispersed phase with dispersion medium, they need stabilizing agent to preserve them , irreversible. Ex: colloidal solutions of gold , silver,  $\text{Fe}(\text{OH})_3$ ,  $\text{As}_2\text{S}_3$ , etc.

**Lyophilic colloids ( solvent loving):** Directly formed by mixing DP with a suitable dispersion medium), self-stabilizing , reversible sol, sol of starch, gum, gelatin, rubber.

### **Classification based on type of particles of the dispersed phase**

- **Multimolecular colloids :** Consists of aggregates of a large number of atoms or molecules of a substance whose diameter is less than 1 nm. Ex Au sol
- **Macromolecular colloids:** In these colloids the molecules have sizes and dimensions in the colloidal range Ex: proteins, starch, cellulose.
- **Associated colloids:** At low concentrations, behave as normal, strong electrolytes and at higher concentrations exhibit colloidal state properties due to the formation of aggregated particles (micelles). e.g Soaps and detergents
- The temperature only above which the formation of micelles takes place is called **Kraft temperature (TK) .**
- **Critical Micelle Concentration:** The concentration above which micelle formation takes place

### **Methods of preparation of colloids**

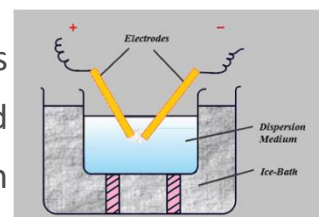
#### **Chemical Methods:**





### Bredig's method:

An electric arc is struck between two metallic electrodes immersed in dispersion medium. The arc produced vapourises the metal which on further condensation produces particles of colloidal size.



- **Peptization:**

Process of converting a precipitate into colloidal sol by shaking it with dispersion medium in the presence of a small amount of electrolyte. During this method the precipitate adsorbs one of the ions of the electrolyte on its surface.

### Purification of Colloidal solutions

- **Dialysis** : Purification of colloidal solutions from the impurities(electrolytes) by diffusion through a porous membrane such as parchment paper, cellophane sheet, etc.
- **Electro dialysis** : When dialysis process is accelerated by the application of a potential difference across the membrane, So ions migrate faster than the colloids .**this is applicable only if the dissolved substance in the impure colloidal solution is an electrolyte.**
- **Ultra filtration** : purification of colloidal solution using special filter paper called ultra filters ( the pores of filter paper are reduced by impregnating with colloidal solution to stop the flow of colloidal particles. followed by hardening in formaldehyde) **Colloidion**: it is 4% nitrocellulose solution in a mixture of alcohol and ether.

## Properties of colloids:

**Optical properties: Tyndall effect :** Due to scattering of light by colloidal particles by which the beam of light becomes visible.

**Brownian movement:** Zig zag movement of colloidal particles due to collision between particles of DP & DM, responsible for stability of colloids. **The Brownian movement has a stirring effect which does not permit the particles to settle down and thus is responsible for stability of the sol.**

**Electrophoresis :** Movement of colloidal particles under influence of electric field .

**Electroosmosis:** molecules of dispersion medium allowed to move under influence of electric field

**Coagulation or flocculation:** Process of settling of colloidal particles

## Hardy Schulze Rule:

- Ion carrying charge opposite to the colloidal particle has capacity to coagulate the colloid.
- Greater the valency of ion, greater will be the coagulating power.

.For negatively charged sol, the coagulating power of electrolytes are:

$AlCl_3 > BaCl_2 > NaCl$  or  $Al^{3+} > Ba^{2+} > Na^+$

For positively charged, then the coagulating power of electrolytes follow the following order:

$K_4 [Fe(CN)_6] > PO_4^{3-} > SO_4^{2-} > Cl^-$

**The minimum concentration of the electrolyte required to cause precipitation of the sol in two hours is called coagulating value. The smaller the quantity needed the higher will be the coagulating power.**

**Emulsion:** liquid – liquid colloidal system..e.g. milk, soaps, vanishing cream, etc

## Emulsions:

- **Emulsion of oil in water:** Those emulsions in which the dispersed phase is oil and water is the dispersion medium. These emulsion are generally represented as O in W emulsions. Examples are milk, vanishing cream etc.

- **Emulsions of water in oil:** Those emulsion in which the dispersed phase is water while oil is the dispersion medium. These emulsion are generally represented as W in O emulsions. Examples are butter, ice cream etc.

### QUESTION BANK

#### SECTION A

**NOTE** ---- 10-MCQ ONLINE BY FOLLOWING THE LINK GIVEN IN GUIDELINES

#### Fill in the blanks

Q11 At high concentration of soap in water , soap behaves as \_\_\_\_\_.

Q12 The lyophobic colloid is protected by \_\_\_\_\_

Q13 Starch is an example of \_\_\_\_\_ colloids.

Q14 Collodion is a 4% solution of \_\_\_\_\_  
in a alcohol or ether.

Q15 At equilibrium position in the process of adsorption  $\Delta H$  is \_\_\_\_\_

#### Assertion Reason Type Questions

The question given below consist of an assertion and reason.

Use the following key to choose appropriate answer

- (a) Both assertion and reason are true and reason is the correct explanation of assertion.
- (b) Both assertion and reason are true but reason is not the correct explanation of assertion.
- (c) Assertion is true but reason is false.
- (d) Both assertion and reason are false.

Q16 Assertion : A colloidal sol scatters light but a true solution does not.

Reason : The particles in a colloidal sol move slowly than in a true solution.

Q17 Assertion : Activation energy for both the forward and backward reactions is lowered to the same extent by a catalyst.

Reason : A reaction cannot become fast by itself unless a catalyst is added.

Q18 Assertion : Hydrolysis of ester is an example of auto - catalytic reaction.

Reason : A catalyst speeds up the process without participating in the mechanism.

Q19 Assertion : Hydrated ferric oxide can be easily coagulated by sodium phosphate in comparison to KCl.

Reason : Phosphate ions has higher negative charge than chloride ions. Hence, they are more effective for coagulation.

Q20 Assertion : During preparation of ice - cream, gelatin is added in it.

Reason : Ice -creams are emulsions which get stabilised by gelatin as it acts as an emulsifying agent.

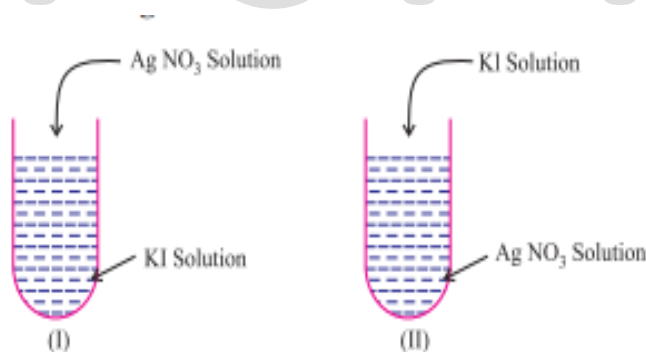
### TWO MARKS QUESTIONS

Q21 What is adsorption isotherm? Describe Freundlich adsorption isotherm at intermediate pressure.

Q22 Define :- a zeta potential  
b)CMC.

Q23 Out of  $\text{BaCl}_2$  and KCl which is more effective in causing coagulation of negatively charged sol .give reason.

Q24 What will be the charge on colloidal solutions in the following cases ?



Give reasons for the origin of charge

### THREE MARKS QUESTIONS

Q25 What happens : (a) By persistent dialysis of a sol.

(b) When river water meets the sea water.

(c) When alum is applied on cuts during bleeding.

Q26. What are the differences between multimolecular, macromolecular and associated colloids?

Q27 What happens when—

- a) A freshly prepared precipitate of  $\text{Fe}(\text{OH})_3$  is shaken with small amount of  $\text{FeCl}_3$  solution.
- b) electric current is passed through colloidal sol.
- c) an emulsion is centrifuged.

Q28 Define

- a) Micelles
- b) Peptization
- c) desorption.

Q 29 Write short notes on the following :

- (a) Tyndall Effect
- (b) Brownian Movement
- (c) Hardy Schulze Rule

Q30 How are the following colloids different from each other in respect of dispersion medium and dispersed medium ?

Give one example of each type. (a) An aerosol (b) A hydrosol (c) An emulsion