

Chapter-5 SURFACE CHEMISTRY

The branch of the Chemistry which deals with the study of surface phenomena is called surface Chemistry.

POINTS TO BE REMEMBERED: ---

1. **Adsorption**: - The accumulation of molecules species at the surface rather in the bulk of a solid or liquid is termed adsorption.

2. **Desorption**: - Removal of adsorbate from the surface of adsorbent is known as Desorption.

3. **Sorption**: - When adsorption and absorption both takes place simultaneously.

4. **Type of adsorption**: - On the basis of interaction between adsorption and absorption, adsorbate are of two types:

(i) **Physical adsorption/physisorption**: - When weak vander waal interaction involve between adsorbate and adsorbent.

(ii) **Chemical adsorption/chemisorption**: - When chemical bonds form between adsorbate and adsorbent.

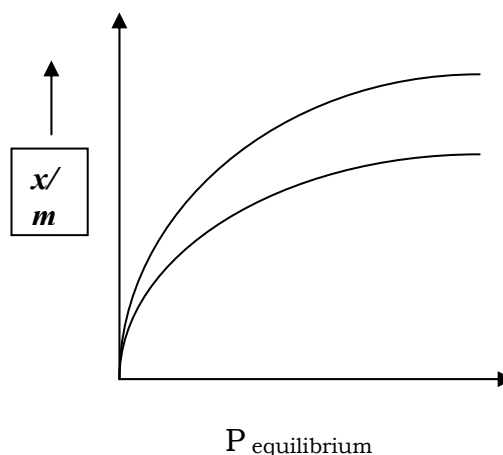
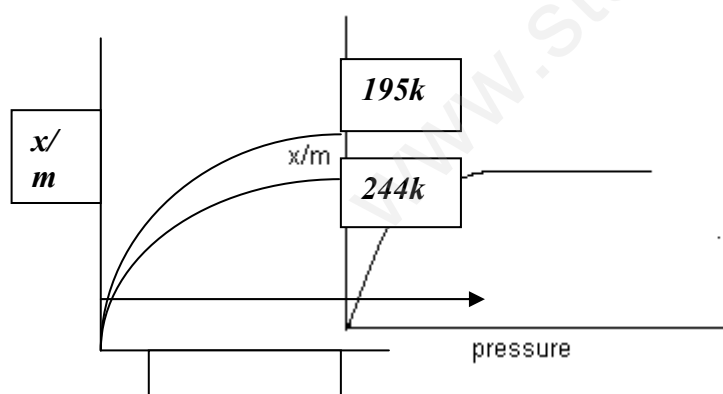
5. **Adsorption isotherm**: - The variation in the amount of gas adsorbed by the adsorbent with pressure at constant temperature can be expressed by means of a curve termed as adsorption isotherm.

6. **Application of adsorption**: -

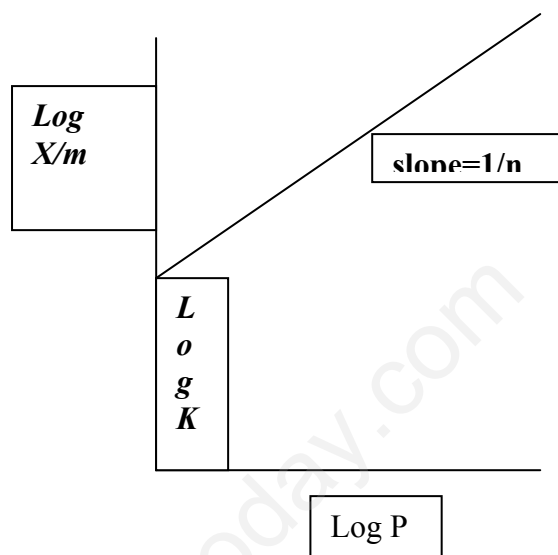
(a) Removal of colouring matter from solution using animal charcoal.

(b) Chromatographic analysis is based on adsorption.

7. **Freundlich adsorption isotherm**: - It is a graph which shows relationship between the quantity of gas adsorbed by unit mass of solid adsorbent and pressure at a particular temperature.



$$x/m = kp^{1/n}$$



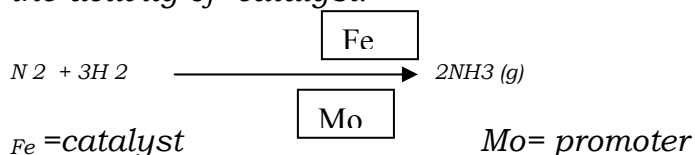
8 .Factors affecting adsorption:-

- (i) **Surface area:** - Adsorption increases with increases of surface area of adsorbent.
- (ii) **Nature of adsorbate:** - Easily liquefiable gases are readily adsorbed.
- (iii) **Temperature:** - Low temperature is favorable for physical adsorption and High temperature for chemisorption.
- (iv) **Pressure:** - Pressure increases, adsorption increases.

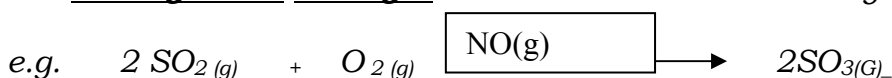
9. CATALYSIS:- Substances which alter the rate of chemical reaction and themselves remain chemically and quantitatively unchanged after the reaction are known as catalyst and the phenomenon is known as catalysis.

10. PROMOTERS AND POISONS

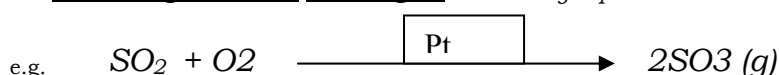
Promoters are substance that enhance the activity of catalyst while poisons decrease the activity of catalyst.



11. Homogenous catalyst – when reactants and catalyst are in same phase.



12. Heterogeneous catalyst – the catalytic process in which the reactants and catalyst are in different phase.



13. Adsorption theory of Heterogeneous catalysis – It explains the mechanism of heterogeneous catalyst.

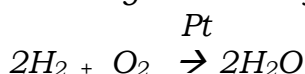
The mechanism involves 5 steps:-

- a. Diffusion of reactants to the surface of catalyst.

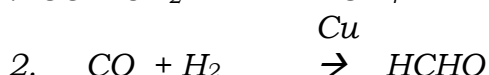
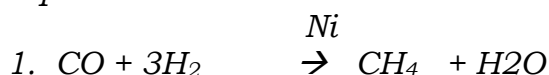
- b. Adsorption of reactant molecules on the surface of catalyst.
- c. Chemical reaction on the catalyst surface through formation of an intermediate.
- d. Desorption of reaction product from the catalyst surface.
- e. Diffusion of reaction product away from the catalyst surface.

14. IMPORTANT FEATURES OF SOLID CATALYST

Activity - The activity of a catalyst depend on the strength of chemisorption. Catalytic activity increases from group 5 to group 11 elements of the periodic table.



Selectivity - The selectivity of a catalyst is its ability to direct a reaction to yield a particular product.



15. SHAPE SELECTIVE CATALYSIS

The catalytic reaction that depends upon the pure substance of the catalyst and the size of reactant and product molecules is called shape selective catalysis.

e.g. Zeolites are good shape selective catalyst.

16. ENZYME CATALYSIS

Enzymes are protein molecules of high molecular mass which catalyse the biochemical reaction.

e.g. Inversion of cane sugar by invertase enzyme.

17. Characteristic of enzyme catalysis -

- a. **Enzymes are specific to substrate.**
- b. **Enzymes are highly active under optimum temperature.**
- c. **Enzymes are specific to pH. e.g. Pepsin act in acidic medium**
- d. **Enzymes are inhibited by the presence of certain substance.**

Mechanism of enzyme catalysis -

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



- 2. Decomposition of activated complex to form product.



18. Colloid-a colloid is a heterogeneous system in which one substance is dispersed(dispersed phase)in another substance called dispersion medium and size of dispersed phase is from 1nm-1000 nm.

19. TYPES OF COLLOIDS

(1) On the basis of nature of interaction between dispersed phase and dispersion medium.

(a) Lyophobic colloid-solvent , hating colloid, these colloids can not be prepared by simply mixing of dispersed phase into dispersion medium.

e.g. metallic sols.

(b) Lyophobic colloid-solvent loving these colloids can be prepared by simply mixing of dispersion phase into dispersion medium.

e.g. Starch sol.

(2) On the basis of types of particles of the dispersed phase

(a) Multimolecular colloid-on dissolution, a large number of atoms or smaller molecules of a substance aggregate together to form species having size in colloidal range. The species thus formed are called Multimolecular colloids.

e.g. Sulphur sol.

(b) Macromolecular colloids -macromolecules are suitable solvent from solution in which size of the particles are in range of colloidal range.

e.g. starch sol.

(c) Associated colloids (micelles)-some substances in low concentration behaves as normal strong electrolyte but at higher concentration exhibit colloidal behavior due to formation of aggregates. The aggregated particles are called micelles and also known as associated colloids.

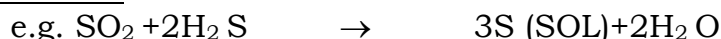
(3) **Kraft temperature**- Temp. above which formation of micelles takes places.

(4) **Critical micelle concentration (cmc)** - concentration above which micelle formation takes place is known as cmc.

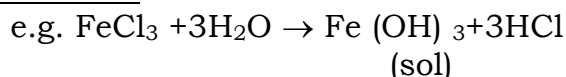
(5) PREPERATION OF COLLOIDS

(a) **Chemical methods**- By double decomposition, oxidation reaction or hydrolysis

OXIDATION



HYDROLYSIS



(b) **Bredig's arc method**- For preparation of metallic sol. It involves dispersion as well as condensation.

(c) **Peptization**- Process of converting a precipitate into colloidal sol. By shaking it with dispersion medium in the presence of a small amount of electrolyte.

(6) PURIFICATION OF COLLOIDAL SOLUTION :-

(a) **Dialysis**-it is a process of removing a dissolved substance from a colloidal solution by membrane.

(b) **Electro dialysis**-when dialysis is carried out with an electric field applied around the membrane.

(c) **Ultra filtration**- Use of special filters which are permeable to all ionic substances except colloidal particles.

(7) PROPERTIES OF COLLOIDAL SOLUTION:-

(1) They show colligative properties

(2) Brownian movement-zig-zag motion of colloidal particles

(3) Tyndall effect-scattering of light by colloidal particles by which path of beam becomes clearly visible. This effect is known as Tyndall effect.

1. Charge on colloidal particles – Colloidal particles which carry on electric charge and nature of charge is same on all particles.

2. Electrophoresis - Movement of Colloidal particles towards opposite electrode in presence of external electric field.

3. Coagulation – The process of setting of colloidal particles is called coagulation of the sol.

4. Hardy Schulze Law – Coagulating value of a coagulating ion is directly proportional to the charge on the ion.

Eg: $\text{Na}^+ < \text{Ca}^{++} < \text{Al}^{3+}$ for negatively charged sol.

$\text{Cl}^- < \text{CO}_3^{2-} < \text{PO}_4^{3-} < [\text{Fe (CN)}_6]^{4-}$ for positive sol.

5. Emulsion – Liquid – liquid colloidal system is known as Emulsion.

There are two types of Emulsion.

a) O/W type - Oil dispersed in water. Eg: milk, vanishing cream.

b) W/O type – Water dispersed in oil. Eg: Butter & Cream.

6. Emulsifying Agent – The substance which stabilizes emulsion.

VERY SHORT ANSWER TYPE QUESTION

(1 marks)

1. What are the physical states of dispersed phase and dispersion medium of froth?

Ans - Dispersed phase is gas, dispersion medium is liquid.

2. What is the cause of Brownian movement among colloidal particles?

Ans - Due to collision between particles.

3. Arrange the solutions: True solution, colloidal solution, suspension in decreasing order of their particles size?

Ans – Suspension > colloidal > true solution.

4. Give an example of micelles system?

Ans – Sodium stearate ($C_{17}H_{35}COO^-Na^+$)

5. Why is it necessary to remove CO when ammonia is obtained by Haber's process?

Ans- CO acts as poison catalyst for Haber's process therefore it will lower the activity of solution therefore it is necessary to remove when NH_3 obtained by Haber's process.

6. How is adsorption of a gas related to its critical temperature?

Ans- Higher the critical temperature of the gas. Greater is the ease of liquefaction.

i.e. greater Vander walls forces of attraction and hence large adsorption will occur.

7. What is meant by Shape Selective Catalyst?

Ans – On the Shape Selective Catalyst, the rate depends upon pore size of the catalyst and the shape & size of the reactant and products molecules.

8. Of the physisorption & chemisorptions, which type of adsorption has higher enthalpy of adsorption?

Ans - chemisorptions.

9. Write down the Example of Positive Sol?

Ans – Ferric hydro-oxide sol.

10. Write down the Example of Negative Sol?

Ans – Arsenic sulphide.

SHORT ANSWER TYPE QUESTION

(2 marks)

1. Differentiate between physical & chemical adsorption?

Ans –

Physical adsorption	Chemical adsorption
a) Forces between adsorbate & adsorbent are weak Vander waal forces.	a) Forces between adsorbate & adsorbent are strong chemical forces.
b) Low heat of Adsorption.	b) High heat of Adsorption.

2. Differentiate between Lyophobic & Lyophilic colloids?

3. Ans –

Lyophilic colloids	Lyophobic colloids
a) These are easily formed by direct mixing.	a) These are easily formed by Special method.
b) Particles of colloids are not easily visible even under ultra microscope.	b) Particles of colloids are easily visible under ultra microscope.
c) These are very stable.	c) These are unstable.

4. Differentiate between multi molecular, macromolecular and associated colloids?

5. Ans:-

Multi molecular colloids	Macromolecular colloids	Associated colloids
a) They consist of	a) They consist of	a) Behave as colloidal

aggregates of atoms or molecules which generally have diameter less than 1nm. b) They are usually lyophobic	large molecules. b) They are hydrophilic.	size particles at higher conc. b) They have both lyophobic character & Lyophilic
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6. What is difference between Sol. & Gel?

Ans – Both are colloidal solutions. Sol has solid as ‘dispersed phase & liquid as dispersion medium’. While ‘Gel’ has liquid as dispersed phase and solid as dispersion medium.

7. Action of Soap is due to Emulsification & Micelle formation? Comment.

Ans – soaps are sodium & potassium salts of higher fatty acids.

Eg: $C_{17}H_{35}COONa$ oil & Grease in dirt adhere firmly to clothing and is undisturbed by washing in tap water. Soap acts as an Emulsifying agent and brings the Greasy dirt into colloidal dispersion the hydrocarbon chain of soap molecule is soluble in oil or grease. It dissolves in grease and encapsulates. It to form micelle. The anionic ends of chain protrude from droplets and interact with water molecules, preventing coalescence of droplets.

SHORT ANSWER TYPE QUESTION

(3 marks)

8. Discuss the effect of pressure & temperature on the adsorption of gases on solids?

Ans – Effect of pressure on adsorption: - At constant temp the extent of adsorption of gas (x/m) in the solid increases with pressure. A graph between x/m and the pressure P of a gas at constant temp is called adsorption isotherm.

Freundlich adsorption isotherm -

i) At lower range of pressure, (x/m) is directly proportional to the applied pressure.

$$X/m \propto p^1$$

ii) At high pressure range, the extent of adsorption of a gas (x/m) is independent of the applied pressure i.e.

$$X/m \propto p^0$$

iii) At intermediate pressure range, the value of (x/m) is proportional to the fractional power of pressure i.e.

$$X/m \propto p^{1/n}$$

Where $1/n$ is fraction. Its value may be between 0 and 1

$$X/m = kp^{1/n}$$

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

Effect of temp on Adsorption – Adsorption is generally temp. depended. Mostly adsorption processes are exothermic and hence, adsorption decreases with increasing temp. However for an endothermic adsorption process adsorption increases with increase in Temperature.

1. Explain What is observe when

- An electrolyte, NaCl is added to hydrate ferric oxide sol.
- Electric current is passed through a colloidal sol.

iii) When a beam of light is passed through a colloidal sol.

Ans –(i) The positively charged colloidal particles of $\text{Fe}(\text{OH})_3$ get coagulated by the positively charged Cl^- ions provided by NaCl .

(ii) On passing direct current, colloidal particles move towards the positively charged electrode where they lose their charge and get coagulated.

(iii) Scattering of light by the colloidal particles takes place and the path of light becomes visible (Tyndall effect).

2. Describes some features of catalysis by Zeolites?

Ans – Features of catalysis by Zeolites:-

I) Zeolites are hydrated alumino silicates which have a three dimensional network structure containing water molecules in their pores.

II) To use them as catalysts, they heated so that water of hydration present in the pores is lost and the pores become vacant.

III) The size of pores varies from 260 to 740 pm. Thus, only those molecules can be adsorbed in these pores and catalyzed whose size is small enough to enter these pores. Hence, they act as molecular sieves or shape selective catalysts.

An important catalyst used in petroleum industries is zsm-5. It converts alcohols into petrol by first dehydrating them to form a mixture of hydrocarbons.

Alcohols $\xrightarrow[\text{Dehydration}]{\text{ZSM-5}}$ Hydrocarbons

3. Comment on the statement that “colloid is not a substance but state of a substance”?

Ans – The given statement is true. This is because the statement may exist as a colloid under certain conditions and as a crystalloid under certain other conditions. e.g: NaCl in water behaves as a crystalloid while in benzene, behaves as a colloid (called associated colloid). It is the size of the particles which matters i.e. the state in which the substance exist. If the size of the particles lies in the range 1nm to 1000nm it is in the colloid state.

4. Write short notes on followings:-

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

Ans- (a) Tyndall effect-scattering of light by colloidal particles by which path of beam becomes clearly visible. this effect is known as tyndall effect

(b) Brownian movement-zig-zag motion of colloidal particles.

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