

SURFACE CHEMISTRY

by Apmi Kaksha

Class XII Board Exams

- Verified by CBSE
Science Topper's

- All PYQ's
Integrated

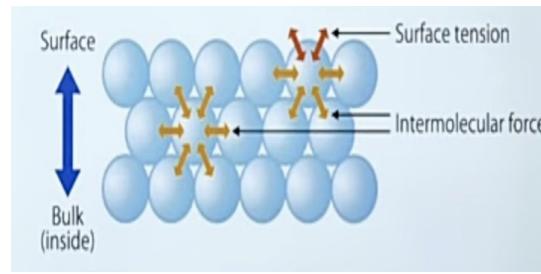
- **BEST NOTES**
for Class XII
Board
Exams



Raman Dhattarwal

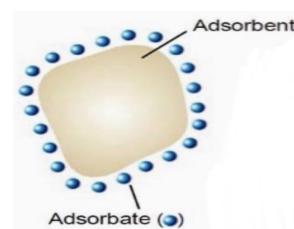
Surface Chemistry

- Surface chemistry deals with phenomena that occur at the surface or interface.
- The surface or interface is represented by separating the bulk phases by a hyphen or slash. For example -:
 - i) Interface between a solid and gas → Solid-gas or $\frac{\text{solid}}{\text{gas}}$
 - ii) Interface between liquid and liquid → Liquid-liquid
 - iii) But there is no interface between two gases, due to complete miscibility.
- Molecules on surface experiences unbalanced attractive force resulting in a net inward pull. This produces surface tension.
- Molecules in bulk phases experiences balanced forces from all the directions and are in state of equilibrium.



Adsorption -: The accumulation of molecular species at the surface rather than in bulk of a solid or liquid is termed adsorption. [Delhi 2015C, 2014C | CBSE 2013] 1M

Adsorbate -: The molecular species or substance which concentrate or accumulates at the surface is termed adsorbate.



Adsorbent -: The material on the surface of which the adsorption takes place is called adsorbent.

Apni Kaksha :-

Example → silica gel, charcoal, colloids.

Adsorption vs Absorption

[Delhi 2016 | CBSE 2010C] 1M

Absorption

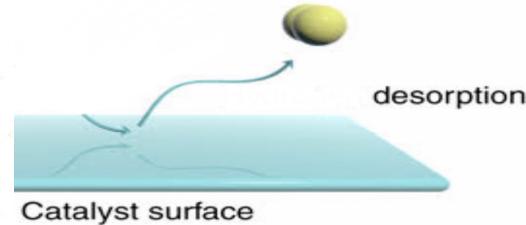
i) The substance is uniformly distributed throughout the bulk of solid.

i) The substance is concentrated only at the surface and does not penetrate through surface to the bulk of adsorbent.



Desorption -: The process of removing an adsorbed substance from a surface. [Reverse of adsorption]

[Delhi 2011] 1M



Sorption :- When adsorption and absorption take place simultaneously. [Delhi 2014 Q1] 1M

Thermodynamics of adsorption :- [Why is adsorption always exothermic?]

- During adsorption there is always a decrease in residual forces of surface, there is a decrease in surface energy, which appears as heat. That's why adsorption is an exothermic process. [$\Delta H = \text{Ove}$] 1M [Delhi 2014 / CBSE 2010]
- After adsorption randomness of the system decreases. So for adsorption $\Delta S = \text{Ove}$.
- For adsorption, thermodynamic requirement is that at constant T and P, ΔH must be negative. [$\Delta H = \text{Ove}$]

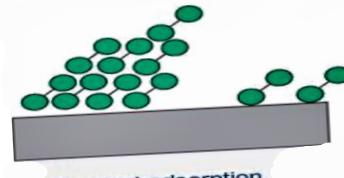
$$\Delta G = \Delta H - T \Delta S$$

Ove value ← ↓ More Ove value → +ve value

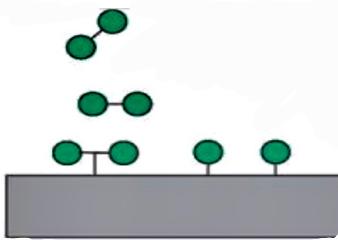
(1M) [Delhi 2010 / 2012 C]

Types of adsorption :-

- i) **Physical Adsorption** :- When the particles of adsorbate are held to the surface of adsorbent by physical forces such as Vander waal's forces. Then adsorption is called physical adsorption.
- ii) **Chemical Adsorption** :- When the molecules of adsorbate are held to the surface of the adsorbent by chemical forces. the adsorption is known as chemical adsorption. [Delhi 2011 C] 1M



Physical adsorption



Chemical adsorption

→ Difference between physisorption and chemisorption

Physisorption

[Delhi 2013] 2M [CBSE 2015 / 2012] 3M

Chemisorption

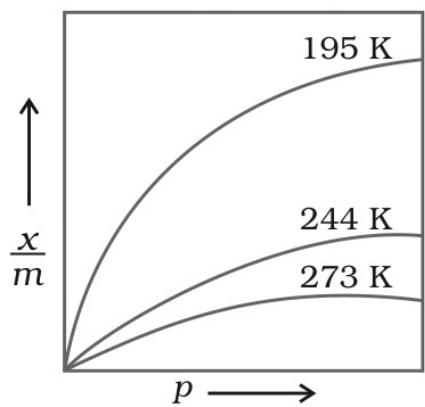
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|---|--|
| i) Example → Adsorption of SO_2 on charcoal | i) Example → Adsorption of H_2 on platinum. |
| ii) Lack of specificity :- A given surface of an adsorbent does not show any preference for a particular gas. | ii) High specificity :- It will only occur if there is some possibility of chemical bonding between adsorbent and adsorbate. |
| iii) It arises due to Vander waal force. | iii) It is caused by chemical bond formation |
| iv) It is reversible in nature. | iv) It is irreversible in nature. |
| v) As the surface of adsorbent increases physisorption increases. | v) As the surface area of adsorbent increases chemisorption increases. |
| vi) Enthalpy of adsorption is low due to weak force of attraction between adsorbent and adsorbate. | vi) Enthalpy of adsorption is relatively high due to bond formation [strong attractive force] |

Absorption Isotherms :- The graph between amount of gas adsorbed and pressure at constant temperature is known as absorption isotherm.

$x \rightarrow$ mass of gas adsorbed.

$m \rightarrow$ mass of adsorbent.

(3M)
[CBSE 2010 / 2010 C]



Freundlich adsorption isotherm :-

→ Empirical relationship between quantity of gas adsorbed and pressure at constant temperature.

$$\frac{x}{m} = K P^{\frac{1}{n}} \quad [0 < n \leq 1]$$

[CBSE 2014] (1M)

Apni Kaksha :-

→ K and n are constants which depends on nature of adsorbent and gas.

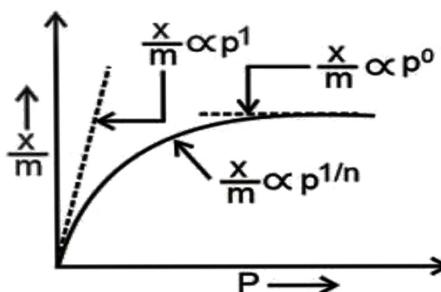
→ From Graph : i) As temperature increases extent of adsorption increases.

ii) At low pressure : $\frac{x}{m} \propto P^1$

iii) At high pressure : $\frac{x}{m} \propto P^0$: curve seem to approach saturation at high pressure.

iv) At moderate pressure : $\frac{x}{m} \propto P^{\frac{1}{n}}$ where $[0 < n \leq 1]$

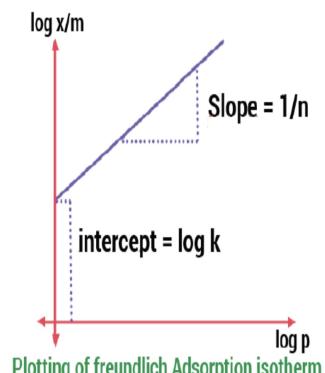
Taking log of $\frac{x}{m} = K P^{\frac{1}{n}}$:



$$\log \frac{x}{m} = \log K + \frac{1}{n} \log P$$

$$\text{Slope } [m] = \frac{1}{n}$$

$$\text{Intercept } [c] = \log K$$

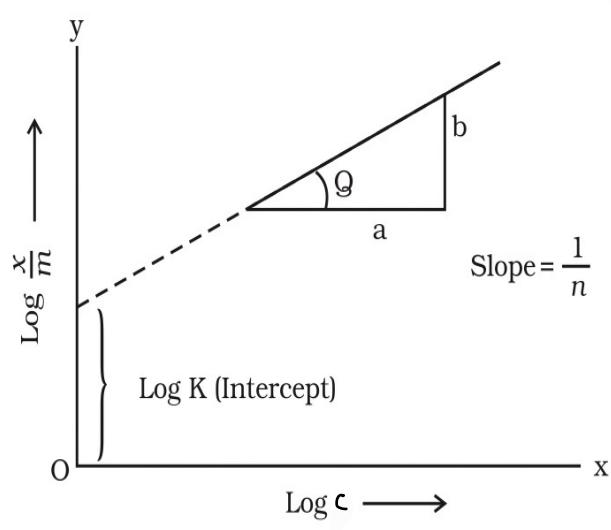


Absorption from solution phase :- Solids can adsorb solutes from solutions. Freundlich equation approximately describes the behaviour of adsorption from solution with a difference that instead of pressure, concentration of solution is taken into account.

$$\rightarrow \frac{x}{m} = K c^{\frac{1}{n}}$$

$$\rightarrow \log \frac{x}{m} = \frac{1}{n} \log c + \log K$$

$$y = m x + c$$

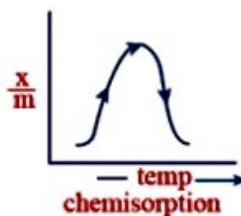
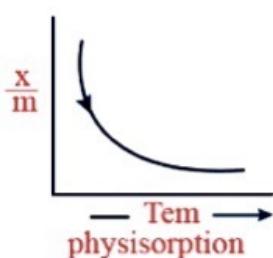


Question :- What is the effect of temperature on physisorption and chemisorption?

CBSE 2019
Delhi 2019
1M

Answer :- As temperature ↑
 \downarrow

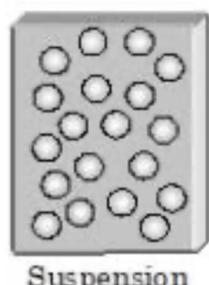
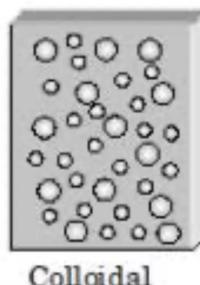
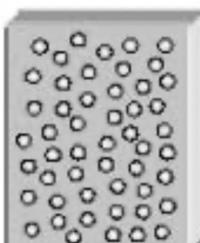
physisorption ↓.



- Chemisorption first increases and then decreases with increase in temperature.

[Delhi 2019] 1M

Colloids



→ The colloidal solutions are intermediate between true solutions and suspensions.

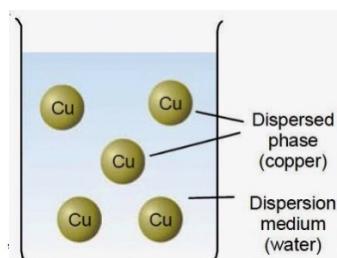
→ Colloidal solution = Dispersed phase + Dispersion medium.

→ Size of colloidal particles = 1 to 1000 nm.

Disperse Phase -: The phase which is distributed (or dispersed) through the medium is called disperse phase [DP].

Dispersion Medium -: A medium in which colloidal particles are dispersed is called continuous phase or dispersion medium [DM].

For example -: Gold sol \rightarrow Gold particles are D.P. and water is DM.



Classification of Colloids

i) On the basis of physical state of DP and DM :- [Most important]



Dispersed phase	Dispersion medium	Type of colloid	Examples
Solid	Solid	Solid sol	Some coloured glasses and gem stones
Solid	Liquid	Sol	Paints, cell fluids
Solid	Gas	Aerosol	Smoke, dust
Liquid	Solid	Gel	Cheese, jellies
Liquid	Liquid	Emulsion	Milk, hair cream, butter
Liquid	Gas	Aerosol	Fog, mist, cloud, insecticide sprays
Gas	Solid	Solid sol	Pumice stone, foam rubber
Gas	Liquid	Foam	Froth, whipped cream, soap lather



(ii) On the basis of interaction between DP and DM :- [CBSE 2013] [Delhi 2014C] [3M]

Lyophilic colloids

- i) Lyophilic means liquid loving.
- ii) Colloidal solution in which the particles of dispersed phase (solute) have great affinity for dispersion medium (solvent).
- iii) Example → Glue, gelatin, starch, protein with a suitable liquid. [CBSE 2014] [1M]
- iv) It is a reversible sol means that if DM is separated from DP, the sol can be reconstituted by simply mixing of DM and DP. [CBSE 2010] [1M]
- v) It is a stable colloid. It can not be precipitated easily.
- vi) Lyophobic means liquid hating.
- vii) Colloidal solution in which the particles of the dispersed phase have no affinity for DM.
- viii) Example → Solution of metals [Ag, Au] → Gold sol.

[2M]

Lyophobic Colloids

- vii) It is an irreversible sol means that it can not be prepared just by mixing of DP and DM. It can be prepared only by special methods.
- viii) It is an unstable colloid. So this sol needs stabilising agent for preservation.

iii) On the basis of particles of the D.P. :-

- a) Multimolecular Colloids -: On dissociation, a large no. of atoms or molecules of a substance aggregate together to form species having size in colloidal range. The species thus formed are called multimolecular colloid. Example → Gold sol and sulphur [S₈] sol.

[CBSE 2013]

[1M]

[Delhi 2013
2010]

- b) Macromolecular Colloids -: Macromolecules [polymers] in suitable solvents form solution in which the size of macromolecules may be in colloidal range. Such systems are called macromolecular colloids.

Example → Polymers [like starch, cellulose, proteins, enzymes, polythene etc.]

[1M]

[CBSE 2013 / Delhi 2012
2010]

- c) Associated Colloids -: There are some substances which at low concentrations behave as normal strong electrolytes, but at higher concentrations exhibit colloidal behaviour due to formation of aggregates. [CBSE 2013 / Delhi 2010/2012]
→ The aggregated particles are called micelles or associated colloids.

Example → Soap | Detergents

[1M]

→ The formation of micelles takes place only above a particular temperature called Kraft temperature (T_K) and above a particular concentration called CMC means Critical micelle Concentration.

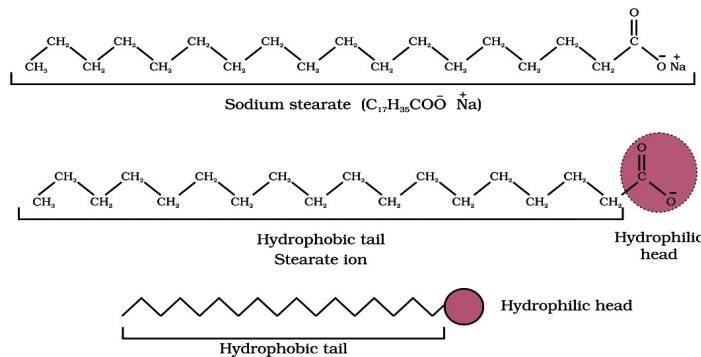
Mechanism of micelle formation :-

→ To understand the mechanism, let us take an example of soap solution.

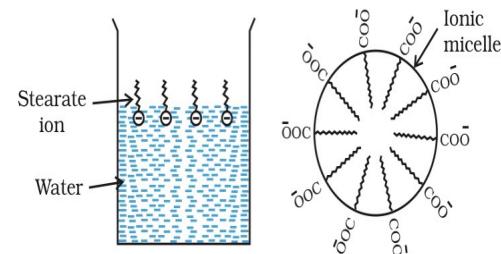
→ Soap : Sodium or potassium stearate

→ Sodium stearate has two parts

- Hydrophobic part [water repelling] : A long hydrocarbon chain (Non-polar tail)
- Hydrophilic part [water loving] : $-COO^-$ group (polar-ionic head) $[C_{17}H_{35}COO^-]$



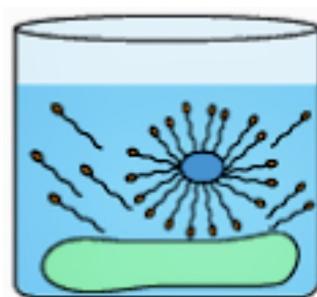
→ The $C_{17}H_{35}COO^-$ ions are present on the surface with their COO^- group in water and the hydrocarbon chains [$C_{17}H_{35}$] staying away from it and remain at the surface.



→ But at CMC, the anions are pulled into the bulk of solution and aggregate to form a spherical shape with their hydrocarbon chains pointing towards the centre of sphere with COO^- part remaining outward on the surface of sphere. This spherical aggregate is known as ionic micelle.

→ Detergents : sodium laurylsulphate $[CH_3(CH_2)_10SO_4^{\ominus} Na^{\oplus}]$

Cleaning action of soap :- The cleaning action of soap is due to the fact that soap particles form micelle around the oil droplet in such a way that hydrophobic part of the stearate ions is in oil droplet and hydrophilic part projects out of the grease droplet. Because hydrophilic part is outside of oil droplet, so it can interact with water due to polarity.



Apni
Kaksha



→ The oil droplet surrounded by stearate ions is now pulled in water and removed from dirty surface.

[CBSE 2012]

2M

