Adsorption: The phenomenon in which the molecules of a substance are attracted and adhered to the surface of a solid or liquid.

- Adsorption is a surface phenomenon.
- Adsorption is a exothermic reaction. Released heat is called Heat of adsorption.

Adsorbent: The liquid or solid on the surface of which the molecule of the substance are adsorbed is called adsorbent.

Adsorbate: The substance whose molecules are attracted by the adsorbent and there by if the substance is adhered to the surface of the adsorbent. Then the substance is called adsorbate.

$$C_2H_4 + H_2 \xrightarrow{\text{Pt (or) Ni}} C_2H_6$$

- Surface of solids extends upto 100 nm.
- In the exterior of solid unbalanced forces and interior of the solid balanced forces are present.
- Due to unbalanced forces on the surface it attracts molecules of gas or liquid.
- The attraction and accumulation of gas or liquid molecules on to the surface of solid is called Adsorption.
- If gas or liquid molecules are uniformly distributed through out the interior is called absorption.
- Thus adsorption is surface phenomenon and absorption is bulk phenomenon.
- In most of the instances both absorption and adsorption will occur simultaneously and they are not easily distinguishable.
- If both absorption and adsorption will occur it is called sorption, given by mc Bain.
- If the adsorbed gas or liquid leaves the surface it is called as dissipation.
- Generally absorption occur at uniform rate while adsorption occurs rapidly in the beginning.

Example :

Adsorption	**Absorption**
1. Charcoal adsorbs aceticacid from solutions.	Sponge absorbs water.
2. Animal charcoal adsorbs colours and impurities from cane sugar solutions.	An hydrous $CaCl_2$ absorbs moisture
3. Activated charcoal adsorbs noble gases.	NaOH absorbs moisture and $CO_2 \rightarrow$ hygroscopic
4. Silica gel adsorbs moisture	Ammonical cuprous chloride absorbs CO and acetylene.

5. Transition metals adsorbs gases like H_2, N_2, O_2 etc.,	Terpentyne oil absorbs ozone.
6. Fullers earth (impure clay) adsorbs impurities from vegetable oils.	Pyrogallol absorbs oxygen.
7. Ni adsorbs H_2 gas in the manufacture of Dalda.	Chalk dipped in ink.

Adsorbent (medium) :

- It is the substance whose surface adsorbs gas or liquid molecules.

Adsorbate $\rightarrow$ the substance whose molecules are adsorbed on to the surface of adsorbent.

- Adsorbent may be a solid or liquid.
- Adsorbate may be gas or liquid.
- Based on the nature of forces holding the adsorbate molecules to the adsorbent surface.

Adsorption are of two types.

1) Physical adsorption :

- Weak – Vanderwall's forces exist between adsorbent and adsorbate.

  Eg: Charcoal adsorbs gases. Charcoal adsorbs acetic acid ; Silica jel adsorbs moisture.

2) Chemical adsorption :

- Strong chemical forces will exists between adsorbate and adsorbent and these forces may be ionic or covalent.
- Adsorption of H_2, N_2,O_2 gases by Ni, Pd, Pt etc..

PHYSICAL	CHEMICAL
1. Weak vander – wall forces	1. Strong forces
2. It is weak adsorbtion	2. Strong adsorbtion
3. Enthalpy is low 20 – 40 kJ	3. High that 40 – 400 k.J
4. Less activation energy	4. More activation energy
5. Not specific that any adsorbent can adsorbs any gas	5. Specific that is a particular adsorbent adsorbs particular gas.
6. With in increase in pressure physical adsorbtion increases.	6. Both adsorbate and adsorbent effect of pressure is neglizable.
7. It is favourable at low temperature that is adsorption decreases with rise in temperature	7. Adsorbtion increases with rise in temperature.

8. It is mutimolecular layer [at low pressure unimolecular layer and high pressure multi molecular layer is formed.	8.Unimolecular layer formation.
9. If is reversible and affects equilibrium.	9. It is irreversible
10.easily liquefied gases are more adsorbed.	10.No relation between liquefaction & adsorbtion

Adsorption of a gas by solids :

Surface area $\rightarrow$ with increase in surface area adsorption increases.

- Finely divided metals and porous substances with large surface area have more adsorption capacity.

Activation: Removal of impurities and cleaning the surface of adsorbent is called activation.

- Activation is done by heating in vacuum or in presence of inert gas.
- Activated adsorbent has more adsorption capacity.

Nature of the gas :

- The gas with higher critical temperature is easily liquefiable.
- The easily liquefiable gases are more readily adsorbed.

Eg: HCl, SO_2, NH_3, CO_2

Pressure : With increase in pressure physical adsorption increases, effect of pressure on chemical adsorption is negligible

Temperature : Low temperature favours physical adsorption and high temperature favours chemical adsorption.

- In some cases increases in temperature will convert physical adsorption into chemical adsorption.

Eg: At 463 K N_2 is physically adsorbed by iron.

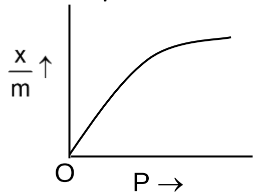
At 773 K N_2 is chemical adsorbed by iron.

Adsorption isotherm:

[Freundlich adsorption isotherm]

These adsorption isotherms will explain the variation magnitude of adsorption with pressure at given temperature. These are obtained by plotting magnitude of adsorption Vs pressure.

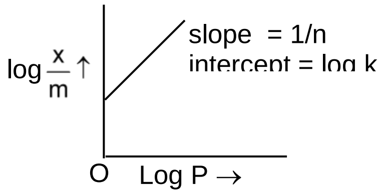
- As shown below rate of adsorption increases with pressure after reaching a limiting value rate of adsorption remains constant and that pressure is called equilibrium pressure. At that stage, rate of adsorption and rate of disorption are same.



Freundlich adsorption isotherm,

$\frac{x}{m} \propto p^{1/n}$; $\qquad \frac{x}{m} = kp^{1/n}$

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



$\frac{x}{m}$ = magnitude of adsorption. P = pressure

x = amount of gas adsorbed m = mass of adsorbent

value of n is equal to 0 to 1

at low pressure n = 1

at high pressure n = 0

at optimum pressure n = > 0 / < 1

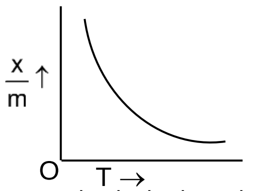
by applying logarithm on both sides of Freundlich equation.

$\text{Log}\frac{x}{m} = \log k + \frac{1}{n}\log p$ by plotting log(x/m) verses 'logp' = a straight line is obtained, slope gives n and intercept gives 'logk'.

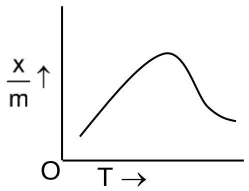
Adsorption isobar:

These isobars will explain variation of magnitude of adsorption with temperature at given pressure.

- These are obtained by plotting x/m verses temperature at constant pressure.
- These adsorption isobars are useful to distinguish physical and chemical adsorption.
- In physical adsorption x/m decreases with increase in temperature.
- In chemical adsorption x/m increases with T upto a limiting value and then decrease.



Physical adsorption



Chemical adsorption

Langmuir adsorption isotherm:

- Langmuir has theoretically derived the following expression which explains the variation of adsorption with pressure at given temperature

$\frac{x}{m} = \frac{bp}{1+ap}$ p = pressure, a, b = constant

- Freundlich isotherm is a special case of langmuir adsorption isotherms.
- Langmuir adsorption isotherms is applicable for unimolecular layer adsorption.
- Both Freundlich and langmuir adsorption isotherms hold good at low pressure and fail at high pressure.

Adsorption from solutions:

- Like gases are adsorbed by solids, powdered substance adsorb various dissolved substances from solution.
- Charcoal or activated charcoal adsorbs colours and acetic acid from solution.
- Animal charcoal adsorbs colours and impurities from raw sugar solution.
- Freshly precipitated metal hydroxides $Fe(OH)_3$, $Al(OH)_3$ are better adsorbent for dyes.
- In column chromatography the mixture of organic and inorganic substances can be separated based on the difference in the rate of adsorption.
  Al_2O_3 is used as adsorbent.
- In froth floatation process in the concentration of sulphide ore froth adsorbs oar particles.

Applications of adsorption:

- In heterogeneous catalysis, catalyst adsorbs gaseous reactants.
  1) Haber's process 2) Ostwald process 3) Contact process
- In chromatography.
- In the production of gas masks. In producing high vacuum's.
- In washing by detergents. In softening of hard water.
- In metallurgy for the concentration of ores
- In the digestion of food and assimilation of various medicines.