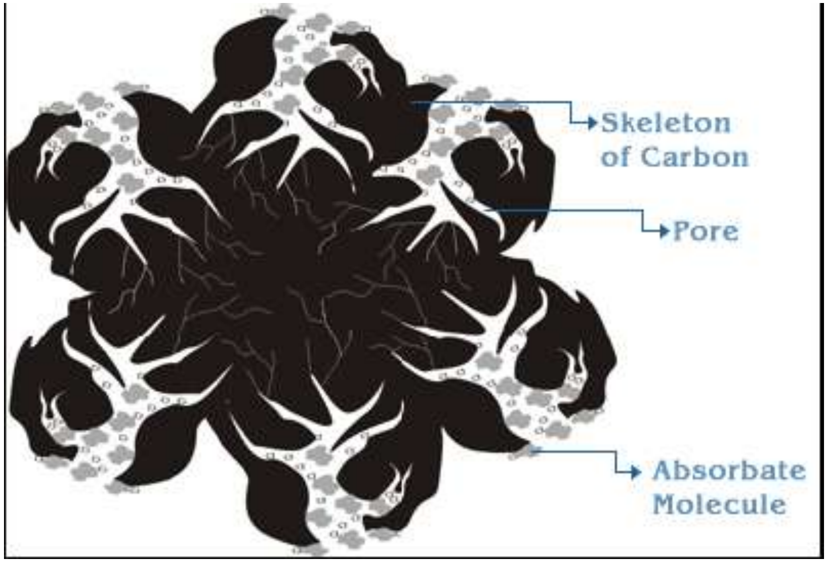
Adsorption

DEFINATION:

- The concentration of gases, liquids or dissolved substances (**adsorbate**) on the surface of solids (**adsorbent**).
- the process of accumulation at an interface
- Absorption : penetration of one component throughout the body of a second.
- *The term **sorption** is used to describe both the processes*



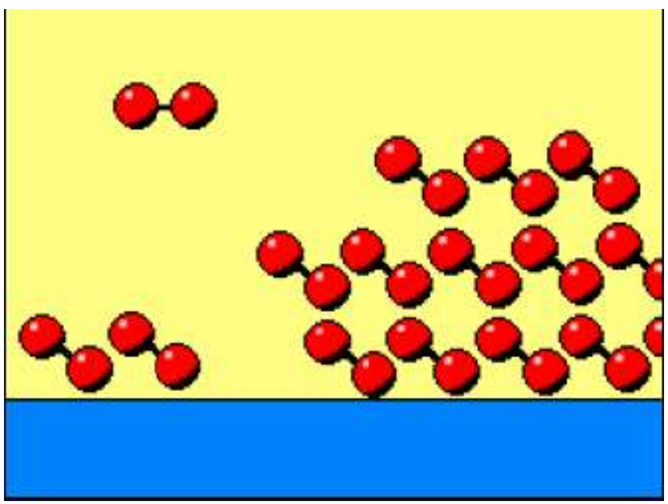
Types of adsorption

A-physical adsorption

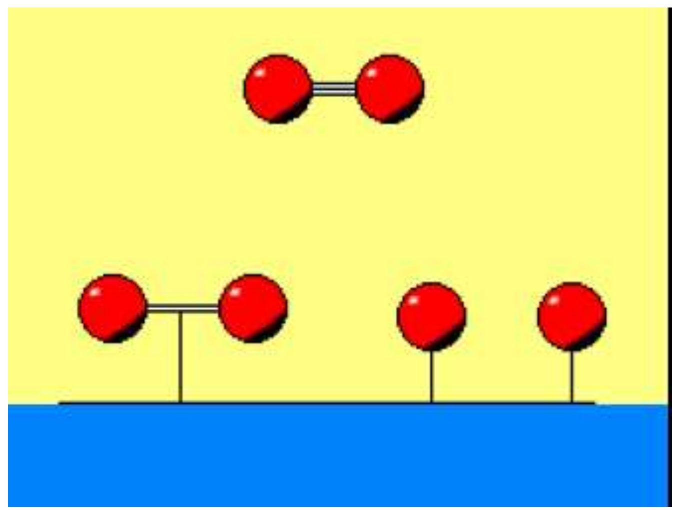
in which the adsorbate is bound to the surface through the weak van der Waals forces

B-Chemical adsorption or chemisorptions

Which involves the stronger valence forces.



physisorption



chemisorption

Physical Adsorption / Physisorption

a.Not Specific

b.No electron transfer , although polarization of adsorbate may occur

c.Rapid, non-activated & reversible

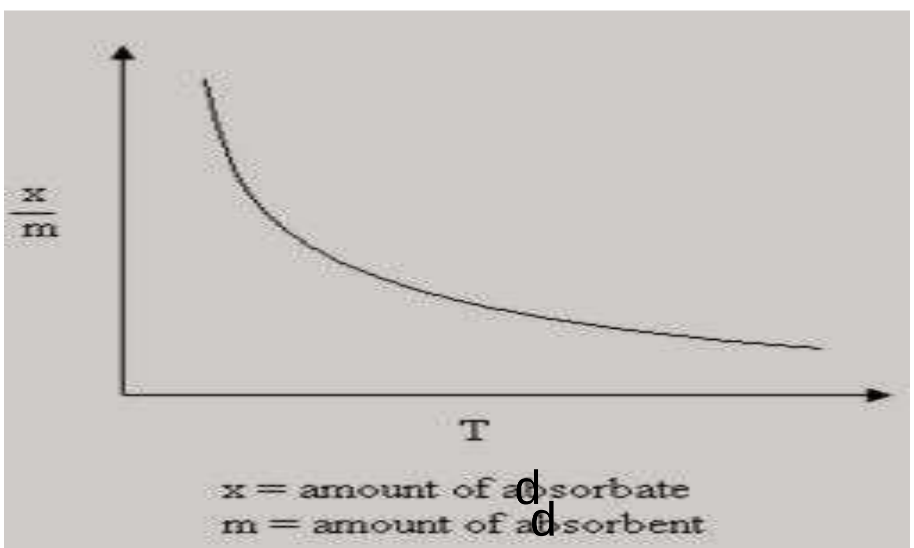
d.No dissociation of adsorbed species

e.Monolayer or Multilayer

f.Only significant at relatively low temperatures

g.Enthalpies are in the region of 50 kJ/mol

h.As the temperature increases, process of Physisorption decreases



Chemical Adsorption/Chemisorption

a.Highly Specific

b.Electron transfer leading to bond formation between adsorbate & adsorbent

c.Activated , slow & irreversible

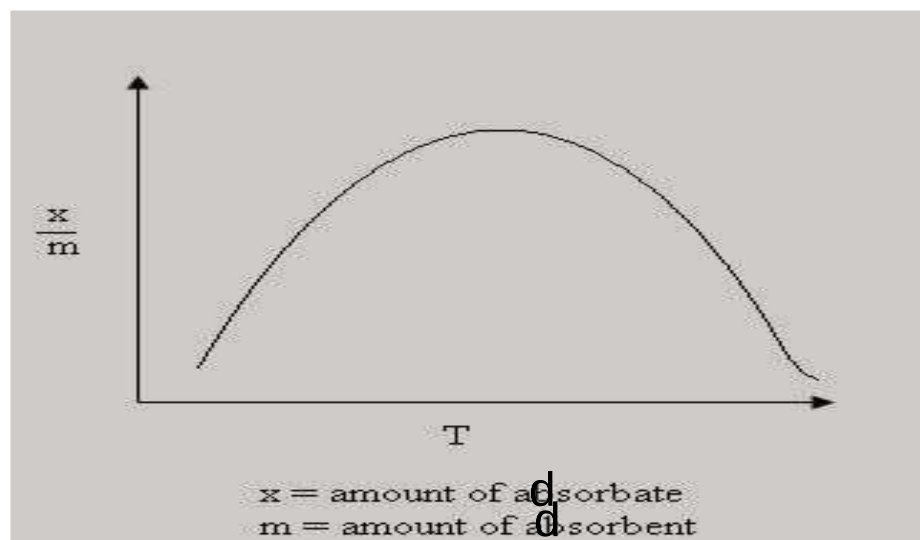
d.May involve dissociation

e.Monolayer only

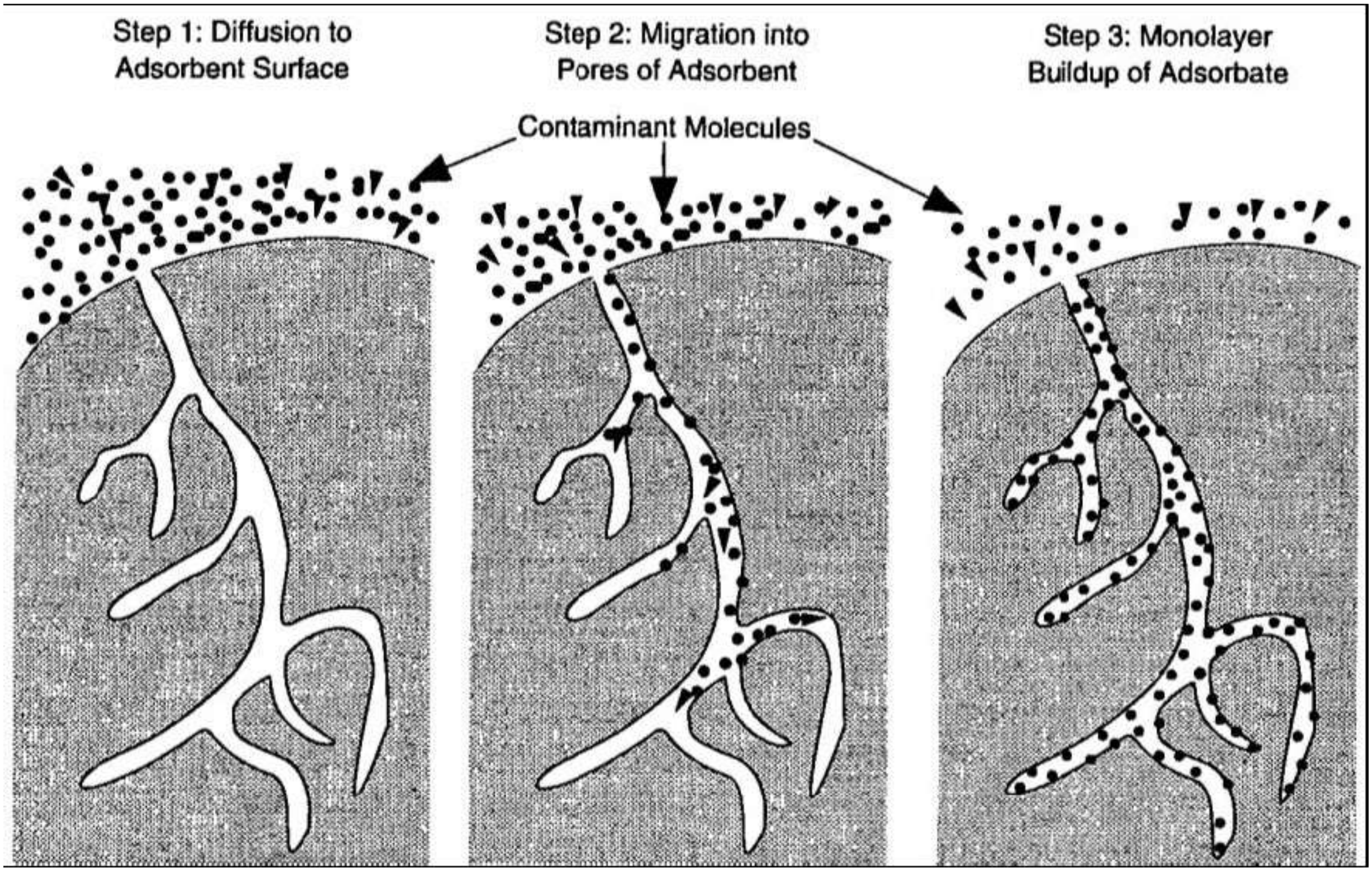
f. Signficant over a wide range of temperatures

g.Enthalpies are in the region of 100 kJ/mol or more

h.With the increases in temperature, Chemisorption first increases & then decreases



Adsorption Mechanism



Adsorption isotherms

- Adsorption Isotherm: the mass of adsorbate per unit mass of adsorbent at equilibrium & at a given temperature. (X/M)
- The study of adsorption from solution is experimentally straightforward.
- A known mass of the adsorbent material is shaken with a solution of known concentration at a fixed temperature. The concentration of the supernatant solution is determined by either physical or chemical means and the experiment continued until no further change in the concentration of the supernatant is observed, that is, until equilibrium conditions have been established.

Langmuir adsorption isotherm

- Langmuir equation assumes that:
  - At equilibrium at any concentration, the rate of adsorption should be equal to the rate of desorption.

Thus, if *x/m* = fraction of the surface covered by adsorbate molecules, then (*1- x/m*) = fraction of the surface not covered by molecules and therefore available for adsorption.
where *x* is the amount of solute adsorbed by a weight, *m*, of adsorbent,

Adsorption

ADSORBATE + ADSORBENT ⇌ ADSORPTION

Desorption

if *c* is the concentration of solution at equilibrium and the value of a is a measure of the adsorptive capacity of the adsorbent for the particular adsorbate under examination. the rate of adsorption is

k1 (a- x/m) c

The rate of desorptin is

k2 x/m

At equilibrium the two processes must be balanced so that:

k1 (a- x/m

x/m = k1a

$$\frac{x}{m}=\frac{abc}{1+bc}$$

x/m = a b c/1+bc where b =k1/k2

c is the concentration of solution at equilibrium,

b is a constant related to the enthalpy of adsorption

a is related to the surface area of the solid.

Freundlich equation

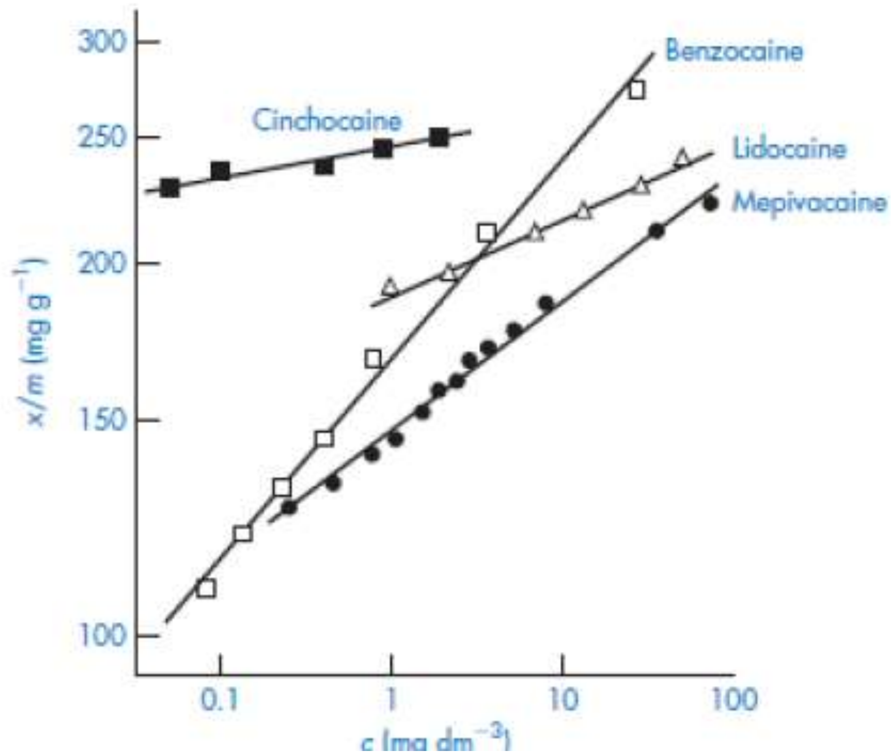
$$\frac{x}{m} = ac^{1/n}$$

Where a and n are constants

can be written in a linear form by taking logarithms of both sides, giving

$$\log(x/m) = \log a + (1/n)\log c$$

A plot of log(x/m) against log c should be linear, with an intercept of log a and slope of 1/n;



Freundlich adsorption isotherms of local anaesthetics on activated carbon at pH 7.0 and 25°C

Factors affecting adsorption

1-Solubility of the adsorbate

- Solubility is an important factor affecting adsorption. In general, the extent of adsorption of a solute is inversely proportional to its solubility in the solvent from which adsorption occurs.

2- pH

- pH affects adsorption for a variety of reasons, the most important from a pharmaceutical viewpoint being its effect on the ionization and solubility of the adsorbate drug molecule.
- In general, for simple molecules adsorption increases as the ionization of the drug is suppressed, the extent of adsorption reaching a maximum when the drug is completely unionized.
- In general, pH and solubility effects act in concert, since the unionized form of most drugs in aqueous solution has a low solubility.

3-Nature of the adsorbent

- The physicochemical nature of the adsorbent can have effects on the rate and capacity for adsorption.
- The most important property affecting adsorption is the surface area of the adsorbent; the extent of adsorption is proportional to the specific surface area. Thus the more finely divided or the more porous the solid, the greater will be its adsorptive capacity.

4-Effect of temperature

- Physical adsorption occurs rapidly at low temperature and decreases with increasing temperature.
- Chemisorption, like most chemical changes, generally increases with temperature

Medical and pharmaceutical applications of adsorption

1-Adsorption at the solid-liquid interface plays a crucial role in

- preparative and analytical chromatography
- heterogeneous catalysis,
- water purification and solvent recovery .

2-Adsorption of poisons-toxins

- The 'universal antidote' for use in reducing the effects of poisoning by the oral route is composed of activated charcoal, magnesium oxide and tannic acid.

3-Taste masking

- Diazepam adsorbed onto an inorganic colloidal magnesium aluminium silicate (Veegum) had the same potency in experimental animals as a solution of the drug, but when adsorbed onto microcrystalline cellulose (Avicel) its efficacy was much reduced.

4-Haemoperfusion

- Carbon haemoperfusion is an extracorporeal method of treating cases of severe drug overdoses, and originally involved perfusion of the blood directly over charcoal granules
- Although activated charcoal granules were very effective in adsorbing many toxic materials