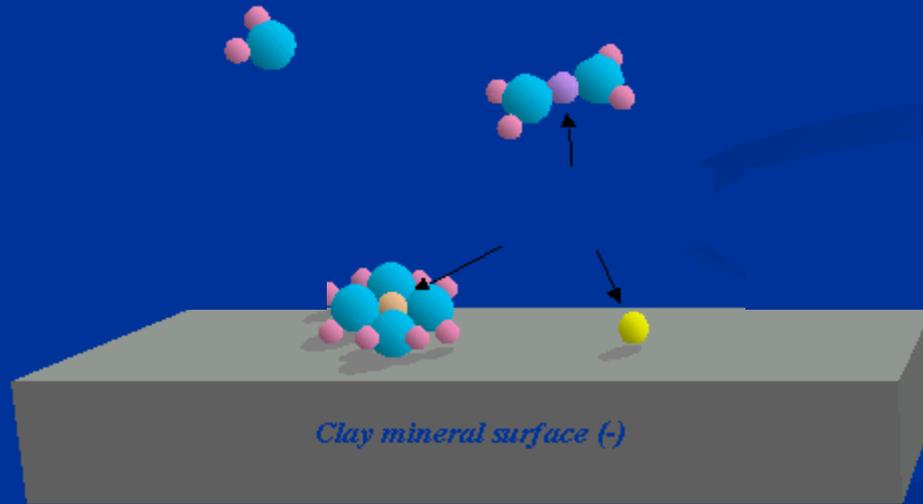


ADSORPTION

ADSORPTION

Dr. L.T.M. Muungo

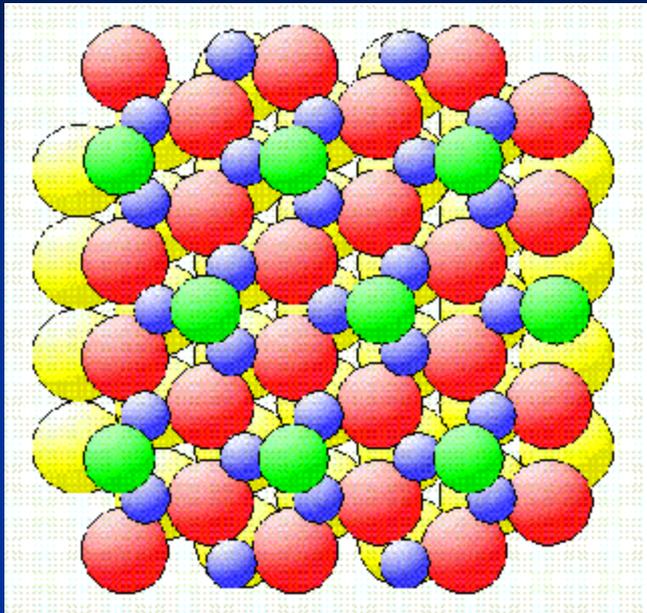


Adsorption: is the accumulation of a substance at a surface or interface

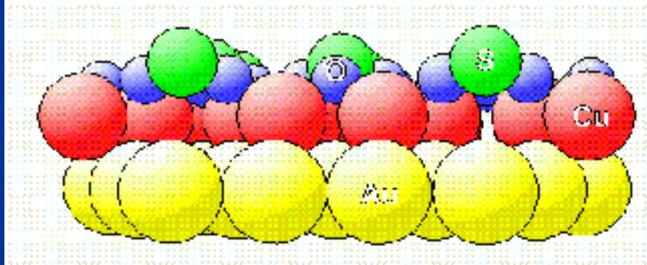
Absorption: is the accumulation and distribution of a substance throughout a phase.

Drugs are adsorbed by a membrane, enzyme or cell wall when they are attached to its surface.

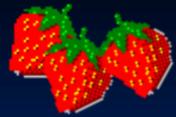
They are absorbed by a tissue, organ or blood when they permeate its entire bulk or volume.



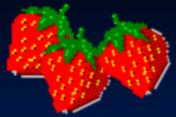
← *Absorption:*



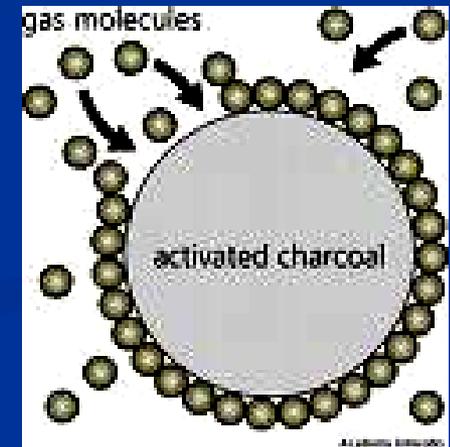
← *Adsorption:*



APPLICATIONS OF ADSORPTION



- ❖ Adsorption of material at solid interface may take place from either liquid or gas phase.
- ❖ The adsorption of gases at solid interface can be applied in the removal of odors, the operation of gas masks, and the measurement of the dimensions of particles as powders.
- ❖ The adsorption of liquids at solid interface can be applied in the decolorizing solutions, adsorption chromatography, detergency and wetting.

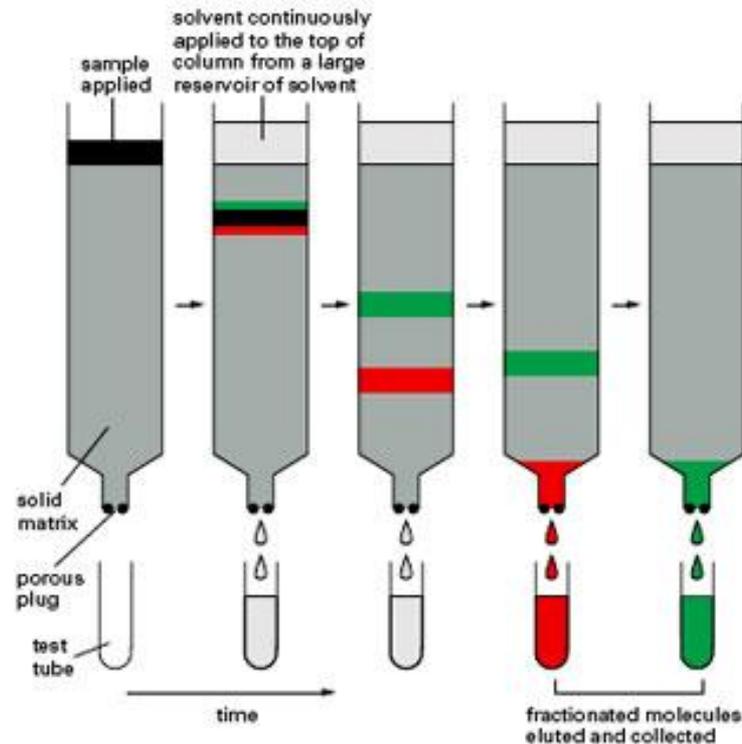




Adsorption chromatography

COLUMN CHROMATOGRAPHY

Proteins are often fractionated by **column chromatography**. A mixture of proteins in solution is applied to the top of a cylindrical column filled with a permeable solid matrix immersed in solvent. A large amount of solvent is then pumped through the column. Because different proteins are retarded to different extents by their interaction with the matrix, they can be collected separately as they flow out from the bottom. According to the choice of matrix, proteins can be separated according to their charge, hydrophobicity, size, or ability to bind to particular chemical groups (see *below*).





Decolorization

When a chemical is tinted with colouring matter, it is not removed in the usual stages of purification involving partition between immiscible solvents, crystallization or precipitation.



A colourless solution may be obtained by shaking with about 1 % of activated charcoal, allowing to stand for some time and then filtering.

The process of decolorization should be used with discrimination since charcoal will adsorb inorganic and organic compounds.

Alkaloids are readily adsorbed by charcoal and decolorization of Alkaloidal solutions would best be done with a weaker adsorbent such as kieselguhr.

Desiccation



Desiccation is the adsorption of water vapour.

❑ **Alumina and silica gel** are powerful adsorbents of water vapour. These desiccants remain as dry powders even on taking up as much as 40 % water.

❑ Refrigerated **silica gel** has been used as a desiccant in freeze drying where the low temperature increases the efficiency of the adsorption process.

❑ They possess definite advantages over **calcium chloride and phosphorous pentoxide** which liquefy on adsorbing water.

Adsorption of Pyrogens

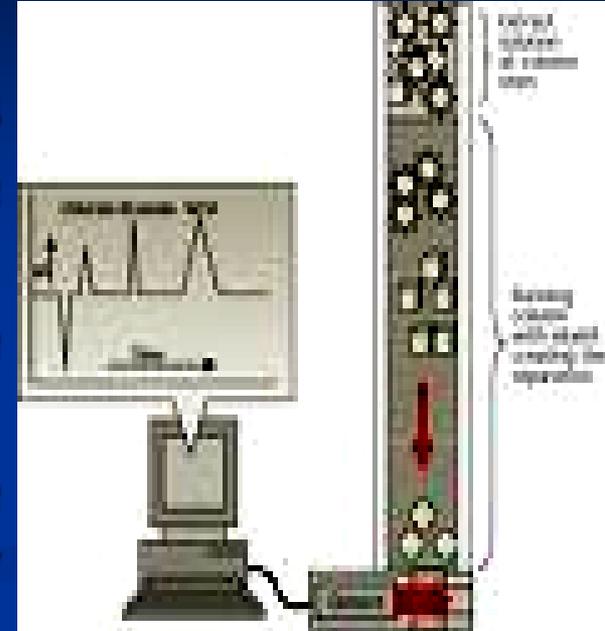
Water for injection can be pyrogen-free by using activated charcoal for the removal of pyrogen.

Caution must be taken to prevent the loss of drugs from the solution.



Chromatography

Chromatography is a process which permits the resolution of mixtures depending on the degree to which the various solutes are adsorbed, partitioned or exchanged between the original solution (the moving phase) and a second solid or liquid phase which is known as the stationary phase.



The method may be used for the removal of calcium and magnesium ions from hard water.

Medicinal Uses

 **Kaolin** has a sheet-like structure, one surface formed of aluminium hydroxide residues that are responsible for its capacity to adsorb both basic and acidic intestinal toxins by ion exchange.



The reactions take place only at the surface of the kaolin and as a consequence depend on its particle size. However, the use of kaolin or charcoal have low value for adsorbing gases, toxins and bacteria from the lower gastrointestinal tract since passage through the upper tract saturates and deactivates the them.



Activated charcoal is a valuable emergency antidote in poisoning due to alkaloids taken by mouth, but its value is restricted to the first phase of therapy when adsorption takes place from the stomach before the alkaloids are absorbed.

Types of Adsorption

Physical adsorption

Physical or van der Waals' adsorption is:

- Reversible, rapid, weak and non-specific.
- The removal of the adsorbate from the adsorbent being known as desorption.
- A physically adsorbed gas may be desorbed from a solid by increasing temperature and reducing the pressure.
- Multilayer adsorption is possible.

Chemical adsorption

In chemical adsorption or Chemisorption the adsorbate is attached to the adsorbent by primary chemical bond. It is:

- Irreversible, stronger, specific, and may require an activation energy and therefore be slow.
- Only monomolecular chemisorbed layers are possible.

Factors Affecting Adsorption

Temperature

↑ Temperature → ↓ The amount adsorbed.
Adsorption is generally exothermic process

pH

↑ Ionization → ↓ The amount adsorbed
The pH affects the ionization and solubility of adsorbate drug molecule. The extent of adsorption reaching a maximum when the drug is completely ionized.

Solute concentration

↑ The concentration of the solute → ↑ The amount adsorbed
○ At equilibrium until a limiting value (saturation).

❑ Define the following terms:

[solid, liquid, gas, adhesive force, cohesive force, interface, adsorption, Absorption, catalyst, dipole, physisorption, Chemisorption, hydrophilic, hydrophobic, detergent, surfactant, surface tension, adsorbate, adsorbent, etc]

❑ Respond to the following questions:

- Illustrate the knowledge of adsorption process applications in pharmaceutical process
- State and describe the types of adsorption in pharmaceutical procedures
- What are surface and Inter-facial tension forces and respective association with adsorption process on the surface material substance
- Describe some key factors that have primary effect on the process of adsorption.
- Illustrate the meaning of adsorption isotherm
- changes of materials substance when exposed to some environmental conditions .
- How is a chemical change different from a physical change at the surface of a material
- What is contact angle of a substance and its significant role when two materials surface are adsorbed to each other
- Describe the role of contact angle during the adsorption process of a material substance

❑ Group work discussional questions:

- Give a detailed descriptive account of functional classification of adsorbate agents
- Give a detailed descriptive account of structural classification of adsorbent agents
- Explain the process of micelle formation in a given favourable environment

Surface Area of Adsorbent

↑ Surface Area of Adsorbent → ↑ The amount adsorbed
Surface area can be increased by a reduction in particle size or the use of porous material.

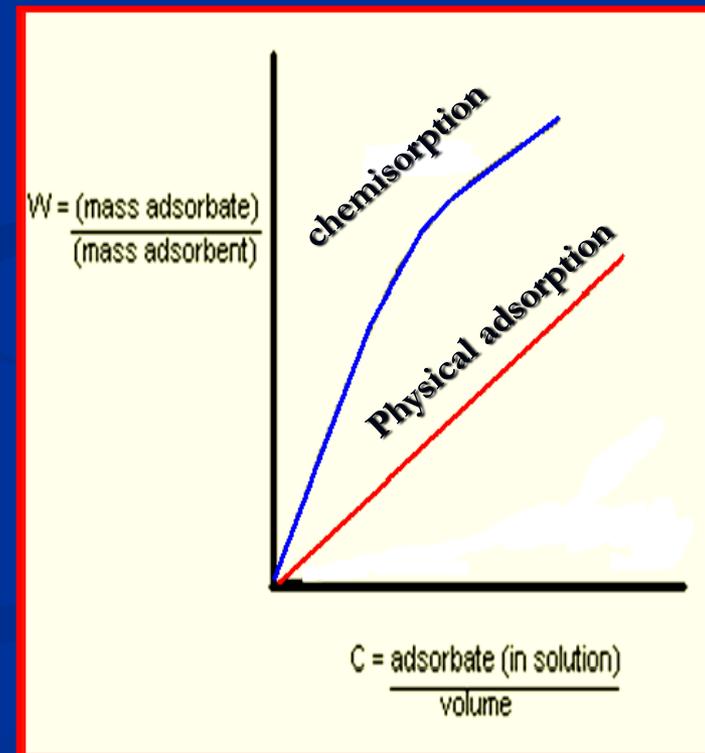
Solubility of the Adsorbate

↑ The solubility in the solvent → ↓ The amount adsorbed
The greater the solubility, the stronger are the adsorbate bonds with the solvent and hence the smaller the extent of adsorption.

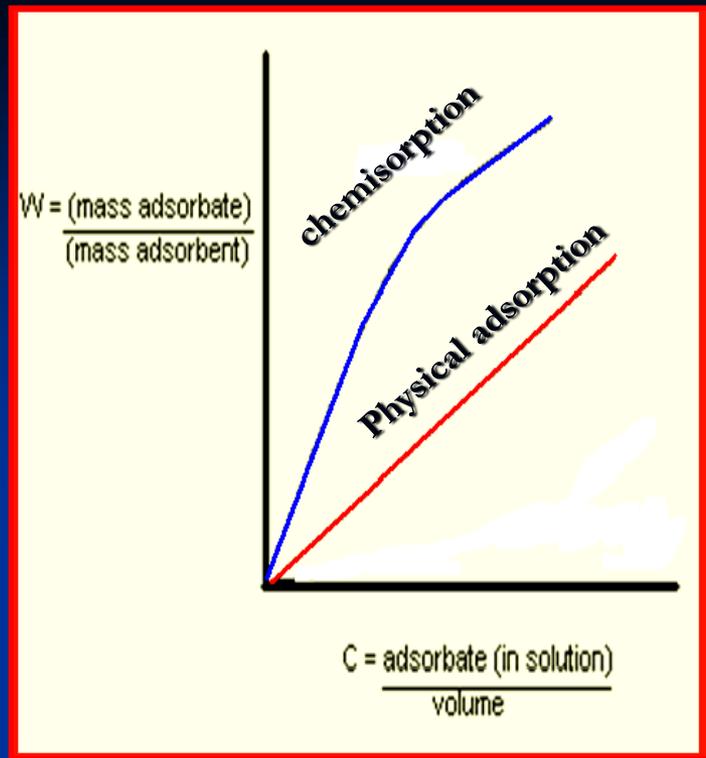
Adsorption Isotherm

The relationship between the amount of gas physically adsorbed on a solid and the equilibrium pressure or concentration at constant temperature yields an adsorption isotherm. The term isotherm refers to a plot at constant temperature.

The number of moles, grams, or milliliters (x) of a gas adsorbed on (m) grams of adsorbent at STP (standard temperature and pressure) is plotted on the vertical axis against the equilibrium pressure of the gas on the horizontal axis.



● The number of moles, grams, or milliliters (x) of a gas adsorbed on (m) grams of adsorbent at STP (standard temperature and pressure) is plotted on the vertical axis against the equilibrium pressure of the gas on the horizontal axis.

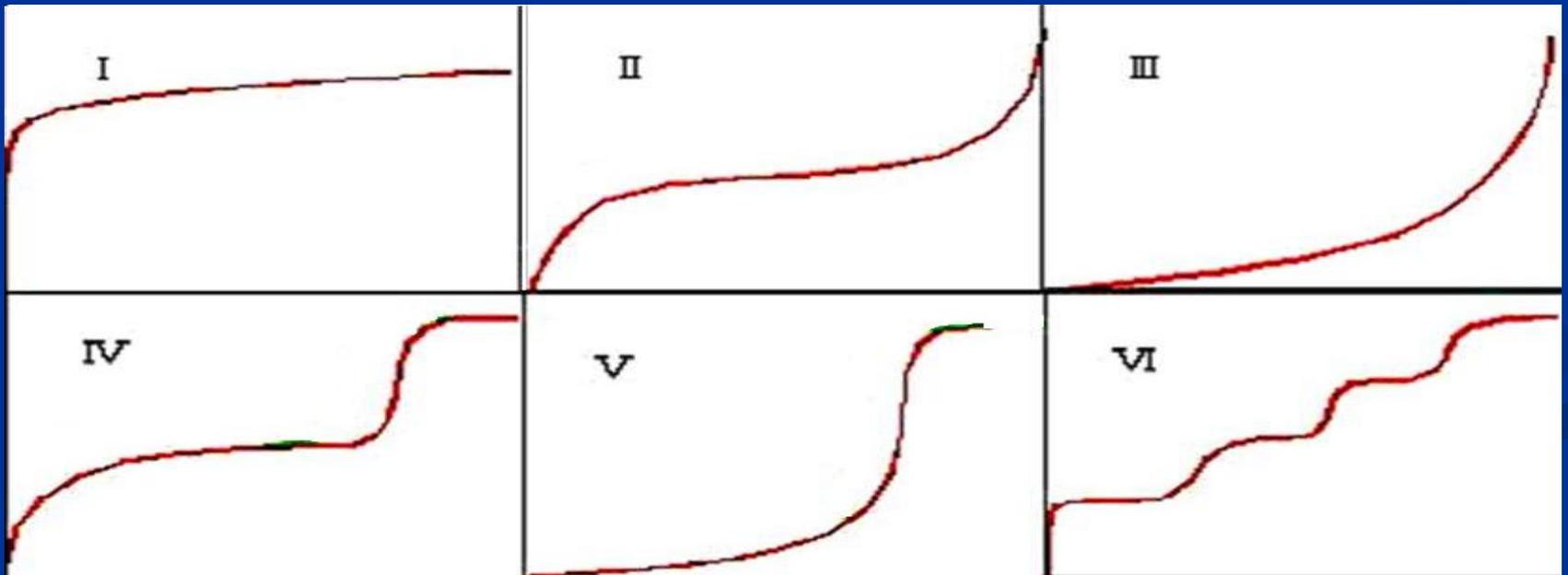


● The extent of adsorption $\frac{x}{m}$ increases as its equilibrium Pressure (concentration) P or C increases

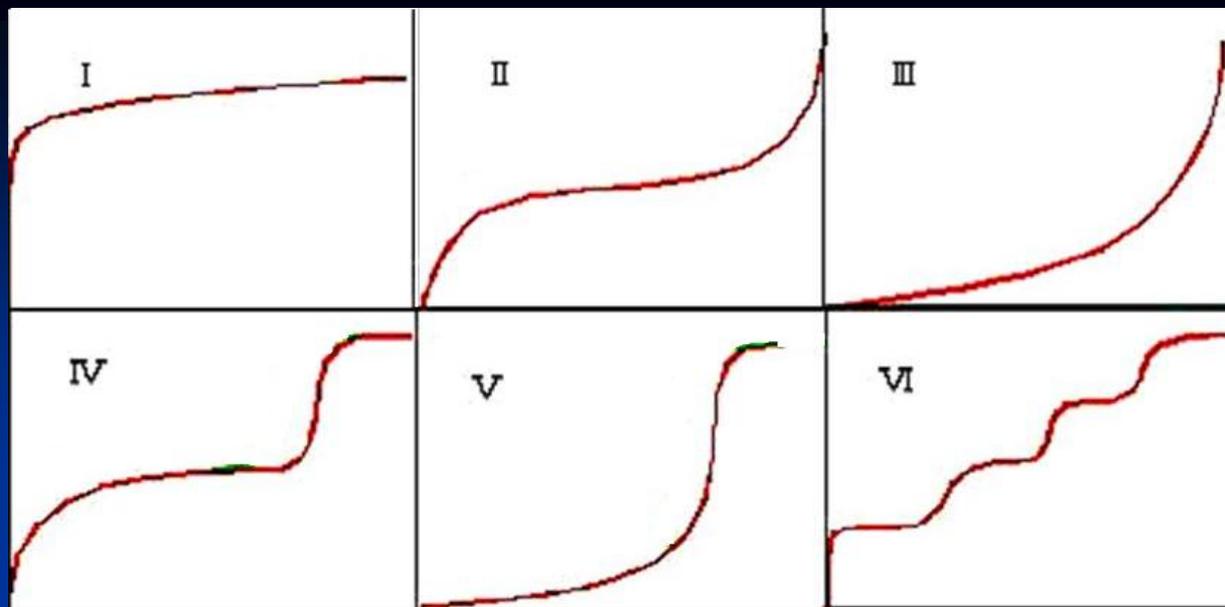
● Isotherms representing chemisorption have a steep initial rise, indicating that adsorbent removes the solute almost completely from solution, i.e., that $\frac{x}{m}$ increases much faster than P or C

ISOTHERM TYPES

Isotherm
The Type
I, II, III, IV, V



Isotherm
The Type
I, II, III, IV, V



The Type I isotherm: Called **Langmuir isotherm**.

It exhibit a rapid rise in adsorption up to a limiting value. This type is restricted to a monolayer, hence chemisorption give this type of isotherm.

The Type II isotherm: It represents multilayer physical adsorption on non porous materials.

The Type III and type V isotherms: are typical of vapor adsorption (i.e. water vapor on hydrophobic materials).

This type of isotherm occurs when the adsorption in the first layer is weak and rare.

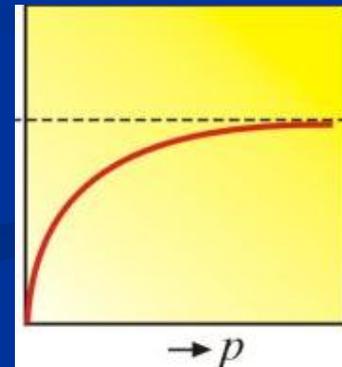
The Type IV and type V isotherms: This type of isotherm occurs due to condensation of vapour in fine capillary of the solid.

There are basically two well established types of adsorption isotherm:

- ❑ The Langmuir adsorption isotherm
- ❑ The Freundlich adsorption isotherm

The Langmuir adsorption isotherm describes quantitatively the build up of a layer of molecules on an adsorbent surface as a function of the concentration of the adsorbed material in the liquid in which it is in contact. In a modified form it can also describe a bi-layer deposition.

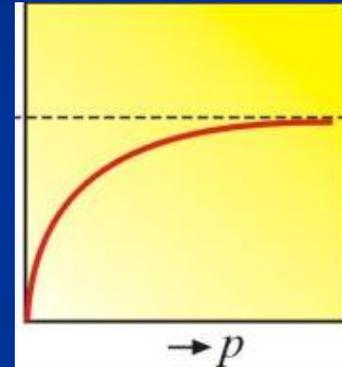
➤ The shape of the isotherm (assuming the (x) axis represents the concentration of adsorbing material in the contacting liquid) is a gradual positive curve that flattens to a constant value.



Langmuir Isotherm

Langmuir developed an equation based on the theory that the molecules or atoms of gas are adsorbed on active sites of the solid to form a layer one molecule thick (monolayer).

$$P \frac{m}{x} = \frac{1}{b} P + \frac{1}{ab}$$



Where: P = the equilibrium pressure of the gas at constant temperature (the pressure attained after adsorption)

m = mass of adsorbent

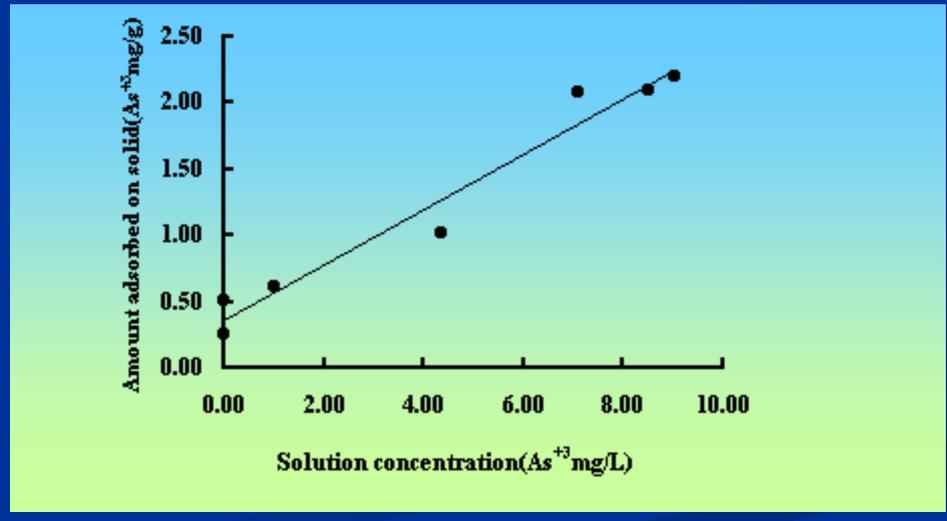
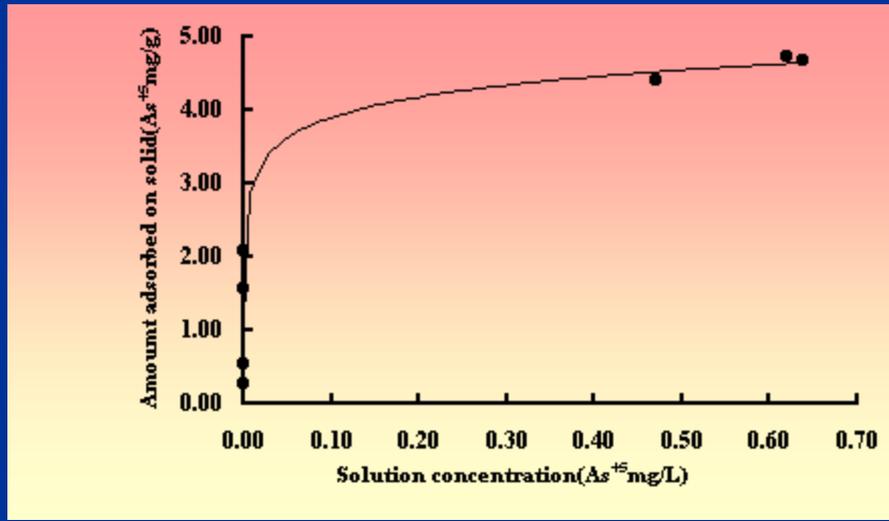
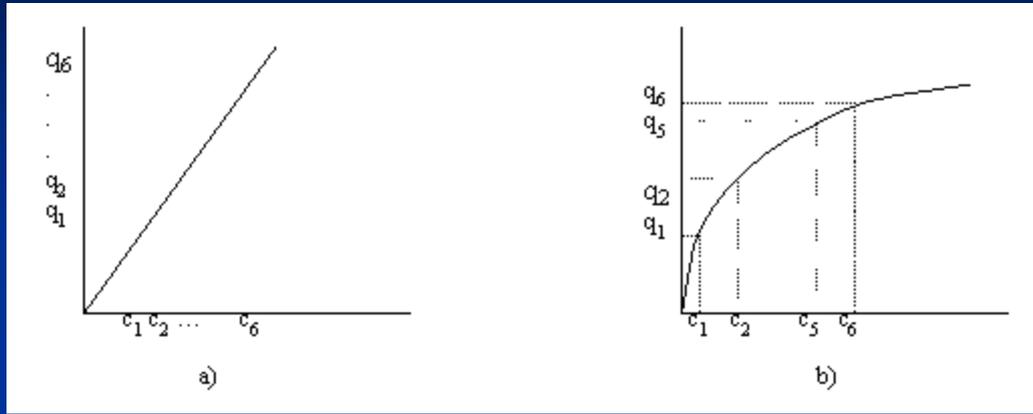
x = the amount of gas adsorbed

Freundlich Isotherm

An adsorption isotherm is a curve relating the concentration of a solute on the surface of an adsorbent, to the concentration of the solute in the liquid with which it is in contact .

➤ In chromatography the Freundlich isotherm is not common, most adsorption processes are best described by the Langmuir isotherm.

Freundlich Adsorption Isotherm



Any Questions

❑ Define the following terms:

[solid, liquid, gas, adhesive force, cohesive force, interface, adsorption, catalyst, dipole, physisorption, Chemisorption, hydrophilic, hydrophobic, detergent, surfactant, surface tension, adsorbate, adsorbent, etc]

❑ Respond to the following questions:

- Give a descriptive account of the phases of matter with logical relevance to state of medicines as they are taken for their respective therapeutical values
- What is viscosity and its relation with fluids
- What are surface and Inter-facial tension forces and respective association with activities of a substance material with surface area
- Describe some key phase changes of materials substance when exposed to some environmental conditions .
- How is a chemical change different from a physical change at the surface of a material
- What is contact angle of a substance and its significant role when two materials surface are in contact
- Describe the role of contact angle during the wetting process of a material substance
- What is a detergent and justified reasons for its variable composition

❑ Group work discussional questions:

- Give a detailed descriptive account of functional classification of surface active agents
- Give a detailed descriptive account of structural classification of surface active agents
- Explain the process of desiccation and decolourization during the process of asorption