All the Important Formulae that a student should know from….

XII Chemistry

CHAPTER 5 - SURFACE CHEMISTRY

1. Freundlich Adsorption isotherm:

$$\frac{x}{m} = kP^{1/n}\,(n > 1)$$

Where x- mass of the gas adsorbed on mass m of the adsorbent at pressure P.

k and n depends upon the nature of the adsorbent and the gas at particular temperature.

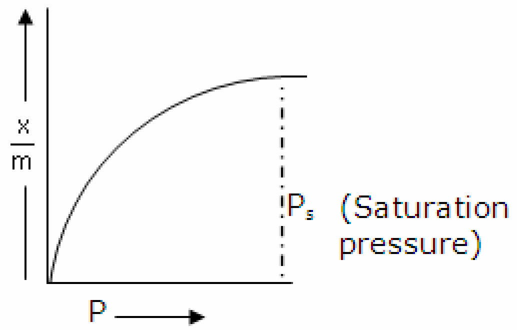
$$\log\frac{x}{m} = \log k + \frac{1}{n}\log P$$

Freundlich's equation approximately describes the behaviour of adsorption from solution with a difference that instead of pressure, concentration of the solution is taken into account, i.e.,

$$\frac{x}{m} = k\,C^{1/n}\,(n > 1)$$

Where *C* is the equilibrium concentration, i.e., when adsorption is complete. On taking logarithm of the above equation, we have

$$\log\frac{\quad}{m} = \log k + \frac{\quad}{n}\log C$$

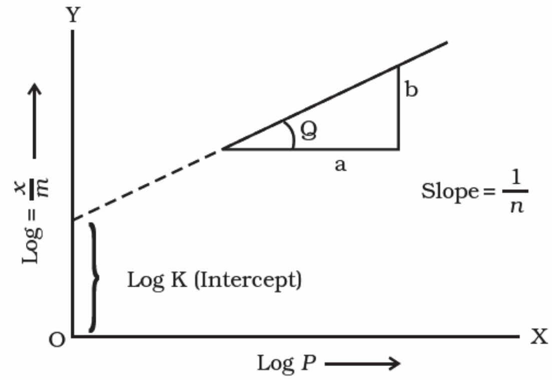


Freundlich adsorption isotherm

Taking logarithm on both sides, we get,

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

If we plot a graph between log $\frac{x}{m}$ and log P, we get a straight line.



The slope of the line is $\frac{1}{n}$ and intercept on log ($\frac{x}{m}$) axis will be equal to log k.

2. Catalyst: Substances which alter the rate of a chemical reaction and themselves remain chemically and quantitatively unchanged after the reaction are known as catalysts and the phenomenon is known as catalysis.

3. Promoters. Those substances which increase the activity of catalyst are called promoters e.g., Mo is promoter whereas Fe is catalyst in Haber's Process.

   $N_2\,(g) + 3H_2\,(g) \xrightleftharpoons[Mo(s)]{Fe(s)} 2NH_3\,(g)$

4. Catalytic poisons (Inhibitors). The substances which decrease the activity of catalyst are called catalytic poisons or inhibitors e.g., arsenic acts as catalytic poison in the manufacture of sulphuric acid by 'contact process.'

5. Types of catalysis:
   a. Homogeneous catalysis. When the catalyst and the reactants are in the same phase, this kind of catalytic porcess is known as homogeneous catalysis.
   b. Heterogeneous catalysis. When the catalyst and the reactants are in different phases, the catalytic process is said to be heterogeneous catalysis.

6. Activity of catalyst. The abiloity of a catalyst to increase the rate of a chemical reaction is called activity of a catalyst.

7. Selectivity of catalyst. It is the ability of catalyst to direct a reaction to yield particular products (excluding others). For example:

   CO and H_2 react to form different products in presence of different catalysts as follows:

   a) $CO(g) + 3H_2(g) \xrightarrow{Ni} CH_4(g) + H_2O(g)$

   b) $CO(g) + 2H_2(g) \xrightarrow{Cu/ZnO-Cr_2O_3} CH_3OH(g)$

   c) $CO(g) + H_2(g) \xrightarrow{Cu} HCHO(g)$

8. Shape – selective catalysis. The catalysis which depends upon the pore structure of the catalyst and molecular size of reactant and product molecules is called shape- selective catalysis. E.g. Zeolites are shape – selective catalysts due to their honey- comb structure.

9. Enzymes. Enzymes are complex nitrogenous organic compounds which are produced by living plants and animals. They are actually protein molecules of high molecular mass. They are biochemical catalysts

10. Steps of enzyme catalysis:

(i) Binding of enzyme to substrate to form an activated complex

$$E + S \rightleftharpoons ES^{\neq}$$

ii)Decomposition of the activated complex to form product

$$E\,S^{\neq} \rightarrow E + P$$

11.Characteristics of enzyme catalysis:

i) They are highly efficient. One molecule of an enzyme can transform 10^6 molecules of reactants per minute.

ii) They are highly specific in nature, e.g., urease catalysis hydrolysis of urea only.

iii) They are active at optimum temperature (298 – 310 K). The rate of enzyme catalysed reaction becomes maximum at a definite temperature called the optimum temperature.

iv)They are highly active at a specific pH called optimum pH.

v) Enzymatic activity can be increased in presence of coenzymes which can be called as promoters.

Activators are generally metal ions Na^+, Co^{2+} and Cu^{2+} etc. They weakly bind to enzyme and increase its activity.

vi) Influence of inhibitors (poison). Enzymes can also be inhibited or poisoned by the presence of certain substances.

12. Distinction between true solution, colloids and Suspension.

True solution	Colloids	Suspension
It is homogeneous	It appears to be homogeneous but actually heterogeneous	It is heterogeneous
Its particle size is less than 1 nm	Its particle size is 1 nm to 100 nm	Its particles are larger that 100 nm
It passes through filter paper	It passes through ordinary filter paper but not through ultra-filters	It does not pass through filter paper
It does not show Tyndall effect	It shows Tyndall effect	It does not show Tyndall effect appreciably
It has higher value of colligative property	It has low value of collligative property	It has very low value of colligative property
Its particles cannot be seen microscope	Its particles can be seen by powerful microscope due to scattering of light	Its particles can be seen even with naked eye

13. Colloids: A colloid is a heterogeneous system in which one substance is dispersed as very fine particles in another substance called dispersed medium.
14. Dispersed phase: The substance which is dispersed as very fine particles is called dispersed phase.
15. Dispersion medium: The substance present in larger quantity is called dispersion medium.

16. Classification of colloids on the basis of the physical state of dispersed phase and dispersion medium:

Dispersed phase	Dispersion medium	Name	Examples
Solid	Gas	Aerosol	Smoke, dust
Solid	Liquid	Sol	Paints
Solid	Solid	Solid sol	Coloured gem tones
Liquid	Solid	Gel	Jellies, cheese
Liquid	Liquid	Emulsion	Milk, hair cream
Liquid	Gas	Aerosol	Fog, mist, cloud
Gas	Solid	Solid sol	Pumice stone, foam rubber
Gas	Liquid	Foam	Whipped cream, froth

17. Classification of colloids on the basis of nature of interaction between dispersed phase and dispersion medium :

Lyophobic sols	Lyophilic sols
These colloids are liquid hating.	These colloids are liquid loving.
In these colloids the particles of dispersed phase have no affinity for the dispersion medium.	In these colloids, the particles of dispersed phase have great affinity for the dispersion medium.
They are not stable.	They are stable.
They can be prepared by mixing substances directly.	They cannot be prepared by mixing substances directly. They are prepared only by special methods
They need stabilizing agents for their preservation.	They do not need stabilizing agents for their preservation.
They are irreversible sols.	They are reversible sols.

18. Classification of colloids on the basis of types of particles of the dispersed phase:
    a. Multimolecular colloids: The colloids in which the colloidal particles consist of aggregates of atoms or small molecules. The diameter of the colloidal particle formed is less than 1 nm.
    b. Macromolecular colloids: These are the colloids in which the dispersed particles are themselves large molecules (usually polymers). Since these molecules have dimensions comparable to those of colloids particles, their dispersions are called macromolecular colloids, e.g., proteins, starch and cellulose form macromolecular colloids.
    c. Associated colloids (Micelles). Those colloids which behave as normal, strong electrolytes at low concentrations, but show colloidal properties at higher concentrations due to the formation of aggregated particles of colloidal dimensions. Such substances are also referred to as associated colloids.
19. Kraft Temperature (T_k): Micelles are formed only above a certain temperature called Kraft temperature.
20. Critical Micelle Concentration (CMC): Micelles are formed only above a particular concentration canned critical micelle concentration.
21. Soaps: Soaps are sodium or potassium salts of higher fatty acids e.g., sodium stearate $CH_3(CH_2)_{16}COO^-Na^+$, Sodium palmitate $CH_3(CH_2)_{14}COO^-Na^+$.
22. Cleansing action of soaps and detergents: Hydrocarbon parts of soap molecules from micelle entrap the dirt and grease whereas carboxylate ions attract water. Since polar groups are attracted towards water, the oils droplets, surrounded by stearate ion, are now pulled in water and removed from the dirty surface.
23. Methods of preparation of colloids:

   a. Chemical methods: Colloids can be prepared by chemical reactions leading to the formation of molecules. These molecules aggregate leading to formation of sols.
   b. Electrical disintegration or Bredig's Arc method: In this method, electric arc is truck between electrodes of the metal immersed in the dispersion medium. The intense heat produced vaporizes the metal which then condenses to form particles of colloidal size.
   c. Peptization: Peptization may be defined as the process of converting a precipitate into colloidal sol by shaking it with dispersion medium in the presence of a small amount of electrolyte. The electrolyte used for this purpose is called peptizing agent.

24. Purification of colloidal sols:
   a. Dialysis: It is a process of removing a dissolved substance from a colloidal solution by means of diffusion through a suitable membrane.
   b. Electro dialysis. The process of dialysis is quite slow. It can be made faster by applying an electric field if the dissolved substance in the impure colloidal solution is only an electrolyte.
   c. Ultrafiltration: Ultrafiltration is the process of separating the colloidal particles from the solvent and soluble solutes present in the colloidal solution by specially prepared filters, which are permeable to all substances except the colloidal particles.
   d. Ultracentrifugation. In this process, the colloidal solution is taken in a tube which is placed in ultracentrifuge. On rotating the tube at very high speed, the colloidal particles settle down at the bottom of the tube and the impurities remain in solution called centrifugate. The settled particles are mixed with dispersion medium to regenerate the sol.

25. Properties of colloids:

a. Colour: The colour of colloidal solution depends upon the wavelength of light scattered by the colloidal particles which in turn depends upon the nature and size of particles.The colour also depends upon the manner in which light is received by the observer.

b. Brownian movement. Colloidal particles move in zig – zag path. This type of motion is due to colliding molecules of dispersion medium constantly with colloidal particles.

c. Colligative properties: The values of colligative properties (osmotic pressure, lowering in vapour pressure, depression in freezing point and elevation in boiling point) are of small order as compared to values shown by true solutions at the same concentrations.

d. Tyndall effect: The scattering of a beam of light by colloidal particles is called Tyndall effect. The bright cone of light is called the Tyndall cone.

e. Charge on colloidal particles: Colloidal particles always carry an electric charge. The nature of this charge is the same on all the particles in a given colloidal solution and may be either positive or negative.

Positively charged colloids	Negatively charged colloids
$Fe(OH)_3$, $Al(OH)_3$	Metals like copper gold, silver, platinum sols due to capture of electrons in Bredig's arc method
Hydrated metallic oxides such as $Fe_2O_3 . xH_2O$,$Cr_2O_3 . xH_2O$,$Al_2O_3 . xH_2O$	Metallic sulphides like As_2S_3, Sb_2S_3 sols
Basic dyes like malachite green, methylene blue sols	Acid dyes like eosin, methyl orange, Congo red sols
Haemoglobin (blood)	Starch sol, gum, gelatin, clay, charcoal, egg albumin, etc.

   f. Helmholtz electrical double layer. When the colloidal particles acquire negative or positive charge by selective adsorption of one of the ions, it attracts counter ions from the medium forming a second layerThe combination of these two layers of opposite charges around colloidal particles is called Helmholtz electrical double layer.
   g. Electrokinetic potential or zeta potential: The potential difference between the fixed layer and the diffused layer of opposite charges is called electrokinetic potential or zeta potential.
   h. Electrophoresis: The movement of colloidal particles under an applied electric potential is called electrophoresis.
   i. Coagulation or precipitation: The process of settling of colloidal particles as precipitate is called coagulation.
      Hardy – Schulze Rules:
      i) Oppositely charged ions are effective for coagulation.
      ii) The coagulating power of electrolyte increases with increase in charge on the ions used for coagulation, e.g.
      $Al^{3+} > Ba^{2+} > Na^{+}$ for negatively charged colloids.
      $[Fe\,(CN)_6]^{4-} > PO_4^{3-} > SO_4^{2-} > Cl^{-}$ for positively charged colloids

26. Types of emulsions:

a. Water dispersed in oil: When water is the dispersed phase and oil is the dispersion medium. E.g. butter
b. Oil dispersed in water: When oil is the dispersed phase and water is the dispersion medium. E.g. milk

27. Emulsification: The process of stabilizing an emulsion by means of an emulsifier.
28. Emulsifying agent: The substance which are added to stabilize the emulsions are called emulsifying agents or emulsifiers. E.g. soaps, gum

29. Demulsification: The process of breaking an emulsion into its constituent liquids is called demulsification by freezing, boiling, centrifugation or some chemical methods.