1. Give reason why a finely divided substance is more effective as an absorbent?

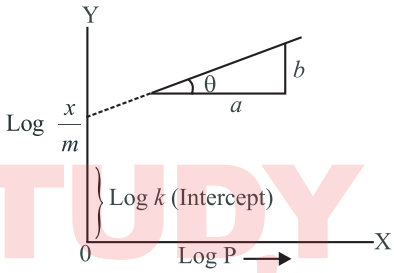
Sol. Finely divided substance has large surface area and hence greater adsorption.

2. What is an adsorption isotherm? Describe Freundlich adsorption isotherm.

Sol. Adsorption isotherm represents the variation of the mass of the gas adsorbed per gram of the adsorbent with pressure at constant temperature.

Freundlich Adsorption Isotherm:

Freundlich, in 1909, gave an empirical relationship between the quantity, of gas adsorbed by unit mass of solid adsorbent and pressure at a particular temperature. The relationship can be expressed by the following equation:



$$\frac{x}{m} = k\,P^{1/n} \quad (n>1) \qquad \text{...(i)}$$

where x is the mass of the gas adsorbed on mass 'm' of the adsorbent at pressure P, k and n are constants which depend on the nature of the adsorbent and the gas at a particular temperature.

The relationship is generally represented in the form of a curve where mass of the gas adsorbed per gram of the adsorbent is plotted against pressure. These curves indicate that at a fixed pressure, there is a decrease in physical adsorption with increase in temperature. These curves always seem to approach saturation at high pressure.

Taking log of equation (i), we get

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

3. What role does adsorption play in heterogeneous catalysis?

Sol. In heterogeneous catalysis, generally the reactants are gaseous, whereas catalyst is a solid. The reactant molecules are adsorbed on the surface of the solid catalyst by physical adsorption or chemisorption. As a result, the concentration of the reactant molecules on the surface increases further leading to increase in rate of reaction. Alternatively, one of the reactant molecules undergo fragmentation on the surface of the solid catalyst

producing active species which react faster. The product molecules in either case have no affinity for the solid catalyst and are de-adsorbed making the surface free for fresh adsorption.

4. Why is adsorption always exothermic?

Sol. When a gas is adsorbed on the surface of a solid, its entropy decreases (i.e. ΔS is negative).

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

For a process to be spontaneous, ΔG must be negative. As here, ΔS is negative, therefore, $T\Delta S$ is positive

ΔG can be negative only if ΔH is negative.

Hence, adsorption is always exothermic.

5. Why is hydrophobic sol easily coagulated?

Sol. The stability of hydrophobic sol is only due to the presence of charge on the colloidal particles. If charge is removed, for example by addition of suitable electrolytes, the particles will come nearer to each other to form aggregate (i.e. they will coagulate and settle down). On the other hand, the stability of hydrophilic sol is due to charge as well as solvation of the colloidal particles. Thus, for coagulation to occur easily both the mentioned factors have to be removed.

6. What is the difference between multi-molecular and macro-molecular colloids? Give one example of each. How are associated colloids different from those two types of colloids?

Sol. Comparison of some important characteristic of multi-molecular, macro-molecular and associated colloids.

Multi-molecular Colloids	*Macro-molecular Colloids*	*Associated Colloids*
(a) They are formed by the aggregation of a large number of atoms or molecules which generally have diameters less than 1 nm.	(a) They are molecules of large size.	(a) They are formed by the aggregation of a large number of ions in concentrated solution.
(b) Examples – sols of gold and sulphur.	(b) Examples – polymers like rubber, nylon, starch, protein.	(b) Examples – soap sol.

(c) Their molecular masses are not very high.	(c) They have high molecular masses.	(c) Their molecular masses are generally high.
(d) Their atoms or molecules are held together by weak van der Waal's force.	(d) Due to long chain, the van der Waal's force holding them are comparatively stronger.	(d) Higher is the concentration, greater are the van der Waal's forces.

7. Explains what is observed when

(a) an electrolyte is added to ferric hydroxide sol.

(b) an emulsion is subjected to centrifugation.

(c) direct current is passed through a colloidal sol.

(d) a beam of light is passed through a colloidal solution.

Sol. (a) The positively charged colloidal particles of $Fe(OH)_3$ get coagulated by the oppositely charged Cl^- ions provided by NaCl.

(b) The constituent liquids of the emulsion separate out (i.e. demulsification occurs).

(c) On passing direct current, colloidal particles move towards the oppositely charged electrode where they lose their charge and get coagulated.

(d) Scattering of light by the colloidal particles takes place and the path of light becomes visible (Tyndall effect).

8. What is demulsification? Name two demulsifiers.

Sol. The process of separation of the constituent liquids of an emulsion is called demulsification. Demulsification can be done by centrifuging or boiling.

9. Describe some features of catalysis by zeolites.

Sol. Features of catalysis by zeolites are:

(a) Zeolites are hydrated aluminosilicates which have a three dimensional network structure containing water molecules in their pores.

(b) To use them as catalyst, they are heated so that water of hydration present in the pores in lost and the pores become vacant.

(c) The size of the pores varies from 260 to 740 pm. Thus, only those molecules can be adsorbed in those pores and catalysed whose size is small enough to enter these pores. Hence, they act as molecular sieves or shape-selective catalysts.

ZSM-5 (Zeolite sieve of molecular porosity-5) is used in petroleum industry. It converts alcohols into petrol by first dehydrating them to form a mixture of hydrocarbons.

$$\text{Alcohols} \xrightarrow[\text{Dehydration}]{\text{ZSM}-5} \text{Hydrocarbons}$$

10. Explain the following terms with suitable examples:

(a) Alcosol (b) Aerosol

(c) Hydrosol

Sol. (a) Alcosol: It is a colloidal dispersion having alcohol as the dispersion medium (e.g. colloidal – a colloidal sol of cellulose – a colloidal sol of cellulose nitrate in ethyl alcohol).

(b) Aerosol: It is a colloidal dispersion of a liquid in a gas (e.g. fog).

(c) Hydrosol: It is a colloidal sol of a solid in water as the dispersion medium (e.g. starch sol or gold sol).

11. Comment on the statement, 'Colloid is not a substance but state of a substance'.

Sol. Colloid is not a substance but state of a substance because the same substance may exist as a colloid under certain conditions and as a crystalloid under certain other conditions.

For example, NaCl in water behaves as a crystalloid while in benzene it behaves as a colloid.

Similarly, dilute soap solution behaves like a crystalloid while concentrated solution behaves as a colloid (called associated colloid). It depend upon the size of the particles (i.e. the state in which the substances exists). If the size of the particles lies in the range 1 to 1000 nm, it is in the colloidal state.