SURFACE CHEMISTRY

TOPIC-1

Concepts of adsorption and absorption, Langmuir and Freundlich adsorption isotherms and effects of temperature on surface phenomena, Catalysis and types of catalysis

VERY SHORT ANSWER QUESTIONS

1. What is adsorption?

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.

2. What is absorption?

When a substance is uniformly distributed throughout the bulk of another substance, this shows that absorption has taken place. It occurs at the uniform rate throughout the body of the material

3. What is physorption?

Physical adsorption : In physisorption Weak – Vanderwall's forces exist between adsorbent and adsorbate.

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

4. What is Chemisorption?

Chemical adsorption: In chemisorption strong chemical forces will exists between adsorbate and adsorbent and these forces may be ionic or covalent.

Eg: Adsorption of H_2, N_2, O_2 gases by Ni, Pd, Pt etc..

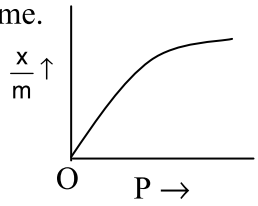
5. Give the mathematical equation relating the pressure (P) and the extent of adsorption (x/m) of gas on metal.

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,

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

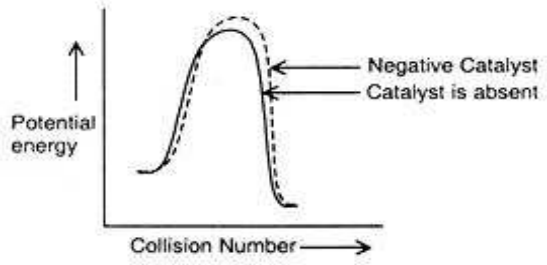


6. What is a catalyst?

Catalysis is the phenomenon by which the rate of a reaction is altered (accelerated or retarded) by the presence of a substance, which itself remains unchanged chemically in the process. The substance altering the rate of the reaction is a catalyst.

7. **What is negative catalyst?**

(ii) Negative catalysis (Inhibitor or retarder): Chemical reactions are sometimes retarded by the presence of a foreign substance the substance is known as a negative catalyst.



Examples

Alcohol, Acetanilide: Prevents oxidation of Na_2SO_3 by air

H_3PO_4: Prevents decomposition of H_2O_2.

8. **What is auto catalysis?**

Auto catalysis: In this type of catalysis, one of the products of the reaction catalyses the reaction. In the oxidation of oxalic acid by $KMnO_4$, Mn^{2+} ion formed is known to accelerate the reaction. So, when $KMnO_4$ solution is run into warm solution of oxalic acid (+ dil. H_2SO_4), initially there is a time lag before decolourisation occurs; as more $KMnO_4$ is added, the decolourisation becomes almost instantaneous.

9. What is Homogeneous catalysis?

Homogeneous catalysis: A catalytic process in which the catalyst is in the same phase as the reactant is called homogenous catalysis.

$$2SO_2(g) + O_2(g) \xrightarrow{NO} 2SO_3(g) \text{ (Lead chamber process)}$$

$$C_{12}H_{22}O_{11}(aq.) + H_2O \xrightarrow{H^+(aq)} C_2H_{12}O_6(aq) + C_6H_{12}O_6(aq.)$$
(Inversion of cane sugar)

10. What is Heterogeneous catalysis?

Heterogeneous catalysis: A catalytic process in which the catalyst and the reactants are in different phases is called heterogeneous catalysis. This process is also called contact or surface catalysis.

Examples

(i) $2H_2O_2(l) \xrightarrow{Pt} 2H_2O(l) + O_2(g)$

(ii) $2SO_2(g) + O_2(g) \xrightarrow{Pt\ asbestos} 2SO_3(g)$

(iii) $N_2(g) + 3H_2(g) \xrightarrow{Fe+Mo} 2NH_3(g)$

(iv) $4NH_3(g) + 5O_2(g) \xrightarrow{Pt\ gauze} 4NO(g) + 6H_2O(l)$

(v) $CO(g) + 2H_2(g) \xrightarrow{ZnO+Cr_2O_3} CH_3OH(l)$

11. **What is induced catalysis?**

Induced catalyst: When one reaction influences the rate of other reaction, which does not occur under ordinary conditions, the phenomenon is known as induced catalysis.

SHORT ANSWER QUESTIONS

1. **Explain the types of adsorptions.**

Adsorption: The phenomenon in which the molecules of a substance are attracted and adhered to the surface of a solid or liquid. There are two types of adsorption. They are;

- **Physical adsorption**
- **Chemical adsorption**

Physical adsorption: In physical adsorption Weak – Vander wall's forces exist between adsorbent and adsorbate.

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

Chemical adsorption: In chemisorption strong chemical forces will exists between adsorbate and adsorbent and these forces may be ionic or covalent.

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

2. **Write the differences between Physical adsorption and chemical adsorption.**

Adsorption	Absorption
1. Charcoal adsorbs acetic acid 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.

3. Explain the factors that effect the adsorption of gases on metals.

Ans:

Adsorption of a gas by solids:

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1. 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.

2. 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

4. Explain Freundlich adsorption isotherm

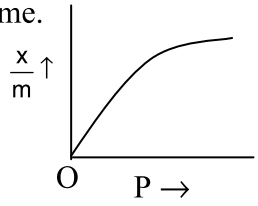
Adsorption isotherm : These adsorption isotherms will explain the variation magnitude of adsorption with pressure at given temperature. These are obtained by plotting magnitude of adsorption Vs pressure.

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.

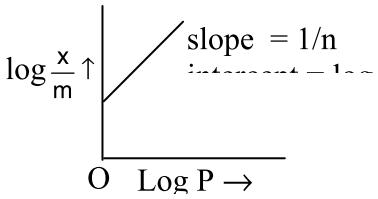
Freundlich adsorption isotherm,

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

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



$\frac{x}{m}$ **= 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 *l* < 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'.

5. **Explain Langmuir adsorption isotherm**

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 are applicable for uni molecular layer adsorption.

Both Freundlich and langmuir adsorption isotherms hold good at low pressure and fail at high pressure.

LONG ANSWER QUESTIONS

1. **Explain the terms adsorption and absorption with at least two examples. Give the differences between physical adsorption and chemical adsorption.**

Adsorption

The phenomenon of existence of a substance in different concentrations at the surface of another substance than in the bulk phases is called **adsorption**.

The substance whose surface **adsorbs** molecular species of another substance is called adsorbent and the substance, which gets adsorbed, is called **adsorbate.**

Ex: 1. Charcoal adsorbs gases. Charcoal adsorbs acetic acid; Silica gel adsorbs moisture.

2. Charcoal adsorbs gases. Charcoal adsorbs acetic acid; Silica gel adsorbs moisture

Absorption

When a substance is uniformly distributed throughout the bulk of another

substance, this shows that absorption has taken place. It occurs at the uniform rate throughout the body of the material.
Ex: Absorption of water by Sponge.

In certain cases, both the adsorption and the absorption take place simultaneously and it is not easy to distinguish them. Such substance is said to be absorbed and the phenomenon is known as absorption.

The differences between physisorption and chemisorption are;

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
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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.

2. **Give an account of adsorption of gases by metals with examples.**

Adsorption of Gases on Solids

The extent of adsorption of a gas on the surface of a solid depends on the following factors:
(a) Nature of gas
(b) Nature of solid
(c) Specific area of solid
(d) Pressure of gas
(e) Temperature
(f) Activation of solid

(i) Nature of gas:

Since physical adsorption is non-specific in nature, any gas will be adsorbed on the surface of a solid to some extent or other. However, under any given conditions of temperature and pressure, easily liquefiable gases such as NH_3, CH_4HCI, CI_2, SO_2, CO etc. are adsorbed more than permanent gases like H_2, O_2, N_2 etc. Chemisorption is specific in nature. Therefore, only those gases will be adsorbed which form chemical bonds with it.

(ii) Nature of solid:

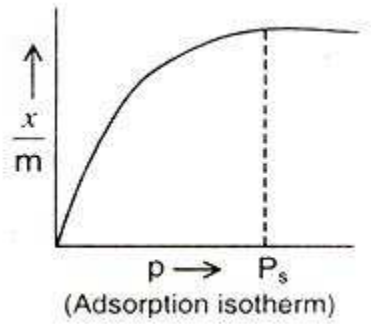
Activated charcoal is the most common adsorbent for easily liquefiable gases. Poisonous gases such as CH_4 and CO fall in this group. Therefore, it is used in gas masks. Other gases such as O_2, H_2 and N_2 adsorb more on metals such as Ni, Pt and Pd.

(iii) Specific area of solid:

Specific area of an adsorbent is the surface area available for adsorption per gm of adsorbent. Greater the specific area of an adsorbent, greater will be the adsorption. The specific area of an adsorbent can be increased by making the surface rough. The pores must be large enough to allow penetrations of gas molecules.

(iv) Pressure of a gas:

As physical adsorption is reversible, it is accompanied by decrease in pressure. Therefore, it is expected that at a given temperature the extent of adsorption will increase with the increase of pressure of the gas. The extent of adsorption is measured as x/m where m is the mass of adsorbent and x that of adsorbate. If the physical adsorption is limited to uni molecular layer, the plot of x/m vs. equilibrium pressure at a constant temperature is as shown.



(Adsorption isotherm)

It is evident from the graph that at a certain pressure the adsorption reaches a maximum value i.e. the adsorption becomes saturated and the corresponding pressure is called saturation pressure (Ps). Beyond this pressure the adsorption remains constant.

At low pressures, x/m varies linearly with p
$\therefore x/m \mu p^1$ or $x/m = kp^1$

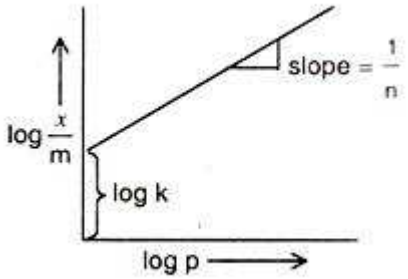
At high pressures, x/m is independent of p
$\therefore x/m \mu p^1$ or $x/m = kp^0$

At intermediate pressures, the variation of x/m vs p can be expressed as x/m μ $p^{(1/n)}$ where

$n > 1$.

or $x/m = k\, p^{(1/n)}$

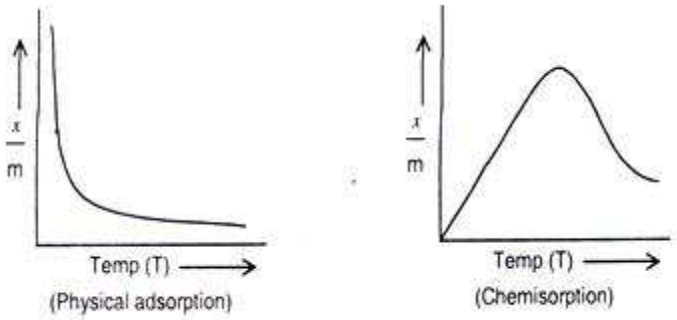
or $\log x/m = \log k + 1/n \log p$



This is called **Freundlich adsorption isotherm.**

(v) Temperature

As adsorption is accompanied by release of heat energy, so in accordance with Le-Chatelier's principle, the increase of temperature should decrease the extent of adsorption. This has indeed been found to be so. A plot of x/m vs. temperature at constant pressure is called adsorption isobar. In the case of physical adsorption x/m decreases with increase of temperature. However, in the case of chemisorption x/m initially increases with temperature and then decreases as shown below. The initial increase is due to the fact that chemisorptions require activation energy.



(vi) Activation of solid:

Activation of adsorbent means increasing its adsorbing power. This is increased by increasing specific area either by making the surface rough or by breaking the solid into smaller particles. But care must be taken so that particles do not become very

small, otherwise the inter-particle spaces will be too small to allow penetration of gas molecules.

3. **Give an account of Langmuir adsorption isotherm.**

Langmuir Isotherm

Langmuir adsorption isotherm is based on the following assumptions.

i) Adsorption does not proceed beyond monolayer coverage.

ii) All the sites available on the adsorbent surface are equivalent and the surface is perfectly uniform, that is flat.

iii) The ability of a gas molecule to get adsorbed at a particular site is independent of the occupation of neighboring sites. This implies that there is no interaction between adjacent adsorbed molecules.

iv) A dynamic equilibrium exists between the adsorbed molecules and the free gas molecules.

Initially, since the surface is completely bereft of any gas molecules, every molecule of the gas that strikes the surface of solid may get adsorbed. After some time, only those gas molecules may get adsorbed which strike the part of the surface that is not already covered. This means, that initially the rate of adsorption is high and then decreases as less surface is available for adsorption.

Since a dynamic equilibrium exists between the adsorbed molecules and the free gas molecules, it implies that the adsorbed molecules also undergo desorption, probably due to thermal agitation. When the rate of adsorption equals the rate of desorption, dynamic equilibrium is attained.

If q is the fraction of the total available surface covered with gas molecules, at any instant, then (1-q) is the fraction of the surface of the solid which is empty. From kinetic theory of gases, it is known that the rate at which gas molecules collide per unit area of a surface is directly proportional to the pressure of the gas. The rate of adsorption depends on both the pressure of the gas and fraction of surface available for adsorption. Hence,

Rate of adsorption = K_a (1-q) P …..(3)

Rate of desorption = K_d (q) …..(4)

At equilibrium, the rate of adsorption is equal to the rate of desorption i.e.,

K_a (1-q) P = K_d (q)

$$\text{or, } \theta = \frac{K_a P}{K_d + K_a P}$$

$$\text{or, } \theta = \frac{KP}{1+KP} \qquad .....(5)$$

$$\text{where } K = \frac{K_a}{K_d}$$

Now, the extent of adsorption (x/m) is proportional to the fraction of surface covered. Therefore,

$$\frac{x}{m} = k\theta = \frac{kKP}{1+KP} \quad .....(6)$$

$$\text{or, } \frac{x}{m} = \frac{aP}{1+KP} \qquad .....(7) \qquad (a = kk)$$

This is the equation which describes the Langmuir adsorption isotherm. Here a and K are the Langmuir parameters and are characteristic of a particular system at a particular temperature.

At very high pressure, the Langmuir isotherm acquires the limiting form.

$$\frac{x}{m} = \frac{a}{k} \qquad .....(8)$$

At very low pressure,

$$\frac{x}{m} = aP \qquad .....(9)$$

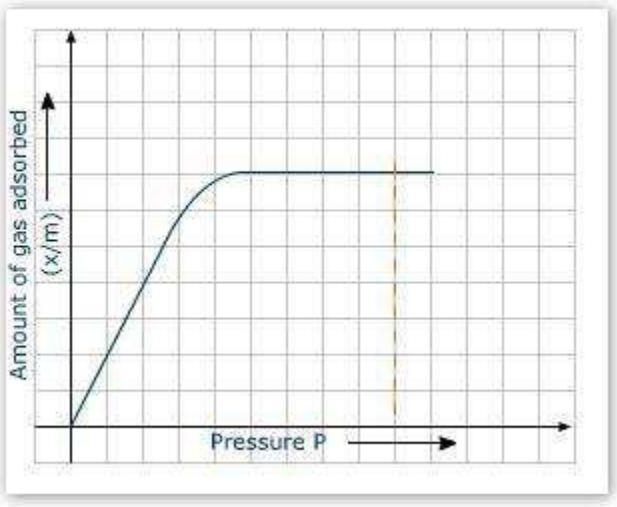
i.e., the extent of adsorption is proportional to pressure.

The parameters a and K can be determined by taking the inverse form of equation 7.

$$\frac{m}{x} = \frac{1}{ap} + \frac{K}{a} \quad .....(10)$$

A plot of m/x against 1/P gives a straight line with slope and intercept equal to 1/a and K/a respectively.

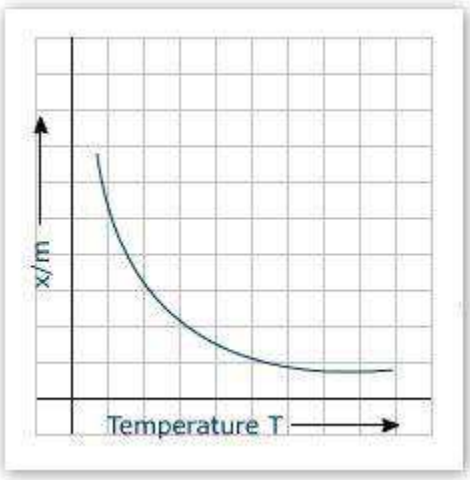
Langmuir isotherm shows that at low pressures of the adsorbate, the extent of adsorption is linear and at high pressure the extent of adsorption is a constant. This form of isotherm is shown in figure 7.4.



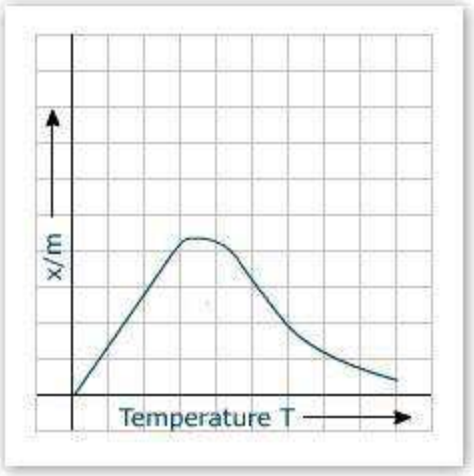
Langmuir adsorption isotherm

v) Effect of temperature

Most adsorption processes are exothermic; hence adsorption decreases with increasing temperature. This is especially true for physisorption. For chemisorption, extent of adsorption initially increases with temperature and then decreases. The plot of extent of adsorption versus temperature T at a constant pressure is called the adsorption isobar. How the extent of adsorption (x/m) varies with temperature for physisorption and chemisorption as shown in figures 7.5 (a) and 7.5 (b).



Physical adsorption at a given pressure



Chemical adsorption at a given pressure

In chemisorption, the initial increase of x/m with temperature is due to the fact that like chemical reactions, chemisorption also requires activation energy.

(vi) Activation of adsorbent

Activation of an adsorbent implies enhancing the adsorptive powers of an adsorbent. This is done by either increasing the specific area of the adsorbent by breaking the solid adsorbent into fine pieces or activating the surface of the adsorbent by specific treatments. How charcoal is activated is already discussed in the section pertaining to nature of the adsorbent.

4. **What is catalysis? How catalysis is classified? Give two examples for each.**

Catalysis is the phenomenon by which the rate of a reaction is altered (accelerated or retarded) by the presence of a substance, which itself remains unchanged chemically in the process. The substance altering the rate of the reaction is a catalyst.

Types of Catalysts

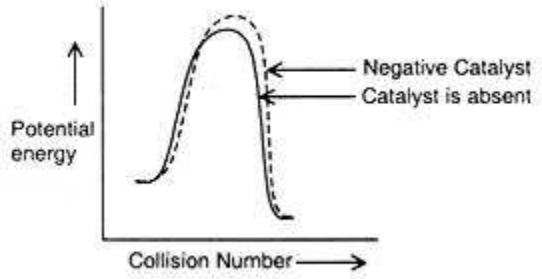
(i) Positive catalysis: The catalyst increases the rate of a reaction.

Example:

$$2SO_2 + O_2 \xrightarrow{V_2O_5} 2SO_3 \text{ (Contact process)}$$

$$C_2H_4 + H_2 \xrightarrow[\Delta]{Ni} C_2H_6 \text{ (Ethane)}$$

(ii) Negative catalysis (Inhibitor or retarder): Chemical reactions are sometimes retarded by the presence of a foreign substance the substance is known as a negative catalyst.



Examples
Alcohol, Acetanilide: Prevents oxidation of Na_2SO_3 by air
H_3PO_4: Prevents decomposition of H_2O_2

(iii) Auto catalysis: In this type of catalysis, one of the products of the reaction catalyses the reaction. In the oxidation of oxalic acid by $KMnO_4$, Mn^{2+} ion formed is known to accelerate the reaction. So, when $KMnO_4$ solution is run into warm solution of oxalic acid (+ dil. H_2SO_4), initially there is a time lag before decolourisation occurs; as more $KMnO_4$ is added, the decolourisation becomes almost instantaneous.

5. Explain Homogeneous and Heterogeneous catalysis. Give two examples for each.

Types of Catalysts
(iv) Homogeneous catalysis: A catalytic process in which the catalyst is in the same phase as the reactant is called homogenous catalysis.

$$2SO_2(g) + O_2(g) \xrightarrow{NO} 2SO_3(g) \text{ (Lead chamber process)}$$

$$C_{12}H_{22}O_{11}(aq.) + H_2O \xrightarrow{H^+(aq)} C_2H_{12}O_6(aq) + C_6H_{12}O_6(aq.)$$
(Inversion of cane sugar)

(v) Heterogeneous catalysis: A catalytic process in which the catalyst and the reactants are in different phases is called heterogeneous catalysis. This process is also called contact or surface catalysis.

Examples

(i) $2H_2O_2(l) \xrightarrow{Pt} 2H_2O(l) + O_2(g)$

(ii) $2SO_2(g) + O_2(g) \xrightarrow{Pt\ asbestos} 2SO_3(g)$

(iii) $N_2(g) + 3H_2(g) \xrightarrow{Fe+Mo} 2NH_3(g)$

(iv) $4NH_3(g) + 5O_2(g) \xrightarrow{Pt\ gauze} 4NO(g) + 6H_2O(l)$

(v) $CO(g) + 2H_2(g) \xrightarrow{ZnO+Cr_2O_3} CH_3OH(l)$

(vi) Induced catalyst: When one reaction influences the rate of other reaction, which does not occur under ordinary conditions, the phenomenon is known as induced catalysis.

Examples of induced catalysis:
(1) Sodium arsenite solution is not oxidised by air. If, however, air is passed through a mixture of the solution of sodium arsenite and sodium sulphite, both of them undergo simultaneous oxidation. The oxidation of sodium sulphite, thus, induces the oxidation of sodium arsenite.
(2) The reduction of mercuric chloride ($HgCI_2$) with oxalic acid is very slow, but potassium permanganate is reduced readily with oxalic acid. If, however, oxalic acid is added to a mixture of $KMnO_4$ and $HgCI_2$, both are reduced simultaneously. The reduction of potassium permanganate, thus, induces the reduction of $HgCI_2$.

6. What are the characteristics of a catalyst?

Characteristics of Catalytic Reactions
(i) The catalyst remains unchanged in amount and chemical composition at the end of the reaction; it may, however, undergo considerable change in physical form.

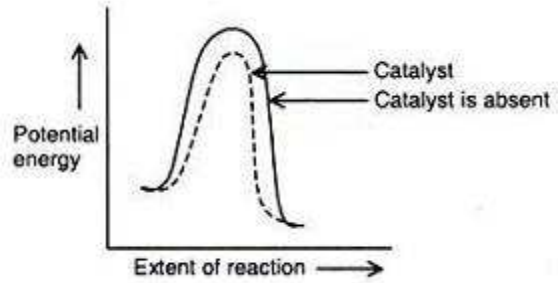
(ii) A small quantity of the catalyst is capable of producing the desired effect.

(iii) The action of a catalyst is specific to a large extent. Thus, the decomposition of KCIO3 is catalyzed by MnO_2 but not by platinum.

(iv) The catalyst does not initiate a reaction; it merely accelerates the reaction that is already occurring.

(v) A catalyst does not alter the final state of equilibrium in a reversible reaction.

A certain minimum energy must be possessed by the reactants so that they may react and produce the products. This is called the activation energy (Ea) for the reaction. A catalyst is said to lower the activation energy and thus increase the rate of the reaction.

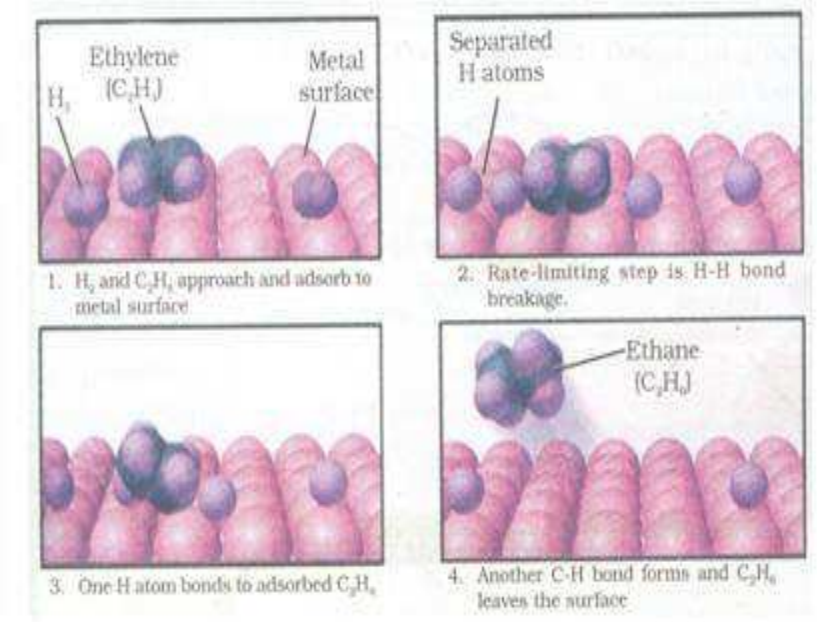


Thus, a catalyst increases the rate of a reaction by providing a pathway whose activation energy is lower than the activation energy of the uncatalysed reaction.

7. Explain the nature of Solid catalysts.

Nature of Solid Catalysts

Solid catalysts may be metals, metal oxides, metal sulphides, clays etc. These materials may be used in their pure form or in the form of their mixtures. Further, they may be crystalline, microcrystalline (in the form of fine particles) or amorphous.



Important features of solid catalysts:

1. Activity: The activity of a catalyst depends upon the strength of chemisorptions to a large extent. The reactant must adsorb reasonably strongly for the catalyst to be active but must not adsorb so strongly that they are immobilized and other reactants are left with no space on the catalyst surface adsorption. It has been found that for hydrogenation the catalytic activity increases as we go from group 5 metals to group 11 with maximum activity shown by group 7-9 elements of the periodic table.

$$2H_2(g) + O_2(g) \xrightarrow{Pt} 2H_2O(l)$$

2. Selectivity: The selectivity of a catalyst is its ability to direct a reaction to yield a particular product. For example, starting with H_2 and CO using different catalysts we get different products.

$$\text{(i)}\quad CO\,(g) + 3H_2\,(g) \xrightarrow{Ni} CH_4\,(g) + H_2O\,(g)$$

$$\text{(ii)}\quad CO\,(g) + 2H_2\,(g) \xrightarrow{Cu/ZnO-Cr_2O_3} CH_3OH\,(g)$$

$$\text{(iii)}\quad CO\,(g) + H_2\,(g) \xrightarrow{Cu} HCHO\,(g)$$

Action of a catalyst is highly specific (selective) in nature i.e., a given substance can act as a catalyst only in a particular reaction and not for all the reactions. It means a substance which acts as a catalyst in one reaction may fail to catalyze other reaction i.e., a catalyst is highly selective in nature.

SURFACE CHEMISTRY

TOPIC-2

Colloidal state and classification of colloids, gold number and related phenomena, emulsions and classification of emulsions, cleaning action of soap

VERY SHORT ANSWER QUESTIONS

1. **What is Lyophillic colloid? Give example.**

Ans: Lyophilic colloids (or) Hydrophilic colloids:

Strong attractions will exist between colloids particles and medium.

Eg: organic substances like Starch, RBC, Albumin, Blue gelatin etc., and certain polymers in organic medium also formed.

2. **What is Lyoohobic colloid? Give example.**

Ans: No attractions will exist between colloidal particles and medium

Eg: Metalsols, Metaloxidesols, Metalsulphide sols

3. **What is emulsion? Give example**.

Ans: **Emulsion:** Emulsion is liquid in liquid type colloid. These two liquids are immiscible with one another.

One of the liquid is water and other one is oil in nature.

Based on the relative amounts of these two liquids emulsions are two types

1) **Oil in water type:**

Eg : Milk [liquid disguised liquid water)

Kerosene oil in H_2O ; Vanishing cream.

2) **Water in oil type:**

Cold cream, stiff greases, cold liver oil

These emulsions are unstable. As they contain immiscible liquid

4. **What is Micelle? Give examples.**

Ans: Micelles:

It is the colloidal size particles formed by the spontaneous aggregation of soap anions or molecules at higher concentration (CMC). If the dispersed phase consists of micelles, such a colloid is called associated colloid. Soaps and detergents will form micelles at higher concentrations. The minimum concentration above which micelles are formed is called critical micellisation concentration.

Ex: At very low concentration soaps and detergents exist as true solution.

Soap : Sodium stearate: $C_{17}H_{35}COO^{-}Na^{\oplus}$

stearate : $C_{17}H_{35}COO^{-}$

5. **What is Gold sol?**

Ans: GOLD SOL: It is an aquasol or hydrosol. It is a lyophobic colloid. It is a solid in liquid type colloid. It is coagulated by adding small amount of electrolytes. Dispersion phase is gold particles and dispersion medium is water. It is prepared by **Bredig arc** method.

6. What is Cloud?

Ans: CLOUD: Cloud is an aerosol. It is a colloidal suspension of water droplets in air. It is a lyophobic colloid. Droplets in cloud precipitate as rain. It is a liquid in gas sol. Dispersion phase is droplets of water (liquid) and dispersion medium is air (gas).

7. What is milk?

Ans: MILK: It is an emulsion. It is oil in water (O/W) type emulsion. It is a liquid in liquid type colloid. Dispersion phase is droplets of liquid fat and dispersion medium is water. Milk on coagulation gives emulsified fat (casein). Milk cream from milk can be separated by centrifugation. Curding of milk is coagulation of milk. On souring lactose in milk converts to lacticacid which coagulates the milk.

8. What is emulsifying agent or emulsifier?

Ans: Emulsifier: Emulsifier or emulsifying agent is the substance which stabilizes the emulsion when added to it. Emulsifier stabilizes the emulsion by reducing the surface tension. Any hydrophilic colloid can act as emulsifier.

Eg : Gelatin, Egg albumin, Soap, Mercuric iodide etc

9. What is smoke?

Ans: SMOKE: It is an aerosol, A colloidal solution of carbon in air. A lyophobic colloid, dispersion phase is carbon and dispersion medium is air. A solid in gas sol. Carbon particles are precipitated electrically to avoid pollution in electrified chimney, where carbon particles can get discharged.

10. What is Gold number?

Ans: It is defined as the weight of protective colloid (in mg) which prevents the coagulation of a given gold solution on adding I ml o f 10% solution of sodium chloride.

11. **What is protective colloid?**

Ans: Some lyophillic colloids possess the property by which they protect lyophobic colloids from precipitation (or coagulation) when an electrolyte is added to it. Lyophillic colloids used for this purpose are called protective colloids.

Ex: Gelatin is lyophillic colloid which acts as protective colloid when added to gold sol. which is lyophobic.

SHORT ANSWER QUESTIONS

1. **What is colloidal solution? Give two examples.**

   Ans: Colloidal solution: It is the heterogeneous binary system in which the dispersed particle is the aggregate of few hundreds of molecules or ions. Colloid consists of two phases.

   Dispersed phase → particles which are dispersed in medium. It is also called distentinuous phase or internal phase.

   Dispersion medium → It is the medium in which particles are dispersed. It is also called as external phase.

   Dispersed phase can be a solid or liquid or gas. Dispersion medium can be a solid or liquid or gas.

   Ex: Shaving cream, soda water froth, soap surf lemonade froths

2. **Give the differences between true solutions and colloidal solutions.**

Properties	**Colloidal solution**	**True solution**
Size	1 mμ → 1 μ	Less than 1 m μ
Diffusion through animal membrane	Diffuses slowly	Diffuses rapidly
Settling of particles	Will not settle by gravity but settles by centrifugation	Will not settle at all
Filterability	Can not be filtered	Can not be filtered
Filtration with ultrafilter	Can be filtered	Can not be filtered
Appearance	Turbid (clear)	Very clear
Nature	Heterogeneous	Homogenous
Tyndall effect	Will show tyndall effect	Does not show
Number of molecules are in one particle	Particle is the aggregate of few hundreds of molecules	Particle is single molecule or ion

3. **What are lyophilic colloid and lyophobic collids? Give two examples.**

Ans: Based on the affinity between particles and medium, colloids are classified into two types

1) **Lyophilic colloids (or) Hydrophilic colloids:** Strong attractions will exist between colloids particles and medium.

   Eg: organic substances like Starch, RBC, Albumin, Blue gelatin etc., and certain polymers in organic medium also formed.

2) **Lyophobic colloids or hydrophobic colloids:** No attractions will exist between colloidal particles and medium

Eg: Metalsols, Metaloxidesols, Metalsulphide sols.

4. **What is emulsion? Give two examples.**

Emulsion:

Emulsion is liquid in liquid type colloid. These two liquids are immiscible with one another. One of the liquid is water and other one is oil in nature based on the relative amounts of these two liquids.

Emulsions are two types

1) **Oil in water type:**
   Eg : Milk [liquid disguised liquid water)
   Kerosene oil in H_2O ; Vanishing cream.
2) **Water in oil type:**
   Cold cream, stiff greases, cold liver oil

5. **How emulsions are classified?**

Ans: Emulsions are two types. They are;

1) **Oil in water type:**
   Eg : Milk [liquid disguised liquid water)
   Kerosene oil in H_2O; Vanishing cream
2) **Water in oil type:**
   Cold cream, stiff greases, cold liver oil

- These emulsions are unstable. As they contain immiscible liquid

6. **What is micelle? Give an example.**.

Ans: Micelle: It is the colloidal size particles formed by the spontaneous aggregation of soap anions or molecules at higher concentration (CMC).

If the dispersed phase consists of micelles, such a colloid is called associated colloid. Soaps and detergents will form micelles at higher concentrations. The minimum concentration above which micelles are formed is called critical micellisation concentration.

Ex; At very low concentration soaps and detergents exist a true solution.

Soap : Sodium stearate: $C_{17}H_{35}COO^{\ominus}Na^{\oplus}$

stearate: $C_{17}H_{35}COO^{\ominus}$

Detergent: Sod. Lauryl sulphate – $C_{12}H_{25}OSO_3Na$

Lauryl sulphate $\rightarrow C_{12}H_{25}OSO_3$

7. **Explain the cleaning action of soap?**

Cleaning action of soap: In aqueous solution of soap head is towards the surface of water and tail is pointing away from the water, tail part being non – polar it has affinity towards grease, dust on the clothes. Micelles are formed by the soap with grease or dust. The micelles are then emulsified by soap. The charged layer

present around the micelle will present from aggregation.

LONG ANSWER QUESTIONS

1. **What are colloids? Give the differences between "colloidal solutions and true solution".**

   Colloids : which diffuse slowly through parchment membrane are Eg: starch, gum, gelatin etc.,In practice it is found that a crystalloid can be made into colloid and some of the colloids were found to be crystalline in nature. There fore the term colloidal substance is replaced by colloidal state

Properties	**Colloidal solution**	**True solution**	**Suspension**
Size	1 mμ → 1 μ	Less than 1 m μ	More than 1μ
Diffusion through animal membrane	Diffuses slowly	Diffuses rapidly	Will not diffuse
Settling of particles	Will not settle by gravity but settles by centrifugation	Will not settle at all	Settles by just gravity
Filterability	Can not be filtered	Can not be filtered	Can be filtered
Filtration with ultrafiltor	Can be filtered	Can not be filtered	Can be filtered
Appearance	Turbid (clear)	Very clear	Opaque
Nature	Heterogeneous	Homogenous	Heterogeneous
Tyndall effect	Will show tyndall effect	Does not show	Will show tyndall effect
Number of molecules are in one particle	Particle is the aggregate of few hundreds of molecules	Particle is single molecule or ion	Particle is the aggregate of millions of molecule

2. **Explain the terms "disperse phase" and "dispersion medium" with reference to smoke, cloud, blood, Gold Sol and milk.**

Ans: Colloid consists of two phases.

1. Dispersed phase → particles which are dispersed in medium. It is also called distentinuous phase or internal phase.
2. Dispersion medium → It is the medium in which particles are dispersed. It is also called as external phase.

- Dispersed phase can be a solid or liquid or gas.
- Dispersion medium can be a solid or liquid or gas.
- Based on the physical state phase and medium colloids are classified into 8 types.

- Gas in gas will not form colloid because it is homogenous mixture. \

SMOKE:

- An aerosol,
- A colloidal solution of carbon in air.
- A lyophobic colloid, dispersion phase is carbon and dispersion medium is air.
- A solid in gas sol. Carbon particles are precipitated electrically to avoid pollution in electrified chimney, where carbon particles can get discharged.

CLOUD:

- Is an aerosol.
- It is a colloidal suspension of water droplets in air.
- It is a lyophobic colloid.
- Droplets in cloud precipitate as rain.
- It is a liquid in gas sol.
- Dispersion phase is droplets of water (liquid) and dispersion medium is air (gas).

BLOOD:

- It is an aquasol or hydrosol.
- It is a colloidal suspension of albuminoid substance in water.
- Addition of ferric chloride (large amounts) coagulates the blood and clot during bleeding of wound.
- Dispersion phase is albuminoid substance containing RBC (erythrocytes) WBC (leucocytes).
- Dispersion medium is water containing some inorganic ions and organic molecules.
- It is a solid in liquid colloid.
- Impure blood is purified by kidneys through dialysis.
- It is a negative colloid, It coagulates with positive ions like Al^{+3} or Fe^{+3} etc,.

MILK:

- It is an emulsion.
- It is an oil in water (O/W) type emulsion.
- It is a liquid in liquid type colloid.
- Dispersion phase is droplets of liquid fat and dispersion medium is water.
- Milk on coagulation gives emulsified fat (casein).
- Milk cream from milk can be separated by centrifugation.
- Curding of milk is coagulation of milk.
- On souring lactose in milk converts to lactic acid which coagulates the milk.

GOLD SOL:

- It is an aquasol or hydrosol.
- It is a lyophobic colloid.
- It is a solid in liquid type colloid.
- It is coagulated by adding small amount of electrolytes.

- Dispersion phase is gold particles and dispersion medium is water.
- It is prepared by **Bredig arc** method.

3. **How colloids are classified/ Give two examples.**

Ans: Based on the affinity between particles and medium, colloids are classified into two types

1) **Lyophilic colloids (or) Hydrophilic colloids:**
   Strong attractions will exist between colloids particles and medium.
   Eg: organic substances like Starch, RBC, Albumin, Blue gelatin etc., and certain polymers in organic medium also formed.
2) **Lyophobic colloids or hydrophobic colloids:**
   No attractions will exist between colloidal particles and medium
   Eg: Metalsols, Metaloxidesols, Metalsulphide sols.

Some example of colloids:

Property	**Lyophilic**	**Lyophobic**
Attractive forces	Strong attractions will exist [H –H bonds]	No attractions will exist
Salvation	Particles are more solvated	Particles are not solvated
Viscosity	Is more than that of medium	Same as that of medium
Ease of preparation	Can be easily prepared by direct mixing of particles with medium	Cannot be prepared by direct mixing and requires special methods.
Reversible nature	Reversible	Irreversible
Tyndall effect	Weak	Strong Tyndall effect
Stability	More stable due to salvation	Less stable because of no salvation.
Presence of electric charge	Particles may carry little charge or no charge	Particles defiantly carry charge
Ease of coagulation	Not easily coagulated. It requires large amounts of electrolyte for coagulation.	Easily coagulated by adding little amount of electrolyte.

4. **What are protective colloids? Define and explain gold number.**

Ans: Protective Colloids and Gold Number

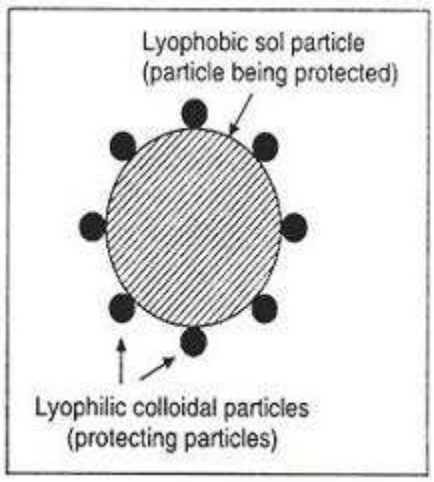
Lyophobic sols such as those of metals (e.g. Au, Ag, Pt etc.) are not very stable in the sense that they get easily coagulated (precipitated) in the presence of an electrolyte. This poses a big problem in their storage and usage. Contrary to this, lyophilic sols are much more stable and do not get coagulated easily under similar conditions.

It has been observed that in the presence of certain lyophilic colloids such as gum Arabic, gelatin, starch etc. the hydrophobic sols acquire greater stability towards coagulation, i.e. they get protected and do not get coagulated easily when an electrolyte is added.

The process of protecting a lyophobic sol from being coagulated (precipitated) on addition of an electrolyte by the use of a lyophilic colloids is called protection and the lyophilic colloid used for purpose is called a protective colloid.

For example, the addition of gelatin (a lyophilic colloid) to a gold sol (lyophobic sol) protects the latter from being coagulated on addition of sodium chloride solution.

The exact mechanism of protection is not very clearly understood. However, it is believed that the lyophilic colloid particles get adsorbed on the surface of the colloid particles present in the lyophobic sol. The adsorbed lyophilic particles thus form an envelope around the lyophobic sol particles and protect them from the action of electrolytes.



Protective action of lyophillic colloid particles

Gold Number: The protective power a lyophilic colloid is usually expressed in terms of a number called gold number introduced by Zsigmondy (1901). It may be defined as follows.

The gold number of a protective colloid is its minimum amount in milligrams which is just sufficient to prevent the coagulation of 10 ml of a gold sol on the addition of 1 mL of 10% sodium chloride solution**.**

It is to be noted that the smaller the value of gold number, the greater is the protective power of the protective colloid. The gold numbers of a few protective colloids are given in the Table below.

Table: Gold Number of Some Protective Colloids

Protective (Lyophilic) Colloid	Gold Number
Gelatin	0.005-0.01
Casein	0.01-0.02
Haemoglobin	0.03-0.07
Egg albumin	0.08-0.10
Gum Arabic	0.10-0.15
Dextrin	6-20
Starch	20.25

5. **What are emulsions how they are prepare? Give examples. Explain how emulsions are prepared and what is the role of emulsifier?**

Emulsions

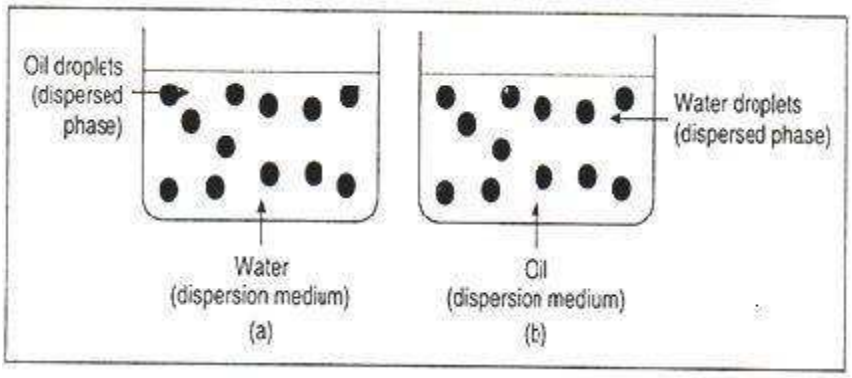
The liquid-liquid colloidal dispersions are called emulsions. An emulsion may be defined as follows:

The colloidal dispersion of two immiscible liquids in which one liquid acts as the dispersion medium and the other as dispersed phase is called an emulsion.

Types of emulsion: Depending upon the nature of dispersed phase, emulsions can be classified into following two types.

(i) Oil-in-water (O/W) type emulsions: In oil-in-water emulsions, oil acts as the dispersed phase while water acts as the dispersion medium. The most common example of oil in water type emulsion is milk which consists of liquid fat globules dispersed in water.

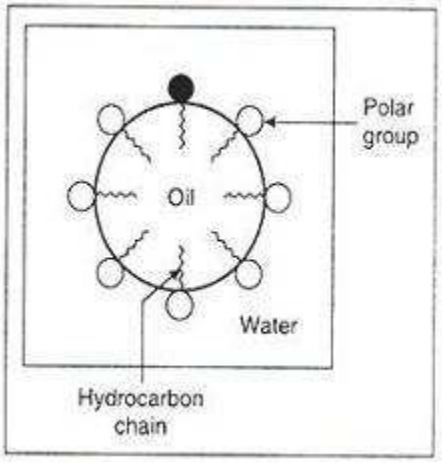
(ii) Water-in-oil (W/O) type emulsions: In water-in-oil type emulsions, water acts as the dispersed phase, whereas oil acts as the dispersion medium. This type of emulsions is also referred to as oil emulsions. Cod liver oil emulsion is a typical example of this type of emulsions in which water is dispersed in cod liver oil. The two types of emulsions are diagrammatically shown in figure below.



(a) Oil-in-water type emulsion (b) Water-in-oil type emulsion

Preparation of emulsions: Emulsions are usually prepared by vigorously mixing the two liquids by using either a high speed mixing machine or by using ultrasonic vibrators. The process is known as emulsification. Since the two liquids used for the preparation of an emulsion are completely immiscible, a stabilizing substance, known as emulsifying agent or emulsifier is required to stabilize the resulting emulsion. The emulsifier is added along with the component liquids. In the absence of emulsifying agent, the dispersed phase particles of colloidal size combine together resulting in the breaking up of emulsion into two separate layers. Some of the important emulsifying agents are soaps, detergents, proteins, gums and agar. Among these, soaps and detergents are most commonly used emulsifiers.

Role of emulsifier: The emulsifiers for a protective film around the oil droplets dispersed in water. This prevents them to come closer and to coalesce, i.e. to combine together. Thus, the emulsion gets stabilized. For example, let us consider the role of soap which acts as an emulsifier for an oil-in-water emulsion. When soap is added to an o/w emulsion, the soap molecule ($RCOO^-Na^+$) arrange themselves in such a way that the polar end groups dip in water whereas the hydrocarbon chains dip in oil droplet as shown in the figure below. Thus soap molecules get concentrated over the surface of the oil droplet and form a protective film. This decreases the interfacial between oil and water and the emulsion gets stabilized.



Emulsification of an oil droplet by soap

SURFACE CHEMISTRY

TOPIC-3

Properties of colloids, effects of colloids, properties and Tyndall effect, Brownian movement, coagulation

VERY SHORT ANSWER QUESTIONS

1. **What is Brownian movement?**

Brownian Movement: When a colloidal solution is examined by ultra microscope, the colloidal particles are seem to be moving in a rapid zigzag motion called Brownian movement.

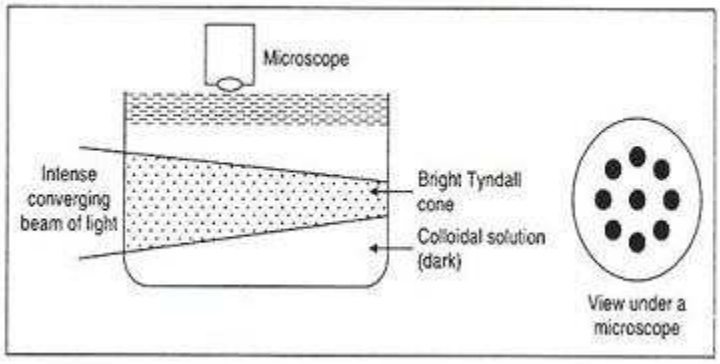
2. **What is coagulation?**

Ans: The phenomenon of colloidal substances loosing charge and coming down as precipitate on addition of an electrolyte to the colloidal solution is called as coagulation.

SHORT ANSWER QUESTIONS

1. **Explain Tyndall Effect.**

Ans: Tyndall Effect: When an intense converging beam of light is passed through a colloidal solution kept in dark, the path of the beam gets illuminated with a bluish light. This phenomenon is called Tyndall effect and the illuminated path is known as **Tyndall cone**. The phenomenon was first observed by Tyndall in 1869.



Tyndall effect

The Tyndall effect is due to the scattering of light by colloidal particles. Since the dimensions of colloidal particles are comparable to the wavelength of ultraviolet and visible radiations, they scatter these radiations and get illuminated. Tyndall observed that the zone of scattered light is much larger than the particle itself. This is why colloidal particles look like bright spots when viewed with a microscope at right angles to the beam of light as shown in figure. Thus, Tyndall effect may be defined as the scattering of

light by colloidal particles present in a colloidal solution.

Tyndall effect is not exhibited by true solutions. This is because the particles (ions or molecules) present in a true solution are too small to scatter light. Thus, Tyndall effect can be used to distinguish a colloidal solution from a true solution. The phenomenon has also been used to devise an instrument known as ultra microscope. The instrument is used for the detection of the particles of colloidal dimensions. Tyndall effect also establishes the fact that colloidal systems are heterogeneous in nature.

2. What is coagulation? Write about Hardy-Schultze law.

Ans: **Coagulation or flocculation:** The stability of a sol is due to the charge present on the colloidal particles. Due to similar charges, colloidal particles repel one another and are unable to combine together to form larger particles. However, if the charge on colloidal particles is destroyed, they are free to come nearer and grow in size. When the particles become sufficiently large, they get precipitated. This phenomenon is termed as coagulation or flocculation. The coagulation of colloidal solution can be achieved by the addition of an electrolyte. It is to be noted that a small amount of electrolyte is necessary for the stability of a sol because the ions of the electrolyte get adsorbed on colloidal particles and impart them some charge. However, when an electrolyte is added in substantial amount the positively charged ions of the electrolyte neutralize the charge on colloidal particles and compel the sol to get coagulated. Coagulation may be defined as follows.

The phenomenon involving the precipitation of a colloidal solution on addition of an electrolyte is called coagulation or flocculation.

Hardy-Schulze rule: The coagulation capacity of an electrolyte depends upon the valence of ion responsible for causing coagulation. As we have seen above, the ion responsible for causing coagulation is the one which carries charge opposite to that present on colloidal particles. For example, a positively charged sol gets coagulated by the negatively charged ions of the added electrolyte. From a study of the coagulation behavior of various electrolytes towards a particular sol, Hardy and Schulze suggested a general rule known as Hardy-Schulze rule. The rule can be stated as follows.

The greater is the valence of the oppositely charged ion of the electrolyte added to a colloidal solution, the faster is the coagulation of the colloidal solution.

3. **What is Brownian movement?**

Ans:

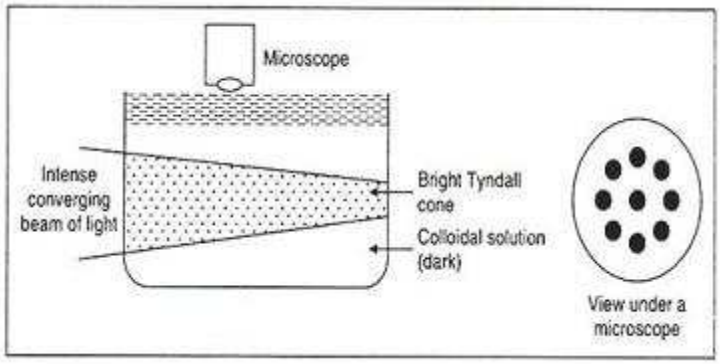
Brownian movement or motion, zigzag, irregular motion exhibited by minute particles of matter when suspended in a fluid. The effect has been observed in all types of colloidal suspensions—solid-in-liquid, liquid-in-liquid, gas-in-liquid, solid-in-gas, and liquid-in-gas. It is named for the botanist Robert Brown who observed (1827) the movement of plant spores floating in water. The effect, being independent of all external factors, is

ascribed to the thermal motion of the molecules of the fluid. These molecules are in constant irregular motion with a velocity proportional to the square root of the temperature. Small particles of matter suspended in the fluid are buffeted about by the molecules of the fluid. Brownian motion is observed for particles about 0.001 mm in diameter; these are small enough to share in the thermal motion, yet large enough to be seen with a microscope or ultra microscope.

LONG ANSWER QUESTIONS

1. **Explain Tyndall Effect and Brownian Movement.**

Tyndall Effect: When an intense converging beam of light is passed through a colloidal solution kept in dark, the path of the beam gets illuminated with a bluish light. This phenomenon is called Tyndall effect and the illuminated path is known as **Tyndall cone**. The phenomenon was first observed by Tyndall in 1869.



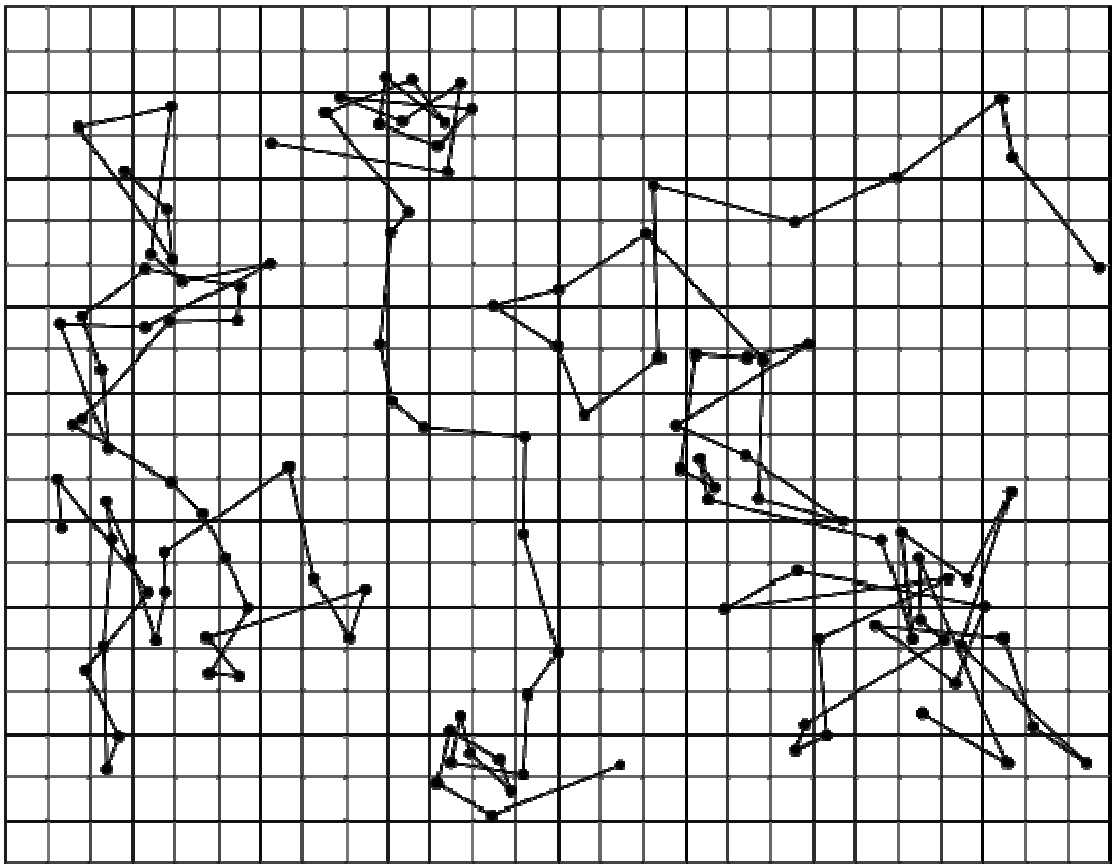
Tyndall effect

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2. **What is coagulation? Explain with suitable example.**

Coagulation or flocculation: The stability of a sol is due to the charge present on the colloidal particles. Due to similar charges, colloidal particles repel one another and are unable to combine together to form larger particles. However, if the charge on colloidal particles is destroyed, they are free to come nearer and grow in size. When the particles become sufficiently large, they get precipitated. This phenomenon is termed as coagulation or flocculation. The coagulation of colloidal solution can be achieved by the addition of an electrolyte. It is to be noted that a small amount of electrolyte is necessary for the stability of a sol because the ions of the electrolyte get adsorbed on colloidal particles and impart them some charge. However, when an electrolyte is added in substantial amount the positively charged ions of the electrolyte neutralize the charge on

colloidal particles and compel the sol to get coagulated. Coagulation may be defined as follows.

The phenomenon involving the precipitation of a colloidal solution on addition of an electrolyte is called coagulation or flocculation.

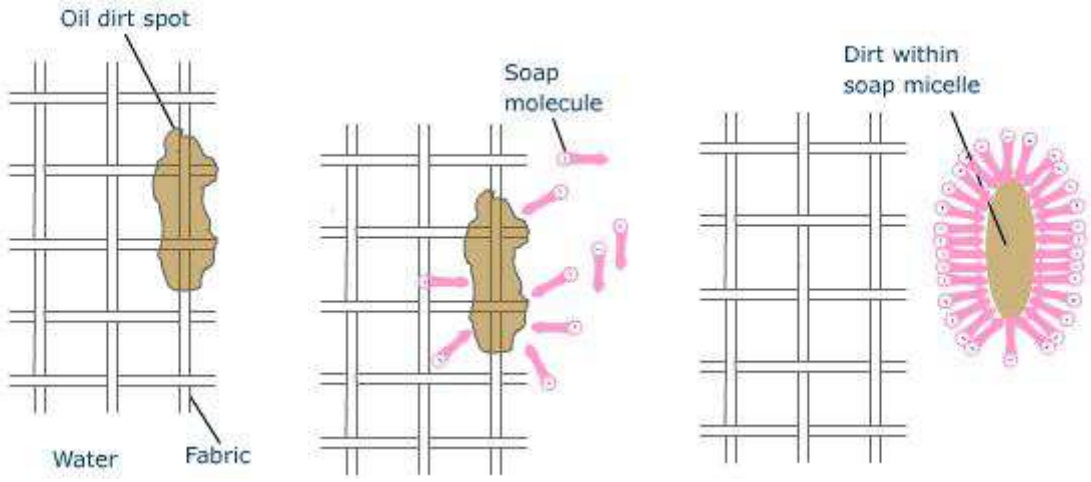
Hardy-Schulze rule: The coagulation capacity of an electrolyte depends upon the valence of ion responsible for causing coagulation. As we have seen above, the ion responsible for causing coagulation is the one which carries charge opposite to that present on colloidal particles. For example, a positively charged sol gets coagulated by the negatively charged ions of the added electrolyte. From a study of the coagulation behavior of various electrolytes towards a particular sol, Hardy and Schulze suggested a general rule known as Hardy-Schulze rule. The rule can be stated as follows.

The greater is the valence of the oppositely charged ion of the electrolyte added to a colloidal solution, the faster is the coagulation of the colloidal solution.

3. **Explain the phenomena of cleaning action of soap**.

Cleansing Action of Soaps

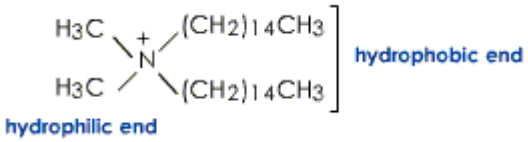
The cleaning action of soap occurs when oil and grease are absorbed into the hydrophobic centers of soap micelles and are washed away.



Cleansing action of soap

Sodium lauryl sulphate is a synthetic detergent present in laundry soaps, toothpastes and shampoos. The formula of sodium lauryl sulphate is $CH_3(CH_2)_{11}SO_4^-\ Na^+$. It has a hydrophilic sulphate group and a hydrophobic dodecyl ($C_{12}H_{25}$) group. These detergent molecules are called 'anionics' because they have negative charge at the hydrophilic end. There are detergents which are 'cationics' that is they have positive charge at the hydrophilic end.

For e.g.,



which is a quaternary ammonium compound.

Many cationic detergents have germicidal properties and are therefore used in hospital disinfectants, mouthwashes and certain eye wetting solutions.