CHAPTER

4 SURFACE CHEMISTRY

Syllabus

➢ *Adsorption-physisorption and chemisorption, factors affecting adsorption of gases on solids, catalysis, homogeneous and heterogeneous activity and selectivity, enzyme catalysis colloidal state, distinction between true solutions, colloids and suspension; lyophilic, lyophobic, multi-molecular and macromolecular colloids; properties of colloids; Tyndall effect, Brownian movement, electrophoresis, coagulation, emulsion–types of emulsions.*

Chapter Analysis

List of Topics	2016		2017		2018
	D	OD	D	OD	D/OD
Adsorption, Absorption	1Q (3 marks)*		1Q (1 mark)		
Coagulation	1Q (3 marks)*				
Colloids	1Q (3 marks)*	1Q (1 mark) 1Q (3 marks)#		1Q (1 mark)	
Zeta Potential		1Q (3 marks)#			
Difference between type			1Q (3 marks)	1Q (3 marks) ^	
Miscellaneous type				1Q (3 marks) ^	
Give reason type					1Q (3 marks)

- * One question of 3 marks on Adsorption, Absorption, Coagulation and Colloids was asked.
- # One question of 3 marks on Colloids and Zeta Potential was asked.
- ^ One question of 3 marks with two options i.e., one on Difference between various topics of Surface Chemistry and other miscellaneous type of question on topics of Surface Chemistry was asked.

On the basis of above analysis, it can be said that from exam point of view, Colloids, Adsorption and Absorption are the most important topics of the chapter. "Difference between type" question is also frequently asked.

TOPIC-1
Adsorption and its Types, Factors Affecting Adsorption

Revision Notes

➢ **Surface chemistry :** The branch of chemistry which deals with the phenomenon that occur at the surfaces is called surface chemistry. This phenomenon is studied with the help of adsorption and colloidal state.

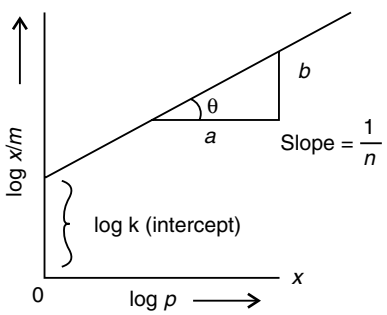
- **Adsorption :** Adsorption is a surface phenomenon in which the substance gets accumulated on the surface of a solid rather than in the bulk of a solid or liquid. The surface that adsorbs is called **adsorbent** and the one that gets adsorbed is called an **adsorbate.** For example : Pt can adsorb large amount of hydrogen gas.
- **Types of adsorption :**
  - **(i) Physisorption :** Physisorption is also called physical adsorption. If the adsorbate is held on a surface of adsorbent by weak van der Waals forces, the adsorption is called **physical adsorption or physisorption.**
  - **(ii) Chemisorption :** Chemisorption is also called chemical adsorption. If the forces holding the adsorbate are as strong as in chemical bonds, the adsorption process is known as **chemical adsorption or chemisorption.**
- **Desorption :** The process of removing an adsorbed substance from a surface on which it is adsorbed is called **desorption.**
- In **adsorption**, molecules of a substance are uniformly distributed throughout the body of solid or liquid. For example : Ammonia absorbed by water, water absorbed by anhydrous $CaCl_2$.
- **Sorption :** When adsorption and absorption take place simultaneously, it is called sorption, *e.g.*, dying of cotton fabrics. The dye is adsorbed on the surface of cotton fibre but after it is dyed, the fibre has dye uniformly throughout.
- **Enthalpy of adsorption :** Adsorption generally occurs with release in energy, *i.e.*, it is exothermic in nature. The enthalpy change for the adsorption of one mole of an adsorbate on the surface of adsorbent is called **enthalpy** or **heat of adsorption.**
- **Differences between Adsorption and Absorption :**

S. No.	Adsorption	Absorption
(i)	It is *surface phenomenon*. Adsorbate molecules are held at the surface of adsorbent.	Absorption occurs in the *bulk* of absorbing substance.
(ii)	The concentration of the adsorbate at the adsorbent is much more than that in the bulk.	Absorbed material is uniformly distributed throughout the bulk. Thus, concentration is same throughout.
(iii)	Initially rate of adsorption is rapid. It decreases slowly till equilibrium is attained.	Absorption occurs with uniform rate.
(iv)	**Example :** Water vapours on silica gel.	**Example :** Water vapours are absorbed by anhydrous $CaCl_2$.

- **Factors affecting adsorption of gases on solids :**
  (i) Nature of gas. **(ii)** Nature of adsorbent.
  (iii) Specific area of the solid. **(iv)** Pressure of the gas.
  (v) Effect of temperature. **(vi)** Activation of adsorbent.
- **Adsorption isobar :** A plot of extent of adsorption (x/m) *vs.* temperature at constant pressure is called adsorption isobar.
- **Adsorption isotherm :** The plot of extent of adsorption (x/m) *vs.* pressure (p) at constant temperature is called adsorption isotherm, where, 'x' is the quantity of gas adsorbed by unit mass 'm' of the solid adsorbed. It is called adsorption isotherm.
- **Freundlich Adsorption Isotherm :** It gives the relationship between magnitude of adsorption (x/m) and pressure at a constant temperature. It can be given by mathematical equation.

$$\frac{x}{m} = kp^{1/n} \quad \text{....(i)}$$

$$\log \frac{x}{m} = \log k + \frac{1}{n} \log p \quad \text{...(ii)}$$



A plot of $\log \frac{x}{m}$ *vs.* $\log p$ gives a straight line with slope $\frac{1}{n}$ and y intercept $= \log k$.

In case of solution, the isotherm takes the form

$$\frac{x}{m} = k(C)^{1/n} ; \log \frac{x}{m} = \log k + \frac{1}{n} \log C$$

where x is the amount of adsorbate adsorbed on m gram of adsorbent at pressure p or concentration C of the adsorbate, k and n are constants, $n > 1$.

➢ **Applications of Adsorption :**

(i) In removing colouring matter from solution.
(ii) In gas masks.
(iii) In separating noble gases.
(iv) In dyeing of cloth.
(v) In chromatography.
(vi) In froth flotation process.
(vii) In curing diseases.
(viii) In dehumidifiers.
(ix) In adsorption analysis.
(x) In creating high vacuum.
(xi) In ion-exchange resins.

Know the Terms

➢ **Saturation pressure :** The pressure beyond which adsorption becomes independent of pressure is called as saturation pressure.

➢ **Competitive adsorption :** A strong adsorbate get adsorbed more efficiently as compared to weak adsorbate. That strong adsorbate can displace already adsorbed one from the surface of the adsorbent. This is known as competitive adsorption or preferential adsorption.

Very Short Answer-Objective Type Questions (1 mark each)

A. Multiple choice Questions:

Q. 1. The term 'sorption' stands for
(a) absorption.
(b) adsorption.
(c) both absorption and adsorption.
(d) desorption.
R **[NCERT Exemp. Q. 4, Page 63]**

Ans. Correct option : (c)
Explanation : When both adsorption and absorption processes takes place simultaneously, the process is called as sorption.

Q. 2. Extent of physisorption of a gas increases with
(a) increase in temperature.
(b) decrease in temperature.
(c) decrease in surface area of adsorbent.
(d) decrease in strength of van der Waals forces.
U **[NCERT Exemp. Q. 5, Page 64]**

Ans. Correct option : (b)
Explanation : Physical adsorption of a gas increases with decrease in temperature. It occurs because at higher temperature, weak van der Waals forces between gas and the surface become difficult to exist.

Q. 3. Which of the following is an example of absorption?
(a) Water on silica gel
(b) Water on calcium chloride
(c) Hydrogen on finely divided nickel
(d) Oxygen on metal surface
R **[NCERT Exemp. Q. 11, Page 64]**

Ans. Correct option : (b)
Explanation : Calcium chloride ($CaCl_2$) absorbs water and other examples show adsorption.

Q. 4. In physisorption, adsorbent does not show specificity for any particular gas because :
(a) involved van der Waals forces are universal.
(b) gases involved behave like ideal gases.
(c) enthalpy of adsorption is low.
(d) it is a reversible process.
U **[NCERT Exemp. Q. 10, Page 64]**

Ans. Correct option : (a)
Explanation : Physisorption is not specific to any gas since it involves van der Waals forces and no specific bond formation takes place.

B. Answer the following:

Q. 1. Define Adsorption giving an example.
R **[CBSE OD 2013]**

Ans. Adsorption is a surface phenomenon in which a substance gets accumulated on the surface of the solid rather than in the bulk of a solid or liquid. The surface that adsorbs is called adsorbent and the one that gets absorbed a called an adsorbate. For example, air becomes dry in the presence of silica gel **1**

Answering Tip
- State precise definition and support it with example.

Q. 2. Write two applications of adsorption.
U **[CBSE Comptt. Delhi 2012]**

Ans. The two applications of adsorption are :
(i) Activated charcoal is used in gas masks to remove poisonous gases such as carbon monoxide, methane etc. Animal charcoal is used to remove colouring matter from sugarcane juice in the manufacture of sugar. ½
(ii) Ion exchange resin is used to remove hardness of water. ½

Q. 3. Why is adsorption always exothermic ?
A&E **[CBSE Comptt. OD 2018; OD 2014]**

Ans. Due to the bond formation between the adsorbent and the adsorbate. **1**
[CBSE Marking Scheme 2014]

Detailed Answer :

In adsorption there is a decrease in residual forces of the surface which evolves as heat. Hence, it is exothermic in nature. **1**

AI **Q. 4. Out of physisorption or chemisorption, which has higher enthalpy of adsorption ?**

U **[CBSE OD 2013]**

Ans. Chemisorption has higher enthalpy of adsorption *i.e.*, 80-240 kJ mol^{-1} as it involves chemical bond formation. **1**

Q. 5 Write one similarity between Physisorption and Chemisorption. U **[CBSE Delhi Set-1, 2, 3 2017]**

Ans. Both are surface phenomenon/both increase with increase in surface area (or any other correct similarity). **[CBSE Marking Scheme 2017] 1**

Answering Tip

- As it is one mark question, write only one main difference between the two.

Q. 6. What is the effect of temperature on chemisorption ? U **[CBSE OD 2014]**

Ans. It first increases (as heat supplied acts as activation energy) then decreases or graphical representation. **[CBSE Marking Scheme 2014] 1**

Q. 7. Out of NH_3 and CO_2, which gas will be absorbed more readily on the surface of activated charcoal and why ? A&E **[CBSE Comptt. Delhi 2012]**

Ans. NH_3 will be absorbed more readily on the surface of charcoal because it has higher critical temperature due to van der Waals forces of attraction. **1**

Short Answer Type Questions (2 marks each)

AI **Q. 1. What is an adsorption isotherm ? Describe Freundlich adsorption isotherm.**

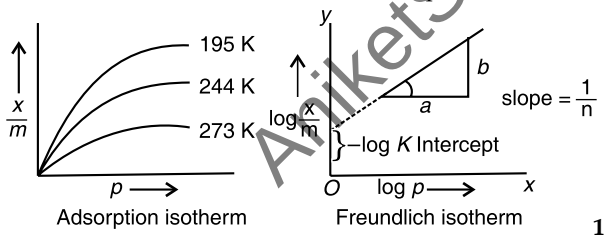
R **[CBSE Comptt. Delhi 2013; NCERT]**

Ans. A graph drawn between extent of adsorption and the pressure of the gas at constant temperature is called **adsorption isotherm.** **1**

A relationship between the amount adsorbed (x/m) and the equilibrium pressure (p) can be given by

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

where, n is a positive integer and k is the constant. This is known as Freundlich adsorption isotherm.



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Commonly Made Error

- Students often plot the graph and do not write the variables.

Answering Tip

- While plotting a graph, both the independent and dependent variables must be written.

Q. 2. Why are powdered substances more effective adsorbents than their crystalline forms?

A&E **[NCERT]**

Ans. Powdered substances are more effective adsorbents than their crystalline forms because when a substance is powdered, its surface area increases and physisorption is directly proportional to the surface area of the adsorbent. **2**

Q. 3. Give an example where physisorption changes to chemisorption with rise in temperature. Explain the reason for change. C **[NCERT Exemplar]**

Ans. The process of physisorption for example that of H (hydrogen) on finely divided nickel, involves weak van der Waals forces. With increase in temperature, hydrogen molecules dissociate into hydrogen atoms which are held on the surface by chemisorption. **2**

Long Answer Type Question-I (3 marks)

Q. 1. Write three distinctive features of chemisorption, which are not found in physisorption.

U **[CBSE OD 2012]**

OR

Write any three differences between Physisorption and Chemisorption. **[CBSE OD 2015]**

OR

Write three differences between Physisorption and Chemisorption. **[CBSE Foreign Set-1, 2 2017]**

Ans.

S. No.	Physisorption	Chemisorption
(i)	Because of van der Waals forces	Caused by chemical bond formation
(ii)	Reversible	Irreversible
(iii)	Enthalpy of adsorption is low (20-40 kJ/mol)	Enthalpy of adsorption is high (80-240) kJ/mol
(or any other correct difference)		

1+1+1

[CBSE Marking Scheme 2017]

Detailed Answer:

S. No.	Physisorption	Chemisorption
(i)	It arises by weak van der Waals forces.	It arises by strong forces like chemical bond.
(ii)	It usually takes place at a low temperature and decreases with increasing temperature.	It takes place at a high temperature and increases with increase in temperature.
(iii)	It is reversible.	It is irreversible.
(iv)	It depends on the ease of liquification of the gas.	The extent of adsorption is not related to liquification of the gas.
(v)	It is not very specific.	It is highly specific.
(vi)	It forms multi-molecular layers.	It forms mono-molecular layers.
(vii)	It does not require any activation energy.	It requires activation energy.

Write "(Any three correct difference)" 3

TOPIC-2
Catalysis and its Types, Enzyme Catalysis

Revision Notes

- **Catalysis :** The process in which catalyst is used to increase the rate of reaction without changing itself is called catalysis.

$$2KClO_3 \xrightarrow[473-633K]{MnO_2} 2KCl + 3O_2$$

The catalyst remains unchanged with respect to mass and composition. Catalyst does not affect ΔH, ΔS, ΔG and equilibrium constant k.

- **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.

$$N_2(g) + 3H_2(g) \underset{Mo}{\overset{Fe}{\rightleftharpoons}} 2NH_3(g)$$

- **Poisons or Inhibitors :** Those 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.

- **Types of Catalysis :**

(i) Homogeneous Catalysis : When the catalyst mixes homogeneously with the reactant and forms a single phase, the catalyst is said to be homogeneous and this kind of catalysis is known as homogeneous catalysis. *e.g.*, catalytic oxidation of SO_2 to SO_3 in presence of NO is an example of homogeneous catalysis.

$$2SO_2(g) + O_2(g) \xrightarrow{NO(g)} 2SO_3(g)$$

(ii) Heterogeneous Catalysis : When the catalyst forms a separate phase (usually a solid phase) it is said to be heterogeneous catalysis. In a heterogeneous catalysis, the reactants are gases and reaction starts from the surface of the solid catalyst. This is the reason why heterogeneous catalysis is also called 'surface catalysis'. *e.g.*

$$CO(g) + 2H_2(g) \xrightarrow[ZnO/Cr_2O_3]{Cu(Solid)} CH_3OH(l)$$

- **Adsorption theory of Heterogeneous Catalysis :** According to modern adsorption theory, there are free valencies on the surface of solid catalyst and mechanism involves following five steps :

(i) Diffusion of reactant molecules on the surface of the catalyst.

(ii) Adsorption of the reactant molecules on the surface of the catalyst by forming loose bonds with the catalyst due to presence of free valencies.

(iii) Occurrence of a chemical reaction forming an intermediate on the surface.

(iv) Desorption of the product molecules from the surface.

(v) Diffusion of product molecules away from the surface of the catalyst.

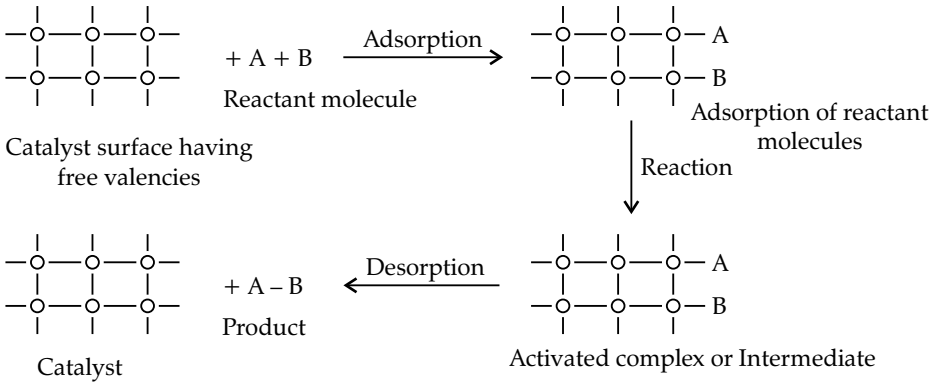


Fig. 1: Adsorption of reacting molecules, formation of intermediate and desorption of products.

- **Important features of solid catalysts :**
  (i) **Activity :** It is the ability of catalyst to increase the rate of a reaction.
  (ii) **Selectivity :** It is the ability of a catalyst to direct a reaction to yield a particular product.
- **Shape-selective catalysis by zeolites :** It is the catalytic reaction that depends upon the pore structure of the catalyst and the size of the reactant and product molecules. Zeolites are the shape selective catalyst having honey comb structures. Zeolite catalyst, ZSM-5 is used in petroleum industry to convert alcohols into gasoline by dehydration.
- **Enzyme Catalysis :** In enzyme catalysis, enzymes are biological catalyst which catalyse specific biochemical reactions. They are globular proteins having high molecular mass *e.g.*,

$$\underset{\text{(Urea)}}{NH_2CONH_2} + H_2O \xrightarrow{\text{Urease}} 2NH_3 + CO_2$$

- **Characteristics of enzymes :**
  (i) Enzymes form a colloidal solution in water and hence they are very active catalysts.
  (ii) Like inorganic catalyst they cannot disturb the final state of equilibrium of a reversible reaction.
  (iii) They are highly specific in nature *i.e.*, one catalyst cannot catalyse more than one reaction.
  (iv) They are highly specific to temperature. The optimum temperature of their activity is 25°C – 35°C. They are deactivated at 70°C.
  (v) A small quantity of enzyme catalyst is sufficient for a large change.
  (vi) They are destroyed by UV rays.
  (vii) Their efficiency is decreased in the presence of electrolytes.
- **Some examples of enzyme catalyst reaction.**
  (i) $\underset{\text{(Cane sugar)}}{C_{12}H_{22}O_{11}} \xrightarrow{\text{Invertase}} \underset{\text{(Glucose)}}{C_6H_{12}O_6} + \underset{\text{(Fructose)}}{C_6H_{12}O_6}$ (Inversion of cane sugar)
  (ii) Maltose $\xrightarrow{\text{Maltase}}$ Glucose + Glucose
  (iii) Lactose $\xrightarrow{\text{Lactase}}$ Glucose + Galactose
  (iv) $\underset{\text{(Glucose)}}{C_6H_{12}O_6} \xrightarrow{\text{Zymase}} \underset{\text{(Ethyl alcohol)}}{2C_2H_5OH} + 2CO_2$
  (v) Proteins $\xrightarrow{\text{Pepsin}}$ Peptides
  (vi) Milk $\xrightarrow[\text{enzyme}]{\text{Lactobacilli}}$ Curd
- **Mechanism of enzyme catalysed reaction :**
  (i) Binding of enzyme to substrate to form an activated complex.
  $$E + S \rightarrow ES$$
  (ii) Decomposition of the activated complex to form the product.
  $$ES \rightarrow E + P$$
  where E is enzyme, S is substrate and P is product.
- **Co-enzymes :** Certain substances, which can increase the activity of enzymes are known as Co-enzymes.

Know the Terms

- **Zeolites :** Aluminosilicate with three dimensional network containing Al—O—Si network which acts as a good shape-selective catalyst.
- **Enzymes :** Complex nitrogenous organic compounds which are produced by living plants and animals.
- **Optimum pH :** Particular pH at which the rate of an enzyme catalysed reaction is maximum.

Very Short Answer-Objective Type Questions (1 mark each)

A. Multiple choice Questions:

Q. 1. Which of the following process does not occur at the interface of phases?

(a) Crystallisation
(b) Heterogeneous catalysis
(c) Homogeneous catalysis
(d) Corrosion R **[NCERT Exemp. Q. 1, Page 63]**

Ans. Correct option : (c)
Explanation : In homogeneous catalysis, the catalyst mixes homogeneously with the reactant and forms a single phase.

Q. 2. In which of the following reactions, heterogeneous catalysts is involved ?

(a) $2SO_2(g) + O_2(g) \xrightarrow{NO(g)} 2SO_3(g)$

(b) $2SO_2(g) \xrightarrow{Pt(s)} 2SO_3(g)$

(c) $N_2(g) + 3H_2(g) \xrightarrow{Fe(s)} 2NH_3(g)$

(d) $CH_3COOCH_3(l) + H_2O(l) \xrightarrow{HCl(l)} CH_3COOH(aq) + CH_3OH(aq)$

(a) (b), (c) **(b) (b), (c), (d)**
(c) (a), (b), (c) **(d) (d)**

A **[NCERT Exemp. Q. 13, Page 65]**

Ans. Correct option : (d)
Explanation : In reactions (b) and (c), catalysts are in solid state, and reactants and products are in gaseous states.

B. Answer the following:

Q. 1. What is meant by 'shape selective' catalysis ? R **[CBSE OD 2014; SQP 2016]**

Ans. Shape selective catalysis is a chemical reaction in which the rate depends on the pore size of the catalyst, and also on the shape and size of the reactant and product molecules. Zeolite acts as shape selective catalyst. **1**
[CBSE Marking Scheme 2016]

Q. 2. What is the role of desorption in the process of catalysis? R **[CBSE Foreign Set-1, 2, 3 2017]**

Ans. To make the surface available again for more reaction to occur/To remove the product formed from the surface of the catalyst. **1**
[CBSE Marking Scheme 2017]

Long Answer Type Questions-I (3 marks each)

Q. 1. How does a solid catalyst enhance the rate of combination of gaseous molecules? How does a solid catalyst enhance the rate of combination of gaseous molecules? A&E **[NCERT Exemplar]**

Ans. When gaseous molecules come in contact with the surface of a solid catalyst, a weak chemical combination takes place between the surface of the catalyst and the gaseous molecules, which increase the concentration of reactants on the surface. Different molecules adsorbed have better chance to react and form new molecules. This enhances the rate of reaction. Adsorption is an exothermic process. The heat released in the process of adsorption is utilised in enhancing the reaction rate. **3**

Q. 2. What do you mean by activity and selectivity of catalysts? R **[NCERT Ex. Q. 5.20, Page 148]**

Ans. Activity of a catalyst : The activity of a catalyst is to increase the rate of a particular reaction. Chemisorption is the main factor which decides the activity of a catalyst. The adsorption of reactants on the catalyst surface should be neither too strong nor too weak. It should just be strong enough to make the catalyst active. **[1½]**

Selectivity of the catalyst : The ability of the catalyst to direct a reaction to yield a particular product is called as the selectivity of the catalyst. For example, by using different catalysts, we can get different products for the reaction between H_2 and CO.

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

$$CO(g) + 2H2(g) \xrightarrow{Cu/ZnO-CrO_3} CH_3OH(g)$$

$$CO(g) + H_2(g) \xrightarrow{Cu} HCHO(g)$$ **[1½]**

TOPIC-3
Colloids, Types of Colloids, Characteristics and Preparation of Colloids

Revision Notes

- **Colloids :** A colloid is a heterogeneous system in which one substance is dispersed (dispersed phase) as very fine particles in another substance called dispersion medium. The size of colloidal particles is in the range 1–1000 nm.

- **Colloidal solution :** A colloidal solution is a heterogeneous system in which a definite substance is distributed in the form of very small particles as dispersed phase in another substance called dispersion medium, *e.g.*, glue, ink, smoke, etc.
- **Dispersed phase :** Dispersed phase is the component present in small proportion like solute in the solution.
- **Dispersion medium :** The medium in which the colloidal particles are dispersed is called dispersion medium.
- **Crystalloids :** The substances whose aqueous solution can pass through the semi-permeable membrane are called crystalloids.
- **Types of Colloidal solutions :**

S. No.	Dispersed phase	Dispersion medium	Name	Examples
1.	Solid	Gas	Aerosol	Smoke, dust particles.
2.	Solid	Liquid	Sol	As_2S_3, Gold sol, starch, gum, muddy water.
3.	Solid	Solid	Solid sol	Coloured gem stones, some alloys, pearls, ruby glass.
4.	Liquid	Solid	Gel	Jellies, cheese, butter.
5.	Liquid	Liquid	Emulsion	Milk, hair cream, cod-liver oil.
6.	Liquid	Gas	Aerosol	Fog, mist, cloud.
7.	Gas	Solid	Solid foam	Pumice stone, foam rubber, cork.
8.	Gas	Liquid	Foam	Whipped cream, froth, soap lather.

- **Classification based on nature of interaction between dispersed phase and dispersion medium :**
  - **(i) Lyophilic colloids :** Lyophilic means "solvent loving". Those substances which when mixed with a suitable solvent as the dispersion medium directly form the colloidal solution are called lyophilic substances and the solution thus formed is called lyophilic solutions. They are also known as intrinsic colloids. For example : gum, gelatin, starch, rubber, etc.
  - **(ii) Lyophobic colloids :** Lyophobic means "solvent hating". These are the substances, when mixed with dispersion medium do not form colloidal solution. Their solution can be prepared only by special method, such substances are called lyophobic and the solutions formed by them are called lyophobic solutions. They are also known as extrinsic colloids. For example : metals and their sulphides.
- **Classification based on the type of particles of the dispersal phase :** Multimolecular, Macromolecular and Associated colloids :
  - **(i) Multimolecular Colloids :** Multimolecular colloids contains dispersed particles less than 1 nm made of aggregates of many molecules. These are lyophobic colloids. In multimolecular colloids, particles are held by weak van der Waals forces. For example, sulphur sol, gold sol etc.
  - **(ii) Macromolecular Colloids :** Macromolecular colloids are molecularly dissolved solutions of a polymer with particle size of colloidal range and are lyophilic colloids. In macromolecular colloids, particles are held by chemical bonds.

    For example :

    (a) Naturally occurring macromolecular colloids (starch, cellulose, proteins and enzymes).

    (b) Man-made macromolecular colloids (polythene, nylon).
  - **(iii) Associated Colloids (Micelles)**

Micelles : Those colloids which behave as normal strong electrolytes at low concentrations, show colloidal properties at higher concentrations due to the formation of aggregated particles of colloidal dimensions. Such compounds are also referred to as associated colloids. Surface active agents like soaps and synthetic detergents belong to this class. They also form ions. Micelles may contain 100 molecules or more.

Mechanism of micelle formation : Micelle are generally formed by the specific type of molecules which have lyophilic as well as lyophobic ends. Such molecules are known as surface active molecules or surfactant molecules.

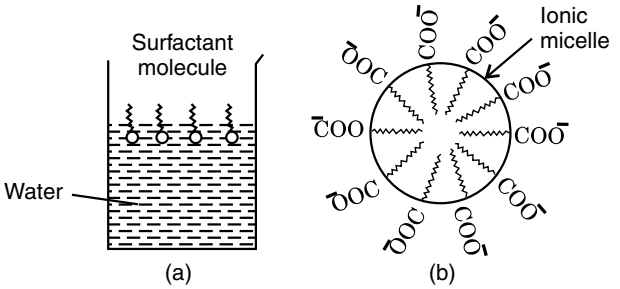


Fig. 2. (a) : Arrangement of oleate ions on the surface of water at low concentrations of soap.
(b) : Arrangement of oleate ions inside the bulk of water (ionic micelle) at critical micelle concentrations of soap.

Sodium oleate, $C_{17}H_{33}COO^-Na^+$ (one of the soaps) is a typical example of such type of molecule. The long hydrocarbon part of oleate radical ($C_{17}H_{33}$—) is lyophobic end while COO^- part is lyophilic end. When the

concentration of the solution is below its CMC (3×10^{-3} mol L^{-1}), sodium oleate behaves as normal electrolyte and ionises to give Na^+ and $C_{17}H_{33}COO^-$ ions. As the concentration exceeds CMC, the lyophobic part starts receding away from the solvent and are made to approach each other. However, the polar —COO^- part tend to interact with the solvent. This ultimately leads to the formation of the cluster having the dimensions of the colloidal particles. In each such cluster, a large number of (usually 100 or more) oleate groups are clumped together in a spherical manner so that their hydrocarbon parts interact with one another but —COO^- parts remain projected in water. Hence, the mechanism of micelles formation is same as that of soap.

➢ **Preparation of colloidal solution :** Colloidal solutions can be prepared by following methods :

(i) Mechanical dispersion : A suspension of coarsely ground particles prepared in dispersion medium is fed into a colloidal mill and speed of rotation is adjusted so as to get the particles of colloidal size.

(ii) Electrodispersion : (Bredig's arc method). In this method, two rods of the metal (Au, Cu, Pt, Ag) to be dispersed are kept immersed in cold and a direct electric arc is struck between them. In this way, vapours of metal are formed which then immediately condense to form particles of colloidal size.

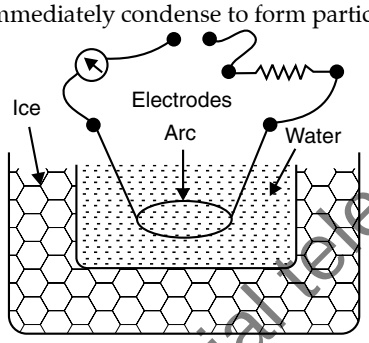


Fig. 3 : Bredig's arc method

(iii) Chemical methods :

- **Oxidation :** Solutions of non-metals are prepared by this method; *e.g.*, colloidal solution of sulphur.

$$2H_2S + 2(O) \xrightarrow{HNO_3\,(conc.)} 2S + 2H_2O$$

- **Reduction :** Metal sols can be prepared by this method; *e.g.*, gold sol

$$2AuCl_3 + 3SnCl_2 \longrightarrow 2Au + 3SnCl_4$$

$$2AuCl_3 + 3HCHO + 3H_2O \longrightarrow 2Au\ (sol) + 3HCOOH + 6HCl$$

- **Hydrolysis :** Hydroxides sols are prepared by this method; *e.g.*, $Fe(OH)_3$, $Al(OH)_3$

$$FeCl_3 + 3H_2O \longrightarrow Fe(OH)_3 + 3HCl$$

- **Double decomposition :** This method is used to prepare colloids from inorganic salts; *e.g.*,

$$As_2O_3 + 3H_2S \longrightarrow As_2S_3 + 3H_2O$$

- **Exchange of solvent :** Some substances which form true solution in one solvent, forms colloidal solution in another due to lowering of solubility, *e.g.*, sulphur dissolved in alcohol forms colloidal solution in water and phenolphthalein dissolved in alcohol forms colloidal solution in water.
- **Excessive cooling :** The colloidal solution of ice in $CHCl_3$ or ether can be obtained by freezing a solution of water in solvent. The molecules of water combine to form particles of colloidal size.

➢ **Peptization :** The conversion of precipitate into colloidal solution in presence of peptizing agent is called peptization. Peptizing agent is generally an electrolyte.

➢ **Purification methods of colloidal solutions :** Colloidal solution can be purified by following methods :

(i) Dialysis : In dialysis, particles of true solutions can pass through parchment paper or cellophane membrane. On the other hand, sol particles cannot pass through these membranes. A bag made up of such a membrane is filled with the colloidal solution and is then suspended in fresh water. The crystalloid particles pass out leaving behind the colloidal sol.

(ii) Electrodialysis : Movement of ions across the membrane can be quickened by applying electric potential through two electrodes. This method is faster than simple dialysis and is known as electrodialysis.

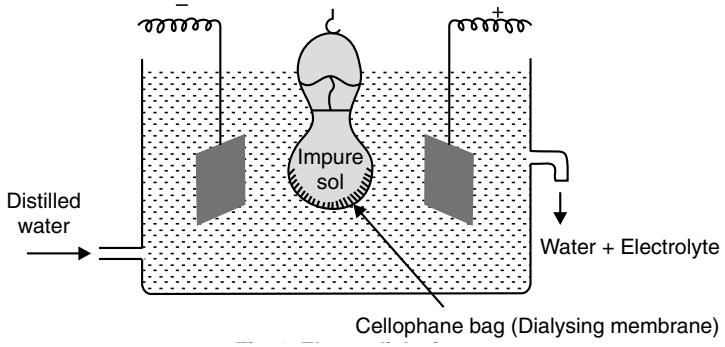


Fig. 4 : Electrodialysis

(iii) Ultrafiltration : The process of separating colloidal particles by specially prepared filter papers whose pore size is reduced by dipping it in colloidal solution (e.g., 4% nitrocellulose in mixture of alcohol and ether)

➢ **Properties of colloids :**

(i) Brownian movement : The zig-zag movement of colloidal particles when seen under powerful microscope is called Brownian movement.

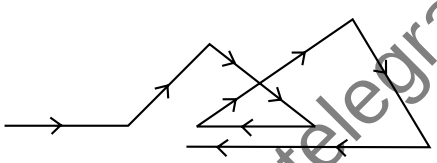


Fig. 5 : Brownian movement

(ii) Tyndall effect : Scattering of light by colloidal particles is called Tyndall effect.

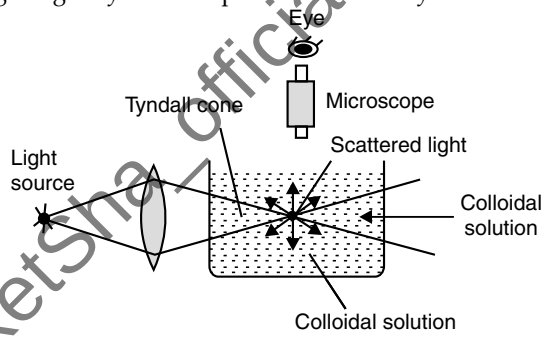


Fig. 6 : Tyndall effect

(iii) Electrophoresis : The movement of colloidal particles towards one of the electrodes on passage of electricity through colloidal solution is called electrophoresis.

➢ **Hardy-Schulze rule :**

(i) Opposite 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.

The reciprocal of coagulation value is called coagulating power. *i.e.*, lower the coagulation value, higher will be coagulating power.

➢ **Electrokinetic potential or Zeta potential :** The potential difference between the fixed layer and diffused layer of opposite charges is called zeta potential.

➢ **Coagulation :** Coagulation which can be reversed by shaking is called flocculation or coagulation.

➢ **Coagulating value :** The minimum concentration of an electrolyte which is required to cause the coagulation or flocculation of a sol is known as coagulation value.

$$\text{Coagulation value} \propto \frac{1}{\text{Coagulating power}}$$

➢ **Gold number :** The number of milligram of protective colloids which must be added to 10 ml of given gold sol to prevent it from coagulation by addition of 1 ml of 10% of NaCl solution.

➢ **Emulsions :** Emulsions are colloidal system in which both the dispersed phase and dispersion medium are liquids. There are two types of emulsions :

(i) **Oil in water :** In such emulsion oil is dispersed phase and water is dispersion medium. For example, milk, vanishing cream.

(ii) **Water in Oil :** In such emulsion, water is dispersed phase and oil is dispersion medium. For example, butter.

- **Emulsification :** The process of making emulsion is called emulsification.
- **Emulsifying agent :** The substances which help in stabilising emulsion are called emulsifying agents or emulsifiers. Soap and detergent are most frequently used as emulsifiers.
- **Demulsification :** The process of decomposing an emulsion into its constituent liquids is called demulsification. It is carried out by centrifugation, freezing, boiling or chemical methods which destroy the emulsifying agent.
- **Applications of colloids :**

(i) Sewage disposal (ii) Purification of drinking water
(iii) Smoke precipitation (iv) Medicines
(v) Tanning (vi) Rubber industry.

- **Distinction between true solution, colloids and suspension :**

S. No.	True Solution	Colloids	Suspension
1.	It is homogeneous.	It appears to be homogeneous but actually it is heterogeneous.	It is heterogeneous.
2.	Its particle size is less than 1 nm.	Its particle size is 1 nm to 1000 nm.	Its particles are larger than 1000 nm.
3.	It passes through filter paper.	It passes through ordinary filter paper but not through ultrafilters.	It does not pass through filter paper.
4.	It does not show Tyndall effect.	It shows Tyndall effect.	It does not show Tyndall effect appreciably.
5.	It has higher value of colligative property.	It has low value of colligative property.	It has very low value of colligative property.
6.	Its particles cannot be seen even with powerful microscope.	Its particles can be seen by powerful microscope due to scattering of light.	Its particles can be seen even with naked eye.

Know the Terms

- **Crystalloids :** The substances whose aqueous solution can pass through the semipermeable membrane.
- **CMC :** Critical Micellization Concentration is the lowest concentration of surfactant at which micelle formation takes place.
- **Streaming potential :** When a liquid is forced through a porous material or a capillary tube, a potential difference is set up between the two sides. This is known as streaming potential.
- **Dorn potential :** When a particle is forced to move through a resting liquid, a potential difference is set up. It is known as Dorn potential.
- **U-number :** The number of milligrams of a hydrophilic sol which is sufficient to produce the colour change from red to blue in 1 cc of gold sol.

Very Short Answer-Objective Type Questions (1 mark each)

A. Multiple choice Questions:

Q. 1. Which of the following process is responsible for the formation of delta at a place where rivers meet the sea?

(a) Emulsification (b) Colloid formation
(c) Coagulation (d) Peptization

U **[NCERT Exemp. Q. 22, Page 67]**

Ans. Correct option : (c)

Explanation : A delta is formed at a place where rivers meet the sea due to the process of setting down of colloidal particles. The ions which are present in sea water are responsible for coagulation.

Q. 2. At high concentration of soap in water, soap behaves as :

(a) molecular colloid
(b) associated colloid
(c) macromolecular colloid
(d) lyophilic colloid

R **[NCERT Exemp. Q. 14, Page 65]**

Ans. Correct option : (b)

Explanation : At low concentration soaps behaves as strong electrolyte but at higher concentration it behaves as colloid due to formation of aggregates called micelles. These are called as associated colloids.

Q. 3. Which of the following will show Tyndall effect?
(a) Aqueous solution of soap below critical micelle concentration.
(b) Aqueous solution of soap above critical micelle concentration.
(c) Aqueous solution of sodium chloride.
(d) Aqueous solution of sugar.
U **[NCERT Exemp. Q. 15, Page 65]**

Ans. Correct option : (b)
Explanation : Tyndall effect is a characteristic of colloidal solution in which colloidal particles show a coloured appearance when sunlight is passed through it and seen perpendicularly.

Q. 4. Method by which lyophobic sol can be protected
(a) by addition of oppositely charged sol.
(b) by addition of an electrolyte.
(c) by addition of lyophilic sol.
(d) by boiling. R **[NCERT Exemp. Q. 16, Page 65]**

Ans. Correct option : (c)
Explanation : Lyophobic sol can be protected by adding lyophilic sol which is known as protective colloid.

Q. 5. Freshly prepared precipitate sometimes gets converted to colloidal solution by
(a) coagulation. **(b) electrolysis.**
(c) diffusion. **(d) peptization.**
R **[NCERT Exemp. Q. 17, Page 65]**

Ans. Correct option : (d)
Explanation : Peptization is the process of converting freshly prepared precipitate into colloid.

Q. 6. A colloidal system having a solid substance as a dispersed phase and a liquid as a dispersion medium is classified as :
(a) solid sol. **(b) gel.**
(c) emulsion. **(d) sol.**
R **[NCERT Exemp. Q. 19, Page 66]**

Ans. Correct option : (d)

Q. 7. Which of the following electrolytes will have maximum coagulating value for AgI/Ag+ sol?
(a) Na_2S **(b) Na_3PO_4**
(c) Na_2SO_4 **(d) NaCl**
U **[NCERT Exemp. Q. 18, Page 66]**

Ans. Correct option : (b)
Explanation : According to Hardy-Schulze law, the greater the charge on anion, the greater will be its coagulating power.

Electrolytes	Anionic part	Charge on anion
Na_2S	S^{2-}	2
Na_3PO_4	PO_4^{3-}	3
Na_2SO_4	SO_4^{2-}	2
NaCl	Cl^-	1

Here, PO_4^{3-} have high charge. Hence, PO_4^{3-} have the highest coagulating power.

B. Match the following :

Q. 1. Match the items given in Column I and Column II.

S. No.	Column I	S. No.	Column II
(i)	Protective colloid	(a)	$FeCl_3$ + NaOH
(ii)	Liquid-liquid colloid	(b)	Lyophilic colloids
(iii)	Positively charged colloid	(c)	Emulsion
(iv)	Negatively charged colloid	(d)	$FeCl_3$ + Hot water

[NCERT Exemp. Q. 69, Page 72]

Ans. (i) → (b) (ii) → (c)
(iii) → (d) (iv) → (a)
Explanation : **(i)** Lyophobic colloid (solvent hating colloid) is readily protected by small amount of electrolyte. These colloids are also stabilised by addition of lyophilic colloids which makes a protective layer around lyophobic sol. Hence, lyophilic sol is known as protective colloid.
(ii) Liquid-liquid colloid is also known as emulsion if they are partially miscible or immiscible liquids.
(iii) When $FeCl_3$ is added to hot water, it leads to the formation of positively charged colloid.
(iv) When NaOH is added to $FeCl_3$, it leads to the formation of negatively charged colloid.

C. Answer the following:

Q. 1. What are emulsions ? Give one example.
R **[CBSE Comptt. OD Set-1 2017, Comptt. Delhi 2015]**

Ans. Liquid –Liquid colloidal systems: example–milk (or any other) ½+½
[CBSE Marking Scheme 2017]

Q. 2. Write the dispersion medium and dispersed phase in milk. R **[CBSE Comptt. OD Set-2 2017]**
OR
What are the dispersed phase and dispersion medium in milk ? R **[CBSE OD 2014]**

Ans. Dispersion medium – Liquid/water; Dispersed phase –Liquid /oil. ½+½
[CBSE Marking Scheme 2017]

Q. 3. Write the dispersed phase and dispersion medium in butter. R **[CBSE Comptt. OD Set-3 2017]**

Ans. Dispersed phase–liquid /water ; Dispersed medium -liquid/oil. ½+½
[CBSE Marking Scheme 2017]

Q. 4. What type of colloid is formed when a liquid is dispersed in a solid ? Given an example.
U **[CBSE OD Set-1 2017]**

Ans. Gel eg. cheese, butter, jellies (any one). ½+½
[CBSE Marking Scheme 2017]

Q. 5. What type of colloid is formed when a solid is dispersed in a liquid ? Give an example.
U **[CBSE OD Set-2 2017]**

Ans. example –paints, cell fluids **(Any one) [CBSE Marking Scheme 2017] ½+½**

OR

A sol is formed when a solid is dispersed in a liquid.
Example – Cell fluids, paints, Gold sol, etc.

[Topper's Answer 2017] 1

Q. 6. What type of colloid is formed when a gas is dispersed in a liquid ? Give an example.
U **[CBSE OD Set-3 2017]**

Ans. Foam; e.g. froth, whipped cream, soap lather
(Any one) ½ + ½
[CBSE Marking Scheme 2017]

Q. 7. What are Associated Colloids ? Give an example.
R **[CBSE Comptt. OD 2016]**

Ans. Associated colloids are the colloids which act as electrolyte at low concentration and show colloidal behaviour at high concentration. Example : Soap solution. **[CBSE Marking Scheme 2016] 1**

Q. 8. Give one example each of 'oil in water' and 'water in oil' emulsion. U **[CBSE Delhi 2014]**

Ans. Oil in water : Milk/vanishing cream. **(Any one)** ½
Water in oil : Butter/cold cream. **(Any one)** ½
[CBSE Marking Scheme 2014]

Q. 9. Give one example each of sol and gel.
R **[CBSE Delhi 2014]**

Ans. Sol : Paint/cell fluids. ½
Gel : Cheese/butter/jellies (or any other, any one example of each). ½
[CBSE Marking Scheme 2014]

Q. 10. Give one example each of lyophobic sol and lyophilic sol. R **[CBSE Delhi 2014]**

Ans. Lyophilic sol : Metal sol, metal sulphides/ hydroxides (or any other, any one example in each case). ½
Lyophobic sol : Gum/gelatin/starch/rubber. ½
[CBSE Marking Scheme 2014]

Q. 11. To which colloidal system does milk belong ?
U **[CBSE Comptt. OD 2013]**

Ans. Milk belong to oil in water type emulsion, where dispersed phase is oil and dispersion medium is water. **1**

Q. 12. How is a sol different from an emulsion?
U **[CBSE Comptt. OD 2012]**

Ans. In sol, the dispersed phase is solid and dispersion medium is liquid.
Example : Paint
In emulsion, the dispersed phase is liquid and dispersion medium is also liquid.
Example : Milk. **1**

Q. 13. How can a colloidal solution and true solution of the same colour be distinguished from each other ?
U **[CBSE Comptt. Delhi 2012]**

Ans. When a beam of light is passed through true solution and colloidal solution kept in glass vessel, then only colloidal solution exhibits Tyndall effect whereas true solution does not. Through visibility of the solution, true solution is transparent while colloidal solution is blue. **1**

Answering Tip
- Read the question carefully and give to the point explanations.

Q. 14. What is electrophoresis ?
R **[CBSE Comptt. OD 2013]**

Ans. The movement of colloidal particles towards a particular electrode under the influence of an electric field is called electrophoresis. **1**

Q. 15. What is meant by the term peptization ?
R **[CBSE Comptt. OD 2013]**

Ans. Peptization may be defined as the process of converting a precipitate into colloidal form by shaking it with dispersion medium in the presence of small amount of electrolyte. **1**

Q. 16. Based on the type of dispersed phase, what type of colloids are dispersed phase?
R **[CBSE SQP 2018-2019]**

Ans. Associated Colloids **1**
[CBSE Marking Scheme 2018]

Q. 17. Which of the following is most effective in coagulating negatively charged hydrated ferric oxide sol?
(i) $NaNO_3$
(ii) $MgSO_4$
(iii) $AlCl_3$ U **[CBSE Comptt. Delhi Set-1 2017]**

Ans. $AlCl_3/Al^{3+}$. **1**
[CBSE Marking Scheme 2017]

Q. 18. Which of the following is most effective in coagulating positively charged hydrated ferric oxide sol?
(i) $NaNO_3$ (ii) Na_2SO_4 (iii) $(NH_4)_3PO_4$
U **[CBSE Comptt. Delhi Set-2 2017]**

Ans. $(NH_4)_3PO_4/PO_4^{3-}$. **1**
[CBSE Marking Scheme 2017]

AI **Q. 19. Which of the following is most effective in coagulating positively charged methylene blue sol?**
(i) Na_3PO_4 (ii) $K_4[Fe(CN)_6]$ (iii) Na_2SO_4
U **[CBSE Comptt. Delhi Set-3 2017]**

Ans. $K_4[Fe(CN)_6]/[Fe(CN)_6]^{4-}$. **1**
[CBSE Marking Scheme 2017]

Q. 20. Out of $BaCl_2$ and KCl, which one is more effective in causing coagulation of a negatively charged colloidal Sol ? Give reason. U **[CBSE Delhi 2015]**

Ans. The coagulation power increases with increase in charge on the ions used for coagulation. Thus, $BaCl_2$ is more effective in causing coagulation.

$Ba^{++} > K^+$ **1**

Q. 21. In reference to surface chemistry, define dialysis. R **[CBSE Comptt. Delhi 2015]**

Ans. Dialysis : Dialysis is a process of removing a dissolve substance from a colloidal solution by means of diffusion through a suitable membrane. **1**

[CBSE Marking Scheme 2015]

OR

Dialysis : The separation of soluble impurities from a colloidal solution on the basis of their different rates of diffusion through parchment membrane is known as dialysis. **1**

Answering Tip

- As it is a 1 mark question, write only the definition.

Q. 22. Write the main reason for the stability of colloidal sols. A&E **[CBSE Comptt. OD 2016]**

Ans. The stability for colloidal sols is due to Brownian movement and presence of equal and similar charges which causes repulsion between them and prevents the coagulation of the sol. **1**

[CBSE Marking Scheme 2016]

Q. 23. Which of the following is most effective electrolyte in the coagulation of AgI/Ag^+ Sol. ?
K_2SO_4, $MgCl_2$, $K_4[Fe(CN)_6]$. U **[CBSE SQP 2016]**

Ans. $K_4[Fe(CN)_6]$. Greater the valence of the flocculating ion, greater is its ability to bring coagulation as per Hardy-Schulze rule. Thus, $K_4[Fe(CN)_6]$ is most effective in coagulating AgI/Ag^+. **1**

Q. 24. Out of NH_3 and CO_2, which gas will be adsorbed more readily on the surface of activated charcoal and why ? U **[CBSE Comptt. Delhi 2012]**

Ans. NH_3 will be adsorbed more readily on the surface of charcoal because it has higher critical temperature due to van der Waals forces of attraction. **1**

Q. 25. Where does the water present in the egg go after boiling the egg ? U **[CBSE Comptt. Delhi 2012]**

Ans. When an egg is boiled, the proteins present inside the egg gets denatured and coagulate. After boiling the egg, the water present in it is absorbed by the coagulated protein through H-bonding. **1**

Q. 26. A delta is formed at the meeting point of sea water and river water. Why ? A&E **[CBSE OD 2015]**

Ans. Due to coagulation of colloidal clay particles by electrolytes present in the sea. **1**

Q. 27. Why is Tyndall effect shown by colloidal solutions ? A&E **[CBSE OD 2016]**

Ans. Colloidal solutions show Tyndall effect due to the large size of colloidal particles. **1**

[CBSE Marking Scheme 2016]

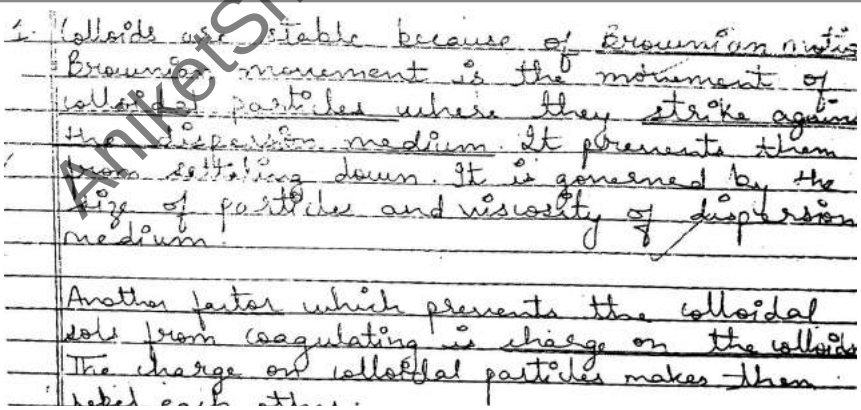
Q. 28. How is Brownian movement responsible for the stability of sols? U **[CBSE SQP 2017]**

Ans. The Brownian movement has a stirring effect, which does not allow the particles to settle. **1**

[CBSE Marking Scheme 2017]

Q. 29. Write the reason for the stability of colloidal sols. A&E **[CBSE OD Set 2 2016; KVS]**

Ans.


1. Colloids are stable because of Brownian motion. Brownian movement is the movement of colloidal particles when they strike against the dispersion medium. It prevents them from settling down. It is governed by the size of particles and viscosity of dispersion medium.

Another factor which prevents the colloidal sols from coagulating is charge on the colloids. The charge on colloidal particles makes them

1

[Topper's Answer 2016]

Detailed Answer:

Brownian movement has a stirring effect which does not permit the particles to settle resulting in the stability of colloidal sols.

Due to presence of equal and similar charges on colloidal particles causing repulsion also results in the stability of colloidal sol. **1**

Short Answer Type Questions **(2 marks each)**

AI **Q. 1. How are the following colloidal solutions prepared ?**
(i) Sulphur in water,
(ii) Gold in water. U **[CBSE Comptt. Delhi 2013]**

Ans. (i) A colloidal solution of sulphur can be obtained by passing hydrogen sulphide gas into a solution of sulphur dioxide in water.

$SO_2 + 2H_2S \rightarrow 3S + 2H_2O$ **1**

(ii) A colloidal solution of gold in water can be prepared by reducing auric chloride with stannous chloride.

$$2AuCl_3 + 3SnCl_2 \rightarrow 2Au + 3SnCl_4$$ **1**

Answering Tip

- While writing the process of preparation of each, give the corresponding chemical reactions also.

Q. 2. Explain the following :

(i) Same substance can act both as colloids and crystalloids.

(ii) Artificial rain is caused by spraying salt over clouds. A&E **[CBSE Comptt. Delhi 2013]**

Ans. (i) The nature of the substance whether colloid or crystalloid depends upon size of the solute particles. When the size of solute particles lies between 1 to 1000 nm, it behaves as a colloid. **1**

(ii) The colloidal water particles of the clouds get neutralized and coagulated to bigger water drops by spraying salt over clouds and as a result artificial rain is caused. **1**

Q. 3. How does the precipitation of colloidal smoke take place in Cottrell precipitator?

C **[NCERT Exemplar]**

Ans. In Cottrell precipitator, charged smoke particles are passed through a chamber containing plates with charge opposite to the smoke particles. Smoke particles lose their charge on the plates and get precipitated. **2**

Q. 4. Do the vital functions of the body such as digestion get affected during fever? Explain your answer.

A&E **[NCERT Exemplar]**

Ans. The rate of an enzyme reaction is maximum at a particular temperature range, called optimum temperature. On either side of the optimum temperature, the enzyme activity decreases. The optimum temperature range for enzymatic activity is 298–310 K. Normal human body temperature being 310 K is suited for enzyme-catalysed reactions. If a person is suffering from fever, the temperature will be over 310 K. This will adversely affect the enzymatic reactions. **2**

Long Answer Type Questions-I (3 marks each)

Q. 1. Write one difference in each of the following:

(i) Lyophobic sol and Lyophilic sol

(ii) Solution and Colloid

(iii) Homogeneous catalysis and Heterogeneous catalysis U **[CBSE Delhi Set-1, 2 2017]**

Ans. (i) Lyophobic are liquid(dispersion medium)-hating and lyophillic are liquid (dispersion medium)-loving colloids. **1**

(ii) Solution is a Homogeneous mixture while colloid is heterogeneous mixture /does not show tyndall effect – shows tyndall effect. **1**

(iii) Homogeneous catalysis: reactant and catalyst are in same phase – Heterogeneous catalysis: reactant and catalyst are not in same phase. **1**

(or any other correct difference)

[CBSE Marking Scheme 2017]

Commonly Made Error

- Students write more than one point of difference, which is not required, as each part carries just one mark.

Q. 2. Write one difference between each of the following :

(i) Multimolecular colloid and Macromolecular colloid

(ii) Sol and Gel

(iii) O/W emulsion and W/O emulsion

R **[CBSE Delhi Set-3 2017]**

Ans. (i) Multimolecular colloid : A large number of atoms or smaller molecules of a substance aggregate together to form species having size in the colloidal range. **1**

Macromolecular : A large sized molecules whose particle size lies in the colloidal range .

(ii) Sol are solid dispersed in liquid while gel are liquid dispersed in solid. **1**

(iii) In O/W emulsion , water acts as dispersion medium while in W/O oil acts as dispersion medium. **1**

[CBSE Marking Scheme 2017]

Q. 3. Write one difference in each of the following :

(i) Multimolecular colloid and Associated colloid

(ii) Coagulation and Peptization

(iii) Homogeneous catalysis and Heterogeneous catalysis

OR

(i) Write the dispersed phase and dispersion medium of milk.

(ii) Write one similarity between physisorption and chemisorption.

(iii) Write the chemical method by which $Fe(OH)_3$ sol is prepared from $FeCl_3$.

U **[CBSE OD Set-1, 2, 3 2017]**

Ans.

(i)

Multimolecular colloid	Associated colloid
(a) Aggregation of large number of small atoms or molecules.	**(a)** Aggregation of large number of ions in concentrated solution.

1

(ii)

Coagulation	Peptization
(a) Settling down of colloidal particles.	**(a)** Conversion of precipitate into colloidal sol by adding small amount of electrolyte.

1

(iii)

Homogenous catalysis	Heterogenous catalysis
(a) Reactant and catalyst are in same phase.	**(a)** Reactants and catalyst are in **different phases.**

1

[CBSE Marking Scheme 2017]

OR

(i) Dispersed phase – liquid, Dispersion medium – liquid **1**

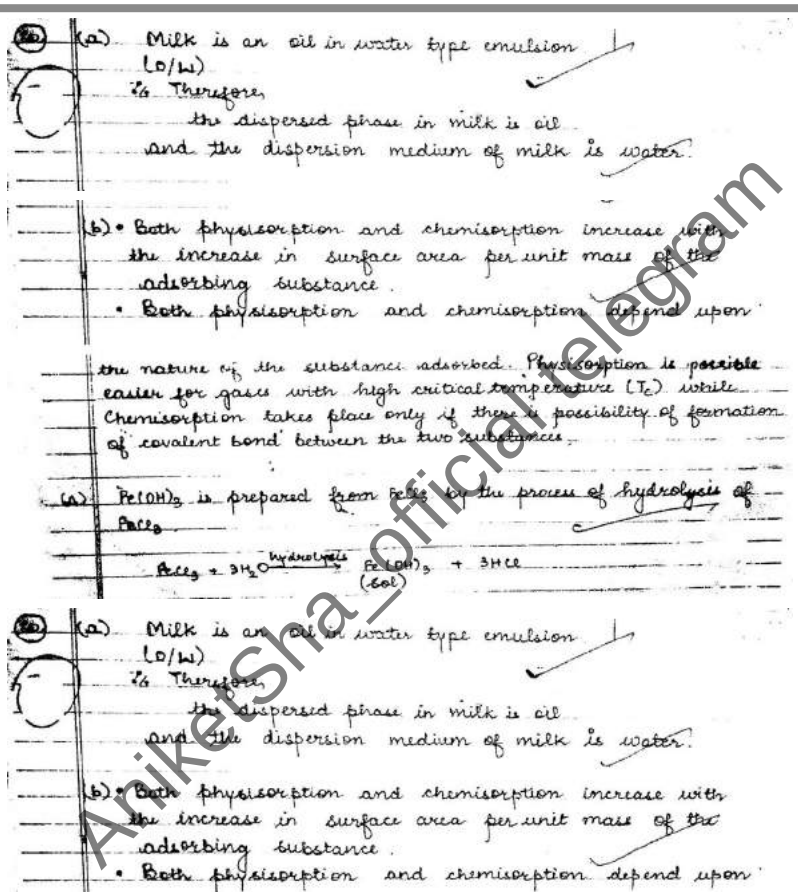
(ii) Both are surface phenomenon / both increase with increase in surface area (or any other correct similarity) **1**

(iii) Hydrolysis/

$$FeCl_3 + 3H_2O \xrightarrow{\text{hydrolysis}} Fe(OH)_3(sol) + 3HCl$$

[CBSE Marking Scheme 2017] 1

OR



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[Topper's Answer 2017]

Q. 4. Define the following terms with an example in each:

(i) Lyophobic colloids

(ii) Homogeneous catalysis

(iii) O/W emulsion R **[CBSE Foreign Set-1, 2, 3 2017]**

Ans. (i) The particles of the dispersed phase have no affinity for the dispersion medium / solvent repelling (hating) colloidal sols. Example, metal and their sulphides. ½+½

(ii) The reactant and the catalyst are in the same phase.

$$CH_3COOCH_3(l) + H_2O(l) \xrightarrow{HCl(l)} CH_3COOH(aq) + CH_3OH(aq)$$

½+½

(iii) Oil is dispersed in water /oil is dispersed phase and water is dispersion medium. Ex-milk ½+½

(or any other correct example)

[CBSE Marking Scheme 2017]

Q. 5. Explain the following phenomenon giving reasons:

(i) Tyndall effect

(ii) Brownian movement

(iii) Physical adsorption decreases with increase in temperature. R **[CBSE Comptt. Set-1, 2, 3 2017]**

Ans. (i) The colloidal particles scatter light in all direction in space. **1**

(ii) The zig-zag movement of particles of the dispersed phase due to unbalanced bombardment of the colloidal particles by the molecules of dispersion medium. **1**

(iii) As the adsorption is an exothermic process, it decreases with increase in temperature. **1**

[CBSE Marking Scheme 2017]

Q. 6. Define the following terms:

(i) Desorption

(ii) Critical micelle concentration

(iii) Shape selective catalysis

[R] **[CBSE Comptt. Delhi Set-1 2017]**

Ans. (i) The process of removing an adsorbed substance from a surface on which it is absorbed. **1**

(ii) The formation of micelles takes place only above a particular concentration called CMC. **1**

(iii) The catalytic reaction that depends upon the pore structure of the catalyst and size of the reactant and product molecules. **1**

[CBSE Marking Scheme 2017]

Answering Tip

- As it is a 3 marks question, just write the definition of each.

Q. 7. Define the following terms:

(i) Kraft temperature

(ii) Peptization

(iii) Electrokinetic potential

[R] **[CBSE Comptt. Delhi Set-2 2017]**

Ans. (i) Temperature above which micelle formation takes place. **1**

(ii) Process of converting freshly prepared precipitate into sol by shaking it with dispersion medium along with a small amount of suitable electrolyte. **1**

(iii) The potential difference between fixed layer and the diffused layer. **1**

[CBSE Marking Scheme 2017]

Detailed Answer:

(iii) The potential difference developed by charges of opposite signs between the fixed layer and the diffused layer is known as electrokinetic potential. **1**

Q. 8. Define the following terms :

(i) Lyophilic colloid,

(ii) Zeta potential,

(iii) Associated colloids. [R] **[CBSE OD 2016]**

Ans. (i) Lyophilic colloid : Liquid loving colloidal sols directly formed by mixing substances like gum, gelatine, starch, rubber, etc., with a suitable liquid (the dispersion medium) are called lyophilic sols. *e.g.*, muddy water. **1**

(ii) Zeta potential : The potential difference between the fixed layer and the diffused layer of opposite charges is called the electrokinetic potential or zeta potential. **1**

(iii) Associated colloids : There are some substances which at low concentrations behave as normal strong electrolytes, but at higher concentrations exhibit colloidal behaviour due to the formation of aggregates. The aggregated particles thus formed are called associated colloids or micelles. **1**

[AI] **Q. 9. Define the following terms :**

(i) Electrophoresis,

(ii) Adsorption,

(iii) Shape-selective catalysis.

[R] **[CBSE Comptt. Delhi 2015]**

Ans. (i) Electrophoresis : The movement of colloidal particles towards oppositely charged electrode in an electric field is called electrophoresis. **1**

(ii) Adsorption : The phenomenon of attracting and retaining the molecules of a substance on the surface of a liquid or solid leading to a higher concentration on the surface in comparison to the bulk is called adsorption. **1**

(iii) Shape-selective catalysis : The catalytic reaction which depends upon the pore structure of the catalyst and the size of the reactant and product molecules is known as shape-selective catalysis. **1**

Q. 10. Describe the following processes :

(i) Dialysis,

(ii) Electrophoresis,

(iii) Tyndall effect. [R] **[CBSE Comptt. OD 2015]**

Ans. (i) Dialysis : It is a process of removing a dissolved substance from a colloidal solution by means of diffusion through a suitable membrane. **1**

(ii) Electrophoresis : The movement of colloidal particles towards oppositely charged electrode in an electric field. **1**

(iii) Tyndall effect : When a strong converging beam of light is passed through a colloidal solution placed in a dark room, the path of beam gets illuminated with a bluish light when viewed at right angles to the direction of the passage of light. This phenomenon is known as Tyndall effect. **1**

Answering Tips

- Write the precise definition of each of the following.

Q. 11. What are emulsions ? What are their different types ? Give one example of each type.

[R] **[CBSE OD 2014; Comptt. Delhi 2013; NCERT]**

Ans. Emulsions are liquid-liquid colloidal systems or the dispersion of one liquid in another liquid. **1**

Types : (i) Oil dispersed in water (O/W type) Example ; milk and vanishing cream. ½ + ½

(ii) Water dispersed in oil (W/O type) Example; butter and cold cream. ½ + ½

(Any one example of each type)

[CBSE Marking Scheme 2014]

Q. 12. How are the two types of emulsions different from one another ? Give suitable examples to justify the difference. State two applications of emulsions.

[U] **[CBSE Comptt. OD 2012]**

Ans. Two types of emulsions are as follows :

Oil in Water	Water in Oil
In this type of emulsions, dispersed phase is oil and dispersion medium is water. *e.g.*, Milk.	In this type of emulsions, water acts as dispersed phase while the oil behaves as dispersion medium. *e.g.*, Butter.

2

Application of Emulsions :

(i) In medicine : The various pharmaceuticals and cosmetics are available in liquid form such as cod liver oil etc., and some creams and ointment are emulsions of water in oil type.

(ii) Cleaning action of soap : This action is based on the formation of oil in water type emulsions. **1**

Q. 13. (i) Differentiate between adsorption and absorption.

(ii) Out of $MgCl_2$ and $AlCl_3$, which one is more effective in causing coagulation of negatively charged sol and why ?

(iii) Out of sulphur sol and proteins, which one forms multimolecular colloids ? [U] **[CBSE Delhi 2016]**

Ans. (i)

S. No.	Adsorption	Absorption
(a)	It is a surface phenomenon.	It is a bulk phenomenon.
(b)	The accumulation of molecular species at the surface rather than in the bulk of a solid or liquid is called as adsorption.	The substance is uniformly distributed throughout the bulk of the solid essentially a bulk phenomenon.

[Any one difference] 1

(ii) $AlCl_3$ is more effective in causing coagulation of negatively charged sol because according to Hardy and Schulze rule greater the valency of the flocculating ion, greater is its ability to bring coagulation. **1**

(iii) Sulphur sol forms multimolecular colloids. **1**

[CBSE Marking Scheme 2016]

Q. 14. (i) How can we get the following colloidal solutions :

(a) Silver in water,

(b) Sulphur in water,

(c) $Fe(OH)_3$ in water,

(d) Gold in water.

(ii) List two applications of adsorption.

U **[CBSE Comptt. OD 2013]**

Ans. (i) (a) Silver sol in water is prepared by striking electric arc between two silver rods suspended in alkaline water. (Bredig's arc method) ½

(b) $2H_2S + SO_2 \rightarrow 2H_2O + 3S$ ½

(Sulphur sol)

(c) $FeCl_3 + 3H_2O \rightarrow Fe(OH)_3 + 3HCl$ ½

(Ferric hydroxide sol)

(d) $2AuCl_3 + 3SnCl_2 \rightarrow 2Au + 3SnCl_4$ ½

(Gold sol)

(ii) (a) The gas masks function on principle of adsorption.

(b) Chromatography is based on adsorption phenomenon. **1**

Q. 15. Give reasons for the following observations :

(i) Leather gets hardened after tanning.

(ii) Lyophilic sol is more stable than lyophobic sol.

(iii) It is necessary to remove CO when ammonia is prepared by Haber's process.

A&E **[CBSE Delhi 2015]**

Ans. (i) Mutual coagulation **1**

(ii) Strong interaction between dispersed phase and dispersion medium or solvated layer **1**

(iii) CO acts as a poison for catalyst **1**

[CBSE Marking Scheme 2015]

Detailed Answer:

(i) Animal hides are colloidal in nature. When a hide which has positively charged particles, is soaked in tannin, which contains negatively charged colloidal particles, mutual coagulation takes place. This results in the hardening of leather. **1**

(ii) Lyophilic colloids have great affinity for the dispersion medium *i.e.,* dispersed phase particles are solvated to a greater extent in case of lyophilic colloids. Hence, lyophilic sols are relatively more stable than lyophobic sols. **1**

(iii) It is necessary to remove CO when ammonia is prepared by Haber's process because it acts like a poison which reduces the activity of catalyst ion. 1

Q. 16. Explain what is observed when :

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

(ii) NaCl solution is added to hydrated ferric oxide sol.

(iii) Electric current is passed through a colloidal solution. U **[CBSE Comptt. OD 2013]**

Ans. (i) Scattering of light by the colloidal particles takes place and the path of light becomes illuminated. This is called **Tyndall effect.** **1**

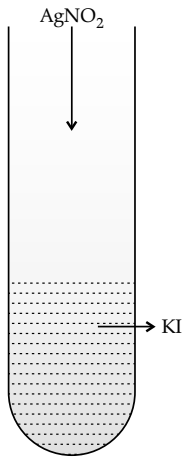
(ii) The positively charged colloidal particles of hydrated ferric oxide sol get coagulated by the oppositely charged ions provided by electrolyte NaCl. **1**

(iii) On passing direct current, the colloidal particles move towards the oppositely charged electrode where they lose their charge and get coagulated. **1**

Commonly Made Error

- **(ii)** Students get confused between coagulation and peptization concept.

Q. 17. (a) A colloidal sol is prepared by the given method in figure. What is the charge of AgI colloidal particles in the test tube? How is the sol formed, represented?



(b) Explain how the phenomenon of adsorption finds application in Heterogeneous catalysis.

(c) Which of the following electrolytes is the most effective for the coagulation of $Fe(OH)_3$ sol which is a positively charged sol ?

NaCl, Na_2SO_4, Na_3PO_4

U **[CBSE SQP 2018-2019]**

Ans. (a) Negative charge is developed on the sol. ½

Sol is represented as AgI /I– ½

(b) Adsorption of reactants on the solid surface of the catalysts increases the rate of reaction. **1**

(c) Na_3PO_4 ½

Hardy-Schulze rule ½

[CBSE Marking Scheme 2018]

Q. 18. Answer the following questions :

(i) What happens when a freshly precipitated $Fe(OH)_3$ is shaken with a little amount of dilute solution of $FeCl_3$?

(ii) Why are lyophilic colloidal sols more stable than lyophobic colloidal sols ?

(iii) What form Freundlich adsorption equation will take at high pressure ? U + A & E **[CBSE SQP 2016]**

Ans. (i) A reddish brown coloured colloidal solution is obtained. **1**

(ii) Stability of lyophilic sols is due to :

(a) same charge on all the colloidal particles.

(b) solvation of the colloidal particles. ½ + ½

(iii) At high pressures, amount of gas adsorbed (x/m) becomes independent of pressure (P).

$$\frac{x}{m} = k \times P^0$$ **1**

Q. 19. Explain the following phenomenon giving reasons:

(i) Chemical adsorption increases with increase in temperature.

(ii) Alum is applied on a cut to stop bleeding.

(iii) Sky appears blue in colour.

A&E **[CBSE Comptt. OD Set-3 2017]**

Ans. (i) High energy of activation is needed. 1

(ii) Blood being a colloidal solution, gets coagulated by alum (an electrolyte). **1**

(iii) Dust particles along with water suspended in air scatter blue light which reaches our eyes. **1**

[CBSE Marking Scheme 2017]

Detailed Answer:

(i) This happens initially as increase in temperature provides high energy of activation required in chemical adsorption. **1**

(ii) Because of scattering and dispersion of light. The light gets incident on the atmospheric particles scattering the sunlight. Due to larger scattering of blue colour, sky appears blue in colour. **1**

Q. 20. Give a reason for the following :

(i) Rough surface of catalyst is more effective than smooth surface.

(ii) Smoke is passed through charged plates before allowing it to come out of chimneys in factories.

(iii) Ne gets easily adsorbed over charcoal than He.

A&E **[CBSE SQP 2012]**

Ans. (i) Rough surface of a catalyst provides more surface area for adsorption. **1**

(ii) So that unburnt charged carbon particles get settled between the charged plate leaving behind air free from pollutants. **1**

(iii) Ne has higher critical temperature *i.e.*, stronger van der Waals forces therefore gets easily adsorbed. **1**

Q. 21. Give reason for the following observations :

(i) When Silver nitrate solution is added to Potassium iodide solution, a negatively charged colloidal solution is formed.

(ii) Finely divided substance is more effective as an adsorbent.

(iii) Lyophilic colloids are also called reversible sols.

A&E **[CBSE Comptt. Delhi/OD 2018]**

Ans. (i) The precipitated silver iodide adsorbs iodide ions from the dispersion medium resulting in the negatively charged colloidal solution. **1**

(ii) Due to large surface area **1**

(iii) If the dispersion medium is separated from the dispersed phase , the sol can be reconstituted by simply remixing with the dispersion medium. That is why these sols are also called reversible sols. **1**

[CBSE Marking Scheme 2018]

Q. 22. (i) Adsorption of a gas on surface of solid is generally accompanied by a decrease in entropy, still it is a spontaneous process. Explain.

(ii) Some substances can act both as colloids and crystalloids. Explain. **1**

(iii) What will be the charge on AgI colloidal particles when it is prepared by adding small amount of $AgNO_3$ solution to KI solution in water ? What is responsible for the development of this charge ?

A&E **[CBSE Comptt. Delhi 2012]**

Ans. (i) ΔS = negative but ΔH is also negative due to attraction. $\Delta G = \Delta H - T\Delta S$, ΔG can be negative if ΔH has sufficiently high negative value as $-T\Delta S$ is positive. So, in adsorption process, a combination of these two factors makes ΔG negative. **1**

(ii) There are some substances which at low concentration behave as normal strong electrolytes, but at higher concentrations exhibit colloidal behaviour due to the formation of aggregates. **1**

(iii) When silver nitrate solution is added to KI solution, the precipitated AgI adsorbs iodide ions from the dispersion medium and negatively charged colloidal solution results. Since KI is in excess, iodide ions (I^-) will be adsorbed on the surface of AgI particles thereby giving them a negative charge.

$AgI + I^- \rightarrow AgI : I^-$ **1**

(from KI) Negative sol

Q. 23. What happens when

(a) a freshly prepared precipitate of $Fe(OH)_3$ is shaken with a small amount of $FeCl_3$ solution ?

(b) persistent dialysis of a colloidal solution is carried out ?

(c) an emulsion is centrifuged ?

U **[CBSE Delhi/OD 2018]**

Ans. (a) Peptization occurs / Colloidal solution of $Fe(OH)_3$ is formed **1**

(b) Coagulation occurs **1**

(c) Demulsification or breaks into constituent liquids **1**

[CBSE Marking Scheme 2018]

OR

Detailed Answer:

(a) When a freshly prepared precipitate of $Fe(OH)_3$ is shaken with a small amount of $FeCl_3$ solution, peptization occurs by converting the $Fe(OH)_3$ precipitate into colloidal solution of positively charged $Fe(OH)_3$. **1**

(b) On persistent dialysis, the electrolyte present are completely removed resulting in the coagulation of the colloidal solution. **1**

(c) On centrifugation, an emulsion gets separated into its constituent liquids. **1**

AI **Q. 24. (i) Write the expression for Freundlich's equation to describe the behaviour of absorption from solution.**

(ii) What causes charge on sol particles?

(iii) Name the promoter used in the Haber's process for the manufacture of ammonia.

U **[CBSE SQP 2017]**

Ans. (i) $\frac{x}{m} = kC^{1/n}$ **1**

(ii) The charge on the sol particles is due to

(a) Electron capture by sol particles during electrodispersion.

(b) Preferential adsorption of ions from solution. **1**

(c) Formulation of electrical double layer.

(Any one reason)

(iii) Molybdenum acts as a promoter for iron. **1**

[CBSE Marking Scheme 2017]

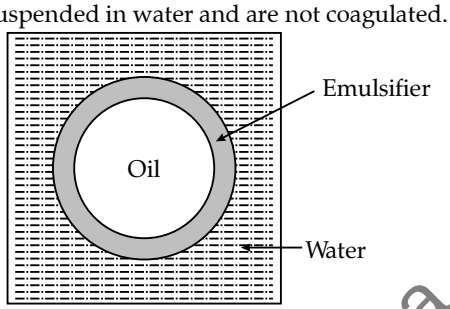
Answering Tip

- Don't forget to answer the sub-parts.

Long Answer Type Question-II (5 marks each)

Q. 1. How do emulsifiers stabilise emulsion? Name two emulsifiers. U **[NCERT]**

Ans. (i) It is believed that an emulsifier gets concentrated at the oil-water interface i.e., the surface at which oil and water come in contact with each other. It forms a protective coating around each drop of oil and thus, prevents the oil drop from coming in contact with one another. The oil drops remain suspended in water and are not coagulated.



(ii) According to an another view, the role of the emulsifier is the same as that of lubricant in a machine. Just as a lubricant reduces the friction in the various parts of machine, an emulsifier also tries to reduce the interfacial tension between oil and water by suitable means. Thus, oil and water remain in company of each other and do not get separated. The commonly used emulsifying agents are soaps, detergents, lyophilic colloids, proteins, gums, gelatin, caesin, agar etc. **5**

Q. 2. What is the difference between multi-molecular and macro-molecular colloids? Give one example of each. How are associated colloids different from these two types of colloids?

U **[NCERT Ex. Q. 5.12, Page 148]**

Ans. (i) In multi-molecular colloids, the colloidal particles are an aggregate of atoms or small molecules with a diameter of less than 1 nm. The molecules in the aggregate are held together by van der Waals forces of attraction. Examples of such colloids include gold sol and sulphur sol. **[1]**

(ii) In macro-molecular colloids, the colloidal particles are large molecules having colloidal dimensions. These particles have a high molecular mass. When these particles are dissolved in a liquid, sol is obtained.

For example : Starch, nylon, cellulose, etc. **[1]**

(iii) Certain substances tend to behave like normal electrolytes at lower concentrations. **[1]** However, at higher concentrations, these substances behave as colloidal solutions due to the formation of aggregated particles. Such colloids are called aggregated colloids. **[2]**

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