

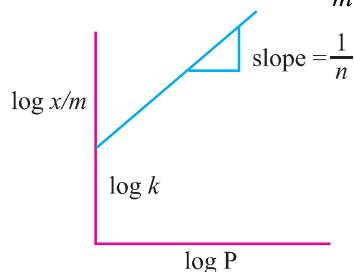
UNIT 4

SURFACE CHEMISTRY

Points to Remember

1. Adsorption occurs because of unbalanced forces acting inwards on the surface of the solid or a liquid.
2. The substance adsorbed is called **adsorbate** and substance on which adsorption takes place is **adsorbent**.
3. In physical adsorption, adsorbate is held to adsorbent by weak van der Waals forces. In chemisorptions, adsorbate is held to adsorbent by strong chemical bond type of forces.
4. Water vapours are adsorbed in silica gel but absorbed in CaCl_2 .
5. If the concentration of adsorbate is more on the surface with respect to bulk, it is called **positive adsorption**. If it is less on the surface with respect to bulk, it is called **negative adsorption**.
6. Greater the surface area of the adsorbent, the more is the extent of adsorption.
7. Higher the critical temperature of a gas, greater is its extent of adsorption.
8. Physical adsorption is due to van der Waals forces and is reversible. Chemisorption involves the formation of compounds on the surface and is irreversible.
9. At constant temperature, adsorption generally increases with pressure. The lower the temperature, the greater is the effect of pressure.
10. Freundlich adsorption isotherm is

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



The plot of $\log x/m$ vs $\log P$ gives a straight line with slope = $1/n$ and y-intercept = $\log k$.

11. Adsorption is generally temperature dependent. Generally adsorption is **exothermic** and, therefore, adsorption decreases with the increase in temperature.
12. For adsorption from solution, pressure (P) is replaced by equilibrium concentration (C).
13. A catalyst is a substance that increases the rate of reaction without being consumed in the reaction. In general, a catalyst functions by lowering the energy of activation which in turn makes the rate constant larger and, hence, the rate of reaction higher. (The catalysts take part in reaction but get regenerated during course of reaction.)
14. In **homogeneous catalysis**, the catalyst is in the same phase as that of reactants and in **heterogeneous catalysis**, the catalyst is in the different phase from the reactants.
15. **Enzymes** are biological catalysts. Their main characteristics are their high *specificity*, efficiency (even in traces) and activity at physiological temperature of 37° C and pH of 7.4.
16. Enzyme catalysed reaction takes place in two steps :
$$E + S \rightarrow [ES] \text{ (fast and reversible)}$$
$$[ES] \rightarrow E + P \text{ (slow and rate determining)}$$

(E is enzyme, S is substrate and P is product.)
17. **Colloidal solutions** are intermediate between true solutions and suspensions. Their size ranges in the order 1 nm to 1000 nm.
18. A colloidal system consists of two phases : the dispersed phase and dispersion phase.
19. **Lyophilic sols** : There is strong attraction between dispersed phase and dispersion medium. These are formed by organic substances like gum, starch, protein etc. These are reversible and more stable.
20. **Lyophobic sols** : There is very little interaction between dispersed phase and dispersion medium and are formed by inorganic substances like metals, their sulphides etc. These are irreversible and less stable.
21. The stability of lyophilic sols is due to their greater hydration in the solution.
22. The colloidal systems show Brownian movement, Tyndall effect and electrophoresis.
23. Aggregate of ions in an associated colloidal sol is called **ionic micelle**. The concentration above which these are formed is called **critical micelle concentration** (CMC) and the temperature above which these are formed is called **Kraft temperature** (T_k).

24. Conversion of a freshly precipitated substance into colloidal sol by shaking with a suitable electrolyte is called **peptization**.
25. The movement of colloidal particles under the influence of an electric field is called **electrophoresis**.
26. The process of changing the colloidal particles in a sol into the insoluble precipitate by the addition of some suitable electrolytes is known as **coagulation**.
27. According to Hardy Schulze rule, greater the valency of the flocculating ion of the electrolyte, the faster is the coagulation.
28. The minimum number of millimoles of the electrolyte required for complete coagulation of one litre of a colloidal sol is called its **coagulation or flocculation value**.
30. **Emulsions** are colloidal systems in which both dispersed phase and dispersion medium are liquids. These can be of (i) oil in water (o/w) and (ii) water in oil (w/o) type.
31. The process of making emulsion is called emulsification.
32. To stabilize an emulsion, an emulsifying agent or emulsifier is added. Soap and detergents are most frequently used as **emulsifiers**.
33. The potential difference between the fixed layer and the diffused layer of opposite charges in colloids is called electrokinetic potential or zeta potential.

MULTIPLE CHOICE QUESTIONS (1 Mark)

1. **Rate of physisorption increases with:**
 - (a) decrease in temperature
 - (b) increase in temperature
 - (c) decrease in pressure
 - (d) decrease in surface area
2. **The colloidal system consisting of a liquid adsorbate in a solid adsorbent is termed as:**
 - (a) aerosol
 - (b) foam
 - (c) emulsion
 - (d) Gel
3. **Which of the following has least coagulating value for positive sol?**
 - (a) Cl^-
 - (b) SO_4^{2-}
 - (c) PO_4^{-3}
 - (d) $[\text{Fe}(\text{CN})_6]^{-4}$
4. **Which can adsorb larger volume of hydrogen gas?**
 - (a) Colloidal solution of platinum
 - (b) finely divided nickel
 - (c) finely divided platinum
 - (d) colloidal $\text{Fe}(\text{OH})_3$

- 5. What is the emulsifier in milk?**
(a) albumin (b) soap
(c) gelatin (d) caesin
- 6. Which one of the following gases will be adsorbed most easily?**
(a) N_2 (b) H_2
(c) O_2 (d) CO_2
- 7. Cottrell precipitator works on the principle of:**
(a) distribution law (b) addition of electrolyte
(c) Le-chattelier principle (d) Neutralisation of charge on colloids
- 8. The formation of micelles takes place only above:**
(a) inversion temperature (b) Boyle temperature
(c) critical temperature (d) Kraft temperature
- 9. A colloidal solutions show:**
(a) very high osmotic pressure (b) high osmotic pressure
(c) low osmotic pressure (d) no osmotic pressure
- 10. Alums purify muddy water by:**
(a) dialysis (b) adsorption
(c) absorption (d) coagulation
- 11. Which of the following is an example of associated colloid?**
(a) soap in water (b) protein in water
(c) rubber in benzene (d) $AgNO_3$ in water
- 12. The coagulating power of an electrolyte for blood decrease in the order.**
(a) Na^+ , Al^{+3} , Ba^{+2} (b) PO_4^{-3} , SO_4^{-2} , Cl^-
(c) Al^{+3} , Ba^{+2} , Na^+ (d) Cl^- , SO_4^{2-} , PO_4^{-3}
- 13. A catalyst do not change:**
(a) gibbs energy of reaction (b) enthalpy of reaction
(c) equilibrium constant (d) Activation energy of reaction
- 14. Bredig's arc method can not be used for the preparation of colloidal sol of**
(a) Cu (b) Mg
(c) Ag (d) Na
- 15. Which is method of purification of colloidal solution?**
(a) ultrafiltration (b) electro dialysis
(c) bredig's arc method (d) dialysis

16. Match the column and choose correct option:

- | | |
|------------------------|------------------------|
| (A) Smoke | P. foam |
| (B) Butter | Q. emulsion |
| (C) Hair cream | R. aerosol |
| (D) Whipped cream | S. gel |
| (a) A–P, B–S, C–Q, D–R | (b) A–R, B–Q, C–S, D–P |
| (c) A–R, B–S, C–Q, D–P | (d) A–S, B–P, C–R, D–Q |

Matching Column Type**17. Column 1**

- (A) Soap in water
 (B) Starch gelatin
 (C) Gold sol
 (D) Cellulose nitrate in alcohol
 (a) A–R, B–S, C–Q, D–P
 (c) A–R, B–S, C–P, D–Q

Column 2

- P. Associated colloid
 Q. Lyoptrilic colloid
 R. Collodion
 S. Lyophobic colloid
 (b) A–P, B–Q, C–S, D–R
 (d) A–P, B–Q, C–R, D–S

Fill in the blanks take question

18. Collodion is a 4% solution of in a alcohol or ether.
 19. Starch is an example of colloids.

Assertion and Reason Type Question

20. **Statement 1 :** Lyophilic sols are more stable than Lyophobic sols.

Statement 2 : Lyophilic sols are highly hydrated in the solution.

- (a) both statement are correct and statement 2 is correct explanation of statement 1
 (b) both are correct explanation but statement 2 is not explain statement 1.
 (c) statement 1 is true both statement 2 is false
 (d) statement 2 is false but statement 2 is true

ANSWERS

1. (a) 2. (d) 3. (d) 4. (a) 5. (b) 6. (d) 7. (d) 8. (d) 9. (c) 10. (d)
 11. (a) 12. (c) 13. (a, b, c) 14. (b, d) 15. (a, b, d) 16. (c)
 17. (b) 18. (Cellulose nitrate) 19. lyophilic colloids 20. (a)

VERY SHORT ANSWER TYPE QUESTIONS (1 Mark)

Q. 1. Why does a gas mixed with another gas not form a colloidal system ?

[Hint : Gaseous mixture is homogeneous.]

Q. 2. Why are adsorbate particles attracted and retained on the surface of adsorbent ?

[Hint : The unbalanced forces of the adsorbent are responsible for attracting adsorbate particles at adsorbent surface.]

Q. 3. Explain the terms sorption and desorption.

[Hint : Sorption is used to describe the process when adsorption and absorption take place simultaneously.

Desorption : Removal of adsorbate from the surface of adsorbent.]

Q. 4. “Chemisorption is highly specific.” Illustrate with an example.

[Hint : As it involves chemical bonding between adsorbent and adsorbate.]

Q. 5. “Adsorbents in finely divided form are more effective.” Why ?

[Hint : Due to their more surface area in finely divided form.]

Q. 6. Name two compounds used as adsorbent for controlling humidity.

Ans. Silica gel, Alumina gel

Q. 7. Mention one shape selective catalyst used to convert alcohol directly into gasoline.

[Hint : ZSM-5]

Q. 8. ‘Generally high temperature is favourable for chemisorption.’ Why ?

[Hint : To provide energy of activation.]

Q. 9. Name the catalyst used in the following process :

(a) Haber’s process for the manufacture of NH_3 gas.

(b) Ostwald process for the manufacture of nitric acid.

[Hint : (a) Finely divided Fe/FeO, MO as promoter.

(b) Pt (Platinised asbestos)]

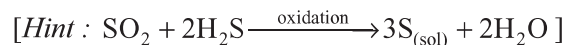
Q. 10. Which group elements show maximum catalytic activity for hydrogenation reactions ?

[Hint : 7-9 group elements.]

Q. 11. Why gas masks are used by miners in coal mines while working ?

[Hint : To absorb poisonous gases.]

Q. 12. Write the chemical reaction involved in the preparation of sulphur sol.



Q. 13. What are the optimum temperature and pH at which enzymes are highly active ?

[Hint : Temperature 298-310 K and pH 5 to 7]

Q. 14. What are the physical states of dispersed phase and dispersion medium in foam rubber ?

[Hint : Dispersed phase : Gas; Dispersion medium : Solid]

Q. 15. What is the composition of colloidal solution ?

[Hint : 4% solution of nitrocellulose in a mixture of alcohol and ether.]

Q. 16. Why do colloidal particles show Brownian movement ?

[Hint : Due to unbalanced bombardment of the dispersed phase particles by the molecules of the dispersion medium.]

Q. 17. State the sign of entropy change involved when the molecules of a substance get adsorbed on a solid surface.

[Hint : $\Delta S = -ve$]

Q. 18. Why does sky appear blue to us ?

[Hint : Due to scattering of blue light by dust particles and water suspended in air.]

Q. 19. What happens when hydrated ferric oxide and arsenious sulphide sols are mixed in almost equal proportions ?

[Hint : Mutual precipitation/coagulation took place.]

Q. 20. Gelatin is generally added to ice-cream. Why ?

[Hint : Ice-cream is water in oil type emulsion and gelatin acts as emulsifier.]

Q. 21. How is lake test for aluminium ion based upon adsorption ?

[Hint : $\text{Al}_2\text{O}_3 \cdot x\text{H}_2\text{O}$ has the capacity to adsorb the colour of blue litmus from the solution.]

Q. 22. Mention the two conditions for the formation of micelles.

[Hint : CMC and T_k .]

Q. 23. How is Brownian movement responsible for the stability of sols ?

[Hint : Stirring effect due to Brownian movement does not allow the particles to settle down.]

Q. 24. Which of the following is more effective in coagulating positively charged hydrated ferric oxide sol : (i) KCl, (ii) CaSO_4 , (iii) $\text{K}_3[\text{Fe}(\text{CN})_6]$?

[Hint : $\text{K}_3[\text{Fe}(\text{CN})_6]$]

Q. 25. State the purpose of impregnating the filter paper with colloidal solution.
 [Hint : To reduce pore size of filter paper, so that colloidal particles cannot pass through.]

Q. 26. Mention one use of ZSM-5 catalyst.

[Hint : In dehydration of alcohols in formation of synthetic gasoline.]

Q. 27. Why is it necessary to remove CO (carbon monoxide) when ammonia is obtained by Haber's process ?

Ans. CO acts as poison catalyst for Haber's process therefore, it will lower the activity of the Fe catalyst.

Q. 28. Explain the terms : (i) CMC, (ii) Kraft temperature (T_k).

[Hint : CMC : Concentration above which micelle formation took place.

Kraft Temperature : It is the temperature above the micelle formation took place.]

SHORT ANSWER-I TYPE QUESTIONS (2 Marks)

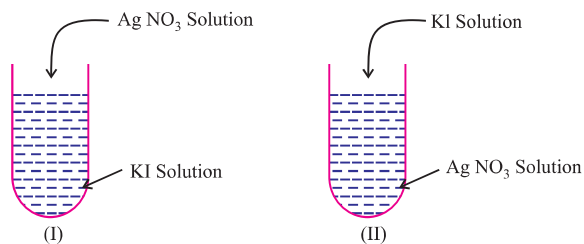
Q. 1. Explain the effect of temperature on the extent of physical and chemical adsorption.

[Hint : Physical adsorption decreases with increase of temperature, while chemical adsorption increases with increase of temperature.]

Q. 2. Define the term peptization and mention its cause.

[Hint : It is the process of converting a ppt into a colloidal sol by shaking it with small amount of electrolyte with dispersion medium. Ppts adsorb one of the ions of the electrolyte on its surface.]

Q. 3. What will be the charge on colloidal solutions in the following cases ?



Give reasons for the origin of charge.

Ans. (i) I^- ions are adsorbed on AgI, forming negatively charged colloid.
 (ii) Ag^+ ions are adsorbed on AgI, forming positively charged colloid.

Reason for origin of charge is the preferential adsorption of common ions of the electrolyte present in excess.

Q. 4. Write the factors upon which the catalytic reaction of shape-selective catalyst depends ?

[Hint : (a) Pore structure of the catalyst.

(b) Size and shape of the reactant and product molecules.]

Q. 5. Mention two examples of emulsifying agents for o/w emulsions and w/o emulsions.

[Hint : For o/w emulsions : Proteins, gums, soaps.

For w/o emulsions : Fatty acids, long chain alcohols, lampblack.]

Q. 6. A small amount of silica gel and a small amount of anhydrous calcium chloride are placed separately in two beakers containing water vapour. Name the phenomenon that takes place in both the beakers.

[Hint : Silica gel : Adsorption, Anhydrous CaCl_2 : Absorption, as it forms $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$]

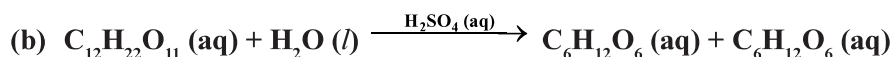
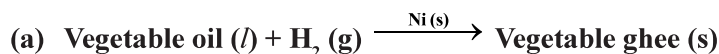
Q. 7. Write the differences between adsorption and absorption.

[Hint : Adsorption is surface, while absorption is bulk phenomenon.]

Q. 8. How can physisorption be distinguished from chemisorptions ?

[Hint : Physisorption arises because of van der Waal's forces, not specific and reversible while chemisorptions is caused by chemical bond formation, highly specific and irreversible.]

Q. 9. Classify the following reactions as homogeneous and heterogeneous catalysis :



[Hint : (a) : Heterogeneous catalysis

(b) : Homogeneous catalysis

Q. 10. In what ways these are different : (a) a sol and a gel (b) a gel and an emulsion ?

[Hint :

(a) For a sol : Dispersed phase : Solid, Dispersion medium : Liquid

For a gel : Dispersed phase : Liquid, Dispersion medium : Solid

(b) For a gel : Dispersed phase : Liquid, Dispersion medium : Solid

For an emulsion : Dispersed phase : Liquid, Dispersion medium : Liquid]

Q. 11. State 'Hardy Schulze Rule' with one example.

[Hint : It states that greater the valency of the flocculating ion of the electrolyte, the faster is the coagulation.]

Q. 12. What is an emulsifying agent ? What role does it play in forming an emulsion ?

[Hint : Those agents which stabilize emulsions. It acts as binding agent between two immiscible liquid phases.]

Q. 13. Define the terms :

(a) **Helmholtz electrical double layer**

(b) **Zeta potential**

[Hint : (a) The combination of the two layers of opposite charges around the colloidal particles. *E.g.*, AgI/I⁻-K⁺.

(b) The potential difference between the fixed layer and diffused layer of opposite charges is called zeta potential.]

Q. 14. Mention the two necessary conditions for the observation of Tyndall effect.

[Hint : (a) The size of dispersed phase particles is not much smaller the wavelength of light used.

(b) The refractive indices of the dispersed phase and the dispersion medium differ greatly in magnitude.]

Q. 15. Account for the following :

(a) **Artificial rain can be caused by spraying electrified sand on the clouds.**

(b) **Electrical precipitation of smoke.**

Q. 16. Write chemical equations for the preparation of sols :

(a) **Gold sol by reduction**

(b) **Hydrated ferric oxide sol by hydrolysis.**

[Hint : (a) $2\text{AuCl}_3 + 3\text{SnCl}_2 \xrightarrow{\text{Reduction}} 2\text{Au (sol)} + 3\text{SnCl}_4$

(b) $\text{FeCl}_3 + 3\text{H}_2\text{O} \xrightarrow{\text{Hydrolysis}} \text{Fe(OH)}_3 \text{ (sol)} \text{ (Or } \text{Fe}_2\text{O}_3 \cdot x\text{H}_2\text{O)} + 3\text{HCl}$]

Q. 17. How can the two emulsions can be distinguished :

(a) **oil in water type (o/w) and**

(b) **water in oil type (w/o)**

[Hint : (a) By dilution test

(b) By dye test]

Q. 18. Leather gets hardened after tanning. Why ?

Ans. Animal hide is colloidal in nature and has positively charged particles. When it is soaked in tannin which has negatively charged colloidal particles, it results in mutual coagulation. This results in the hardening of leather.

Q. 19. Why are some medicines more effective in the colloidal form ?

Ans. Medicines are more effective in the colloidal form because of large surface area and are easily assimilated in this form.

Q. 20. What happens when dialysis is prolonged ?

Ans. When dialysis is prolonged the traces of electrolyte which stabilises the colloids are removed completely. This makes the colloid unstable and therefore coagulation takes place.

SHORT ANSWER-II TYPE QUESTIONS (3 Marks)

Q. 1. Write the difference between :

- (a) catalysts and enzymes
- (b) promoters and poisons

[Hint : (a) Catalyst is a substance that alters the rate of reaction without consuming itself in the reaction. Ezymes are biocatalysts, they are highly specific than catalysts.

(b) Promoters enhance the activity of a catalyst while poisons decrease the activity of catalysts.]

Q. 2. Write the steps of 'Modern Adsorption Theory of Heterogenous Catalysis'.

[Hint : (a) Diffusion and adsorption of reactant molecules on the surface of catalyst.

(b) Formation of intermediate on the surface of catalyst.

(c) Desorption of the products from catalysts surface.

(d) Diffusion of products away from the catalyst surface.]

Q. 3. Mention two important features of solid catalysts and explain them with the help of suitable examples.

[Hint : Heterogeneous catalyst, activity and selectivity of catalysts. Example, Hydrogenation of unsaturated hydrocarbons in presence of Raney Ni or any other example.]

Q. 4. How are the following colloids different from each other in respect of dispersion medium and dispersed medium ? Give one example of each type.

- (a) An aerosol (b) A hydrosol (c) An emulsion

[Hint : D.P.	D.M.	Example
(a) Solid/liquid	Gas	Smoke, dust, fog, cloud
(b) Solid	Water	Muddy water
(c) Liquid	Liquid	Milk, hair cream]

Q. 5. What happens :

- (a) By persistent dialysis of a sol.
 (b) When river water meets the sea water.
 (c) When alum is applied on cuts during bleeding.

[Hint : (a) Coagulation of sol takes place.
 (b) Delta formation takes place due to coagulation of river water.
 (c) Clot is formed due to coagulation of blood which stops further bleeding.]

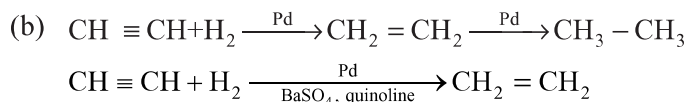
Q. 6. Distinguish between multimolecular, macromolecular and associated colloids with the help of one example of each.

[Hint : (i) Multimolecular colloids formed by aggregation of small atoms or molecules. Example, gold sol, sulphur sol.
 (ii) Macromolecular colloids formed by dispersing macromolecules having colloidal size in proper dispersion medium. Example, protein, starch colloid.
 (iii) Associated colloids are formed by aggregation of particles at higher concentration to colloidal range. Example, micelles.]

Q. 7. (a) Which property of colloids is responsible for the sun to look red at the time of setting ?

(b) C_2H_2 on addition with H_2 forms ethane in presence of palladium catalyst but if reaction is carried in the presence of barium sulphate and quinoline, the product is ethene and not ethane. Why ?

Ans. (a) Sun is at horizon and blue part of the light is scattered away by the dust particles as light has to travel a long distance through the atmosphere.



($BaSO_4$ in presence of quinoline act as poison. The catalyst in this case is not effective in further reduction.)

LONG ANSWER TYPE QUESTIONS (5 Marks)

Q. 1. Comment on the statement that “colloid is not a substance but state of a substance.”

Ans. The given statement is true. This is because the substance may exist as a colloid under certain conditions and as a crystalloid under certain other conditions. E.g., NaCl in water behaves as a crystalloid while in benzene, behaves as a colloid (called associated colloid). It is the size of the particles which matters *i.e.*, the state in which the substance exist. If the size of the particles lies in the range 1 nm to 1000 nm it is in the colloid state.

Q. 2. Write short notes on the following :

- (a) Tyndall Effect
- (b) Brownian Movement
- (c) Hardy Schulze Rule

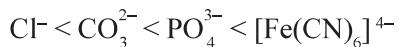
Ans. (a) **Tyndall Effect :** Scattering of light by colloidal particles by which part of beam becomes clearly visible. This effect is known as tyndall effect.

(b) **Brownian Movement :** Zig-zag motion of colloidal particles.

(c) **Hardy Schulze Rule :** Coagulating value of a coagulating ion is directly proportional to the charge on the ion.



For negatively charged sol



For positive sol

