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CLASS XII CHEMISTRY NOTES

SURFACE CHEMISTRY

KEY NOTES AND IMPORTANT QUESTIONS WITH ANSWERS



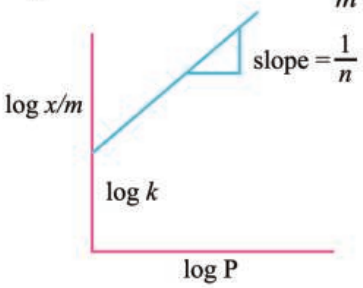
UNIT 5

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 foces.
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

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



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 :

    $E+S \rightarrow [ES]$ (fast and reversible)

    $[ES] \rightarrow E + P$ (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.**

29. The minimum number of milligrams of a lyophilic sol needed to protect 10 mL of gold sol by the addition of 1 mL of 10% NaCl is called **gold number.** Protective power is the reciprocal of gold number.

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.

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. Write Freundlich adsorption isotherm relation.

[*Hint :* $\frac{x}{m} = kP^{1/n}\ (n > 1),\ \log\frac{x}{m} = \log k + \frac{1}{n}\log P$]

Q. 11. Which group elements show maximum catalytic activity for hydrogenation reactions ?

[*Hint :* 7-9 group elements.]

Q. 12. Why gas masks are used by miners in coal mines while working ?

[*Hint :* To absorb poisonous gases.]

Q. 13. Write the chemical reaction involved in the preparation of sulphur sol.

[*Hint :* $SO_2 + 2H_2S \xrightarrow{\text{oxidation}} 3S_{(sol)} + 2H_2O$]

Q. 14. Name the enzyme which converts milk into curd.

[*Hint :* Lactobacilli.]

Q. 15. What are the optimum temperature and pH at which enzymes are highly active ?

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

Q. 16. What are the physical states of dispersed phase and dispersion medium in foam rubber ?

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

Q. 17. What is the composition of colloidion solution ?

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

Q. 18. 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. 19. State the sign of entropy change involved when the molecules of a substance get adsorbed on a solid surface.

[*Hint :* S = – ve]

Q. 20. Why does sky appear blue to us ?

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

Q. 21. What happens when hydrated ferric oxide and arsenious sulphide sols are mixed in almost equal proportions ?

[*Hint :* Mutual precipitation/coagulation took place.]

Q. 22. Gelatin is generally added to ice-cream. Why ?

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

Q. 23. How is lake test for aluminium ion based upon adsorption ?

[*Hint :* $Al_2O_3.xH_2O$ has the capacity to adsorb the colour of blue litmus from the solution.]

Q. 24. What is saturation pressure in Freundlich's isotherm ?

[*Hint :* High pressure]

Q. 25. Mention the two conditions for the formation of micelles.

[*Hint :* CMC and T_k.]

Q. 26. 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. 27. Which of the following is more effective in coagulating positively charged hydrated ferric oxide sol : (i) KCl, (ii) $CaSO_4$, (iii) $K_3[Fe(CN)_6]$?

[*Hint :* $K_3[Fe(CN)_6]$]

Q. 28. State the purpose of impregnating the filter paper with colloidion solution.
[*Hint :* To reduce pore size of filter paper, so that colloidal particles cannot pass through.]

Q. 29. Mention one use of ZSM-5 catalyst.

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

Q. 30. Name the enzyme which convert starch into maltose.

Ans. Diastase/Salivary amylase.

Q. 31. 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. 32. 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)

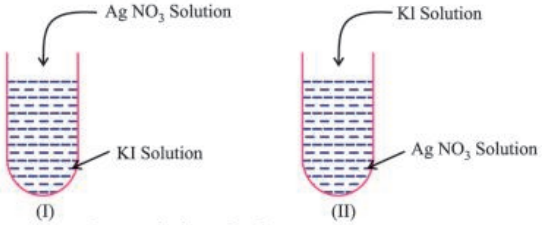
Q. 1. Explain the effect of temperature on the extent of physical and chemical adsorption.

[*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 ppts 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. Suggest a mechanism of enzyme catalysed reaction.

[*Hint :* (a) Binding of enzyme and substrate : $E + S \rightarrow [ES]$

(b) Decomposition of activated complex to product : $[ES] \rightarrow E + P$

Q. 7. 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 $CaCl_2.2H_2O$]

Q. 8. Write the differences between adsorption and absorption.

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

Q. 9. 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. 10. Classify the following reactions as homogeneous and heterogeneous catalysis :

(a) $\textbf{Vegetable oil } (l) + H_2\ (g) \xrightarrow{Ni\ (s)} \textbf{Vegetable ghee (s)}$

(b) $C_{12}H_{22}O_{11}\ (aq) + H_2O\ (l) \xrightarrow{H_2SO_4\ (aq)} C_6H_{12}O_6\ (aq) + C_6H_{12}O_6\ (aq)$

[*Hint :* (a) : Heterogeneous catalysis

(b) : Homogeneous catalysis

Q. 11. 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. 12. 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. 13. 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. 14. 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. 15. A graph between *x/m* and log p is a straight line at an angle of 45° with intercept on the y-axis *i.e.,* (log k) equal to 0.3010. Calculate the amount of the gas absorbed per gram of the adsorbent under a pressure of 0.5 atmosphere.

[*Hint* : Refer to NCERT Textbook page 125, Fig. 5.2

$\frac{1}{n} = \tan 45^\circ = 1, \log k = 0.3010, k = 2, p = 0.5 \text{ atm}$

$\frac{x}{m} = kp^{1/n} = 2 \times (0.5)^1 = 1.0$]

Q. 16. 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. 17. Account for the following :

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

(b) Electrical precipitation of smoke.

Q. 18. Write chemical equations for the preparation of sols :

(a) Gold sol by reduction

(b) Hydrated ferric oxide sol by hydrolysis.

[*Hint :* (a) $2AuCl_3 + 3SnCl_2 \xrightarrow{\text{Reduction}} 2Au\ (sol) + 3SnCl_4$

(b) $FeCl_3 + 3H_2O \xrightarrow{\text{Hydrolysis}} Fe(OH)_3\ (sol)\ (\text{Or } Fe_2O_3.xH_2O) + 3HCl$]

Q. 19. 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. 20. 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. 21. 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. 22. What happens when dialysis is prolonged ?

Ans. When dialysis is prolonged the traces of electrolyte which stabilies 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.

(b) $CH \equiv CH + H_2 \xrightarrow{Pd} CH_2 = CH_2 \xrightarrow{Pd} CH_3 - CH_3$

$$CH \equiv CH + H_2 \xrightarrow[BaSO_4, \text{ quinoline}]{Pd} CH_2 = CH_2$$

($BaSO_4$ 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. Describe some features of catalysis by Zeolites.

Ans. **Features of catalysis by Zeolites :**

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

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

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

An important catalyst used in petroleum industries is ZSM-5. It converts alcohols into petrol by first dehydrating them to form a mixture of hydrocarbons.

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

Q. 2. 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 statement 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. 4. 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.

E.g., $Na^{+} < Ca^{++} < Al^{3+}$ For negatively charged sol

$Cl^{-} < CO_3^{2-} < PO_4^{3-} < [Fe(CN)_6]^{4-}$ For positive sol

