Chapter.5
Surface Chemistry
Class-XII
Subject-Chemistry

5.1 Distinguish between the meaning of the terms adsorption and absorption. Give one example of each.

Answer 5.1

Adsorption	Absorption
• Surface phenomenon	• Bulk phenomenon
• In this, accumulation of molecules of a substance takes place at the surface only. The substance that gets adsorbed is called the 'adsorbate' and the substance on whose surface the adsorption takes place is called the 'adsorbent'	• In absorption, the substance gets uniformly distributed throughout the bulk of the solid or liquid.
• In this, the concentration of the adsorbate on the surface of the adsorbent increases. Here, substance gets concentrated at the surface only. It does not penetrate through the surface to the bulk of the solid or liquid.	• In this, the concentration of the molecules does not increase on the surface rather than penetrate & distribute in the bulk of solid or liquid.
• For example, if a chalk stick is dip into an ink solution, only its surface becomes coloured. If we break the chalk stick, it will be found to be white from inside.	• For example- if cotton dip into water, we will observe that water will enter into bulk of cotton & make it wet.

5.2 What is the difference between physisorption and chemisorption?

Answer 5.2

	Physisorption	Chemisorption
1.	In this, the adsorbate is attached to the surface of the adsorbent through weak Vander Waal's forces of attraction.	In this, the adsorbate is attached to the surface of the adsorbent through strong chemical bonds.
2.	Reversible in nature.	Irreversible in nature.
3.	New products are not formed in the process.	New products are formed at the surface of the adsorbent.
4.	It is favoured by low temperature conditions.	It is favoured by high temperature conditions.
5.	Enthalpy of adsorption is low as weak Vander Waal's forces of attraction are involved.	Enthalpy of adsorption is high as chemical bonds are formed.
6.	It is an example of multi-layer adsorption	It is an example of mono-layer adsorption.

5.3 Give reason why a finely divided substance is more effective as an adsorbent.

Answer 5.3

A finely divided substance has a large surface area. We know that adsorption is a surface phenomenon & is directly proportional to the surface area. Whether adsorption is physisorption or chemisorption, it increases with an increase in the surface area. Thus, a finely divided substance behaves as a good adsorbent.

5.4 What are the factors which influence the adsorption of a gas on a solid?

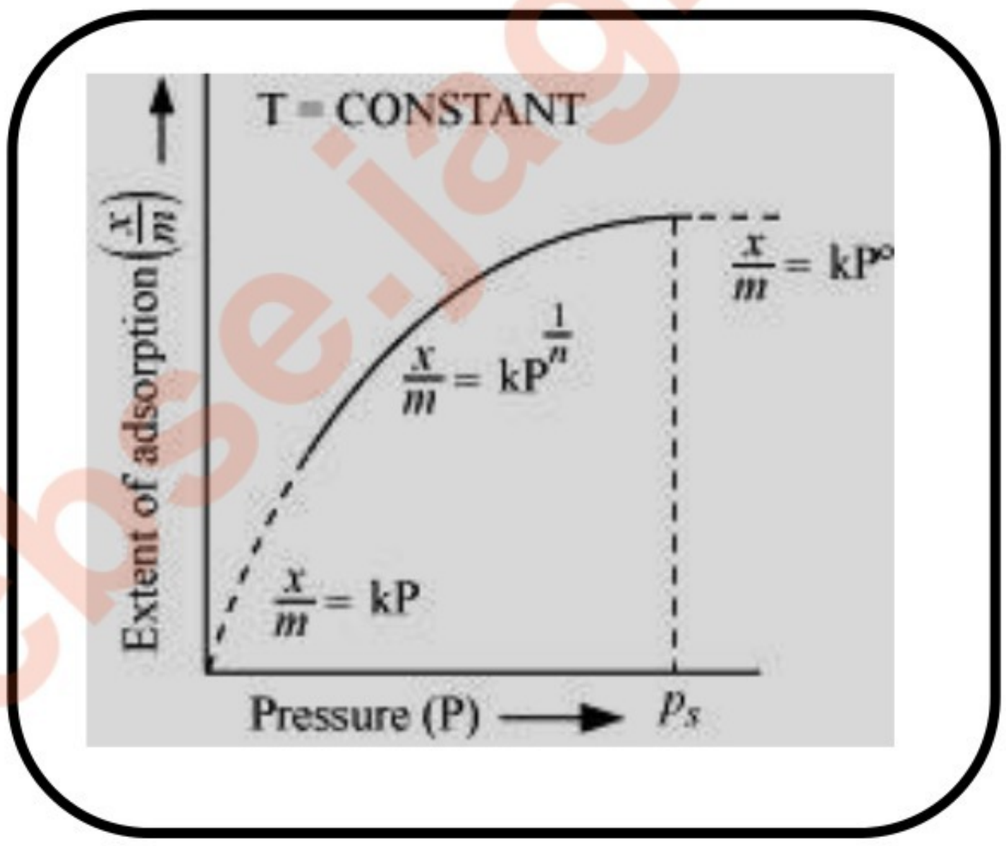
Answer 5.4

The factors which affect the rate of adsorption of a gas on a solid surface are: -

a) **Nature of the gas:** The gases which are easily liquefiable for example- HCl, NH_3 etc. are adsorbed to a great extent as compared to gases such as O_2, H_2 etc. This happens because Vander Waal's forces are stronger in easily liquefiable gases.
b) **Surface area of the solid:** The greater the surface area of the adsorbent, the greater is the adsorption of a gas on the solid surface.
c) **Effect of pressure:** Adsorption increases with an increase in pressure because adsorption is a reversible process and is accompanied by a decrease in pressure.
d) **Effect of temperature:** Adsorption is an exothermic process. Thus, according to Le-Chatelier's principle, the adsorption decreases with an increase in temperature.

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

Answer 5.5



Adsorption isotherm: - The plot between $\chi/_m$ against the pressure of gas (*P)* at constant temperature (T) is called the adsorption isotherm.

Freundlich adsorption isotherm: - this isotherm gives an empirical relationship between the quantity of gas adsorbed by the unit mass of solid adsorbent and pressure at a specific temperature.

From the plot, we can say that at pressure P_S, $\chi/_m$ reaches the maximum valve. *Ps* is called the saturation pressure. Now, we discuss three cases which arise from the graph.

Case I- At high pressure:

When pressure exceeds the saturated pressure, P_S there $\chi/_m$ becomes independent of P values.

$$\frac{\chi}{m} \alpha\ P^0$$

$$\frac{\chi}{m} = \mathrm{k}P^0$$

Case II- At low pressure:

The plot is a straight line & sloping, which indicates that the pressure in directly proportional to $\chi/_m$

$$\chi/_m \alpha\ P$$

$$\frac{\chi}{m} = kP$$

Case III- At intermediate pressure:

At intermediate pressure, $\chi/_m$ depends on *P* raised to the powers between 0 and 1. This relationship is known as the Freundlich adsorption isotherm.

$$\frac{\chi}{m} \alpha\ P^{\frac{1}{n}}$$

$$\frac{\chi}{m} = \mathrm{k}P^{\frac{1}{n}}$$

$$n > 1$$

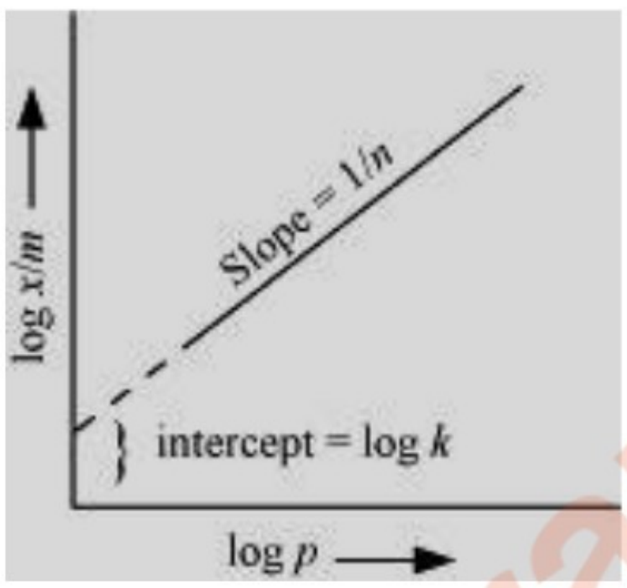
Taking log both sides

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

On plotting the graph between log χ/m and log P, a straight line is obtained

Slope = $1/n$

The intercept = log k



5.6 What do you understand by activation of adsorbent? How is it achieved?

Answer 5.5

Activation of adsorbent means increase in activity of adsorbent so that it can easily adsorb adsorbate on its surface.

By activating an adsorbent, we can increase the adsorbing power of the adsorbent.

The ways by which we can activate an adsorbent are:

- Adsorption is directly proportional to the surface area. Thus, Increase in the surface area of the adsorbent will increase the adsorbing power. This can be done by breaking it into smaller pieces or powdering it.
- Some reactions like; wood charcoal can be activated by heating it between 650 K and 1330 K in vacuum or air. It expels all the absorbed or adsorbed gases. This, creates a space for adsorption of gases.

5.7 What role does adsorption play in heterogeneous catalysis?

Answer 5.7

Heterogeneous catalysis: it is a catalytic process in which the catalyst and the reactants are present in different phases.

This process can be explained through adsorption theory. The mechanism of catalysis involves the following steps:

1. Adsorption of reactant molecules on the catalyst surface
2. Chemical reaction through the formation of an intermediate molecule
3. De-sorption of products from the catalyst surface
4. Diffusion of products away from the catalyst surface

In this process, the reactant molecules are usually present in the gaseous state and he catalyst is in the solid state. Then gaseous molecules are adsorbed on the surface of the catalyst. The rate of reaction increases as we increase the concentration of reactants on the surface of the catalyst. In such reactions, the products have very less affinity for the catalyst and are easily desorbed, make the surface free for other reactants.

5.8 Why is adsorption always exothermic?

Answer 5.8

Adsorption is always exothermic. This can be explained by 2 approaches:

- In adsorption, whenever a gas is adsorbed on a solid surface, it leads to a decrease in the entropy of the gas i.e., ΔS = negative.

For a process to be spontaneous, ΔG should be negative.

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

We know that, ΔS = negative, ΔH = should be negative to make ΔG negative. Hence, adsorption is always exothermic.

- After adsorption, there is a decrease in the residual forces on the surface of the adsorbent. This results in decrease in the surface energy of the adsorbent. Hence, adsorption is always exothermic.

5.9 How are the colloidal solutions classified on the basis of physical states of the dispersed phase and dispersion medium?

Answer 5.9

Depend upon the type of the dispersed phase and dispersion medium; there are eight types of colloidal systems: -

Dispersed phase		Dispersion medium	Type of colloid	Example
1.	Solid	Solid	Solid Sol	Gemstone
2.	Solid	Liquid	Sol	Paint
3.	Solid	Gas	Aerosol	Smoke
4.	Liquid	Solid	Gel	Cheese
5.	Liquid	Liquid	Emulsion	Milk
6.	Liquid	Gas	Aerosol	Fog
7.	Gas	Solid	Solid foam	Pumice stone
8.	Gas	Liquid	Foam	Froth

5.10 Discuss the effect of pressure and temperature on the adsorption of gases on solids.

Answer 5.10

Effect of pressure: -

Adsorption is a reversible process. Adsorption increases with an increase in pressure because it is accompanied by a decrease in pressure.

Effect of temperature: -

Adsorption is an exothermic process. Thus, according to Le-Chatelier's principle, adsorption decreases with an increase in temperature.

5.11 What are lyophilic and lyophobic sols? Give one example of each type. Why hydrophobic sols are easily coagulated?

Answer 5.11

1. **Lyophilic sols: -** Lyophilic sols are liquid loving colloids. these are colloidal sols which are formed by mixing substances like gum, starch, etc. with a suitable liquid. These sols are reversible in nature, which means, if constituents of the sol are separated by any process like evaporation, then we can prepare the sol again by simply mixing the dispersion phase & dispersion medium. For example- Sols of organic substances like gum, starch

2. **Lyophobic sols: -** Lyophobic sols are liquid hating colloids. They do not form colloidal sols. These sols are prepared when substances like metals and their sulphides etc. are mixed with the dispersion medium. Their colloidal sols can be prepared only by special methods. These sols are irreversible in nature. For example: Sols of inorganic substances like Arsenic (As_2S_3).

Stability of hydrophilic sols depends on two factors: -

- Presence of a charge
- The salvation of colloidal particles.

And, the stability of hydrophobic sols depends only because of the presence of a charge. Thus, the hydrophobic are much less stable than the hydrophilic. If we remove the charge of hydrophobic sols by addition of electrolytes, then the particles present in them form aggregates. This leads to precipitation.

5.12 What is the difference between multimolecular and macromolecular colloids? Give one example of each. How are associated colloids different from these two types of colloids?

Answer 5.12

Multi-molecular colloids	Macro-molecular colloids
➢ In multi-molecular colloids, the colloidal particles are an aggregate of atoms or small molecules with a	In macro-molecular colloids, the colloidal particles are large molecules having colloidal dimensions. These particles have a high molecular mass.

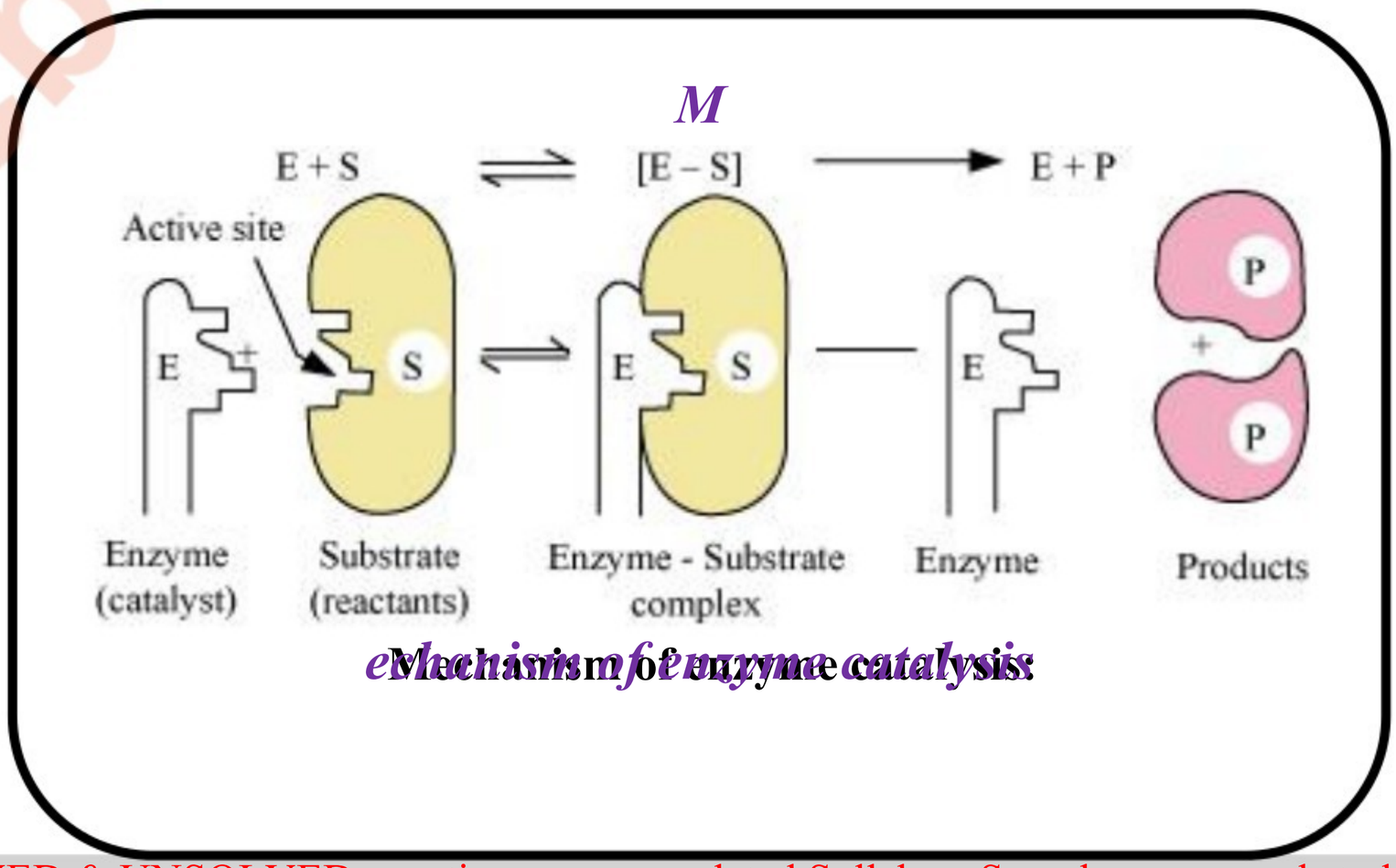
diameter of less than 1 nm.	
➢ The molecules in the aggregate are held together by Vander Waal's forces of attraction.	Due to long chain, the Vander Waal's forces holding them are comparatively stronger.
➢ Examples - gold sol and sulphur sol.	When these particles are dissolved in a liquid, sol is obtained. For example- starch, nylon, etc.
➢ They are generally lyophilic in nature.	They are generally lyophobic in nature.

Associated colloids: - They are formed by of aggregation of a large number of ions in concentrated solution for e.g. soap sol. Their molecular masses are generally high. They can be both lyophobic and lyophilic in nature.

5.13 What are enzymes? Write in brief the mechanism of enzyme catalysis.

Answer 5.13

Enzymes: - Enzymes are protein molecules of high molecular masses. These are complex, nitrogenous organic compounds which are produced by living plants and. animals. When dissolved in water, they form colloidal solutions. They are also called 'biochemical catalysts'



Mechanism of enzyme catalysis

Various cavities are present on the surface of the enzymes, with characteristic shapes. These cavities possess various active groups such as −COOH, etc. The reactant molecules which have a complementary shape fit into the cavities just like a lock- key & forms of an activated complex. This complex then decomposes to give the product.

Therefore,

Step 1: $E + S \rightarrow ES^+$

Step 2: $ES^+ \rightarrow E + P$

5.14 How are colloids classified on the basis of?

a) Physical states of components
b) Nature of dispersion medium and
c) Interaction between dispersed phase and dispersion medium?

Answer 5.14

Colloids can be classified on different bases:

a) On the basis of the physical state of the components i.e., weather the components are solids, liquids, or gases; we have eight types of colloids.

Dispersed phase		Dispersion medium	Type of colloid	Example
1.	Solid	Solid	Solid Sol	Gemstone
2.	Solid	Liquid	Sol	Paint
3.	Solid	Gas	Aerosol	Smoke
4.	Liquid	Solid	Gel	Cheese
5.	Liquid	Liquid	Emulsion	Milk
6.	Liquid	Gas	Aerosol	Fog
7.	Gas	Solid	Solid foam	Pumice stone
8.	Gas	Liquid	Foam	Froth

b) On the basis of the dispersion medium, sols can be divided as:

Dispersion medium	Name of sol
Water	Aquasol or hydrosol
Alcohol	Alcosol
Benzene	Benzosol
Gases	Aerosol

c) On the basis of the nature of the interaction between the dispersed phase and dispersion medium, the colloids can be classified as:

- Lyophilic (solvent attracting)
- Lyophobic (solvent repelling)

5.15 Explain what is observed

a) When a beam of light is passed through a colloidal sol.
b) An electrolyte, NaCl is added to hydrated ferric oxide sol.
c) Electric current is passed through a colloidal sol?

Answer 5.15

a) When a beam of light is passed through a colloidal solution, then scattering of light takes place. This effect is known as the Tyndall effect. Scattering of light illuminates the path of the beam in the colloidal solution.

b) When NaCl is added to ferric oxide sol, it dissociates to give Na^+ and Cl^- ions. Constituents of ferric oxide sol are positively charged. Thus, they get coagulated in the presence of negatively charged Cl^- ions.

c) The colloidal particles are charged and carry charged particles. The dispersion medium carries an equal and opposite charge. Because of which the whole system remains neutral. When electric current is passed, the colloidal particles move towards the oppositely charged electrode. When they come in contact with the electrode, they lose their charge and coagulate.

5.16 What are emulsions? What are their different types? Give example of each type.

Answer 5.16

Emulsion: - emulsions are the colloidal solution in which both the dispersed phase and dispersion medium are liquids.

There are two types of emulsions:

a) **Oil in water type: -**in this, oil is the dispersed phase while water is the dispersion medium. For example- vanishing cream, milk, etc.
b) **Water in oil type: -**in this, water is the dispersed phase while oil is the dispersion medium. For example- butter, cold cream, etc.

5.17 What is demulsification? Name two demulsifiers.

Answer 5.17

Demulsification: - it is the process in which there is decomposition of an emulsion into its constituent liquids. Examples of demulsifiers- ethylene oxide, surfactants, etc

5.18 Action of soap is due to emulsification and micelle formation. Comment

Answer 5.18

The cleansing action of soap is due to emulsification and micelle formation.

Soap molecules are sodium and potassium salts of long chain fatty acids, $R\text{-}COO^- Na^+$. The molecular end to which sodium is attached is polar in nature, whereas the alkyl-end is non-polar in nature. Thus, a soap molecule contains both hydrophilic as well as hydrophobic part.

When soap is added to water containing dirt, the soap molecules attached to the dirt particles in such a manner that their hydrophobic parts get attached to the dirt molecule and the hydrophilic parts point away from the dirt molecule. Thus, the structure formed is known as micelle formation. Hence, we can say that the polar group dissolves in water whereas the non-polar group dissolves in the dirt particle.

5.19 Give four examples of heterogeneous catalysis.

Answer 5.19

1. **Haber's process**: - Formation of ammonia by the addition of dinitrogen and dihydrogen in the presence of finely divided iron.

$$N_{2(g)} + 3H_{2(g)} \xrightarrow{Fe_{(s)}} 2NH_{3(g)}$$

2. Oxidation of sulphur dioxide to form sulphur trioxide in the presence of Pt catalyst.

$$2SO_{2(g)} \xrightarrow{Pt_{(s)}} 2SO_{3(g)}$$

3. Hydrogenation of vegetable oils in the presence of Ni.

$$\text{vegetable oil}_{(l)} + H_{2(g)} \xrightarrow{Ni_{(s)}} \text{vegetable ghee}_{(s)}$$

4. **Oswald's process**: Oxidation of ammonia to nitric oxide in the presence of platinum.

$$4NH_{3(g)} + 5O_{2(g)} \xrightarrow{Pt_{(s)}} 4NO_{(g)} + 6H_2O_{(g)}$$

5.20 What do you mean by activity and selectivity of catalysts?

Answer 5.20

Activity of a catalyst: - it is the ability of a catalyst to increase the rate of a reaction. Chemisorption is the main factor which decides the activity of a catalyst. The adsorption of reactants on the catalyst surface should just be strong enough to make the catalyst active. Interaction should neither be strong nor weak.

Selectivity of the catalyst:

It is the ability of the catalyst to direct a reaction to yield a particular product. For example- by using different catalysts, different products for the reaction between H_2 and CO can be obtained.

$$CO_{(g)} + H_{2(g)} \xrightarrow{Cu} HCHO_{(g)}$$

$$CO_{(g)} + 3H_{2(g)} \xrightarrow{Ni} CH_{4(g)} + H_2O_{(g)}$$

$$CO_{(g)} + 2H_{2(g)} \xrightarrow{CuZnO-CrO_3} CH_3OH_{(g)}$$

5.21 Describe some features of catalysis by zeolites.

Answer 5.21

Zeolites are the alumino-silicates which are micro-porous in nature. They have a honeycomb-like structure. This structure makes them shape-selective catalysts. These are commonly used in the petrochemical industry.

They have an extended 3D-network of silicates in which some silicon atoms are replaced by aluminium atoms, & give them an Al−O−Si framework. The reactions taking place in zeolites are very sensitive to the pores and cavity size of the zeolites.

5.22 What is shape selective catalysis?

Answer 5.22

Shape selective catalysis: - it is a catalytic reaction which is dependent on the size of the reactant, the product molecules & the pore structure of the catalyst.

Example of this catalysis is catalysis by zeolites. Range of the pore size present in the zeolites is 260-740 pm. Molecules having a pore size more than this cannot enter the zeolite and undergo the reaction.

5.23 Explain the following terms:

a) **Electrophoresis**
b) **Coagulation**
c) **Dialysis**
d) **Tyndall effect.**

Answer 5.23

a) **Electrophoresis: -**it is the movement of colloidal particles under the influence of an applied electric field. Positively charged particles move towards cathode, & negatively charged particles move towards the anode. After attachment of negative & positive charge particles with oppositely charged electrodes, they become neutral and get coagulated.
b) **Coagulation: -** when colloids are converted into a precipitate, it is called coagulation. It can also be defined as settling down of colloidal particles.
c) **Dialysis: -**when a dissolved substance is removed from a colloidal solution by the means of diffusion through a membrane is known as dialysis. The principle lie behind this process is that the ions and small molecules can pass through animal membranes unlike colloidal particles.
d) **Tyndall effect: -** When a beam of light is allowed to pass through a colloidal solution, it becomes visible. This is known as the Tyndall effect. This happens because of scattering of light by colloidal particles in all directions.

5.24 Give four uses of emulsions.

Answer 5.24

Four uses of emulsions are**:**

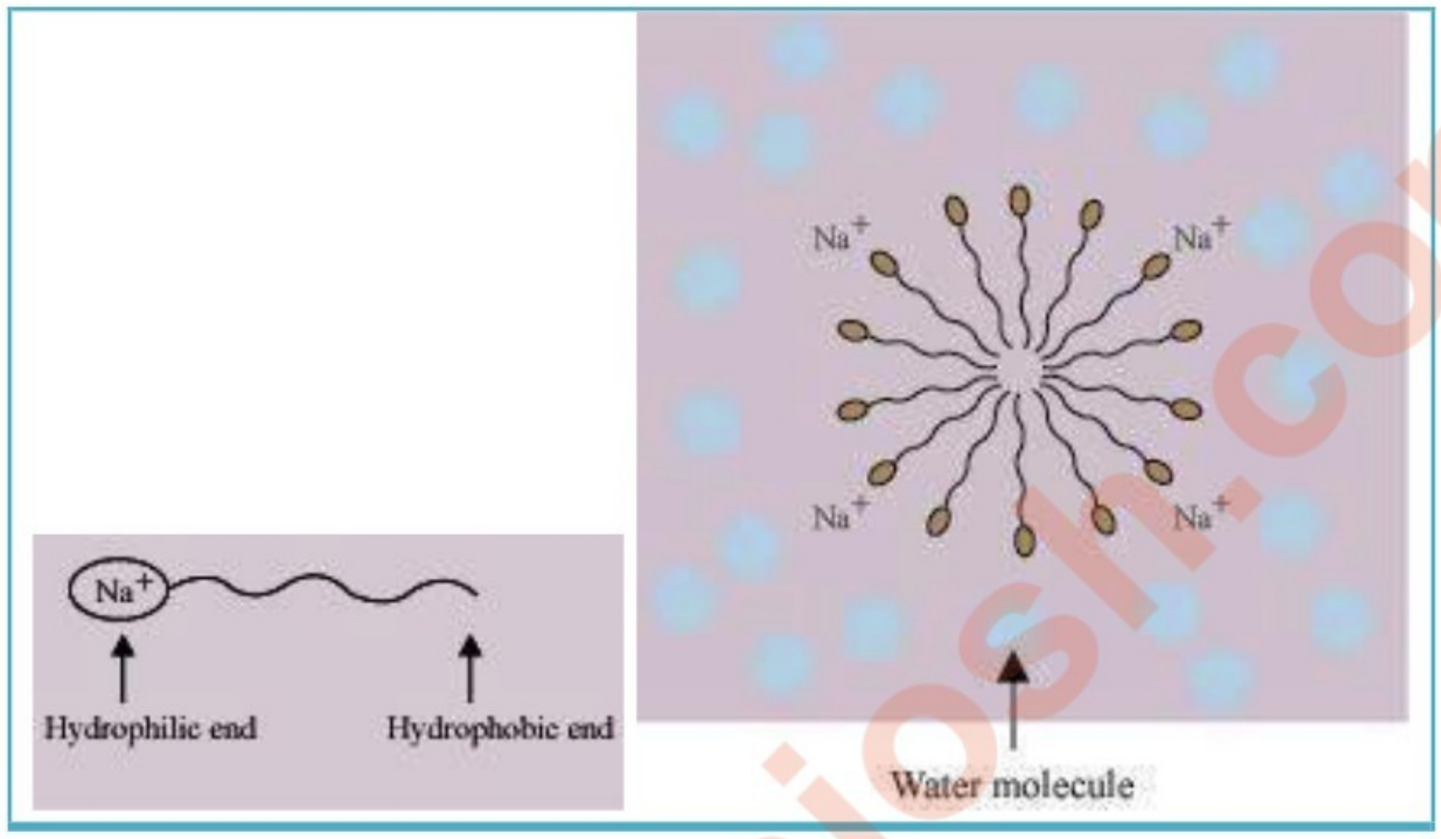
- Emulsions are formed when disinfectants & antiseptics are added to water.
- Cleansing action of soaps is also based on the formation of emulsions.
- Emulsification process is used in making medicines.
- In intestines, digestion of fats takes place through emulsification.

5.25 What are micelles? Give an example of a micellers system.

Answer 5.25

Micelle: - when, soaps and detergents dissolved in water, they form micelles. The molecules of such substances contain a hydrophobic and a hydrophilic part. When

present in water, these substances arrange themselves in spherical structures in such a manner that their hydrophobic parts are present towards the centre, while the hydrophilic parts are pointing towards the outside. This structure is known as micelle formation.



5.26 Explain the terms with suitable examples:

1. **Alcosol**
2. **Aerosol**
3. **Hydrosol**

Answer 5.23

1. **Alcosol: -** it is a colloidal solution in which alcohol act as a dispersion medium and a solid substance as a dispersed phase. For example- colloidal sol of cellulose nitrate in ethyl alcohol
2. **Aerosol: -** it is a colloidal solution in which dispersion medium is a gas and dispersed phase is a solid. For example- fog
3. **Hydrosol: -** it is a colloidal solution in which dispersion medium is water and dispersed phase is a solid. For example- gold sol

5.27 Comment on the statement that "colloid is not a substance but a state of substance".

Answer 5.27

When the size of the solute particle lies between 1 nm and 1000 nm, it behaves as a colloid.

Common salt behaves as a colloid in a benzene medium. It means that a colloidal state does not represent a separate class of substances.

Thus, colloid is not a substance but a state of the substance & is dependent on the size of the particle. This state is intermediate between a true solution and a suspension.