5. Surface Chemistry

Exercise questions:

Que:1 Distinguish b/w the meaning of the terms adsorption and absorption. Give one example of each.

Ans:

The accumulation of molecular species at the surface rather than in bulk of solid or liquid is termed as adsorption . It is a surface phenomenon. Solids, particularly in finely divided state, have large surface area and therefore, alumina gel, silica gel, clay, metals in finely divided state etc. act as good adsorbent. For example, when we dip a chalk stick into and ink solution, only its surface becomes coloured, if we break the chalk stick, it will be found to be white from inside.

In absorption, the substance is uniformly distributed throughout the bulk of the solid. Both adsorption and absorption can take place simultaneously

Que:2 Give reason why a finally divided substances more effective as an adsorbent.

Ans:

Adsorption $\propto$ surface area.

Adsorption is a surface phenomenon. It means adsorption is directly proportional to the surface area. A finely divide substance has a large area. Both physisorption and chemisorption increase with an increase in the surface area. Hence, a finely divided substance behave as a good adsorbent

Que:3 What is the difference b/w physisorption and chemisorption.

Ans:

Physisorption	Chemisorption
1. It arises because of van der waal's force.	1. It is caused by chemical bond formation.
2. It is reversible in nature.	2. It is irreversible.
3. It is not specific in nature.	3. It is highly specific in nature.
4. Enthalpy of adsorption is low.	4. Enthalpy of adsorption is high.
5. It depends on the nature of gas. More easily liquefiable gases are adsorbed readily.	5. It also depends on the nature of gas. Gases which can react with the adsorbent show chemisorption.
6. No appreciable activation energy is needed.	6. High activation energy is sometimes needed.

Que:4 What are the factors which influence the adsorption of a gas on a solid?

Ans:

Following are the factors that affect the rate of adsorption of a gas on a solid surface.

1. **Nature of the gas:** Easily liquefiable gases such as NH_3, HCl etc, are adsorbed to a great extent in comparison to gases such as H_2O_2 etc. This is because Van der Waal's forces are stronger in easily liquefiable gases.
2. **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.
3. **Effect of pressure:** Adsorption is reversible process and is accompanied by decrease in pressure. Therefore, adsorption increase with an increase in pressure.
4. **Effect of temperature:** Adsorption is an exothermic process. Thus, in accordance with Le – Chatelier's principle, the magnitude of adsorption decreases with an increase in temperature.

Que:5 What do you understand by activation of adsorbent? How is it achieved?

Ans:

By activating an adsorbent, we tend to increase adsorbing powerof th adsorbent. Some ways to activate an adsorbent are:

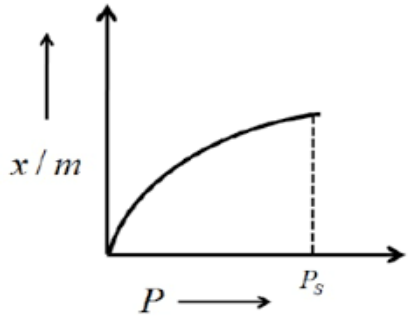
By increasing the surface area. This can be done by breaking the substance into small pieces or powdering it.

Some specific treatment also to the activation of an adsorbent. For eg., wood charcoal is activated by heating it b/w 650K and 1330K in vacuum or air. It expels all the gases absorbed or adsorbed and thus, creates a space for adsorption of gases

Que:6 What is an adsorption isotherm? Describe Freundlich adsorption isotherm.

Ans:

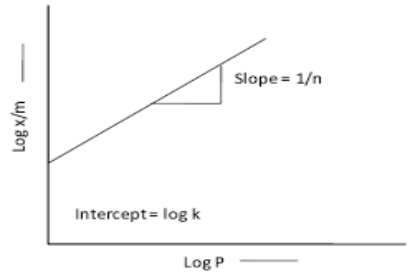
The variation in the amount of gas adsorbed by the adsorbent with pressure at constant temperature can be expressed by means of a curve termed as adsorption isotherm.



Freundlich adsorption isotherm: Freundlich gave an empirical relationship b/w the quantity of gas adsorbed by unit mass of solid adsorbent and pressure at particular temperature. The relationship can be expressed as:

$x/m = k.P^{1/n} (n > 1)$

(x is the mass of the gas adsorbed on mass m of the adsorbent at pressure P, k and n are constant which depends on the nature of adsorbent and gas at a particular temperature.)



Case:1 At low pressure: The plot is straight and sloping indicating that the pressure is directly proportional to x/m i.e., $x/m \propto P$, $x/m = k P$ (k is constant)

Case 2 - At high pressure: When pressure exceed the saturated pressure, x/m becomes independent of P values.

$x/m \propto P^0$

$x/m = kP^0$

now taking log:

$\log x/m = \log k + 1/n \log P$

On plotting the graph b/w log x/m and log P, a straight line is obtained with the slope equal to 1/n and the intercept equal to log k as shown in figure.

Que:7 Why is adsorption always exothermic?

Ans:

i.) Adsorption leads to a decrease in residual forces on the surface of the adsorbent. This causes a decrease in the surface energy of the adsorbent. Therefore, adsorption is always exothermic.

ii.)ΔH of adsorption is always negative. When a gas is adsorbed on a solid surface, its movement is restricted leading to a decrease in entropy of the gas i.e. ΔS is negative. Now for a process to be spontaneous, ΔG should be negative.

$\therefore \Delta G = \Delta H - T\Delta S$

Since ΔS is negative ΔH has to be negative to make ΔG negative. Hence, adsorption is always exothermic

Que:8 What role does adsorption play in heterogeneous catalysis?

Ans:

Heterogeneous catalysis: A catalytic process in which the reactants and the catalyst are in different phase is known as heterogeneous catalysis. This heterogeneous catalytic action can be explained in terms of adsoption theory. The mechanism involves five steps:

i.) Diffusion of reactants to the surface of the catalyst.

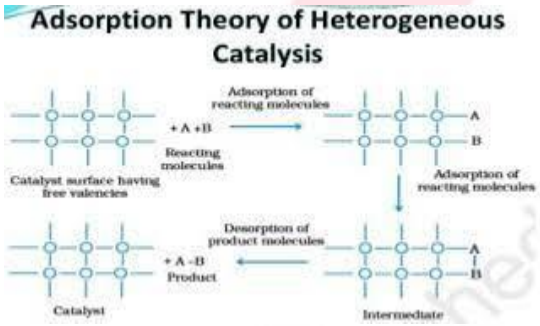
ii.) Adsorption of reactant molecules on the surface of the catalyst.

iii.) Occurrence of chemical reaction on the catalyst's surface through formation of an intermediate.

iv.) Desorption of reaction products from the catalyst surface, and thereby making the surface available again for more reaction to occur.

Diffusion of products away from the catalyst surface.

In this process, the reactants are usually present in the gaseous state and the catalyst is present in the solid state. Gaseous molecules are than absorbed on the surface of the catalyst. As the concentration of the reactants on the surface of the catalyst increases, the rate of reaction also increases. In such reactions, the products have very less affinity for the catalyst and quickly desorbed, thereby making the surface free for other reactants.



Que:9 How are the colloidal solutions classified on the basis of physical states of the dispersed phase and dispersion medium?

Ans:

Depending upon whether the dispersed phase and the dispersion medium are solids, liquids or gases, eight types of colloidal system are possible.

Dispersed phase	Dispersion medium	Type of Colloid	Examples
Solid	Solid	Solid sol	Gem stones
Solid	Liquid	Sol	Paints, cell fluids
Solid	Gas	Aerosol	Smoke, dust
Liquid	Solid	Gel	Cheese, butter

Liquid	Liquid	Emulsion	Milk, hair
Liquid	Gas	Aerosol	Fog, mist
Gas	Solid	Solid sol	Foam rubber
Gas	Liquid	Foam	Froth, soap lather

Que:10 Discuss the effect of pressure and temperature on the adsorption of gases on solids.

Ans:

Effect of pressure: Adsorption is reversible process and is accompanied by a decrease in pressure. Therefore, adsorption increase with an increase in pressure.

Effect of temperature: adsorption is an exothermic process. Thus, in accordance with Le–Chatelier's principle the magnitude of adsorption decrease with an increase in temperature

Que:11 What is the difference b/w multi - molecular and macro – molecular colloids? Give one example of each. How are associated colloids different from these two types of colloids

Ans:

i.) In multi-molecular collides, the colloidal particles are and 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 Waal's forces of attraction. Example of such colloids includes gold sol and sulphur sol.

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 e.g.: starch, nylon, etc.

iii.) Certain substances tend to behave like normal electrolytes at lower concentration. However, at high concentrations, these substances behave as colloidal solutions due to the formation of aggregated particles. Such colloids are called aggregated colloids

Que:12 What are lyophilic and lyophobic sols? Give one example of each type. Why are hydrophobic sols easily coagulated?

Ans:

i.) **Lyophilic sols:** Colloid sols that are formed by mixing substances such as gum, starch, etc. with a suitable liquid are called lyophilic sols. These sols are reversible in nature i.e. if two constituents of the sol are separated by any means, than the sol can be prepared again by simply mixing the dispersion medium with the dispersion phase and shaking the mixture.

ii.)**Lyophobic sols:** When substance such as metals and their sulphides etc. mixed with the dispersion medium they do not form colloidal sols. Their colloidal sols can be prepared only by special methods. Such sols are called lyophobic sols. These sols are irreversible in nature. For example: Sols of metals. Now the stability of hydrophilic sols depends on two things the pressure of a charge and the salvation of colloidal particles. On the other hand, the stability of hydrophobic sols is only because of pressure of a charge. Therefore, the latter are much less stable than the former. If the charge of hydrophobic sols is removed, than the particles present in them come c loser and form aggregates, leading to precipitation.

Que:13 What are enzymes? Write in brief the mechanism enzyme catalysis.

Ans:

Enzymes are complex nitrogenous organic compounds which are produced by living plants and animals. They are actually protein molecules of high molecular mass and form colloidal solutions in water. They are very effective catalysis; catalyse numerous reactions, especially those connected with natural processes. The enzymes are, thus, termed as biochemical catalysts.

Mechanism of enzyme catalysis:

On the surface of the enzymes, various cavities are present with characteristic shapes. These possess active groups such as - NH_3, -COOH, etc. The reactant molecules having of complimentary shape fit into the cavities just like a keyfits into a lock. This leads to the formation of an achieved complex. This complex than decomposes to give the product.

Step 1: Binding of enzyme to substrate to form an achieved complex.

$E + S \rightarrow ES^{\neq}$

Step 2: Decomposition of the activated complex to form product.

$ES^{\neq} \rightarrow E + P$

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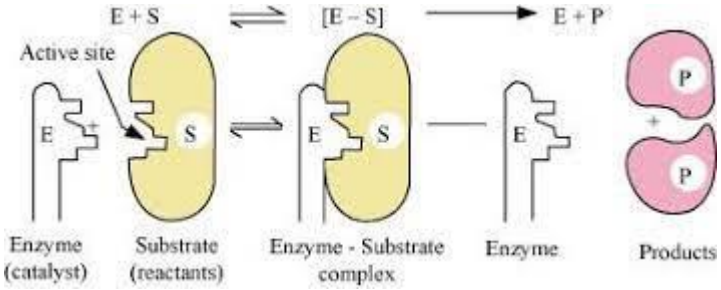

Que:14 How are colloids classified on the basis of:

i.) Physical states of components

ii.) Nature of dispersion medium and

iii.) Interaction b/w dispersed phase and dipersion medium?

Ans:

Colloids can be classified on various basis:

i.)On the basis of the physical state of the components (by components we mean the dispersed phase and dispersion medium). Depending on the whether the components are solids, liquids or gases, we can have eight types of colloid. (See ans. 9)

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

i.)	**Dispersion medium**	**ii.)**	**Name of sol**
iii.)	Water	iv.)	Aquasol or hydrosol
v.)	Alcohol	vi.)	Alcosol
vii.)	Benzene	viii.)	Benzosol
ix.)	Gases	x.)	Aerosol

iii.)On the basis of the nature of the interaction b/w the dispersed phase and dispersion medium, the colloids can be classified as lyophilic (solvent attracting) and lyophobic (solvent repelling).

Que:15 What are emulsions ? what are their different types ? Give example of each type.

Ans:

The colloidal solution in which both the dispersed phase and dispersion medium are liquids is called an emulsion. There are two types of emulsions:

i.) Oil in water type: Here, oil is the dispersed phase while water is the dispersion medium. For example: milk, vanishing cream, etc.

ii.) Water in oil type: Here, water is the dispersed phase while oil is the dispersion medium. For example: cold cream, butter,etc.

Que:16 What is demulsification ? Name two demulsifiers .

Ans:

Demulsification: The process of decomposition of an emulsion into its constituents liquids is called demulsification. Examples of demulsifiers are surfactants, ethylene oxide, etc.

Que:17 Explain what is observed

i.) When a beam of light is passed through a colloidal sol .

ii.) An electrolyte, NaCl is added to hydrated ferric oxide sol.

iii.) Electric current is passed through a colloidal sol?

Ans:

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

ii.)When NaCl is added to ferric oxide sol, it dissociates to give Na^{+} and Cl^{+} ions. Particles of ferric oxide sol are positively charged. Thus, they get coagulated in the presence of negatively charged Cl^{-1} ions.

iii.)The colloidal particles are charged and carry either a positive or negative charge. The dispersion medium carries an equal and opposite charge. This makes the whole system neutral. Under the influence of an electric current, the colloidal particles move towards the oppositely charged electrode. When they come in contact with the electrode, they lose their charge and coagulate.

Que:18 Explain the following terms:

i.) Electrophoresis

ii.) Coagulation

iii.) Dialysis

iv.) Tyndall effect.

Ans:

i.)**Electrophoresis:** The movement of colloidal particles under the influence of an applied electric field is known as electrophoresis. Positively particles move towards cathode, while the negative particles move towards anode. As the particles reach oppositely electrodes, they become neutral and get coagulated.

ii.) **Coagulation:** The process of setting of colloidal particles is call coagulation or precipitation of the sol. Coagulation can be achieved by persistent dialysis, persistent boiling. Electrophoresis and mutual coagulation.

iii.)Dialysis: It is a process of removing a dissolved substance from a colloidal solution by means of diffusion through a suitable membrane. Ions or smaller molecules in a true solution can pass through animal membrane but colloidal particles cannot passed through animal membrane.

iv.)Tyndall effect: When a beam of light is allowed to pass through a colloidal solution it becomes visible like a column of life this known as the tyndall effect. This phenomenon takes place as particle soap colloidal dimensions scatter light in all directions.

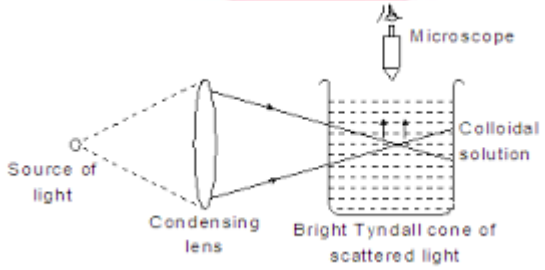

Figure: Tyndall effect

Que:19 Explain the terms with suitable examples:

i.) Alcosol

ii.) Aerosol

iii.) Hydrosol .

Ans:

i.)Alcosol: A colloidal solution having alcohol as the dispersion medium and a solid substance as the dispersed phase is known as alcosol. For example – colloidal sol of cellulose nitrate in ethyl alcohol is an alcosol.

ii.)Aerosol: A colloidal solution having a gas as the dispersion medium and a solid as the dispersed phase is called an aerosol. For example – fog.

iii.)Hydrosol: A colloidal solution having water as the dispersion medium and a solid as the dispersed phase is called a hydrosol. For example – starch sol or gold sol

Que:20 Action of soap is due to emulsification and micelle formation . Comment.

Ans:

The cleansing action of soap is due to emulsification and micelle formation. Soaps are basically sodium and potassium salts of long chain fatty acids, $RCOO^-Na^+$. The end of the molecule to which the sodium is attached is polar in nature, while the alkyl-end is non-polar. Thus, a soap molecule contains a hydrophilic (polar) and a hydrophobic (non-polar) part.

When soap is added to water containing dirt, the soap molecules surround the dirt particles in such a manner that their hydrophobic parts get attached to the dirt molecule and hydrophilic parts point away from the dirt molecule. This is known as micelle formation. Thus we can say that the polar group dissolved in water while the non-polar group dissolves in the dirt particles. Now as these micelles are negatively charged, they do not coalesce and a stable emulsion is formed.

Que:21 Give four examples of heterogeneous catalysis .

Ans:

i.) Oxidation of Sulphur dioxide to form sulphur trioxide. In this reaction, Pt acts as catalyst.

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

ii.) Combination b/w dinitrogen and dihydrogen to form ammonia in the presence of finely divided iron in Haber's process.

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

iii.) Oxidation of ammonia into nitric oxide in the presence of platinum gauze in Ostwald's process.

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

iv.) Hydrogenation of vegetable oils in the presence of finely divided nickel as catalyst.

Vegetable oils (I) $+H_2(g) \xrightarrow{Ni(s)}$ Vegetable ghee (s)

Que:22 Describe some features of catalysis of zeolites .

Ans:

Zeolites are alumina – silicates that are micro – porous in nature. Zeolites have honeycomb like structure, which makes them shape selective catalysts. They have an extended 3D – network of

silicates in which some silicon atoms are replaced by aluminium atom giving them an Al – O – Si framework. The relations taking place in zeolites are very sensitive to the pores and cavity size of the zeolites. Zeolites are commonly used in the petrochemical industry as ZSM-5.

Que:23 What do you mean by activity and selectivity of catalysis ?

Ans:

1.) **Activity of catalyst:** The activity of a catalyst is its ability to increase the rate of a particular reaction. Chemisorption is the main factor in deciding 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.

2.) **Selectivity of the catalyst:** The ability of the catalyst to direct a reaction to yield a particular product is referred to as the selectivity of the catalyst. For example, by using different catalyst, we can get different products for the reaction b/w H_2 and CO.

Que:24 What are micelles ? Give an example of micellers system.

Ans:

Micelles: These 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 micelles.

Example: Soap sodium stearate

Que:25 What is shape selectivity catalysis ?

Ans:

A catalytic reaction which depends upon the pore structure of the catalyst and on the size of the reactant and the product. Molecules is called shape selective catalysis. For example, catalysis by zeolites is shape-selective catalysis. The pore size present in the zeolites ranges from 260 – 740 pm. Molecules having a pore size more than this cannot enter the zeolite and undergo the reaction.

Que:26 Comment on the statement that “colloid is not a substance but a state of substance” .

Ans:

Common salt behaves as a colloid in a benzene medium. Hence, we can say that a colloidal substance does not represent a separate class of substances. When the size of the solute particle lies b/w 1 nm and 1000nm, it behaves as a colloid.

Hence, we can say that colloid is not a substance but a state of the substance which is dependent on the size of the particle. A colloidal state is intermediate b/w a true solution and a suspension.

Que:27 Give four uses of emulsion .

Ans:

Uses:

i.) Cleansing action of soaps is based on the formation of soaps.

ii.) Digestion of fats in intestines takes place by the process of emulsification.

iii.) Antiseptics and disinfectants when dissolved in water form emulsion.

iv.) The process of emulsification is used to make medicines.