Chapter 5

Surface Chemistry

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1 Marks Questions

1. What do you mean by the term –Adsorption ?

Ans. The accumulation of molecular species at the surface rather than in bulk of a solid liquid is termed as Adsorption.

2. Explain the terms – Adsorbate and Adsorbent with examples

Ans. The molecular species which get concentrated or accumulated at the surface are adsorbate eg. O_2, H_2, CO, Cl_2, NH_3, etc. and the material on the surface of which the adsorption takes place is adsorbent. eg. Charcoal, silica gel, alumina gel, clay etc.

3. Why do finely divided solids act as good adsorbents ?

Ans. Powdering of solids increase its surface and therefore it can adsorb a greater amount of the adsorbate. Thus finely divided solids act as good adsorbents.

4. What is the sign of ΔH, ΔS and ΔG when a gas is adsorbed by an adsorbent and when ΔG becomes zero?

Ans. ΔH is negative, ΔS is negative and ΔG is negative. When $\Delta H = \Delta S$ the ΔG is zero. This state equilibrium is attained.

5. Name the factors which influence the extent of adsorption of a gas on solid.

Ans. Factors affecting extent of adsorption are –

(i) Nature of adsorbent and adsorbate.

(ii) Surface area of solid

(iii) Pressure of gas

(iv) Temperature

6. What is 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 known as adsorption isotherm.

7. ΔH for chemisorption is high. why?

Ans. In chemisorption, chemical bonds are formed that evolves a large amount of energy. Therefore ΔH for chemisorption is high.

8. Give an equation showing variation of extent of adsorption with concentration of a solution?

Ans. $x/m = K\ C^{1/n}\ (n\ >\ 1)$

Where x/m is the extent of adsorption - k &n are constants and c is the concentration of solution.

9. What are positive and negative catalysts? Explain.

Ans. A catalyst which increases the rate of a reaction is positive catalyst and which decrease the rate is a negative catalyst.

10. What do you mean by the term promoter? Give an example.

Ans. Promoters are substances that enhance the activity of a catalyst e.g. molybdenum acts as a promoter in Haber's process.

11. How do metal ions act as activators?

Ans. The metal ions like Na^{+}, Mn^{2+}, Co^{2+}, Cu^{2+} etc. can bind weakly to enzyme molecules. This increases their catalytic activity and therefore metal ions can act as activators.

12. What is the optimum temperature and pH for enzyme catalysed reactions?

Ans. The optimum temperature is 298K – 310K and optimum pH is 5 – 7 for enzyme –

catalysed reactions.

13. What are colloids?

Ans. A colloid is a heterogeneous system in which one substance is dispersed (dispersed phase) as very fine particles in another substance called dispersion medium.

14. What is the range of particle size in colloids?

Ans. The range of diameter of colloidal particles is 1 to 1000 nm.

15. Give two examples of solid Sol and Gel?

Ans. Solid sol – coloured glass, pumice stone.

Gel – Cheese, Butter.

16. Colloid is a state not a substance. Explain?

Ans. Every solute can be converted into the particle size of a colloid which is 1-1000 nm. Therefore every solute can act as a colloidal particle under suitable conditions.

17. Give two examples of substances that form: –

(a) Hydrophobic sol.

(b) Hydrophilic sol.

Ans. (a) hydrophobic sol: Gold, platinum

(b) hydrophilic sol: starch, proteins in water.

18. State Hardy- Schulze rule?

Ans. According to Hardy- Schulze rule-The greater the valence of the flocculating ion added, the greater is its power to cause precipitation.

19. What is a protective colloid?

Ans. A lyophillic colloid which is used to protect lyophobic colloid from electrolyte and from getting coagulated is called protective colloid.

20. What is flocculation?

Ans. When a colloid precipitates and floats on the solvent, it is called flocculation.

21. What is the role of desorption in the process of catalysis?

Ans. The role of desorption in the process of catalysis is to make the surface of the solid catalyst free for the fresh adsorption of the reactants on the surface.

22. What is demulsification? Name two demulsifiers.

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

2 Marks Questions

1. Why do the solution of organic dye turns colourless when charcoal is added?

Ans. Because the molecules of the dye accumulated on the surface of charcoal and turns into the solution colourless.

2. Define the term – desorption?

Ans. The process of removing an adsorbed substance from a surface on which it is adsorbed is called desorption.

3. Give two differences between adsorption and absorption ?

Ans.

Adsorption	Absorption
1. It occurs on the surface of the Are Adsorbent.	1. The molecules of the substance uniformly distributed throughout the body of the solid or liquid.
2. Rate of adsorption decreases until throughout.	2. Rate of absorption is same the equilibrium is reached.

4. Name the two types of adsorptions ?

Ans. Two types of adsorptions are –

1. Physical adsorption or physisorption .

2. Chemical adsorption or chemisorption .

5. Write the four differences between physisorption and chemisorption?

Ans.

Physical Adsorption	Chemical Adsorption
1. It is caused by Vander Waals forces. formation.	1. It is caused by chemical bond
2. It is not specific in nature.	2. It is highly specific in nature.
3. It is reversible in nature.	3. It is irreversible.
4. Enthalpy of adsorption is low.	4. Enthalpy of adsorption is high.

6. 'Adsorption is an exothermic process '. Explain.

Ans. During adsorption, there is always a decrease in residual forces of the surface. Therefore the surface energy decreases which appears as heat. Therefore adsorption is exothermic process.

7. Explain the Mechanism of adsorption.

Ans. Adsorption arises due to presence of unbalanced forces or residual attractive forces on the particles of the surface. These forces are responsible for attracting the adsorbate particles on its surface and they cause the adsorption.

8. (a) Which gas is adsorbed more readily on charcoal lump: ammonia or carbon dioxide and why ?

(b) Which adsorbs more of carbon monoxide: charcoal lump or charcoal powder & why?

Ans. (a) Ammonia gets adsorbed more readily because it is polar molecule and easily liquifiable.

(b) Charcoal powder adsorbs more of carbon monoxide because it has larger surface area than charcoal lump.

9. Name the adsorbent used

a) To remove coloured impurities from sugar solution.

b) In gas masks to remove chlorine.

c) To remove moisture from air.

Ans. (a) Activated charcoal

(b) Activated charcoal

(c) Silica gel.

10. Define the terms – catalysis and catalyst.

Ans. (a) The phenomenon in which a small quantity of a substance known as catalyst alters the rate of a reaction is known as catalysis.

(b) The substance which alter the rate of a reaction and themselves remain chemically and quantitatively unchanged after the reaction are known as catalysts.

11. What is meant by activity and selectivity of a catalyst?

Ans. Activity of a catalyst is the extent to which a catalyst can increase the rate of reaction. It depends upon the strength of chemisorption.Selectivity of a catalyst is its ability to direct a reaction to yield a particular product. The action of a catalyst is highly selective in nature.

12. What is shape – selective catalysis? Give an example of shape selective catalyst.

Ans. The catalytic reaction that depends upon the pore structure of the catalyst and the size of the reactant and product molecules is called shape selective catalysis. Zeolites are good shape catalysts due to there honeycomb – like structure. The reactions taking place in zeolites depends upon the size and the shape of reactant and product molecules as well as upon the pores and cavities of the zeolites.

13. Give two examples of enzyme catalysed reaction.

Ans. Examples of enzyme- catalysed reactions are –

(1) Inversion of cane sugar:

$$C_{12}H_{22}O_{11}(aq) + H_2O(\ell) \xrightarrow{Invertase} C_6H_{12}O_6(aq) + C_6H_{12}O_6(aq)$$

2. Decomposition of urea into ammonia and carbon dioxide.

$$NH_2CONH_2(aq) + H_2O(\ell) \xrightarrow{Urease} 2NH_3(g) + CO_2(g)$$

14. Write characteristics of enzyme catalysed reactions.

Ans. The characteristics of enzyme catalysed reactions are –

(1) They are highly efficient and specific in nature.

(2) They have maximum activity under specific temperature and pH.

(3) Their activity increases on adding activators and coenzymes while decreases in the presence of poison or inhibitors.

15. Name some important industrial catalytic process and their catalysts.

Ans.

Process	Catalyst
(i) Haber's process for preparation of ammonia.	(i) Iron , Molybdenum
(ii) Ostwald's process for manufacture of nitric acid.	(ii) Platinised asbestos.
(iii) Contact process for manufacture of sulphuric acid.	(iii) Vanadium pentaoxide(V_2O_5).

16. Give two examples of reactions catalysed by zeolites.

Ans. Example of zeolite catalysed reactions are:

(a) Cracking of hydrocarbons in petroleum industries.

(b) Conversion of alcohols into gasoline.

17. What is dispersed phase and dispersion medium in

(i) sol (ii) Aerosol (iii) Foam?

Ans.

Dispersion medium	Dispersion phase	Colloid
(i) Solid	(i) Liquid	(i) Sol
(ii) Solid	(ii) Gas	(ii) Aerosol
(iii) Liquid	(iii) Gas	(iii) Aerosol
(iv) Gas	(iv) Liquid	(iv) Foam

18. Differentiate between multimolucular and macromolecular colloid?

Ans.

Macromolecular colloid	Multimolecular colloid
1. It consist of aggregates of atoms or molecules with diameter less then 10^{-9}m.	1. They are themselves Large.
2. The atoms or molecules are held tog-ether by weak Vander Waal's forces.	2. Since the molecules are flexible. They can take Various shapes.
3. Example - Gold sol, sulphur sol.	3. Example – starch, proteins.

19. What are associated colloids? Give an example?

Ans. The substances, which at low concentration behave as normal electrolyte but at higher concentration exhibit colloidal behavior due to formation of aggregates, are called associated colloids. For example – soaps and detergents. They are also called micelle.

20. What is CMC and Kraft's temperature?

Ans. CMC or critical micelle concentration and Kraft's temperature are the concentration and temperature above which micelle formation or associated colloid formation takes place.

21. Write the equation for formation of

(a) Sulphur sol.

(b) Ferric hydroxide sol.

Ans. (a) $SO_2 + 2H_2S \xrightarrow{Oxidation} 3S + 2H_2O$

(b) $FeCl_3 + 3H_2O \xrightarrow{Hydrolysis} \underset{(Sol)}{Fe(OH)_3} + 3HCl$

22. Define the term peptization?

Ans. The process of converting a precipitate into colloidal sol by shaking it with dispersion medium in the presence of small amount of electrolyte is called peptisation.

23. How is a colloidal solution purified by dialysis?

Ans. Dialysis is a process of removing a dissolved substance from a colloidal solution by means of diffusion through a suitable membrane. A bag of suitable membrane containing the colloidal solution is suspended in a vessel through which fresh water is continuously flowing. The molecules and ions diffuse through membrane into outer water and pure colloidal solution is left behind

24. What is observed when light is passed through a colloidal solution?

Ans. When light is passed through a colloidal solution, the colloidal particles scattered the lght and the path of light gets illuminated and a bright cone of light is observed due to scattering of light in all direction. This is called Tyndal effect.

25. Define the terms – (a) Brownian movement (b) Electrophoresis?

Ans. (a) Brownian movement:-

The continuous zig-zag movement of particles in a colloidal solution is called Brownian movement.

(b) Electrophoresis:-

The movement of particles under an applied electric potential is called electrophoresis.

26. Alum is used for purification of water. Why?

Ans. The dirty water contains electrically charged impurities which get coagulated on adding alum which contains Al^{3+} ion. These impurities settle down after coagulation and are then filtered.

27. Give three applications of colloidal solutions?

Ans. Application of colloids-

1. Colloidal antimony is used in curing kalaazar.

2. Paints, synthetic plastics, rubber etc. all are colloidal solutions.

3. Rubber is obtained by coagulation of latex.

28. What are the two types of emulsions?

Ans. The two types of emulsions are-

(a) Oil dispersed in water (o/w type)

(b) Water dispersed in oil (w/o type)

29. How does an emulsifying agent work? Give an example of emulsifying agent.

Ans. An emulsifying agent is added to emulsions for its stabilization. It forms an interfacial film between suspended particles and the medium eg. For o/w emulsions, Proteins, gums soaps etc. can be used an emulsifying agent whereas for w/o long chain alcohols lamp black etc. can be used.

30. Write any two characteristics of Chemisorption.

Ans. 1. Chemisorption is highly specific in nature. It occurs only if there is a possibility of chemical bonding between the adsorbent and the adsorbate.

2. Like physisorption, chemisorption also increases with an increase in the surface area of the adsorbent.

31. Why does physisorption decrease with the increase of temperature?

Ans. Physisorption is exothermic in nature. Therefore, in accordance with Le-Chateliere's

principle, it decreases with an increase in temperature. This means that physisorption occurs more readily at a lower temperature.

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

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.

33. Why is the ester hydrolysis slow in the beginning and becomes faster after sometime?

Ans. Ester hydrolysis can be represented as: $\text{Ester} + \text{Water} \rightarrow \text{Acid} + \text{Alcohol}$

The acid produced in the reaction acts as a catalyst and makes the reaction faster. Substances that act as catalysts in the same reaction in which they are obtained as products are known as autocatalysts.

34. What modification can you suggest in the Hardy-Schulze law?

Ans. Hardy-Schulze law states that 'the greater the valence of the flocculating ion added, the greater is its power to cause precipitation.'

This law takes into consideration only the charge carried by an ion, not its size. The smaller the size of an ion, the more will be its polarising power. Thus, Hardy-Schulze law can be modified in terms of the polarising power of the flocculating ion. Thus, the modified Hardy-Schulze law can be stated as 'the greater the polarising power of the flocculating ion added, the greater is its power to cause precipitation.'

35. Why is it essential to wash the precipitate with water before estimating it quantitatively?

Ans. When a substance gets precipitated, some ions that combine to form the precipitate get adsorbed on the surface of the precipitate. Therefore, it becomes important to wash the precipitate before estimating it quantitatively in order to remove these adsorbed ions or other such impurities.

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

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

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

Ans. By activating an adsorbent, we tend to increase the adsorbing power of the adsorbent. Some ways to activate an adsorbent are:

(i) By increasing the surface area of the adsorbent. This can be done by breaking it into smaller pieces or powdering it.

(ii) Some specific treatments can also lead to the activation of the adsorbent. For example, wood charcoal is activated by heating it between 650 K and 1330 K in vacuum or air. It expels all the gases absorbed or adsorbed and thus, creates a space for adsorption of gases.

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

Ans. **Effect of pressure**

Adsorption is a reversible process and is accompanied by a decrease in pressure. Therefore, adsorption increases 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 decreases with an increase in temperature.

39. 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:

(a) Oil in water type:

Here, oil is the dispersed phase while water is the dispersion medium. For example: milk, vanishing cream, etc.

(b) Water in oil type:

Here, water is the dispersed phase while oil is the dispersion medium. For example: cold cream, butter, etc.

40. Describe some features of catalysis by zeolites.

Ans. Zeolites are alumino-silicates that are micro-porous in nature. Zeolites have a 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 atoms, giving them an Al-O-Si framework. The reactions taking place in zeolites are very sensitive to the pores and cavity size of the zeolites. Zeolites are commonly used in the petrochemical industry.

41. What is shape selective 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 a shape-selective catalysis. The pore size present in the zeolites ranges from 260-740 pm. Thus, molecules having a pore size more than this cannot enter the zeolite and undergo the reaction.

42. Give four uses of emulsions.

Ans. Four uses of emulsions:

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

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

(iii) Antiseptics and disinfectants when added to water form emulsions.

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

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

Ans. Common salt (a typical crystalloid in an aqueous medium) 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 between 1 nm and 1000 nm, 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 between a true solution and a suspension.

3 Marks Questions

1. Explain modern theory of heterogeneous catalysis.

Ans. According to modern theory of catalysis, the mechanism of heterogeneous catalysis involves following steps –

(i) Diffusion of reactants on the surface of catalyst.

(ii) Adsorption of reactant molecules on the surface.

(iii) Occurrence of reaction on the catalysts surface through formation of an intermediate.

(iv) Desorption of products from surface.

(v) Diffusion of products away from surface.

2. Differentiate between lyophobic and lyophillic sol?

Ans.

Lyophobic sol	**Lyophillic sol.**
1. It is relatively unstable due to Repulsion between dispersion ium and dispersed phase.	1. It is relatively more stable due to med-attraction between dispersion medium and dispersed Phase.
2. It is irreversible.	2. It is reversible.
3. It cannot be easily peptised.	3. It can be easily peptised.
4. Small quantities of electrolyte cause precipitation.	4. Small quantities of electrolyte has no effect larger concentration causes precipitation.

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

Ans. *Adsorption* is a surface phenomenon of accumulation of molecules of a substance at the surface rather than in the bulk of a solid or liquid. The substance that gets adsorbed is called the 'adsorbate' and the substance on whose surface the adsorption takes place is called the 'adsorbent'. Here, the concentration of the adsorbate on the surface of the adsorbent increases. In adsorption, the substance gets concentrated at the surface only. It does not penetrate through the surface to the bulk of the solid or liquid. For example, when we dip a chalk stick into an ink solution, only its surface becomes coloured. If we break the chalk stick, it will be found to be white from inside.

On the other hand, the process of *absorption* is a bulk phenomenon. In absorption, the substance gets uniformly distributed throughout the bulk of the solid or liquid.

4. Why is adsorption always exothermic?

Ans. Adsorption is always exothermic. This statement can be explained in two ways.

(i) Adsorption leads to a decrease in the 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 the 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.

5. How are colloids classified on the basis of

(i) Physical states of components

(ii) Nature of dispersion medium and

(iii) Interaction between dispersed phase and dispersion medium?

Ans. Colloids can be classified on various bases:

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

(ii) 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

(iii) 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) and lyophobic (solvent repelling).

6. 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^- 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.

7. 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, $R-COO^-Na^+$. 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 the hydrophilic parts point away from the dirt molecule. This is known as micelle formation. Thus, we can say that the polar group dissolves in water while the non-polar group dissolves in the dirt particle. Now, as these micelles are negatively charged, they do not coalesce and a stable emulsion is formed.

8. What do you mean by activity and selectivity of catalysts?

Ans. (a) Activity of a 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.

(b) 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 catalysts, we can get different products for the reaction between H_2 and CO.

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

(ii) $CO_{(g)} + 2H_{2(g)} \xrightarrow{Cu/ZnO-Cr_2O_3} CH_3OH_{(g)}$

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

9. 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 called an 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

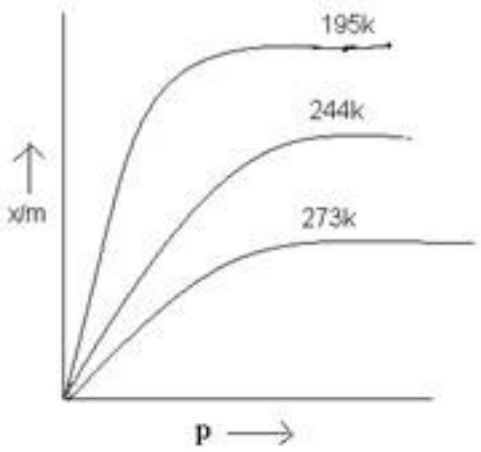
(iii) Hydrosol

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.

5 Marks Questions

1. Explain Freundlich adsorption isotherm.

Ans. Freundlich adsorption isotherm gives an empirical relationship between the quantity of gas adsorbed by unit mass of solid adsorbent and pressure at a particular temperature The relationship is $\frac{x}{m} = K.P^{1/n\,(n>1)}$ Where x is a mass of gas adsorbed on mass m of adsorbent at pressure P, K &n are constant that depend on the nature of adsorbent and adsorbate – The Relationship can be represented by plotting curves between x/m and P. They show that at a fix pressure, the physical adsorption decreases with increase in temperature.



2. What are homogeneous and heterogeneous catalysis? Give example.

Ans. Homogeneous catalysis –

When reactant and catalyst are in the same phase, the process is said to be homogeneous catalysis.

Examples –

(1) Oxidation of sulphur dioxide in the presence of oxygen gas and nitric oxide gas as catalyst.

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

(2) Hydrolysis of methyl acetate catalysed by H^+ ions.

$$CH_3COOCH_3(\ell) + H_2O(\ell) \xrightarrow{H_2SO_4(aq)} CH_3COOH(aq) + CH_3OH(aq)$$

(3) Hydrolysis of sugar catalysed by H_2SO_4.

Hetrogeneous Catalysis –

The catalytic process in which the reactant and catalyst are in different phases is known as heterogeneous catalysis.

Examples:-

(1) Oxidation of sulphur dioxide in presence of platinum.

$$O_2(g) + 2SO_2(g) \xrightarrow{pt(s)} 2SO_3\ (g)$$

(2) Preparation of ammonia by Haber's process

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

(3) Oxidation of ammonia in Ostwald's process.

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

3. Explain the mechanism of enzyme catalysis.

Ans. Mechanism of enzyme catalysed reactions-

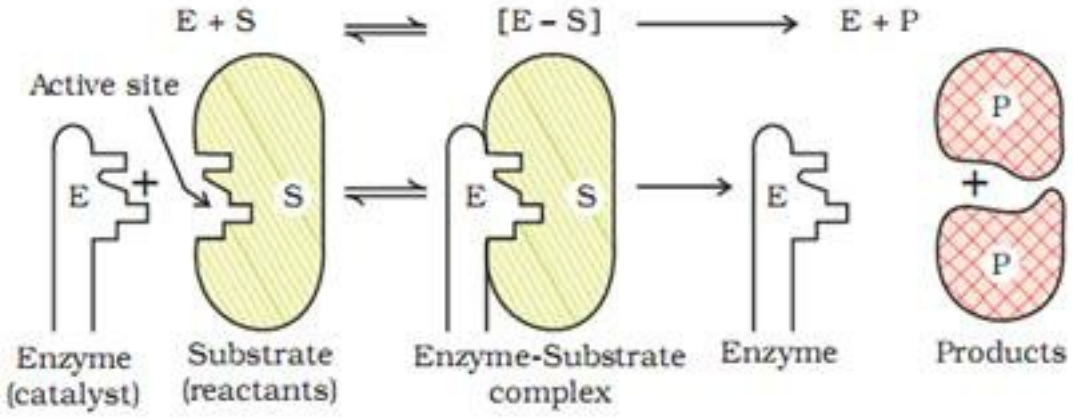
There are active centres or cavities on the surface of enzyme particles. The molecules of the reaction or substrate which have complementary shape fit into these just like a key fits into a lock. This forms an activated complex which decomposes to yield products. The reactions proceed in two steps –

Step 1: Binding of enzymes to substrate to form activated complex.

$$E + S \dashrightarrow ES$$

Step 2 : Decomposition of complex to form products.

$$ES \dashrightarrow E + P.$$



4. What is the difference between physisorption and chemisorption?

Ans.

	Physisorption	**Chemisorption**
1.	In this type of adsorption, the adsorbate is attached to the surface of the adsorbent with weak van der Waal's forces of attraction.	In this type of adsorption, strong chemical bonds are formed between the adsorbate and the surface of the adsorbent.
2.	No new compound is formed in the process.	New compounds are formed at the surface of the adsorbent.
3.	It is generally found to be reversible in nature.	It is usually irreversible in nature.
4.	Enthalpy of adsorption is low as weak van der Waal's forces of attraction are involved. The values lie in the range of $20-40\,\mathrm{kJ\,mol^{-1}}$.	Enthalpy of adsorption is high as chemical bonds are formed. The values lie in the range of $40-400\,\mathrm{kJ\,mol^{-1}}$.
5.	It is favoured by low temperature conditions.	It is favoured by high temperature conditions.
6.	It is an example of multi-layer adsorption	It is an example of mono-layer adsorption.

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

Ans. There are various 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_2, O_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 a reversible process and is accompanied by a decrease in pressure. Therefore, adsorption increases 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.

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

Ans. The plot between the extent of adsorption $\left(\frac{x}{m}\right)$ against the pressure of gas (*P)* at constant temperature (T) is called the adsorption isotherm.

Freundlich adsorption isotherm:

Freundlich adsorption 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 given plot it is clear that at pressure *P*S, $\left(\frac{x}{m}\right)$ reaches the maximum valve. *Ps* is called the saturation pressure. Three cases arise from the graph now.

Case I- At low pressure:

The plot is straight and sloping, indicating that the pressure in directly proportional to $\left(\frac{x}{m}\right)$

i.e., $\frac{x}{m} \alpha P$.

$\frac{x}{m} kP$ (k is constant)

Case II- At high pressure:

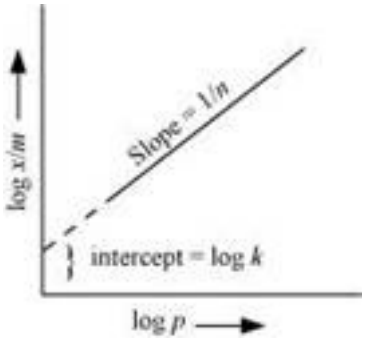
When pressure exceeds the saturated pressure, $\left(\frac{x}{m}\right)$ becomes independent of P values.

$$\frac{x}{m} \alpha P^{\circ}$$

$$\frac{x}{m} kP^{\circ}$$

Case III- At intermediate pressure:

At intermediate pressure, $\left(\frac{x}{m}\right)$ depends on *P* raised to the powers between 0 and 1. This relationship is known as the Freundlich adsorption isotherm.



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

$$\frac{x}{m} kP^{\frac{1}{n}} \quad n > 1$$

Now, taking log:

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

On plotting the graph between log $\left(\frac{x}{m}\right)$ and log *P*, a straight line is obtained with the slope equal to $\frac{1}{n}$ and the intercept equal to log k.

7. What role does adsorption play in heterogeneous catalysis?

Ans. Heterogeneous catalysis:

A catalytic process in which the catalyst and the reactants are present in different phases is known as a heterogeneous catalysis. This heterogeneous catalytic action can be explained in terms of the adsorption theory. The mechanism of catalysis involves the following steps:

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

(ii) Occurrence of a chemical reaction through the formation of an intermediate.

(iii) De-sorption of products from the catalyst surface

(iv) 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 then adsorbed on the surface of the catalyst. As the concentration of 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 are quickly desorbed, thereby making the surface free for other reactants.

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

Ans. One criterion for classifying colloids is the physical state of the dispersed phase and dispersion medium. Depending upon the type of the dispersed phase and dispersion medium (solid, liquid, or gas), there can be 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

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

Ans. (i) Lyophilic sols:

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

(ii) Lyophobic sols:

When substances such as metals and their sulphides etc. are 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 presence of a charge and the salvation of colloidal particles. On the other hand, the stability of hydrophobic sols is only because of the presence of a charge. Therefore, the latter are much less stable than the former. If the charge of hydrophobic sols is removed (by addition of electrolytes), then the particles present in them come closer and form aggregates, leading to precipitation.

10. 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?

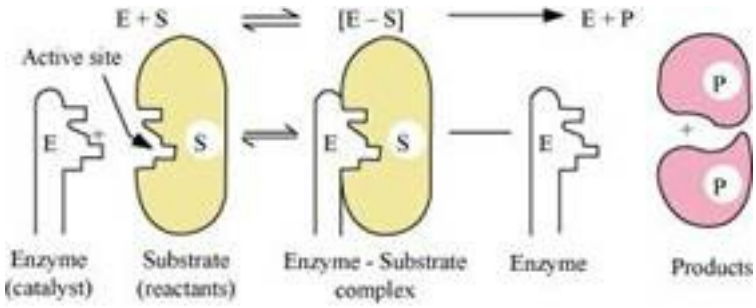
Ans. (i) In multi-molecular colloids, the colloidal particles are an aggregate of atoms or small molecules with a diameter of less than 1 nm. The molecules in the aggregate are held together by van der Waal's forces of attraction. Examples of such colloids include gold sol and sulphur sol.

(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 example: starch, nylon, cellulose, etc.

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

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

Ans.



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

Mechanism of enzyme catalysis:

On the surface of the enzymes, various cavities are present with characteristic shapes. These cavities possess active groups such as $-NH_2, -COOH$ etc. The reactant molecules having a complementary shape fit into the cavities just like a key fits into a lock. This leads to the formation of an activated complex. This complex then decomposes to give the product.

Hence,

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

(Activated complex)

Step 2: $ES \rightarrow E + P$

12. Give four examples of heterogeneous catalysis.

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

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

(ii) Formation of ammonia by the combination of dinitrogen and dihydrogen in the presence of finely divided iron.

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

This process is called the Haber's process.

(iii) Oswald's process: Oxidation of ammonia to nitric oxide in the presence of platinum.

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

(iv) Hydrogenation of vegetable oils in the presence of Ni.

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

13. 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 charged particles move to the cathode, while negatively charged particles move towards the anode. As the particles reach oppositely charged electrodes, they become neutral and get coagulated.

(ii) Coagulation:

The process of settling down of colloidal particles i.e., conversion of a colloid into a precipitate is called coagulation.

(iii) Dialysis

The process of removing a dissolved substance from a colloidal solution by the means of diffusion through a membrane is known as dialysis. This process is based on the principle that ions and small molecules can pass through animal membranes unlike colloidal particles.

(iv) Tyndall effect:

When a beam of light is allowed to pass through a colloidal solution, it becomes visible like a column of light. This is known as the Tyndall effect. This phenomenon takes place as particles of colloidal dimensions scatter light in all directions.