5 CHAPTER

Surface Chemistry

Past Year NEET Trend

No. of MCQs vs Year (2011–2020)

Investigation Report

TARGET EXAM	PREDICTED NO. OF MCQs	CRITICAL CONCEPTS
NEET 2021	0-1	• Classification of colloids • Important properties of colloidal solution

Perfect Practice Plan

TOPIC-WISE MCQs	NCERT BASED MCQs	MULTI-CONCEPT MCQs	NEET PAST 10 YEAR QUESTIONS	TOTAL MCQs
70	31	21	14	136

INTRODUCTION

☺ Surface chemistry is that branch of chemistry which deals with study of the phenomenon occurring at the surface or interface, i.e. at the boundary separating two bulk phases. In this chapter our main emphasis will be on three important topics related to surface chemistry, viz., adsorption, colloids and emulsions.

ADSORPTION

☺ The phenomenon of attracting and retaining the molecules of a substance on the surface of a liquid or a solid resulting into a higher concentration of the molecules on the surface is called adsorption.

☺ As a result of adsorption, there is a decrease of surface energy.

☺ The process of removal of an adsorbed substance from the surface on which it is adsorbed is called desorption.

☺ It is the reverse of adsorption and can be brought about by heating or by reducing the pressure.

Adsorbent and adsorbate

● The substance on the surface of which adsorption occurs is known as adsorbent.

● The substances that get adsorbed on the solid surface due to intermolecular attractions are called adsorbate.

● Charcoal, silica, gel, alumina gel are good adsorbents because they have highly porous structures and have large surface area.

● Colloids on account of their extremely small dimensions possess enormous surface area per unit mass and are, therefore, also good adsorbents.

Examples of adsorption

☺ **Adsorption of a gas by charcoal:** Finely divided activated charcoal has a tendency to adsorb a number of gases like ammonia, sulfur dioxide, chlorine, phosgene, etc In this case, charcoal acts as an adsorbent while gas molecules act as adsorbate.

☺ **Adsorption of a dye by charcoal:** Animal charcoal is used for decolourising a number of organic substances in the form of their solutions. The discharge of the colour is due to the fact that the coloured component (generally an organic dye) gets adsorbed on the surface of the adsorbent (animal charcoal).

☺ **Sorption :** When both adsorption and absorption take place simultaneously.

Eg : Dyes get adsorbed as well as absorbed in the cotton fiber i.e. sorption takes place.

Difference between adsorption and absorption

☺ Adsorption is a phenomenon in which there is higher concentration of another substance on the surface than in the bulk.

☺ On the other hand, absorption is a phenomenon in which the molecules of a substance are uniformly distributed throughout the body of other substance.

☺ For example, when silica gel is placed in the environment of water, it **adsorbs** the water vapour.

☺ On the other hand, when calcium chloride is placed in the environment of water, it **absorbs** water.

☺ The water vapour uniformly get distributed throughout the body of calcium chloride.

☺ Thus, silica gel adsorbs water vapour while anhydrous calcium chloride absorbs water.

Table: The important points of distinction between adsorption and absorption are

Absorption	Adsorption
◆ It is the phenomenon in which the particles of gas or liquid get uniformly distributed throughout the body of the solid.	It is the phenomenon of higher concentration of gas or liquid on the surface than in the bulk of the solid.
◆ The concentration is the same throughout the material. Therefore, it is a bulk phenomenon.	The concentration on the surface of the adsorbent is different (has higher concentration) from the bulk.
◆ Absorption occurs at uniform rate.	Adsorption is rapid in the beginning and its rate slowly decreases. It is a surface phenomenon decreases.

Mechanism of adsorption

☺ Adsorption arises due to the fact that the surface particles of the adsorbent are not in the same environment as the particles inside the bulk.

☺ Inside the adsorbent the particles are surrounded by atoms on all sides. Force acting on these particles are mutually balanced but on the surface, particles are not surrounded by atoms or molecules on all sides. Therefore, they posess unbalanced or residual forces, which are responsible for attracting the adsorbate particles on its surface.

☺ During adsorption, there is always a decrease in residual forces of surface i.e. there is decrease in surface energy which appears as heat.

Thermodynamics of adsorption

☺ Adsorption is an exothermic process. Therefore ΔH of adsorption is always negative. When a gas is adsorbed the entropy of the gas decreases i.e. ΔS is negative. Adsorption is thus accompanied by decrease in enthalpy as well as entropy of the system, for a process to be spontaneous, requirement is that ΔG must be negative.

☺ On the basis of equation, $\Delta G = \Delta H - T\Delta S$, ΔG can be negative if ΔH has sufficiently high negative value as $- T\Delta S$ is positive.

☺ Thus, in an adsorption process, which is spontaneous, ΔS is negative, and ΔH is also sufficiently negative and as a combination of these two factors, ΔG is negative.

☺ ΔH becomes less and less negative as adsorption proceeds further and further. Ultimately ΔH becomes equal to $T\Delta S$ and ΔG becomes zero. This is the state at which equilibrium is attained.

Types of adsorption

(i) **Physical adsorption (i.e. physisorption):** When the particles of the adsorbate are held to the surface of the adsorbent by the physical forces such as Van der Waal's forces, the adsorption is called physical adsorption or Vander Waals adsorption.

(ii) **Chemical adsorption (i.e. chemisorption):** When the molecules of the adsorbate are held to the surface of the adsorbent by the chemical forces, the adsorption is called chemical adsorption.

Characteristics of Physisorption

(i) **Lack of specificity:** A given surface of an adsorbent does not show any preference for a particular gas as the Van der Waals forces are universal.

(ii) **Nature of adsorbate:** The amount of gas adsorbed by a solid depends on the nature of gas. In general, easily liquefiable gases (i.e., with higher critical temperatures) are readily adsorbed as van der Waals forces are stronger near the critical temperatures.

(iii) **Reversible nature:** Physical adsorption of a gas by a solid is generally reversible. Thus,

Solid + Gas $\rightleftharpoons$ Gas/Solid + Heat

More of gas is adsorbed when pressure is increased as the volume of the gas decreases (Le-Chatelier's principle) and the gas can be removed by decreasing pressure. Since the adsorption process is exothermic, the physical adsorption occurs readily at low temperature and decreases with increasing temperature (Le-Chatelier's principle).

(iv) **Surface area of adsorbent:** The extent of adsorption increases with the increase of surface area of the adsorbent. Thus, finely divided metals and porous substances having large surface areas are good adsorbents.

(v) **Enthalpy of adsorption:** Physical adsorption is an exothermic process but its enthalpy of adsorption is quite low (20-40 kJ mol-1). This is because the attraction between gas molecules and solid surface is only due to weak Van der Waal's forces.

Characteristics of Chemisorption

(i) **High specificity:** Chemisorption is highly specific and it will only occur if there is some possibility of chemical bonding between adsorbent and adsorbate. **For example** oxygen is adsorbed on metals by virtue of oxide formation and hydrogen is adsorbed by transition metals due to hydride formation.

(ii) **Irreversibility:** As chemisorption involves compound formation it is usually irreversible in nature. Chemisorption is also an exothermic process but the process is very slow at low temperatures on account of high energy of activation. Like most chemical changes, adsorption often increases with rise of temperature.

(iii) **Surface area:** Like physical adsorption, chemisorption also increases with increase of surface area of the adsorbent.

(iv) **Enthalpy of adsorption:** Enthalpy of chemisorption is high ($80 – 240$ kJ mol^{-1})as it involves chemical bond formation.

Table: Difference between Physisorption and chemisorption

Physisorption	Chemisorption
◆ The forces between the adsorbate molecules and the adsorbent are weak Van der Waal's forces	◆ The forces between the adsorbate molecules and the adsorbent are strong chemical forces.
◆ Low heat of adsorption of the order of 20-40 kJ mol^{-1}	◆ High heat of adsorption of the order 80-240 kJ mol^{-1}
◆ Usually occurs at low temperature and decreases with increasing temperature.	◆ It occurs at high temperature
◆ It is reversible.	◆ It is irreversible.
◆ It forms multimolecular layers.	◆ It forms mono-molecular layer.
◆ extent of adsorption (x/m) increases with increases of pressure	◆ extent of adsorption (x/m) increases with increase pressure

Adsorption of gases on solids

☺ **The nature of the gas (i.e. nature of the adsorbate).** The easily liquefiable gases such as HCl, NH_3, Cl_2 etc are adsorbed more than the permanent gases such as H_2, N_2 and O_2. The ease with which a gas can be liquefied is primarily determined by its critical temperature. Higher the critical temperature (T_c) of a gas, the more easily it will be liquefied and, therefore, more readily it will be adsorbed on the solid.

Gas	SO_2	CH_4	H_2
T_C	630K	190 K	33 K

☺ **Nature of adsorbent.** The extent of adsorption of a gas depends upon the nature of adsorbent. Activated charcoal (i.e. activated carbon), metal oxides (silica gel and aluminium oxide) and clay can adsorb gases which are easily liquified Gases such as H_2, N_2 and O_2 are generally adsorbed on finely divided transition metals Ni and Co.

☺ **Activation of adsorbent:**

(a) Metallic adsorbents are activated by mechanical rubbing or by subjecting it to some chemical reactions.

(b) To increase the adsorbing power of adsorbents, they are sub-divided into smaller pieces. As a results, the surface area is increased and therefore, the adsorbing power increases.

☺ **Effect of temperature:** Mostly the process of adsorption is exothermic and the reverse process or desorption is endothermic If the above equilibrium is subjected to increase in temperature, then according to Le-Chaterlier's principle, with increase in temperature, the desorption will be favoured Physical adsorption decreases continuously with increase in temperature whereas chemisorption increases initially, shows a maximum in the curve and then it decreases continuously.
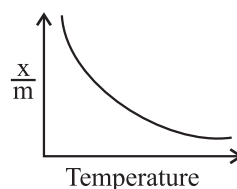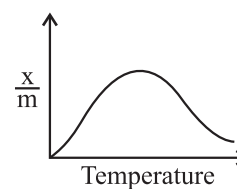

Fig.: *Physisorption*   **Fig.:** *Chemisorption*

☺ **Effect of pressure.** The extent of adsorption of a gas per unit mass of adsorbent depends upon the pressure of the gas. The variation of extent of adsorption expressed as x/m (where x is the mole of adsorbate and m is the mass of the adsorbent) and the pressure is given as below. A graph between the amount of adsorption and gas pressure keeping the temperature constant is called an **adsorption isotherm.**
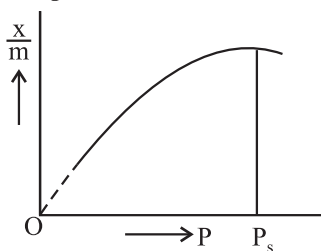

Fig.: *Adsorption isotherm*

☺ From the given figure that extent of adsorption (x/m) increases with pressure and becomes maximum corresponding to pressure P_s called equilibrium pressure. Since adsorption is a reversible process, the desorption also takes place simultaneously. At this pressure (P_s) the amount of gas adsorbed becomes equal to the amount of gas desorbed.

Freundlich Adsorption isotherm

The variation of extent of adsorption (x/m) with pressure (P) was given mathematically by Freundlich.

☺ **At low pressure** the graph is almost straight line which indicates that x/m is directly proportional to the pressure. This may be expressed as :

$(x/m) \propto p$ or $(x/m) = kp$ where k is constant.

☺ **At high pressure** the graph becomes almost constant which means that x/m becomes independent of pressure. This may be expressed as :

$(x/m) = $ constant   or $(x/m) \propto p^0$

$(since p^0 = 1)$ or $(x/m) = kp^0$.

☺ **Thus, in the intermediate range of pressure,** x/m will depend upon the power of pressure which lies between 0 to 1, fractional power of pressure. This may be expressed as

$(x/m) \propto p^{1/n}$ or $(x/m) = kp^{1/n}$

Where n can take any whole number value which depends upon the nature of adsorbate and adsorbent. The above relationship is also called **Freundlich's adsorption isotherm.**

The constant k and n can be determined as explained below : Taking logarithms on both sides of

Eq. $(x/m) = kp^{1/n}$ we get

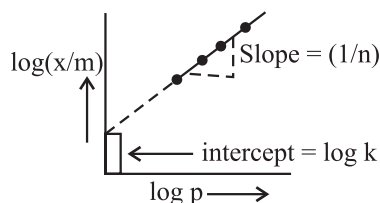$\log (x/m) = \log k + (1/n) \log p$.

Fig.: *Freundlich Adsorption isotherm*

◆ One of the drawbacks of Freundlich isotherm is that it fails at high pressure of the gas.

◆ This equation is applicable only when adsorbate substance form unimolecular layer on adsorbent surface. i.e. chemical adsorption.

Langmuir Adsorption Isotherm

☺ He considered adsorption to consist of the following two opposing processes:

(i) Adsorption of the gas molecules on the surface of the solid

(ii) Desorption of the adsorbed molecules from the surface of the solid

☺ He believed eventually a dynamic equilibrium is established between the above two opposing processes.

☺ He also assumed that the layer of the adsorbed gas was unimolecular. This isotherm works particularly well for chemisorption.

☺ It is represented by the relation: $\dfrac{x}{m} = \dfrac{ap}{1+bp}$ ... (a)

☺ Where 'a' and 'b' are Langmuir parameter.

☺ **At very high pressure :** x/m = a/b   ...(b)

☺ **At very low pressure :** x/m = ap   ... (c)

☺ For determination of the parameters 'a' and 'b', Eq. (a) may be written in its inverse form.

$\dfrac{m}{x} = \dfrac{1+bp}{ap} = \dfrac{b}{a} + \dfrac{1}{ap}$ ... (d)

☺ **A plot of m/x against 1/p gives a straight line with slope** and intercept equal to 1/a and b/a respectively.

☺ At low pressure according to Eq. (c) x/m increases linearly with p. At high pressure according to Eq. (b) x/m becomes constant i.e. the surface is fully covered and change in pressure has no effect and no further adsorption takes place.

Adsorption from solutions

☺ The process of adsorption can take place from solutions also. It is observed that solid adsorbents adsorb certain solutes from solution in preference to other solutes and solvents. For example, animal charcoal decolourise impure sugar solution by adsorbing colouring dye in preference to sugar molecules.

☺ The extent of adsorption from solution depends upon the concentration of solute in the solution as given by Freundlich isotherm : $(x/m) = k(c)^{1/n}$ $(n \geq 1)$

Where c is the equilibrium concentration of the solute in solution.

☺ Temperature dependence here also is similar to that for adsorption of gases and in place of equilibrium pressure, we use equilibrium concentrations of the adsorbate's in the solution.

Applications of adsorption

☺ **In gas masks:** Activated charcoal is generally used in gas masks to adsorb poisonous and toxic gases from air. These

masks are commonly used by the miners because there are poisonous gases like CO, CH_4 etc in the atmosphere in coal mines.

☺ **In dyeing of cloths:** Mordants such as alums are used in dyeing of cloths. They adsorb the dye particles which, otherwise, do not stick to the cloths.

☺ **In dehumidizers:** Silica gel is commonly used to adsorb humidity or moisture from air.

☺ **Removal of colouring matter:** Many substances such as sugar, juice and vegetable oils are coloured due to the presence of impurities. They can be decolourised by placing them in contact with adsorbents like activated charcoal or fuller's earth.

☺ **Refining Petroleum:** Silica gel is used as adsorbent in petroleum refining.
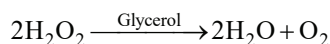
CATALYSIS

☺ A catalyst is that which increases the rate of reaction without itself undergoing any change.

Characteristics of Catalyst

☺ A catalyst does not initiate a reaction.

☺ A catalyst remains chemically unaffected at the end of the chemical reaction.

☺ Small amount of the catalyst are generally sufficient to speed up a chemical reaction.

☺ A catalyst does not effect the position of equilibrium. It helps to attain the equilibrium quickly. It catalyses both the forward and the backward reactions.

☺ A catalyst may get poisoned (loss of its activity) by the presence of even traces of impurities. This is called **catalytic poison.** H_2S is poison for Fe catalyst (Haber's process). As_2O_3 is poison for Pt catalyst. (contact process).

☺ Catalytic poison is specific for a catalyst.

☺ The action of catalyst in many instances is selective. Change of catalyst may give changed products. A catalyst gives specific products only. For example.

$$CO + 3H_2 \xrightarrow[\text{catalyst}]{Ni} CH_4 + H_2O$$

$$CO + H_2 \xrightarrow[\text{catalyst}]{Cu} HCHO$$
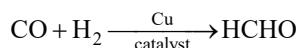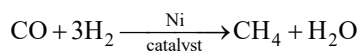
☺ The substance which increases the activity of catalyst is called **promoter.** Promoter is selective for a catalyst. For example, molybdenum (Mo) is promoter to the catalyst Fe in the Haber's process.

☺ If the rate of reaction is decreased in the presence of catalyst then the catalyst is called **negative catalyst.**

☺ Ex.: Decomposition of H_2O_2 is retarded by the presence of glycerol or acetanilide.

$$2H_2O_2 \xrightarrow{\text{Glycerol}} 2H_2O + O_2$$

☺ Change in temperature may alter the rate of a catalytic action. Bio-catalysts (enzymes) may lose their activity at higher temperatures. Catalysts thus function at optimum temperatures
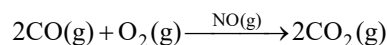
Types of Catalysis

Homogeneous Catalysis

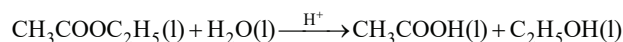☺ If the reactants and catalyst are present in a same phase, it is called homogeneous catalysis.

Eg.: 1. The preparation of SO_3 by lead-chamber process

$$2SO_2(g) + O_2(g) \xrightarrow{NO(g)} 2SO_3(g)$$
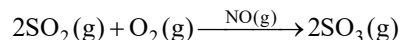
2. The conversion of Carbon monoxide to Carbon dioxide in the presence of NO

$$2CO(g) + O_2(g) \xrightarrow{NO(g)} 2CO_2(g)$$

3. Hydrolysis of ester in presence of acid.

$$CH_3COOC_2H_5(l) + H_2O(l) \xrightarrow{H^+} CH_3COOH(l) + C_2H_5OH(l)$$

4. Hydrolysis of sucrose in presence of mineral acids

Heterogeneous Catalysis

If the reactants and catalysts are present in different phases, it is called heterogeneous catalysis.

Eg.: 1. Preparation of SO_3 by contact process

$$2SO_2(g) + O_2(g) \xrightarrow{Pt/V_2O_5(s)} 2SO_3(g)$$
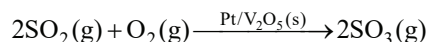
2. The preparation of ammonia by Haber's process

$$N_2(g) + 3H_2(g) \xrightarrow{Fe + Mo(s)} 2NH_3(g)$$
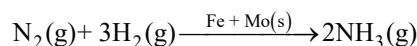
3. Oxidation of ammonia into nitric oxide in the presence of platinum gauze in Ostwald's process.

$$4NH_3(g) + 5O_2(g) \xrightarrow{Pt(s)} 4NO(g) + 6H_2O(g)$$
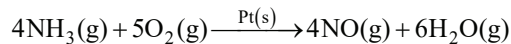
The reactants are in gaseous state while the catalyst is in the solid state.

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

$$\text{Vegetable oils (l)} + H_2(g) \xrightarrow{Ni(s)} \text{Vegetable ghee (s)}$$
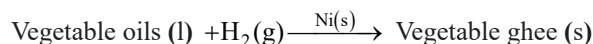
One of the reactants is in liquid state and the other in gaseous state while the catalyst is in the solid state.

Adsorption theory of Hetrogeneous Catalysis

(Mechanism of heterogeneous catalysis)

☺ The modern adsorption theory is the combination of Intermediate compound formation theory and the old adsorption theory.

☺ The catalytic activity is localised on the surface of the catalyst.

Mechanism

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

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

(iii) Formation of Intermediate due to the chemical reaction on the surface of catalyst.

(iv) Desorption of reaction products from the catalyst surface and there by catalyst whose surface available to further reaction to occur.

(v) Diffusion of reaction products away from the surface of catalyst.

☺ This theory explains why the catalyst remains unchanged in mass and chemical composition at the end of the reaction and is effective even in small quantities.

☺ This theory does not explain the action of catalytic promoters and catalytic poisons.

Fig.: *Adsorption or reacting molecules formation of intermediate and desorption of products*

Solid catalysts posses Two important features

☺ (A) Activity   (B) Selectivity

(A) Activity

☺ The ability of a catalyst to accelerate chemical reactions is called activity of a catalyst.

Catalytic activity increases from group 5 to group 11.

☺ Metals with maximum activity being shown by groups 7-9 elements of the periodic table.

$$2H_2(g) + O_2(g) \xrightarrow{Pt} 2H_2O(l)$$

(B) Selectivity

☺ The ability of catalysts to direct a reaction to give particular product is called selectivity of that catalyst.

☺ Ex.:– Different catalysts yield different products for the same reacting substances.

(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) $CO(g) + H_2(g) \xrightarrow{Cu} HCHO(g)$

Enzyme catalysis

☺ 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.

The enzymes are also sometimes called biocatalysts.

☺ Though enzymes are produced by living beings, they themselves are non-living and can act as catalysts even outside the living bodies.

☺ Numerous reactions that occur in the bodies of animals and plants to maintain the life process catalysed by enzymes. The enzymes are, thus, termed as biochemical catalysts and the phenomenon is known as biochemical catalysis.

☺ Enzymes are capable of bringing about complex reactions at body temperature. Some examples of enzyme catalysed reactions are:

(i) $2(C_6H_{10}O_5)_x (aq) + x H_2O(aq) \xrightarrow{Diastase} x C_{12}H_{22}O_{11}(aq)$
     Starch   Maltose

(ii) $C_{12}H_{22}O_{11}(aq) + H_2O(l) \xrightarrow{Maltase} 2C_6H_{12}O_6(aq)$
      Maltose   Glucose

(iii) $C_{12}H_{22}O_{11}(aq) + H_2O(l) \xrightarrow{Invertase} C_6H_{12}O_6(aq) + C_6H_{12}O_{6(aq)}$
       Cane Sugar   Glucose   Fructose

(iv) $C_6H_{12}O_6(aq) \xrightarrow{zymase} 2C_2H_5OH(aq) + 2CO_2(g)$
      Glucose   Ethyl Alcohol

(v) $H_2N.CO.NH_2(aq) + H_2O(l) \xrightarrow{urease} 2NH_3(g) + CO_2(g)$
     Urea

(vi) In stomach, the pepsin enzyme converts proteins into peptides while in intestine, the pancreatic trypsin converts proteins into amino acids by hydrolysis.

(vii) Conversion of milk into curd is an enzymatic reaction brought about by lacto bacilli enzyme present in curd.

Table: Same Enzymatic reactions

Enzyme	Source	Enzymatic reaction
Invertase	Yeast	Sucrose → Glucose + Fructose
Zymase	Yeast	Glucose → Ethylalcohol+CO_2
Diastase	Malt	Starch → Maltose
Maltase	Yeast	Maltose → Glucose
Urease	Soyabean	Urea → Ammonia + CO_2
Pepsin	Stomach	Proteins → Amino acids
Trypsin	Intestine	Proteins → Peptides
Lactobacilli	Curd	Lactose → Lactic acid

Charateristics of Enzyme Catalysis

1. High Efficiency

One molecule of an enzyme may transform one million molecules of the reactant per minute.

2. Highly specific nature

Each enzyme is specific for a given reaction.

3. Highly active under optimum temperature

The rate of an enzyme reaction becomes maximum at a definite temperature, called the optimum temperature. On either side of the optimum temperature, the enzyme activity decreases. The optimum temperature range for enzymatic activity is 298-310K. Human body temperature being 310 K is suited for enzyme catalysed reactions.

4. Highly active under optimum pH

The rate of an enzyme-catalysed reaction is maximum at a particular pH called optimum pH, which is between pH values 5-7.

5. Increasing activity in presence of activators and co-enzymes

The enzymatic activity is increased in the presence of a certain substances, known as co-enzymes. It has been observed that when a small non-protein (vitamin) present along with an enzyme, the catalytic activity is enhanced considerably.

6. Influence of inhibitors and poisons

Like ordinary catalysts, enzymes are also inhibitors or poisons interact with the active functional groups on the enzyme surface and often reduce or completely destroy the catalytic activity of the enzymes. The use of many drugs is related to their action as enzyme inhibitors in the body.

Mechanism of enzyme Catalysed Reaction

☺ The molecules of the reactant (substrate) which have complementary shape, comparing with the shape of cavities on the surface of colloidal particles of enzymes.

☺ Therefore molecules of reactant fit into cavities of colloidal particles of enzymes just like key fits into lock.

☺ The enzyme-catalysed reactions be considered to proceed in two steps.

Step-I: Binding of enzyme to substrate (reactant) to form an activated complex.

$E + S \rightarrow ES^{\neq}$
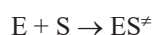
Step-II: Decomposition of the activated complex to form product.

$ES^{\neq} \rightarrow E$ (enzyme) $+ P$(product)
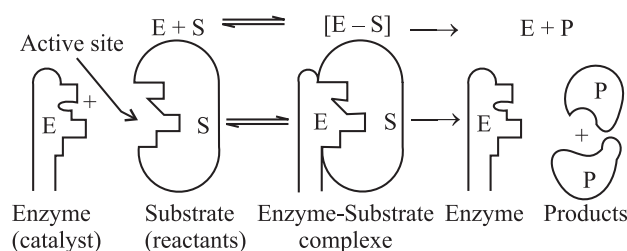
Fig.: *Mechanism of enzyme catalysed reaction*

Catalyst in Industry

Some of the important technical catalytic processes are listed in below table.

Process	Catalyst
Haber's Process for the manufacture of ammonia $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$	Finely divided iron. molybdenum as promoter, conditions: 200 bar pressure and 723-773 K temp
Ostwald's process for the manufacture of nitric acid $4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$ $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$ $4NO_2(g) + 2H_2O(l) + O_2(g) \rightarrow 4HNO_3(aq)$	Platinised asbestos temp. 573 K
Contact process for the manufacture of sulphuric acid. $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$ $SO_3(g) + H_2SO_4(aq) \rightarrow H_2S_2O_7(l)$ $H_2S_2O_7(l) + H_2O(l) \rightarrow 2H_2SO_4(aq)$	Platinised asbestos or vanadium pentoxide (V_2O_5) temp: 673–723 K

Shape-Selective Catalysis by Zeolites

☺ 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 alumino silicates i.e., three dimensional network silicates in which some silicon atoms are replaced by aluminium atoms giving **Al – O – Si** frame work.

☺ Zeolites are good shape-selective catalysts because of their honeycomb-like structures.

COLLOIDS

Colloid State: A substance is said to be in colloidal state when the size of the particle of disperse phase is greater than particle of true solution and less than that of suspension solution particle, their range of diameters between 1 and 1000 nm (10^{-9} to 10^{-6} m).

Colloid solution: It is a heterogeneous system consisting of 2 phase :

 (i) Dispersed Phase (D.P.): The phase which is dispersed through the medium is called dispersed phase or discontinuous phase or internal phase.

(ii) Dispersion Medium (D.M.): A medium in which colloidal particles are dispersed is called dispersion medium. It is also known as continuous phase or outer phase or external phase.

Colloidal solution = D.P. + D.M.

Ex. In Gold sol, Gold is D.P. and water is D.M.

☺ If the particle size of the solute in the binary system is less than $1m\mu(10^{-9}$ m), a true solution is formed.

☺ Examples for true solutions are-solutions of Common salt, sugar, acids,bases etc.

☺ If the particle size of the solute in the binary system is in the range $1m\mu$-1μ a colloidal solution is formed.

☺ Colloidal solutions are - Starch paste, gelatin (or) glue added to hot water.

Table: Difference between true solution, suspension and colloidal solution

Property	True Solution	Suspension	Colloidal solution
Nature	Homogeneous	Heterogeneous	Appears to be homogeneous but actually heteroge-neous
Particle size	< 10 A° (1nm)	>1000 A° (100 nm)	Between 10 A° (1 nm) to 1000 A° (100 nm)
Sedimenta-tion	Do not settle	Settle on stand-ing	Do not settle but settle by centrifu-gation
Diffusion	Diffuse quickly	Unable to diffuse	Diffuse slowly
Visibility	Particles invisible	Particles visible by naked eye or under micro-scope	Particles scatter light and can be observed under ultramicroscope
Filterability	Pass easily through ani-mal membrane and filter paper	Unable to pass through animal membrane or filter paper	Pass through filter paper but not through animal membrane
Appearance	Clear and transparent	Opaque	Translucent

Physics Wallah

Differentiating point of colloids

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

(2) The solution and colloid essentially differ from one another by particle size.

In a solution, the particles are ions or small molecules.

In a colloid, the dispersed phase may consist of particles of a single macromolecule (such as protein or synthetic polymer) or an aggregate of many atoms, ions or molecules.

(3) Colloidal particles are larger than simple molecules but small enough to remain suspended They have a range of diameters between 1 and 1000 nm (10^{-9} to 10^{-6} m).

CLASSIFICATION OF COLLOIDS

1. On the Basis of physical state of Dispersed phase (D.P.) and Dispersion Medium (D.M.)

On the bases of physical state of D.P. and D.M. colloidal solution may be divided into eight system.

D.P.	D.M.	Type of colloid	Examples
Solid	Solid	Solid Sol	Some coloured glasses, and gem stones
Solid	Liquid	Sol	Paints, cell fluids
Solid	Gas	Aerosol	Smoke, dust
Liquid	Solid	Gel	Cheese, butter, jellies
Liquid	Liquid	Emulsion	Milk, hair cream
Liquid	Gas	Liquid Aerosol	Fog, mist, cloud, insecticide sprays
Gas	Solid	Solid Sol	Pumice stone, foam rubber
Gas	Liquid	Foam	Froth, whipped cream, soap lather.

— *KEY NOTE* —

• Solution of gas in gas is not a colloidal system because it form homogeneous mixture.

• On the basis of Dispersion medium Colloidal solution are classified as

D.M.	Name of colloidal system
Water	Hydro sol or aqua sol
Alcohol	Alco sols
Benzene	Benzo sols
Air	Aerosols

• Aquadag & oildag are colloidal solution of graphite in water & oil respectively.

• Colloidal solution are often termed as sol.

2. On the Basis of interaction of Dispersed phase for Dispersion Medium.

(i) Lyophilic colloids/liquid loving sols/intrinsic colloid.

● The colloidal solution in which the particles of the dispersed phase have a great affinity (or love) for the dispersion medium, are called lyophilic colloids.

● These solutions are easily formed and the lyophilic colloids are **reversible** in nature.

● In case water acts as the dispersion medium, the lyophilic colloid is called **hydrophilic colloid.**

● The common examples of lyophilic colloids are glue, gelatin, starch, proteins, egg albumin, rubber, etc.

(ii) Lyophobic colloids/solvent hating colloid/extrinsic colloid

● The colloidal solutions in which there is no affinity between particles of the dispersed phase and the dispersion medium are called lyophobic colloids. Such solutions are formed with difficulty only by special methods.

● These sols are readily precipitated (or coagulated) on the addition of small amounts of electrolytes, by heating or by **shaking and hence are not stable.**

● Further, once precipitated, they do not give back the colloidal sol by simple addition of the dispersion medium. Hence these sols are also called **irreversible sols.**

● They need stabilising agents for their preservation.

● In case the dispersion medium is water, the lyophobic sol is called **hydrophobic colloid.**

● For example, the solution of metals like Ag and Au, hydroxides like Al $(OH)_3$, $Fe(OH)_3$, metal sulphides like As_2S_3 etc.

— *KEY NOTE* —

Lyophilic sols are more stable than lyophobic sols, the additional stability is due presence of an envelope of the solvent layer (say water) around the colloidal particle, the process is known as hydration, To coagulate a hydrophilic sols we have to add a dehydrating agent in addition to electrolyte.

3. On the basis of type of particle of dispersed phase

Multimolecular colloids

In this type, the particles consist of an aggregate of atoms or small molecules size between (1-1000nm)

☺ For example, sols of gold atoms and sulphur (S_8) molecules. In these colloids, the particles are held together by van der Waal's forces.

Macromolecular colloids

In this types, the particles of the dispersed phase are sufficiently big in size (macro) to be of colloidal dimensions.

☺ These macromolecules forming the dispersed phase are generally polymers having very high molecular masses.

☺ These colloids are quite stable and resemble true solutions in many respects. Naturally occuring macromolecules are starch, cellulose, proteins, enzymes, gelatin, etc.

Associated colloids (Micelles)

These are the substances which behave as normal strong electrolytes at low concentration but behave as colloidal particles at higher concentration due to formation of aggregates.

☺ These associated particles are also called micelles. Ex. Soap.

☺ **Micelles:** There are some substances which at low concentrations behave as normal strong electrolytes but at higher concentrations exhibit colloidal behaviour due to the formation of aggregated particles. The aggregated particles thus formed are called micelles.

☺ The formation of micelles takes place only above a particular temperature called **Kraft Temperature (T$_k$)** and above a particular concentration **called Critical Micelle Concentration (CMC).**

☺ On dilution, these colloids revert back to individual ions.

☺ Surface active agents such as soaps and synthetic detergents belong to this class. For soaps, the CMC is $\sim 10^{-4}$ to 10^{-3} mol L^{-1}.

☺ These colloids have both lyophobic and lyophilic parts. Micelles may contain as many as 100 molecules or more.

☺ **Mechanism of micelle formation:**

Let us take the example of soap solutions.

☺ Soap is sodium or potassium salt of a higher fatty acid and may be represented as RCOO$^-$Na$^+$ e.g., sodium stearate viz. CH$_3$(CH$_2$)$_{16}$COO– Na$^+$ which is a major component of many bar soaps.

☺ When dissolved in water, it dissociates into RCOO$^-$ and Na$^+$ ions.

☺ The RCOO$^-$ ions, however, consist of two parts i.e., long hydrocarbon chain R **(also called non-polar 'tail')** which is hydrophobic (water repelling) and the polar group COO$^-$ **(also called polar-ionic 'head')** which is hydrophilic (water loving).

☺ The RCOO$^-$ Ions are, therefore, present on the surface with their COO$^-$ groups in water and the hydrocarbon chains R staying away from it, and remain at the surface, but at higher concentration these are pulled into the bulk of the solution and aggregate in a spherical form with their hydrocarbon chains pointing towards the centre with COO$^-$ part remaining outward on the surface.

☺ An aggregate thus formed is known as **'Ionic micelle'.**

☺ These micelles may contain as many as upto 100 such ions.

☺ Aggregation of RCOO– ions to form an ionic micelle.

☺ Similarly, in case of detergents, e.g., sodium lauryl sulphate viz. CH$_3$(CH$_2$)$_{11}$SO$_4^-$ Na$^+$, the polar group is – SO$_4^-$ along with the long hydrocarbon chain. Hence, the mechanism of micelle formation is same as that of soaps.
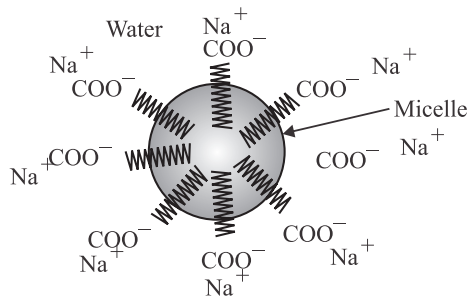

Fig.: *Arrangement of ionic micelle at crtical micelle concentrations of soap*

The Cleansing Action of Soaps

It is known that a micelle consists of a hydrophobic hydrocarbon like central core. The cleansing action of soap is due to these micelles, because oil and grease can be solubilised in their hydrocarbon, like centres which are not otherwise soluble in water. This is shown diagrammatically in figure the dirt goes out along with the soap micelles.
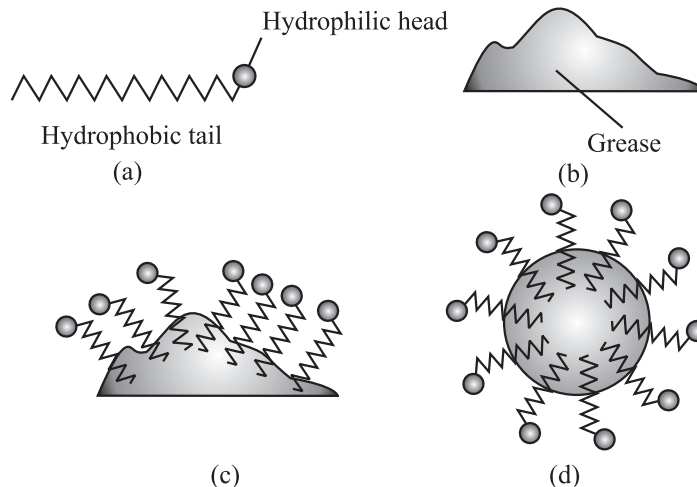

Fig.: (a) The simplified representation of the molecule that shows a hydrophilic head and a hydrophobic tail

(b) Grease (oily substance) is not soluble in water

(c) When soap is added to water, the non-polar tails of soap molecules dissolve in grease

(d) Finally, the grease is removed in the form of micelles containing grease.

## Preparation of colloids

1. Chemical methods

Double Decomposition: An arsenic sulphide (As$_2$S$_3$) sol is prepared by passing H$_2$S through cold solution of As$_2$O$_3$ till yellow colour deepens to its maximum.

As$_2$O$_3$ + 3H$_2$S $\rightarrow$ As$_2$S$_3$(sol) + 3H$_2$O
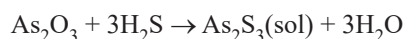
Oxidation: A sol of sulphur is prepared by passing H$_2$S into solution of SO$_2$

2H$_2$S + SO$_2$ $\rightarrow$ 2H$_2$O + S $\downarrow$
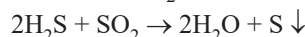
Reduction: Gold, platinum and silver sols are prepared by reduction of their compounds in water by using formaldehyde (or) hydrogen or tannic acid.

AgNO$_3$ + Tannic acid $\rightarrow$ Ag Sol

AuCl$_3$ + Tannic acid $\rightarrow$ Au Sol
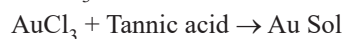
Hydrolysis: Ferric hydroxide sol is prepared by pouring dilute solution of ferric chloride into boiling water

FeCl$_3$ + 3H$_2$O $\rightarrow$ Fe(OH)$_3$ +3HCl
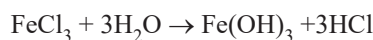
Red sol (Positive in nature)

Sols of chromium and aluminium can also be prepared by this method.

2. Electrical disintegration or Bredig's Arc method

This process involves dispersion as well as condensation. Colloidal sols of less reactive metals such as gold, silver, platinum, copper, lead etc., can be prepared by this method In

this method, electric arc is struck between electrodes of the metal immersed in the dispersion medium as shown in fig. The intense heat produced vaporises the metal, which then condenses to form particles of colloidal size by surrounding cooling mixture (ice).

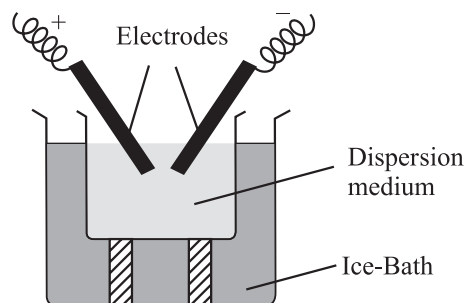A slight trace of KOH is added in water to stabilized colloidal solutions.

Fig.: *Bredig's Arc method*

3. Peptization

The term has originated from the digestion of proteins by the enzyme pepsin.

● Peptization is defined as (the process of converting a precipitate into colloidal sol by shaking it with dispersion medium in the presence of a small amount of electrolyte).

● The electrolyte used for this purpose is called peptizing agent. This method is applied, generally, to convert a freshly prepared precipitate into a colloidal sol.

● During peptization, the precipitate adsorbs one of the ions of the electrolyte on its surface.

● The ion adsorbed on the surface is common either with the anion or cation of the electrolyte. This causes the development of positive or negative charge on precipitates which ultimately break up into smaller particles having the dimensions of colloids.

For example :

When freshly precipitated $Fe(OH)_3$ is shaken with aqueous solution of $FeCl_3$ (peptizing agent) it adsorbs Fe^{3+} ions and thereby breaks up into small-sized particles.

Purification of Colloidal Sols

The colloidal sols obtained by various methods are impure and contain impurities of electrolytes and other soluble substances. These impurities may destabilise the sol. Hence, they have to be removed A very important method of removal of soluble impurities from sols by a semipermeable membrane is known as dialysis.

1. Dialysis

It is a process of removing a dissolved substance from a colloidal solution by means of diffusion through suitable membrane. Since particles in true solution (ions or smaller molecules) can pass through animal membrane or parchment paper or cellophane sheet but colloidal particle do not, the apparatus used for this purpose is called Dialyser.

2. Electrodialysis.

If dialysis is carried out in presence of electric field is called electro dialysis.

This method is used only when colloidal solutions possess electrolytic impurities.

The most important applications of dialysis is in the purification of blood in the artificial kidney machine. In case of kidney failure, blood cannot be purified under such condition, the blood is separated from dissolved toxic impurities by dialysis and re-introduced in the bloods stream.

— *KEY NOTE* —

Dialysis is not applicable for non-electrolytes like glucose, sugar, etc.

Ultra Filtration

In this method, colloidal sols are purified by carrying out filtration through special type of graded filters called ultra-filters. These filter papers allow only the electrolytes to pass through. These filter papers are made of particular pore size by impregnating with colloidal solution and subsequently hardened by soaking in formaldehyde. In order to accelerate the filtration through such filter papers, increased pressure or suction is employed.

Train Your Brain

Q. When SO_2 is bubbled into H_2S gas, colloidal sol is formed What type of colloidal sol is it ?

Ans. $2H_2S + SO_2 \longrightarrow 2H_2O + 3S$ (colloidal).

Lyophobic colloidal sol of sulphur is formed.

Q. A reddish brown positively charged sol is obtained by adding small quantity of $FeCl_3$ solution to freshly prepared and well washed $Fe(OH)_3$ precipitate.

How does it take place ?

Ans. It is due to adsorptions of Fe^{3+} ions on the surface of $Fe(OH)_3$ which gives colloidal sol.

$Fe(OH)_3 + Fe^{3+} \longrightarrow [Fe(OH)_3]Fe^{3+}$

(ppt.)   (ions adsorbed)   (colloidal sol).

Important properties of colloidal sols

1. Colligative Properties

☺ Colloidal sols show the colligative properties viz. relative lowering of vapour pressure, elevation in boiling point, depression in freezing point and osmotic pressure.

☺ However, due to high average molecular masses of colloidal particles, mole fraction of the dispersed phase is very low.

☺ Hence, the values of the colligative properties observed experimentally are very small. Only osmotic pressure measurements are used in determining the molecular mass of polymers.

2. Optical Properties-Tyndall effect

☺ Tyndall, in 1869, observed that if a strong beam of light is passed through a colloidal sol placed in a dark place, the path of the beam gets illuminated This phenomenon is called Tyndall effect, which is due to the scattering of light by the colloidal particles.

☺ The illuminated path of beam is called Tyndall cone.

☺ This phenomenon is due to scattering of light from the surface of colloidal particles. In a true solution there are no particles of sufficiently large diameter to scatter light & hence the beam is invisible.
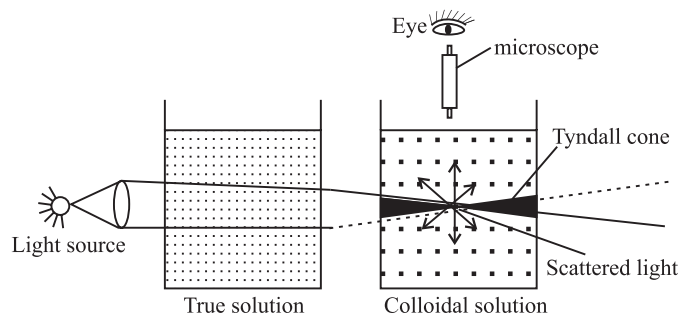

Fig.: *Tyndall effect*

The intensity of scattered light depends on the difference between the refractive indices of the D.P and D.M.,

Tydalls effect is applicable when:

(a) The diameter of the dispersed particles is not much smaller than the wavelength of the light used.

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

Example of Tyndall Effect

☺ Blue colour of sky and sea water.

☺ Visibility of tail of comets.

☺ Light thrown from a projector in cinema hall.

☺ Appearance of dust particle in a semi darked room.

☺ **Application of Tyndall Effect**

 (i) In making ultramicroscopes.

 (ii) In finding heterogenity of solution.

3. Colour

☺ The colour of colloidal solution depends on the wavelength of light scattered by the dispersed particles.

☺ The wavelength of light scattered further depends on the size and nature of the particles.

☺ The colour of colloidal solution also changes with the manner in which the observer receives the light.

☺ For example, a mixture of milk and water appears blue when viewed by the reflected light and red when viewed by the transmitted light.

☺ Finest gold sol is red in colour; as the size of particles increases, it appears purple, then blue and finally golden.

4. Brownian movement

This phenomenon was observed in case of colloidal particles when they were seen under an ultramicroscope. The particles were seen to be in constant zig-zag motion as shown in fig. This zig-zag motion is called Brownian movement.
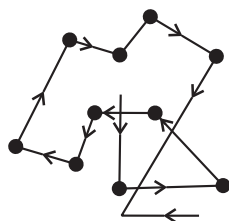

Fig.: *Brownian Movement*

☺ Brownian movement arises because of the impact of the molecules of the dispersion medium with the colloidal particles.

☺ It has been postulated that the impact of the molecules of the dispersion medium on the colloidal particle are unequal leading to zig-zag motion.

☺ However, as the size of the particle increases, the effect of the impacts average out and the Brownian movement becomes slow.

☺ Ultimately, when the dispersed particle becomes big enough to acquire the dimensions of suspension, no Brownian movement is observed.

☺ **Factors Affecting Brownian Movement**

● If particles is large then brownian movement becomes less.

● Brownian movement increases with increasing temperature.

● The brownian movement does not change with time & remains same for months or even for a year.

☺ **Brownian movement important**

● In confirmation of kinetic energy.

● Determination of Avogadro numbers.

● Stability of colloidal solution : Brownian movement does not allow the colloidal particles to settle down to gravity & thus is responsible for their stability.

5. Charge on colloidal particles

● Colloidal particles are either positively charged or negatively charged.

● This charge is due to preferential adsorption of either positive or negative ions on their surface.

● There is adsorption of common ion present in excess.

● When two or more ions are present in the dispersion medium, preferential adsorption of the ion common to the colloidal particle usually takes place. This can be explained by taking the following examples.

● $Fe(OH)_3$ sol prepared by the hydrolysis of $FeCl_3$ solution adsorbs Fe^{3+} and this is positively charged.

$FeCl_3 + 3H_2O \rightleftharpoons Fe(OH)_3 + 3HCl$;

$Fe(OH)_3 + FeCl_3 \rightarrow Fe(OH)_3 Fe^{3+}$**:** $3Cl^-$
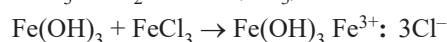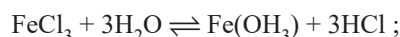
  Fixed part Diffused part.

Positive charge on colloidal sol is due to adsorption of Fe^{3+} ion (common ion between $Fe(OH)_3$ and $FeCl_3$).

☺ As_2S_3 colloidal sol is obtained when As_2O_3 is saturated with H_2S :

$As_2O_3 + 3H_2S \rightarrow As_2S_3 + 3H_2O$.
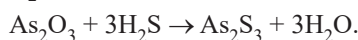
☺ As_2S_3 adsorbs S^{2-} ions (common between H_2S and As_2S_3 and thus is negatively charged).

$As_2S_3 + H_2S \rightarrow As_2S_3$: S^{2-} : $2H^+$.

● If silver nitrate solution is added to potassium iodide solution taken in excess, the preceipitated silver iodide will adsorb iodide ions from the dispersion medium and negatively charged colloidal solution will result. However, when KI solution is added to $AgNO_3$ solution taken in excess, positively charged sol will result due to adsorption of Ag^+ ions from dispersion medium.

AgI/I⁻   AgI/Ag⁺

Negatively charged   Positively charged

**Table:** Positively Charged Sols and Negatively Charged Sols

Positively charged sols	Negatively charged sols
Hydrated metallic oxides. e.g., $Al_2O_3.xH_2O$. $CrO_3.xH_2O$ and $Fe_2O_3.xH_2O$, etc.	Metals, e.g., copper, siver, gold sols.
Basic dye stuffs. e.g., methylene blue sol.	Metallic sulphides, e.g., As_2S_3, Sb_2S_3. CdS sols.
Haemoglobin (blood)	Acid dye stuffs, e.g., eosin, congo red sols.
Oxides, e.g., TiO_2 sol.	Sols of starch, gum, gelatin, clay, charcoal, etc.

Helmholtz electrical double layer

☺ The each sol particle is surrounded by either positive or negative ions in the form of fixed layer or compact layer. The second layer is diffuse or mobile layer consisting of ions of both the signs but net charge being equal and opposite to the fixed layer. This is known as Helmholtz electrical double layer.

Zeta potential

☺ The potential difference developed between the two layers is known as zeta potential or electric kinetic potential.
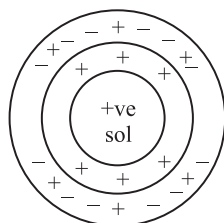
6. Electrophoresis

☺ The movement of sol particles under an applied electric potential is called electrophoresis or cataphoresis. The phenomenon helps in

- Removing suspended impurities
- Removing smoke from chimney gases
- Electroplating of rubber
- Painting metals with colloidal pigments
- Coagulation of sols
- Determination of charge

Electro-Osmosis

The movement of the dispersion medium under the influence of applied electric potential is known as electro osmosis. The phenomenon helps in

(a) Removing water from peat (Coal)

(b) Dewatering of moist clay

(c) Drying dye pastes.

Train Your Brain

Q. Classify the following sols according to theirs charges

(a) gold sol (b) ferric hydroxide sol
(c) gelatine (d) blood
(e) sulphur (f) arsenious sulphide
(g) titanium oxide.

Ans. Negatively charged colloidal sol : (a), (c), (d), (e), (f).
positively charged colloidal sol : (b), (g).

Q. SnO_2 forms positively charged colloidal sol in acidic medium and negatively charged colloidal sol in basic medium. Explain ?

Ans. SnO_2 is amphoteric reacting with acid and base both. In acidic medium (say HCl) Sn^{4+} ion is formed which is preferentially adsorbed on SnO_2 giving positively charged colloidal sol :

$SnO_2 + 4HCl \longrightarrow SnCl_4 + 2H_2O$;

$SnO_2 + SnCl_4 \longrightarrow [SnO_2]Sn^{4+}$(positively charged) $+ 4Cl^-$.

---

7. Coagulation/Flocculation

The presence of small amounts of appropriate electrolytes is necessary for the stability of the colloids.

However, when an electrolyte is added in larger concentration; the particles of the sol take up the ions which are oppositely charged and thus get neutralised.

The neutral particles then start aggregating giving particles of larger size which are then precipitated.

This process of aggregation of colloidal particles into an insoluble precipitate by the addition of some suitable electrolyte is known as coagulation.

☺ At lower concentration of electrolytes, the aggregation of particles is called flocculation that can be reversed on shaking while at higher concentration of electrolyte, coagulation takes place and the same cannot be reversed simply by shaking.

☺ The stability of the lyophobic colloids is due to presence of charge on colloidal particles. If, somehow, the charge is removed, the particles will come near to each other to form aggregates and settled down under the force of gravity.

Coagulation of lyophobic sols can be carried out by the following methods.

 (i) **By electrophoresis**

(ii) **By mutual precipitation :** It is a process in which oppositely charged sol are mixed in proper proportion to neutralise the charge of each other causing coagulation of both the sol.

Example: Positively charged $Fe(OH)_3$ and negatively charged As_2S_3 colloidal particle containing sol on mixing get coagulated.

(iii) **By Prolonged Dialysis :** On prolonged dialysis, traces of the electrolyte present in the sol are removed almost completely and the colloidal unstable and ultimately coagulate.

(iv) **By Boiling :** Sols such as sulphur and silver halides dispersed in water may be coagulated by boiling because increased collisions between sol particle and the water molecule removed the adsorbed electrolytes. This takes away the charge from the particles and helps them to coagulate.

(v) **By the addition of electrolyte :** When excess of an electrolyte is added, the colloidal particles are precipitated.

Coagulation value or Flocculation value : the coagulation

of a colloidal solution by an electrolyte does not take place until the added electrolyte has certain minimum concentration in the solution.

The minimum concentration of electrolyte in millimoles required to cause coagulation of one litre of colloidal solution is called coagulation value. It is express in terms of millimoles/litre.

$$\text{Coagulation value} = \frac{\text{millimoles of electrolyte}}{\text{volume of sol in litre}}$$

**Comparision of relative coagulating power of two electrolyte for the same colloidal solution:**

The coagulation value decrease with increase in charge of the coagulating ion.

$$\text{Coagulating power} \propto \frac{1}{\text{coagulation value}}$$

$$\frac{\text{coagulating power of electrolyte A}}{\text{coagulating power of electrolyte B}} = \frac{\text{coagulation value B}}{\text{coagulation value A}}$$

☺ **Factor-Affecting Coagulations**

(i) **Nature of sols :** The lyophobic colloid can easily coagulate because it is a less stable colloid, but lyophilic colloids coagulate hardly by the addition of electrolyte due to protective layer of D.M. surrounding the colloidal particle.

(ii) **Nature of electrolyte :** In equimolar electrolyte, strong electrolyte have greater coagulating power than weak electrolyte. Example:

$$0.1M\ NaCl > 0.1M\ CH_3COOH.$$
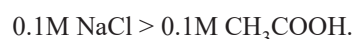
Hardy-Schulze Rule

According to this rule greater is the valency of coagulating ion, greater its power to cause precipitation. This is known as Hardy-Schulze rule.

In case of positive charged sol, the coagulating power of anion is in the order of $[Fe(CN)_6]^{4-} > PO_4^{3-} > SO_4^{2-} > Cl^-$

In case of negative charged sol, the coagulating power of cation is in the order of $Al^{3+} > Ba^{2+} > Na^+.$

— *KEY NOTE* —

The coagulating power of bivalent ion is 20-80 times higher than monovalent ion and coagulating power of trivalents is many times more than bivalent.

Train Your Brain

Q. The particles of a particular colloidal solution of arsenic trisulphide (As_2S_3) are negatively charged.

Which 0.0005 M solution would be most effective in coagulating this colloidal solution. KCl, $MgCl_2$, $AlCl_3$ or Na_3PO_4? Explain.

Ans. Since As_2S_3 is a negatively charged colloidal sol hence positively charged ion will cause its coagulation. By Hardy-Schulze rule "greater the charge on ion, greater the coagulating power to coagulate oppositely charged colloidal sol", hence out of K^+, Mg^{2+}, Al^{3+} and Na^+, Al^{3+} would be most effective.

Protective colloidal sols

Lyophilic colloidal sols are much more stable than lyophobic colloidal sols. This is due to the extensive solvation of lyophilic colloidal sols, which forms a protective layer outside it and thus prevents it from forming associated colloids.

Lyophobic sols can easily precipitate by addition of small amount of an electrolyte. They can be prevented from coagulation by previous addition of some lyophilic colloid. This is due to formation of a protective layer by lyophilic sols outside lyophobic sols.

Process of protecting the lyophobic colloid solution from precipitation by an electrolyte due to previous addition of some lyophilic colloid is called protection of colloid and lyophilic colloidal sols are called protective sols.

Eg.: Gelatin, Sodium caseinate, Egg albumin, Gum arabic, Potato starch etc.,

Gelatin (lyophilic) protects gold sol (lyophobic) colloids is expressed in terms of gold number.

Gold Number : It is defined as ''the minimum amount of the protective colloid in milligrams which when added to 10 ml of a standard gold sol is just sufficient to prevent a colour change from red to blue on the addition of 1 ml of 10% sodium chloride solution.

It may be noted that smaller of the gold number, greater will be protecting power of the protective colloid

$$\text{Protecting power} \propto \frac{1}{\text{gold number}}.$$

$$\text{Gold Number} = \frac{\text{weight of lyophilic sol in mg} \times 10}{\text{volume of gold sol in mL}}$$

The gold numbers of a few protective colloids are as follows :

Gelatin	Haemoglobin	Egg albumin	Gum arabic	Dextrin	Starch
0.005 – 0.01	0.03 – 0.07	0.1 – 0.2	0.15 – 0.25	6 – 6.2	20 – 25

Uses of protective action

(i) Gelatin is added in the preparation of ice cream to protect the particle of ice.

(ii) Protargol and Argyrol, is a silver sol protected by organic material used as eye drop.

EMULSIONS

☺ Pair of immiscible liquid is called **emulsion.**

☺ Emulsion are unstable and some time they are separated into two layers on keeping still, for the stabilising of an emulsion, a third component is added called emulsifying agent form an interracial film between D.P. and D.M.

☺ Emulsion droplets are bigger than sol particles and can be seen under an ordinary microscope and sometimes even with a magnifying glass.

Example: Milk is an emulsion in which liquid fat is D.P. and liquid water is D.M. and casein is emulsifying agent.

Types of emulsions

Depending on the nature of the dispersed phase, the emulsions are classified as:

(a) Oil in water emulsions (b) Water in oil emulsions

(a) Oil in water emulsions (o/w) : This type of emulsions is formed when oil D.P. and water D.M.

Ex. :– Milk and vanishing cream are oil - in - water type emulsions.

(b) Water in oil emulsions (w/o): This type of emulsions is formed when water is D.P. and oil is D.M.

Ex. :– Cold cream and cod liver oil.

☺ **Inversion of phase :** The conversion of emulsion of oil in water (o/w) into water in oil (w/o) or vice versa is called the inversion of phase.

Identification of the type of emulsion: These two types may be identified by:

☺ **Dilution test:** An emulsion can be diluted with any amount of the dispersion medium, while the dispersed liquid, if added, forms a separate layer. Thus if a few drops of water added to the emulsion are soluble in it, it is oil in water type and if immiscible, it is water in oil type.

☺ **Dye test:** If a small amount of oil soluble dye gives a uniform colour to the emulsion, it is water in oil type otherwise it is oil in water type.

☺ **Electrical conductivity test:** If conductivity of emulsion increases significantly by adding a very small amount of electrolyte, it is oil in water type and if there is no significant increase in conductivity, it is water in oil type.

Applications of emulsions

- Disinfectants like phenyl, dettol when mixed with water form emulsion.
- Digestion of fat in small intestine occurs easily due to emulsion.
- In metallurgical process the concentration of ore by froth flotation method is based upon emulsion.
- Milk is an emulsion of liquid fat in water in which casein emulsifying agent.

☺ Cleansing action of soap is due to formation of emulsions. Soaps and detergents emulsify the grease along with the adhering dirt and carry them away in the wash water.

Train Your Brain

Q. Which of the following is (are) lyophobic colloids?
(a) Gold sol   (b) As_2S_3 sol
(b) Starch sol   (d) $Fe(OH)_3$ sol

Ans. (a,b,d) Gold sol, As_2S_3 and $Fe(OH)_3$ are lyophobic colloid.
   Therefore, (a, b, d) are correct options.

Q. The presence of colloidal particles of dust in air imparts blue colour to the sky. This is due to
(a) Absorption of the light   (b) Scattering of the light
(c) Reflection of the light   (d) None of these

Ans. (b) Due to scattering of the light.
   Therefore, (b) is correct option.

APPLICATIONS OF COLLOIDS

Colloids including emulsions find a number of uses in our daily life and industry. Some of the uses are given below.

☺ **In medicines :** A wide variety of medicinal and pharmaceutical preparations are emulsions. Colloidial medicines are easily adsorbed by the body tissue because of large surface area.

--- *KEY NOTE* ---

- **Colloidal antimony** is used in curing **kalaazar.**
- **Milk of magnesia,** an emulsion, is used for **stomach disorder.**
- **Colloidal gold** is used for **intramuscular injection.**
- **Colloidal sulphur** are used as **Germicides.**
- **Argyrol** is a silver sol used as an **eye lotion.**
- **Colloidal $Fe(OH)_3$** is given to **arsenic poisoning** patients as it adsorbs arsenic and then gets omited out.

☺ **Tanning:** Animal hides are colloidal in nature. Which contain positive charge colloidal particles of protein. This hide is kept in a tank containing tannic acid, which contains negatively charge colloidal particle. Therefore, mutual coagulation takes place this results in hardening of leather, this process is termed as tanning of leather. Chromium salts are also used in place of tannic acid.

☺ **Photographic plate & Film:** Photographic plate or films are prepared by coating an emulsion of the light sensitive silver bromide in gelatin over glass plates or celluloid films. Gelatin prevent the coagulation of colloidal particle of AgBr.

☺ **Rubber plating:** The negatively charged rubber particles from rubber sol are deposited on wares and handles of different tools. Rubber gloves are formed by rubber plating on suitable templates.

☺ **Sewage disposal:** Sewage water contains charged colloidal particles of dirt, rubbish, etc., and these do not settle down easily. The particles can be removed by discharging them at electrodes. Dirty water is passed through a tunnel fitted with metallic electrodes which are maintained at high potential difference. The particles migrate to the oppositely charged electrode, lose their charge and get coagulated. The deposited matter is used as a manure and the water left behind is used for irrigation.

☺ **Formation of deltas:** The river water contains colloidal particles of sand and clay which carry negative charge. The sea water contains +ve ions such as Na^+, Mg^{2+}, Ca^{2+}, etc. As the river water meets sea water, these ions discharge the sand or clay particle which are precipitated in the form of delta.

☺ **Artificial rain:** Cloud consists of charge particle of water disperse in air. Rain is caused by aggregation of these minute particles, artificial rain can be done by throwing electrified sand or AgI from aeroplanes, colloidal H_2O particle present in cloud will get coagulated by these sand or AgI particles to form bigger water drops causing rain.

☺ **Stop bleeding from a cut:** Blood is a colloidal solution containing a –ve charge colloidal particle (Albuminoid), bleeding can be stopped by use of alum or $FeCl_3$ solution. The addition of Al^{3+} or Fe^{3+} causes coagulation of blood, so bleeding stops.

☺ **Preparation of nano-materials :** These materials are prepared for use as catalyst by using reverse micelles.

☺ **In disinfectants:** The disinfectants such as dettol and lysol give emulsions of the oil-in-water type when mixed with water.

☺ **In metallurgical operations:** Emulsions play an important role in industry. The metal ores are concentrated by froth-floatation process which involves the treatment of the pulverised ore in emulsion of pine oil.

☺ **Building roads:** Asphalt emulsified in water is used for building roads without the necessity of melting the asphalt.

Topic-wise Questions

Adsorption

1. Which of the following is a property of physisorption?
   a. High specificity   b. Irreversibility
   c. Non-specificity   d. Non of these

2. In Freundlich adsorption equation $x/m = kp^{1/n}$, the value of n is:
   a. Always greater than one
   b. Always smaller
   c. Always equal to one
   d. Greater than one at low temperature and smaller than one at high temperature

3. A graph is plotted between log (x/m) and log P according to the equation $\frac{x}{m} = KP^{1/n}$
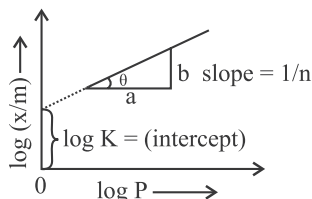
Which of the following statements about this graph is not correct?
   a. The figure shows Freundlich adsorption isotherm
   b. The figure shows Langmuir adsorption isotherm
   c. The adsorption varies directly with pressure
   d. The factor 1/n can have values between 0 and 1

4. Which of the following is less than zero during adsorption?
   a. ΔG b. ΔS
   c. ΔH d. All the above

5. Considering Freundlich adsorption isotherm, at low pressure, the fraction of the surface covered follows:
   a. Zero-order kinetics   b. First order kinetics
   c. Second order kinetics   d. Fractional order kinetics

6. Which of the following gases is least adsorbed on charcoal?
   a. HCl   b. NH_3
   c. O_2 d. CO_2

7. Chemisorption involves formation of bond between gaseous molecules or atoms and the solid surface for which energy is required, thus it is also referred as:
   a. Chemical adsorption   b. Positive adsorption
   c. Activated adsorption   d. Passive adsorption

8. If x is the amount of adsorbate and m is the amount of adsorbent, which of the following relations is not related to adsorption process?
   a. $\frac{x}{m} = P \times T$ b. $\frac{x}{m} = f(P)$ at constant T
   c. $\frac{x}{m} = f(T)$ at constant P   d. $P = f(T)$ at constant $P\left(\frac{x}{m}\right)$

9. Rate of physical adsorption increases with:
   a. Decrease in temperature
   b. Decrease in pressure
   c. Increase in temperature
   d. Decrease surface area

10. Which type of phenomenon is seen when coloured dye is removed from the solution of sugar by charcoal?
   a. Absorption   b. Adsorption
   c. Both (a) and (b)   d. None of the above

11. In adsorption of oxalic acid on activated charcoal, the activated charcoal is called:
   a. Adsorber   b. Adsorbate
   c. Adsorbent   d. Occlusion

Catalysis

12. Zeigler-Natta Catalyst is:
   a. $ZnCl_2$ b. $Et_3Al + TiCl_4$
   c. $Cu/ZnO\text{-}Cr_2O_3$ d. Pt

13. Shape selective catalysis is a reaction catalysed by:
   a. Acid or bases   b. Zeolite
   c. Platinum   d. Zeigler-Natta catalyst

14. The best condition for heterogeneous catalysis is:
   a. Adsorption   b. Absorption
   c. Diffusion   d. Occulsion

15. What is the role of a catalyst in a reaction?
   a. Lowers the activation energy
   b. Increase the activation energy
   c. Affects the free energy change
   d. Affects the enthalpy change

16. In which of these process, platinum is used as a catalyst?
   a. Oxidation of ammonia to form HNO_3
   b. Hardening of oils
   c. Production of synthetic rubber
   d. Synthesis of methanol

17. In ostwald process of manufacturing of HNO_3, catalyst used is:
   a. Mo   b. Fe
   c. Mn   d. Pt

18. A biological catalyst is:
   a. The N_2 molecule   b. An enzyme
   c. An amino acid   d. A carbohydrate

19. The conversion of maltose to glucose is possible by the enzyme:
   a. Zymase   b. Lactase
   c. Maltase   d. Diastase

20. Which type of metal form effective catalyst?
    a. Alkali metal
    b. Transition metal
    c. Alkaline earth metal
    d. Radioactive metal

21. Which kind of catalysis can be explained on the basis of adsorption theory?
    a. Homogeneous catalysis
    b. Heterogeneous catalysis
    c. Negative catalysis
    d. Auto catalysis

22. Which of the following can adsorb large volume of hydrogen gas?
    a. Finely divided platinum
    b. Colloidal solution of palladium
    c. Small pieces of palladium
    d. A single metal surface of platinum

23. The oxide of nitrogen which acts as a catalyst in lead chamber process is:
    a. NO
    b. NO_2
    c. N_2O_4
    d. N_2O_5

24. The activity of an enzyme becomes ineffective:
    a. At low temperature
    b. At atmospheric pressure
    c. At high temperature
    d. In aqueous medium

25. Which of the following is not correct for enzyme catalysis?
    a. The enzyme activity is maximum at optimum pH which is between 5-7
    b. Each enzyme is specific for a given reaction
    c. The favourable temperature range of enzyme activity between (50-60)°C
    d. The enzymatic activity is increased in presence of certain substance called co-enzymes

Colloids

26. The dispersed phase and dispersion medium in soap lather are respectively.
    a. Gas and liquid
    b. Liquid and gas
    c. Solid and gas
    d. Solid and liquid

27. Fog is a colloidal solution of
    a. Solid in gas
    b. Gas in gas
    c. Liquid in gas
    d. Gas in liquid

28. Stability of lyophilic colloids is due to
    a. Same charge on all the colloidal particles
    b. Solvation of the colloidal particles
    c. Both (a) and (b)
    d. The fact that they are organic substances

29. Among the following, surfactant that will form micelles in aqueous solution at the lowest molar concentration at ambient conditions is:
    a. $(CH_3)(CH_2)_{15}N^+(CH_3)_3\,Br^-$
    b. $CH_3(CH_2)_{11}\,OSO_3^-\,Na^+$
    c. $CH_3(CH_2)_6COO^-\,Na^+$
    d. $CH_3(CH_2)_{11}N^+(CH_3)_3Br^-$

30. When dilute aqueous solution of $AgNO_3$ (excess) is added to KI solution, positively charged sol of AgI is formed due to adsorption of
    a. NO_3^-
    b. O_2^-
    c. Ag^+
    d. K^+

Classification of Colloids

31. Which of the following will not form a colloidal system?
    a. Solid-gas
    b. Liquid gas
    c. Gas-gas
    d. Gas-liquid

32. Fog is an example of colloidal system of:
    a. Liquid in Gas
    b. Gas in liquid
    c. Solid in gas
    d. Gas in solid

33. The formation of micelles takes place only above:
    a. Critical temperature
    b. Kraft temperature
    c. Inversion temperature
    d. Absolute temperature

34. The substances which behave as colloidal solutions at higher concentration are called:
    a. Associated colloids
    b. Multimolecular colloids
    c. Macromolecular colloids
    d. Protective colloids

35. Movement of dispersion medium under the influence of electric field is known as:
    a. Electrodialysis
    b. Electrophoresis
    c. Electrosmosis
    d. Cataphoresis

36. Which of the following is not a method of removing impurities from a colloidal sol?
    a. Electrodialysis
    b. Ultrafiltration
    c. Ultra contrifugation
    d. Distillation

37. At CMC (Critical micelle concentration) the surface molecules:
    a. Dissociate
    b. Associate
    c. Become bigger in size due to adsorption
    d. Become smaller in size due to decomposition

38. White of an egg whipped with water acts as:
    a. Macromolecular colloid
    b. Associate colloid
    c. Molecular colloid
    d. Normal electrolytic solution

39. Tyndall effect is not observed in:
    a. Smoke
    b. Emulsions
    c. Sugar solution
    d. Gold sol

40. What happens when a lyophilic sol is added to a lyophobic sol?
    a. Lyophilic sol is protected from coagulation
    b. Lyophobic sol is protected from coagulation
    c. Both the sols are coagulated
    d. Electrophoresis takes place

41. Soap mixed with water below critical micelle concentration behaves as:
    a. Associated colloid
    b. Macromolecular colloid
    c. Normal electrolytic solution
    d. Multimolecular colloid

42. Which of the following is not a method for coagulation of lyophobic sols?
    a. By electrolysis
    b. By mixing oppositely charged sols
    c. By adding electrolyte
    d. By adding a protective colloid.

43. The size of colloidal particles lie between:
    a. $10^{-7} - 10^{-9}$ cm
    b. $10^{-9} - 10^{11}$ cm
    c. $10^{-5} - 10^{-7}$ cm
    d. $10^{-2} - 10^{-3}$ cm

44. Butter is a colloidal solution of:
    a. Solid – solid   b. Liquid – solid
    c. Solid – liquid   d. Gas – solid

45. Which of the following property of colloids is not dependent on the charge of colloidal particles?
    a. Coagulation   b. Electrophoresis
    c. Electroosmosis   d. Tyndall effect

46. The colloid is:
    a. Urea   b. Blood
    c. Cane sugar   d. NaCl

47. Gold Sol is not:
    a. A macromolecular colloid
    b. Lyophobic colloid
    c. A multimolecular colloid
    d. Negatively charge colloid

48. Which substance is not used for preparing lyophilic sols?
    a. Starch   b. Gum
    c. Gelatin   d. Metal sulphide

49. Milk is a kind of:
    a. Sol   b. Gel
    c. Emulsion   d. Mixture

50. The simple way to check whether a system is colloidal is:
    a. Electrodialysis
    b. Finding out particle size
    c. Tyndall effect
    d. Brownian movement

51. Which one of the following is correctly matched?
    a. Emulsion - smoke   b. Gel - butter
    c. Aerosol - hair cream d. Sol - whipped cream

52. Example of intrinsic colloid is:
    a. Glue   b. Sulphu
    c. Fe   d. As_2S_3

53. The colour of sky is due to:
    a. Transmission of light
    b. Wavelength of scattered light
    c. Absorption of light by atmospheric gases
    d. All the above

54. Which has least gold number?
    a. Gelatin   b. Starch
    c. Albumin   d. Blood

55. The physical states of dispersed phase and dispersion medium in colloid like pesticide and spray, respectively are:
    a. Gas, liquid   b. Solid, gas
    c. Liquid, solid   d. Liquid, gas

56. Which of the following metal sols cannot be prepared by Bredig's arc methed?
    a. Copper   b. Potassium
    c. Gold   d. Platinum

57. The phenomenon observed when a beam of light is passed through a colloidal solution is:
    a. Cataphoresis   b. Electrophoresis
    c. Coagulation   d. Tyndall effect

58. The presence of electric charge on colloidal particles is indicated by the property called-
    a. Dialysis   b. Solubility
    c. Electrophoresis   d. Osmosis

59. The greater the charge on an ion, the greater its coagulating power, is a statement of:
    a. Tyndall effect   b. Faraday's law
    c. Mosley's law   d. Hardy - schulze rule

60. When a sulphur sol is evaporated, sulphur is obtained On mixing with water, sulphur sol is not formed The sol is:
    a. Lyophilic   b. Reversible
    c. Hydrophobic   d. Hydrophilic

Colloids Around Us

61. Which of the following is application of adsorption in chemical analysis?
    a. Adsorption indicators
    b. Thin layer chromatography
    c. Qualitative Analysis
    d. All of above

62. Which of the following process is responsible for the formation of delta at a place where rivers meet the sea?
    a. Emulsification   b. Colloid formation
    c. Coagulation   d. Peptisation

63. What is the role of adsorption in froth floatation process used especially for concentration of sulphide ores?
    a. Shape selective catalysts
    b. Adsorption of pine oil on sulphide are particles
    c. Adsorption of pine oil on Impurities
    d. Production of heat in the process of exothermic reaction

64. At high concentration of soap in water, soap behaves as:

  a. Molecular colloid

  b. Associate colloid

  c. Macromolecular colloid

  d. Lyophilic colloid

65. Muddy water can be purified through coagulation using:

  a. Common salt   b. Alums

  c. Sand   d. Lime

66. Blue colour of water in sea is due to:

  a. Refraction of blue light by impurities

  b. Refraction of blue sky by water

  c. Scattering of light by water

  d. None of above

67. Hair cream is an example of:

  a. Gel   b. Sol

  c. Aerosol   d. Emulsion

68. Which of the following forms cationic micelles above certain concentration?

  a. Sodium ethyl sulphate

  b. Sodium acetate

  c. Urea

  d. Ethyl trimethyl ammonium bromide

69. During preparation of ice-cream gelatin is added in ice-creams. What could be the role of gelatin in the process?

  a. Ice-creams are emulsions which get stabilised by gelatin which acts as an emulsifying agent

  b. Gelatin is added to the ice-creams to make it sweet

  c. Gelatin acts as coagulating agent and helps the ice-cream to become solid

  d. Gelatin is adsorbed on milk particles which are later converted to solids

70. Milk can be preserved by adding a few drops of:

  a. Acetaldehyde solution   b. Formaldehyde solution

  c. Sodium carbonate solution   d. Acetic acid solution

NCERT Based Questions

1. Which of the following process does not occur at the interface of phases?
   a. Crystallisation
   b. Heterogeneous catalysis
   c. Homogeneous catalysis
   d. Corrosion

2. At the equilibrium position in the process of adsorption:
   a. $\Delta H > 0$
   b. $\Delta H = T\Delta S$
   c. $\Delta H > T\Delta S$
   d. $\Delta H < T\Delta S$

3. Which interface cannot be obtained?
   a. Liquid-liquid
   b. Solid-liquid
   c. Liquid-gas
   d. Gas-gas

4. The term 'sorption' stands for:
   a. Absorption
   b. Adsorption
   c. Both absorption and adsorption
   d. Desorption

5. Extent of physisorption of a gas increases with:
   a. Increase in temperature
   b. Decrease in temperature
   c. Decrease in surface area of adsorbent
   d. Decrease in strength of van der Waals' forces

6. Extent of adsorption of adsorbate from solution phase increases with:
   a. Increase in amount of adsorbate in solution
   b. Decrease in surface area of adsorb
   c. Increase in temperature of solution
   d. Decrease in amount of adsorbate in solution

7. Which one of the following is not applicable to the phenomenon of adsorption?
   a. $\Delta H > 0$
   b. $\Delta G < 0$
   c. $\Delta S < 0$
   d. $\Delta H < 0$

8. Which of the following is not a favourable condition for physical adsorption?
   a. High pressure
   b. Negative ΔH
   c. Higher critical temperature of adsorbate
   d. High temperature

9. Physical adsorption of a gaseous species may change to chemical absorption with:
   a. Decrease in temperature
   b. Increase in temperature
   c. Increase in surface area of adsorbent
   d. Decrease in surface area of a adsorbent

10. In physisorption adsorbent does not show specificity for any particular gas because:
    a. Involved Van der Waals' forces are universal
    b. Gases involved behave like ideal gases
    c. Enthalpy of absorption is low
    d. I t is reversible process

11. Which of the following is an example of absorption?
    a. Water on silica gel
    b. Water on calcium chloride
    c. Hydrogen on finely divided nickel
    d. Oxygen on metal surface

12. On the basis of data given below predict which of the following gases shows least adsorption on a definite amount of charcoal?

Gas	CO_2	SO_2	CH_4	H_2
Critical temperature/K	304	630	190	33

   a. CO_2
   b. SO_2
   c. CH_4
   d. H_2

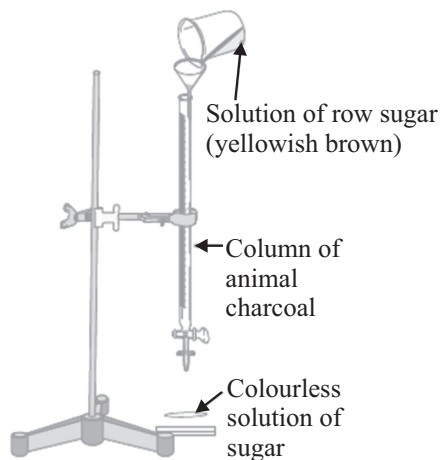13. At high concentration of soap in water, soap behaves as:
    a. Molecular colloid
    b. Associated colloid
    c. Macromolecular colloid
    d. Lyophilic colloid

14. Which of the following will show Tyndall effect?
    a. Aqueous solution of soap below critical micelle concentration
    b Aqueous solution of soap above critical micelle concentration
    c Aqueous solution of sodium chloride
    d Aqueous solution of sugar

15. Method by which lyophobic sol can be protected:
    a. By addition of oppositely charged sol
    b. By addition of an electrolyte
    c. By addition of lyophilic sol
    d. By boiling

16. Freshly prepared precipitate sometimes gets converted to colloidal solution by:
    a. Coagulation
    b. Electrolysis
    c. Diffusion
    d. Peptisation

17. Which of the following electrolytes will have maximum coagulating value for Ag/Ag^+ sol?
    a. Na_2S
    b. Na_3PO_4
    c. Na_2SO_4
    d. NaCl

18. A colloidal system having a solid substance as a dispersed phase and a liquid as a dispersion medium is classified as:
    a. Solid sol
    b. Gel
    c. Emulsion
    d. Sol

19. The values of colligative properties of colloidal solution are of small order in comparison to those shown by true solutions of same concentration because of colloidal particles:
a. Exhibit enormous surface area
b. Remain suspended in the dispersion medium
c. Form lyophilic colloids
d. Are comparatively less in number

20. Which of the following process is responsible for the formation of delta at a place where rivers meet the sea?
a. Emulsification   b Colloid formation
c Coagulation   d Peptisation

21. Which of the following curves is in according with Freundlich adsorption isotherm?
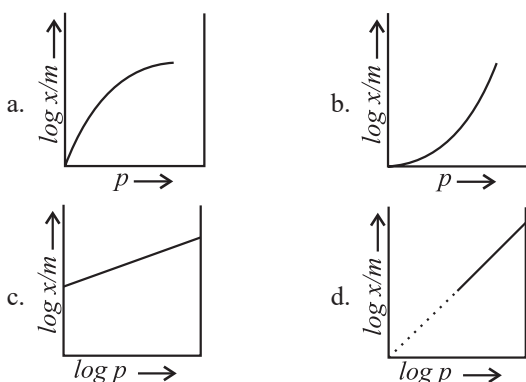
22. Which of the following process is not responsible for the presence of electric charge on the sol particles?
a. Electron capture by sol particles
b. Adsorption of ionic species from solution
c. Formation of Helmholtz electrical double layer
d. Absorption of ionic species from solution

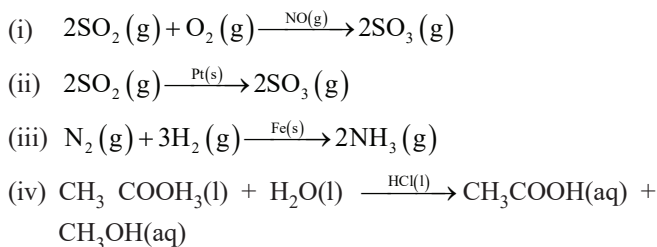**23.** Which of the following phenomenon is applicable to the process shown in the figure?

Solution of row sugar (yellowish brown)

Column of animal charcoal

Colourless solution of sugar

a. Absorption   b. Adsorption
c. Coagulation   d. Emulsification

24. H_2 gas is adsorbed on activated charcoal to a very little extent in comparison to easily liquefiable gases due to:
a. Very strong van der Waals' interaction
b. Very weak van der Waals' forces
c. Very low critical temperature
d. Very high critical temperature

25. An emulsion cannot be broken by:
a. Heating
b. Adding more amount of dispersion medium
c. Freezing
d. Adding emulsifying agent

26. Which of the following substances will precipitate the negative charged emulsions?
a. KCl   b. Glucose
c. Urea   d. NaCl

27. Which of the following colloids cannot be coagulated easily?
a. Lyophobic colloids
b. Irreversible colloids
c. Reversible colloids
d. Lyophilic colloids

28. What happens when a Lyophilic sol is added to a Lyophobic sol?
a. Lyophobic sol is protected
b. Lyophilic sol is protected
c. Film of lyophilic sol is formed over lyophobic sol
d. Film of lyophobic sol is formed over lyophilic sol

29. Which phenomenon occurs when an electric field is colloidal solution and electrophoresis is prevented?
a. Reverse osmosis takes place
b. Electroosmosis takes place
c. Dispersion medium begins to move
d. Dispersion medium becomes stationary

30. In a reaction, catalyst changes:
a. Physically   b. Qualitatively
c. Chemically   d. Quantitatively

31. Which of the following phenomenon occurs when a chalk stick is dipped in ink?
a. Adsorption of coloured substance
b. Adsorption of solvent
c. Absorption and adsorption both of solvent
d. Absorption of solvent

Multi-Concept Questions

1. In which of the following reactions heterogeneous catalysis is involved?

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

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

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

   (iv) $CH_3COOH_3(l) + H_2O(l) \xrightarrow{HCl(l)} CH_3COOH(aq) + CH_3OH(aq)$

   a. (ii), (iii)
   b. (ii), (iii) and (iv)
   c. (i), (ii) and (iii)
   d. (iv)

2. Arrange the following diagrams in correct sequence of steps involved in the mechanism of catalysis, in accordance with modern adsorption theory:
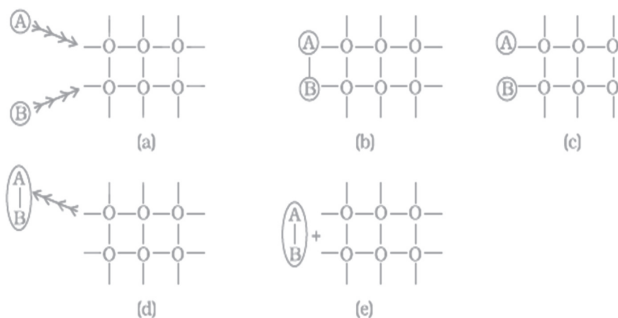
   a. $a \to b \to c \to d \to e$
   b. $a \to c \to b \to d \to e$
   c. $a \to c \to b \to e \to d$
   d. $a \to b \to c \to e \to d$

3. Which of the following options are correct?

   a. Micelle formation by soap in aqueous solution is possible at all temperatures
   b. Micelle formation by soap in aqueous solution occurs above a particular concentration
   c. On dilution of soap solution micelles may revert to individual ions
   d. Soap solution behaves as a normal strong electrolyte at all concentrations

4. Which of the following statements are correct?

   a. Mixing two oppositely charged sols neutralises their charges and stabilizes the colloid
   b. Presence of equal and similar charges on colloidal particles provides stability to the colloids
   c. Any amount of dispersed liquid can be added to emulsion without destabilizing
   d. Brownian movement stabilises sols

5. The ratio of number of moles of $AgNO_3$, $Pb(NO_3)_2$ and $Fe(NO_3)_3$ required for the coagulation of definite amount of colloidal sol of silver iodide prepared by mixing $AgNO_3$ with excess of KI will be:

   a. 1 : 2 : 3
   b. 3 : 2 : 1
   c. 6 : 3 : 2
   d. 2 : 3 : 6

6. For a gas adsorbed on a particular surface (adsorbent) at 0°C, the plot of $\log \dfrac{x}{m}$ v/s log P where P is in atm has a slope and intercept as shown–
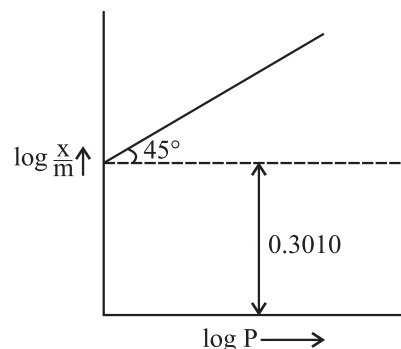
   Calculate the mass of gas adsorbed by 10 gm of adsorbent at 0.2 atm:

   a. 2 g
   b. 4 g
   c. 8 g
   d. 6 g

7. Select correct statements about macromolecular colloids.

   a. Multimolecular or macromolecular colloids consist of aggregate of atoms or small molecules with diameter less than 1 nm.
   b. Molecules are held together by van der Waals forces.
   c. Most lyophilic sols belong to this class.
   d. All are correct

8. The correct characteristics of lyophilic and lyophobic colloids are

   a. Lyophilic sols are highly hydrated while lyophobic sols are not
   b. Lyophilic sols have lower surface tension and viscosity than that of the dispersion medium
   c. Lyophobic sols can be easily coagulated but lyophilic sols are not
   d. Both are (a) and (c)

9. Among the electrolytes Na_2SO_4, $CaCl_2$, $Al_2(SO_4)_3$ and NH_4Cl, the most effective coagulating agent for Sb_2S_3 sol is

   a. Na_2SO_4
   b. $CaCl_2$
   c. $Al_2(SO_4)_3$
   d. NH_4Cl

10. On addition of one mL solution of 10% NaCl to 10 mL gold sol in the presence of 0.0250 g of starch, the coagulation is just prevented starch has the following gold number:

    a. 0.025
    b. 0.25
    c. 2.5
    d. 25

11. Gold number of gum arabic is 0.15. The amount of gum arabic required to protect 100 mL of red gold sol from coagulation by 10 mL of 10% NaCl solution is

a, 0.15 millimoles   b. 0.15 mg

c. 1.5 millimoles   d. 1.5 mg

12. The coagulation values in millimoles per litre of the electrolytes used for the coagulation of As_2O_3 are given below:

(I) (NaCl) = 52, (II) $(BaCl_2)$ = 0.69, (III) $(MgSO_4)$ = 0.22

The correct order of their coagulating power is:

a. III > II > I   b. III > I > II

c. I > II > III   d. II > I > III

13. The formation of micelles (Associated colloids) takes place

a. Above CMC and at kraft temperature

b. At CMC and above kraft temperature

c. At CMC and at kraft temperature

d. Above CMC and above kraft temperature

14. Which of the following is an example of positively charged sols?

a. As_2S_3

b. Gold sol

c. Congo red sol

d. Haemoglobin

15. 50 ml of 1M oxalic acid is shaken with 0.5g of wood charcoal. The final concentration of the solution after adsorption is 0.5M. What is the amount of oxalic acid adsorbed per gram of charcoal.

a. 3.15 g   b. 3.45 g

c. 4.5 gm   d. 5.20 g

16. For Freundlich isotherm, a graph of log x/m is plotted against log P, the slope of the line and its y-axis intercept, respectively corresponds to:

a. $\dfrac{1}{n}, K$

b. $\log\dfrac{1}{n}, K$

c. $\log\dfrac{1}{n}, \log K$

d. $\dfrac{1}{n}, \log K$

17. Which type of graph gives straight line in langmuir adsorption isotherm?

a. $\dfrac{x}{m} \to \dfrac{1}{P}$

b. $\dfrac{m}{x} \to \dfrac{1}{P}$

c. $\log_{10}\dfrac{x}{m} \to \dfrac{1}{P}$

d. $\log_{10}\dfrac{x}{m} \to P$

18. Which of the following adsorption isotherms shows the adsorption of a gas by a solid involving multi-adsorption layer? (P_s denotes saturation pressure)
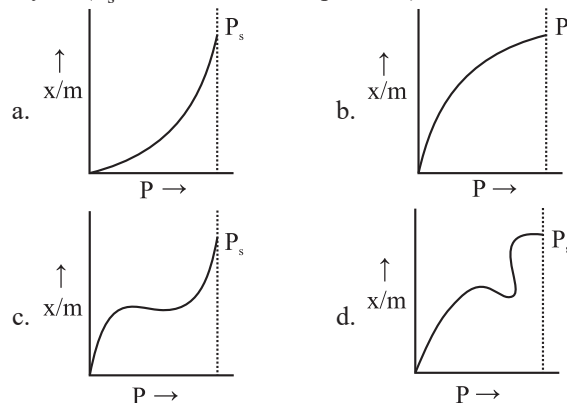
19. The given graph/data, I, II, III and IV represent general trends observed for different physisorption and chemisorption processes under mild conditions of temperature and pressure. Which of the following choice(s) about I, II, III and IV is (are) correct?
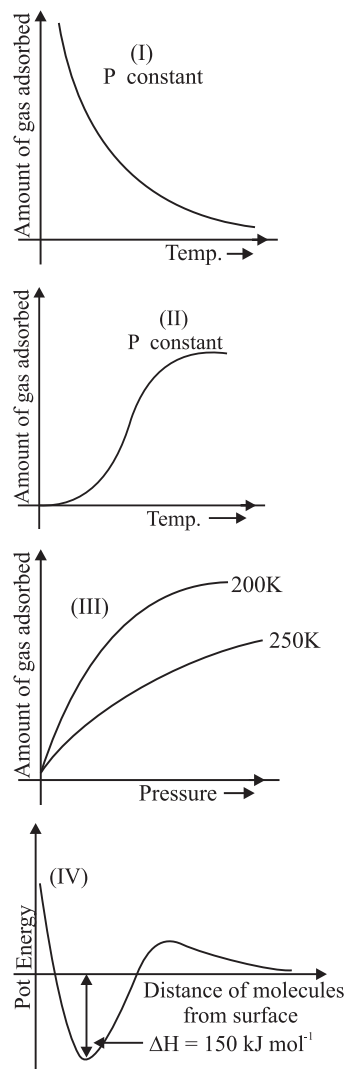
a. I is physiorption and II is chemisorption

b. I is physiorption & III is chemisorption

c. IV is chemisorption and II is chemisorption

d. IV is chemisorption and III is chemisorption

20. A colloidal solution of AgI is prepared by two different methods as shows in the figure below

AgNO₃   KI

→KI   →AgNO₃

(A)   (B)
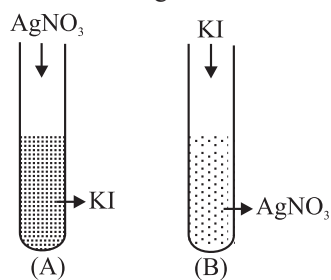
a. What is the charge of AgI colloidal particles in the two test tubes (A) and (B)?

a. –ve & +ve   b. +ve & -ve

c. –ve & –ve   d. + ve & +ve

21. Identify the method of preparation of the colloids which is shown in the given figure

Electrodes

Dispersion medium

Ice   Ice

Ice
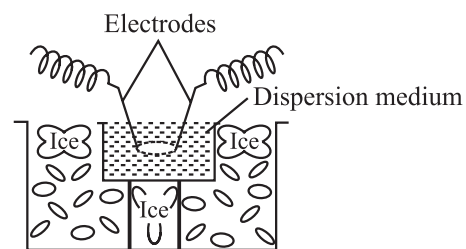
a. Chemical method

b. Peptisation

c. Bredig's arc method

d. Al of these

1. Measuring Zeta potential is useful in determining which property of colloidal solution? (2020)
   a. Solubility
   b. Stability of the colloidal particles
   c. Size of the colloidal particles
   d. Viscosity

2. In which of the sols, the colloidal particles are with negative charge? (2020 Covid Re-NEET)
   a. Haemoglobin
   b. Starch
   c. Hydrated Al_2O_3
   d. TiO_2

3. Which mixture of the solutions will lead to the formation of negatively charged colloidal $[AgI]I^-$ sol? (2019)
   a. 50 mL of 1 M $AgNO_3$ + 50 mL of 1.5 M KI
   b. 50 mL of 1 M $AgNO_3$ + 50 mL of 2 M KI
   c. 50 mL of 2 M $AgNO_3$ + 50 mL of 1.5 M KI
   d. 50 mL of 0.1 M $AgNO_3$ + 50 mL of 0.1 M KI

4. On which of the following properties does the coagulating power of an ion depend? (2018)
   a. The magnitude of the charge on the ion alone
   b. Size of the ion alone
   c. The sign of charge on the ion alone
   d. Both magnitude and sign of the charge on the ion

5. Which of the following statements is incorrect? (2017-Gujarat)
   a. Lyophilic sols are more stable than lyophobic sols
   b. In coagulation of a negative sol, flocculating power is in the order of Al^{3+}, Ba^{2+}, Na^+
   c. In the flocculation of a positive sol, flocculating power is in the order,

   $Cl^- > SO_4^{2-} > PO_4^{3-} > [Fe(CN)_6]^{4-}$

   d. Lyophilic colloids have greater affinity for solvents

6. The coagulation values in millimoles per litre of the electrolytes used for the coagulation of As_2S_3 are given below:
   I. (NaCl) = 52
   II. ($BaCl_2$) = 0.69
   III. ($MgSO_4$) = 0.22
   The correct order of their coagulating power is: (2016-II)
   a. I > II > III
   b. II > I > III
   c. III > II > I
   d. III > I > II

7. Fog is a Colloidal solution of: (2016 - I)
   a. Gas in gas
   b. Liquid in gas
   c. Gas in liquid
   d. Solid in gas

8. Which one of the following characteristics is associated with adsorption? (2016 - I)
   a. ΔG and ΔS are negative but ΔH is positive
   b. ΔG is negative but ΔH and ΔS are positive
   c. ΔG, ΔH and ΔS all are negative
   d. ΔG and ΔH are negative but ΔS is positive

9. Which property of colloidal solution is independent of charge on the colloidal particles? (2015, 2014)
   a. Electrophoresis
   b. Electro-osmosis
   c. Tyndall effect
   d. Coagulation

10. Which of the following statements is correct for the spontaneous adsorption of a gas? (2014)
    a. ΔS is negative and therefore, ΔH should be highly negative
    b. ΔS is positive and, therefore, ΔH should be negative
    c. ΔS is positive and, therefore, ΔH should also be highly positive
    d. ΔS is negative and, therefore, ΔH should be highly positive

11. Which one of the following statements is incorrect about enzyme catalysis? (2012 Pre)
    a. Enzymes are least reactive at optimum temperature
    b. Enzymes are mostly proteinaceous in nature
    c. Enzyme action is specific
    d. Enzymes are desaturated by ultraviolet rays and at high temperature

12. The protecting power of lyophilic colloidal sol is expressed in terms of: (2012 Pre)
    a. Oxidation number
    b. Coagulation value
    c. Gold number
    d. Critical micelles concentration

13. In Freundlich adsorption isotherm, the value of $1/n$ is: (2012 Pre)
    a. 1 in case of chemisorption
    b. Between 0 and 1 in all cases
    c. Between 2 and 4 in all cases
    d. 1 in case of physical adsorption

14. If x is amount of adsorbate and m is amount of adsorbent, which of the following relations is not related to adsorption process? (2011 Pre)
    a. $\dfrac{x}{m} = p \times T$

    b. $\dfrac{x}{m} = f(p)$, at constant T

    c. $\dfrac{x}{m} = f(T)$, at constant p

    d. $p = f(T)$, at constant $\left(\dfrac{x}{m}\right)$

Answer Key

Topic-wise Questions

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
c	a	b	d	b	c	c	a	a	b	c	b	b	a	a	a	d	b

19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
c	b	b	b	a	c	c	a	c	c	a	c	c	a	b	a	c	d

37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
b	a	c	b	c	d	c	b	d	b	a	d	c	c	b	a	b	a

55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70
d	b	d	c	d	c	d	c	b	b	b	c	d	b	a	b

NCERT Based Questions

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
c	b	d	c	b	a	a	d	b	a	b	d	b	b	c	d	d	d

19	20	21	22	23	24	25	26	27	28	29	30	31
d	c	c	d	b	b,c	b,d	a,d	c,d	a,c	b, c	a,b	a,d

Multi-Concept Questions

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
a	b	b,c	b,d	c	b	d	d	c	d	d	a	d	d	c	d	b	b

19	20	21
a	a	c

NEET Past 10 Year Questions

1	2	3	4	5	6	7	8	9	10	11	12	13	14
b	b	b	d	c	c	b	c	c	a	a	c	b	a