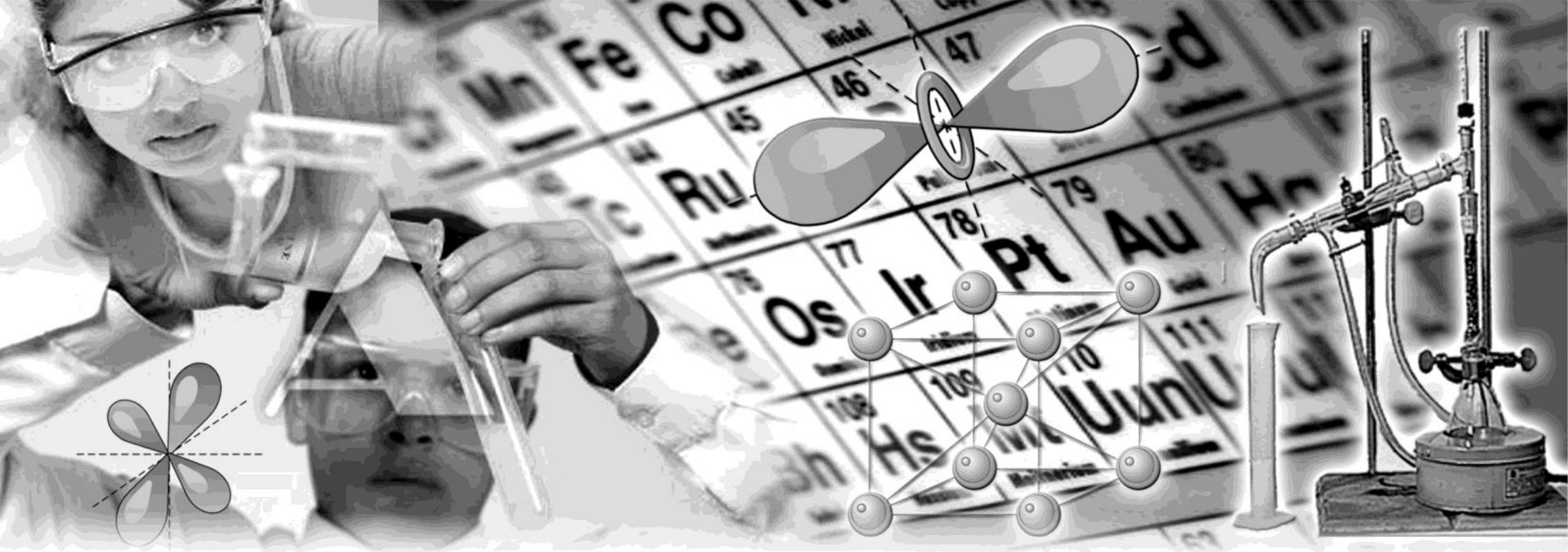


Chapter
14
Surface Chemistry

"The branch of physical chemistry, which deals the nature of surfaces and also with the chemical and physical processes which takes place on the surfaces, is called surface chemistry".

In surface chemistry, we study the phenomenon of adsorption, catalysis and colloidal properties.

Adsorption

(1) **Definition :** The phenomenon of attracting and retaining the molecules of a substance on the surface of a liquid or solid resulting in to higher concentration of the molecules on the surface is called ***adsorption***.

(2) **Causes of adsorption :** Unbalanced forces of attraction or free valencies which is present at the solid or liquid surface, have the property to attract and retain the molecules of a gas or a dissolved substance on to their surfaces with which they come in contact.

Example : Ammonia gas placed in contact with charcoal gets adsorbed on the charcoal whereas ammonia gas placed in contact with water gets absorbed into water,

Table : 14.1 Some basic terms used in adsorption

Interface : Any surface is a plane which separates any two phases in contact with each other. The plane which separates any two phase is generally called an **interface** between the two phases.	**Adsorbate and Adsorbent :** The substance which gets adsorbed on any surface is called **adsorbate** for example, if a gas gets adsorbed on to the surface of a solid, then the gas is termed as the adsorbate. The substance on the surface of which adsorption takes place is called **adsorbent**.
Desorption : The removal of the adsorbed substance from a surface is called **desorption**.	**Absorption :** When the molecules of a substance are uniformly distributed throughout the body of a solid or liquid. This phenomenon is called **absorption**.
Sorption : The phenomenon in which adsorption and absorption occur simultaneously is called **sorption**. **Mc. Bain** introduced a general term sorption describeing both the processes, however adsorption is instantaneous *i.e.* a fast process while absorption is a slow process.	**Occlusion :** When adsorption of gases occur on the surface of metals this is called **occlusion**.

(3) **Difference between adsorption and absorption**

Adsorption	Absorption
It is a surface phenomenon.	It concerns with the whole mass of the absorbent.

In it, the substance is only retained on the surface and does not go into the bulk or interior of the solid or liquid.	It implies that a substance is uniformly distributed, through the body of the solid or liquid.
In it the concentration of the adsorbed molecules is always greater at the free phase.	In it the concentration is low.
It is rapid in the beginning and slows down near the equilibrium.	It occurs at the uniform rate.
Examples : (i) Water vapours adsorbed by silica gel. (ii) NH_3 is adsorbed by charcoal.	*Examples :* (i) Water vapours absorbed by anhydrous $CaCl_2$ (ii) NH_3 is absorbed in water forming NH_4OH

(4) **Surface forces :** Only the surface atoms of an adsorbent play an active role in adsorption. These atoms posses unbalanced forces of various types such as, Vander Waal's forces and chemical bond forces.

Thus***, the residual force-field on a free surface which is responsible for adsorption is produced***. For example, when a solid substance is broken into two pieces, two new surfaces are formed and therefore, the number of unbalanced forces becomes more. As a result the tendency for adsorption become large.

(5) **Reversible and Irreversible adsorption :** The adsorption is reversible, if the adsorbate can be easily removed from the surface of the adsorbent by physical methods.If the adsorbate can not be easily removed from the surface of the adsorbent is called irreversible adsorption.

Example for reversible adsorption: A gas adsorbed on a solid surface can be completely removed in vacuum.

Example for irreversible adsorption: Adsorption of O_2 on tungsten adsorbent.

(6) **Characteristics of adsorption**

(i) Adsorption refers to the existence of a higher concentration of any particular component at the surface of a liquid or a solid phase.

(ii) Adsorption is accompanied by decrease in the ΔG (free energy change) of the system when $\Delta G = 0$, ***adsorption equilibrium is said to be established.***

(iii) Adsorption is invariably accompanied by evolution of heat, *i.e.* it is an exothermic process. In other words, ***ΔH of adsorption is always negative.***

(iv) When a gas is adsorbed, the freedom of movement of its molecules becomes restricted. On account of it decrease in the entropy of the gas after adsorption, *i.e.* ***ΔS is negative.***

(v) For a process to be spontaneous, the thermodynamic requirement is that ΔG ***must be negative***, *i.e.* there is decrease in free energy. On the basis of ***Gibb's Helmholtz equation***, $\Delta G = \Delta H - T\Delta S$, ΔG can be negative if ΔH has sufficiently high negative value and $T\Delta S$ ***has positive value.***

Classification of adsorption

Adsorption can be classified into two categories as described below,

(1) **Depending upon the concentration :** In adsorption the concentration of one substance is different at the surface of the other substance as compared to adjoining bulk or interior phase.

(i) ***Positive adsorption*** **:** If the concentration of adsorbate is more on the surface as compared to its concentration in the bulk phase then it is called ***positive adsorption***.

Example : When a *concentrated* solution of KCl is shaken with blood charcoal, it shows positive adsorption.

(ii) ***Negative adsorption*** **:** If the concentration of the adsorbate is less than its concentration in the bulk then it is called ***negative adsorption***.

Example : When a *dilute* solution of KCl is shaken with blood charcoal, it shows negative adsorption.

(2) **Depending upon the nature of force existing between adsorbate molecule and adsorbent**

(i) ***Physical adsorption*** **:** If the forces of attraction existing between adsorbate and adsorbent are Vander Waal's forces, the adsorption is called physical adsorption. This type of adsorption is also known as ***physisorption or Vander Waal's adsorption.*** It can be easily reversed by heating or decreasing the pressure.

(ii) ***Chemical adsorption*** **:** If the forces of attraction existing between adsorbate particles and adsorbent are almost of the same strength as chemical bonds, the adsorption is called chemical adsorption. This type of adsorption is also called as ***chemisorption or Langmuir adsorption.*** This type of adsorption cannot be easily reversed.

Comparison between physisorption and chemisorption

Physisorption (Vander Waal's adsorption)	**Chemisorption** (Langmuir adsorption)
Low heat of adsorption usually in range of 20-40 *kJ/mol*	High heat of adsorption in the range of 50-400 *kJ/mol*
Force of attraction are ***Vander Waal's forces***.	Forces of attraction are ***chemical bond forces.***
It is reversible	It is irreversible

It is usually takes place at ***low temperature*** and decreases with increasing temperature.	It takes place at ***high temperature***.
It is related to the case of liquefication of the gas.	It is not related.
It forms ***multimolecular layers***.	It forms ***monomolecular layers***.
It does not require any activation energy.	It requires high *activation energy*.
High pressure is favourable. Decrease of pressure causes ***desorption***	High pressure is favourable. Decrease of pressure does not cause desorption.
It is not very specific.	It is highly specific.

Factors which affect the extent of adsorption **:** The following are the factors which affect the adsorption,

(1) **Nature of the adsorbate** (gas) **and adsorbent** (solid)

(i) In general, easily liquefiable gases e.g., CO_2, NH_3, Cl_2 and SO_2 etc. are adsorbed to a greater extent than the elemental gases e.g. H_2, O_2, N_2, *He* etc. (while chemisorption is specific in nature.)

(ii) Porous and finely powdered solid e.g. charcoal, fullers earth, adsorb more as compared to the hard non-porous materials. Due to this property powdered charcoal is used in gas masks.

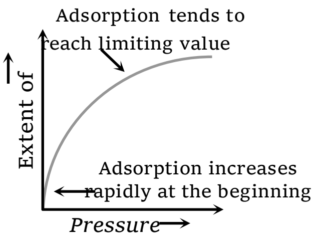
(2) **Surface area of the solid adsorbent**

(i) The extent of adsorption depends directly upon the surface area of the adsorbent, *i.e. larger the surface area of the adsorbent, greater is the extent of adsorption.*

(ii) Surface area of a powdered solid adsorbent depends upon its particle size. Smaller the particle size, greater is its surface area.

(3) **Effect of pressure on the adsorbate gas**

(i) An increase in the pressure of the adsorbate gas increases the extent of adsorption.



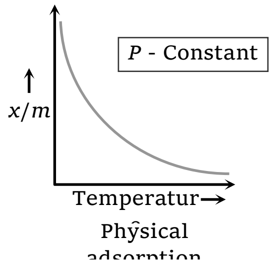
(ii) *At low temperature,* the extent of adsorption increases rapidly with pressure.

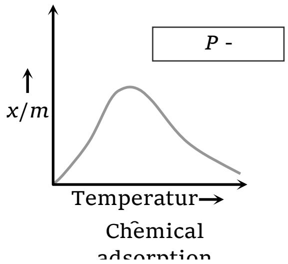
(iii) *Small range of pressure,* the extent of adsorption is found to be directly proportional to the pressure.

(iv) *At high pressure* (closer to the saturation vapour pressure of the gas), the adsorption tends to achieve a limiting value.

(4) **Effect of temperature**

(i) As adsorption is accompanied by evolution of heat, so according to the ***Le-Chatelier's principle***, the magnitude of adsorption should decrease with rise in temperature.





(ii) The relationship between the extent of adsorption and temperature at any constant pressure is called ***adsorption isobar.***

(iii) A physical adsorption isobar shows a decrease in x/m (where 'm' is the mass of the adsorbent and 'x' that of adsorbate) as the temperature rises.

(iv) The isobar of chemisorption show an increase in the beginning and then decrease as the temperature rises.

Adsorption isotherms

A mathematical equation, which describes the relationship between pressure (p) of the gaseous adsorbate and the extent of adsorption at any fixed temperature, is called ***adsorption isotherms***.

The extent of adsorption is expressed as mass of the adsorbate adsorbed on one unit mass of the adsorbent.

Thus, if *x g* of an adsorbate is adsorbed on *m g* of the adsorbent, then

$$\text{Extent of adsorption} = \frac{x}{m}$$

Various adsorption isotherms are commonly employed in describing the adsorption data.

(1) **Freundlich adsorption isotherm**

(i) Freundlich adsorption isotherm is obeyed by the adsorptions where the adsorbate forms a ***monomolecular*** *layer* on the surface of the adsorbent.

$\frac{x}{m} = kp^{\frac{1}{n}}$ (Freundlich adsorption isotherm) or

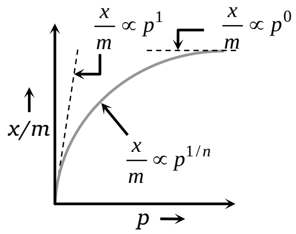
$$\log \frac{x}{m} = \log k + \frac{1}{n} \log p$$

where x is the weight of the gas adsorbed by m *gm* of the adsorbent at a pressure p, thus x/m represents the amount of gas adsorbed by the adsorbents per *gm* (unit mass), k and n are constant at a particular temperature and for a particular adsorbent and adsorbate (gas), n is always greater than one, indicating ***that the amount of the gas adsorbed does not increase as rapidly as the pressure.***

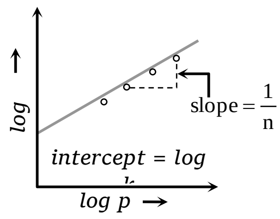
(ii) At *low pressure*, the extent of adsorption varies linearly with pressure. $\frac{x}{m} \propto p'$

(iii) At *high pressure*, it becomes independent of pressure. $\frac{x}{m} \propto p^0$

(iv) At *moderate pressure* $\frac{x}{m}$ depends upon pressure raised to powers $\frac{x}{m} \propto p^{\frac{1}{n}}$



Freundlich adsorption isotherm: plot of x/m



Plot of log x/m against log p for the adsorption of a gas on a solid

(2) **The Langmuir - adsorption isotherms**

(i) One of the drawbacks of Freundlich adsorption isotherm is that it fails at high pressure of the gas. ***Irving Langmuir in* 1916** derived a simple adsorption isotherm, on theoretical considerations based on ***kinetic theory of gases.*** This is named as ***Langmuir adsorption isotherm.***

(a) Adsorption takes place on the surface of the solid only till the whole of the surface is completely covered with a unimolecular layer of the adsorbed gas.

(b) Adsorption consists of two opposing processes, namely ***Condensation*** of the gas molecules on the solid surface and ***Evaporation*** (desorption) of the gas molecules from the surface back into the gaseous phase.

(c) The rate of condensation depends upon the uncovered (bare) surface of the adsorbent available for condensation. Naturally, at start when whole of the surface is uncovered the rate of condensation is very high and as the surface is covered more and more, the rate of condensation progressively decreases. On the contrary, the rate of evaporation depends upon the covered surface and hence increases as more and more of the surface is covered ultimately an equilibrium will be set up at a stage when the rate of condensation becomes equal to the rate of evaporation (adsorption equilibrium).

(d) The rate of condensation also depends upon the pressure of the gas since according the kinetic theory of gases, ***the number of molecules striking per unit area is proportional to the pressure.***

Mathematically, $\frac{x}{m} = \frac{ap}{1+bp}$, where *a* and *b* are constants and their value depends upon the nature of gas (adsorbate), nature of the solid adsorbent and the temperature. Their values can be determined from the experimental data.

Limitation of Langmuir theory

(a) Langmuir's theory of unimolecular adsorption is valid only at ***low pressures and high temperatures.***

(b) When the pressure is increased or temperature is lowered, additional layers are formed. This has led to the modern concept of ***multilayer adsorption.***

Adsorption from solutions

(1) The process of adsorption can take place from solutions also.

(2) In any solution, there are two (or more) components ; ***solute*** and ***solvent.*** The solute may be present in the molecular or ionic form.

(3) The extent of adsorption from solution depends upon the concentration of the solute in the solution, and can be expressed by the ***Freundlich isotherm***.

(4) The Freundlich adsorption isotherm for the adsorption from solution is, $\frac{x}{m} = kc^{\frac{1}{n}}$ where, *x* is the mass of the solute adsorbed, *m* is the mass of the solid adsorbent, *c* is the equilibrium concentration of the solute in the solution, *n* is a constant having value greater than one,

k is the proportionality constant, (The value of *k* depends upon the nature of solid, its particle size, temperature, and the nature of solute and solvent etc.)

(5) The plot of *x/m* against *c* is similar to that Freundlich adsorption isotherm. The above equations may be written in the following form, $\log\frac{x}{m} = \log k + \frac{1}{n}\log c$ where *c,* is the equilibrium concentration of the solute in the solution.

Application of adsorption

The phenomenon of adsorption finds a number of applications. Important applications are given as follows.

(1) **Production of high vacuum**

(2) **In Gas masks** : This apparatus is used to adsorb poisonous gases (e.g. Cl_2, CO, oxide of sulphur etc.) and thus purify the air for breathing.

(3) **For desiccation or dehumidification :** These substances can be used to reduce/remove water vapours or moisture present in the air. Silica gel and alumina are used for dehumidification in electronic equipment.

(4) **Removel of colouring matter from solution :** (i) Animal charcoal removes colours of solutions by

adsorbing coloured impurities. (ii) Animal charcoal is used as decolouriser in the manufacture of cane sugar.

(5) **Heterogeneous catalysis :** Mostly heterogeneous catalytic reactions proceed through the adsorption of gaseous reactants on solid catalyst. For example,

(i) Finely powdered nickel is used for the hydrogenation of oils.

(ii) Finely divided vanadium pentaoxide (V_2O_5) is used in the contact process for the manufacture of sulphuric acid.

(6) **Separation of inert gases :** Due to the difference in degree of adsorption of gases by charcoal, a mixture of inert gases can be separated by adsorption on coconut charcoal at different low temperatures.

(7) **Softening of hard water**

(i) The hard water is made to pass through a column packed with zeolite (sodium aluminium silicate)

(ii) Ca^{++}, Mg^{++} ions which are responsible for hardness, get adsorbed on zeolite, exchanging sodium ions.

$$Na_2Al_2Si_2O_8 + CaCl_2 \longrightarrow CaAl_2Si_2O_8 + 2NaCl$$

(iii) The exhausted zeolite is regenerated with 10% of sodium chloride solution.

$$CaAl_2Si_2O_8 + 2NaCl \longrightarrow Na_2Al_2Si_2O_8 + CaCl_2$$

(8) **De-ionisation of water**

(i) Water can be de-ionised by removing all dissolved salts with the help of cation and anion-exchanger resin.

(ii) Cation-exchanger is an organic synthetic resin such as polystyrene-containing a macroanion $(R - SO_3^-$ etc.$)$ which has adsorbed H^+ ions.

(iii) A resin containing a basic group $(R_3N^+$ etc.$)$ which has adsorbed OH^- ions acts as anion exchanger.

(9) **In curing diseases :** A number of drugs are adsorbed on the germs and kill them or these are adsorbed on the tissues and heat them.

(10) **Cleaning agents :** Soap and detergents get adsorbed on the interface and thus reduce the surface tension between dirt and cloth, subsequently the dirt is removed from the cloth.

(11) **Froth floatation process**

A low grade sulphide ore is concentrated by separating it from silica and other earthy matter by this method.

(12) **In adsorption indicators**

Surface of certain precipitates such as silver halide, have the property of adsorbing some dyes like eosin, fluorescein etc.

(13) **Chromatographic analysis**

The phenomenon of adsorption has given an excellent technique of analysis known as chromatographic analysis.

(14) **In dyeing :** Many dyes get adsorbed on the cloth either directly or by the use of mordants.

Catalysis

"Catalyst is a substance which speeds up and speeds down a chemical reaction without itself being used up."

Berzelius (1836) introduced the term ***catalysis*** and ***catalyst***.

Ostwald (1895) redefined a catalyst as, "*A substance which changes the reaction rate without affecting the overall energetics of the reaction is termed as a catalyst and the phenomenon is known as catalysis.*"

Types of catalysis

Catalytic reactions can be broadly divided into the following types,

(1) **Homogeneous catalysis** : When the reactants and the catalyst are in the same phase (*i.e.* solid, liquid or gas). The catalysis is said to be ***homogeneous***. The following are some of the examples of homogeneous catalysis.

(i) In the lead chamber process

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

(ii) In the hydrolysis of ester

$$CH_3COOCH_3(l) + H_2O(l) \xrightarrow{HCl(l)}$$

$$CH_3COOH(l) + CH_3OH(l)$$

(iii) In the hydrolysis of sugar

$$\underset{\text{(Sucrose solution)}}{C_{12}H_{22}O_{11}(l)} + H_2O(l) \xrightarrow{H_2SO_4(l)}$$

$$\underset{\text{(Glucose solution)}}{C_6H_{12}O_6(l)} + \underset{\text{(Fructose solution)}}{C_6H_{12}O_6(l)}$$

(2) **Heterogeneous catalysis** : The catalytic process in which the reactants and the catalyst are in different phases is known as ***heterogeneous catalysis.*** Some of the examples of heterogeneous catalysis are given below.

(i) In contact process for H_2SO_4

$$2SO_2(g) + O_2(g) \xrightarrow[BrV_2O_5]{Pt(s)} 2SO_3(g)$$

(ii) In Haber's process for NH_3

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

(iii) In Ostwald's process for HNO_3

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

(3) **Positive catalysis** : When the rate of the reaction is accelerated by the foreign substance, it is said to be a ***positive catalyst*** and phenomenon as

positive catalysis. Some examples of positive catalysis are given below.

(i) Decomposition of $KClO_3$

$$2KClO_3(s)\xrightarrow[270^oC]{MnO_2(s)}2KCl(s)+3O_2(g)$$

(ii) Oxidation of SO_2

$$2SO_2(g)+O_2(g)\xrightarrow[or\ Pt(s)]{V_2O_5(s)}2SO_3(g)$$

(iii) Decon's process

$$4HCl(g)+O_2(g)\xrightarrow[450^oC]{CuCl_2(s)}2Cl_2(g)+2H_2O(g)$$

(4) **Negative catalysis** : There are certain, substance which, when added to the reaction mixture, retard the reaction rate instead of increasing it. These are called ***negative catalyst*** or ***inhibitors*** and the phenomenon is known as ***negative catalysis***. Some examples are as follows.

(i) Oxidation of sodium sulphite

$$2Na_2SO_3(s)+O_2(g)\xrightarrow{Alcohol(l)}2Na_2SO_4(s)$$

(ii) Oxidation of benzaldehyde

$$2C_6H_5CHO(l)+O_2(g)\xrightarrow[amine\ (l)]{Diphenyl}2C_6H_5COOH(l)$$

(iii) Tetra ethyl lead (TEL) is added to petrol to retard the ignition of petrol vapours on compression in an internal combustion engine and thus minimise the ***knocking effect.***

(5) **Auto-catalysis :** In certain reactions, one of the product acts as a catalyst. In the initial stages the reaction is slow but as soon as the products come into existences the reaction rate increases. This type of phenomenon is known as ***auto-catalysis.*** Some examples are as follows,

(i) The rate of oxidation of oxalic acid by acidified potassium permanganate increases as the reaction progresses. This acceleration is due to the presence of Mn^{2+} ions which are formed during reaction. Thus Mn^{2+} ions act as auto-catalyst.

$$5H_2C_2O_4+2KMnO_4+3H_2SO_4\to 2MnSO_4+K_2SO_4$$

$$+10CO_2+8H_2O$$

(ii) When nitric acid is poured on copper, the reaction is very slow in the beginning, gradually the reaction becomes faster due to the formation of nitrous acid during the reaction which acts as an auto-catalyst.

(6) **Induced catalysis :** When one reaction influences the rate of other reaction, which does not occur under ordinary conditions, the phenomenon is known as ***induced catalysis.*** Some examples are as follows,

(i) Sodium arsenite solution is not oxidised by air. If, however, air is passed through a mixture of the solution of sodium arsenite and sodium sulphite, both of them undergo simultaneous oxidation. The oxidation of sodium sulphite, thus, induces the oxidation of sodium arsenite.

(ii) The reduction of mercuric chloride $(HgCl_2)$ with oxalic acid is very slow, but potassium permanganate is reduced readily with oxalic acid. If, however, oxalic acid is added to a mixture of potassium permanganate and $HgCl_2$ both are reduced simultaneously. The reduction of potassium permanganate, thus, induces the reduction of mercuric chloride.

(7) **Acid-base catalysis** : According to the ***Arrhenius*** and ***Ostwald*** H^+ or H^- ion act as a catalyst.

(i) For example, Hydrolysis of an ester,

$$CH_3COOC_2H_5(l)+H_2O(l)\xrightarrow[OH^-]{H^+\ or}CH_3COOH(l)+C_2H_5OH(l)$$

(ii) Inversion of cane sugar,

$$\underset{\text{Sugar}}{C_{12}H_{22}O_{11}(l)}+H_2O\xrightarrow{H^+}\underset{\text{Fructose}}{C_6H_{12}O_6(l)}+\underset{\text{Glucose}}{C_6H_{12}O_6(l)}$$

(iii) Conversion of acetone into diacetone alcohol,

$$CH_3COCH_3(l)+CH_3COCH_3(l)\xrightarrow{OH^-}$$

$$CH_3COCH_2.C(CH_3)_2OH(l)$$

Characteristics of catalysis

The following are the characteristics which are common to must of catalytic reactions.

(1) A catalyst remains unchanged in mass and chemical composition at the end of the reaction.

(2) **A small quantity of the catalyst is generally sufficient to catalyses almost unlimited reactions**

(i) For example, in the decomposition of hydrogen peroxide, one gram of colloidal platinum can catalyses 10^8 litres of hydrogen peroxide.

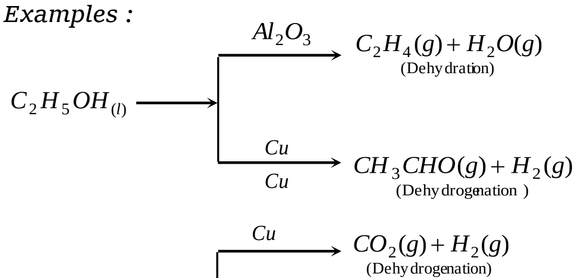
(ii) In Friedel craft's reaction, anhydrous aluminium chloride is required in relatively large amount to the extent of 30% of the mass of benzene,

$$C_6H_6+C_2H_5Cl\xrightarrow{AlCl_3}C_6H_5C_2H_5+HCl$$

(3) **The catalyst can not initiate the reaction:** The function of the catalyst is to alter the speed of the reaction rather than to start it.

(4) **The catalyst is generally specific in nature:** A substance, which acts as a catalyst for a particular reaction , fails to catalyse the other reaction , different catalysts for the same reactant may for different products.

Examples :



(5) **The catalyst can not change the position of equilibrium :** The catalyst catalyse both forward and backward reactions to the same extent in a reversible reaction and thus have no effect on the equilibrium constant.

(6) **Catalytic promoters :** Substances which themselves are not catalysts, but when mixed in small quantities with the catalysts increase their efficiency are called as ***promoters*** or ***activators.***

(i) For example, in Haber's process for the synthesis of ammonia, traces of molybdenum increases the activity of finely divided iron which acts as a catalyst.

(ii) In the manufacture of methyl alcohol from water gas $(CO+H_2)$, chromic oxide (Cr_2O_3) is used as a promoter with the catalyst zinc oxide (ZnO).

(7) **Catalytic poisons :** Substances which destroy the activity of the catalyst by their presence are known as ***catalytic poisons.***

(i) For example, the presence of traces of arsenious oxide (As_2O_3) in the reacting gases reduces the activity of platinized asbestos which is used as catalyst in contact process for the manufacture of sulphuric acid.

(ii) The activity of iron catalyst is destroyed by the presence of H_2S or CO in the synthesis of ammonia by Haber's process.

(iii) The platinum catalyst used in the oxidation of hydrogen is poisoned by CO.

(8) **Change of temperature alters the rate of catalytic reaction as it does for the same reaction in absence of catalyst :** By increasing the temperature, there is an increase in the catalytic power of a catalyst but after a certain temperature its power begins to decrease. A catalyst has thus, a particular temperature at which its catalytic activity is maximum. This temperature is termed as ***optimum temperature.***

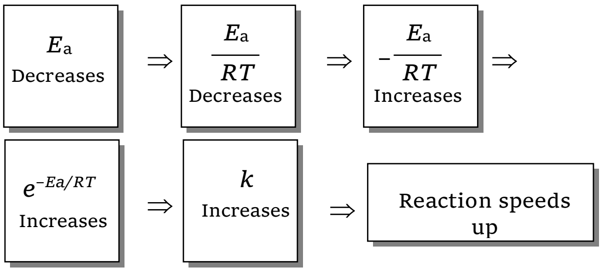
(9) **A positive catalyst lowers the activation energy**

(i) According to the collision theory, a reaction occurs on account of effective collisions between the reacting molecules.

(ii) For effective collision, it is necessary that the molecules must possess a minimum amount of energy known as activation energy (E_a).

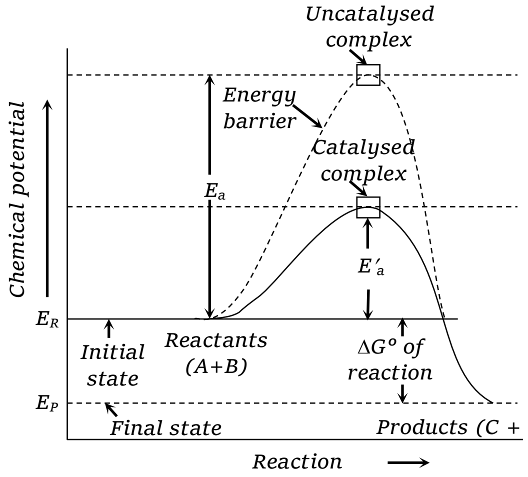
(iii) After the collision molecules form an activated complex which dissociate to yield the product molecules.

(iv) The catalyst provides a new pathway involving lower amount of activation energy. Thus, larger number of effective collisions occur in the presence of a catalyst in comparison to effective collisions at the same temperature in absence of a catalyst. Hence the presence of a catalyst makes the reaction to go faster.



(v) Figure shows that activation energy E_a, in absence of a catalyst is higher than the activation energy E_a, in presence of a catalyst.

(vi) E_R and E_p represent the average energies of reactants and products. The difference gives the value of ΔG, *i.e.,* $\Delta G = E_R - E_P$



Theories of catalysis

There are two theories of catalysis which is described as follows.

(1) **Intermediate compound theory**

(i) This theory was proposed by ***Clement and Desormes in*** 1806. According to this theory, the desired reaction is brought about by a path involving the formation of an unstable intermediate compound, followed by its decomposition into the desired end products with the regeneration of the catalyst.

(ii) The intermediate compund may be formed in either of two ways

(a) When the intermediate compound is reactive and reacts with the other reactants.

$$AB + X \rightarrow \underset{\text{intermediate}}{BX} + A$$

$$BX + C \rightarrow CB + X \quad .....(i)$$

(b) When the intermediate is unstable and decomposes to give the final product.

$$A + B + X \rightarrow \underset{\text{intermediate}}{ABX} \rightarrow AB + X \quad .....(ii)$$

Where, *A, B* and *C* are the reactant molecules and *X* is the molecule of the catalyst. The first type of reaction sums up to, $AB + C \rightarrow CB + A$

While the second to, $A + B \rightarrow AB$ in many cases, the intermediate compounds postulated to be formed are known compounds and often their presence is detected.

(2) **Adsorption theory**

(i) This theory is applicable to reactions between gases in the presence of a solid catalyst. Some typical examples are as follows.

(ii) The contact process for the oxidation of SO_2 to SO_3 with atmospheric oxygen in the presence of platinum as the catalyst.

(iii) The Haber's process for the synthesis of ammonia with iron as the catalyst.

(iv) Adsorption results in the loosening of the chemical bonds in the reactant molecules, so that their rupture becomes easier. This is confirmed by the observed lower activation energies for heterogeneous catalytic reactions in the presence of the catalysts as compared to that for the same reaction in the absence of the catalyst.

Enzyme catalysis

(1) Enzymes are complex nitrogenous substances these are actually protein molecules of higher molecular mass.

(2) Enzymes catalyse numerous reactions, especially those connected with natural processes.

(3) Numerous reactions occur in the bodies of animals and plants to maintain the life process. These reactions are catalysed by enzymes. The enzymes are thus, termed as ***bio-chemical catalysts*** and the phenomenon is known as ***bio-chemical catalysis***.

(4) ***Nitrogenase*** an enzyme present in bacteria on the root nodules of leguminous plants such as peas and beans, catalyses the conversion of atmospheric N_2 to NH_3.

(5) In the human body, the enzyme carbonic anhydrase catalyses the reaction of CO_2 with H_2O,

$$CO_2(aq) + H_2O(l) \rightleftharpoons H^+(aq.) + HCO_3^-(aq.)$$

The forward reaction occurs when the blood takes up CO_2 in the tissues, and the reverse reaction occurs when the blood releases CO_2 in lungs.

(6) **In manufacturing of ethyl alcohol**

(i)

$$C_{12}H_{22}O_{11}(l) + H_2O(l) \xrightarrow{\text{Invertase}} \underset{\text{Glucose}}{C_6H_{12}O_6(l)} + \underset{\text{Fructose}}{C_6H_{12}O_6(l)}$$

$$C_6H_{12}O_6(l) \xrightarrow{\text{Zymase}} 2C_2H_5OH(l) + 2CO_2(l)$$

(ii) Starch $(l) \xrightarrow{\text{Diastase}} \text{Maltose}(l)$

$$\text{Maltose} \xrightarrow{\text{Maltase}} \text{Glucose} \xrightarrow{\text{Zyamase}} \text{Alcohol}$$

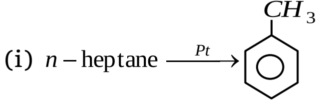
Activity and Selectivity

(1) **Activity :** Activity is the ability of catalysts to accelerate chemical reaction, the degree of acceleration can be as high as 10^{10} times in certain reactions. For example reaction between H_2 and O_2 to form H_2O in presence of platinum as catalyst takes place with explosive violence.

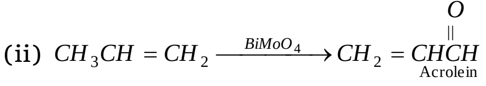
In absence of catalyst, H_2 and O_2 can be stored indefinitely without any reaction.

(2) **Selectivity :** Is the ability of catalysts to direct reaction to yield particular products (excluding other).

Example :



Toluen



(ii) $CH_3CH = CH_2 \xrightarrow{BiMoO_4} \underset{\text{Acrolein}}{CH_2 = CH\overset{\overset{O}{||}}{C}H}$

Zeolite (Shape selective catalysis)

(1) Zeolite are alumino–silicates of the general formula, $M_{x/n}[AlO_2]_x.(SiO_2)_y.mH_2O$, where, *M* may be simple cation like Na^+, K^+ or Ca^{2+}, *n* is the charge on the simple cation, *m* is the number of molecules of water of crystallization.

(2) Some well known zeolites are as follows,

Erionite $\rightarrow Na_2K_2CaMg(AlO_2)_2(SiO_2)_2.6H_2O$

Gemelinite $\rightarrow Na_2Ca(AlO_2)_2(SiO_2)_4.6H_2O$

Faujasite (natural) $\rightarrow Na_{56}(AlO_2)_{56}(SiO_2)_{136}.250\,H_2O$

ZSM-5 $\rightarrow H_x[(AlO_2)_x(SiO_2)_{96-x}].16H_2O$

Linde-A (synthetic) $\rightarrow [Na_{12}(AlO_2)_{12}(SiO_2)_{12}.27H_2O]_8$

(3) The characteristic feature of zeolites is the openness of the structure, which permits cavities of different sizes.

(4) The open structure is provided by silica in which aluminium occupies *x/(x+y)* fraction of the telrahedral sites.

(5) The negative charge of the aluminosilicate framework is neutralized by the replaceable cations.

(6) The void space forms more than 50% of the total volume, which is occupied by water molecules.

(7) The reaction- selectivity of zeolites depends upon the size of cavities (cages), pores (apertures) and the distribution of pores in the structure. The pore size in zeolites generally varies from 260 *pm* to 740 *pm*.

(8) Zeolite have high porosity due to the presence of one, two, or three dimensional networks of interconnected channels and cavities of molecular dimensions.

(9) There is a new class of highly siliceous zeolites with an optimal pore diameter of 550*pm*. ZSM-5 is one such zeolite having the formula. $[H_x(AlO_2)_x.(SiO_2)_{96-x}].16H_2O$

(10) The zeolite catalyst ZSM-5 converts alcohols to gasoline (petrol) by dehydrating the alcohol and producing a mixture of wide variety of hydrocarbons.

Colloidal state

(1) The foundation of colloidal chemistry was laid down by an English scientist, ***Thomas Graham,*** in 1861**.** The credit for the various advances in this field goes to eminent scientists like ***Tyndall, Hardy, Zsigmondy, N.R. Dhar, S.S. Bhatnagar and others.***

(2) **Thomas Graham** classified the soluble substances into two categories depending upon the rate of diffusion through animal and vegetable membranes or ***parchment paper.***

(i) ***Crystalloids*** **:** They have higher rate of diffusion and diffused from parchment paper.

Examples : All organic acids, bases and salts and organic compounds such as sugar, urea etc.

(ii) ***Colloids*** (*Greek word, kolla, meaning glue-like*) **:** They have slower rate of diffusion and can not diffused from parchment paper.

Examples : Starch, gelatin, gums, silicic acid and hdemoglobin etc.

(3) The above classification was discarded *i.e.,* the terms colloid does not apply to a particular class of substances but is a state of matter like solid, liquid and gas. Any substance can be brought into colloidal state.

(4) The colloidal state depends on the particle size. If is regarded as intermediate state between true solution and suspension.

Table : 14.2 Features of the three types of solutions

Property	**Suspension**	**Colloid solution**	**True solution**
Nature	Heterogeneous	Heterogeneous	Homogeneous
Particle size	> 100 *nm*	1 *nm* – 100 *nm*	< 1 *nm*
Separation by (i) Ordinary filtration (ii) Ultra-filtration	Possible Possible	Not possible Possible	Not possible Not possible
Settling of particles	Settle under gravity	Settle only on centrifugation	Do not settle
Appearance	Opaque	Generally transparent	Transparent
Tyndall effect	Shows	Shows	Does not show
Diffusion of particles	Does not diffuse	Diffuses slowly	Diffuses rapidly
Brownian movement	May show	Shows	Negligible

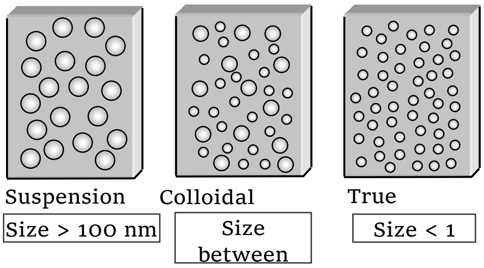


Fig. 14.1 Three types solutions

Phases of colloids and Their classification

(1) **Phases of colloids :** We know that a colloidal solution is of heterogeneous nature. It consists of two phases which are as follows

(i) ***Internal phase or Dispersed phase*** (Discontinuous phase) **:** It is the component present in small proportion and is just like a solute in a solution. For example in the colloidal solution of silver in water (silver acts as a dispersed phase)

(ii) ***External phase or Dispersion medium*** (continuous phase) **:** It is generally component present in excess and is just like a solvent in a solution. For example, in the colloidal solution of silver in water. Water act as a dispersion medium.

(2) **Classification of colloids :** The colloids are classified on the basis of the following criteria

(i) ***Classification based on the physical state of the dispersed phase and dispersion medium*** **:** Depending upon the physical state of dispersed phase and dispersion medium whether these are solids, liquids or gases, eight types of colloidal systems are possible.

Table : 14.3 Different types of colloidal systems

Dispersed phase	Dispersion Medium	Colloidal System	Examples
Liquid	Gas	Aerosol of liquids	Fogs, clouds, mists, fine insecticide sprays
Solid	Gas	Aerosol of solids	Smoke, volcanic dust, haze
Gas	Liquid	Foam or froth	Soap lather. Lemonade froth, foam, whipped cream, soda water
Liquid	Liquid	Emulsions	Milk, emulsified oils, medicines
Solid	Liquid	Sols	Most paints, starch in water, proteins, gold sol, arsenic sulphide sol, ink
Gas	Solid	Solid foam	Pumice stone, styrene rubber, foam rubber
Liquid	Solid	Gels	Cheese, butter, boot polish, jelly, curd
Solid	Solid	Solid sols (coloured glass)	Ruby glass, some gem stones and alloys

(ii) ***Classification based on Nature of interaction between dispersed phase and dispersion medium*****:** Depending upon the nature of interactions between dispersed phase and the dispersion medium, the colloidal solutions can be classified into two types as (a) Lyophilic and (b) Lyophobic sols.

(a) *Lyophilic colloids* (water loving) : “The colloidal solutions in which the particles of the dispersed phase have a great affinity for the dispersion medium, are called ***lyophilic collodis.”***

(b) *Lyophobic colloids* (water hateing) : *“The colloidal solutions in which* there *is no affinity between particles of the dispersed phase and the dispersion medium are called* ***lyophobic colloids****.”*

Distinction between lyophilic and lyophobic sols

Property	Lyophilic sols (suspensoid)	Lyophobic sols (Emulsoid)
Surface tension	Lower than that of the medium	Same as that of the medium
Viscosity	Much higher than that of the medium	Same as that of the medium
Reversibility	Reversible	Irreversible
Stability	More stable	Less stable
Visibility	Particles can’t be detected even under ultramicroscope	Particles can be detected under ultramicroscope.
Migration	Particles may migrate in either direction or do not migrate in an electric field because do not carry any charge.	Particles migrate either towards cathode or anode in an electric field because they carry charge.
Action of electrolyte	Addition of smaller quantity of electrolyte has little effect	Coagulation takes place
Hydration	Extensive hydration takes place	No hydration
Examples	Gum, gelatin, starch, proteins, rubber etc.	Metals like *Ag* and *Au*, hydroxides like $Al(OH)_3$, $Fe(OH)_3$ metal sulphides like AS_2S_3 etc.

(iii) ***Classification based on types of particle of dispersed phase*** **:** Depending upon the type of the particles of the dispersed phase, the colloids are classified as follows.

(a) *Multimolecular colloids*

- When on dissolution, atoms or smaller molecules of substances (having diameter less than 1*nm*) aggregate together to form particles of colloidal dimensions, the particles thus formed are called ***multimolecular colloids***.
- In these sols the dispersed phase consists of aggregates of atoms or molecules with molecular size less than 1 *nm*.
- For example, sols of gold atoms and sulphur (S_8) molecules. In these colloids, the particles are held together by ***Vander Waal's forces.*** They have usually ***lyophilic character.***

(b) *Macromolecular colloids*

- These are the substances having big size molecules (called macromolecules) which on dissolution form size in the colloidal range. Such substances are called ***macromolecular colloids***.
- These macromolecules forming the dispersed phase are generally ***polymers*** having very high molecular masses.
- Naturally occurring macromolecules are starch, cellulose, proteins, enzymes, gelatin etc. Artificial macromolecules are synthetic polymers such as nylon, polythene, plastics, polystyrene etc.

- They have usually ***lyophobic character.***

(c) *Associated colloids*

- These are the substances which on dissolved in a medium behave as normal electrolytes at low concentration but behave, as colloidal particles at higher concentration due to the formation of aggregated particles. The aggregates particles thus formed are called ***micelles.***
- Their molecules contain both ***lyophilic*** and ***lyophobic*** groups.

Micelles

- Micelles are the cluster or aggregated particles formed by association of colloid in solution.
- The common examples of micelles are ***soaps*** and ***detergents***.
- The formation of micelles takes place above a particular temperature called ***Kraft temperature*** (T_k) and above a particular concentration called ***critical micellization concentration*** (CMC).
- They are capable of forming ions.
- Micelles may contain as many as 100 molecules or more.
- For example sodium stearate $(C_{17}H_{35}COONa)$ is a typical example of such type of molecules.
- When sodium stearate is dissolved in water, it gives Na^+ and $C_{17}H_{35}COO^-$ ions.

$$\underset{\text{Sodium stearate}}{C_{17}H_{35}COONa} \rightleftharpoons \underset{\text{Stearate ion}}{C_{17}H_{35}COO^-} + Na^+$$

The stearate ions associate to form ***ionic micelles*** of colloidal size.

- It has long hydrocarbon part of $C_{17}H_{35}$ radical. Which is ***lyophobic*** and COO^- part which is ***lyophilic.***
- In the figure, the chain corresponds to stearate ion, $(C_{17}H_{35}COO^-)$. When the concentration of the solution is below from its CMC $(10^{-3}\ mol\ \ L^{-1})$, it behaves as normal electrolyte. But above this concentration it is aggregated to behave as micelles.

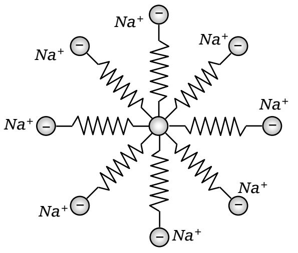


Fig. 14.2 Aggregation of several ions to form ionic

- The main function of a soap is to reduce oily and greasy dirt to colloidal particles (an emulsion). Soap therefore, are known as ***emulsifying agents***.
- Some other examples of micelles are sodium palmitate $(C_{15}H_{31}COONa)$, Sodium lauryl sulphate $[CH_3(CH_2)_{11}SO_3O^-Na^+]$, Cetyl trimethyl ammonium bromide $CH_3(CH_2)_{15}(CH_2)_3N^+Br^-$ etc.

General methods of preparation of colloids

Lyophilic and lyophobic colloidal solutions (or sols) are generally prepared by different types of methods. Some of the common methods are as follows.

(1) **Preparation of Lyophilic colloids**

(i) The lyophilic colloids have strong affinity between particles of dispersed phase and dispersion medium.

(ii) Simply mixing the dispersed phase and dispersion medium under ordinary conditions readily forms these colloidal solutions.

(iii) For example, the substance like gelatin, gum, starch, egg, albumin etc. pass readily into water to give colloidal solution.

(iv) They are reversible in nature become these can be precipitated and directly converted into colloidal state.

(2) **Preparation of Lyophobic colloids :** Lyophobic colloids can be prepared by mainly two types of methods.

(i) ***Condensation method*** **:** In these method, smaller particles of dispersed phase are condensed suitably to be of colloidal size. This is done by the following methods.

(a) *By oxidation* **:** A colloidal solution of sulphur can be obtained by bubbling oxygen (or any other oxidising agent like HNO_3, Br_2 etc.) through a solution of hydrogen sulphide in water.

$$2H_2S + O_2 \text{ (or any other oxidising agent)} \longrightarrow 2H_2O + 2S$$

(b) *By reduction* **:** A number of metals such as silver, gold and platinum, have been obtained in colloidal state by treating the aqueous solution of their salts, with a suitable reducing agent such as formaldehyde, phenyl hydrazine, hydrogen peroxide, stannous chloride etc.

$$2AuCl_3 + 3SnCl_2 \longrightarrow 3SnCl_4 + \underset{\text{Gold sol}}{2Au}$$

$$2AuCl_3 + 3HCHO + 3H_2O \longrightarrow \underset{\text{Gold sol}}{2Au} + 3HCOOH + 6HCl$$

The gold sol, thus prepared, has a purple colour and is called purple of cassius.

(c) *By hydrolysis* **:** Many salt solutions are rapidly hydrolysed by boiling dilute solutions of their salts. For example, ferric hydroxide and aluminium hydroxide sols are obtained by boiling solutions of the corresponding chlorides.

$$FeCl_3 + 3H_2O \longrightarrow \underset{\text{Colloidal sol}}{Fe(OH)_3} + 3HCl$$

Similarly silicic acid sol is obtained by the hydrolysis of sodium silicate.

(d) *By double decomposition* **:** A sol of arsenic sulphide is obtained by passing hydrogen sulphide through a cold solution of arsenious oxide in water.

$$As_2O_3 + 3H_2S \longrightarrow As_2S_3 + 3H_2O$$

(e) *By excessive cooling* **:** A colloidal solution of ice in an organic solvent like ether or chloroform can be prepared by freezing a solution of water in the solvent. The molecules of water which can no longer be held in solution, separately combine to form particles of colloidal size.

(f) *By exchange of solvent* **:** Colloidal solution of certain substances such as sulphur, phosphorus, which are soluble in alcohol but insoluble in water can be prepared by pouring their alcoholic solution in excess of water. For example, alcoholic solution of sulphur on pouring into water gives milky colloidal solution of sulphur.

(g) *By change of physical state* **:** Sols of substances like mercury and sulphur are prepared by passing their vapour's through a cold water containing a suitable stabilizer such as ammonium salt or citrate.

(ii) ***Dispersion methods*** **:** In these methods, larger particles of a substance (suspensions) are broken into smaller particles. The following methods are employed.

(a) *Mechanical dispersion*

- In this method, the substance is first ground to coarse particles.
- It is then mixed with the dispersion medium to get a suspension.

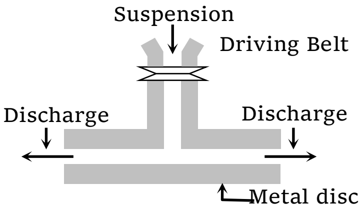


Fig. 14.3 Colloidal mill

- The suspension is then grinded in colloidal mill.
- It consists of two metallic discs nearly touching each other and rotating in opposite directions at a very high speed about 7000 revolution per minute.
- The space between the discs of the mill is so adjusted that coarse suspension is subjected to great shearing force giving rise to particles of colloidal size.
- Colloidal solutions of black ink, paints, varnishes, dyes etc. are obtained by this method.

(b) *By electrical dispersion or Bredig's arc method*

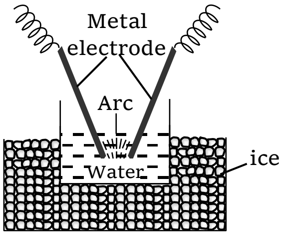


Fig. 14.4 Bredig's arc method

- This method is used to prepare sols of platinum, silver, copper or gold.
- The metal whose sol is to be prepared is made as two electrodes which immerged in dispersion medium such as water etc.
- The dispersion medium is kept cooled by ice.
- An electric arc is struck between the electrodes.
- The tremendous heat generate by this method and give colloidal solution.
- The colloidal solution prepared is stabilised by adding a small amount of KOH to it.

(c) *By peptisation*

- The process of converting a freshly prepared precipitate into colloidal form by the addition of suitable electrolyte is called ***peptisation.***
- The electrolyte is used for this purpose is called ***peptizing agent*** or ***stabilizing agent***.
- Cause of peptisation is the adsorption of the ions of the electrolyte by the particles of the precipitate.
- Important peptizing agents are sugar, gum, gelatin and electrolytes.
- Freshly prepared ferric hydroxide can be converted into colloidal state by shaking it with water containing Fe^{3+} or OH^- ions, viz. $FeCl_3$ or NH_4OH respectively.

$$\underset{\text{Precipitate}}{Fe(OH)_3} + \underset{\text{electrolyte}}{FeCl_3} \longrightarrow \underset{\text{Colloidal sol}}{[Fe(OH)_3Fe]^{3+}} + 3Cl^-$$

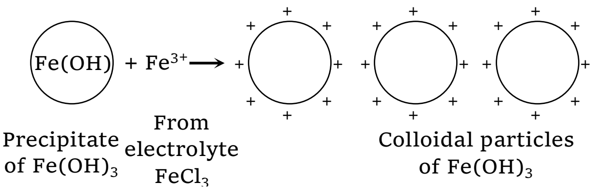


Fig. 14.5 Preparation of colloidal sol by

- A stable sol of stannic oxide is obtained by adding a small amount of dilute HCl to stannic oxide precipitates.
- Similarly, a colloidal solution of $Al(OH)_3$ and $AgCl$ are obtained by treating the corresponding freshly prepared precipitate with very dilute solution of HCl and $AgNO_3$ or KCl respectively.

Purification of colloidal solution

The following methods are commonly used for the purification of colloidal solutions.

(1) **Dialysis**

(i) The process of separating the particles of colloid from those of crystalloid, by means of diffusion through a suitable membrane is called dialysis.

(ii) It's principle is based upon the fact that colloidal particles can not pass through a parchment or cellophane membrane while the ions of the electrolyte can pass through it.

(iii) The impurities slowly diffused out of the bag leaving behind pure colloidal solution

(iv) The distilled water is changed frequently to avoid accumulation of the crystalloids otherwise they may start diffusing back into the bag.

(v) Dialysis can be used for removing HCl from the ferric hydroxide sol.

(2) **Electrodialysis**

(i) The ordinary process of dialysis is slow.

(ii) To increase the process of purification, the dialysis is carried out by applying electric field. This process is called ***electrodialysis.***

(iii) The important application of electrodialysis process in the artificial kidney machine used for the purification of blood of the patients whose kidneys have failed to work. The artificial kidney machine works on the principle of ***dialysis.***

(3) **Ultra – filtration**

(i) Sol particles directly pass through ordinary filter paper because their pores are larger (more than 1μ or $1000\,m\mu$) than the size of sol particles (less than $200\,m\mu$).

(ii) If the pores of the ordinary filter paper are made smaller by soaking the filter paper in a solution of gelatin of colloidion and subsequently hardened by soaking in formaldehyde, the treated filter paper may retain colloidal particles and allow the true solution particles to escape. Such filter paper is known as ***ultra - filter*** and the process of separating colloids by using ultra – filters is known as ***ultra – filtration.***

(4) **Ultra – centrifugation**

(i) The sol particles are prevented from setting out under the action of gravity by kinetic impacts of the molecules of the medium.

(ii) The setting force can be enhanced by using high speed centrifugal machines having 15,000 or more revolutions per minute. Such machines are known as ***ultra–centrifuges***.

Properties of colloidal solutions

The main characteristic properties of colloidal solutions are as follows.

(1) **Physical properties**

(i) ***Heterogeneous nature*** **:** Colloidal sols are heterogeneous in nature. They consists of two phases; the dispersed phase and the dispersion medium.

(ii) ***Stable nature*** **:** The colloidal solutions are quite stable. Their particles are in a state of motion and do not settle down at the bottom of the container.

(iii) ***Filterability*** **:** Colloidal particles are readily passed through the ordinary filter papers. However they can be retained by special filters known as ultrafilters (parchment paper).

(2) **Colligative properties**

(i) Due to formation of associated molecules, observed values of colligative properties like relative decrease in vapour pressure, elevation in boiling point, depression in freezing point, osmotic pressure are smaller than expected.

(ii) For a given colloidal sol the number of particles will be very small as compared to the true solution.

(3) **Mechanical properties**

(i) ***Brownian movement***

(a) ***Robert Brown,*** a botanist discovered in 1827 that the ***pollen grains*** suspended in water do not remain at rest but move about continuously and randomly in all directions.

(b) Later on, it was observed that the colloidal particles are moving at random in a ***zig – zag*** motion. This type of motion is called ***Brownian movement.***

(c) The molecules of the dispersion medium are constantly colloiding with the particles of the dispersed phase. It was stated by ***Wiener*** in 1863 that *the impacts of the dispersion medium particles are unequal, thus causing a zig-zag motion of the dispersed phase particles.*

(d) The Brownian movement explains the force of gravity acting on colloidal particles. This helps in providing stability to colloidal sols by not allowing them to settle down.

(ii) ***Diffusion*** **:** The sol particles diffuse from higher concentration to lower concentration region. However, due to bigger size, they diffuse at a lesser speed.

(iii) ***Sedimentation*** **:** The colloidal particles settle down under the influence of gravity at a very slow rate. This phenomenon is used for determining the molecular mass of the macromolecules.

(4) **Optical properties :** ***Tyandall effect***

(i) When light passes through a sol, its path becomes visible because of scattering of light by particles.

It is called ***Tyndall effect.*** This phenomenon was studied for the first time by ***Tyndall.*** The illuminated path of the beam is called ***Tyndall cone.***

(ii) The intensity of the scattered light depends on the difference between the refractive indices of the dispersed phase and the dispersion medium.

(iii) In lyophobic colloids, the difference is appreciable and, therefore, the Tyndall effect is well - defined. But in lyophilic sols, the difference is very small and the Tyndall effect is very weak.

(iv) The Tyndall effect confirms the ***heterogeneous nature of the colloidal solution.***

(v) The Tyndall effect has also been observed by an instrument called ***ultra – microscope.***

Some example of Tyndall effect are as follows

(a) *Tail of comets is seen as a* ***Tyndall cone due*** *to the scattering of light by the tiny solid particles left by the comet in its path.*

(b) *Due to scattering the sky looks blue.*

(c) *The blue colour of water in the sea is due to scattering of blue light by water molecules.*

(d) *Visibility of projector path and circus light.*

(e) *Visibility of sharp ray of sunlight passing through a slit in dark room.*

(5) **Electrical properties**

(i) ***Electrophoresis***

(a) The phenomenon of movement of colloidal particles under an applied electric field is called ***electrophoresis.***

(b) If the particles accumulate near the negative electrode, the charge on the particles is ***positive.***

(c) On the other hand, if the sol particles accumulate near the positive electrode, the charge on the particles is ***negative.***

(d) The apparatus consists of a U-tube with two *Pt*-electrodes in each limb.

(e) When electrophoresis of a sol is carried out with out stirring, the bottom layer gradually becomes more concentrated while the top layer which contain pure and concentrated colloidal solution may be decanted. This is called ***electro decanation*** and is used for the purification as well as for concentrating the sol.

(f) The reverse of electrophoresis is called ***Sedimentation potential or Dorn effect.*** The sedimentation potential is setup when a particle is forced to move in a resting liquid. This phenomenon was discovered by ***Dorn*** and is also called ***Dorn effect.***

(ii) ***Electrical double layer theory***

(a) The electrical properties of colloids can also be explained by electrical double layer theory. According to this theory ***a double layer of ions appear at the surface of solid.***

(b) The ion preferentially adsorbed is held in fixed part and imparts charge to colloidal particles.

(c) The second part consists of a diffuse mobile layer of ions. This second layer consists of both the type of charges. The net charge on the second layer is exactly equal to that on the fixed part.

(d) The existence of opposite sign on fixed and diffuse parts of double layer leads to appearance of a difference of potential, known as ***zeta potential or electrokinetic potential.*** Now when electric field is employed the particles move (electrophoresis)

(iii) ***Electro-osmosis***

(a) In it the movement of the dispersed particles are prevented from moving by ***semipermeable membrane.***

(b) Electro-osmosis is a phenomenon in which dispersion medium is allowed to move under the influence of an electrical field, whereas colloidal particles are not allowed to move.

(c) The existence of electro-osmosis has suggested that when liquid forced through a porous material or a capillary tube, a potential difference is setup between the two sides called as streaming potential. So the reverse of electro-osmosis is called ***streaming potential.***

Origin of the charge on colloidal particles

The origin of the charge on the sol particles in most cases is due to the preferential adsorption of either positive or negative ions on their surface. The sol particles acquire electrical charge in any one or more of the following ways.

(1) **Due to the dissociation of the surface molecules :** Some colloidal particles develope electrical charge due to the dissociation / ionisation of the surface molecules. The charge on the colloidal particles is balanced by the oppositely charged ions in the sol. For example, an aqueous solution of soap (sodium palmitate) which dissociates into ions as,

$$\underset{\text{Sodium palmitate}}{C_{15}H_{31}COONa} \rightleftharpoons C_{15}H_{31}COO^- + Na^+$$

The cations (Na^+) pass into the solution while the anions ($C_{15}H_{31}COO^-$) have a tendency to form aggregates due to weak attractive forces present in the hydrocarbon chains.

(2) **Due to frictional electrification**

(i) It is believed that the frictional electrification due to the rubbing of the dispersed phase particles with that of dispersion medium results in some charge on the colloidal particles.

(ii) The dispersion medium must also get some charge, because of the friction. Since it does not carry any charge, the theory does not seem to be correct.

(3) **Due to selective adsorption of ions**

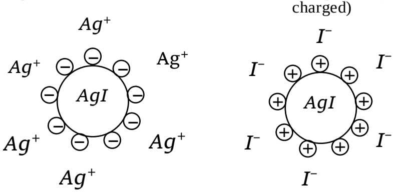
(i) The particles constituting the dispersed phase adsorb only those ions preferentially which are common with their own lattice ions.

(ii) For example, when a small quantity of silver nitrate $(AgNO_3)$ solution is added to a large quantity of potassium iodide (KI) solution, the colloidal particles of silver iodide adsorb I^- from the solution to become ***negatively charged,*** *(at this stage KI is in excess, and I^- being common to AgI)*

$$\underset{\text{(Colloidal particle)}}{AgI} + \underset{\text{(in excess in the medium)}}{I^-} \longrightarrow \underset{\text{(Colloidal particle becomes positively charged)}}{(AgI)I^-}$$

But, when a small quantity of potassium iodide (KI) solution is added to a large quantity of silver nitrate solution $(AgNO_3)$; the colloidal silver iodide particles adsorb Ag^+ from the solution to become ***positively charged,*** *(at this stage $AgNO_3$ is in excess and Ag^+ is common to AgI),*

$$\underset{\text{(Colloidal particle)}}{AgI} + \underset{\text{(in excess in the medium)}}{Ag^+} \longrightarrow \underset{\text{(Colloidal particle becomes positively charged)}}{(AgI)Ag^+}$$



Ag^+ ions remain in dispersed medium (AgI, I^- Sol)

I^- ions remain in dispersion medium (AgI, Ag^+ Sol)

Fig. 14.6

(iii) Depending upon the nature of charge on the particles of the dispersed phase, the colloidal solutions are classified into positively charged and negatively charged colloids. Some typical examples are as follows

(a) Negatively charged colloids	**(b) Positively charged colloids**
• Metal sulphides : As_2S_3, CdS	• Metal hydroxides : $Al(OH)_3$, $Fe(OH)_3$
• Metal dispersions : Ag, Au, Pt	• Metal oxide : TiO_2
• Acid dyes : Eosin, congo red	• Basic dyes : Methylene blue
• Sols of starch, gums, gold, gelatin etc.	• Haemoglobin
	• Sulphur sol

Stability of sols

Sols are thermodynamically unstable and the dispersed phase (colloidal particles) tend to separate out on long standing due to the ***Vander Waal's attractive forces.*** However sols tend to exhibit some stability due to

(1) **Stronger repulsive forces between the similarly charged particles**

(2) **Particle-solvent interactions :** Due to strong particle-solvent (dispersion medium) interactions, the colloidal particles get strongly solvated.

Coagulation or Flocculation or Precipitation

"*The phenomenon of the precipitation of a colloidal solution by the addition of the excess of an electrolyte is called* ***coagulation or flocculation***."

The coagulation of the ***lyophobic sols*** can be carried out by following methods.

(1) **By electrophoresis :** In electrophoresis the colloidal particles move towards oppositely charged electrode. When these come in contact with the electrode for long these are discharged and precipitated.

(2) **By mixing two oppositely charged sols :** When oppositely charged sols are mixed in almost equal proportions, their charges are neutralised. Both sols may be partially or completely precipitated as the mixing of ferric hydroxide (+*ve* sol) and arsenious sulphide (–*ve* sol) bring them in precipitated form. This type of coagulation is called ***mutual coagulation*** *or* ***meteral coagulation.***

(3) **By boiling :** When a sol is boiled, the adsorbed layer is disturbed due to increased collisions with the molecules of dispersion medium. This reduces the charge on the particles and ultimately they settle down to form a precipitate.

(4) **By persistent dialysis :** On prolonged dialysis, the traces of the electrolyte present in the sol are removed almost completely and the colloids become unstable.

(5) **By addition of electrolytes :** The particles of the dispersed phase *i.e.,* colloids bear some charge. When an electrolyte is added to sol, the colloidal particles take up ions carrying opposite charge from the electrolyte. As a result, their charge gets neutralised and this causes the uncharged, particles to come closer and to get coagulated or precipitated. For example, if $BaCl_2$ solution is added to As_2S_3 sol the Ba^{2+} ions are attracted by the negatively charged sol particles and their charge gets neutralised. This lead to coagulation.

(6) **Hardy schulze rule :** The coagulation capacity of different electrolytes is different. It depends upon

the valency of the active ion are called flocculating ion, which is the ion carrying charge opposite to the charge on the colloidal particles. "*According to Hardy Schulze rule, greater the valency of the active ion or flocculating ion, greater will be its coagulating power*" thus, Hardy Schulze law state:

(i) *The ions carrying the charge opposite to that of sol particles are effective in causing coagulation of the sol.*

(ii) *Coagulating power of an electrolyte is directly proportional to the valency of the active ions (ions causing coagulation).*

For example to coagulate ***negative sol*** of As_2S_3, the ***coagulation power*** of different cations has been found to ***decrease*** in the order as, $Al^{3+} > Mg^{2+} > Na^{+}$

Similarly, to coagulate a ***positive sol*** such as $Fe(OH)_3$, the ***coagulating power*** of different anions has been found to ***decrease*** in the order : $[Fe(CN)_6]^{4-} > PO_4^{3-} > SO_4^{2-} > Cl^{-}$

(7) **Coagulation or flocculation value**

*"The minimum concentration of an electrolyte which is required to cause the coagulation or flocculation of a sol is known as **flocculation value**."*

or

*"The number of millimoles of an electrolyte required to bring about the coagulation of one litre of a colloidal solution is called its **flocculation value**."*

Coagulation value or flocculating value $\propto \frac{1}{\text{Coagulating power}}$

(8) **Coagulation of lyophilic sols**

(i) There are two factors which are responsible for the stability of lyophilic sols.

(ii) These factors are the charge and solvation of the colloidal particles.

(iii) When these two factors are removed, a lyophilic sol can be coagulated.

(iv) This is done (i) by adding electrolyte (ii) and by adding suitable solvent.

(v) When solvent such as alcohol and acetone are added to hydrophilic sols the dehydration of dispersed phase occurs. Under this condition a small quantity of electrolyte can bring about coagulation.

Protection of colloids and Gold number

- Lyophilic sols are more stable than lyophobic sols.
- Lyophobic sols can be easily coagulated by the addition of small quantity of an electrolyte.
- When a lyophilic sol is added to any lyophobic sol, it becomes less sensitive towards electrolytes. Thus, lyophilic colloids can prevent the coagulation of any lyophobic sol.

"The phenomenon of preventing the coagulation of a lyophobic sol due to the addition of some lyophilic colloid is called sol protection or protection of colloids."

- The protecting power of different protective (lyophilic) colloids is different. The efficiency of any protective colloid is expressed in terms of ***gold number.***

Gold number **:** ***Zsigmondy*** introduced a term called ***gold number*** to describe the protective power of different colloids. This is defined as, *"weight of the dried protective agent in milligrams, which when added to 10 ml of a standard gold sol* (0.0053 to 0.0058%) *is just sufficient to prevent a colour change from red to blue on the addition of 1 ml of 10 % sodium chloride solution, is equal to the gold number of that protective colloid."*

Thus, smaller is the gold number, higher is the protective action of the protective agent.

$$\text{Protective power} \propto \frac{1}{\text{Gold number}}$$

Table : 14.4 Gold numbers of some hydrophilic substances

Hydrophilic substance	Gold number	Hydrophilic substance	Gold number
Gelatin	0.005 - 0.01	Sodium oleate	0.4 – 1.0
Sodium caseinate	0.01	Gum tragacanth	2
Hamoglobin	0.03 – 0.07	Potato starch	25
Gum arabic	0.15 – 0.25		

Congo rubin number : ***Ostwald*** introduced congo rubin number to account for protective nature of colloids. It is defined as "*the amount of protective colloid in milligrams which prevents colour change in 100 ml of 0.01 % congo rubin dye to which 0.16 g equivalent of KCl is added.*"

Mechanism of sol protection

(i) The actual mechanism of sol protection is very complex. However it may be due to the adsorption of the protective colloid on the lyophobic sol particles, followed by its solvation. Thus it stabilises the sol *via* ***solvation effects***.

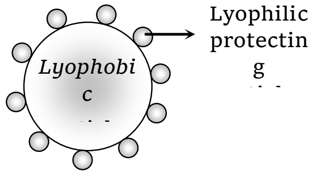


Fig. 14.7 Protection of

(ii) Solvation effects contribute much towards the stability of lyophilic systems. For example, gelatin has a sufficiently strong affinity for water. It is only because of the solvation effects that even the addition of electrolytes in small amounts does not cause any flocculation of hydrophilic sols. However at higher concentration, precipitation occurs. This phenomenon is called ***salting out.***

(iii) The salting out efficiency of an electrolyte depends upon the tendency of its constituents ions to get hydrated *i.e,* the tendency to squeeze out water initially fied up with the colloidal particle.

(iv) The cations and the anions can be arranged in the decreasing order of the salting out power, such an arrangement is called ***lyotropic series.***

Cations

: $Mg^{2+} > Ca^{2+} > Sr^{2+} > Ba^{2+} > Li^{+} > Na^{+} > K^{+}$

$> NH_4^{+} > Rb^{+} > Cs^{+}$

Anions : $\text{Citrate}^{3-} > SO_4^{2-} > Cl^{-} > NH_3^{-} > I^{-} > CNS^{-}$

Ammonium sulphate, due to its very high solubility in water, is oftenly used for precipitating proteins from aqueous solutions.

(v) The precipitation of lyophilic colloids can also be affected by the addition of organic solvents of non-electrolytes. For example, the addition of acetone or alcohol to aqueous gelatin solution causes precipitation of gelatin. Addition of petroleum ether to a solution of rubber in benzene causes the precipitation of rubber.

Emulsion

"The colloidal systems in which fine droplets of one liquid are dispersed in another liquid are called emulsions the two liquids otherwise being mutually immiscible." **or**

"Emulsion are the colloidal solutions in which both the dispersed phase and the dispersion medium are liquids."

A good example of an emulsion is milk in which fat globules are dispersed in water. The size of the emulsified globules is generally of the order of $10^{-6}\,m$. Emulsion resemble lyophobic sols in some properties.

(1) **Types of Emulsion :** Depending upon the nature of the dispersed phase, the emulsions are classified as;

(i) ***Oil-in-water emulsions*** *(O/W)* **:** The emulsion in which oil is present as the dispersed phase and water as the dispersion medium ***(continuous phase)*** is called an oil-in-water emulsion. Milk is an example of the oil-in-water type of emulsion. In milk liquid fat globules are dispersed in water. Other examples are, vanishing cream etc.

(ii) ***Water-in-oil emulsion*** *(W/O)* **:** The emulsion in which water forms the dispersed phase, and the oil acts as the dispersion medium is called a water-in-oil emulsion. These emulsion are also termed ***oil emulsions. Butter*** and ***cold cream*** are typical examples of this types of emulsions. Other examples are cod liver oil etc.

(2) Properties of emulsion

(i) Emulsions show all the characteristic properties of colloidal solution such as Brownian movement, Tyndall effect, electrophoresis etc.

(ii) These are coagulated by the addition of electrolytes containing polyvalent metal ions indicating the negative charge on the globules.

(iii) The size of the dispersed particles in emulsions in larger than those in the sols. It ranges from 1000 Å to 10,000 Å. However, the size is smaller than the particles in suspensioins.

(iv) Emulsions can be converted into two separate liquids by heating, centrifuging, freezing etc. This process is also known as ***demulsification***.

(3) Applications of emulsions

(i) Concentration of ores in metallurgy

(ii) In medicine (Emulsion water-in-oil type)

(iii) Cleansing action of soaps.

(iv) Milk, which is an important constituent of our diet an emulsion of fat in water.

(v) Digestion of fats in intestine is through ***emulsification***.

Gels

(1) "A gel is a colloidal system in which a liquid is dispersed in a solid."

(2) The lyophilic sols may be coagulated to give a semisolid jelly like mass, which encloses all the liquid present in the sol. The process of gel formation is called ***gelation*** and the colloidal system formed called ***gel.***

(3) Some gels are known to liquify on shaking and reset on being allowed to stand. This reversible ***sol-gel transformation*** is called ***thixotropy.***

(4) The common examples of gel are gum arabic, gelatin, processed cheese, silicic acid, ferric hydroxide etc.

(5) Gels may shrink by loosing some liquid help them. This is known as ***synereises or weeping.***

(6) Gels may be classified into two types

(i) ***Elastic gels*** **:** These are the gels which possess the property of elasticity. They readily change their shape on applying force and return to original shape when the applied force is removed. Common examples are gelatin, agar-agar, starch etc.

(ii) ***Non-elastic gels*** **:** These are the gels which are rigid and do not have the property of elasticity. For example, silica gel.

Application of colloids

(1) **Purification of water by alum** (coagulation) **:** Alum which yield Al^{3+} ions, is added to water to coagulate the negatively charged clay particles.

(2) **In rubber and tanning industry** (coagulation and mutual coagulation) **:** Several industrial processes such as rubber plating, chrome tanning, dyeing, lubrication etc are of colloidal nature

(i) In rubber platting, the negatively charged particles of rubber (latex) are made to deposit on the wires or handle of various tools by means of electrophoresis. The article on which rubber is to be deposited is made anode.

(ii) In tanning the positively charged colloidal particles of hides and leather are coagulated by impregnating, them in negatively charged tanning materials (present in the barks of trees). Among the tanning agent chromium salts are most commonly used for the coagulation of the hide material and the process is called ***chrome tanning***.

(3) **Artificial rains :** It is possible to cause artificial rain by throwing the electrified sand or silver iodide from an aeroplane and thus coagulating the mist hanging in air.

(4) **Smoke precipitation** (Coagulation) **:** Smoke is a *negative* sol consisting of carbon particles dispersed in air. Thus, these particles are removed by passing through a chamber provided with highly positively charged metallic knob.

(5) **Formation of deltas** (coagulation) **:** River water consists of negatively charged clay particles of colloidal dimension. When the river falls into the sea, the clay particles are coagulated by the positive Na^+, K^+, Mg^{2+} ions etc. present in sea water and new lands called deltas are formed.

(6) **Clot formation :** Blood consists of negatively charged colloidal particles (albuminoid substance). The colloidal nature of blood explains why bleeding stops by applying a ferric chloride solution to the wound. Actually ferric chloride solution causes coagulation of blood to form a clot which stops further bleeding.

(7) **Colloidal medicine :** Argyrol and protargyrol are colloidal solution of silver and are used as eye lotions colloidal sulphur is used as disinfectant colloidal gold, calcium and iron are used as tonics.

(8) **Coating of Photographic plates :** These are thin glass plates coated with gelatin containing a fine suspension of silver bromide. The particles of silver bromide are colloidal in nature.

Tips & Tricks

- ✍ Chemisorption and physisorption both are exothermic.
- ✍ Charcoal adsorbs many gases. It even adsorbs polluting gases present in air in small concentration.
- ✍ The langmuir adsorption isotherm is restricted to the formation of unimolecular layer of gas molecules on the surface of solids. However, it was suggested that there is possibility of multimolecular layer of gas molecules on the surface of the solids rather than single layer on this basis Brunauer, Emmett and Teller proposed a new theory known as B.E.T. theory.
- ✍ All Bronsted acids and bases act as acid base catalysts.
- ✍ The principle of electrophoresis is employed for the separation of proteins from nucleic acids removing sludge from sewage waste etc.
- ✍ Hydrophilic sols show greater stability than hydrophobic sols.
- ✍ Colloidal solution of graphite is called aquadug.
- ✍ The phase in which the emulsifier is more soluble becomes outer phase of the emulsion that is called Ben croft rule.

Ordinary Thinking

Objective Questions

Adsorption and Adsorption isotherm

1. Chemisorption

(a) Involves the weak attractive interactions between adsorbent and adsorbate

(b) Is irreversible in nature

(c) Decreases with increase of temperature

(d) Involves multilayer formation of adsorbent on adsorbate

2. Chemisorption

(a) Increases with temperature

(b) Decreases with temperature

(c) Remains unaffected by change of temperature

(d) Either increases or decreases with temperature

3. Which among the following statement is false **[KCET (Med.) 2002]**

(a) The adsorption may be monolayered or multilayered

(b) Particle size of adsorbent will not affect the amount of adsorption

(c) Increase of pressure increases amount of adsorption

(d) Increase of temperature may decrease the amount of adsorption

4. Wood charcoal is used to decolourise sugar because it **[CPMT 2002]**

(a) Adsorbs coloured material

(b) Absorbs decolorised material

(c) Reduces coloured material

(d) None of these

5. If the absorbate is held on a surface by weak Vander Waal's forces, the absorption process is called **[Kerala (Med.) 2002]**

(a) Physical adsorption (b) Chemical adsorption

(c) Heat of adsorption (d) Enthalpy of adsorption

6. When the temperature is raised, the viscosity of liquid decreases, this is because **[Kerala (Med.) 2002]**

(a) Decreased volume of the solution

(b) Increase in temperature increases the average kinetic energy of molecules, which overcome the attractive force between them

(c) Decreased covalent and hydrogen bond forces

(d) Increased attraction between molecules

7. A solid acts as an adsorbent because it has

(a) A definite shape

(b) Small pores in it

(c) Unsaturated valencies

(d) A high lattice energy

8. Point out the wrong statement :

Physical adsorption is characterised by

(a) Attraction due to weak Vander Waal's forces

(b) Irreversible nature of adsorption

(c) Multimolecular adsorption layers

(d) Decrease in adsorption with increase in temperature

9. When the temperature is lowered and pressure is raised, the adsorption of a gas on a solid **[MP PMT 1997]**

(a) Decreases

(b) Increases

(c) Remains unaffected

(d) Decreases first then increases

10. In physical adsorption, the gas molecules are held on solid surface by **[MP PET 1996; AIIMS 1998]**

(a) Chemical forces (b) Electrostatic forces

(c) Gravitational forces (d) Vander Waal's forces

11. Adsorption is multilayer in the case of **[MP PET 1999]**

(a) Physical adsorption (b) Chemisorption

(c) Both (d) None of both

12. Physical adsorption

(a) Involves the weak attractive interaction between the adsorbent and adsorbate

(b) Involves the chemical interactions between the adsorbent and adsorbate

(c) Is irreversible in nature

(d) Increases with increase of temperature

13. The charge on As_2S_3 sol is due to the adsorbed **[MP PMT 1985]**

(a) H^+ (b) OH^-

(c) O^{2-} (d) S^{2-}

14. In the adsorption of acetic acid on activated charcoal, the acetic acid is an **[MP PET 1994; MP PMT 2002]**

(a) Adsorber (b) Absorber

(c) Adsorbent (d) Adsorbate

15. Sticking of one substance at the surface of another is called

(a) Absorption (b) Chemisorption

(c) Adsorption (d) Desorption

16. The charge on colloidal particles is due to

(a) Presence of electrolyte

(b) Very small size of particles

(c) Adsorption of ions from the solution

(d) None of these

17. Which one of the following statement is not correct

(a) The extent of adsorption depends on the nature of the adsorbent and adsorbate

(b) The extent of adsorption depends on the pressure of the gas

(c) The extent of adsorption depends on the temperature

(d) The extent of adsorption has no upper limit

18. For the adsorption of a gas on a solid, the plot of log (x/m) versus log P is linear with slope equal to **[CBSE PMT 1994]**

(a) k (b) log k

(c) n (d) $1/n$

19. According to Langmuir adsorption isotherm, the amount of gas adsorbed at very high pressures **[MP PMT 1993]**

(a) Reaches a constant limiting value

(b) Goes on increasing with pressure

(c) Goes on decreasing with pressure

(d) Increases first and decreases later with pressure

20. Which of the following statement is not correct **[MP PET 1993]**

(a) Physical adsorption is due to Vander Wall's forces

(b) Chemical adsorption decreases at high temperature and low pressure

(c) Physical adsorption is reversible

(d) Adsorption energy for a chemical adsorption is generally greater than that of physical adsorption

21. In adsorption of oxalic acid on activated charcoal, the activated charcoal is known as

(a) Adsorbent (b) Absorbate

(c) Adsorber (d) Absorber

22. Adsorption is phenomenon is which a substance

(a) Goes into the body of the other substance

(b) Remains close the other substance

(c) Accumulates on the surface of the other substance

(d) None of these

23. Physical adsorption is essentially quite appreciable

(a) At room temperature (b)At higher temperature

(c) At lower temperature (d) None of these

24. Adsorption increase when

(a) Temperature increases

(b) Temperature decreases

(c) Temperature remains constant

(d) None of these

25. In chemical adsorption, how many layers are adsorbed **[MP PMT 1996]**

(a) One (b) Two

(c) Multi (d) Zero

26. The adsorption of a gas on a solid surface varies with pressure of the gas in which of the following manner **[CPMT 1999]**

(a) Fast $\rightarrow$ slow $\rightarrow$ independent of the pressure

(b) Slow $\rightarrow$ fast $\rightarrow$ independent of the pressure

(c) Independent of the pressure $\rightarrow$ fast $\rightarrow$ slow

(d) Independent of the pressure $\rightarrow$ slow $\rightarrow$ fast

27. Which of the following statements is not applicable to chemisorption **[KCET (Med.) 1999; BHU 2000]**

(a) It is slow

(b) It is irreversible

(c) It is highly specific

(d) It is independent of temperature

28. Adsorption is always **[DPMT 2000]**

(a) Endothermic (b) Exothermic

(c) Either (a) or (b) (d) None of these

29. The colloidal system consisting of a liquid adsorbent in a solid adsorbate is termed as

(a) Aerosol (b) Sol

(c) Foam (d) Gel

30. Which one of the following substances adsorb hydrogen gas most strongly

(a) Activated carbon (b) Silica gel

(c) Platinum black (d) Iron powder

31. According to the adsorption theory of catalysis, the speed of the reaction increases because **[CBSE PMT 20**

(a) Adsorption lowers the activation energy of the reaction

(b) The concentration of reactant molecules at the active centres of the catalyst becomes high due to adsorption

(c) In the process of adsorption, the activation energy of the molecules becomes large

(d) Adsorption produces heat which increases the speed of the reaction

32. In Freundlich adsorption, isotherm adsorption is proportional to pressure P as

(a) P^0 (b) P

(c) P^n (d) $P^{1/n}$

33. Which one of the following characteristics is not correct for physical adsorption

(a) Adsorption on solids is reversible

(b) Adsorption increases with increase in temperature

(c) Adsorption is spontaneous

(d) Both enthalpy and entropy of adsorption are negative

34. Which of the following is not a characteristic of chemisorption **[KCET 2003]**

(a) ΔH is of the order of 400 kJ

(b) Adsorption is irreversible

(c) Adsorption may be multimolecular layer

(d) Adsorption is specific

35. The viscosity of the solvent depends on

[Kerala (Med.) 2002]

(a) Isothermic nature
(b) Solute - solute interaction
(c) Solute - solvent interaction
(d) Density of the liquid

36. Which of the following kinds of catalysis can be explained by the adsorption theory ?**[MP PET/PMT 1998]**
(a) Homogeneous catalysis (b)Acid base catalysis
(c) Heterogeneous catalysis (d) Enzyme catalysis

37. Adsorption due to strong chemical forces is called **[KCET (Med.) 2001]**
(a) Chemisorption (b) Physiosorption
(c) Reversible adsorption (d) Both (b) and (c)

38. In neutralisation of KI by $AgNO_3$ positive charge is due to absorption of **[AMU 2000]**
(a) Ag^+ ions (b) Ag
(c) I ions (d) Both (b) and (c)

39. Physical adsorption is inversely proportional to the **[AFMC 2000]**
(a) Volume (b) Concentration
(c) Temperature (d) All of these

40. 50 *ml* of 1 *M* oxalic acid is shaken with 0.5 *gm* of wood charcoal. The final concentration of the solution after adsorption is 0.5 *M*. Amount of oxalic acid absorbed per *gm* of charcoal is
(a) 3.45 *gm* (b) 3.15 *gm*
(c) 6.30 *gm* (d) None

41. Noble gases are adsorbed by **[DCE 2004]**
(a) Anhydrous calcium chloride
(b) Ferric hydroxide
(c) Conc. H_2SO_4
(d) Activated coconut charcol

42. Animal charcoal is used in decolourising colour of liquids because it is a good
(a) Adsorbate (b) Adsorbent
(c) Oxidising agent (d) Reducing agent

43. What will be the effect of increase in temperature on physical adsorption **[Pb. CET 2000]**
(a) It will decrease
(b) It will increase
(c) First increase then decrease
(d) None of these

44. 0.2 *gm* of fine animal charcoal is mixed with half litre of acetic acid solution and shaken for 30 minutes **[DPMT 2004]**
(a) Concentration remains same
(b) Concentration increases
(c) Concentration of the solution decrease
(d) None of these

45. The equation for Freundlich adsorption isotherm is **[MHCET 2004]**
(a) $\frac{x}{m} = kp^{1/n}$ (b) $x = mkp^{1/n}$
(c) $x/m = kp^{-n}$ (d) All of these

46. The extent of adsorption of a gas on a solid depends on **[KCET 2005]**
(a) Nature of the gas (b) Pressure of the gas
(c) Temperature of the gas (d)

47. Activated charcoal is used to remove colouring matter from pure substances. It works by **[KCET 2005]**
(a) Oxidation (b) Reduction
(c) Bleaching (d) Adsorption

Catalyst and Catalysis

1. Mark the correct statement in a reversible reaction
[CPMT 1974; EAMCET 1978, 79; MP PMT 1993]
(a) The catalyst catalyses the forward reaction
(b) The catalyst catalyses the backward reaction
(c) The catalyst influences the direct and the reverse reaction to the same extent
(d) The catalyst increases the rate of forward reaction and decreases the rate of backward reaction

2. A catalyst is used **[MP PET 2004]** **[CPMT 1989]**
(a) Only for increasing the velocity of the reaction
(b) For altering the velocity of the reaction
(c) Only for decreasing the velocity of the reaction
(d) All (a), (b) and (c) are correct

3. A catalyst is a substance which **[NCERT 1981; CPMT 1996]**
(a) Alters the equilibrium in a reaction
(b) Is always in the same phase as the reactants
(c) Participates in the reaction and provides **[MHCET 2004]** easier pathway for the same
(d) Does not participate in the reaction but speeds it up

4. In Haber's process for the manufacture of ammonia **[AMU 1984; CPMT 1974, 90]**
(a) Finely divided iron is used as catalyst
(b) Finely divided molybdenum is used as catalyst
(c) Finely divided nickel is used as catalyst
(d) No catalyst is necessary

5. When $KClO_3$ is heated, it decomposes into $KCl + O_2$. If some MnO_2 is added, the reaction goes much faster because **[CPMT 1971,76,80,94]**
(a) MnO_2 decomposes to give O_2
(b) MnO_2 provides heat by reacting
(c) Better contact is provided by MnO_2
(d) MnO_2 acts as a catalyst

6. In the reaction $2SO_2 + O_2 \xrightarrow[As_2O_3]{Pt} 2SO_3$, As_2O_3 acts as a

[MP PET 1995]

(a) Autocatalyst (b) Poison

(c) Promotor (d) Positive catalyst

7. Reactions in Zeolite catalysts depend on **[BHU 2000]**

(a) Pores (b) Apertures

(c) Size of cavities (d) All of these

8. What is the role of a catalyst in a catalysed reaction

[MP PMT 1996; Pb. PMT 2000;UPSEAT 2001,02]

(a) Lowers the activation energy

(b) Increases the activation energy

(c) Affects the free energy change

(d) Affects the enthalpy change

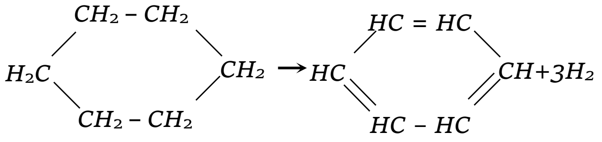
9. The catalyst used in the lead chamber process of sulphuric acid manufacture is

[CPMT 1977]

(a) Platinum (b) Oxide of nitrogen

(c) Nickel (d) Vanadium compounds

10. In the following reaction the catalyst used is



[AMU (Engg.) 1999]

(a) Al_2O_3 (b) Cr_2O_3

(c) Cr_2O_3 and Al_2O_3 (d) Zn dust

11. Enzymes with two sites are called **[AIIMS 2002]**

(a) Apoenzyme (b) Holoenzyme

(c) Allosteric enzyme (d) Conjugate enzyme

12. Which of the following types of metals make the most efficient catalysts **[DPMT 1985]**

(a) Alkali metals (b) Transition metals

(c) Alkaline–earth metals (d) Radioactive metals

13. An example of autocatalytic reaction is **[NCERT 1983]**

(a) The decomposition of nitroglycerine

(b) Thermal decomposition of $KClO_3$ and MnO_2 mixture

(c) Break down of ${}_6C^{14}$

(d) Hydrogenation of vegetable oil using nickel catalysts

14. In the case of auto catalysis

(a) Solvent catalyses

(b) Product catalyses

(c) Reactant catalyses

(d) Heat produced in the reaction catalyses

15. In a reversible reaction, a catalyst will affect the rate of

[KCET (Med.) 2002]

(a) Forward reaction

(b) Reverse reaction

(c) Forward and reverse reaction

(d) Neither (a) nor (b)

16. The role of a catalyst in a reversible reaction is to

[KCET (Med.) 2001]

(a) Increase the rate of forward reaction

(b) Decrease the rate of backward reaction

(c) Alter the equilibrium constant of the reaction

(d) Allow the equilibrium to be achieved quickly

17. The catalyst used in the contact process for manufacturing of sulphuric acid is **[MP PMT 1987]**

(a) Copper (b) Iron/aluminium oxide

(c) Vanadium pentoxide (d) Platinized asbestos

18. For the functioning of enzymes which of the following statements is not correct **[MP PMT 2000]**

(a) An optimum temperature is needed

(b) An optimum pH is needed

(c) They are substrate specific

(d) They always increase activation energy

19. When a catalyst is added to a system the **[JIPMER 2000]**

(a) Value of equilibrium constant is decreased

(b) The rate of forward reaction is increased and that of backward reaction is decreased

(c) Equilibrium concentrations are unchanged

(d) Equilibrium concentrations are increased

20. A catalyst can affect reversible reaction by **[CPMT 2002]**

(a) Changing equilibrium

(b) Slowing forward reaction

(c) Attaining equilibrium in both direction

(d) None of these

21. $\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{dil.\,H_2SO_4} \underset{\text{Fructose}}{C_6H_{12}O_6\,(aq)} + \underset{\text{Glucose}}{C_6H_{12}O_6(aq)}$

In this reaction, dilute H_2SO_4 is called **[AFMC 1997]**

(a) Homogeneous catalysis (b) Homogeneous catalyst

(c) Heterogeneous catalysis (d) Heterogeneous catalyst

22. Which one of the following statement is wrong in case of enzyme catalysis **[MP PMT 1985, 2001]**

(a) Enzymes work best at an optimum temperature

(b) Enzymes work at an optimum pH

(c) Enzymes are highly specific for substances

(d) An enzyme raises activation energy

23. Which of the following catalyses the conversion of glucose into ethanol

[CPMT 1983, 84; CBSE PMT 1989; KCET 1993]

(a) Zymase (b) Invertase

(c) Maltase (d) Diastase

24. Which of the following is used as a catalyst in the manufacture of toluene from benzene with CH_3Cl

[KCET (Med.) 2002]

[CPMT 1985]

(a) Ni (b) Anhydrous $AlCl_3$

(c) Pd (d) Pt

25. Hydrolysis of ethyl acetate is catalysed by aqueous

[MP PMT 2002]

(a) Na_2SO_4 (b) K_2SO_4

(c) H_2SO_4 (d) $BaSO_4$

26. Which of the following statements about a catalyst is true **[AIIMS 1996]**

(a) It lowers the energy of activation

(b) The catalyst altered during the reaction is regenerated

(c) It does not alter the equilibrium

(d) All of these

27. Which of the following statements is true for a catalyst

(a) It increases the energy of the reactants

(b) It decreases the energy of the products

(c) It decreases the energy of the reactants

(d) It does not change the enthalpy of the reactants

28. Which is not a characteristic of a catalyst **[AFMC 1992]**

(a) It changes the equilibrium constant

(b) It alters the reaction path

(c) It increases the rate of reaction

(d) It increases the average K.E. of the molecules

29. Which one of the following statements is correct in reversible reaction. A catalyst **[MP PET 1994; EAMCET 1987]**

(a) Increases the rate of forward reaction

(b) Decreases the rate of forward reaction

(c) Increases the rate of backward and forward reactions

(d) Alters the equilibrium constant of the reaction

30. A catalyst **[MNR 1987; UPSEAT 2002]**

(a) Increases the free energy change in the reaction

(b) Decreases the free energy change in the reaction

(c) Does not increase or decrease the free energy change in the reaction

(d) Can either increase or decrease the free energy change depending on what catalyst we use

31. Which one of the following changes when catalyst is used in a reaction

(a) Heat of reaction (b) Product of reaction

(c) Equilibrium constant (d) Activation energy

32. In the reversible reaction a catalyst is the substance which **[CBSE PMT 1992]**

(a) Increases the rate of the forward reaction

(b) Decreases the value of enthalpy change in the reaction

(c) Reduces the time required for reaching the equilibrium state in the reaction

(d) Decreases the rate of the reverse reaction

33. In the titration between oxalic acid and acidified potassium permanganate, the manganous salt formed catalyses the reaction. The manganous salt is **[KCET 1992]**

(a) A promoter (b) A positive catalyst

(c) An autocatalyst (d) None of these

34. Which one of the following statements is incorrect in the case of heterogeneous catalysis **[CPMT 199**

(a) The catalyst lowers the energy of activation

(b) The catalyst actually forms a compound with the reactant

(c) The surface of the catalyst plays a very important role

(d) There is no change in the energy of activation

35. Regarding criteria of catalysis which one of the following statements is not true **[CPMT 1990]**

(a) The catalyst is unchanged chemically at the end of the reaction

(b) A small quantity of catalyst is often sufficient to bring about a considerable amount of reaction

(c) In a reversible reaction the catalyst alters the equilibrium position

(d) The catalyst accelerates the reaction

36. Which of the following reaction is catalysed by enzyme maltase **[MP PMT 2003]**

(a) Starch → maltose

(b) Maltose → glucose

(c) Lactose → maltose

(d) Maltose → glucose + fructose

37. The efficiency of an enzyme in catalysing a reaction is due to its capacity

(a) To form a strong enzyme-substrate complex

(b) To decrease the bond energies of substrate molecule

(c) To change the shape of the substrate molecule

(d) To lower the activation energy of the reaction

38. A catalyst in a chemical reaction **[BHU 1998]**

(a) Does not initiate a reaction

(b) Increases the activation energy of the reaction

(c) Changes the equilibrium constant of a reaction

(d) Does not change the rate of the reaction

39. Platinized asbestos is used as a catalyst in the manufacture of H_2SO_4. It is an example of **[CPMT 1975]**

(a) Heterogeneous catalyst (b) Autocatalyst

(c) Homogenous catalyst (d) Induced catalyst

40. Catalyst used in hydrogenation of oils is **[CPMT 1975; MNR 1986; DPMT 1982, 85; BHU 1973, 87; EAMCET 1987; AFMC 1993; CET Pune 1998]**

(a) Pt (b) Mo

(c) Fe (d) Ni

41. Addition of catalyst in a system **[MP PMT 1992]**

(a) Increases equilibrium concentrations

(b) No effect on equilibrium concentrations

(c) Decreases equilibrium concentrations

(d) Increases rate of forward reaction and decreases rate of backward reaction

42. In which of the following processes, platinum is used as a catalyst **[NCERT 1978, 79]**

(a) Oxidation of ammonia to form nitric acid

(b) Hardening of oils
(c) Production of synthetic rubber
(d) Synthesis of methanol

43. Enzymes are **[CPMT 1974, 81]**
(a) Micro-organisms (b) Proteins
(c) Inorganic compounds (d) Moulds

44. Protons accelerate the hydrolysis of esters. This is an example of **[MP PMT 1987]**
(a) A heterogeneous catalysis
(b) An acid-base catalysis
(c) A promoter
(d) A negative catalyst

45. Which of the following processes does not involve a catalyst
[KCET 1991; AIIMS 1996]
(a) Haber's process (b) Thermite process
(c) Ostwald process (d) Contact process

46. Which of the statement is wrong among the following
[AFMC 1993]
(a) Haber's process of NH_3 requires iron as catalyst
(b) Friedel–Craft's reaction uses anhydrous $AlCl_3$
(c) Hydrogenation of oils uses iron as catalyst
(d) Oxidation of SO_2 to SO_3 requires V_2O_5

47. A catalyst is a substance which
(a) Increases the rate of a reaction
(b) Increases the amount of the products formed in a reaction
(c) Decreases the temperature required for the reaction
(d) Alters the speed of the reaction remaining unchanged chemically at the end of the reaction

48. In the Ostwald's process for the manufacture of HNO_3, the catalyst used is**[AMU 1982, 83; MP PET 1999]**
(a) Mo (b) Fe
(c) Ni (d) Pt

49. A biological catalyst is essentially
[NCERT 1978; AFMC 1998]
(a) An amino acid (b) A carbohydrate
(c) The nitrogen molecule (d) An enzyme

50. A catalyst added to a reaction mixture
(a) Increases the equilibrium constant
(b) Decreases the equilibrium constant
(c) Does not change the equilibrium constant
(d) None of these

51. The components of Zigler Natta catalyst, used in the polymerisation of propylene, are
(a) $TiCl_3 + Al(C_2H_5)_3$ (b) $TiCl_4 + Al(C_2H_5)_3$
(c) $Ti(C_2H_5)_3 + AlCl_3$ (d) $Ti(C_2H_5)_4 + AlCl_3$

52. Which of the following statements regarding catalyst is not true
[CPMT 1983, 84; MNR 1993; KCET 1999]
(a) A catalyst remains unchanged in composition and quantity at the end of the reaction
(b) A catalyst can initiate a reaction
(c) A catalyst does not alter the equilibrium in a reversible reaction
(d) Catalyst are sometimes very specific in respect of reaction

53. The enzyme ptylin used for the digestion of food is present in
[CPMT 1981]
(a) Saliva (b) Blood
(c) Intestine (d) Adrenal glands

54. Amongst the following chemical reactions, the one representing homogeneous catalysis is**[MP PMT 1999]**
(a) $N_2(g) + 3H_2(g) \xrightarrow{Fe} 2NH_3(g)$
(b) $2SO_2(g) + O_2(g) \xrightarrow{2NO} 2SO_3(g) + 2NO(g)$
(c) $CO(g) + 3H_2(g) \xrightarrow{Ni} CH_4(g) + H_2O$
(d) $2SO_2(g) + O_2(g) \xrightarrow{V_2O_5} 2SO_3(g)$

55. Platinised asbestos helps in the formation of SO_3 form SO_2 and O_2. But, if even a small amount of As_2O_3 is present the platinised asbestos does not help in the formation of SO_3. As_2O_3 acts here as**[MP PMT**
(a) A positive catalyst (b) A negative catalyst
(c) An autocatalyst (d) A poison

56. Which of the following statements is wrong
(a) Catalysts can aid a rapid reaching of the equilibrium position, but do not change the position of the equilibrium
(b) Homogeneous catalysis generally involves an equilibrium reaction between at least one of the reactants and the catalyst
(c) Heterogeneous catalysis involves chemisorption on the surface of the catalyst
(d) Positive catalysts raise the energy of activation of the reaction they catalyse

57. Which one is *false* in the following statement
[MP PET 1997]
(a) A catalyst is specific in its action
(b) A very small amount of the catalyst alters the rate of a reaction
(c) The number of free valencies on the surface of the catalyst increases on subdivision
(d) Ni is used as catalyst in the manufacture of ammonia

58. In the redox reaction

$$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \rightleftharpoons 2Mn^{2+} + 10CO_2 + 8H_2O$$

The ion acting as autocatalyst is
[MP PMT 2003]
(a) MnO_4^- (b) $C_2O_4^{2-}$
(c) H^+ (d) Mn^{2+}

59. In a homogeneous catalysis
(a) The catalyst and the reactants should be gases
(b) The catalyst and the reactants should form a single phase

(c) Catalyst and the reactants are all solids
(d) The catalyst and the reactions are all liquids

60. Which of the following statements is incorrect **[CPMT 1985]**
(a) Enzymes are in colloidal state
(b) Enzymes are catalysts
(c) Enzymes can catalyse any reaction
(d) Urease is an enzyme

61. Enzymes are **[BHU 1982]**
(a) Substances made by chemists to activate washing powder
(b) Very active vegetable catalysts
(c) Catalysts found in organism
(d) Synthetic catalysts

62. Catalyst used in the oxidation of $SO_2 \to SO_3$ **[AIIMS 1996]**
(a) Nickel (b) $ZnO.Cr_2O_3$
(c) V_2O_5 (d) Iron

63. Which requires catalyst **[AFMC 1987; MP PET 1999]**
(a) $S + O_2 \to SO_2$ (b) $2SO_2 + O_2 \to 2SO_3$
(c) $C + O_2 \to CO_2$ (d) All

64. The process which is catalysed by one of the products is called**[MP PET 1999; AIIMS 2000; J & K 2005]**
(a) Acid-base catalysis (b) Autocatalysis
(c) Negative catalysis (d) None of these

65. Adam's catalyst is **[Pb.CET 2001]**
(a) Platinum (b) Iron
(c) Molybdenum (d) Nickel

66. A catalyst remains unchanged at the end of the reaction regarding **[MP PET 1995]**
(a) Mass
(b) Physical state
(c) Physical state and chemical composition
(d) Mass and chemical composition

67. Wilhem Ostwald redefined the action of **[Kerala (Med.) 2002]**
(a) Anamers
(b) Isomers
(c) Catalyst
(d) Geometry of monomers

68. In a reversible reaction, a catalyst used
(a) Increases the speed of the forward reaction
(b) Decreases the speed of the backward reaction
(c) Does not alter the final state of equilibrium
(d) Increases the amount of the products formed

69. Enzyme activity is maximum at **[KCET 1989]**
(a) 300 K (b) 310 K
(c) 320 K (d) 330 K

70. A catalyst is used to **[Pb.CET 2000]**
(a) Increase the product
(b) Increase or decrease the rate of reaction
(c) Increase or decrease the products
(d) Decrease the products

71. The transition metal used as a catalyst is**[Pb. PMT 2004]**
(a) Nickel (b) Platinum
(c) Cobalt (d) All of these

72. Which of the following is true about catalyst**[Pb.CET 2000**
(a) It initiates reaction
(b) It changes equilibrium point
(c) It increase average kinetic energy
(d) It accelerates the rate of reaction

73. Which of the following types of metals form the most efficient catalysts **[KCET 2005]**
(a) Alkali metals
(b) Alkaline earth metals
(c) Transition metals
(d) All of these

74. Formation of ammonia from H_2 and N_2 by Haber's process using Fe is an example of **[J & K 2005]**
(a) Heterogeneous catalysis (b)Homogeneous catalysis
(c) Enzyme catalysis (d) Non-catalytic process

Colloids, Emulsion, Gel and Their properties with application

1. Gold number is **[MP PET/PMT 1988]**
(a) The number of *mg* of lyophilic colloid which should be added to 10 *ml* of ferric hydroxide sol so as to prevent its coagulation by the addition of 1 *ml* of 10% sodium chloride solution
(b) The number of *mg* of lyophilic colloid which should be added to 10 *ml* of standard gold sol so as to prevent its coagulation by the addition of 1 *ml* of 10% $NaCl$
(c) The *mg* of gold salt to be added to a lyophilic colloid to coagulate it
(d) The *mg* of an electrolyte required to coagulate a colloid

2. Which of the following statement is wrong for lyophobic sol
(a) Dispersed phase is generally in organic material
(b) Can be easily coagulated by small addition of electrolyte
(c) Dispersed phase particles are poorly hydrated and colloid is stabilised due to charge on the colloidal particles
(d) Reversible in nature that is after coagulation can be easily set into colloidal form

3. Which of the following statements is not true for a lyophobic sol
(a) It can be easily solvated

(b) It carries charge

(c) The coagulation of this sol is irreversible in nature

(d) It is less stable in a solvent

4. As_2S_3 sol has a negative charge. Capacity to precipitate it is highest in **[CPMT 1982, 89, 93; DPMT 1983;MP PET 1999]**

(a) $AlCl_3$
(b) Na_3PO_4
(c) $CaCl_2$
(d) K_2SO_4

5. Starch dispersed in hot water is an example of

(a) Emulsion
(b) Hydrophobic sol
(c) Lyophilic sol
(d) Associated colloid

6. Which of the following is most effective in coagulating a ferric hydroxide sol **[MP PET 1993, 97; MP PMT 2000]**

(a) KCl
(b) KNO_3
(c) K_2SO_4
(d) $K_3[Fe(CN)_6]$

7. Sky looks blue due to **[MNR 1986; MP PET 1992]**

(a) Dispersion effect
(b) Reflection
(c) Transmission
(d) Scattering

8. Which one is an example of gel

(a) Soap
(b) Cheese
(c) Milk
(d) Fog

9. The random or zig-zag motion of the colloidal particles in the dispersion medium is referred to as **[CPMT 1985; JIPMER 1997; MP PET 2000]**

(a) Electro-osmosis
(b) Electrophoresis
(c) Brownian movement
(d) Tyndall effect

10. Which of the following electrolytes is least effective in causing flocculation of ferric hydroxide sol **[MNR 1991; UPSEAT 1999]**

(a) $K_4[Fe(CN)_6]$
(b) K_2CrO_4
(c) KBr
(d) K_2SO_4

11. If the dispersed phase is a liquid and the dispersion medium is a solid, the colloid is known as **[NCERT 1981; CBSE PMT 1989; KCET 1998]**

(a) A sol
(b) An emulsion
(c) A gel
(d) A foam

12. Zig-zag motion (eratic motion) of particles in colloid was observed by **[CPMT 1985]**

(a) Tyndall
(b) Zsigmondy
(c) Robert brown
(d) Thomas Graham

13. On addition of one ml solution of $10\% NaCl$ to 10 *ml* gold sol in the presence of 0.25 *gm* of starch, the coagulation is just prevented. Starch has the following gold number **[MP PET/PMT 1988]**

(a) 0.025
(b) 0.25
(c) 0.5
(d) 250

14. Tyndall effect would be observed in a **[CPMT 1973, 79, 90, 91, 94; MP PET 1999; MP PMT 1973, 89; DPMT 1982, 83; AFMC 1999]**

(a) Solution
(b) Colloidal solution
(c) Precipitate
(d) Solvent

15. Ferric hydroxide sol is positively charged colloid. The coagulating power of NO_3^-, SO_4^{2-} and PO_4^{3-} ions would be in the order

(a) $NO_3^- > SO_4^{2-} > PO_4^{3-}$
(b) $SO_4^{2-} > NO_3^- > PO_4^{3-}$
(c) $PO_4^{3-} > SO_4^{2-} > NO_3^-$
(d) $NO_3^- = SO_4^{2-} = PO_4^{3-}$

16. A colloidal solution can be purified by **[MP PET 1993; CPMT 1990; MP PMT 2001]**

(a) Filtration
(b) Peptization
(c) Coagulation
(d) Dialysis

17. Gold number is associated with

(a) Only lyophobic colloids
(b) Only lyophilic colloids
(c) Both lyophobic and lyophilic colloids
(d) None of these

18. Which of the following forms a colloidal solution in water **[MP PET 1990; CPMT 1988]**

(a) $NaCl$
(b) Glucose
(c) Starch
(d) Barium nitrate

19. A negatively charged suspension of clay in water will need for precipitation the minimum amount of **[CPMT 1973]**

(a) Aluminium chloride
(b) Potassium sulphate
(c) Sodium hydroxide
(d) Hydrochloric acid

20. Difference between colloids and crystalloids is of **[CPMT 1979]**

(a) Particle composition
(b) Particle size
(c) Concentration
(d) Ionic character

21. The purification of the colloidal particles from crystalloid dimensions through semipermeable membrane is known as **[BHU 1979; MP PMT 1999; CBSE 1996; Pb. CET 2002]**

(a) Coagulation
(b) Dialysis
(c) Ultrafiltration
(d) Peptisation

22. The stability of lyophilic colloids is due to **[CPMT 1971, 81, 83, 93, 96; AFMC 1998; MP PMT 1990, 95; MP PET 1992]**

(a) Charge on their particles

(b) A layer of dispersion medium on their particles

(c) The smaller size of their particles

(d) The large size of their particles

23. Milk is a colloid in which **[MP PMT 1985, 2002; MP PET 2001; JIPMER (Med.) 2002]**

(a) A liquid is dispersed in liquid
(b) A solid is dispersed in liquid
(c) A gas is dispersed in liquid
(d) Some suger is dispersed in water

24. Smoke is an example of **[CPMT 1984; BIT 1992]**

(a) Gas dispersed in liquid (b)Gas dispersed in solid
(c) Solid dispersed in gas (d)Solid dispersed in solid

25. Gold number is minimum in case of **[MP PMT 1985]**
(a) Gelatin (b) Egg albumin
(c) Gum arabic (d) Starch

26. Movement of colloidal particles under the influence of electrostatic field is
[AMU 1985, 88,02; MP PMT 1987, 89; CPMT 1988,94; Roorkee 1995; MP PET 1992; AIIMS 2001; UPSEAT 2004]
(a) Electrophoresis (b) Electrolysis
(c) Dialysis (d) Ionisation

27. Which of the following substances gives a positively charged sol
(a) Gold (b) A metal sulphite
(c) Ferric hydroxide (d) An acidic dye

28. Light scattering in colloidal particles is
(a) Visible to naked eye
(b) Not visible by any means
(c) Visible under ordinary microscope
(d) Visible under ultra-microscope

29. Flocculation value is expressed in terms of**[MP PMT 1986]**
(a) millimole per litre (b) mole per litre
(c) gram per litre (d) mole per millilitre

30. Which of the following is an emulsifier
(a) Soap (b) Water
(c) Oil (d) $NaCl$

31. Suspensions are **[CPMT 1984]**
(a) Visible to naked eye
(b) Invisible through microscope
(c) Not visible by any means
(d) Invisible under electron microscope

32. Gelatin is mostly used in making ice cream in order to
[NCERT 1979; MP PET/PMT 1988]
(a) Prevent making of colloid
(b) To stabilise the colloid and prevent crystallisation
(c) To stabilise mixture
(d) To enrich the aroma

33. In emulsions, the dispersion medium and dispersed phase are
(a) Both solids
(b) Both gases
(c) Both liquids
(d) One is solid and other is liquid

34. Lyophilic sols are more stable than lyophobic sols because
[NCERT 1982, 83]
(a) The colloidal particles have positive charge
(b) The colloidal particles have no charge
(c) The colloidal particles are solvated
(d) There are strong electrostatic repulsions between the negatively charged colloidal particles

35. Which is the correct statement in case of milk
[CPMT 1977; MNR 1988; UPSEAT 2000, 01, 02]
(a) Milk is an emulsion of protein in water
(b) Milk is an emulsion of fat in water
(c) Milk is stabilised by protein
(d) Milk is stabilised by fat

36. Which of the following electrolytes have maximum coagulating power
(a) CCl_4 (b) $ZnCl_2$
(c) KCl (d) $NaCl$

37. Which one of the following is not a colloidal solution
[MADT Bihar 1983]
(a) Smoke (b) Ink
(c) Air (d) Blood
[CPMT 1983, 84; MP PMT 1990; MP PET 1992]

38. Detergent action of soap is due to
(a) Emulsification properties (b)
(c) Ionization (d) High molecular weight

39. When dispersion medium is water, the colloidal system is called **[MP PMT 1986]**
(a) Sol (b) Aerosol
(c) Organosol (d) Aquasol

40. When a freshly precipitated substance is converted into a colloidal solution with the help of a third substance, the process is known as
(a) Coagulation (b) Peptization
(c) Electrodispersion (d) Dialysis

41. Which of the following will have highest coagulating power for As_2S_3 colloid
[CPMT 1988; DPMT 1984; Pb. PMT 2001; Pb. CET 2004]
(a) PO_4^{-3} (b) SO_4^{-2}
(c) Na^+ (d) Al^{3+}

42. Which one of the following is a hydrophobic sol
[MP PET 1991]
(a) Starch solution
(b) Gum solution
(c) Protein solution
(d) Arsenic sulphide solution

43. Purification of colloids is done by the process of
[CPMT 1988]
(a) Electrophoresis (b) Electrodispersion
(c) Peptization (d) Ultra-filteration

44. Which of the following terms is not related with colloids
[CPMT 1985, 87, 88]
(a) Dialysis (b) Ultrafiltration
(c) Wavelength (d) Brownian movement

45. When dispersed phase is liquid and dispersion medium is gas, then the colloidal system is called**[CPMT 19**
(a) Smoke (b) Clouds
(c) Emulsion (d) Jellies

46. Tyndall phenomenon is exhibited by **[CPMT 1985]**
(a) $NaCl$ solution (b) Starch solution
(c) Urea solution (d) $FeCl_3$ solution

47. The colloidal solution of gelatin is known**[CPMT 1984]**

(a) Solvent loving sol (b) Reversible sol
(c) Hydrophilic colloids (d) All of these

48. The zig-zag motion of colloidal particles is due to
(a) Small size of colloidal particles
(b) Large size of colloidal particles
(c) The conversion of potential energy into kinetic energy
(d) Bombardment on colloidal particles by molecules of dispersion medium

49. Which is a natural colloidal **[DPMT 1985]**
(a) Sodium chloride (b) Urea
(c) Canesugar (d) Blood

50. Sodium stearate forms in water
(a) True solution (b) A suspension
(c) An emulsion (d) A colloidal solution

51. Blood contains
(a) Positively charged particles
(b) Negatively charged particles
(c) Neutral particles
(d) Negatively as well as positively charged particles

52. Brownian motion is due to
[MNR 1987; CPMT 1987; UPSEAT 2001, 02]
(a) Temperature fluctuation within the liquid phase
(b) Attraction and repulsion between charge on the colloidal
(c) Impact of molecules of the dispersion medium on the colloidal particles
(d) Convective currents

53. Milk can be preserved by adding a few drops of
[MADT Bihar 1981]
(a) Formic acid solution
(b) Formaldehyde solution
(c) Acetic acid solution
(d) Acetaldehyde solution

54. When a colloidal solution is observed under a microscope we can see **[CPMT 1985]**
(a) Light scattered by colloidal particles
(b) Size of colloidal particles
(c) Shape of colloidal particles
(d) Relative size of the colloidal particles

55. Property of the colloidal solution is due to
(a) Nature of dispersed phase
(b) Nature of dispersion medium
(c) Physical state of dispersed phase
(d) Temperature of the system

56. Which of the following has minimum value of flocculating power **[MP PET 1989, 90]**
(a) Pb^{+2} (b) Pb^{+4}
(c) Sr^{+2} (d) Na^{+}

57. According to Graham, colloids are those substances which are
(a) Insoluble in water
(b) In solution do not pass through filter paper
(c) Of definite size of particles
(d) Separated from crystalloids by parchment paper

58. The reason for exhibiting Tyndall effect by the colloidal particle is **[CPMT 1980, 86; MP PMT 1989]**
(a) Reflection of light (b) Refraction of light
(c) Polarisation of light (d) Scattering of light

59. Which of the following shows the maximum hydrophobic behaviour **[NCERT 1982]**
(a) Glycerine (b) Stearic acid
(c) Glucose (d) Adenine

60. A liquid aerosol is a colloidal system of **[MP PMT 1987]**
(a) A liquid dispersed in a solid
(b) A liquid dispersed in a gas
(c) A gas dispersed in a liquid
(d) A solid dispersed in a gas

61. The blue colour of water in the sea is due to **[NCERT 1983]**
(a) Refraction of blue light by the impurities in sea water
(b) Reflection of blue sky by sea water
(c) Scattering of blue light by water moleules
(d) Absorption of other colours except the blue colour by water molecules

62. Butter is a colloid. It is formed when
[MNR 1982; MP PET 1991;
MP PMT 1994; CPMT 2002]
(a) Fat is dispersed in solid casein
(b) Fat globules are dispersed in water
(c) Water is dispersed in fat
(d) Casein is suspended in H_2O

63. Colloidal solution cannot be obtained from two such substances which are
(a) Insoluble in each other (b)In same physical state
(c) In different physical state (d)

64. Which of the following reactions leads to the formation of a substance in the colloidal state
[MP PMT 1984; MP PET/PMT 1988]
(a) $Cu + HgCl_2 \rightarrow CuCl_2 + Hg$
(b) $2HNO_3 + 3H_2S \rightarrow 3S + 4H_2O + 2NO$
(c) $2Mg + CO_2 \rightarrow 2MgO + C$
(d) $Cu + CuCl_2 \rightarrow Cu_2Cl_2$
(in presence of excess of HCl)

65. Lyophobic colloids are **[MP PMT 1986; DPMT 1996]**
(a) Reversible colloids (b) Irreversible colloids
(c) Protective colloids (d) Gum proteins

66. Substances whose solutions can readily diffuse through parchment membranes are
(a) Colloids (b) Crystalloids
(c) Electrolytes (d) Non-electrolytes

67. Size of colloidal particles varies from
[CPMT 1982, 90, 93, 97; CBSE PMT 1996;

MP PMT 1995; AIIMS 2002; KCET 2004]

(a) 10^{-7} to $10^{-9}\ m$ (b) 10^{-9} to $10^{-17}\ m$

(c) 10^{-5} to $10^{-7}\ m$ (d) 10^{-4} to $10^{-10}\ m$

68. Which of the following pairs of ions would be expected to form precipitate when their dilute solution are mixed

[CPMT 1976]

(a) Na^+, SO_3^{2-} (b) NH_4^+, CO_3^{2-}

(c) Na^+, S^{-2} (d) Fe^{+3}, PO_4^{-3}

69. Jelly is a form of

(a) Suspension (b) Colloidal solution

(c) Supersaturated solution (d) True solution

70. Bleeding is stopped by the application of ferric chloride. This is because

(a) Ferric chloride seal the blood cells.

(b) Blood starts flowing in the other direction

(c) Blood is coagulated and blood vessel is sealed

(d) None of these

71. The colloidal particles can pass through

(a) Filter paper as well as animal membrane

(b) Animal membrane but not through filter paper

(c) Filter paper but not through animal membrane

(d) Semipermeable membrane

72. The emulsifying agent in milk is

(a) Lactic acid (b) Casein

(c) Lactose (d) Fat

73. Butter is **[MP PMT 1990]**

(a) A gel (b) An emulsion

(c) A sol (d) Not a colloid

74. An emulsion is a colloidal dispersion of **[BCECE 2005]**

(a) A liquid in a gas (b) A liquid in a liquid

(c) A solid in a liquid (d) A gas in a solid

75. The colloidal solution of mercury in water can be easily obtained by

(a) Mechanical precipitation (b)Bredig's arc method

(c) Repeated washing (d) Ultrasonic dispersion

76. The rate of dialysis depends upon

(a) Nature of colloidal substance

(b) Temperature of the solution

(c) Both of these

(d) None of these

77. An emulsifier **[MP PET 1995]**

(a) Accelerates the dispersion

(b) Homogenises the emulsion

(c) Stabilizes the emulsion

(d) Aids the flocculation of emulsion

78. The difference between a lyophilic and lyophobic colloid is in their

(a) Particle size

(b) Behaviour towards dispersion medium

(c) Filtrability

(d) None of these

79. When a substance comes in colloidal state the surface area of the particles

(a) Increases

(b) Decreases

(c) Remains unchanged

(d) First increases then decreases

80. Which of the impurity can be separated from a solution by electrodialysis

(a) Alcohol (b) Alum

(c) Sugar (d) Parchment paper

81. The reason for the stability of a lyophobic sol is

(a) Brownian movement

(b) Tyndall effect

(c) Electric charge

(d) Brownian movement and electric charge

82. For coagulating As_2S_3 colloidal sol, which of the following will have the lowest coagulation value

[MP PMT 1996; DCE 2000]

(a) $NaCl$ (b) KCl

(c) $BaCl_2$ (d) $AlCl_3$

83. Some substances behave as electrolytes in dilute solutions and as colloids in their concentrated solutions. Their colloidal forms are said to form **[AMU 200**

(a) Emulsions (b) Gels

(c) Micelles (d) Sols

84. Which one can act as semipermeable membrane

[Pb. PMT 2002]

(a) Phenol layer (b) $Ca_3(PO_4)_2$

(c) $Cu_2Fe(CN)_6$ (d) All of these

85. In which particles can pass through semipermeable membrane

(a) Molecules of solvent (b) Complex ions

(c) Simple ions (d) Molecules of solute

86. Silver iodide is used for producing artificial rain because AgI

[NCERT 1984]

(a) Is easy to spray at high altitudes

(b) Is easy to synthesize

(c) Has crystal structure similar to ice

(d) Is insoluble in water

87. Surface water contains **[AFMC 2003]**

(a) Salt

(b) Salt and organic compound

(c) Organic compounds

(d) Suspended impurities

88. Gelatin is mixed in ice-cream

(a) As a coagulant (b) For taste

(c) For colour (d) As a protective colloid

89. Which of the following is an example of `water in oil' type emulsion

(a) Butter (b) Milk
(c) Cream (d) Face cream

90. In which of the following Tyndall effect is *not* observed

[MP PET/PMT 1998]

(a) Suspensions (b) Emulsions
(c) Sugar solution (d) Gold sol

91. Which of the following is a lyophilic colloid

[MP PET/PMT 1998]

(a) Milk (b) Gum
(c) Fog (d) Blood

92. Which characteristic is true in respect of colloidal particle

[CPMT 1993; UPSEAT 2000]

(a) They always have two phases
(b) They are only in liquid state
(c) They can't be electrolysed
(d) They are only hydrophilic

93. Gold number is a measure of the

[MP PMT 1989; MP PET 1989,90; DCE 1999; BHU 1999; CBSE PMT 1989]

(a) Protective action by a lyophilic colloid on a lyophobic colloid
(b) Protective action by a lyophobic colloid on a lyophilic colloid
(c) Number of *mg* of gold in a standard red gold sol
(d) Stability of gold sol

94. Sulphur sol contains **[UPSEAT 2002]**

(a) Discrete sulphur atoms
(b) Discrete sulphur molecules
(c) Large agreegates of sulphur molecules
(d) Water dispersed in solid sulphur

95. Pick out the statement which is not relevant in the discussion of colloids

(a) Sodium aluminium silicate is used in the softening of hard water
(b) Potash alum is used in shaving rounds and as antiseptic in medicine
(c) Artificial rain is caused by throwing electrified sand on the clouds from an aeroplane
(d) Deltas are formed at a place where the river pours its water into the sea

96. Surface tension of lyophilic sols is

(a) Lower than H_2O (b) More than H_2O
(c) Equal to H_2O (d) None of these

97. When excess of electrolyte is added to a colloid it

[CBSE PMT 1989]

(a) Coagulates (b) Precipitates
(c) Gets diluted (d) Does not change

98. The shape of colloidal particles is

(a) Sphere like (b) Rod like
(c) Disc like (d) Thread like
(e) All of these

99. Colloidal solution of arsenious sulphide is coagulated by

[MP PMT 1992]

(a) Addition of electrolyte
(b) Addition of non-electrolyte
(c) Addition of solid As_2S_3
(d) None of these

100. Different colloidal particles of gold having different colours, obtained from different methods due to

[MP PET 1989; UPSEAT 2001, 02; EAMCET 2003]

(a) Variable valency of gold
(b) Different concentration of gold particles
(c) Different types of impurities
(d) Different radius of colloidal particles

101. Which one of the following is lyophilic colloid

[MP PET 1989]

(a) Gelatin (b) Sulphur
(c) Gold (d) Carbon

102. Which one of the following properties of colloids is related with scattering of light **[MP PMT 1989]**

(a) Diffusion (b) Peptization
(c) Tyndall effect (d) Brownian movement

103. Which one of the following is a hydrophilic colloidal sol

(a) Barium hydroxide sol (b)Arsenic sulphide sol
(c) Starch solution (d) Silver chloride sol

104. The coagulation power of an electrolyte for arsenious sulphide decreases in the order **[JIPMER 1997]**

(a) Na^+, Al^{+3}, Ba^{+2} (b) $PO_4^{-3}, SO_4^{-2}, Cl^-$
(c) Al^{+3}, Ba^{+2}, Na^+ (d) $Cl^-, SO_4^{-2}, PO_4^{-3}$

[KCET 2003]

105. Size of colloidal particle is **[BCECE 2005]**

(a) 1 *nm* (b) 1 – 100 *nm*
(c) > 100 *nm* (d) > 1000 *nm*

106. The concentration of electrolyte required to coagulate a given amount of As_2S_3 sol is minimum in the case of

[KCET 2003]

(a) Magnesium nitrate
(b) Potassium nitrate
(c) Potassium sulphate

[MP PMT 1992]

(d) Aluminium nitrate

107. When a strong beam of light is passed through a colloidal solution, the light will **[BHU 1996; JIPMER 1997]**

(a) Give a rainbow
(b) Be scattered
(c) Be reflected
(d) Absorbed completely

108. A cleared solution which is again converted into colloidal solution, the process is called **[DPMT 1996]**

(a) Peptisation (b) Electrolytic addition

(c) Electrophoresis (d) None of these

109. In dialysis, colloidal particles are separated from **[DPMT 1996]**

(a) Solvent
(b) Dispersed phase
(c) Ions of electrolytes
(d) Particles of dispersion medium

110. Colour of colloidal solution is due to **[CPMT 1996]**

(a) Different size of colloidal particles
(b) Due to formation of complex
(c) Due to formation of hydrated crystal
(d) None of these

111. Which of the following is property of colloid **[CPMT 1996]**

(a) Scattering of light (b) They show attraction
(c) Dialysis (d) Emulsion

112. The size of particles in suspension, true solution and colloidal solution varies in the order **[BHU 1997]**

(a) Suspension > Colloidal > True solution
(b) Suspension > (Colloidal + True solution)
(c) True solution > Suspension > Colloidal
(d) None of these

113. Which of the following represents surfactant molecule **[JIPMER 1997]**

(a) $C_{17}H_{36}$ (b) $C_{17}H_{25}COO^{-}Na^{+}$
(c) H_2O (d) None of these

114. In lyophilic sols the attraction of sol particles towards the medium is due to

(a) Covalent bond (b) Vander Waal's force
(c) Hydrogen bond (d) None of these

115. If some gelatin is mixed in colloidal solution of gold, then it does

(a) Coagulation of gold
(b) Peptization of gold
(c) Protection of gold sol
(d) Protection of gelatin

116. Emulsifiers are generally

(a) Soap (b) Synthetic detergents
(c) Lyophilic sols (d) All of these

117. In shaving cream, the dispersion medium is

(a) Liquid (b) Gas
(c) Solid (d) None of these

118. The minimum quantity of sodium chloride which is necessary to precipitate 10 litres of sol in two hours is 0.585 *gm*. The flocculation value of sodium chloride is

(a) 0.585 (b) 0.0585
(c) 0.1 (d) One

119. Which one is an example of miceller system

(a) Soap + water (b) Protein + water
(c) Rubber + benzene (d) $As_2O_3 + Fe(OH)_3$

120. "Delta" at the rivers are formed due to

(a) Peptization (b) Coagulation
(c) Hydrolysis (d) Precipitation

121. Tyndall effect is more pronounced in

(a) Hydrophilic sols (b) Hydrophobic sols
(c) Starch solution (d) Both (b) and (c)

122. Emulsifier is mixed to

(a) Increase the stability of emulsion
(b) Decrease the stability of emulsion
(c) Change oil into water like emulsion
(d) None of these

123. White of an egg is partly coagulated by heating which can be again obtained back by some pepsin and little HCl. This process is called

(a) Peptization (b) Coagulation
(c) Precipitation (d) None of these

124. When sugar is added to a colloidal solution it brings about

(a) Ionization (b) Coagulation
(c) Peptization (d) None of these

125. Colloidal solutions of metals like gold, silver and platinum are generally prepared by using **[DPMT 1984]**

(a) Peptization (b) Bredig's arc method
(c) Exchange of solvent (d) Oxidation method

126. Liquid–liquid sols are known as **[CPMT 1999]**

(a) Aerosols (b) Emulsions
(c) Foam (d) Gel

127. Tyndall effect depends upon the

(a) Charge on the colloidal particles
(b) Osmotic pressure of colloidal solution
(c) Difference between the refractive indices of dispersed phase and dispersion medium
(d) Size of colloidal particles

128. Which one of the sols acts as protective colloid **[MP PMT 1990; MP PET 1990, 92; RPET 2003]**

(a) As_2S_3 (b) Gelatin
(c) Au (d) $Fe(OH)_3$

129. The example of heteropolar sol is

(a) Starch sol in water (b) Rubber sol in water
(c) Protein sol in water (d) Sulphur sol

130. In Bredig's arc method some alkali is added because

(a) It increases electrical conductance
(b) To obtain molecular colloid
(c) To obtain colloidal particles of same size
(d) To stabilise the sol

131. Which one of the following is not a colloid **[BIT 1992]**

(a) Milk (b) Blood
(c) Solution of urea (d) Ice cream

132. Milk is an example of **[BIT 1992; CPMT 1994; MP PET 1996; BHU 1996]**

(a) Pure solution (b) Emulsion
(c) Gel (d) Suspension

133. Dialysis is the process of separation of

(a) Suspended particles from colloids

(b) Suspended particles from crystalloids
(c) Colloidal particles from crystalloids
(d) Colloidal particles from gel

134. Minimum concentration of electrolyte which can precipitate any sol is **[BIT 1992]**
(a) Peptization value (b) Gold number
(c) Avogadro's number (d) Flocculation value

135. Whipped cream is an example of

	Dispersion medium	Dispersed phase
(a)	Gas	Liquid
(b)	Liquid	Gas
(c)	Liquid	Liquid
(d)	Liquid	Solid

136. Milk is **[MP PMT 1995;CPMT 1988; MP PET 1991; MNR 1982]**
(a) Dispersed fats in oil (b) Dispersed fats in water
(c) Dispersed water in fats (d) Dispersed water in oil

137. A coagulating agent frequently added to water to remove the suspended and colloidal impurities is
(a) Mohr salt (b) Alum
(c) Bleaching powder (d) Copper sulphate

138. $Fe(OH)_3$ when treated with $FeCl_3$ solution a reddish-brown solution is formed. The process involved is **[AFMC 1982]**
(a) Dispersion (b) Exchange of solvent
(c) Peptization (d) None of these

139. Alum purifies muddy water by
(a) Dialysis (b) Absorption
(c) Coagulation (d) Forming a true solution

140. Which of the following statements is not true for a lyophilic sol
(a) It can be easily solvated
(b) It carries no charge
(c) Coagulation of this sol is reversible in nature
(d) It is not very stable in a solvent

141. High concentration of gelatin in water on heating gives colloidal solution, which is called
(a) Foam (b) Gel
(c) Gas (d) Air

142. Size of colloidal particle is **[CPMT 1988; MP PMT 1991; RPET 2000]**
(a) 1 to 10 Å (b) 20 to 50 Å
(c) 10 to 1000 Å (d) 1 to 280 Å

143. Which one is Freundlich's equation
(a) $\frac{x}{m} = \log K + \frac{1}{n} \log P$ (b) $\frac{x}{m} = \exp(-KP)$
(c) $\frac{x}{m} = KP^2$ (d) $\log \frac{x}{m} = \log K + \frac{1}{n} \log C$

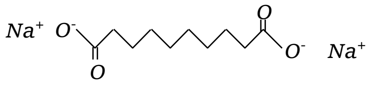
144. Ferric chloride is applied to stop bleeding cut because
(a) Fe^{3+} ion coagulates blood, which is a negatively charged sol
(b) Fe^{3+} ion coagulates blood, which is a positively charged sol
(c) Cl^- coagulates blood, which is a positively charged sol
(d) Cl^- ion coagulates blood, which is a negatively charged sol
[MNR 1978]

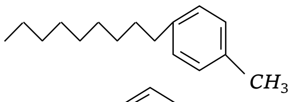
145. At the critical micelle concentration, the surfactant molecules **[CBSE PMT 1998]**
(a) Decompose
(b) Dissociate
(c) Associate
(d) Become completely soluble

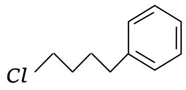
146. The decomposition of H_2O_2 can be slowed down by the addition of small amount of phosphoric acid which act as **[JIPMER 2000]**
(a) Promoter (b) Inhibitor
(c) Detainer (d) Stopper

147. Which of the following molecules is most suitable to disperse benzene in water **[AIIMS 2005]**

(a) 

(b) 

(c) 

(d) 

148. Luminosity observed as a result of scattering of light by particles is observed in **[RPET 2000]**
(a) Suspension (b) Colloidal solution
(c) True solution (d) None of these

149. Which of the following makes the lyophilic solution unstable **[MP PMT 1994]**
(a) Dialysis
(b) Addition of electrolyte
(c) Addition of alcohol
(d) Addition of alcohol and electrolyte both

150. A detergent is a **[CPMT 1993]**
(a) Cleaning agent (b) Drug
(c) Catalyst (d) Vitamin

151. Gold number is related with **[MP PET 2000]**
(a) Colloids (b) Radioactivity
(c) Gas equation (d) Kinetic energy

152. Small liquid droplets dispersed in another liquid is called **[Pb. PMT 2000]**
(a) Gel (b) Emulsion
(c) Suspension (d) True solution

153. Which of the following is used for the destruction of colloids **[CBSE PMT 2000]**

(a) Dialysis (b) Condensation

(c) By ultrafiltration (d) By adding electrolyte

154. An example of an associated colloid is **[CBSE PMT 2000; MP PET 2000]**

(a) Milk (b) Soap solution

(c) Rubber latex (d) Vegetable oil

155. The movement of colloidal particles towards the oppositely charged electrodes on passing electricity is known as **[AFMC 2000]**

(a) Cataphoresis (b) Tyndall effect

(c) Brownian movement (d) None of these

156. Tyndall effect is shown by **[Pb. PMT 1999]**

(a) Sol (b) Solution

(c) Plasma (d) Precipitation

157. Colloidal solutions of gold prepared by different methods have different colours owing to **[JIPMER 1999]**

(a) The difference in the size of the colloidal particles

(b) The fact that gold exhibits a variable valency of + 1 and + 3

(c) Different concentrations of gold

(d) Presence of different types of foreign particles depending upon the method of preparation of the colloid

158. Which of the following colloids are formed when hydrogen sulphide gas is passed through a cold solution of arsenious oxide

(a) As_2S_3 (b) As_2O_3

(c) As_2S (d) As_2H_2

159. The simplest way to check whether a system is colloidal, is **[KCET (Med.) 2002]**

(a) Tyndall effect (b) Electro dialysis

(c) Brownian movement (d) Finding out particle size

160. Fog is an example of colloidal system **[MNR 1985; NCERT 1985; CPMT 1988; MP PMT 1991; MP PET 1996; UPSEAT 1999, 2000]**

(a) Liquid dispersed in gas (b) Gas dispersed in gas

(c) Solid dispersed in gas (d) Gas dispersed in liquid

161. In the measurement of gold number, the useful electrolyte is

(a) $AuCl_3$ (b) $NaCl$

(c) $AlCl_3$ (d) $FeCl_3$

162. Blood may be purified by **[MP PMT 2000]**

(a) Dialysis (b) Electro-osmosis

(c) Coagulation (d) Filtration

163. The stability of lyophilic colloidal sol is due to

(a) Both charge and solvation

(b) Only solvation

(c) Only charge

(d) None of these

164. The impurities present in rain water possess ..... charge

(a) Positive (b) Negative

(c) Zero (d) Positive and negative

165. Sodium lauryl sulphate is **[RPET 2003]**

(a) Cationic sol (b) Anionic sol

(c) Neutral sol (d) None of these

166. Which of the following statement is false

(a) Every solid substance can be brought into colloidal state

(b) Colloidal particles carry electrical charges

(c) Every solid substance can be made to behave like a lyophilic colliod

(d) Addition of electrolytes causes flocculation of colloidal particles

167. Which is a colloid **[CPMT 1984]**

(a) Sugar solution (b) Urea solution

(c) Silicic acid (d) $NaCl$ solution

168. Alum helps in purifying water by **[AIEEE 2002]**

(a) Forming Si complex with clay particles

(b) Sulphate part which combines with the dirt and removes it

(c) Aluminium which coagulates the mud particles

(d) Making mud water soluble

169. Maximum coagulation power is in **[CPMT 2000]**

(a) Na^+ (b) Ba^{++}

(c) Al^{+++} (d) Sn^{++++}

170. Which of the following is not an emulsion **[MP PET 2003]**

(a) Butter (b) Ice cream

(c) Milk (d) Cloud

171. Colloidal solution of gold cannot be prepared by

(a) Bredig's arc method (b) Mechanical dispersion

(c) Reduction of gold chloride (d) Exchange of solvents

172. Which of the following ions can cause coagulation of proteins **[KCET 2000]**

(a) Ag^+ (b) Na^+

(c) Mg^{++} (d) Ca^{++}

173. Light scattering takes place in **[MP PMT 1991; BHU 2000; AFMC 2001; Kerala PET 2002]**

(a) Solutions of electrolyte (b) Colloidal solutions

(c) Electrodialysis (d) Electroplating

174. Which of the following can stabilize gold sol from coagulation by $NaCl$ solution

(a) $Fe(OH)_3$ (b) Gelatin

(c) As_2S_3 (d) None of these

175. At isoelectric point

(a) Colloidal sol becomes highly stable

(b) Precipitation of a colloidal sol takes place

(c) Colloidal particles becomes uncharged
(d) Peptization can be carried out

176. Which one is an example of multimolecular colloid system
(a) Soap dispersed in water (b) Protein dispersed in water
(c) Gold dispersed in water (d) Gum dispersed in water

177. Metals like Pt and Pd can adsorb large volume of hydrogen under specific conditions. Such adsorbed hydrogen by the metal is known as
(a) Occluded hydrogen (b) Absorbed hydrogen
(c) Reactive hydrogen (d) Atomic hydrogen

178. A colloidal system in which gas bubbles are dispersed in a liquid is known as **[MP PMT 1993]**
(a) Foam (b) Sol
(c) Aerosol (d) Emulsion

179. On adding few drops of dilute HCl or $FeCl_3$ to freshly precipitated ferric hydroxide a red coloured colloidal solution is obtained. The phenomenon is known as
[NCERT 1981; AFMC 1982; MP PMT 1989, 97]
(a) Peptisation (b) Dialysis
(c) Protective action (d) Dissolution

180. Surface tension of lyophilic sols is **[MP PMT 2002]**
(a) Lower than that of H_2O (b) More than that of H_2O
(c) Equal to that of H_2O (d) None of these

181. Which of the following is not true of a detergent molecule
[JIPMER 2002]
(a) It has a non-polar organic part and a polar group
(b) It is not easily biodegraded
(c) It is a sodium salt of fatty acid
(d) It is a surface active agent

182. Which of the following can act as protective colloids
(a) Hydrophobic sols (b) Hydrophilic sol
(c) Gold sol (d) None of these

183. Which of the following substances is not used for preparing lyophilic sols **[MP PET 2002]**
(a) Starch (b) Gum
(c) Gelatin (d) Metal sulphide

184. Hydrophilic sols are
(a) Reversible (b) Irreversible
(c) Unstable (d) None of these

185. Soap essentially forms a colloidal solution in water and removes the greasy matter by
(a) Absorption (b) Emulsification
(c) Coagulation (d) None of these

186. Toilet soap is a mixture of **[UPSEAT 2001]**
(a) Calcium and sodium salts of fatty acids
(b) Fatty acids and glycerol
(c) Sodium salts of fatty acids
(d) Potassium salt of fatty acids

187. Gold sol is an electronegative sol. The amount of electrolyte required to coagulate a certain amount of gold sol is minimum in the case of
(a) $CaCl_2$ (b) $NaCl$
(c) $AlCl_3$ (d) Na_2SO_4

188. In the case of small cuts, bleeding is stopped by applying potash alum. Here alum acts as **[KCET (Med.) 200**
(a) Fungicide (b) Disinfectant
(c) Germicide (d) Coagulating agent

189. If gold number of A,B,C and D are 0.005, 0.05, 0.5 and 5 respectively, then which of the following will have the highest protective power **[Pb. CET 2001; CPM**
(a) A (b) B
(c) C (d) D

190. Bredig arc method can not be used to prepare colloidal solution of which of the following **[AFMC 2004]**
(a) Pt (b) Fe
(c) Ag (d) Au

191. Gold number is maximum for the lyophilic sol is
[BVP 2004]
(a) Gelatin (b) Haemoglobin
(c) Sodium oleate (d) Potato starch

192. Which of the following is the best protective colloid
[UPSEAT 2004]
(a) Gelatin (Gold No. = 0.005)
(b) Gum arabic (Gold No. = 0.15)
(c) Egg albumin (Gold No. = 0.08)
(d) None of these

193. The gold number of A, B C and D are 0.04, 0.002, 10 and 25 respectively. Protective power of A, B, C and D are in order **[DCE 2003]**
(a) $A > B > C > D$ (b) $B > A > C > D$
(c) $D > C > B > A$ (d) $C > A > B > D$

194. A catalyst is a substance which **[Pb. CET 2004]**
(a) Is always in the same phase as in the reactions
(b) Alters the equilibrium in a reaction
(c) Does not participate in the reaction but alters the rate of reaction
(d) Participates in the reaction and provide an easier pathway for the same

195. Cod liver oil is **[MHCET 2004]**
(a) An emulsion (b) Solution
(c) Colloidal solution (d) Suspension

196. Paste is **[MHCET 2004]**
(a) Suspension of solid in a liquid
(b) Mechanical dispersion of a solid in liquid
(c) Colloidal solution of a solid in solid
(d) None of these

197. A precipitate is changed to colloidal solution by the following process **[UPSEAT 2004]**
(a) Dialysis (b) Ultrafiltration
(c) Peptization (d) Electrophoresis

198. An aerosol is a **[UPSEAT 2004]**

(a) Dispersion of a solid or liquid in a gas
(b) Dispersion of a solid in a liquid
(c) Dispersion of a liquid in a liquid
(d) Solid solution

199. Lyophilic sols are **[IIT 2005]**
(a) Irreversible sols
(b) They are prepared from inorganic compound
(c) Coagulated by adding electrolytes
(d) Self–stabilizing

200. The volume of a colloidal particle, V_C as compared to the volume of a solute particle in a true solution V_S, could be **[AIEEE 2005]**
(a) $\frac{V_C}{V_S} \simeq 1$ (b) $\frac{V_C}{V_S} \simeq 10^{23}$
(c) $\frac{V_C}{V_S} \simeq 10^{-3}$ (d) $\frac{V_C}{V_S} \simeq 10^{3}$

201. The disperse phase in colloidal iron (III) hydroxide and colloidal gold is positively and negatively charged, respectivley. Which of the following statements is NOT correct **[AIEEE 2005]**
(a) Magnesium chloride solution coagulates, the gold sol more readily than the iron (III) hydroxide sol
(b) Sodium sulphate solution causes coagulation in both sols
(c) Mixing the sols has no effect
(d) Coagulation in both sols can be brought about by electrophoresis

202. The surface tension of which of the following liquid is maximum ? **[CBSE PMT 2005]**
(a) H_2O (b) C_6H_6
(c) CH_3OH (d) C_2H_5OH

203. Which one of the following forms micelles in aqueous solution above certain concentration ? **[CBSE PMT 2005]**
(a) Urea
(b) Dodecyl trimethyl ammonium chloride
(c) Pyridinium chloride
(d) Glucose

204. Alum is a water purifier because it **[KCET 2005]**
(a) Coagulates the impurities
(b) Softens hard water
(c) Gives taste
(d) Destroys the pathogenic bacteria

205. An emulsifier is a substance which **[KCET 2005]**
(a) Stabilises the emulsion
(b) Homogenises the emulsion
(c) Coagulates the emulsion
(d) Accelerates the dispersion of liquid in liquid

206. Muddy water can be purified through coagulation using **[J & K 2005]**
(a) Common salt (b) Alums
(c) Sand (d) Lime

207. Fog is a colloidal solution of **[J & K 2005]**
(a) Solid in gas (b) Liquid in gas
(c) Gas in liquid (d) Gas in solid

208. Lyophilic sols are more stable than lyophobic sols because their particles are **[Karala CET 2005]**
(a) Positively charged (b) Negatively charged
(c) All soluble (d) Attract each other
(e) Are heavier

209. Oils and fats are obtained by saponification of potassium stearate. Its formula is $CH_3-(CH_2)_{16}-COO^-K^+$. Lyophobic end of atom is (CH_3) and lyophilic end is COO^-K^+. potassium stearate is example of **[Kerala CET 2005]**
(a) Lyophobic colloids (b) Lyophilic colloids
(c) Poly molecular colloids (d)
(e) Combined colloids or Miscells

Critical Thinking

Objective Questions

1. Which of the following is contributed towards the extra stability of lyophilic colloids
(a) Hydration (b) Charge
(c) Colour (d) Tyndall effect

2. Which of the following methods is used for sol destruction **[CPMT 1988]**
(a) Condensation
(b) Dialysis
(c) Diffusion through animal membrane
(d) Addition of an electrolyte

3. A catalyst is a substance which **[IIT 1983]**
(a) Increases the equilibrium concentration of the product
(b) Changes the equilibrium constant of the reaction
(c) Shortens the time to reach equilibrium
(d) Supplies energy to the reaction

4. The decomposition of hydrogen peroxide can be slowed by the addition of a small amount of acetamide. The latter acts as a
(a) Detainer (b) Stopper
(c) Promoter (d) Inhibitor

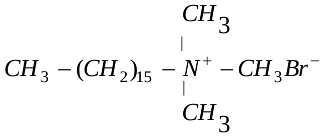
5. The ability of an ion to bring about coagulation of a given colloid depends upon **[CPMT 1980; MP PET/PMT 198 CBSE PMT 1997; MP PMT 1989; MP PET 1994]**
(a) Its size
(b) The magnitude of its charge only
(c) The sign of its charge
(d) Both the magnitude and the sign of its charge

6. Which one of the following is an incorrect statement for physisorption
(a) It is a reversible process

(b) It requires less heat of adsorption
(c) It requires activation energy
(d) It takes place at low temperature

7. Which is not colloidal **[CPMT 1984; MP PET 1989, 91]**
(a) Chlorophyll (b) Egg
(c) Ruby glass (d) Milk

8. Which one of the following is **not** a surfactant **[AIIMS 2003]**

(a) 
$CH_3-(CH_2)_{15}-\overset{CH_3}{\underset{CH_3}{N^+}}-CH_3Br^-$

(b) $CH_3-(CH_2)_{14}-CH_2-NH_2$
(c) $CH_3-(CH_2)_{16}-CH_2OSO_2^-Na^+$
(d) $OHC-(CH_2)_{14}-CH_2-COO^-Na^+$

9. Size of colloidal particles is
[CPMT 1984; MP PMT 1990, 92]
(a) $0.1\,m\mu$ to $0.001\,m\mu$ (b) $10\,\mu$ to $20\,\mu$
(c) $0.05\,m\mu$ to $0.1\,m\mu$ (d) $25\,\mu$ to $30\,\mu$

10. Which of the following electrolytes is most effective in the coagulation of gold solution **[KCET 1996]**
(a) $NaNO_3$ (b) $K_4[Fe(CN)_6]$
(c) Na_3PO_4 (d) $MgCl_2$

11. A catalyst is used in a reaction to
[CPMT 1972, 75, 97; DPMT 1982]
(a) Change the nature of reaction products
(b) Increase the reaction yield
(c) Decrease the need for reactants
(d) Decrease the time required for the reaction

12. Which one of the following is not represented by sols
[MP PMT 1992]
(a) Absorption (b) Tyndall effect
(c) Flocculation (d) Paramagnetism

13. Example of intrinsic colloid is
(a) Glue (b) Sulphur
(c) Fe (d) As_2S_3

14. Colloidal solution of arsenious sulphide can be prepared by
[AMU 1985]
(a) Electrodispersion method
(b) Peptization
(c) Double decomposition
(d) Hydrolysis]

15. The capacity to bring about coagulation increases with
(a) Ionic radii (b) Atomic radii
(c) Valency of an ion (d) Size of an ion

16. Gold number gives
[NCERT 1987; MNR 1987; UPSEAT 2002; Kurukshetra CET 2002; MP PMT 2004]
(a) The amount of gold present in the colloid
(b) The amount of gold required to break the colloid
(c) The amount of gold required to protect the colloid
(d) None of these

17. Point out the *false* statement **[MP PET 1997]**
(a) Brownian movement and Tyndall effect is shown by colloidal systems
(b) Gold number is a measure of the protective power of a lyophilic colloid
(c) The colloidal solution of a liquid in liquid is called is gel
(d) Hardy–Schulze rule is related with coagulation

18. Which of the following does not contain a hydrophobic structure **[NCERT 1983]**
(a) Linseed oil (b) Lanolin
(c) Glycogen (d) Rubber

19. The function of gum-arabic in the preparation of indian ink is
(a) Coagulation (b) Peptization
(c) Protective action (d) Absorption

20. Identify the gas which is readily adsorbed by activated charcol
[KCET 2004]
(a) N_2 (b) SO_2
(c) H_2 (d) O_2

21. The density of gold is $19\,g/cm^3$. If $1.9\times10^{-4}\,g$ of gold is dispersed in one litre of water to give a sol having spherical gold particles of radius 10 *nm*, then the number of gold particles per mm^3 of the sol will be **[Pb.CET 2004]**
(a) 1.9×10^{12} (b) 6.3×10^{14}
(c) 6.3×10^{10} (d) 2.4×10^{6}

22. Which of the following forms cationic miscelles above certain concentration
(a) Urea
(b) Cetyltrimethylammonium bromide
(c) Sodium dodecyl sulphate
(d) Sodium acetate

AR Assertion & Reason

For AIIMS Aspirants

Read the assertion and reason carefully to mark the correct option out of the options given below :

(a) If both assertion and reason are true and the reason is the correct explanation of the assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of the assertion.
(c) If assertion is true but reason is false.
(d) If the assertion and reason both are false.
(e) If assertion is false but reason is true.

1. Assertion : When a finely divided active carbon or clay is stirred into a dilute solution of a dye, the intensity of colour in the solution is decreased.

Reason : The dye is adsorbed on the solid surface.

2. Assertion : The enthalpy of physisorption is greater than chemisorption.

Reason : Molecules of adsorbate and adsorbent are held by van der Waals forces in physisorption and by chemical bonds in chemisorption.

3. Assertion : Silica gel is used for drying air.

Reason : Silica gel adsorbs moisture from air.

4. Assertion : According to Freundlich: $\frac{x}{m}k.P^{1/n}$.

Reason : The isotherm shows variation of the amount of gas adsorbed by the adsorbent with temperature.

5. Assertion : A reaction cannot become fast by itself unless a catalyst is added.

Reason : A catalyst always increases the speed of a reaction.

6. Assertion : ZSM – 5 is used as a catalyst in petrochemical industries.

Reason : Zeolites are three dimensional network silicates in which some silicon atoms are replaced by aluminium atoms.

7. Assertion : Lyophilic colloids are called as reversible sols.

Reason : Lyophilic sols are liquid loving.

8. Assertion : Colloidal sols scatter light while true solutions do not.

Reason : The particles in the colloidal sol more much slower than that of the true solution.

9. Assertion : Colloidal particles show Brownian movement.

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

10. Assertion : For the coagulation of sols carrying positive charge, PO_4^{3-} ions are more efficient than SO_4^{2-} or Cl^- ions.

Reason : This follows Hardy – Schulze rule.

11. Assertion : An emulsion becomes stable if soap is added to it .

Reason : Soap contains hydrophilic and hydrophobic parts.

12. Assertion : Deep electric shock causes death of an animal.

Reason : Electric shock coagulate the blood.

[AIIMS 1995]

13. Assertion : A catalyst is more effective in finely divided form.

Reason : Finely divided form has more surface area.

[AIIMS 1998]

14. Assertion : NH_3 absorb more readily over activated charcoal than CO_2.

Reason : NH_3 is non-polar. **[AIIMS 2000]**

15. Assertion : Sky appears blue colour.

Reason : Colloidal particles of dust scatter blue light.

[AIIMS 2000]

16. Assertion : Physical absorption of molecules takes place on surface only.

Reason : In this process, the bonds of the absorbed molecules are broken.**[AIIMS 2002**

17. Assertion : The micelle formed by sodium stearate in water has $-COO^-$ groups at the surface.

Reason : Surface tension of water is reduced by the addition of stearate.**[AIIMS 2003]**

18. Assertion : Aqueous gold colloidal solution is red in colour.

Reason : The colour arises due to scattering of light by colloidal gold particles.**[AIIMS 20**

19. Assertion : Increase in surface area, increase in rate of evaporation.

Reason : Stronger the intermolecular attractive forces, fast is the rate of evaporation at a given temperature.

Answers

Adsorption and Adsorption isotherm

1	b	2	a	3	b	4	a	5	a
6	b	7	c	8	b	9	b	10	d

11	a	12	a	13	d	14	d	15	c
16	c	17	d	18	d	19	a	20	b
21	a	22	c	23	c	24	b	25	a
26	a	27	d	28	b	29	b	30	c
31	a	32	d	33	b	34	c	35	d
36	c	37	a	38	a	39	c	40	c
41	d	42	a	43	a	44	c	45	d
46	d	47	d						

Catalyst and Catalysis

1	c	2	d	3	d	4	a	5	d
6	b	7	d	8	a	9	d	10	c
11	c	12	b	13	a	14	b	15	c
16	d	17	c	18	d	19	c	20	c
21	b	22	d	23	a	24	b	25	c
26	d	27	d	28	a	29	c	30	c
31	d	32	c	33	c	34	d	35	c
36	b	37	d	38	a	39	a	40	d
41	b	42	a	43	b	44	b	45	b
46	c	47	d	48	d	49	d	50	c
51	b	52	b	53	a	54	b	55	d
56	d	57	d	58	d	59	b	60	c
61	c	62	c	63	b	64	b	65	a
66	d	67	c	68	c	69	b	70	b
71	d	72	d	73	c	74	a		

Colloids, Emulsion, Gel and Their properties with application

1	b	2	d	3	a	4	a	5	c
6	d	7	d	8	b	9	c	10	c
11	c	12	c	13	d	14	b	15	c
16	d	17	b	18	c	19	a	20	b
21	b	22	b	23	a	24	c	25	a
26	a	27	c	28	d	29	a	30	a
31	a	32	b	33	c	34	c	35	b
36	b	37	c	38	a	39	d	40	b
41	d	42	d	43	d	44	c	45	b
46	b	47	d	48	d	49	d	50	d
51	b	52	c	53	b	54	a	55	c
56	d	57	d	58	d	59	d	60	b
61	c	62	c	63	d	64	b	65	b
66	b	67	a	68	d	69	b	70	c
71	c	72	b	73	a	74	b	75	d
76	b	77	c	78	b	79	a	80	b
81	d	82	d	83	c	84	c	85	a
86	c	87	d	88	d	89	a	90	c
91	b	92	a	93	a	94	c	95	a
96	a	97	a	98	e	99	a	100	d
101	a	102	c	103	c	104	c	105	b
106	d	107	b	108	d	109	c	110	a
111	a	112	a	113	b	114	c	115	c
116	d	117	a	118	d	119	a	120	b
121	b	122	a	123	a	124	d	125	b
126	b	127	c	128	b	129	c	130	d
131	c	132	b	133	c	134	d	135	b
136	b	137	b	138	c	139	c	140	d
141	b	142	c	143	d	144	a	145	c
146	b	147	c	148	b	149	d	150	a
151	a	152	b	153	d	154	b	155	a
156	a	157	a	158	a	159	a	160	a
161	b	162	a	163	a	164	b	165	a
166	c	167	c	168	c	169	d	170	d
171	d	172	a	173	b	174	b	175	c
176	c	177	a	178	a	179	a	180	a
181	c	182	b	183	d	184	a	185	b
186	d	187	c	188	d	189	a	190	b
191	d	192	a	193	b	194	c	195	a
196	a	197	c	198	a	199	d	200	d
201	c	202	a	203	b	204	a	205	a
206	b	207	b	208	c	209	e		

Critical Thinking Questions

1	a	2	d	3	c	4	d	5	d
6	c	7	a	8	b	9	a	10	b
11	d	12	d	13	a	14	c	15	c
16	d	17	c	18	d	19	c	20	b
21	d	22	d						

Assertion & Reason

1	a	2	e	3	a	4	c	5	d
6	b	7	b	8	b	9	a	10	a
11	a	12	a	13	a	14	c	15	a
16	d	17	b	18	a	19	c		

AS Answers and Solutions

Adsorption and Adsorption isotherm

1. (b) Chemical adsorption is irreversible due to formation of new bonds and compounds.

2. (a) Chemical adsorption increases with temperature.

6. (b) When the temperature is raised, the viscosity of liquid decreases, this is because increase in temperature increases the average kinetic energy of molecules which overcome the attractive force between them.

13. (d) Charge on As_2S_3 sol is due to the adsorbed sulphide ion.

19. (a) According to langmuir Adsorption isotherm the amount of gas adsorbed at very high pressures reaches a constant limiting volume.

21. (a) According to definition of adsorbent.

24. (b) Adsorption increase when temperature decreases (Adsorption $\propto$ 1/Temperature)

25. (a) In chemical adsorption, one layers are adsorbed.

26. (a) Adsorption of a gas on solid independent of the pressure start fast and after some time becomes slow.

27. (d) Chemisorption first increases and then decreases with temperature.

28. (b) Adsorption is an exothermic process.

32. (d) $\log x/m = \log k + \frac{1}{n}\log p$; this is Freundlich isotherm. Thus $p \propto \frac{1}{n}$.

36. (c) Heterogeneous catalysis can be explained by the adsorption theory.

37. (a) Adsorption due to strong chemical bond is called chemical adsorption or chemisorption or Langmuir adsorption.

39. (c) Physical adsorption decreases with increase of temperature.

40. (c) $W = \frac{126 \times 1 \times 50}{1000} \Rightarrow 6.3$

(Molecular weight of oxalic acid $\Rightarrow$163)

$0.5\ gm \rightarrow \frac{6.3}{2}$

$1\ gm \rightarrow \frac{6.3}{2 \times 0.5} \times 1 \Rightarrow 6.3\ gm.$

41. (d) Noble gases are adsorbed by coconut charcoal. The adsorption of different noble gases occur at different temperatures, hence charcoal is used to separate these gases. Helium is not adsorbed by charcoal (as it is very difficulty liquifiable gas).

42. (a) Animal charcoal is a good adsorbate. The impurities adsorbs on its surface and thus it decolourises colour of liquids.

43. (a) Since adsorption is an exothermic process (taking place with the evolution of heat) therefore in accordance with Lechatelier's principle, the magnitude of physical adsorption will decrease with the increase in temperature. In case of chemisorption the adsorption first increase and then decreases with increase in temperature.

44. (c) Concentration of the solution decreases because acetic acid gets adsorbed on charcoal.

45. (d) $\frac{x}{m} = kp^{1/n}$ or $x = m\,.\,kp^{1/n}$ or $x/m = kp^{-n}$

All of these equation represent freundlich adsorption isotherm.

47. (d) It has been observed that the surface of a solid (or liquid) has the tendency to attract and retain the molecules of other immiscible phase with which it is brought into contact. These molecules remian only at the surface and do not go deeper into the bulk. This tendency of accumulation of molecular species at the surface than in the bulk of a solid (or liquid) it termed adsorption.

Catalyst and Catalysis

3. (d) A catalyst does not take part in the reaction but can speed it up. It can be recovered after the reaction.

4. (a) $\underset{(g)}{N_2} + \underset{(g)}{3H_2} \xrightarrow[Mo\text{ promoter}]{Fe\text{ Catalyst}} \underset{(g)}{2NH_3}$

5. (d) $2KClO_3 \xrightarrow{MnO_2} 2KCl + 3O_2$

6. (b) $2SO_2 + O_2 \xrightarrow[As_2O_3(poison)]{Pt(Catalyst)} 2SO_3$

7. (d) It is a shape-selective catalyst.

8. (a) All substance have average energy and before the reaction occurs energy of the reactant should be higher than the average energy. We also know that catalyst lower the activation energy. Therefore, rate of reaction is increased.

9. (b) $2SO_2 + O_2 \xrightarrow{NO} 2SO_3$

12. (b) Transition metals are most efficient catalysts due to half filled *d*-orbitals.

16. (d) An increase in rate of reaction in forward direction by a catalyst for a reaction in equilibrium brings in an increase in concentration of products and thus rate of backward reaction also increase to same magnitude and so allow the equilibrium to be achieved quickly.

17. (c) $\underset{(g)}{2SO_2} + \underset{(g)}{O_2} \xrightarrow{V_2O_5} \underset{(g)}{2SO_3}$

19. (c) Catalyst never change the equilibrium constant.

21. (b) Because reactant and catalyst are present in same physical state.

23. (a) $\underset{\text{Glucose}}{C_6H_{12}O_6} \xrightarrow[\text{Enzyme}]{\text{Zymase}} \underset{\text{Ethanol}}{2C_2H_5OH} + 2CO_2$

24. (b) $C_6H_6 + CH_3Cl \xrightarrow[AlCl_3]{\text{Anhydrous}} C_6H_5CH_3 + HCl$

25. (c) $CH_3COOC_2H_5 + HOH \xrightarrow[\text{Catalyst}]{\text{Conc. } H_2SO_4}$

$$CH_3COOH + C_2H_5OH$$

27. (d) Catalyst does not depend on the enthalpy of the reactants.

30. (c) Catalyst does not depend on the free energy change in the reaction.

31. (d) Activation energy changes when catalyst is used in a reaction.

32. (c) In the reversible reaction a catalyst is the substance which reduces the time required for reaching the equilibrium state in the reaction.

36. (b) $\text{Maltose} \xrightarrow[\text{enzyme}]{\text{Maltase}} \text{Glucose}$

37. (d) Efficiency of catalysing property is inversely proportional of activation energy.

39. (a) $\underset{(g)}{2SO_2} + \underset{(g)}{O_2} \xrightarrow[\text{Asbestose (s)}]{\text{Platinized}} 2SO_3$; Example of heterogeneous catalyst.

40. (d) $\text{Oil} + \text{H}_2 \xrightarrow{\text{Ni}} \text{Ghee}$.

41. (b) Catalyst is not effect on equilibrium concentrations.

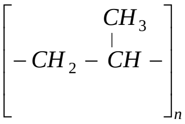
42. (a) $4NH_3 + 5O_2 \xrightarrow[1100\,K]{Pt\ guage} 4NO \xrightarrow{O_2} 4NO_2$

$$\xrightarrow{2H_2O + O_2} 4HNO_3$$

48. (d) $4NH_3 + 5O_2 \xrightarrow[1100\,K]{Pt\ guage} 4NO \xrightarrow{O_2} 4NO_2$

$$\xrightarrow{2H_2O + O_2} 4HNO_3$$

51. (b) $\underset{\text{Propylene}}{nCH_3 - CH = CH_2} \xrightarrow{(CH_3CH_2)_3Al + TiCl_4}$



$$\left[- CH_2 - \overset{\overset{CH_3}{|}}{CH} - \right]_n$$

Polypropylene

53. (a) Ptyline (enzyme) is present in saliva.

54. (b) $\underset{(g)}{2SO_2} + \underset{(g)}{O_2} \xrightarrow{2\ NO(g)} \underset{(g)}{2SO_3} + 2NO_{(g)}$, reactants and catalyst present in same phase.

55. (d) $2SO_2 + O_2 \xrightarrow[As_2S_3\text{(Poison)}]{\text{Platinised asbestos(catalyst)}} 2SO_3$

58. (d) Mn^{++} is a product in reaction so it is auto catalyst (according to definition).

62. (c) $2SO_2 + O_2 \xrightarrow[\text{(Catalyst)}]{V_2O_5} 2SO_3$

63. (b) $\underset{(g)}{2SO_2} + \underset{(g)}{O_2} \xrightarrow[\text{Asbestos(promoter)}]{\text{Pt Catalyst}} 2SO_3(g)$

65. (a) Generally transition elements acts as catalysts. Adam's catalyst is another name of platinum.

69. (b) Enzyme activity is maximum at 310K.

70. (b) Catalyst is a substance which changes the rate of reaction without affecting the overall energetics of the reaction.

71. (d) Ni, Pt and Co all three transition metals are used as a catalysts.

72. (d) Catalyst is a substance which changes the rate of reaction without affecting the overall energetics of the reaction.

73. (c) Many of the d-block (transition) elements and their compounds act as catalyst. Catalytic property is probably due to the utilisation of $(n-1)d$ orbitals or formation of interstitial compounds.

74. (a)The catalytic process in which the reactants and the catalyst are in different phases is known as heterogenous catalysis.

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

The reactants are in gaseous state while the catalyst is in solid state.

Colloids, Emulsion, Gel and Their properties with application

4. (a) Negatively charged As_2S_3 sol coagulated most effectively by $AlCl_3$. This is because oppositely charged Al^{+++} ions have maximum charge.

$As^{3+} > Ca^{2+} > Na^{+}$

6. (d) $K_3[Fe(CN)_6]$ is most effective in coagulating a ferric hydroxide sol.

7. (d) Sky looks blue due to scattering of light by dust particles present in the atmosphere.

10. (c) KBr is least effective in causing flocculation of ferric hydroxide sol due to minimum charge at $(KBr)\ Br^{-}$

11. (c) $\underset{\text{(Dispersed phase)}}{\text{Liquid}} + \underset{\text{(Dispersion medium}}{\text{Solid}} = \underset{\text{(Colloid)}}{\text{Gel}}$ (e.g. Butter)

13. (d) By definition gold number of starch is the amount of starch in *mg* added to 10 *ml* standard gold sol which prevents the coagulation of gold on adding 1 *ml* of *10% NaCl* solution. So the amount of starch is 0.25*g* = 250 *mg*. Hence gold number is 250.

15. (c) According to Hardy schulze rule the ions having opposite charge to sol particle cause coagulation and greater the valency of oppositely charged ion more is the coagulating power ($PO_4^{3-} > SO_4^{2-} > NO_3^-$).

17. (b) Gold number is associated with only lyophilic colloids due to protective nature.

19. (a) Negatively charged sols require minimum amount of electrolyte having higher valence of cation.

22. (b) Lyophilic possesses solvent loving nature and thus a thin layer of dispersed phase is formed round sol particles.

23. (a) Milk is a colloid of liquid (H_2O) dispersed in liquid (fat).

24. (c) Smoke is an example of solid dispersed in gas.

26. (a) Movement of (charged) colloidal particles under the influence of electrostatic field is called electrophoresis due to opposite charge.

27. (c) $Fe(OH)_3$ gives a positively charged sol as it adsorbs Fe^{3+} ions from $FeCl_3$ solution.

29. (a) Flocculation value is expressed in terms of millimole per litre.

32. (b) Gelatin is a protective colloid.

36. (b) $ZnCl_2$ has maximum coagulation power due to more charge on the Zn

37. (c) Air is not a colloidal solution because it is a homogeneous mixture.

43. (d) In Purification separation of colloids from crystalloids is done by the process of ultra-filtration.

45. (b) $\underset{(\text{liquid})}{\text{dispersed phase}} + \underset{(\text{gas})}{\text{dispersion medium}}$

$= \underset{(\text{clouds})}{\text{colloidal system}}$

46. (b) Tyndall phenomenon is exhibited by starch solution because starch solution is a colloidal solution.

53. (b) Milk can be preserved by adding a few drops of $HCHO$ solution. $HCHO$ is an emulsifier.

55. (c) Properties of the colloidal solution depend upon physical state of dispersed phase and mol. wt.

57. (d) According to Graham, colloids are separated from crystalloids by parchment paper.

60. (b) Liquid aerosol involves liquid dispersed in gas, e.g. cloud, fog, mist etc.

64. (b) $2HNO_3 + 3H_2S \rightarrow \underset{(Sol)}{3S} + 4H_2O + 2NO$

65. (b) Lyophobic colloids are irreversible colloids.

66. (b) Crystalloids are diffuse through parchment membranes.

67. (a) Colloidal particles range between 10^{-7} to 10^{-9} m or 10^{-5} to 10^{-7} cm.

70. (c) Fe^{3+} ion coagulates –ve sol particles of blood and seals the cut.

79. (a) When a substance comes in colloidal state the surface area of the particles increases due to small size than substance.

80. (b) Alum can be separated from a solution by electrodialysis due to alum give Al^{3+} ion in solution.

82. (d) The amount of electrolyte required to coagulate a fixed amount of a solution depends upon the valency of the flocculation ion. The flocculating power of the various ions follows the following order, larger the valency lesser will be coagulating value. $Al^{3+} > Mg^{2+} > Na^+$, hence lowest coagulation value is of $AlCl_3$.

88. (d) Gelatin is a protective colloid in ice-cream.

90. (c) Tyndall effect is not observed in sugar solution due to homogeneous nature.

92. (a) Dispersion medium and dispersed phase are phase of colloid.

99. (a) As_2S_3 is coagulated by addition of electrolyte due to opposite charge.

104. (c) According to Hardy-Schulze rule.

111. (a) Scattering of light is a property of colloid.

115. (c) Some gelatin is mixed in colloidal solution of gold to form ppt of gold (peptization of gold). Because formation of layer on colloidal particle.

120. (b) "Delta" at the rivers are formed due to coagulation between sea water (+ve charged particles) and river water (–ve charged particles)

121. (b) Tyndall effect expressed by hydrophobic sols.

129. (c) Protein sol in water is a example of heteropolar sol.

130. (d) For stabilise the sol.

131. (c) Solution of urea is not a colloid.

135. (b) $\underset{(\text{Dispersion medium})}{\text{Liquid}} + \underset{(\text{Dispersed phase})}{\text{Gas}} = \underset{\text{Colloidal solution}}{\text{Whipped cream}}$

137. (b) Alum is a coagulating agent, frequently added to water to remove impurities from water because impurities contain negative charge and alum give positive charge particle for coagulation.

139. (c) Alum is purifies muddy water by coagulation due to opposite charge.

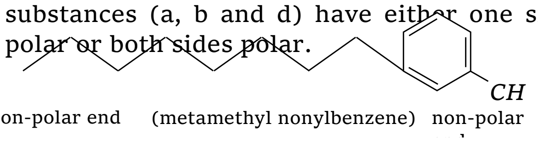
142. (c) The particle size is in the order $10\,Å - 1000\,Å$.

144. (a) $FeCl_3$ is a electrolyte give Fe^{3+} and blood contain negatively colloid so stop bleeding due to coagulation.

145. (c) AT (CMC) critical micellization concentration, the surfactant molecules associate to form miscelles. For soap CMC is 10^{-3} *mol/litre*

146. (b) Inhibitors are also known as negative catalyst.

147. (c) Benzene is non polar in nature. As we know that non-polar disperses more to non-polar substances. Therefore, meta-metyl nonylbenzene being nonpolar from both sides will disperse more to benzene. All other substances (a, b and d) have either one side polar or both sides polar.



$\equiv H_{19}C_9 - C_6H_4 - CH_3$

151. (a) The protective action of different colloids is expressed in terms of Gold number.

156. (a) Tyndall effect may be defined as the scattering of light by the colloidal particles present in a colloidal sol.

158. (a) It is due to adsorption of S^{2-} ions on the surface of the colloidal particles and H^+ ions in the diffused layer.

168. (c) Alum helps in purifying water by Al^{3+} ions which coagulate the negative mud particles.

169. (d) Sn^{+4} contain maximum coagulation power (coagulation power $\propto$ number of charge on ion)

170. (d) It is liquid in gas colloidal solution.

175. (c) Colloidal particles becomes uncharged at isoelectric point.

176. (c) Example of multimolecular colloid system is a gold dispersed in water.

179. (a) The phenomenon of converting of fresh mass into colloidal state by the action of solute or solvent is known as peptization.

180. (a) Surface tension of lyophilic sol is lower than that of the dispersion medium (i.e. H_2O in this case.)

182. (b) Hydrophilic sol can act as protective colloids for hydrophobic solution.

183. (d) Metal sulphide is not used for preparing lyophilic sol.

185. (b) According to definition emulsification.

186. (d) Toilet soap is a mixture of potassium salt of higher fatty acids.

187. (c) Coagulation is governed by Hardy Schulze rule.

189. (a) Protective power $\propto \dfrac{1}{\text{Gold number}}$

Gold number of *A* is least, therefore, it has the highest protective power.

190. (b) Bredig's arc method is suitable for the preparation of colloidal solution of metal like gold silver, platinum etc. An arc is struck between the metal electrode under the surface of water containing some stabilizing agent such as a trace of *KOH*. However, *Fe* does not react with alkalies that is why it is not obtained by Bredig's arc method.

191. (d) Gold number shows the protective power of a lyophilic solution. Lesser the gold number, greater will be the protecting power of that colloid. Gelatin is one of the best protective colloid. Among the given colloids, potato starch has maximum gold number.

192. (a) Protective power $\propto \dfrac{1}{\text{Gold number}}$

Thus gelatin is the best protective colloid.

193. (b) Protective power $\propto \dfrac{1}{\text{Gold number}}$

Hence, the correct order of protective power is $B > A > C > D$.

194. (c) A catalyst does not participate in the reaction but alters the rate of reaction.

195. (a) A colloid of liquid in liquid is called emulsion cod liver oil is such an emulsion.

196. (a) Suspension of solid in a liquid.

197. (c) By the peptization, precipitate is changed to colloidal solution.

198. (a) An aerosol is a dispersion of a solid or liquid in a gas.

199. (d) Lyophilic sols are self stabilizing because these sols are reversible and are highly hydrated in the solution.

200. (d) $\dfrac{V_c}{V_s} = \dfrac{10^{-5}}{10^{-7}} \approx 10^3$

204. (a) Alum contains many cations and water has many anionic impurities. On adding alum coagulates the suspended impurities and make water fit for drinking purposes.

205. (a) For the stabilisation of an emulsion a third component called emulsifying agent is usually added. The emulsifier forms an interfacial film between suspended particles and the medium.

206. (b) Alum is added to muddy water so as to destroy the bacteria as well as to coagulate the suspended impurities.

207. (b) Fog is an example of aerosol where the dispersed phase is liquid and dispersionmedium is gas.

208. (c) Lyophilic sols, are more stable than Lyophobic sols because after vaporization its remaining residue, convert into colloidal state after the addition of solvent.

209. (e) The substance, whose molecules associate with given solvent to form colloidal particle known as association colloidal. The molecule of soap & detergent are generally smaller than colloidal particle. These molecules associate in concentration solution to form colloidal size particle. These association of soap & detergent known as miscelle.

Critical Thinking Questions

1. (a) Lyophillic means liquid loving hence hydration is contributed toward the extra stability of lyophillic colloids.

2. (d) Traces of electrolytes are essential for stabilising the sales hence for sales destruction addition of electrolytes are required.

3. (c) A catalyst is a substance which alters the rate of reaction and shortens the time to reach equilibrium.

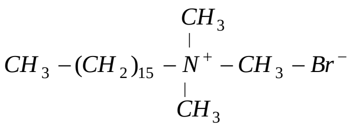
4. (d) Inhibitors are also catalysts but they slow down the rate of reaction.

5. (d) The ability of an ion to bring about coagulation of a given calloid depend upon both the magnitude and sign of its charge.

6. (c) Physiorption is a process in which the particles of adsorbate are held to the surface of adsorbent by physical forces hence does not requires activation energy.

7. (a) Egg is a calloid of solid and liquid; Ruby glass is a colloid of solid and solid. Milk is a colloid of liquid and liquid but chlorophyll is a complex of magnesium.

8. (b) Surfactant are those which have charge on their tail e.g., cetyltrimethyl ammonium bromide.



$$CH_3-(CH_2)_{15}-\overset{\overset{\displaystyle CH_3}{|}}{\underset{\underset{\displaystyle CH_3}{|}}{N^+}}-CH_3-Br^-$$

Surfactants are those, which dissociate in water to yield positively charged ion.

9. (a) The size of colloidal particles is of the order $0.1 m\mu$ to $0.001 m\mu$.

10. (b) $K_4[Fe(CN)_6]$ is most effective in the coagulation of gold-solution.

11. (d) A catalyst is used to decrease the time required for the reaction hence it can decease or increase the rate of reaction.

12. (d) Absorption, Tyndall effect and flocculation all are related to sol but paramagnetism is not represented by sol.

13. (a) On shaking with the dispersion medium, colloids directly form the colloidal sol. Hence they are called intrinsic colloids. *i.e.*, glue.

14. (c) Arsenious sulphide can be prepared by double decomposition

$$As_2O_3+3H_2S \rightarrow As_2S_3+3H_2O$$

15. (c) The amount of electrolyte required to coagulate a fixed amount of a sol depends upon the valency of flocculating ion.

16. (d) Gold no. is a measure of protective power of a lyophillic colloid.

17. (c) The colloidal solution of liquid in liquid is called emulsion not gel.

18. (d) Linseed oil, lanolin and Glycogen attract water hence contain a hydrophobic structure but rubber does not attract water and does not contain a hydrophobic structure.

19. (c) Gum-arabic has protective power hence the function of it ion in preparation of indian ink is protective action.

20. (b) Easily liquefiable gases like SO_2, NH_3, CO_2 are adsorbed to a greater extent than the elemental gases like N_2, O_2, H_2.

21. (d) Volume of the gold dispersed in one litre water $=\frac{\text{Mass}}{\text{Density}} = \frac{1.9\times10^{-4}\ gm}{19\ gm\ cm^{-3}} = 1\times10^{-5}\ cm^{-3}$

Radius of gold sol particle $=10\ nm$

$=10\times10^{-9}\ m \quad =10\times10^{-7}\ cm = 10^{-6}\ cm$

Volume of the gold sol particle $=\frac{4}{3}\pi r^3$

$$=\frac{4}{3}\times\frac{22}{7}\times(10^{-6})^3 \quad = 4.19\times10^{-18}\ cm^3$$

No. of gold sol particle in

$$1\times10^{-5}\ cm^3 = \frac{1\times10^{-5}}{4.19\times10^{-18}}$$

$$=2.38\times10^{12}$$

No. of gold sol particle in one mm^3

$$=\frac{2.38\times10^{12}}{10^6} = 2.38\times10^6$$

22. (d) Sodium acetate forms cationic micelles in the molecule of soap and detergent the negative ions aggregate to form a micelle of colloidal size. The negative ion has a long hydrocarbon chain and a polar group $(-COO^-)$ at one end.

Assertion & Reason

1. (a) Both assertion and reason are true and reason is the correct explanation of assertion.

The surface of a solid (or liquid) tends to attract and retain other molecules when it is brought in contact with a gas or a solution.

2. (e) Assertions is false but reason is true.

The enthalpy of chemisorption is of the order of $200\ kJmol^{-1}$ while for physical adsorption it is of the order of $20\ kJmol^{-1}$.

3. (a) Both assertion and reason are true and reason is the correct explanation of assertion .

4. (c) Assertion is true but reason is false.

Freundlich adsorption isotherm gives an empirical relation ship between the quantity of gas adsorbed by unit mass of solid adsorbent and pressure at a particular temperature.

5. (d) Both assertion and reason are false.

There are reactions in which one of the products acts as catalyst (autocatalysis) and no catalyst is added.

6. (b) Both assertion and reason are true but reason is not the correct explanation of assertion.

ZSM – 5 converts alcohols directly into gasoline (petrol) by dehydrating them so that a mixture of hydrocarbons is formed.

7. (b) Both assertion and reason are true but reason is not the correct explanation of assertion.

If the dispersion medium is separated from the dispersed phase, the lyophilic sol can be reconstituted by simply remixing with the dispersion medium. That is why these sols are also called reversible sols.

8. (b) Both assertion and reason are true but reason is not the correct explanation of assertion.

The size of colloidal particles is large enough to scatter light while particles of a true solution are too small to scatter light.

9. (a) Both assertion and reason are true and reason is the correct explanation of assertion.

The impact of the molecules of the dispersion medium on the colloidal particle are unequal leading to zig-zag motion *i.e.,* Brownian movement.

10. (a) Both assertion and reason are true and reason is the correct explanation of assertion.

According to Hardy – Schulze rule : Coagulating power of an electrolyte is directly proportional to the fourth power of the valency of the ions causing coagulation.

11. (a) Both assertion and reason are true and reason is the correct explanation of assertion.

Soap coats the drops of an emulsion and checks them from coming together and the emulsion is thus stabilised.

12. (a) It is fact that deep electric shock causes death of an animal and the reason for this is that blood is coagulated by electric shock. Therefore, here both assertion and reason are true.

13. (a) A catalyst is more effective in finely divided form because finely divided form has more surface area. Therefore there is an increase in active centres on the surface.

14. (c) NH_3 absorbs more readily over activated charcoal than CO_2 it is correct. The reason is the polar nature of NH_3 due to which it readily absorb. Hence assertion is true but reason is false.

15. (a) The sky appears blue because the colloidal particles of dust, dirt in air scatter blue light to the maximum extent. Here both assertion and reason are correct and reason is the correct explanation of assertion.

16. (d) The assertion that physical absorption of molecules takes place on surface only is false. Actually absorption takes place on the whole body. In physical absorption the bonds of absorption molecules are not broken. Hence, both assertion and reason are false.

17. (b) Here both assertion and reason are correct but reason is not a correct explanation of assertion. Micelle is formed if molecules with polar and nonpolar ends assemble in bulk to give nonpolar interior and polar exterior.

18. (a) Both assertion and reason are true and reason is the correct explanation of assertion. Scattering of light is the main phenomenon of colloidal particles. In which colloidal particles scatter a particular wavelengths light.

19. (c) It is true that if we increase the surface area the rate of evaporation also increase as evaporation is always takes place from the surface. But if the intermolecular attraction is stronger than the rate of evaporation is slower.

Surface Chemistry

SET Self Evaluation Test -14

1. In which of the following commercial processes a catalyst is not used **[CPMT 1989]**

(a) Haber's process

(b) Deacon's process

(c) Solvay process

(d) Lead chamber process

2. A catalyst **[IIT 1984; AFMC 1995; CBSE PMT 1995]**

(a) Increases the average kinetic energy of reacting molecules

(b) Increases the activation energy

(c) Alters the reaction mechanism

(d) Increases the frequency of collisions of reacting species

3. The coagulation of 100 *ml* of a colloidal sol of gold is completely prevented by addition of 0.25 *g* of a substance `$X$' to it before adding 10 *ml* of 1% $NaCl$ solution. The gold number of `X' is

(a) 0.25 (b) 25

(c) 250 (d) 2.5

4. Which one of the following is not a property of hydrophilic sols

(a) High concentrations of dispersed phase can be easily attained

(b) Coagulation is reversible

(c) Viscosity and surface tension are about the same as for water

(d) The charge of the particle depends on the pH values of the medium; it may be positive, negative or even zero

5. Peptising agent is

(a) Always an electrolyte

(b) Always a non-electrolyte

(c) Electrolyte or non-electrolyte

(d) A lyophilic colloid

6. The catalyst used in the manufacture of methanol from water gas is **[MP PET 2002]**

(a) V_2O_5 (b) $Ni + Mo$

(c) $ZnO + Cr_2O_3$ (d) $Pt + W$

7. Organic catalysts differ from inorganic catalysts **[AFMC 1989]**

(a) By acting at very high temperature

(b) By acting at low temperature

(c) Being used up

(d) Being proteinous in nature

8. Commercial detergents mainly contain **[CPMT 1993]**

(a) $RCOONa$

(b) $RONa$

(c) $RSNa$

(d) $ROSO_2Na$

9. In which of the following processes shape-selective catalysis is occurring

(a) Conversion of alcohol to gasoline

(b) Synthesis of methanol from CO and H_2

(c) Polymerisation of ethylene

(d) Synthesis of ammonia

10. Which one of the following is used for reviving the exhausted permutite **[EAMCET 2003]**

(a) HCl solution

(b) 10% $CaCl_2$ solution

(c) 10% $MgCl_2$ solution

[AIIMS 1983, 84]

(d) 10% $NaCl$ solution

11. The ability of a catalyst to accelerate the chemical reaction is known as **[CPMT 2000; KCET 2000]**

(a) Selectivelty

(b) Activity

(c) Negative catalyst

(d) None of these

12. $AlCl_3$, in reactions, acts as

(a) Oxidizing agent

(b) Reducing agent

(c) Acid catalyst

(d) None of these

13. On addition of one *ml* of 10% $NaCl$ solution to 10 *ml* gold sol in the presence of 0.25 *gm* of starch. The coagulation is just prevented, starch has gold number **[MP PET 2004]**

(a) 0.025 (b) 0.25

(c) 2.5 (d) None

14. Milk is an example of

[MP PET 2001; JIPMER 2002; MP PMT 2002,04]

(a) Pure solution

(b) Gel

(c) Emulsion

(d) Suspension

Answers and Solutions

(SET -14)

1. (c) In Haber's process we use iron as a catalyst, In Deacon's process we use Cu_2Cl_2 as a catalyst and in lead chamber process we use N_2O_5 as a catalyst but in solvay process no catalyst is used.

2. (d) A catalyst can increase the rate or reaction and hence increases the frequency of collision of reacting species.

3. (b) 250 *mg* of X is present in 100 *ml* of colloidal sol of gold. By definition, gold no. of X is that amount of it in *mg* which is present in 10 *ml* of colloidal gold solution. Hence in 10 *ml*, the amount of X present is 25 *mg* which is the gold number of X.

4. (c) Viscosity and surface tension are not same for water in hydrophillic sols.

5. (a) Process of converting precipitate into colloidal particles by adding suitable electrolyte called peptisation and stabilizing agent (electrolytes) as peptizing agent.

6. (c) $[CO + H_2] + H_2 \xrightarrow{ZnO + Cr_2O_3} CH_3OH$

7. (d) Organic catalyst are proteinous in nature and obtain from living cell.

8. (a) Commercial detergents mainly contain salts of higher fatty acids.

9. (a,c) Shape selective catalyst are zeolites and zeolites are alminosilicates of general formula $M_{x/n}[(AlO_2)_x.(SiO_2)_y].mH_2O$. Zeolites are used in conversion of alcohol to gasoline and in polymerisation of ethylene.

10. (d) 10% $NaCl$ solution is used for reviving the exhaust permutite.

11. (b) The ability of a catalyst to accelerate the chemical reaction is known as its activity. Degree of acceleration can be as high as 10^{10} times in certain reactions.

12. (c) $AlCl_3$ may be written as $Al^{+3}Cl^{-}$ and all the tri-positive ions are Lewis acid hence it can be acts as acid catalyst.

13. (d) $0.25 \times 1000 = 250$

14. (c) Milk is the example of emulsion of fat globules in water.

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