विध्न विचारत भीरु जन, नहीं आरम्भे काम, विपति देख छोड़े तुरंत मध्यम मन कर श्याम।
पुरुष सिंह संकल्प कर, सहते विपति अनेक, 'बना' न छोड़े ध्येय को, रघुबर राखे टेक।।

रचितः मानव धर्म प्रणेता
सद्गुरु श्री रणछोड़दासजी महाराज

STUDY PACKAGE

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Topic : SURFACE CHEMISTRY

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Index

1. Key Concepts
2. Exercise I
3. Exercise II
4. Exercise III
5. Exercise IV
6. Answer Key
7. 34 Yrs. Que. from IIT-JEE
8. 10 Yrs. Que. from AIEEE

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SURFACE CHEMISTRY

PHASE OF COLLOIDS :

A colloidal system is heterogeneous in character. It consists of two phases, namely a dispersed phase and a dispersion medium.

(a) ***Dispersed Phase :*** It is the component present in small proportion and is just like a solute in a true solution. For example, in the colloidal state of sulphur in water, the formeracts as a dispersed phase.

(b) ***Dispersion Medium :*** It is normally the component present in excess and is just like a solvent in a solution.

The particles of the dispersed phase are scattered in the dispersion medium in a colloidal system.

CLASSIFICATION OF COLLOIDS :

Colloids can be can be classified in a number of ways based upon some of their important characteristics.

(1) ***Physical state of Dispersed Phase & Dispersion Medium:***

Depending upon whether the dispersed phase and the dispersion medium are solids, liquids or gaseous, eight types of colloidal system are possible. A gas mixed with another gas forms a homogeneous mixture and not a colloidal system. Typical examples of various type alongwith their characteristic names are given in table.

Common Colloidal System

Dispersed Phase	*Dispersion medium*	*Colloidal system*	*Examples*
Gas	Liquid	Foam or froth	Soap sols, lemonade froth, whipped cream.
Gas	Solid	Solid foam	Pumice stone, styrene, foam, foam rubber.
Liquid	Gas	Aerosols of Liquids	Fog, clouds, fine insecticide sprays.
Liquid	Liquid	Emulsions	Milk
Liquid	Solid	Gels	Cheese, butter, boot polish, table jellies.
Solid	Gas	Aerosols of Solid	Smoke, dust
Solid	Liquid	Sols	Must paint, starch dispersed in water, gold sol, muddy water, inks.
Solid	Solid	Solid sols	Ruby glass, some gem stones.

* A colloidal system in which the dispersion medium is a liquid or gas are called sols. They are called hydrosols or aqua sols, if the dispersion medium is water. When the dispersion medium is alcohol or benzene , they are accordingly called alcosols or benzosol.

* Colloidal systems in which the dispersion medium is a gas are called aerosols.

* Colloids in which the dispersion medium is a solid are called gels, e.g. cheese etc. They have a more rigid structure. Some colloids, such as gelatin, can behave both as a sol and a gel. At high temperature and low concentration of gelatin, the colloid is a hydrosol. But at low temperature and high gelatin concentration, the hydrosol can change into a gel.

(2) ***Based on interaction or affinity of phases :*** On the basis of the affinity or interaction between the dispersed phase and the dispersion medium, the colloids may be classified into two types :

(i) ***Lyophilic Colloids :*** The colloidal system in which the particle of dispersed phase have great affinity for the dispersion medium, are called lyophilic (solvent-loving) colloids. In such colloids, the dispersed phase does not get easily precipitated and the sols are more stable. Such colloidal systems, even if precipitated, may be reconverted to the colloidal state by simply agitating them with the dispersion medium. Hence lyophilic colloids are reversible. When the dispersion medium is water, these are called hydrophilic colloids. Some common examples of lyophilic colloids are gum, gelatin, starch, rubber, proteins, etc.

(ii) ***Lyophobic colloids :*** The colloidal system in which the dispersed phase have no affinity for the dispersion medium are called lyophobic (solvent hating) colloids. They are easily precipitated (or coagulated) on the addition of small amounts of the electrolyte, by heating or by shaking. They are less stable and irreversible. When the dispersion medium is water, these are known as hydrophobic colloids. Examples of lyophobic colloids include sols of metals and their insoluble compounds like sulphides and oxides.

The essential differences between the lyophilic and lyophobic colloids are summarised in table.

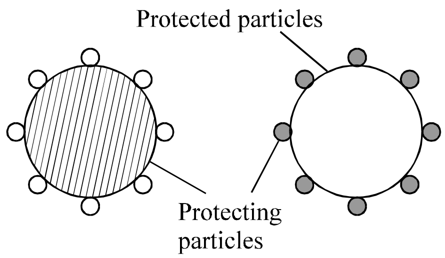
Difference between Lyophilic and Lyophobic sols

Property	***Lyophilic sols***	***Lyophobic sols***
1. Nature	Reversible	Irreversible
2. Preparation	They are prepared very easily by shaking or warming the substance with dispersion medium. They do not required any electrolyte for stabilization.	They are difficult to prepare, Special methods are used. Addition of stabiliser is essential for their stability.
3. Stability	They are very stable and are not easily coagulated by electrolytes.	They are generally unstable and get easily coagulated on addition of electrolytes.
4. Charge	Particles carry no or very little charge depending upon the pH of the medium.	Colloidal particles have characteristic charge (positive or negative)
5. Viscosity	Viscosity is much higher than that of the medium.	Viscosity is nearly the same as that of the medium
6. Surface Tension	Surface tension is usually less than that of the medium.	Surface tension is nearly the same as that of the medium.
7. Migration in electric field	The particles may or may not migrate in an electric field.	The colloidal particles migrate either towards cathode or anode in an electric field.
8. Solvation	Particles are heavily solvated.	Particles are not solvated.
9. Visibility	The particles cannot be seen under ultra microscope.	The particles though invisible, can be seen under ultra microscope.
10. Tyndall effect	Less distinct.	More distinct.
11. Action of electrolyte	Large amount of electrolyte is required to cause coagulation.	Small amount of electrolyte is sufficient to cause cogulation.
12. Examples	Mostly organic substances e.g. starch, gums, proteins, gelatin etc.	Generally inorganic substance e.g., metal sols, sulphides and oxides sols.

* ***PROTECTIVE COLLOIDS :***

Lyophilic sols are more stable than the lyophobic sols. This is because, lyophilic colloids are extensively hydrated and these hydrated particles do not combine to form large aggregates.

Lyophobic sols are more easily coagulated by the addition of suitable electrolyte. To avoid the precipitation of lyohobic sol. by the addition of electrolyte, some lyophilic colloid is added to it. Such lyophilic colloid is called protective colloid and the action of lyophilic colloid by the electrolytes is known as protective anion. The substances commonly used as protective colloids are gelating, albumin, gum arabic, casein, starch, glue etc. A gold sol. containing a little gelatin as protective colloid needs a very large amount of sodium chloride to coagulate the sol.



Explanation : The particles of the protective colloid get adsorbed on the particles of the lyophobic colloid, thereby forming a protective layer around it (figure). The protective layer prevents the precipitating ions from coming in contact with the colloidal particles.

According to a recent view, the increase in stability of the lyophobic colloid is due to the mutual adsorption of the lyophilic and lyophobic colloids. It is immaterial which is adsorbed on which. In fact the smaller particles, whether of the protective colloid or the lyophobic colloid, are adsorbed on the bigger particles.

(3) ***Based on type of particles of the dispersed phase :*** Depending upon the molecular size, the colloidal system has been classified into three classes :

(i) ***Multimolecular colloids :*** The multimolecular colloidal particles consists of aggregate of atoms of small molecules with diameters less than 10^{-9} m or 1 nm.

For example, a sol. of gold contains particles of various sizes having several atoms. A sol. of sulphur consists of particles containing a thousand or so S_2 molecules. These particles are held together by vander Waal's forces. These are usually lyophobic sols.

(ii) ***Macromolecular colloids :*** The macromolecular colloidal particles themselves are large molecules. They have very high molecular weights varrying from thousands to millions. These substances are generally polymers. Naturally occurring macromolecules are such as starch, cellulose and proteins. Artificial macromolecules are such as polyethylene, nylon, polysyrene, dacron, synthetic rubber, plastics, etc. The size of these molecules are comparable to those of colloidal particles and therefore, their dispersion known as macromolecular colloids. Their dispersion also resemble true solutions in some respects.

(iii) ***The associated colloids or miscelles :*** These colloids behave as normal electrolytes at low concentrations but colloids at higher concentrations. This is because at higher concentrations, they form aggregated (associated) particles called miscelles. Soap and synthetic detergents are examples of associated colloids. They furnish ions which may have colloidal dimensions.

$$\underset{\text{Sod. Stearate soap}}{RCOONa} \rightleftharpoons \underset{(R = C_{17}H_{35})}{RCOO^{-} + Na^{+}}$$

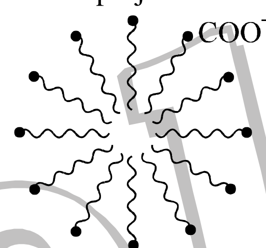
The long-chain $RCOO^{-}$ ions associates or aggregate at higher concentrations and form miscelles and behave as colloids. They may contain 100 or more molecules.

Sodium stearate $C_{17}H_{35}COONa$ is an example of an associated colloid. In water it gives Na^{+} and sterate, $C_{17}H_{35}COO^{-}$ ions. These ions associate to form miscelles of colloidal size.

Colloids which behave as normal electrolytes at low concentration, but exhibit colloidal properties at higher concentration due to the formation of aggregated particles called micelles are referred to as associated colloids. The micelles are formed by the association of dispersed particles above a certain concentration and certain minimum concentration is required for the process of aggregation to take place. The minimum concentration required for micelle formation is called micellisation concentration (CMC) and its value depends upon the nature of the dispersed phase. For soaps CMC is 10^{-3} mole L^{-1}.

Mechanism of Micelle Formation :

Micelles are formed by surface active molecules called surfactants such as soaps and detergents. These molecules have lyophilic group at one end and a lyphobic group at the other end. Let us take the example of a soap (say sodium oleate, $C_{17}H_{33}COO^{-}Na^{+}$). The long hydrocarbon part of oleate radical ($C_{17}H_{33}$–) is lyophobic end while COO^{-} part is lyophilic end. When the concentration of the solution is below its CMC, sodium oleate behaves as a normal electrolyte and ionises to give $C_{17}H_{33}COO^{-}$ and Na^{+} ions. When the concentration exceeds CMC, the lyophobic part starts receding away from the solvent and tends to approach each other. However, the polar COO^{-} ends tends to interact with the solvent (water). This finally leads to the formation of bigger molecules having the dimensions of colloidal particles. Thus 100 or more oleate ions are grouped together in a spherical way keeping their hydrocarbon parts inside and the $–COO^{-}$ part remains projected in water.



PROPERTIES OF COLLOIDAL SOLUTIONS :

(1) ***Physical properties :***

(i) ***Heterogeneity :*** Colloidal solutions are heterogeneous in nature consisting of two phases viz, the dispersed phase and the dispersion medium. Experiments like dialysis and ultra filteration clearly indicate the heterogeneous character of colloidal system. Recent investigations however, shown that colloidal solutions are neither obviously homogeneous nor obviously heterogeneous.

(ii) ***Filterability :*** Colloidal particles readily pass through orginary filter papers. It is because the size of the pores of the filter paper is larger than that of the colloidal particles.

(iii) ***Non-settling nature :*** Colloidal solutions are quite stable as the colloidal particles remain suspended in the dispersion medium indefinitely. Thus there is no effect of gravity on the colloidal particles.

(iv) ***Colour :*** The colour of the colloidal solution is not always the same as the colour of the substances in the bulk. The colour of the colloidal solution depends upon the following factors :

(a) Size and shape of colloidal particles.
(b) Wavelength of the source of light.
(c) Method of preparation of the colloidal solution.
(d) Nature of the colloidal solution.
(e) The way an observer receives the light, i.e., whether by reflection or by transmission.
(f) ***Stability :*** Colloidal solutions are quite stable. Only a few solutions of larger particles may settle but very slowly.

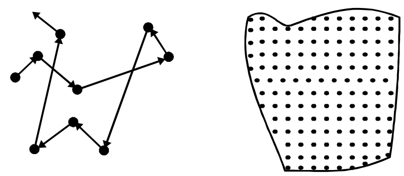
Examples :

(i) Finest gold is red in colour. As the size of particles increases, it becomes purple.
(ii) Dilute milk gives a bluish tinge in reflected light whereas reddish tinge in transmitted light.

(2) ***Mechanical Properties :***

(a) ***Brownian movement :*** Colloids particles exhibit a ceaseless random and swarming motion. This kinetic activity of particles suspended in the liquid is called Brownina movement.
Robert Brown first observed this motion with pollen grains suspended in water.

Cause of movement : Brownian movement is due to bombardment of the dispersed particles by molecules of the medium. The Brownian movement (figure) depends upon the size of sol. particles. With the increase in the size of the particle, the chance of unequal bombardment decrease, and the Brownial movement too disappears. It is due to the fact that the suspension fails to exhibit this phe-nomenon.
It should be noted that Brownian movement does not change with time but changes with temperatures.



Importance :

(i) Brownian movement is a direct demonstration of the assumption that the molecules in a gas or solution are in a state of constant ceaseless motion. Thus it confirms kinetic theory.

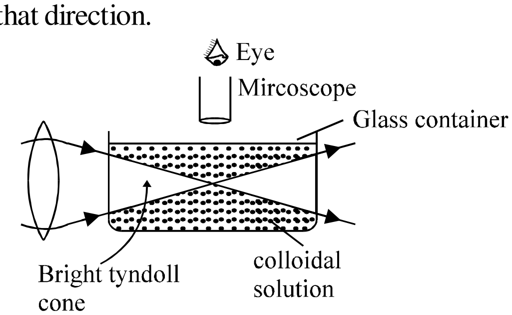
(ii) Brownian movement does not allow the colloidal particles to settle down due to gravity and thus is responsible for their stability.

(iii) Brownian movement helps to calculate the Avogadro's number (Detail beyond the scope of the book).

(b) ***Sedimentation :*** Heavier sol. particle tend to settle down very slowly under the influence of gravity. This phenomenon is called sedimentation.

(3) ***Optical Properties (Tyndal Effect) :***
When a strong and converging beam of light is passed through a colloidal solution, its path becomes visible (bluish light) when viewed at right angles to the beam of light (figure). This effect is called Tyndall effect. The light is observed as a bluish cone which is called Tyndall cone.

The Tyndall effect is due to scattering of light by the colloidal particles. The scattering of light cannot be due to simple reflection, because the size of the particles is smaller than the wave, length of the visible light and they are unable to reflect light waves. In fact, colloidal particles first absorb light and then a part of the absorbed light is scattered from the surface of the colloidal particles as a light of shorter wavelength. Since maximum scattering of light takes place at right angles to the place of incident light, it becomes visible when seen from that direction.



The Tyndall effect is observed under the following conditions :

(i) The diameter of the dispersed particles must not be much smaller than the wavelength of light employed.

(ii) The refractive indices of the dispersed phase and the dispersion medium must differ widely. This condition is fulfilled by lyophobic colloids.

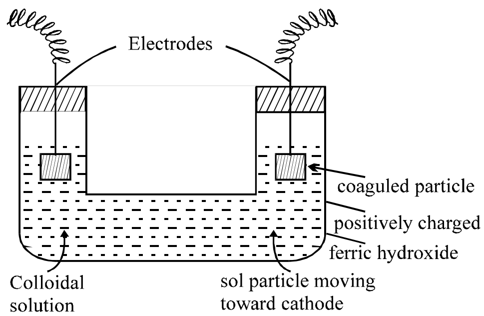
It is important to note that Tyndall effect is not shown by true solutions as their particles are too small to cause scattering. Tyndall effect has been used in devising ultramicroscope and in determining the number of colloidal particles in a colloidal solution.

(4) ***Electrical Properties :***

The two electrical properties of colloidal solutions are :

(a) ***Electrophoresis or Cataphoresis*** and (b) ***Electro-osmosis***

(a) ***Electrophoresis or Cataphoresis :*** In a colloidal solution, the colloidal particles are electrically charged and the dispersion medium has equal but opposite charge. Thus colloidal solution on the whole is electrically neutral. When an electric current is passed through a colloidal solution, the charged particles move towards the oppositely charged electrode where coagulate due to loss of charge.



The phenomenon involving the migration of colloidal particles under the influence of electric field towards the oppositively charged electrode, is called electrophoresis or cataphoresis.

This phenomenon is used to determine the charge on the colloidal particles. For example, when a sol. of ferric hydroxide is taken in a U-tube and subjected to electric field, the ferric hydroxide (sol.) particles get accumulated near the cathode (figure). This shows that ferric hydroxide sol. particles are positively charged.

The sol. particles of metals and their sulphides are found to be negatively charged while those of metal hydroxides are positively charged. Basic dyes such as methylene blue haemoglobin are positively charged while acid dyes like are negatively charged.

Origin of charge : Various reasons have been given regarding the original of charge on the colloidal particles. These are given below :

(i) ***Frictional electrification :*** It is believed to be frictional due to the rubbing of the dispersed phase particles with medium molecules.

(ii) ***Dissociation of the surface molecules :*** It leads to electric charge on colloidal particles. For example, an aqueous solution of a soap (sodium palmitate) dissociates into ions.

$$C_{15}H_{31}COONa \rightleftharpoons C_{15}H_{31}COO^{-} + Na^{+}$$

sod. palmitate

The Na^+ ions pass into the solution while $C_{15}H_{31}COO^{-}$ ions have a tendency to form aggregates due to weak attractive forces present in the hydrocarbon chains. Thus, the anions which are of colloidal size bear negative charge.

(iii) ***Preferential adsorption of ions from solution :*** The charge on the colloidal particles is generally acquired by preferentially adsorbing positive or negative ions from the electrolyte. Thus AgCl particles can adsorb Cl^- ions from chloride solutions and Ag^+ ions; the sol. will be negatively charged in the first case and positively charged in the second case.

(iv) ***Capture of electron :*** It is from air during preparation of sol. by Bredig's arc method.

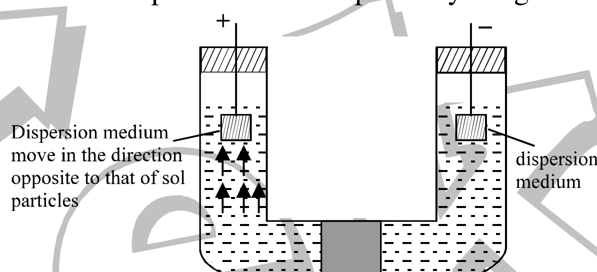
(v) ***Dissociation of molecular electrolytes on the surface of particles :*** H_2S molecules get adsorbed on sulphides during precipitation. By dissociation of H_2S, H^+ ions are lost and colloidal particles become negatively charged.

Electrical charged sols.

	Positively charged sols	***Negatively charged sols***
1.	Ferric hydroxide, aluminium hydroxide	Metals such as Pt, Au, Ag, Metals sulphides, e.g. arsenius sulphide.
2.	Basic dyes such as methylene blue	Starch, clay, silicic acid.
3.	Haemoglobin	Acid dyes, such as eosin.

(b) ***Electro-osmosis :*** The phenomenon involving the migration of the dispersion medium and not the colloidal particles under the influence of an electric field is electro-osmosis.

Take the pure solvent (dispersion medium) in two limbs of U-tube. In the lower middle portion of U-tube, a porous diaphragm containing the colloidal system is present which divides the U-tube in two sections. In each section of U-tube, an electrode is present, as shown in figure. When the electrode potential is applied to the electrodes, the solid phase of sol. (colloidal system) cannot move but the solvent (dispersion medium) moves through the porous diaphragm towards one of the electrodes. The direction of migration of dispersion medium due to electro-osmosis determines the charge on sol. particles e.g., if the dispersion medium moves towards the cathode (negative electrode), the sol. particles are also negatively charged because the dispersion medium is positively charged as on the whole colloidal solution is neutral.



Electric double layer :

The surface of a colloidal particle acquires a positive or a negative charge by selective adsorption of ions carrying +ve or – ve charges respectively. The charged layer attracts counter ions from the medium which forms a second layer. Thus, an electrical double layer is formed on the surface of the particles i.e., one due to absorbed ions and the other due to oppositely charged ions forming a diffused layer. This layer consists of ion of both the signs, but its net charge is equal and opposite to those absorbed by the colloidal particles. The existence of charges of opposite signs on the fixed and diffused parts of the double layer creates a potential between these layers. This potential difference between the fixed charge layer and diffused layer of opposite change is called electrokinetic potential or zeta potential.

(c) ***Coagulation :*** the colloidal sols are stable due to the presence of electric charges on the colloidal particles. Because of the electrical repulsion, the particles do not come close to one another to form precipitates. The removal of charge by any means will lead to the aggregation of particles and hence precipitation will occur immediately.

This process by means of which the particles of the dispersed phase in a sol. are pecipitated is known as *coagulation*.

If the coagulated particles instead of settling at the bottom of the container, float on the surface of the dispersion medium, the coagulation is called *flocculation*.

Most of the sols are coagulated by adding an electrolyte of opposite sign. This is due to the fact that the colloidal particles take up the ions of electrolyte whose charges are opposite to that on colloidal particles with the result that charge on the colloidal particles is neutralized. Thus coagulation takes place. For example, arsenius sulphide sol. (negatively charged) precipitated by adding barium chloride solution. It is due to the fact that the negatively charged particles of the sol. take up barium ions and get neutralized which lower the stability. As a result precipitation takes place.

It is observed that different amounts of different electrolytes is required to bring coagulation of a particular solution.
The minimum amount of an electrolyte required to cause precipitation of one litre of a colloidal solution is called coagulation value or flocculation value of the electrolyte for the sol.
The reciprocal of coagulation value is regarded as the *coagulating power*.
For example, the coagulation values of NaCl, $BaCl_2$ and $AlCl_3$ for arsenic sulphide sol. are 51, 0.69 and 0.093 millimoles/litre respectively. Thus their coagulating powers are $\frac{1}{51}, \frac{1}{0.69}$ and $\frac{1}{0.093}$ i.e., 0.0196, 1.449 and 10.75 respectively.
The coagulation values of a few electrolytes for negatively charged arsenic sulphide and positively charged ferric hydroxide sol. are given in table given below. The valency of the coagulation ion (the ion whose charge is opposite to that of the colloidal particles) is also give.

Coagulation values of different electrolytes

Arsenic sulphide sol.			***Ferric hydroxide sol.***		
Electrolyte	Valency of coagulating cation	coagulation value (millimoles/litre)	Electrolyte	Valency of coagulating cation	coagulation value (millimoles/litre)
K_2SO_4	1	63	KBr	1	138
NaCl	1	51	KNO_3	1	132
KNO_3	1	50	KCl	1	103
$MgSO_4$	2	0.81	K_2CrO_4	2	0.320
$BaCl_2$	2	0.69	K_2SO_4	2	0.215
$AlCl_3$	3	0.093	$K_3Fe(Cn)_6$	3	0.096

From the above table, it is clear that the coagulating power of Al^{3+} ions in precipitating the arsenic sulphide sol. is approximately 550 times more than that of sodium (Na^+) or potassium (K^+) ions. Again, it is observed that the negatively charged arsenic sulphide sol. is coagulated by cations while positively charged ferric hydroxide sol. is coagulated by anions.
Hardy-Schulz rules : H. Schulze (1882) and W.B. Hardy (1900) suggested the following rules to discuss the effect of electrolytes of the coagulation of the sol.

(1) Only the ions carrying charge opposite to the one present on the sol. particles are effective to cause coagulation, e.g., the negative charged sol. is best coagulated by cations and a positive sol. is coagulated by anions.

(2) The charge on coagulating ion influences the coagulation of sol.
In general, the coagulating power of the active ion increases with the valency of the active ion.
After observing the regularities concerning the sing and valency of the active ion, a law was proposed by Hardy and Schulz which is termed as Hardy-Schulze law which is stated as follows: "*Higher is the valency of the active ion, greater will be its power to precipitate the sol.*"

Thus, coagulating power of cations is in the order of $Al^{3+} > Ba^{2+}$ or $Mg^{2+} > Na^+$ or K^+.
Similarly, to coagulating the positively charged sol. the coagulating power of anion is in the order of $[Fe(CN)_6]^{4-} > PO_4^{3-} > SO_4^{2-} > Cl^-$

Some other methods of coagulation :
Apart from the addition of electrolyte, coagulation can also be carried out by following methods:

(i) ***By persistent dialysis :*** It has been observed that traces of electrolytes are associated with the solution due to which it is stable. If the solution is subjected to prolonged dialysis, the traces of electrolytes are removed and coagulation takes place.

(ii) ***By mutual coagulation of colloids :*** When two sols of oppositively charges are mixed together in a suitable proportion, the coagulation takes place. The charge of one is neutralized by the other. For example, when negatively charged arsenic sulphide sol. is added to positively charged ferric hydroxide sol., the precipitation of both occurs simultaneously.

(iii) ***By electrical method :*** If the electrical charge of lyophobic sol. is removed by applying any electric field such as in electrophoresis, they also precipitate out.

(iv) By excessive cooling or by excessive heating.

(5) ***Colligative properties :*** Colloidal solutions too exhibit colligative properties such as osmotic pressure, lowering of vapour pressure, depression in freezing point and elevation in boiling point. But the effect of colloidal particles on colligative properties except osmotic pressure is very small. This is due to the large size of colloidal particles. The number of colloidal particles produced by a given mass of colloid is much less than the number produced in a molecular solution, containing the same mass of solute. Hence the colligative effect in colloidal solutions is too less.

Isoelectric Point of Colloid :

The hydrogen ion concentration at which the colloidal particles are neither positively charged nor negatively charged (i.e. uncharged) is known as isoelectric point of the colloid. At this point lyophilic colloid is expected to have minimum stability because at this point particles have no charge. The isoelectric point of gelatin is 4.7. This indicates that at pH = 4.7, gelating has no electrophoretic motion. Below 4.7, it moves towards the cathode and above 4.7 it moves forwards the anode. It is not always true, e.g., silicic acid has been found to have maximum stability at the isoelectric point.

EMULSIONS :

An emulsion is a colloidal solution of a liquid. It may be defined as a heterogeneous system consisting of more than one immiscible liquids dispersed in one another in the form of droplets whose diameter, in general, exceeds 0.1 μ.

For example, milk is an emulsion in which small drops of liquid fat are dispersed in aqueous medium. Cod liver oil is an emulsion in which the water drops are dispersed in the oil. This means in most of the emulsions one of the liquid is water and the other liquid is oil. Here the term 'oil' is used to represent all organic substances which are soluble in water.

The emulsion are classified as :

(1) ***Oil in water type emulsion (O/W):*** In this emulsion, oil is the dispersed phase and water is the dispersion medium. It is denoted by O/W or O in W. For example, milk (liquid fat dispersed in water), vanishing cream, etc.

(2) ***Water in oil type :*** In this emulsion, water is the dispersed phase and oil is the dispersion medium. It is denoted by W/O or W in O. For example, butter, cod liver oil, cold cream, etc.

The type of emulsion obtained by agitating two immiscible liquids depends upon the relative amounts of two components liquids. The liquid that is in excess forms the dispersion medium. Thus, the two types of emulsions can be interconverted into each other by changing the concentration of one of the liquids.

Distinction between two types of emulsions : the two types of emulsions may be distinguished from each other in a number of ways.

(1) ***Dye test :*** It involves the addition of oil soluble dye to the emulsion under experiment. If the emulsion acquires the colour of the dye readily, it is water-in-oil type emulsion and it the emulsion remains colourless, it is oil-in-water type emulsion.

(2) ***Conductivity test :*** It involves the addition of electrolyte to the emulsion under experiment. If the conductivity of the emulsion increases appreciably with the addition of electrolyte, it is oil-in-water type emulsion and it conductivity is very small, it is water-in-oil type emulsion.

(3) ***Dilution test :*** As a general rule, an emulsion can be diluted with the dispersion medium while the addition of the dispersed phase forms a separate layer. Thus, if an emulsion can be diluted with oil, it is water-in-oil type.

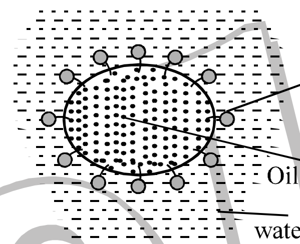
Preparation of emulsion (Emulsification) : Emulsification is the process which involves the preparation of emulsion. Generally, an emulsion is prepared by subjecting a mixture of the immiscible liquid to a distinct layers upon standing. The oil globules rise to form an upper layer while aqueous medium forms lower layers. To prevent the separation of layers and to get the stable emulsion, a small quantity of the third substance is added. This substance which stabilizes the emulsion is called *emulsifier* or *emulsifying agent*. The commonly used emulsifying agents are soaps, detergents and lyophilic colloids. Casein, a lyophilic colloid present in milk, acts as an emulsifier as it forms a protective layer around fat molecules dispersed in water. Hence milk is a fairly stable emulsion.

Function of emulsifier : The main function of emulsifier or emulsifying agents is to lower the interfacial tension between oil and water and thus helps the intermixing of two liquids. For example, a molecule of a soap or detergent (emulsifier) gets concentrated at the interface between oil and water. The polar end of the emulsifier is in water and non-polar end is in oil as shown in figure.
In a soap, RCOONa, R is the non-polar end, whereas COO^{-} Na^{+} is the polar end.

Properties of emulsion :

(i) The size of particles of the dispersed phase of an emulsion is usually larger than in sols.

(ii) Like colloidal particles, emulsions exhibit properties such as Tyndall effect, Brownian movement (provided the particles are not too large), electrophoresis, coagulation, etc.



Demulsification : The process which involves the breaking of an emulsion into two separate liquid layers is called demulsification. The following methods may be used to bring demulsification:

(1) ***Chemical Methods :*** An emulsion may be demulsified by adding a chemical substance whose action on the dispersed phase and the dispersion medium is opposite to that of the original emulsifying agent used to produce the stable emulsion.

(2) ***Centrifugation :*** Cream is separated from milk by the centrifugal method.

(3) ***Cooling :*** Fat can be removed from milk by keeping it in a refrigerator for a few hours.

Demulsification :
Besides the above noted methods of demulsification, the following methods have also been developed :
(i) Suitable centrifugal action-milk cream is separated from milk by centrifugation.
(ii) Application of electric field-electrophoresis.
(iii) Addition of an electrolyte having multivalent opposite charge than that on the dispersed phase.
(iv) Chemical destruction of stabiliser.
(v) Distilling off of one of the components, usually water.
(vi) Addition of demulsifiers like alcohol, phenol etc.

Oil in water type emulsion (O/W) ***Use of emulsion :***

(1) Many pharmaceutical preparations-medicines, ointments, creams and various lotions are emulsions. It is believed that medicines are more effective and easily assimilated by the body tissues when they are in colloidal form i.e., emulsion.

(2) All paints are emulsions.

(3) The digestion of fat in the intestines is helped by emulsification. A little of the fat forms a medium soap (emulsifier) with the alkaline solution of the intestine and this soap emulsifier the rest of the fats, thus making it easier for the digestive enzymes to do their metabolic functions.

(4) Soaps and detergents remove dust and dirt from the dirty piece of cloth by making an oil in water emulsion.

(5) Milk is an emulsion of liquid fats in water.

(6) In the process of metallurgy, one of the important steps is the concentration of ore which is usually done by froth floatation process in which an oil is added to the finely-divided ore taken in water. The particles of ore go on the surface due to formation of foams while the other impurities are left at the bottom of the vessel.

(7) The emulsion of asphalt in water is used in road making and building.

GELS :

Colloidal system in which liquids are the dispersed phase and solid act as the dispersion medium are called gels. The common examples are : boot polishes, jelly, gum arabic, agar agar, processed cheese and silicic acid.

When the gels are allowed to stand for a long time, they give out small quantities of trapped liquids with accumulate on its surface. This action of gels is known as Synresis or Weeping. Some gels such as silica, gelatin and ferric hydroxide liquify on shaking and reset on allowing to stand. This phenomenon of Sol-gel transformation is called thixotropy.

Gels are divided into two categories i.e. elastic gels and non elastic gels. The two categories differ from their behaviour towards dehydration and rehydration as under.

Elastic gels	***Non-elastic gels***
1. They change to solid mass on dehydration which can be changed back to original form by addition of water followed by warming.	1. They change to solid mass on dehydration which cannot be changed back to original form with water.
2. They absorb water when placed in it with simultaneous swelling. This phenomenon is called imbibation.	2. They do not exhibit imbibation.

USES OF COLLOIDS :

(1) ***Medicines :*** The medicines containing gold, silver or calcium etc. in colloidal form are more effective and easily assimilated by the human systems.

(2) ***Dyes :*** In dyeing, mordants colloidal substances are used in textile dyeing industry to fasten dyes.

(3) ***Rubber industry :*** Latex is a colloidal solution of negatively charged particles. The article to be rubber plated is made the anode. Under the influence of electric field the rubber particles get deposited on the anode and the article gets rubber plated.

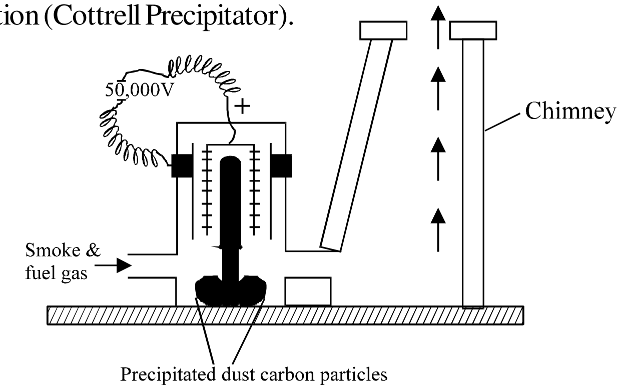
(4) ***Smoke screens :*** Smoke screens which consist of titanium dioxide dispersed in air are used in warfare for the purpose of concealment and camouflage.

(5) ***Formation of delta :*** The river waver carries with it charged clay particles and many other substances in the form of colloidal solution. When the sea water comes in contact with these particles, the colloidal particles in river water are coagulated by the electrolytes present in sea water to form deltas.

(6) ***Purification of water :*** The turbidity in water is due to the presence of negatively charged clay particles. The addition of potash alum, i.e., Al^{3+} ions neutralizes the negative charge on the colloidal particles and thus causes their coagulation. The coagulated matter settles down and thus becomes clear.

(7) ***Artificial rain :*** Artificial rain can be caused by throwing electrified sand on clouds which are colloidal solutions or charged particles of water in air.

(8) ***Smoke precipitation :*** Smoke coming out of the chimney is industrial area is a nuisance and health hazard. It is a colloidal particles are charged particles and thus they are removed from fuel gases by electrical precipitation (Cottrell Precipitator).



In cottrell precipitator, the smoke is made to pass through chambers fitted with highly electrically charged plates which precipitate the carbon and dust particles leaving in the gases to escape through chimney (figure).

(9) ***Sewage disposal :*** Sewage water consists of particles of dirt, rubbish, mud, etc., which are of colloidal dimensions and carry an electric charge and thus do not settle down easily. These particles can thus be removed by cataphoresis. A system of two tanks fitted with metallic electrodes is used for this purpose. When electric field is created, then the dust particles are coagulated on he oppositely charged electrodes. The deposit may be utilized as a manure.

(10) ***Cleansing action of soap and detergent :*** Soap solution may be used to wash off the dirt sticking to the fabric, in the presence

(i) If forms a collodial solution in water forms (miscelles), removes dirt by simple adsorption of oily substance and thus washes away.

(ii) It decreases the interfacial tension between water and grease, and it causes the emulsification of grease in water. By mechanical action such as rubbing, the dirt particles are also detached alongwith the only material.

(11) ***In Photography :*** Various colloidal system are used in photographic process. In the preparation of photographic plates, the silver bromide in gelatin is coated on thin glass plates. In developing and fixation, various colloidal substances are used. In different kinds of colour printing, gelatin and other colloidal mixtures are used.

(12) ***Blue colour of the sky :*** Colloidal particles scatter only blue light and the rest of is absorbed. In sky there are a number of dust and water particles. They scatter blue light and, therefore, sky looks bluish. If there were no scattering, the sky would have appeared totally dark.

SUMMARY OF COLLOIDAL STATE :

(1) Thomas Grahm classified the substances into two categories on the basis of their diffusion through parchment membrane namely (i) Colloids (ii) Crystalloids.

(2) It has been realised that colloid is not a substance but it is a state of a substance which depends upon the molecular size.

(3) When the size of the particles is between 10^{-9} m (1nm) 10^{-7} m (100 nm), it behaves like colloid.

(4) In true solutions, the particle size is less than 1 nm and in suspensions, the particle size is more than 100 nm.

(5) The colloidal solutions in which there is no affinity between particles of the dispersed phase and the dispersion medium are called Iyopholic colloids or irreversible colloids.

(6) Associated colloids are the substances which behave as normal electrolytes at low concentration but behave as colloidal particles at higher concentration. For example, soap i.e. sod. stearate.

(7) Lyophobic colloids are prepared by mainly three types of method
(i) Condensation methods
(ii) Dispersions method
(iii) Peptisation

(8) The process of converting a freshly prepared precipitate into colloidal form by the addition of a suitable electrolyte is called peptisation.

(9) The process of separating the particles of colloids from those of crystalloids by means of diffusion through a suitable membrane is called dialysis.

(10) The process of dialysis i.e. , separation of crystalloids from colloids is quickened by passing electric current through two electrodes suspended around the parchment bag. This process is called electrodialysis.

(11) Ultra filtration is a process of removing the impurities from the colloidal solution by passing it through graded filter papers called ultra-filter papers.

(12) The continuous zig-zag movement of the colloidal particles in a colloidal solutions is called Brownian movement. It is due to the collisions of dispersion medium particles with dispersed phase particles.

(13) The process of scattering of light by the colloidal particles as a result of which the path of the beam becomes visible is called Tyndall effect.

(14) The presence of electric charge either (positive or negative) on colloidal particles is responsible for the stability of colloidal solutions.

(15) The phenomenon of movement of colloidal particles under the influence of electric field is called electrophoresis or cataphoresis.

(16) A phenomenon in which the molecules of the dispersion medium are allowed to move under the influence of an electric current, whereas colloidal particles are not allowed to move, is called Electro-osmosis.

(17) The phenomenon of precipitation of a colloidal solution by the addition of excess of an electrolyte is called coagulation or flocculation.

(18) According to Hardy Schulze rule :
(i) The ions carrying the charge opposite to that of sol particles are effective in causing coagulation of the sol.
(ii) Coagulation power of an electrolyte is directly proportional to the valency of the active ions (ions causing coagulation).

(19) The minimum concentration of an electrolyte which is required to cause the coagulation or flocculation of a sol. is known as flocculation value. It is usually expressed as millimoles per litre. The coagulating power of an electrolyte is inversely related to its coagulating value.

(20) Gold number of a protective colloid is a minimum weight of it in milligrams which must be added to 10 ml of a standard red gold sol so that no coagulation of the gold sol. (i.e. change of colour from red to blue) takes place when 1 ml of 10 % sodium chloride solution is rapidly added to it. Obviously, smaller the gold number of a protective colloid, the greater is the protective action.

ADSORPTION :

(1) Molecules at the surface of a solid, a metal, or a liquid experience in net inward force of attraction with free valencies.

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

(3) The substance adsorbed on the surface is called adsorbate and the substance on which it is adsorbed is called adsorbent.

(4) The reverse process i.e. removal of adsorbed substance from the surface is called desorption.

(5) The adsorption of gases on the surface of metals is called occlusion.

(6) The term sorption is employed when adsoption as well as absorption take place simultaneously.

(7) Adsorption is a surface phenomenon, whereas absorption is a bull phenomenon. Adsorption occurs only at the surface of adsorbent, whereas absorption occurs throughout the body of the material.

(8) When the concentration of the adsorbate is more on the surface of the adsorbent than in the bulk, it is called positive adsorption.

(9) When the concentration of the adsorbate is less relative to its concentration in the bulk, it is called negative adsorption.

(10) When a gas is adsorbed at the surface of a solid by week forces (Vander Waal's forces), it is called physical adsorption.

(11) When a gas is held on the surface of a solid by forces similar to those of a chemical bond, it is called chemical adsorption or chemiosorption.

(12) Adsorption is accompanied by evolution of heat. The amount of heat evolved when one mole of a gas is adsorbed on a solid, is known as molar heat of adsorption. Its magnitude depends upon the nature of the gas.

(13) The magnitude of gaseous adsorption depends upon temperature, pressure, nature of the gas and the nature of the adsorbent.

(14) Adsorption decreases with increase in temperature, since it is accompanied by evolution of heat.

(15) The adsorption increases with increase in pressure, since adsorption of gas leads to decrease in pressure.

(16) The variation of adsorption with pressure at a constant temperature is called isotherm.

(17) At low pressure, the amount of the gas adsorbed per unit quantity of adsorbent is proportional to the pressure. At high pressure, the amount of adsorbed gas is independent of pressure. At intermediate pressures, Freundlich adsorption isotherm is expected to hold

(18) More readily soluble and easily liquefiable gases HCl, Cl_2 , SO_2 and NH_3 are adsorbed more than the so called permanent gases such as H_2 , O_2 , N_2 etc. because Vander Waal's forces involved in adsorption are much predominant in the former gases than the latter category of gases.

PROFICIENCY TEST

Q.1 Fill in the blanks with appropriate items:

1. The substance on whose surface adsorption takes place is called an _____________.
2. Removal of adsorbate from the surface of adsorbent is called _____________.
3. Migration of colloidal particles under the effect of electric field is called _____________.
4. The heat of adsorption in case of physisorption is approximately _____________.
5. The phenomenon of zig-zag motion of colloidal particles is known as _____________.
6. Lyophilic sols are _____________ stable than lyophobic sols.
7. Electrical properties of a colloidal solution are demonstrated by _____________.
8. Tyndall effect takes place due to _____________ of light by collloidal particles.
9. The liquid-liquid colloidal dispersions are called _____________.
10. The movement of dispersion medium under the influence of an electric field is called _____________.
11. Smoke is a colloidal solution of _____________ in _____________.
12. The adhering of the molecules of a gas on the surface of a solid is called _____________.
13. The protective action of different colloids is compared in terms of _____________.
14. The colloidal dispersion of a liquid in a liquid is called _____________.
15. The colloidal dispersions of liquids in solid media are called _____________.

Q.2 True/False statements

1. Physisorption is non-specific.
2. Chemisorption needs activation energy.
3. A graph of x/m vs temperature at constant pressure is called adsorption isotherm.
4. Suspensions have solute particles with size less than 1 nm.
5. $Fe(OH)_3$ sol contains positively charged colloidal particles.
6. Chemisorption is irreversible.
7. Adsorption isobars of chemisorption and physisorption are of the same type.
8. Milk is an example of water in oil emulsions.
9. Gold sol can be prepared by Bredig's arc method.
10. Gel is a system in which liquid is the dispersed phase and solid is the dispersion medium.

***Select the correct alternative*. (Only one is correct)**

Q.1 Which gas will be adsorbed on a solid to greater extent.
(A) A gas having non polar molecule
(B) A gas having highest critical temperature (T_c)
(C) A gas having lowest critical temperature.
(D) A gas having highest critical pressure.

Q.2 Which of the following factors affects the adsorption of a gas on solid?
(A) T_c(critical temp.) (B) Temperature of gas (C) Pressure of gas (D) All of them

Q.3 The volume of gases NH_3, CO_2 and CH_4 adsorbed by one gram of charcoal at 298 K are in
(A) $CH_4 > CO_2 > NH_3$ (B) $NH_3 > CH_4 > CO_2$
(C) $NH_3 > CO_2 > CH_4$ (D) $CO_2 > NH_3 > CH_4$

Q.4 The heat of physisorption lie in the range of
(A) 1 – 10 kJ mol^{-1} (B) 20 to 40 kJ mol^{-1} (C) 40 to 200 kJ mol^{-1} (D) 200 to 400 kJ mol^{-1}

Q.5 Which of the following is not a gel?
(A) Cheese (B) Jellies (C) Curd (D) Milk

Q.6 Which of the following is used to adsorb water
(A) Silica gel (B) Calcium acetate (C) Hair gel (D) Cheese

Q.7 An emulsion is a colloidal system of
(A) two solids (B) two liquids
(C) one gas and one solid (D) one gas and one liquid

Q.8 Which of the following is a lyophobic colloid?
(A) Gelatin (B) Sulphur (C) Starch (D) Gum arabic

Q.9 The nature of bonding forces in adsorption are
(A) purely physical such as Van Der Waal's forces
(B) purely chemical
(C) both chemical and physical
(D) sometimes physical and sometimes chemical

Q.10 The Tyndall effect associated with colloidal particles is due to
(A) presence of electrical charges (B) scattering of light
(C) absorption of light (D) reflection of light

Q.11 Which one of the following is not applicable to chemisorption?
(A) Its heat of adsorption is high (B) It takes place at high temperature
(C) It is reversible (D) It forms mono-molecular layers

Q.12 In the colloidal state the particle size ranges
(A) below 1 nm (B) between 1 nm to 100 nm
(C) more than 100 nm (D) none of the above

Q.13 All colloids
(A) are suspensions of one phase in another
(B) are two-phase systems
(C) contain only water-soluble particles
(D) are true solutions

Q.14 Colloids can be purified by
(A) condensation (B) peptization (C) coagulation (D) dialysis

Q.15 Milk is an example of
(A) emulsion (B) suspension (C) foam (D) sol.

Q.16 Colloidal particles in a sol. can be coagulated by
(A) heating (B) adding an electrolyte
(C) adding oppositely charged sol (D) any of the above methods

Q.17 Emulsifier is an agent which
(A) accelerates the dispersion (B) homogenizes an emulsion
(C) stabilizes an emulsion (D) aids the flocculation of an emulsion

Q.18 Fog is a colloidal system of
(A) gas in liquid (B) liquid in gas (C) gas in gas (D) gas in solid

Q.19 Given below are a few electrolytes, indicate which one among them will bring about the coagulation of a gold sol. quickest and in the least of concentration?
(A) NaCl (B) $MgSO_4$ (C) $Al_2(SO_4)_3$ (D) $K_4[Fe(CN)_6]$

Q.20 When a colloidal solution is observed under ultramicroscope, we can see
(A) light scattered by colloidal particle
(B) size of the colloidal particle
(C) shape of the colloidal particle
(D) relative size of the colloidal particle

Q.21 Colloidal solutions are classified on the basis of
(A) molecular size (B) orgainc or inorganic
(C) surface tension value (D) pH value

Q.22 The electrical charge on a colloidal particle is indicated by
(A) Brownian movement (B) electrophoresis
(C) ultra microscope (D) molecular sieves

Q.23 The minimum concentration of an electrolyte required to cause coagulation of a sol is called
(A) flocculation value (B) gold number (C) protective value (D) none of these

Q.24 Smoke precipitator works on the principle of
(A) distribution law (B) neutralization of charge on colloids
(C) Le-Chaterlier's principle (D) addition of electrolytes

Q.25 Which one of following statements is not correct in respect of lyophilic sols?
(A) There is a considerable interaction between the dispersed phase and dispersion medium
(B) These are quite stable and are not easily coagulated
(C) They carry charge
(D) The particle are hydrated

Q.26 As_2S_3 sol is
(A) positive colloid (B) negative colloid (C) neutral colloid (D) none of the above

Q.27 Crystalloids differ from colloids mainly in respect of
(A) electrical behaviour (B) particle nature
(C) particle size (D) solubility

Q.28 Which of the following electrolyte will be most effective in coagulation of gold sol.?
(A) $NaNO_3$ (B) $K_4[Fe(CN)_6]$ (C) Na_3PO_4 (D) $MgCl_2$

Q.29 At the critical micelle concentration (CMC) the surfactant molecules
(A) decompose (B) dissociate
(C) associate (D) become completely soluble

Q.30 Alums purify muddy water by
(A) dialysis (B) absorption (C) coagulation (D) forming true solution

Q.31 Solute dispersed in ethanol is called
(A) emulsion (B) micelle (C) hydrophilic sol. (D) alcosols

Q.32 Which one of the following is lyophillic colloid?
(A) Milk (B) Gum (C) Fog (D) Blood

Q.33 Small liquid droplets dispersed in another liquid is called
(A) suspension (B) emulsion (C) gel (D) true solution

Q.34 The process which is catalysed by one of the product is called
(A) acid-base catalysis (B) autocatalysis
(C) negative catalysis (D) homogeneous catalysis

Q.35 Tyndall effect would be observed in a
(A) solution (B) solvent (C) precipitate (D) colloidal sol.

Q.36 Adsorption is multilayer in case of
(A) physical adsorption (B) chemisorption
(C) in both (D) none of the these

Q.37 Crystalloids differ from colloids mainly in respect of
(A) electrical behaviour (B) particle size
(C) particle nature (D) solubility

Q.38 A liquid is found to scatter a beam of light out leaves no residue when passed through the filter paper. The liquid can be described as
(A) a suspension (B) oil (C) a colloidal sol. (D) a true solution

Q.39 The ability of an ion to bring about coagulation of a given colloid depends upon
(A) its charge (B) the sign of the charge alone
(C) the magnitude of the charge (D) both magnitude and sign of charge

Q.40 An arsenious sulphide sol. carries a negative charge. The maximum precipitating power of this sol. is possessed by
(A) K_2SO_4 (B) $CaCl_2$ (C) Na_3PO_4 (D) $AlCl_3$

Q.41 Reversible adsorption is
(A) chemical adsorption (B) physical adsorption
(C) both (D) none

Q.42 The function of gum arabic in the preparation of Indian ink is
(A) coagulation (B) peptisation (C) protective action (D) absorption

Q.43 Which of the following is an example of associated colloid?
(A) Protein + water (B) Soap + water (C) Rubber + benzene (D) $As_2O_3 + Fe(OH)_3$

Q.44 Adsorption of gases on solid surface is generally exothermic because
(A) enthalpy is positive (B) entropy decreases
(C) entropy increases (D) free energy increases

Q.45 An emulsifier is a substance
(A) which stabilises an emulsion
(B) which breaks the emulsion into its constituent liquids
(C) which can convert liquid into an emulsion
(D) which brings about coagulation of an emulsion

Question No. 46 to 50 (5 questions)

Whenever a mixture of gases is allowed to come in contact with a particular adsorbent under the same conditions, the more strong adsorbate is adsorbed to greater extent irrespective of its amount present, e.g. H_2O is adsorbed to more extent on silica gel than N_2 and O_2. This shows that some adsorbates are preferentially adsorbed. It is also observed that preferentially adsorbable adsorbents can displace a weakly adsorbed substance from the surface of an adsorbent.

Q.46 Which of the following gases is adsorbed to maximum extent:
(A) He (B) Ne (C) Ar (D) Xe

Q.47 Which of the gas can displace remaining all the gases
(A) O_2 (B) N_2 (C) CO (D) H_2

Q.48 When temperature is increased
(A) extent of adsorption increases
(B) extent of adsorption decreases
(C) no effect on adsorption
(D) extent of adsorption first decreases, then increases

Q.49 Chromatogarphic separations are based on
(A) differential solubility (B) differential adsorption
(C) differential absorption (D) None of these

Q.50 Activated charcoal is prepared by
(A) heated charcoal with steam so that it becomes more porous
(B) adding $Ca_3(PO_4)_2$ to charcoal
(C) adding impurity to charcoal
(D) reacted with conc. HNO_3

Question No. 51 to 54 (4 questions)

The clouds consist of charged particles of water dispersed in air. Some of them are + vely charged, others are negatively charged. When + vely charged clouds come closer they have cause lightening and thundering whereas when + ve and –ve charged colloids come closer they cause heavy rain by aggregation of minute particles. It is possible to cause artificial rain by throwing electrified sand or silver iodide from an aeroplane and thus coagulation the mist hanging in air.

Q.51 When excess of $AgNO_3$ is treated with KI solution, AgI forms
(A) +ve charged sol (B) –vely charged sol (C) neutral sol (D) true solution

Q.52 Clouds are colloidol solution of
(A) liquid in gas (B) gas in liquid (C) liquid in liquid (D) solid in liquid

Q.53 AgI helps in artificial rain because
(A) It helps in coagulation (B) It helps in dispersion process
(C) Both (D) None

Q.54 Electrical chimneys are made on the principle of
(A) Electroosmosis (B) Electrophoresis (C) Coagulation (D) All of these

Question No. 55 to 58 (4 questions)

In macromolecular type of colloids, the dispersed particles are themselves large molecules (usually polymers). Since these molecules have dimensions comparable to those of colloidal particles, their dispersions are called macromolecular colloids. Most lyophilic sols belong to this category. There are certain colloids which behave as normal strong electrolytes at low concentrations, but exhibit colloidal properties at higher concentrations due to the formation of aggregated particles. These are known as micelles or associated colloids. Surface active agents like soaps and synthetic detergents belong to this class.

- Critical micelle concentration (CMC) is the lowest concentration at which micelle formation appears. CMC increases with the total surfactant concentration. At concentration higher than CMC, they form extended parallel sheets known as **lamellar micelles** which resemble biological membranes. With two molecules thick, the individual molecule is perpendicular to the sheets such that hydrophilic groups are on the outside in aqueous solution and on the inside is a non-polar medium.
- In concentrated solutions, micelles take the form of long cylinders packed in hexagonal arrays and are called lytotropic mesomorphs.
- In an aqueous solution (polar medium), the polar group points towards the periphery and the hydrophobic hydrocarbon chains point towards the centre forming the core of the micelle.
- Micelles from the ionic surfactants can be formed only above a certain temperature called the **Kraft temperature**.
- They are capable of forming ions
- Molecules of soaps and detergents consist of lyophilic as well as lyophilic parts which associate together to form micelles.
- Micelles may contain as many as 100 molecules or more.

Q.55 Select incorrect statement(s):
(A) Surface active agent like soaps and synthetic detergents are micelles
(B) Soaps are emulsifying agents
(C) $C_{17}H_{35}$ (hydrocarbon part) and $-COO^-$ (carboxylate) part of stearate ion ($C_{17}H_{35}COO^-$) both are hydrophobic
(D) All are incorrect statements

Q.56 Which part of the soap ($RCOO^-$) dissolves grease and forms micelle?
(A) R part (called tail of the anion) (B) $-COO^-$ part (called head of the anion)
(C) both (A) and (B) (D) none of these

Q.57 In multimolecular colloidal sols, atoms or molecules are held together by:
(A) H-bonding (B) van der Waals forces
(C) ionic bonding (D) polar covalent bonding

Q.58 Cleansing action of soap occurs because:
(A) oil and grease can be absorbed into the hydrophobic centres of soap micelles and washed away
(B) oil and grease can be absorbed into hydrophilic centres of soap micelles acid washed away
(C) oil and grease can be absorbed into both hydrophilic and hydrophobic centres but not washed away
(D) cleansing action is not related to micelles

Question No.59 to 61 (3 questions)

The protective power of the lyophilic colloids is expressed in terms of gold number a term introduced by Zsigmondy.Gold number is the number of milligram of the protective colloid which prevent the coagulation of 10 ml of red gold sol. when 1 ml of a 10 percent solution of sodium chloride is added to it. Thus, smaller the gold number of lyophilic colloid, the greater is the protective power.

Q.59 On addition of one mL of solution of 10% NaCl to 10 mL of red gold sol in presence of 0.025 g of starch, the coagulation is just prevented. The gold number of starch is
(A) 0.025 (B) 0.25 (C) 2.5 (D) 25

Q.60 Which of the following statement(s) is/are correct
(A) Higher the gold number, more protective power of colloid
(B) Lower the gold number, more the protective power
(C) Higher the coagulation value, more the coagulation power
(D) Lower the coagulation value, higher the coagulation power

Q.61 Gold number gives an indication of
(A) protective nature of colloids (B) purity of gold in suspension
(C) the charge on a colloidal solution of gold (D) g-mole of gold per litre

Question No. 62 & 65 (4 questions)
These questions consist of two statements each, printed as assertion and reason, while answering these questions you are required to choose any one of the following responses.
(A) If assertion is true but the reason is false.
(B) If assertion is false but the reason is true.
(C) If both assertion and reason are true and the reason is a correct explanation of assertion.
(D) If both assertion and reason are true but reason is not a correct explanation of assertion.

Q.62 **Assertion :** Isoelectric point is pH at which colloidal can move towards either of electrode
Reason : At isoelectric point, colloidal particles become electrically neutral.

Q.63 **Assertion :** When $AgNO_3$ is treated with excess of potassium iodide, colloidal particles gets attracted towards anode.
Reason : Colloidal particles adsorb common ions and thus become charged.

Q.64 **Assertion :** For adsorption ΔG, ΔH, ΔS all have –ve values
Reason : Adsorption is a spontaneous exothermic process in which randomness decreases due to force of attraction between adsorbent and adsorbate.

Q.65 **Assertion :** A gas with higher critical temperature gets adsorbed to more extent than a gas with lower critical temperature.
Reason : The easily liquifiable gases get adsorbed to more extent.

<u>Select the correct alternative</u>. (More than one are correct)

Q.66 Which of the following is/are correct statements
(A) Hardy Schulz rule is related to coagulation
(B) Brownian movement and Tyndall effect are shown by colloids
(C) When liquid is dispersed in liquid, it is called gel.
(D) Gold number is a measure of protective power of lyophillic colloid.

Q.67 Which statements is/are correct?
(A) Physical adsorption is multilayer non-directional and non specific
(B) Chemical adsorption takes more time to attain equilibrium
(C) Physical adsorption is due to free valence of atoms
(D) Chemical adsorption is stronger than physical adsorption

Q.68 Which of the following is/are correct for lyophillic sols?
(A) Its surface tension is lower than that of H_2O
(B) Its viscosity is higher than that of water
(C) Its surface tension is higher than that of water
(D) Its viscosity is equal to that of water

Q.69 Which statement/s is/are correct
(A) A solution is prepared by addition of excess of $AgNO_3$ solution in KI solution. The charge likely to develop on colloidal particle is positive.
(B) The effects of pressure on physical adsorption is high if temperature is low.
(C) Ultracentrifugation process is used for preparation of lyophobic colloids.
(D) Gold number is the index for extent of gold plating done.

Q.70 Colloidal solution can be purified by
(A) Dialysis (B) Electrodialysis (C) Electrophoresis (D) Ultrafiltration

Q.71 Coagulation of colloids can be achieved by
(A) Centrifugation (B) Adding electrolyte (C) Change in pH (D) Adding water

Q.72 When –vely charged colloid like As_2S_3 sol is added to + vely charged $Fe(OH)_3$ sol in suitable amounts
(A) Both the sols are precipitated simultaneously
(B) This process is called mutual coagulation
(C) They becomes + vely charged colloid
(D) They become – vely charged colloid

Q.73 Which of the following is not lyophillic
(A) Gelatin sol (B) Silver sol (C) Sulphur sol (D) As_2S_3 sol

Q.74 Which of the following are multimolecular colloids
(A) Sulphur sol (B) Egg albumin in water
(C) Gold sol (D) Soap solution

Q.75 Colloidal Gold can be prepared by
(A) Bredig's are method (B) Reduction of $AuCl_3$
(C) Hydrolysis (D) Peptization

Q.76 The coagulation of sol particles may be brought about by
(A) heating (B) adding oppositely charged sol.
(C) adding electrolyte (D) persistent dialysis

Q.77 Which one is not lyophobic in nature?
(A) Gelatine (B) Sulphur (C) Starch (D) Protein

Q.78 Which of the following are colloids?
(A) Milk (B) Ice cream (C) Urea solution (D) Blood

Q.79 Which are the properties of sols?
(A) Adsorption (B) Tyndall effect (C) Flocculation (D) Paramagnetism

Q.80 The migration of colloidal particles under the influence of an electrical field is known as
(A) electro osmosis (B) electrophoresis (C) electrodialysis (D) None

ANSWER KEY

PROFICIENCY TEST

Q.1

1. adsorbent	2. desorption	3. electrophoresis	4. 20–40 kJ-mol^{-1}
5. Brownian movement		6. more	7. elecrophoresis
8. scattering	9. emulsions	10. electro-osmosis	11. solid in gas
12. adsorption	13. gold number	14. emulsion	15. gel

Q.2

1.	T	2.	T	3.	F	4.	F
5.	T	6.	T	7.	F	8.	F
9.	T	10.	T				

<u>Select the correct alternative</u>. (Only one is correct)

Q.1	B	Q.2	D	Q.3	C	Q.4	B	Q.5	D	Q.6	A	Q.7	B
Q.8	B	Q.9	C	Q.10	B	Q.11	C	Q.12	B	Q.13	B	Q.14	D
Q.15	A	Q.16	D	Q.17	C	Q.18	B	Q.19	C	Q.20	A	Q.21	A
Q.22	B	Q.23	A	Q.24	B	Q.25	C	Q.26	B	Q.27	C	Q.28	D
Q.29	C	Q.30	C	Q.31	D	Q.32	B	Q.33	B	Q.34	B	Q.35	D
Q.36	A	Q.37	C	Q.38	D	Q.39	D	Q.40	D	Q.41	B	Q.42	C
Q.43	B	Q.44	B	Q.45	A	Q.46	D	Q.47	C	Q.48	B	Q.49	B
Q.50	A	Q.51	A	Q.52	A	Q.53	C	Q.54	B	Q.55	C,D	Q.56	C
Q.57	B	Q.58	A	Q.59	D	Q.60	B,D	Q.61	A	Q.62	B	Q.63	D
Q.64	C	Q.65	C										

<u>Select the correct alternative</u>. (More than one are correct)

Q.66	A,C,D	Q.67	B	Q.68	A,B	Q.69	A,B
Q.70	A,B,D	Q.71	A,B,C	Q.72	A,B	Q.73	B,C,D
Q.74	A,C	Q.75	A,B	Q.76	B,C	Q.77	B,C
Q.78	A,B,D	Q.79	A,B,C	Q.80	B		