

THE COLLOIDAL STATE

6.1 INTRODUCTION

The foundation of colloid 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.

Thomas Graham classified the soluble substances into two categories depending upon the rate of their diffusion through animal and vegetable membranes or parchment paper. He observed that certain substances diffuse freely through the membrane, whereas others do not diffuse. The former type of substances on account of their crystalline nature like common salt, sugar, urea, etc., were named **crystalloids** while the second type of substances were termed as **colloids** (Greek word, *Kolla*, meaning glue-like). All inorganic acids, bases and salts and organic compounds such as sugar, urea, etc., were included in crystalloids while substances such as starch, gelatin, gums, silicic acid, etc., belonged to the colloidal group.

It was soon realised that the above classification was not perfect since many crystalline substances can be converted into colloidal form by suitable means. The colloidal form of sodium chloride, a crystalloid, can be obtained in benzene. Silver, copper, gold, etc., which are completely insoluble in water, can be transformed into colloidal state by suitable methods. X-ray examination of certain colloids like glue and gelatin revealed that these were crystalline in nature. Thus, the above classification was discarded, *i.e.*, **the term 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 by suitable means.**

6.2 PARTICLE SIZE AND COLLOIDAL STATE

The colloidal state depends on the particle size. **It is regarded as intermediate state between true solution and suspension.** In

Table 6.1 Comparison of Suspensions, Colloids and True Solutions

S.No.	Property	Suspension	Colloid	True solution
1.	Particle size	$> 10^{-5}$ cm or 10^3 Å or 100 μ	10^{-7} cm to 10^{-5} cm or 10 Å to 10^3 Å or 1 μ to 100 μ	$< 10^{-7}$ cm or 10 Å or 1 μ
2.	Visibility	Visible with naked eye	Visible with ultramicroscope	Not visible with any of the optical means
3.	Separation			
	(a) with filter paper	Possible	Not possible	Not possible
	(b) with membranes	Possible	Possible	Not possible
4.	Diffusion	Does not diffuse	Diffuses very slowly	Diffuses rapidly
5.	Settling	Settles under gravity	Does not settle but it may settle under centrifuge	Does not settle
6.	Nature	Heterogeneous	Heterogeneous	Homogeneous
7.	Appearance	Opaque	Generally clear	Clear

true solutions, the size of the particles of solute is very small and, thus, these cannot be detected by any optical means and freely diffuse through membranes while in suspensions the size of the particles is large enough and, thus, can be seen even by naked eye and do not pass through filter paper.

True solutions are homogeneous systems while suspensions are heterogeneous. These are two extreme systems and the colloidal state is an intermediate between the two. If we start with particles of large size (suspension) and go on subdividing them till we reach the size of particles found in solution, there is continuous change in the characteristics. During transition, the mixture passes through an intermediate state which shares the characteristics of both. This has been shown in Fig. 6.1.

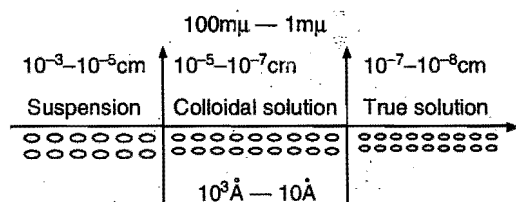


Fig. 6.1

A system is said to be in colloidal state if particles of one or more components have the size range* $10^3 \text{ \AA}$ to $10^3 \text{ \AA}$. However, it is not possible to draw a sharp line of demarcation between colloidal state and suspension. The properties of one gradually appear into those of the other. Roughly speaking, the colloidal state is a heterogeneous dispersion of solute particles of size ranging between $10^3 \text{ \AA}$ to $10^3 \text{ \AA}$ into a solvent.

Some properties of the three systems (suspension colloids and true solutions) are summarized in table 6.1.

6.3 TYPES OF COLLOIDAL SOLUTIONS

The colloidal solutions consist of two-phases, one of which is dispersed in the other. This is called **dispersed phase**, the **internal phase** or the **discontinuous phase**. The phase in which the dispersion is done is termed **dispersion phase**, the **external**

phase or the **continuous phase**. This phase forms the larger part of the colloidal solution. Depending upon the physical state of dispersed and dispersion phases, the types of colloidal solutions given in table 6.2 are possible.

A colloidal solution of gas in gas is not possible as gases are completely miscible and always form true solutions.

Lyophobic and Lyophilic Colloids

Colloidal solutions in which the dispersed phase has very little affinity for the dispersion phase are termed as **lyophobic** (solvent hating) colloids. These are also termed **suspensoids**. Colloidal solutions of metals which have negligible affinity for solvents are examples of this type. Generally, lyophobic sols are less stable. On evaporation of solvent, the residue cannot be easily transformed back into colloidal state by ordinary means. Lyophobic colloids are, therefore, also called **irreversible colloids**.

Table 6.2

S. No.	Dispersed phase (Colloidal particles)	Dispersion phase (Solvent)	Name	Examples
1.	Gas	Liquid	Foam	Froths of air
2.	Gas	Solid	Solid foam	Pumice stone, dried sea foam
3.	Liquid	Gas	Liquid aerosol	Cloud, mist
4.	Liquid	Liquid	Emulsion	Milk, cream
5.	Liquid	Solid	Gel	Jellies, curd, cheese
6.	Solid	Gas	Aerosol	Smoke, haze
7.	Solid	Liquid	Sol	Goldsol, sulphursol
8.	Solid	Solid	Solid-sol	Ruby glass, minerals, gems

Colloidal solutions in which the dispersed phase has considerable affinity for the dispersion phase, i.e., colloidal solution, can be prepared by bringing them together, are called **lyophilic** (solvent loving) colloids. These are also known as

Table 6.3 Comparison of Lyophobic and Lyophilic Sols

S. No.	Property	Lyophobic sols (Suspensoid)	Lyophilic sols (Emulsoid)
1.	Preparation	Cannot be easily prepared. Special methods are required for preparation.	Can easily be prepared by shaking or warming the substance with solvent.
2.	Stability	Are less stable.	Are more stable.
3.	Reversibility	Are irreversible.	Are reversible.
4.	Viscosity	Viscosity is nearly the same as that of solvent.	Viscosity is much higher than that of solvent.
5.	Surface tension	Surface tension is almost the same as that of the solvent.	Surface tension is usually low.
6.	Hydration or solvation	These are less solvated as the particles have less affinity for solvent.	These are highly solvated as the particles have great affinity for solvent.
7.	Charge	The particles carry a characteristic charge either positive or negative.	The particles have little or no charge at all.
8.	Visibility	Particles can be seen under microscope.	Particles cannot be seen under microscope.
9.	Coagulation	Easily coagulated by addition of electrolytes.	Cannot be easily coagulated.

* $1 \text{ \AA}$ (Angstrom unit) = 10^{-8} cm = 10^{-7} mm = $0.1 \text{ m}\mu$ (millimicron)

emulsoids. Gelatin, proteins, starch, etc., are the examples of this type. Colloidal solutions of this type are more stable and are also known as **reversible colloids** since the residue left on evaporation can be readily transformed back into colloidal state simply by adding solvent. When the dispersion medium is water, the above colloidal solutions are termed as **hydrophobic** and **hydrophilic**. (For comparison, see table 6.3)

The colloidal solutions are also named according to the dispersion phase or medium used. The colloidal solutions in alcohol and benzene are known as **alcosols** and **benzosols** respectively. The colloidal solutions where water is used as the dispersion medium are called **hydrosols** or **aquasols**.

Note: Colloidal solutions of solids in liquids are abbreviated as sols.

6.4 PREPARATION OF COLLOIDAL SOLUTIONS

1. Preparation of lyophilic sols: The colloidal solutions of lyophilic colloids like starch, glue, gelatin, etc., can be readily prepared by dissolving these substances in water either in cold or on warming. Solutions of colloidal electrolytes such as soaps and dye stuffs can also be prepared similarly.

2. Preparation of lyophobic sols: To get a substance in colloidal form either the substance in bulk is broken down into fine particles of colloidal dimension ($1 \text{ \AA}$ to $10^3 \text{ \AA}$) or increasing the size of molecular particles as to form larger aggregates. In some cases, a third substance is usually added to increase the stability of the sol. These substances are called **stabilizers**. Thus, there are two ways by which the lyophobic sols can be prepared:

(i) **Dispersion methods:** By splitting coarse aggregates of a substance into colloidal size.

(ii) **Condensation methods:** By aggregating very small particles (atoms, ions or molecules) into colloidal size.

Table 6.4

S. No.	Dispersion methods	Condensation methods
1.	Mechanical dispersion	Exchange of solvents
2.	Electro-dispersion	Change of physical state
3.	Ultrasonic dispersion	Chemical methods:
4.	Peptization	(i) Double decomposition (ii) Oxidation (iii) Reduction (iv) Hydrolysis

Dispersion Methods

1. Mechanical dispersion: Solid material is first finely ground by usual methods. It is then mixed with dispersion medium which gives a coarse suspension. The suspension is now introduced into the **colloid mill**. The simplest form of colloid mill consists of two metal discs held at a small distance apart from one another and capable of revolving at a very high speed (about 7000 revolutions per minute) in opposite directions. The particles are ground down to colloidal size and are then dispersed in the liquid. A stabilizer is often added to stabilize the colloidal solution. Colloidal graphite (a lubricant) and printing ink are made by this method. Tannin is used as a stabilizer in the preparation of

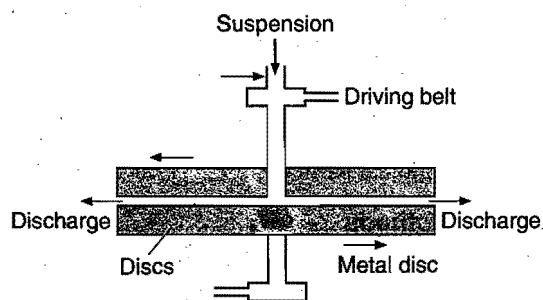


Fig. 6.2

colloidal graphite and gum arabic in lampblack colloidal solution (Indian ink).

2. Electro-dispersion (Bredig's arc method): This method is suitable for the preparation of colloidal solutions of metals like gold, silver, platinum, etc. An arc is struck between the metal electrodes under the surface of water containing some stabilizing

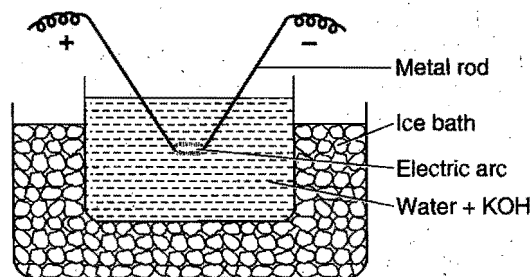


Fig. 6.3

agents such as a trace of KOH. The water is cooled by immersing the container in an ice bath. The intense heat of the arc vaporises some of the metal which condenses under cold water.

Note: 1. This method is not suitable when the dispersion medium is an organic liquid as considerable charring occurs.
2. This method comprises both dispersion and condensation.

3. Ultrasonic dispersion: The sound waves of high frequency are usually called ultrasonic waves. These waves can be produced when quartz crystal discs are connected with a high frequency generator. The application of ultrasonic waves for the preparation of colloidal solutions was first introduced by Wood and Loomis, in 1927. Various substances like oils, mercury, sulphur, sulphides and oxides of metals can be dispersed into colloidal state very easily with the help of ultrasonic waves.

4. Peptization: The dispersion of a freshly precipitated material into colloidal solution by the action of an electrolyte in solution is termed peptization. The electrolyte used is called a **peptizing agent**.

A few examples of sols obtained by peptization are:

(i) Freshly prepared ferric hydroxide on treatment with a small amount of ferric chloride solution at once forms a dark reddish brown solution. Ferric chloride acts as a peptizing agent.

(ii) Freshly prepared stannic oxide on treatment with a small amount of dilute hydrochloric acid forms a stable colloidal solution of stannic oxide.

(iii) Freshly precipitated silver chloride can be converted into a colloidal solution by adding a small amount of hydrochloric acid.

(iv) Cadmium sulphide can be peptized with the help of hydrogen sulphide.

The process of peptization thus involves the adsorption of suitable ions (supplied by the electrolyte added—particularly a common ion) and electrically charged particles then split from the precipitate as colloidal particles.

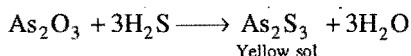
Condensation Methods

1. By exchange of solvents: If a solution of sulphur or phosphorus prepared in alcohol is poured into water, a colloidal solution of sulphur or phosphorus is obtained due to low solubility in water. Thus, there are a number of substances whose colloidal solutions can be prepared by taking a solution of the substance in one solvent and pouring it into another solvent in which the substance is relatively less soluble.

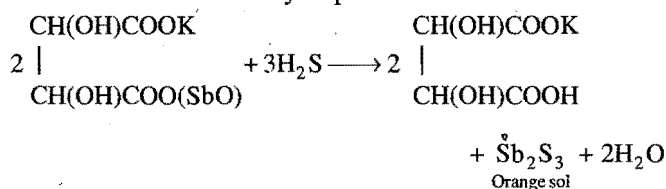
2. By change of physical state: Colloidal solutions of certain elements such as mercury and sulphur are obtained by passing their vapour through cold water containing a stabilizer (an ammonium salt or a citrate).

3. Chemical methods: The chemical methods involve chemical reactions in a medium in which the dispersed phase is sparingly soluble. A condition of supersaturation is produced but the actual precipitation is avoided. Some familiar reactions used are:

(a) *Double decomposition:* (i) Arsenious sulphide sol: A 1% solution of arsenious oxide is prepared in hot water. The solution is cooled, filtered and is then gradually added to water saturated with hydrogen sulphide, whilst a stream of H_2S is being passed through the solution. This is continued till an intense yellow-coloured solution is obtained. Excess of H_2S is removed by bubbling hydrogen through the solution.



(ii) Antimony sulphide sol: A 0.5% solution of potassium antimonyl tartarate is added drop by drop to water saturated with H_2S , whilst H_2S is being passed through the solution. Orange coloured solution of antimony sulphide is obtained.

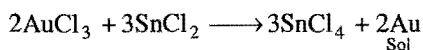


(b) *Oxidation:* A colloidal solution of sulphur is obtained by passing H_2S into a solution of sulphur dioxide.

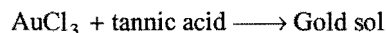
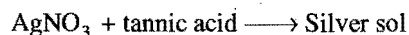


Sulphur sol can also be obtained when H_2S is bubbled through an oxidising agent (bromine water or nitric acid).

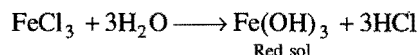
(c) *Reduction:* Colloidal solutions of metals like gold, silver, platinum, lead, etc., can be obtained when their salts solutions are acted upon by reducing agents.



Organic reducing agents such as formaldehyde, phenyl hydrazine, tannic acid, etc., can also be used.



(d) *Hydrolysis:* Colloidal solutions of some salts can be prepared by hydrolysis. A colloidal solution of ferric hydroxide is obtained by boiling a dilute solution of ferric chloride.



The colloidal solution of silicic acid is also obtained by hydrolysis of dilute solution of sodium silicate with 4N hydrochloric acid which is added drop by drop with constant stirring.

6.5 PURIFICATION OF COLLOIDAL SOLUTIONS

Colloidal solutions prepared by above methods generally contain excessive amount of electrolytes and some other soluble impurities. The presence of traces of electrolyte is essential for the stability of the colloidal solution but larger quantities coagulate it. It is, therefore, necessary to reduce the concentration of these soluble impurities to a requisite minimum. **The process used for reducing these impurities to a requisite minimum is known as purification of colloidal solution.** The purification of colloidal solution is carried out by the following methods:

(i) **Dialysis*:** It is a process of removing a dissolved substance from a colloidal solution by means of diffusion through suitable membrane. Since, particles in true solution (ions or smaller molecules) can pass through animal membranes (bladder) or parchment paper or cellophane sheet but colloidal particles do not, the above can be used for dialysis. The apparatus used for this purpose is called **dialyser**. A bag of suitable membrane containing the colloidal solution is suspended in a vessel through which fresh water is continuously flown (Fig. 6.4). The molecules and ions diffuse through the membrane into the outer water and pure colloidal solution is left behind.

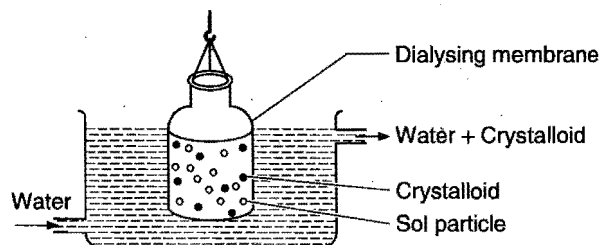


Fig. 6.4

(ii) **Electro-dialysis:** Ordinarily, the process of dialysis is quite slow. It can be made faster by applying an electric field if the dissolved substance in the impure colloidal solution is only electrolyte. The process is then named electro-dialysis. The colloidal solution is placed between two **electrodes** while pure water is taken in a compartment on each side. Electrodes are fitted in the compartment as shown in Fig. 6.5. The ions present

*Blood is a colloidal solution. In case of kidney failure, blood cannot be purified. Under such condition, the blood is separated from dissolved toxic impurities by dialysis and re-introduced in the blood stream.

in the colloidal solution migrate out to the oppositely charged electrodes.

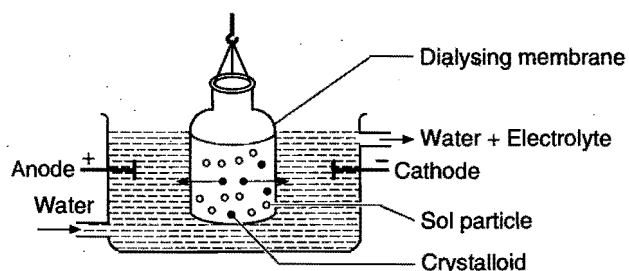


Fig. 6.5

(iii) **Ultrafiltration:** Ultrafiltration is the process of separating the colloidal particles from the solvent and soluble solutes present in the colloidal solution by especially prepared filters, which are permeable to all substances except the colloidal particles.

Colloidal particles can pass through ordinary filter paper because the pores are too large. However, the pores of filter paper can be reduced in size by impregnating with colloidal solution and subsequently hardened by soaking in formaldehyde. The usual colloidion is a 4% solution of nitro-cellulose in a mixture of alcohol and ether. An ultra-filter paper may be prepared by soaking the filter paper in a colloidion solution and hardened by formaldehyde and finally drying it. Thus, by using ultra-filter paper, the colloidal particles are separated from rest of the materials. Ultrafiltration is a slow process. To speed up the process, pressure or suction is used.

The colloidal particles left on the ultra-filter paper are then stirred with fresh dispersion medium (solvent) to get a pure colloidal solution.

6.6 PROPERTIES OF COLLOIDAL SOLUTION

1. Heterogeneous character: Colloidal solutions are heterogeneous in character as they consist of two phases: (a) dispersed phase and (b) dispersion medium.

2. Visibility: It is not possible to see colloidal particles with naked eye or with the help of microscope. It is a well known fact that no particle is visible if its diameter is less than half the wavelength of the light used. The shortest wavelength of the visible light is about $4000 \text{ \AA}$ or $400 \text{ m}\mu$. Hence, no particle of diameter less than $200 \text{ m}\mu$ can be seen. The size of colloidal particles is less than $200 \text{ m}\mu$.

Recently, three new techniques have been developed to determine the size and shape of the colloidal particles. These are:

- (i) Scanning electron microscope (SEM).
- (ii) Transmission electron microscope (TEM).
- (iii) Scanning transmission electron microscope (STEM).

3. Filtrability: Colloidal particles pass through an ordinary filter paper. However, the particles do not pass through parchment and other fine membranes.

4. Surface tension and viscosity: The surface tension and viscosity of lyophobic sols are not very different from those of the dispersion medium. On the other hand, lyophilic sols show

higher viscosity and lower surface tension in comparison to the dispersion medium.

5. Colligative properties: Colloidal particles are bigger aggregates. Thus, the number of particles in the colloidal solution is comparatively small as compared to true solution and hence, the values of colligative properties (osmotic pressure, lowering in vapour pressure, depression in freezing point and elevation in boiling point) are of small order as compared to values shown by true solutions at same concentrations.

6. Tyndall effect: If a heterogeneous solution placed in dark is observed in the direction of light, it appears clear and if it is observed from a direction at right angles to the direction of light beam, it appears perfectly dark. Colloidal solutions show a mild to strong opalescence, when viewed at right angles to the path of light, i.e., the path of the beam is illuminated by a bluish light. This effect was first observed by Faraday and later studied in detail by Tyndall and is termed as **Tyndall effect**. The bright cone of the light is called **Tyndall cone** (Fig. 6.6). The Tyndall effect is due to the fact that colloidal particles absorb light energy and then scatter in all directions in space. This scattering of light illuminates the path of beam in the colloidal dispersion.

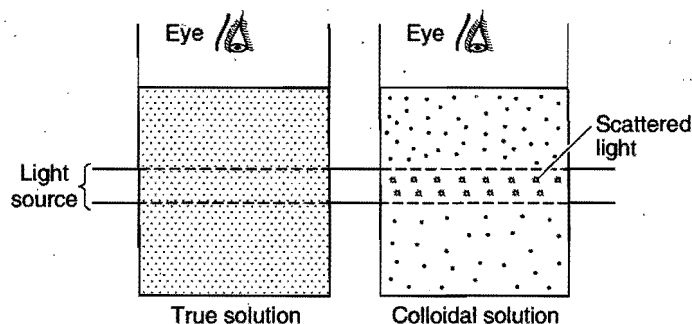


Fig. 6.6

Tyndall effect can be observed during the projection of picture in the cinema hall due to scattering of light by dust and smoke particles present there. Tyndall effect is observed only when the following two conditions are satisfied:

- (i) The diameter of the dispersed particles is not much smaller than the wavelength of the light used; and
- (ii) The refractive indices of the dispersed phase and the dispersion medium must differ greatly in magnitude. This

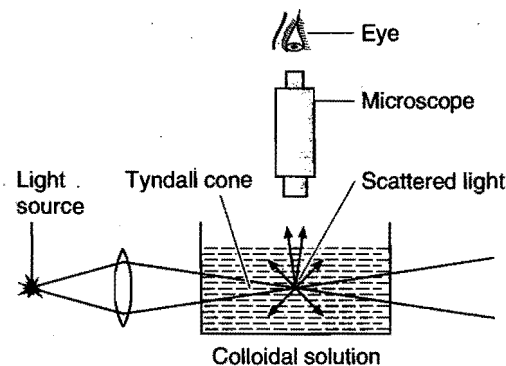


Fig. 6.7

Some examples of Tyndall effects are:

- (i) Blue colour of sky and seawater
- (ii) Visibility of tails of comets
- (iii) Twinkling of stars.

Tyndall effect is used to distinguish between a colloidal and true solution. **Zsigmondy**, in 1903, used Tyndall effect to set up an apparatus known as **ultramicroscope**. An intense beam of light is focussed on the colloidal solution contained in a glass vessel. The focus of the light is then observed with a microscope at right angles to the beam. Individual colloidal particles appear as bright stars against a dark background. Ultramicroscope does not render visible the actual colloidal particles but only the light scattered by them. Thus, ultramicroscope does not provide any information about the size and shape of colloidal particles.

7. Colour: The colour of colloidal solution depends on the wavelength of light scattered by the dispersed particles. The wavelength of light further depends on the size and nature of the particles. The colour of colloidal solution also changes with the way the observer receives the light. For example, milk and water mixture appears blue when viewed by the reflected light and looks red by the transmitted light. Finest gold sol is red in colour. As size of the particles increases, it becomes purple, then blue and finally golden yellow.

8. Brownian movement: When colloidal solutions are viewed under a powerful ultramicroscope, the colloidal particles appear to be in a state of continuous motion in zig-zag directions all over the field of view. This motion was first observed by the

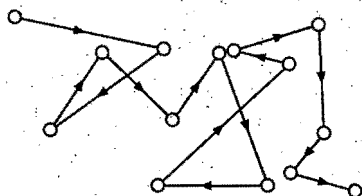


Fig. 6.8

British botanist **Robert Brown** and hence is known as **Brownian movement** (Fig. 6.8). This motion is independent of the nature of the colloid but depends on the size of the particles and the viscosity of solution. **Smaller the size and lesser the viscosity, faster is the motion.** The motion becomes intense at high temperature. The distance between two points decreases at elevated temperature.

The Brownian movement has been explained to be due to the unbalanced bombardment of the particles by the molecules of the dispersion medium. The Brownian movement has a stirring effect which does not permit the particles to settle and thus, is responsible for the stability of sols.

9. Charge on colloidal particles: Colloidal particles always carry an electric charge. This charge is of the same type on all the particles in a given colloidal solution and may be either

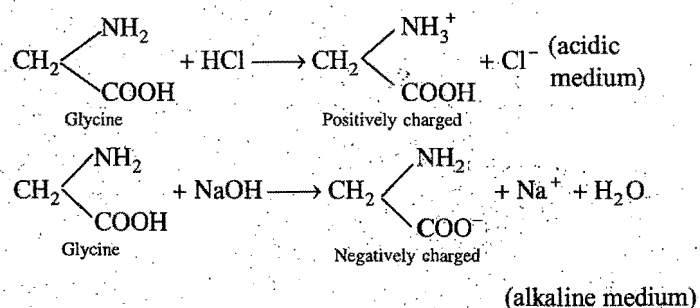
positive or negative. A list of some common sols with the type of charge on their particles is given in table 6.5.

Table 6.5

S. No.	Positively charged	Negatively charged
1.	Metallic hydroxides, e.g., $\text{Cr}(\text{OH})_3$, $\text{Al}(\text{OH})_3$ and $\text{Fe}(\text{OH})_3$ sols.	Metals, e.g., copper, silver, gold-sols.
2.	Basic dyestuffs, e.g., methylene blue sol.	Metallic sulphides, e.g., As_2S_3 , Sb_2S_3 , CdS sols.
3.	Proteins in acidic medium.	Acid dyestuffs, e.g., eosin, congo red-sols.
4.	Oxides, e.g., TiO_2 sol.	Sols of starch, gum, gelatin, clay, charcoal, etc.

The charge on the sol particles is due to one or more of the following reasons:

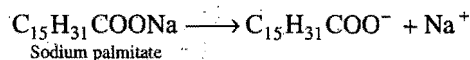
(i) **Due to the presence of acidic or basic groups:** A protein molecule has a carboxylic group and a basic NH_2 group. The particles of proteins in sols can either have positive charge or negative charge depending upon the pH of the medium.



Isoelectric point of a colloid: In case of colloidal solution proteins, the nature of charge depends on the pH of the solution called isoelectric point. Above this pH, the particles are negatively charged and below this pH, they have positive charge. At isoelectric point, colloidal particles exist in the form of Zwitter ion hence they do not migrate under the influence of external electric field.

Examples:	Colloidal sol	Isoelectric pH
	Haemoglobin	4.3—5.3
	Casein from human milk	4.1—4.7
	Gelatin	4.7

(ii) Due to self-dissociation: When colloidal particles such as soaps or detergents are dissolved in water, ionised molecules associate to form a micelle. The outer surface will be thus charged depending on the charge of the ions from which it is formed. Thus, sodium palmitate solution will have negative charge on its sol particles.

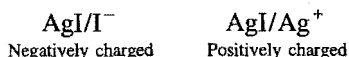


(iii) Due to electron capture by sol particles: *e.g.*, during electro-dispersion of metals.

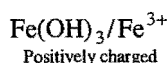
(iv) **Due to preferential adsorption of ions:** This is the most accepted view. The sol particles acquire positive or negative charge by preferential adsorption of +ve or -ve ions. **When two**

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

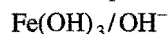
(a) If silver nitrate solution is added to potassium iodide solution, the precipitated silver iodide will adsorb iodide ions from the dispersion medium and negatively charged colloidal solution will result. However, when KI solution is added to AgNO_3 solution, positively charged sol will result due to adsorption of Ag^+ ions from dispersion medium.



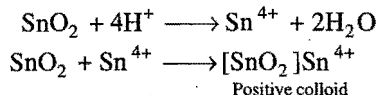
(b) If FeCl_3 is added to excess of hot water, a positively charged sol of ferric hydroxide is formed due to adsorption of Fe^{3+} ions.



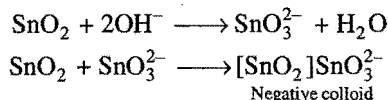
However, when ferric chloride is added to NaOH a negatively charged sol is obtained with adsorption of OH^- ions.



SnO_2 is positively charged colloidal sol due to adsorption of Sn^{4+} ions.



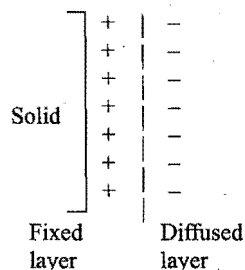
On the other hand in alkaline medium, SnO_2 forms negatively charged colloidal sol due to adsorption of SnO_3^{2-} ions formed.



Electrical double layer: The surface of a colloidal particle acquires a positive or a negative charge by selective adsorption of ions carrying positive or negative charge respectively as stated above. This layer attracts counter ions from the medium which form a second layer.



The combination of the two layers of opposite charges around the colloidal particle is called **Helmholtz electrical double layer**. According to modern views, the first layer of ions is firmly held and is termed **fixed layer** while the second layer is mobile which is termed **diffused layer**. Since, separation of charge is a seat of potential, the charges of opposite signs on the fixed and diffused parts of the double layer results in a difference in potential between these layers. This potential difference between the fixed charged layer and the diffused layer of opposite charge is called the **electrokinetic potential** or **zeta potential**.



$$\xi = \frac{4\pi\eta u}{D}$$

where, η = Coefficient of viscosity

u = Velocity of colloidal particles

D = Dielectric constant of the medium

The presence of equal and similar charges on colloidal particles is largely responsible in providing stability to the colloidal solution because the forces of repulsion exist between same charged particles which prevent them from coalescing or aggregating when they come closer to one another.

10. Electrophoresis: When electric potential is applied across two platinum electrodes dipping in a colloidal solution, the colloidal particles move towards one or the other electrode. This movement of colloidal particles under an applied electric field is called **electrophoresis**. Positively charged particles move towards the cathode while negatively charged particles move towards anode. This can be demonstrated by the following experiment:

The apparatus consists of a U-tube provided with a stopcock through which it is connected to a funnel-shaped reservoir (Fig. 6.9). A small amount of water is first taken in the U-tube and then a requisite quantity of colloidal solution is placed in the

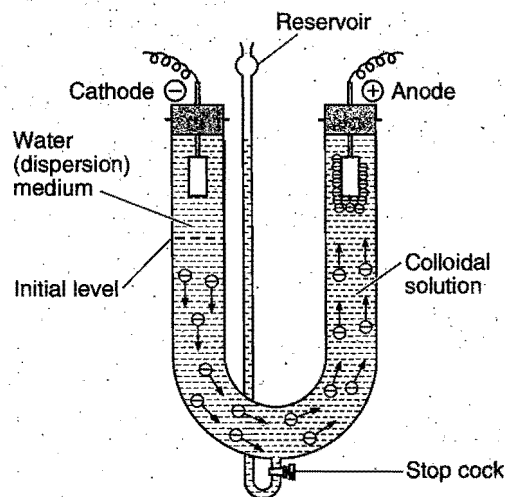


Fig. 6.9

reservoir. The stopcock is slightly opened and the reservoir is gradually raised as to introduce the colloidal solution into the U-tube. The water is displaced upwards producing a sharp boundary line in each arm. The platinum electrodes are fitted in the water layer and a voltage of 50 to 200 volts is applied. The movement of the particles can be observed towards one of the electrodes by seeing the position of boundary. When the colloidal particles are negatively charged, the boundary moves down in the cathodic arm and moves upwards in the anodic arm showing that particles move towards anode. It is, thus, possible to ascertain the charge on particles by noting the movement of boundary.

When electrophoresis, i.e., movement of particles is prevented by some suitable means, it is observed that the dispersion medium begins to move in an electric field. This phenomenon is termed **electro-osmosis**.

Summary of Electrokinetic Phenomena

Motion Causing Potential :

Sedimentation Potential	Streaming Potential
Medium rests but dispersed particles move.	Medium moves but dispersed particles rest.

Potential Causing Motion :

Electrophoresis	Electro-osmosis
Medium rests but dispersed particles move.	Medium moves but dispersed particles rest.

11. Coagulation or precipitation: The stability of the lyophobic sols is due to the presence of charge on colloidal particles. If, some how, the charge is removed, the particles will come nearer to each other and thus, aggregate or flocculate and settle down under the force of gravity.

The flocculation and settling down of the colloidal particles is called coagulation or precipitation of the sol.

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

(i) **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.

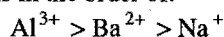
(ii) **By mixing two oppositely charged sols:** When oppositely charged sols are mixed in almost equal proportions, their charges are neutralised. Both sols may be partially or completely precipitated as the mixing of ferric hydroxide (+ve sol) and arsenious sulphide (-ve sol) bring them in precipitated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

(iii) **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.

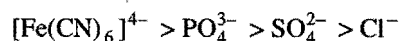
(iv) **By persistent dialysis:** On prolonged dialysis, the traces of the electrolyte present in the sol are removed almost completely and the colloids become unstable.

(v) **By addition of electrolytes:** When excess of an electrolyte is added, the colloidal particles are precipitated. The reason is that colloidal particles take up ions carrying charge opposite to that present on themselves. This causes neutralisation leading to their coagulation. The ion responsible for neutralisation of charge on the particles is called the **flocculating ion**. A negative ion causes the precipitation of positively charged sol and *vice-versa*.

It has been observed that, generally, the greater the valency of the flocculating ion added, the greater is its power to cause precipitation. This is known as **Hardy-Schulze rule**. In the coagulation of a negative sol, the flocculating power of Na^+ , Ba^{2+} and Al^{3+} ions is in the order of:



Similarly, in the coagulation of a positive sol, the flocculation power of Cl^- , SO_4^{2-} , PO_4^{3-} and $[\text{Fe}(\text{CN})_6]^{4-}$ is in the order of:



The minimum concentration of an electrolyte in millimole per litre required to cause precipitation of a sol in 2 hours is called **flocculation value**. The smaller the flocculating value, the higher will be the coagulating power of an ion.

Flocculation value of an ion depends on its charge :

Flocculation value $\propto \frac{1}{(Z)^6}$ where Z = charge of ion

Flocculation value of M^+ , M^{2+} , M^{3+} , M^{4+} ions lies in following ratio.

$$\frac{1}{(1)^6} : \frac{1}{(2)^6} : \frac{1}{(3)^6} : \frac{1}{(4)^6}$$

$$1 : 0.0156 : 0.00137 : 0.00024$$

$$100 : 1.56 : 0.137 : 0.024$$

Coagulation of lyophilic sols: There are two factors which are responsible for the stability of lyophilic sols. These factors are the charge and solvation of the colloidal particles. When these two factors are removed, a lyophilic sol can be coagulated. This is done (i) by adding electrolyte and (ii) by adding suitable solvent. When solvents 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.

12. Protection of colloids: Lyophilic sols are more stable than lyophobic sols. This is due to the fact that lyophilic colloids are extensively solvated, i.e., colloidal particles are covered by a sheath of the liquid in which they are dispersed.

Lyophilic colloids have a unique property of protecting lyophobic colloids. When a lyophilic sol is added to the lyophobic sol, the lyophilic particles form a layer around lyophobic particles and thus, protect the latter from electrolytes. Lyophilic colloids used for this purpose are called **protective colloids**.

The lyophilic colloids differ in their protective power. The protective power is measured in terms of **Gold Number**. This number was introduced by Zsigmondy and is defined as the **number of milligrams of a lyophilic colloid that will just prevent the precipitation of 10 mL of a gold sol on the addition of 1 mL of 10% sodium chloride solution**.

The gold numbers of some of the common protective colloids are listed below:

Table 6.6

S.No.	Protective Colloid	Gold Number
1.	Gelatin	0.005-0.01
2.	Haemoglobin	0.03
3.	Gum arabic	0.15
4.	Egg albumin	0.08-0.10
5.	Potato starch	25
6.	Sodium oleate	0.4
7.	Gum tragacanth	2
8.	Starch	25-50

Higher is the gold number, lower will be the protective power. Thus, gelatin and starch have the maximum and minimum protective powers. The use of protective colloids is widespread. Gelatin is added in the preparation of ice cream as protective agent to the colloidal particles of ice. Argyrol, used as eye drops, is a silver sol protected by organic material.

Some facts :

(i) Blood is a colloidal solution, it is not coagulated by the electrolytes (NaCl, $\text{Ca}_3(\text{PO}_4)_2$ etc.) present in blood itself because proteins present in blood act as protective colloid.

(ii) Milk of human mother is better protected than cow's and buffaloes milk.

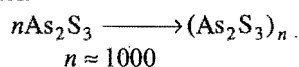
(iii) The proteins which are not coagulated at their iso-electric pH are better protective colloid.

(iv) **Ageing** : It is spontaneous destabilisation of colloidal solution. In this process, dispersed is separated from dispersion medium by itself, i.e., no artificial method is used.

Congo Rubin Number

Ostwald proposed that it is the amount of protective colloid in mg which prevents the colour change in 100 mL of 0.01% Congo rubin dye solution to which 0.16 g equivalent of KCl are added when observed after 10–15 min.

13. Colligative properties: The value of colligative properties are of very small order because they have very small van't Hoff factor.



$$\text{van't Hoff factor } i = \frac{1}{1000}$$

Colligative properties are directly proportional to the van't Hoff factor.

6.7 EMULSIONS

These are liquid-liquid colloidal systems, i.e., the dispersion of finely divided droplets in another liquid. If a mixture of two immiscible or partially miscible liquids is shaken, a coarse dispersion of one liquid in the other is obtained which is called **emulsion**. Generally, one of the two liquids is water. There are two types of emulsions:

- (i) Oil dispersed in water (O/W type),
- (ii) Water dispersed in oil (W/O type).

In the first system, water acts as dispersion medium. Examples of this type of emulsions are milk and vanishing cream. In milk, liquid fat is dispersed in water.

In the second system, oil acts as dispersion medium. Common examples of this type are butter and cream.

Emulsions of oil and water are unstable and sometimes they separate into two layers on standing. For the stabilization of an emulsion, a third component called **emulsifying agent** is usually added. The emulsifying agents form an interfacial film between suspended particles and the medium. The principal agents for O/W emulsions are proteins, gums, natural and synthetic soaps, etc. For W/O emulsions, the principal emulsifying agents are

heavy metal salts of fatty acids, long chain alcohols, lampblack, etc.

Emulsions can be diluted with any amount of the dispersion medium. On the other hand, the dispersed liquid, when mixed, forms at once a separate layer. The droplets in emulsions are often negatively charged and can be precipitated by electrolytes. They also show Brownian movement and Tyndall effect. Emulsions can be broken into constituent liquids by heating, freezing, centrifuging, etc.

Detection of emulsion: Following tests can be used to detect the type of emulsion:

(i) **Dye test:** An oil soluble dye is shaken up with the emulsion and a drop is seen under microscope. If coloured drops are seen, the emulsion is water in oil type otherwise of oil in water type.

(ii) **Viscosity test:** Water in oil type emulsion has greater viscosity than oil in water type emulsion.

(iii) **Electrical conductivity test:** Electrical conductivity of oil in water type emulsion is much greater than water in oil type emulsion. If electrolyte like NaCl is added to oil in water type emulsion, its conductivity greatly increases.

(iv) **Spreading test:** Water in oil type emulsion easily spread on the surface of an oil but not on the surface of water.

(v) **Dilution test:** Oil in water type emulsion can easily be diluted with water. On the other hand water in oil type emulsion cannot be diluted with water. For example, milk-which is oil in water type emulsion can be diluted with water, but butter or milk cream which are water in oil type emulsion cannot be diluted with water.

(vi) **Coalescence:** It is the phenomena of disappearance of the boundary between two particles (generally droplets or bubbles) in contact. Coalescence leads to the reduction of the total surface area. The flocculation of an emulsion, viz., the formation of aggregates, may be followed by coalescence. In extensive condition, the coalescence leads to the formation of a macrophase and emulsion is said to break. Coalescence of solid particles is called sintering.

6.8 CLASSIFICATION OF COLLOIDS BASED ON THE TYPE OF PARTICLES OF DISPERSED PHASE

Depending upon the type of particles of dispersed phase, colloids are classified as:

(i) Multimolecular, (ii) Macromolecular, (iii) Associated colloids.

(i) **Multimolecular colloids:** On dissolution, a large number of atoms or smaller molecules of a substance aggregate together to form species having size in colloidal dimension (diameter less than 1 nm). The species thus formed are called multimolecular colloids. For example: Gold sol, sulphur sol. In these colloids, the particles are held together by van der Waals' forces.

(ii) **Macromolecular colloids:** Macromolecular substances dissolve in suitable solvent to form solutions in which the size of macromolecules lie in colloidal dimension. These are called

macromolecular colloids and they are quite stable. For example: Starch, cellulose, proteins and enzymes, etc.

(iii) **Associated colloids:** Substances whose molecules aggregate spontaneously in a given solvent to form particles of colloidal dimensions are called **associated colloids**. These substances which when dissolved in a medium at low concentrations behave as normal, strong electrolytes, but at higher concentrations they exhibit colloidal properties due to the formation of aggregated particles (also called associated colloids). The molecules of soaps and detergents are usually smaller than the colloidal particles. However, in concentrated solutions, these molecules associate and form aggregates of colloidal size. These aggregates of soaps or detergent molecules are called **micelles**. The formation of micelles takes place only above a particular concentration called **critical micelle concentration (CMC)**. For soaps, the CMC is 10^{-4} to $10^{-3} \text{ mol L}^{-1}$. These colloids have both lyophobic and lyophilic parts. Micelles may contain the aggregate of (30–100) molecules or more. Soaps and detergents are strong electrolytes and when dissolved in water they furnish ions.

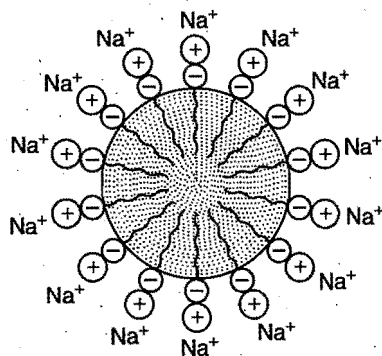
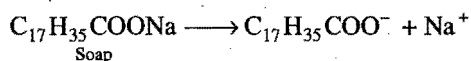


Fig. 6.10

The negative ions aggregate to form a micelle of colloidal size. The negative ion has a long hydrocarbon chain and a polar group ($-\text{COO}^-$) at one end. In micelle formation, the long hydrocarbon chain (tail) which is insoluble in water is directed towards the centre while the soluble polar head is on the surface in contact with water (Fig. 6.10). The charge on the micelle is responsible for the stability of this system. The cleansing action of soap is due to these micelles. The grease stain is absorbed into the interior of the micelle and gets detached from the fabric. The dust particles sticking to the stain are also removed. This action is similar to emulsification of grease.

Some other examples of micelle systems are as follows:

(i) Sodium lauryl sulphate $\text{CH}_3-(\text{CH}_2)_{11}\text{SO}_4^- \text{Na}^+$

(ii) Sodium oleate $\text{C}_{17}\text{H}_{35}\text{COO}^- \text{Na}^+$

(iii) Cetyltrimethyl ammonium bromide;
 $\text{CH}_3(\text{CH}_2)_{15}\text{N}^+(\text{CH}_3)_3 \text{Br}$

Micellisation with cationic terminals are also known, e.g., in cetyltrimethyl ammonium chloride. It may be diagrammatically represented as :

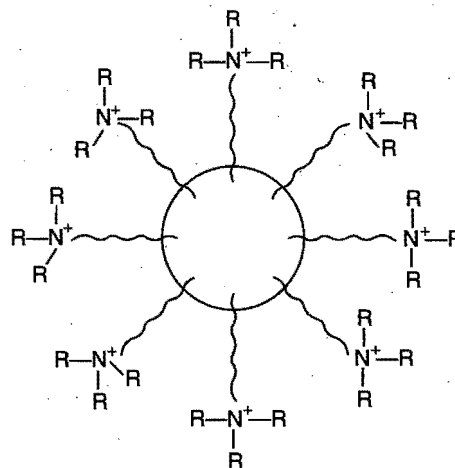
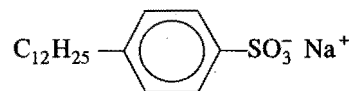


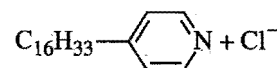
Fig. 6.11

(iv) *p*-Dodecyl benzene sulphonate;



Surfactants are those substances which are preferentially adsorbed at the interfaces like air-water, oil-water and solid-water interfaces. Thus, it is the surfactant which is responsible for **micellisation** and emulsification. Surfactants are divided into three categories:

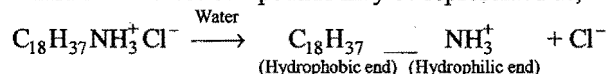
(i) **Cationic surfactants:** Such substances on ionisation give a cation having hydrophobic and hydrophilic group, e.g., cetyl pyridinium chloride,



Cetyltrimethyl ammonium chloride, $\text{C}_{16}\text{H}_{33}(\text{CH}_3)_3\text{N}^+\text{Cl}^-$

Octadecyl ammonium chloride, $\text{C}_{18}\text{H}_{37}\text{NH}_3^+\text{Cl}^-$

Ionisation of these compounds may be represented as,



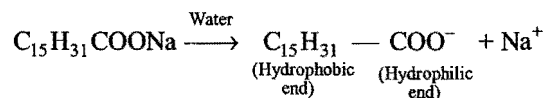
(ii) **Anionic surfactants:** Such substances give anion which act as surfactant, e.g.,

Sodium Palmitate $\text{C}_{15}\text{H}_{31}\text{COONa}$

Sodium Oleate $\text{C}_{17}\text{H}_{35}\text{COONa}$

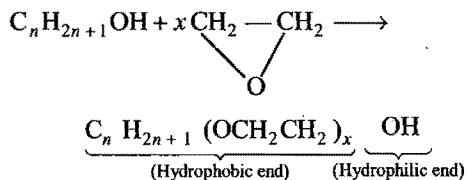
and salts of sulphonic acid having molecular formula

$\text{C}_n\text{H}_{2n+1}\text{SO}_3\text{M}$ where, $\text{M}^+ = \text{Na}^+, \text{K}^+, \text{NH}_4^+$, etc.



(iii) **Non-ionogenic surfactants:** These surfactants do not ionise or dissociate in aqueous medium, but these molecules also have hydrophobic and hydrophilic end.

High molecular mass alcohol adds to several molecules of ethylene oxide to form hydroxy surfactant.



Kraft point: The temperature above which a surfactant forms micelle is called kraft point.

Some Important Features of Micelle

1. At critical micelle concentration (CMC), surfactants begins to form spherical aggregates made of 30 to 100 ions with their hydrocarbon tails in the interior of the aggregate and their charged terminals exposed to water on the out side (see Fig. 6.12).

2. Increase in temperature usually increases CMC.

3. CMC also depends on chain length, greater is the chain length of hydrocarbon tail, smaller is the CMC. Increase in the hydrophobic part of the surfactant molecules, favours the formation of micelles.

4. CMC of ionic micelles decreases on addition of simple electrolyte like NaCl. Screening action of added ions reduces the repulsion between charged groups at the surface of micelles.

5. Below the Kraft temperature, solubility of surfactant is not enough to form micelles. Kraft temperature increases with increase in the number of carbon atoms.

Number of carbon atoms in sodium alkyl sulphates	10	12	14
Kraft temperature °C	8	16	30

6. Micellisation is found to be spontaneous; it is confirmed by negative value of ΔG in following equation :

$$\Delta G = \Delta H - T\Delta S \quad \dots(1)$$

$$\Delta H = -\text{ve and } T\Delta S = +\text{ve for micellisation}$$

Standard enthalpy change of micellisation may be calculated as,

$$\begin{aligned} \Delta H^\circ &= \Delta G^\circ + T\Delta S^\circ \\ &= -2.303 RT^2 \frac{d(\log CMC)}{dT} \end{aligned}$$

Physical Properties of Critical Micelle Concentration

Physico-chemical properties of surfactant solution changes sharply in the region of the C.M.C. Variation of physico-chemical properties of surfactant solution with concentration is represented in following figure :

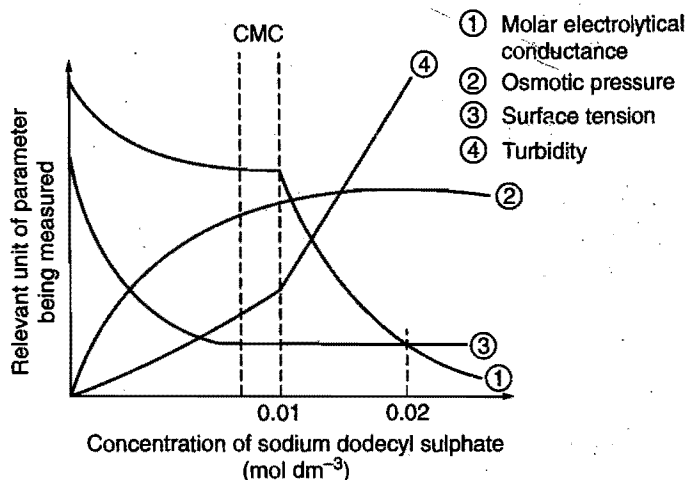


Fig. 6.12

6.9 GELS

When a colloidal solution is coagulated, a precipitate is usually formed which may or may not be gelatinous. Under certain set of conditions, it is possible to obtain the dispersed phase as more or less rigid mass enclosing within it all of the liquid. The product in this form is known as a **gel** and the process is called **gelation**. The gel is, thus, a colloidal semi-solid system rich in liquid phase. Gel usually consists of two components; one is solid, such as gelatin, silicic acid, sodium oleate, etc., and the other is a liquid such as water.

Gels may be elastic or non-elastic according to their mechanical properties. Elastic gels can be prepared by dissolving the substance in warm water and cooling it till sets. Examples are agar-agar and gelatin gels. Non-elastic gels are prepared by appropriate chemical action. The silica gel is formed by action of HCl with sodium silicate solution.

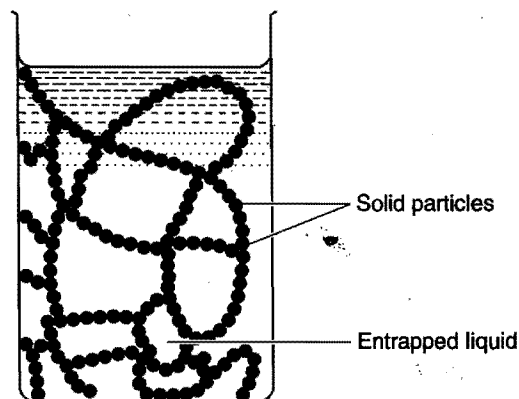


Fig. 6.13

Gel may shrink on keeping by loosing some of the liquid held by them. This is known as **syneresis** or weeping of gel. Some gels liquify on shaking and reset on being allowed to stand. This, reversible Sol-Gel transformation is known as **thixotropy**. The softening behaviour of a marshy land under trading is due to thixotropic behaviour of bentonite clay present in such soils.

Elastic gel can **imbibe** water when placed in it and undergo swelling, non-elastic gels are incapable of doing so. This phenomenon is known as imbibition or swelling.

6.10 APPLICATIONS OF COLLOIDS

Most of the substances, we come across in our daily life, are colloids. The meal we eat, the clothes we wear, the wooden furniture we use, the houses we live in, the newspapers we read, are largely composed of colloids.

The applications of colloid chemistry are limitless. These can be divided mainly into two classes:

1. Natural applications
2. Technical applications

1. Natural Applications

(i) **Blue colour of the sky:** Colloidal particles scatter blue light. Dust particles along with water suspended in air scatter blue light which reaches our eyes and the sky looks blue to us.

(ii) **Fog, mist and rain:** When a large mass of air, containing dust particles, is cooled below its dewpoint, the moisture from the air condenses on the surfaces of these particles forming fine droplets. These droplets being colloidal in nature continue to float in the air in the form of mist or fog.

Clouds are aerosols having small droplets of water suspended in air. On account of condensation in the upper atmosphere, the colloidal droplets of water grow bigger and bigger in size, till they come down in the form of rain. Sometimes, the rainfall occurs when two oppositely charged clouds meet.

It is possible to cause artificial rain by throwing electrified sand or spraying a sol carrying charge opposite to the one on clouds from an aeroplane.

(iii) **Food articles:** Milk, butter, halwa, ice creams, fruit juices, etc., are all colloids in one form or the other.

(iv) **Blood:** Blood is a colloidal solution of an albuminoid substance. The styptic action of alum and ferric chloride solution is due to coagulation of blood forming a clot which stops further bleeding.

(v) **Soils:** Fertile soils are colloidal in nature in which humus acts as a protective colloid. On account of colloidal nature, soils absorb moisture and nourishing materials.

(vi) **Formation of delta:** River water is colloidal solution of clay. Seawater contains a number of electrolytes. When river water meets the seawater, the electrolytes present in seawater coagulate the colloidal solution of clay which gets deposited with the formation of delta.

2. Technical Applications

(i) **Electrical precipitation of smoke:** Smoke is a colloidal solution of solid particles such as carbon, arsenic compounds, dust, etc., in air. The smoke, before it comes out from the chimney, is led through a chamber containing plates having a charge opposite to that carried by smoke particles. The particles on coming in contact with these plates lose their charge and get

precipitated. The particles thus, settle down on the floor of the chamber. The precipitator is called **cottrell precipitator**.

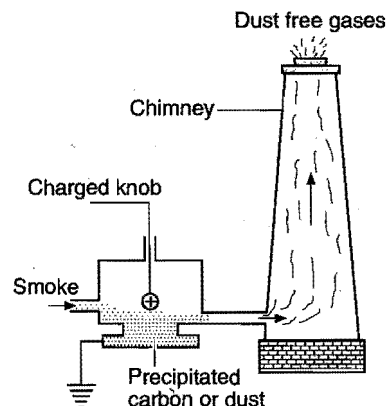


Fig. 6.14

(ii) **Purification of drinking water:** The water obtained from natural sources often contains bacteria and suspended impurities. Alum is added to such water so as to destroy the bacteria as well as to coagulate the suspended impurities and make water fit for drinking purposes.

(iii) **Medicines:** Most of the medicines in use are colloidal in nature. For example, argyrol is a silver sol used as an eye lotion. Colloidal antimony is used in curing kala-azar. Colloidal gold is used for intramuscular injection. Milk of magnesia (an emulsion) is used for stomach disorders. Colloidal medicines are more effective because these are easily assimilated.

(iv) **Tanning:** Animal hides are colloidal in nature. When a hide, which has positively charged particles, is soaked in tannin, which contains negatively charged colloidal particles, mutual coagulation takes place, which results in the hardening of leather. The process is termed as **tanning**. Chromium salts have also been used in place of tannin.

(v) **Cleansing action of soaps and detergents:** Already described in section 6.8.

(vi) **Photographic plates and films:** The photographic plates or films are prepared by coating an emulsion of the light sensitive silver bromide in gelatin over glass plates or celluloid films.

(vii) **Rubber industry:** Latex is a colloidal solution of rubber particles which are negatively charged. Rubber is obtained by coagulation of latex.

(viii) **Industrial products:** Paints, inks, synthetic plastics, rubber, graphite lubricants, cement, etc., are all colloidal solutions. Asphalt emulsion is used in road construction.

(ix) **Disinfectants:** The disinfectants such as dettol and lysol give emulsion of oil in water type when mixed with water.

(x) **In metallurgy:** Sulphide ores are concentrated by froth-flotation process. In this process; pulverised ore is treated with emulsion of pine oil.

SUMMARY AND IMPORTANT POINTS TO REMEMBER

1. Crystalloids and colloids: Thomas Graham classified the soluble substances into two categories; crystalloids and colloids. Crystalloids are the substances which in solution diffuse readily through animal or vegetable membranes, e.g., urea, sugar, salt and other crystalline compounds. Colloids (Greek word, *Kolla*, meaning glue-like) are the substances which in solution diffuse very slowly or do not diffuse through animal or vegetable membranes, e.g., gelatin, glue, silicic acid, etc. It was soon realised that many of the crystalloids can be converted into colloidal form by suitable means. Thus, colloid is a state of matter like solid, liquid or gas in which any substance can be brought by suitable means.

2. Colloidal state: It depends upon the particle size. It is regarded as an intermediate state between true solution and suspension. Colloidal state is a heterogeneous system in which solute particles of size ranging between $10 \text{ \AA}$ to $10^3 \text{ \AA}$ (10^{-7} to 10^{-5} cm) are dispersed into a solvent (dispersion medium).

3. Types of colloidal solutions: A colloidal solution consists two types, viz., dispersed or internal or discontinuous phase and the dispersion or external or continuous phase. Depending on these phases eight types of colloidal solutions are possible. The important ones are:

- (i) Solid dispersed in liquid—It is called sol.
- (ii) Liquid dispersed in liquid—It is called emulsion.
- (iii) Solid dispersed in gas—It is called aerosol.
- (iv) Liquid dispersed in solid—It is called gel.

Lyophobic: Colloidal solutions in which dispersed phase has very little affinity for the dispersion medium. These are less stable and irreversible in nature. These are also called suspensoids.

Lyophilic: Colloidal solutions in which dispersed phase has great affinity for dispersion medium. These are stable and reversible in nature. These are also called emulsoids.

The colloidal solutions are also named according to the dispersion phase or medium used.

Dispersion medium	Name of colloidal solution
Water	Hydrosols
Alcohol	Alcosols
Benzene	Benzosols
Air	Aerosols

4. Preparation of colloidal solutions: To get a substance in colloidal form either the substance is broken down into fine particles of colloidal dimension or increasing the size of molecular particles as to form large aggregates. Thus, there are two ways by which lyophobic sols can be prepared.

(i) Dispersion methods: By splitting coarse aggregates of a substance into colloidal size. The dispersion methods include (a) mechanical dispersion (b) electro-dispersion (c) ultrasonic dispersion and (d) peptization. Peptization is a process of converting precipitates into colloidal state by adding small amount of suitable electrolyte.

(ii) Condensation methods: By aggregating very small particles into colloidal particles. These include (a) exchange of solvents (b) change of physical state and (c) chemical methods such as double decomposition, oxidation, reduction, hydrolysis, etc.

5. Purification of colloidal solutions: The process of reducing the impurities (electrolytes or soluble substances) to a requisite minimum in a colloidal solution is known as purification of colloidal solution.

Dialysis: It is a process of removing a dissolved substance from a colloidal solution by means of diffusion through suitable membrane. Animal membranes, parchment paper or cellophane sheet can be used for this purpose. The electrolytes can be readily removed by electrodialysis.

6. Properties of colloidal solutions: Colloidal solutions possess the following properties:

- (i) Heterogeneous character:** Consist of two phases.
- (ii) Visibility:** Particles are not visible to naked eye or with the help of microscope.
- (iii) Filtrability:** Particles pass through ordinary filter paper but not through parchment and other fine membranes.
- (iv) Surface tension and viscosity:** These are not very different from those of dispersion medium in the case of lyophobic sols. Lyophilic sols show higher viscosity and lower surface tension.
- (v) Colligative properties:** These properties are of small order as compared to true solutions at same concentrations.
- (vi) Tyndall effect:** It is the scattering of light from the surface of colloidal particles. A beam of light passed through a colloidal solution becomes visible as a bright streak. The illuminated path is called Tyndall cone.

(vii) Brownian movement: It is a ceaseless zig-zag motion of colloidal particles. Smaller the size and lesser the viscosity, faster is the motion. This is due to unbalanced bombardment of particles by the molecules of dispersion medium. It is somewhat responsible for stability of sols as the particles are not allowed to settle.

(viii) Charge on colloidal particles: Colloidal particles are electrically charged either carrying positive or negative charge. The origin of charge in most cases is due to preferential adsorption of ions on the surface. When an electric current is passed through the colloidal solution, the particles move towards a particular electrode. This is termed electrophoresis or cataphoresis. When only the medium is allowed to migrate and not the particles, the phenomenon is known as electroosmosis.

(ix) Coagulation: The phenomenon of change of colloidal state to suspension state is known as coagulation or precipitation or flocculation of colloidal solution. The coagulation is affected either by boiling of colloidal solution or by mutual action of colloidal sols (by mixing oppositely charged colloidal solutions) or by electrophoresis or by the addition of electrolytes.

The positive ion is effective in coagulating negative sol and *vice-versa*. The effectiveness of anion is governed by Hardy-Schulze rule. The rule states that the precipitating power of an ion depends upon its valency, *i.e.*, higher the valency of the ion greater is the precipitating power of the ion.

For negative sol, the power varies as $M^{3+} > M^{2+} > M^{+}$ and for positive sol the power varies as $[\text{Fe}(\text{CN})_6]^{4-} > \text{SO}_4^{2-} > \text{Cl}^{-}$.

Flocculating value: It is the minimum concentration in millimoles per litre of an electrolyte required to cause precipitation of a sol in 2 hours. The smaller is the flocculating power greater shall be the precipitating power of an ion.

(x) Protective action: Lyophilic sols are more stable than lyophobic sols. Thus, lyophilic colloids have the property of protecting lyophobic sols. When a lyophilic sol is added to lyophobic sol, the lyophilic particles form a layer around lyophobic particles and thus protect them from electrolytes. The protective power of lyophilic colloid is measured in terms of gold number. It is defined as the number of milligrams of a lyophilic colloid that will just prevent the precipitation of 10 mL of a gold sol on the addition of 1 mL of 10% NaCl solution. Lower the gold number, higher will be the protective power. Gelatin (Gold Number 0.005–0.01) and starch (Gold Number 25–50) have the maximum and minimum protective powers.

(xi) Coacervation: The loss of the stability of a lyophilic sol, quite often results in a separation of the system into two liquid phases. The separation of colloidal sol into two liquid phases is called **coacervation**.

7. Emulsion: It is a colloidal solution of a liquid in another immiscible liquid. Emulsions are usually of two types:

- Oil in water—Examples: Milk, cream, face cream, etc.
- Water in oil—Examples: Butter, cold cream, etc.

Emulsifying agent: It is added to an oil and water emulsion to increase its stability. It has polar and non-polar groups; the former attaches to water and the latter to oil and so binds them together in an emulsion. Soaps and detergents act as emulsifying agents.

8. Gel: It is a colloidal system in which liquid is dispersed in solid. Fruit-jellies, cheese, etc., are the examples of gels. Gels may be elastic or non-elastic according to their mechanical properties.

9. Applications of colloids: The applications can be divided mainly into two classes:

(i) Natural applications:

- Blue colour of the sky
- Fog, mist and rain
- Food articles
- Blood
- Soils
- Formation of delta

(ii) Technical applications:

- Electrical precipitation of smoke
- Purification of drinking water
- Medicines
- Tanning
- Cleansing action of soaps and detergents
- Photographic plates and films
- Rubber industry
- Paints, inks, plastics, lubricants, cement, etc.

Questions

1. Match the following:

[A]

- | | |
|-------------------------|--|
| (i) Gold number | (a) Coagulation |
| (ii) Lyophobic | (b) An emulsion |
| (iii) Butter | (c) Gold sol |
| (iv) Hardy-Schulze rule | (d) Gel |
| (v) Micelles | (e) Purification of colloidal solution |
| (vi) Purple of cassius | (f) Protective colloids |
| (vii) Cheese | (g) Solvent hating |
| (viii) Dialysis | (h) Associated colloids |

[B]

- | | |
|-------------------------------|------------------------|
| (i) Brownian movement | (a) Aerosol |
| (ii) Water loving colloids | (b) Ultramicroscope |
| (iii) Liquid dispersed in gas | (c) Irreversible |
| (iv) Tyndall effect | (d) Sewage disposal |
| (v) Hydrophobic | (e) Smoke precipitator |
| (vi) Coagulation | (f) Hydrophilic |
| (vii) Electrophoresis | (g) Emulsifying agent |
| (viii) Soap | (h) Robert Brown |

[C] Property

Statement

Application / discoverer

- | | | |
|-------------------------|---|------------------------|
| (i) Tyndall effect | (a) Due to unequal bombardment by solvent molecules | 1. Sewage disposal |
| (ii) Coagulation | (b) Surface area is large | 2. Smoke precipitator |
| (iii) Brownian movement | (c) Movement of colloidal particles under the influence of electric field | 3. Ultramicroscope |
| (iv) Adsorption | (d) Due to neutralisation of charge | 4. Ice cream |
| (v) Electrophoresis | (e) Due to scattering of light | 5. Colloidal medicines |
| (vi) Stability | (f) Addition of protective colloid | 6. Robert Brown |

2. Matrix Matching Problems (For IIT Aspirants):

[A] Match the colloids in Column-I with the classifications in Column-II:

Column-I

Column-II

- | | |
|----------------|----------|
| (a) Rain cloud | (p) Gel |
| (b) Smoke | (q) Foam |

(c) Butter

(r) Aerosol

(d) Soap sud

(s) Gas as dispersion medium

[B] Match the terms of List-I with those of List-II:

List-I

List-II

- | | |
|--------------------|---|
| (a) Coagulation | (p) Scattering of light |
| (b) Peptization | (q) Purification of colloidal solution |
| (c) Tyndall effect | (r) Addition of electrolyte |
| (d) Dialysis | (s) Precipitation of colloidal solution |

[C] Match the Column-I with Column-II and Column-III:

Column-I
(Colloidal solution)Column-II
(Dispersed phase)Column-III
(Dispersion medium)

- | | | |
|----------------|---------------|-------------|
| (a) Colloidion | (p) Water | (u) Ethanol |
| (b) Fog | (q) Cellulose | (v) Oil |
| (c) Butter | (r) Fat | (w) Air |
| (d) Milk | (s) Water | (x) Water |

[D] Match the terms in Column-I with their explanations in Column-II:

Column-I

Column-II

- | | |
|----------------------------|--|
| (a) Cottrell precipitation | (p) Purification of blood |
| (b) Electrophoresis | (q) Precipitation of colloidal particles by addition of electrolytes |
| (c) Hemodialysis | (r) Removal of pollutants from industrial waste gases |
| (d) Coagulation | (s) Movement of charged colloidal particles towards oppositely charged electrode |

[E] Match the terms in Column-I with those of Column-II:

Column-I

Column-II

- | | |
|---------------------------|--------------------------------|
| (a) Emulsifier | (p) Colloidal sol. of graphite |
| (b) Colloidal electrolyte | (q) Detergent |
| (c) Oil dag | (r) Cellophane |
| (d) Xerogel | (s) Dextrin |

[F] Match the Column-I with Column-II:

Column-I

Column-II

- | | |
|------------|--------------|
| (a) Milk | (p) Aerosol |
| (b) Dust | (q) Emulsion |
| (c) Cheese | (r) Gel |
| (d) Froth | (s) Foam |

3. The coagulation of 100 mL of a colloidal solution of gold is completely prevented by adding 0.25 g of starch to it before adding 10 mL of 10% NaCl solution. Find out the gold number of starch.

[Hint: 10 mL of 10% NaCl solution is added to 100 mL of solution of gold.

Thus, 1 mL of 10% NaCl solution has been added to 10 mL solution of gold.

Since, 100 mL gold solution required = 0.25 g starch

$$= 0.25 \times 10^3 \text{ mg starch}$$

$$\text{So, 10 mL gold solution required} = \frac{0.25 \times 10^3}{100} \times 10$$

$$= 25 \text{ mg starch}$$

Thus, by definition, the gold number of starch is 25.]

4. For the coagulation of 100 mL of arsenious sulphide solution, 5 mL of 1 M NaCl is required. What is the coagulating power of NaCl?

[Hint: Total volume after addition of 5 mL of 1 M NaCl solution = 105 mL

Thus, $105 \times \text{molarity of NaCl in colloidal solution} = 5 \times 1$

$$\text{Molarity of NaCl in colloidal solution} = \frac{5}{105}$$

$$\text{Concentration in millimole} = \frac{5}{105} \times 1000 = 47.6]$$

Answers

1. [A] (i—d); (ii—g); (iii—b); (iv—a); (v—h); (vi—c); (vii—d); (viii—e)
 [B] (i—h); (ii—f); (iii—a); (iv—b); (v—c); (vi—d); (vii—e); (viii—g)
 [C] (i—e—3); (ii—d—1); (iii—a—6); (iv—b—5); (v—c—2); (vi—f—4).
2. [A] (a—r, s) (b—r, s) (c—p) (d—q)
 [B] (a—r, s) (b—r) (c—p) (d—q)
 [C] (a—q—u) (b—p—w) (c—p—v) (d—r—x)
 [D] (a—r, s) (b—s) (c—p) (d—q)
 [E] (a—q, s) (b—q) (c—p) (d—r)
 [F] (a—q) (b—p) (c—r) (d—s)

OBJECTIVE QUESTIONS

Set-1: Questions with single correct answer

- Difference between crystalloid and colloid is of:
 - particle size
 - chemical composition
 - ionic character
 - solubility
- Substances whose solutions can readily diffuse through animal membranes are called:
 - colloids
 - crystalloids
 - electrolytes
 - non-electrolytes
- Suspensions are:
 - visible to naked eye
 - invisible through microscope
 - not visible by any means
 - invisible under electron microscope
- The size of the colloidal particles is in between: (CPMT 1990)
 - $10^{-7} - 10^{-9}$ cm
 - $10^{-9} - 10^{-11}$ cm
 - $10^{-5} - 10^{-7}$ cm
 - $10^{-2} - 10^{-3}$ cm
- The size of a colloidal particle is: [PMT (MP) 1990]
 - $> 0.1 \mu$
 - $1 \text{ m}\mu$ to 0.1μ
 - $< 0.1 \text{ m}\mu$
 - more than $3000 \text{ m}\mu$
- If liquid is dispersed in solid medium, then this is called: (DCE 2009)
 - sol
 - emulsion
 - liquid aerosol
 - gel
- Which of the following forms a colloidal solution in water? (CPMT 1990)
 - NaCl
 - Glucose
 - $\text{Ba}(\text{NO}_3)_2$
 - Starch
- The number of phases present in colloidal solution is:
 - 2
 - 4
 - 3
 - 1
- The colloidal system of a solid dispersed in liquid medium is called: [CET (J&K) 2007]
 - aerosol
 - sol
 - gel
 - foam
- When dispersed phase is liquid and dispersion medium is gas, the colloidal system is called:
 - smoke
 - emulsion
 - cloud
 - gel
- Water loving colloids are called as:
 - hydrophilic
 - hydrophobic
 - lyophobic
 - irreversible
- An emulsion is a colloidal solution consisting of:
 - two solids
 - two liquids
 - two gases
 - one solid and one liquid
- The colloidal solution of gelatin is known as:
 - solvent loving
 - reversible
 - hydrophilic
 - all of these
- Sol is a type of colloid in which: [PET (Raj.) 2008]
 - solid is dispersed in liquid
 - liquid is dispersed in solid
 - gas is dispersed in liquid
 - solid is dispersed in solid

15. Butter is a colloid formed when:
 - (a) fat is dispersed in fat
 - (b) fat is dispersed in water
 - (c) water is dispersed in fat
 - (d) suspension of casein in water
16. Milk is: [PMT (MP) 2007; C.G. PET 2008]
 - (a) fat dispersed in water
 - (b) water dispersed in fat
 - (c) water dispersed in oil
 - (d) fat dispersed in fat
17. Smoke is an example of: (CPMT 1991)
 - (a) solid dispersed in solid
 - (b) solid dispersed in gas
 - (c) solid dispersed in liquid
 - (d) gas dispersed in solid
18. Fog is a colloidal solution of: [PMT (MP) 1991; CET (J&K) 2005; DUMET 2009]
 - (a) gaseous particles dispersed in gas
 - (b) gaseous particles dispersed in liquids
 - (c) liquid dispersed in gas
 - (d) solid dispersed in liquid
19. Lyophobic colloids are:
 - (a) reversible
 - (b) irreversible
 - (c) water loving
 - (d) solvent loving
20. Sulphur sol contains:
 - (a) discrete sulphur atoms
 - (b) discrete sulphur molecules
 - (c) water dispersed in solid sulphur
 - (d) large aggregates of sulphur molecules
21. Which of the following is not a colloidal system?
 - (a) Bread
 - (b) Muddy water
 - (c) Concrete
 - (d) Sugar in water
22. Peptization denotes: (MHT-CET 2007)
 - (a) digestion of food
 - (b) hydrolysis of proteins
 - (c) breaking and dispersion into colloidal state
 - (d) precipitation of solid from colloidal dimension
23. Colloids are purified by: (CPMT 1990)
 - (a) Brownian motion
 - (b) precipitation
 - (c) dialysis
 - (d) filtration
24. The separation of colloidal particles from those of molecular dimension is known as:
 - (a) dialysis
 - (b) electrophoresis
 - (c) peptization
 - (d) pyrolysis
25. Bredig's arc method is used for the preparation of colloidal solution of:
 - (a) metals like silver, gold, etc.
 - (b) organic compounds
 - (c) two liquids
 - (d) inorganic compounds
26. Which of the following reactions is not used for the preparation of a colloidal solution?
 - (a) $2\text{AuCl}_3 + 3\text{SnCl}_2 \longrightarrow 3\text{SnCl}_4 + 2\text{Au}$
 - (b) $\text{FeCl}_3 + 3\text{H}_2\text{O} \longrightarrow \text{Fe}(\text{OH})_3 + 3\text{HCl}$
 - (c) $2\text{Mg} + \text{CO}_2 \longrightarrow 2\text{MgO} + \text{C}$
 - (d) $2\text{H}_2\text{S} + \text{SO}_2 \longrightarrow 2\text{H}_2\text{O} + 3\text{S}$
27. When freshly precipitated $\text{Fe}(\text{OH})_3$ is boiled with water in the presence of few drops of dil. HCl, a hydrated ferric oxide sol is obtained. This method is termed:
 - (a) dialysis
 - (b) peptization
 - (c) ultrafiltration
 - (d) electro-dispersion
28. Which of the following substances gives a positively charged sol? [PMT (MP) 1990]
 - (a) Gold
 - (b) Arsenious sulphide
 - (c) Starch
 - (d) Ferric hydroxide
29. The kinetic activity of colloidal particles in dispersion medium is known as:
 - (a) electro-osmosis
 - (b) cataphoresis
 - (c) Brownian movement
 - (d) electrophoresis
30. Brownian movement was discovered by:
 - (a) Robert Brown
 - (b) Zsigmondy
 - (c) Hardy-Schulze
 - (d) Graham
31. The Brownian movement is due to:
 - (a) temperature fluctuations within the liquid phase
 - (b) attraction and repulsion between charges on colloidal particles
 - (c) impact of molecules of the dispersion medium on colloidal particles
 - (d) convection currents
32. Tyndall phenomenon is shown by:
 - (a) dilute solution
 - (b) colloidal solution
 - (c) suspension
 - (d) true solution
33. The sky looks blue due to:
 - (a) dispersion effect
 - (b) reflection
 - (c) transmission
 - (d) scattering
34. Tyndall effect in colloidal solution is due to: (MHT-CET 2007)
 - (a) absorption of light
 - (b) scattering of light
 - (c) reflection of light
 - (d) presence of electrically charged particles
35. The migration of colloidal particles under the influence of an electric field is known as:
 - (a) electro-osmosis
 - (b) Brownian movement
 - (c) cataphoresis
 - (d) dialysis
36. The stability of lyophilic colloids is due to: [PMT (MP) 1990]
 - (a) charge on their particles
 - (b) large size of their particles
 - (c) smaller size of their particles
 - (d) a layer of medium of dispersion on their particles
37. 'Greater the valency, the higher is the coagulating power of ion.' This rule was introduced by:
 - (a) Hardy-Schulze
 - (b) Graham
 - (c) Kossel and Lewis
 - (d) Faraday
38. Bleeding is stopped by the application of ferric chloride. This is because:
 - (a) the blood starts flowing in opposite direction
 - (b) the ferric chloride seals the blood vessel
 - (c) the blood reacts and forms a solid which seals the blood vessel
 - (d) the blood is coagulated and thus, the blood vessel is sealed
39. Which property of colloidal solution is used to determine the nature of charge on the particles?
 - (a) Sedimentation
 - (b) Electrophoresis
 - (c) Dialysis
 - (d) Ultrafiltration

40. When excess of electrolyte is added to a colloid it: (CBSE 1990)
 (a) coagulates (b) gets diluted
 (c) precipitates (d) does not change
41. The colloidal solutions of gold prepared by different methods have different colours. This is due to: (MLNR 1993)
 (a) difference in size of colloidal particles
 (b) different concentration of gold
 (c) presence of different types of foreign particles
 (d) the variable valency of gold
42. The capacity of an ion to coagulate a colloidal solution depends on:
 (a) its shape
 (b) the amount of its charge
 (c) the sign of the charge
 (d) both, the amount and the sign of the charge
43. Lyophilic sols are more stable than lyophobic sols because: (AFMC 1998)
 (a) the colloidal particles have positive charge
 (b) the colloidal particles have negative charge
 (c) the colloidal particles are solvated
 (d) there are strong electrostatic repulsions
44. Which of the following will have the highest coagulating power for As_2S_3 colloid?
 (a) PO_4^{3-} (b) Al^{3+} (c) SO_4^{2-} (d) Na^+
45. A negatively charged suspension of clay in water will need for precipitation the minimum amount of:
 (a) aluminium chloride (b) potassium sulphate
 (c) sodium hydroxide (d) hydrochloric acid
46. Which of the following electrolytes is least effective in causing flocculation of ferric hydroxide sol? (MLNR 1991)
 (a) $\text{K}_3\text{Fe}(\text{CN})_6$ (b) K_2CrO_4
 (c) KBr (d) K_2SO_4
47. Fe^{3+} ions coagulate blood. This show blood contains colloidal particles bearing:
 (a) negative charge
 (b) positive charge
 (c) no charge
 (d) either positive or negative charge
48. Gold number is a measure of: (CPMT 1991)
 (a) stability of colloidal system
 (b) coagulating power of a colloid
 (c) size of colloidal particles
 (d) efficiency of the protective colloid
49. Gold number is a measure of: [PET (MP) 2004]
 (a) the amount of gold present in the colloidal solution
 (b) the amount of gold required to break the colloid
 (c) the amount of gold required to protect the colloid
 (d) none of the above
50. Which of the following methods is used for destruction of a colloidal solution?
 (a) Condensation
 (b) Dialysis
 (c) Diffusion through animal membrane
 (d) Addition of an electrolyte
51. Which of the following is not a property of hydrophilic sols?
 (a) High concentration of dispersed phase can be easily attained
 (b) Coagulation is reversible
 (c) Viscosity and surface tension are nearly as that of water
 (d) The charge on the particles depends on the pH value of the medium; it may be positive, negative or even zero
52. Gelatin is added in manufacture of ice cream in order to:
 (a) prevent formation of a colloid
 (b) stabilise the colloid and prevent crystallisation
 (c) cause the mixture to solidify easily
 (d) improve flavour
53. Which one of the following will act as best protective colloid?
 (a) Gelatin (Gold No. 0.005)
 (b) Starch (Gold No. 25)
 (c) Gum arabic (Gold No. 0.15)
 (d) Egg albumin (Gold No. 0.08)
54. Gold number is a measure of the:
 (a) protective action by a lyophilic colloid on lyophobic colloid
 (b) protective action by a lyophobic colloid on lyophilic colloid
 (c) number of mg of gold in a standard red gold sol
 (d) none of the above
55. On addition of one mL solution of 10% NaCl to 10 mL gold sol in presence of 0.025 g of starch, the coagulation is just prevented. The gold number of starch is:
 (a) 25.0 (b) 2.5 (c) 0.25 (d) 0.025
56. The stability of lyophobic sols is due to:
 (a) Brownian motion only
 (b) electric charge only
 (c) both Brownian motion and electric charge
 (d) particle size
57. Which one of the following colloidal solutions is positive sol? (CPMT 1992)
 (a) Blood
 (b) Clay soil
 (c) Smoke
 (d) Gelatin in strongly acidic solution
58. All colloidal solutions show:
 (a) very high osmotic pressure
 (b) high osmotic pressure
 (c) low osmotic pressure
 (d) no osmotic pressure
59. Which of the following is associated colloid?
 (a) Soap (b) Detergent
 (c) Both (d) None of these
60. Which of the following is an emulsifier?
 (a) Oil (b) Soap (c) Solvent (d) KCl
61. An emulsifier is a substance which:
 (a) helps in the dispersion of liquid in liquid
 (b) stabilises the emulsion
 (c) coagulates the emulsion
 (d) purifies the emulsion

62. The gold numbers of some colloidal solutions are given below:

Colloidal solution	Gold number
A	0.01
B	2.5
C	20

The projective powers of these colloidal solutions follow the order: [CET (J&K) 2006; AIEEE 2008]

- (a) $C > B > A$ (b) $A > B > C$
 (c) $A = B = C$ (d) $B > A > C$
63. Dialyser is a name given to:
 (a) lyophilic colloids
 (b) lyophobic colloids
 (c) to a membrane which can separate colloids from the solution
 (d) none of the above
64. Flocculation value is expressed in terms of:
 (a) millimole per litre (b) mol per litre
 (c) gram per litre (d) mol per millilitre
65. Which of the following has minimum flocculation value?
 [PET (MP) 1990]
 (a) Pb^{2+} (b) Pb^{4+} (c) Sr^{2+} (d) Na^+
66. The charge of As_2S_3 sol is due to the absorbed:
 (a) H^+ (b) OH^- (c) O^{2-} (d) S^{2-}
67. Which of the following has maximum flocculation value?
 (a) $[Fe(CN)_6]^{4-}$ (b) Cl^-
 (c) SO_4^{2-} (d) PO_4^{3-}
68. Above critical micelle concentration, particles get:
 [AMU (Medical) 2006]
 (a) associated (b) dissociated
 (c) both (a) and (b) (d) none of these
69. Continuous phase contains dispersed phase throughout. Example is:
 (VITEEE 2008)
 (a) water in milk (b) fat in milk
 (c) water droplets in mist (d) oil in water
70. The movement of dispersion medium in an electric field when the dispersed particles are prevented from moving is called:
 (a) cataphoresis (b) electrophoresis
 (c) electro-osmosis (d) Brownian movement
71. To coagulate gelatin sol, which of the following is most effective?
 (a) NaCl (b) Na_3PO_4 (c) $AlCl_3$ (d) Alcohol
72. The emulsifying agent in milk is: [EAMCET (Med.) 2010]
 (a) lactic acid (b) fat
 (c) lactose (d) casein
73. Colloidal solutions of metals like Cu, Ag, Au and Pt are generally prepared by using:
 (a) peptization (b) Bredig's arc method
 (c) exchange of solvent (d) oxidation method
74. Silver iodide is used for producing artificial rain because AgI:
 (a) has crystal structure similar to ice
 (b) is easy to spray at high altitudes
 (c) is easy to synthesise
 (d) is soluble in water
75. 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) coagulation number
76. Purple of cassius is:
 (a) colloidal solution of silver
 (b) colloidal solution of gold
 (c) colloidal solution of platinum
 (d) oxy acids of gold
77. Which type of molecules form micelles?
 (a) Polar molecules (b) Non-polar molecules
 (c) Surfactant molecules (d) Any of these
78. The name aquadag is given to the colloidal solution of:
 (a) copper in water (b) platinum in water
 (c) gold in water (d) graphite in water
79. A liquid is found to scatter a beam of light but leaves no residue when passed through the filter paper. The liquid can be described as: (AIIMS 1993)
 (a) a suspension (b) oil
 (c) a colloidal sol. (d) true solution
80. Point out the false statement: [CET (Punjab) 1991]
 (a) colloidal sols. are homogeneous
 (b) colloidal sols. carry +ve or -ve charge
 (c) colloidal sols. show Tyndall effect
 (d) the size of colloidal particles ranges between 10–2000 Å
81. The potential difference between the fixed charged layer and the diffused layer having opposite charge is called:
 (a) colloidal potential (b) zeta potential
 (c) electrostatic potential (d) none of these
82. An example of micelle is:
 (a) As_2O_3 sol.
 (b) ruby glass
 (c) Na_2CO_3 solution
 (d) sodium stearate concentrated solution
83. Surface tension of lyophilic sols. is: [PMT (MP) 1992]
 (a) lower than H_2O (b) more than H_2O
 (c) equal to H_2O (d) none of these
84. Which is not shown by sols.? [PMT (MP) 1992]
 (a) Adsorption (b) Tyndall effect
 (c) Flocculation (d) Paramagnetism
85. An example of solid-solid system is:
 (a) smoke (b) coke
 (c) synthetic gems (d) pumice stone
86. Detergent action of synthetic detergents is due to their:
 (a) interfacial area (b) high molecular weight
 (c) ionisation (d) emulsifying properties
87. Blood contains:
 (a) positively charged particles
 (b) negatively charged particles
 (c) neutral particles
 (d) negatively as well as positively charged colloids
88. A colloidal solution always has at least: (CPMT 1993)
 (a) one-phase (b) more than two-phases
 (c) a true solution (d) two phases
89. Silica gel is commonly used as:
 (a) wetting agent (b) drying agent
 (c) solvent (d) catalyst

90. Which is not a colloidal solution of gas in liquid?
 (a) Froth (b) Foams with tiny bubbles
 (c) Mist (d) Whipped cream
91. Fog is a colloidal solution of:
 [MLNR 1995; PMT (MP) 1991]
 (a) liquid particles dispersed in gas
 (b) gaseous particles dispersed in liquid
 (c) solid particles dispersed in liquid
 (d) solid particles dispersed in gas
92. Emulsions of polyvinyl acetate are used in:
 (a) polishes (b) latex paints
 (c) fireworks (d) rayons
93. When white light is passed through a colloidal solution containing fine suspended particles of gold, then the scattering light seen in a direction different from that of incident light is:
 (a) yellow coloured (b) blue coloured
 (c) green coloured (d) red coloured
94. When a sulphur sol is evaporated, solid sulphur is left. On mixing with water no colloidal sol is formed. The sulphur sol is:
 (a) hydrophilic (b) hydrophobic
 (c) reversible (d) lyophilic
95. Tails of comets are visible due to:
 (a) Tyndall effect (b) reflection
 (c) Brownian movement (d) none of these
96. Milk is an example of:
 [CPMT 1995; PET (MP) 2004; CET (J&K) 2004]
 (a) fat dispersed in water
 (b) water dispersed in fat
 (c) water dispersed in oil
 (d) fat dispersed in fat
97. Smog is an example of:
 (a) ice dispersed in air
 (b) water dispersed in air
 (c) smoke dispersed in air
 (d) smoke and water dispersed in air
98. Peptization denotes:
 [ISM (Dhanbad) 1994]
 (a) digestion of food
 (b) hydrolysis of proteins
 (c) breaking of dispersion into colloidal state
 (d) precipitation of a solid from colloidal state
99. Whipped cream is an example of:
- | Dispersion Medium | Dispersed Phase |
|-------------------|-----------------|
| (a) Liquid | Gas |
| (b) Liquid | Liquid |
| (c) Liquid | Solid |
| (d) Gas | Liquid |
100. Cottrell precipitator acts on which of the following principle?
 (a) Hardy-Schulze rule
 (b) Distribution law
 (c) Le Chatelier's principle
 (d) Neutralization of charge on the colloidal particles
101. CMC (critical micelle concentration) is:
 (a) concentration at which micelles are destroyed
 (b) concentration at which micelle formation starts
 (c) concentration of electrolyte added to destroy the micelles
 (d) concentration of micelles at room temperature
102. Cod liver oil is:
 [CPMT 1997]
 (a) fat dispersed in water (b) water dispersed in fat
 (c) water dispersed in oil (d) fat dispersed in fat
103. Which is not lyophilic colloid?
 [PMT (MP) 1998]
 (a) Milk (b) Gum (c) Fog (d) Blood
104. At the critical micelle concentration, the surfactant molecules:
 [CBSE 1998]
 (a) decompose (b) dissociate
 (c) associate (d) become completely soluble
105. Which of the following ions can cause coagulation of proteins?
 [KCET 2000]
 (a) Ag^+ (b) Na^+ (c) Mg^{2+} (d) Ca^{2+}
106. In Brownian movement or motion the paths of the particles are:
 [KMEE 2000]
 (a) linear (b) zig-zag
 (c) uncertain (d) curved
107. Which is used for ending charge on colloidal solutions?
 [CBSE 2000]
 (a) Electrons (b) Electrolysis
 (c) Positively charged ions (d) Compounds
108. Cloud or fog is a colloidal system in which the dispersed phase and the dispersion medium are:
 [KCET 2000]
 (a) gas, liquid (b) liquid, gas
 (c) liquid, liquid (d) solid, solid
109. The electrolyte which has the least effect in the coagulation of $\text{Fe}(\text{OH})_3$ sol is:
 [KCET 2008]
 (a) potassium carbonate (b) sodium sulphate
 (c) potassium ferrocyanide (d) potassium iodide
110. Blood may be purified by:
 [PMT (MP) 2000]
 (a) dialysis (b) electro-osmosis
 (c) coagulation (d) filtration
111. Gold number was given by:
 (a) Ostwald (b) Zsigmondy
 (c) William and Chang (d) Langmuir
112. The diameter of colloidal particle ranges from: [KCET 2004]
 (a) 10^{-9} m to 10^{-6} m (b) 10^{-9} m to 10^{-12} m
 (c) 10^3 m to 10^{-3} m (d) 10^{-3} m to 10^{-6} m
113. The Tyndall effect is not observed in:
 (a) suspensions (b) emulsions
 (c) colloidal solutions (d) true solutions
114. Which one is example of Micelle's system?
 (a) Soap + water (b) Rubber + benzene
 (c) Protein + water (d) None of these
115. Sedimentation potential is the reverse of:
 (a) electro-osmosis (b) electrophoresis
 (c) electrokinetic potential (d) Dorn potential
116. Smoke has generally blue tinge. It is due to:
 (a) scattering (b) coagulation
 (c) Brownian motion (d) electrophoresis
117. On adding AgNO_3 solution to KI solution, a negatively charged colloidal sol will be formed in which of the following conditions?

- (a) 100 mL of 0.1 M AgNO_3 + 100 mL of 0.1 M KI
 (b) 100 mL of 0.1 M AgNO_3 + 50 mL of 0.2 M KI
 (c) 100 mL of 0.2 M AgNO_3 + 100 mL of 0.1 M KI
 (d) 100 mL of 0.1 M AgNO_3 + 100 mL of 0.15 M KI
118. Peptization of SnO_2 by NaOH gives:
 (a) $[\text{SnO}_2]\text{SnO}_3^{2-} : 2\text{Na}^+$ (b) $[\text{SnO}_2]\text{Sn}^{4+} : \text{O}^{2-}$
 (c) $[\text{SnO}_2]\text{Na}^+ : \text{OH}^-$ (d) $[\text{SnO}_2]\text{Sn}^{4+} : \text{OH}^-$
119. Alum helps in purifying water by: (AIEEE 2002)
 (a) forming Si complex with clay particles
 (b) sulphate part which combines with the dirt and remove it
 (c) aluminium which coagulates the mud particles
 (d) making the mud water soluble
120. Surface tension of lyophilic sols is: [PMT (MP) 2002]
 (a) lower than that of H_2O (b) equal to that of H_2O
 (c) more than that of H_2O (d) none of these
121. Arsenic sulphide is negative sol. The reagent with least precipitating power is: [PMT (Manipal) 2002]
 (a) AlCl_3 (b) NaCl (c) CaF_2 (d) glucose
122. Which one of the following is correctly matched? [CEE (Tamil Nadu) 2002]
 (a) Emulsion-curd (b) Foam-mist
 (c) Aerosol-smoke (d) Solid sol-cake
123. When H_2S gas is passed through nitric acid, the product is: [CEE (Kerala) 2002]
 (a) rhombic sulphur (b) prismatic sulphur
 (c) amorphous sulphur (d) monoclinic sulphur
 (e) plastic sulphur
124. Tyndall effect is shown by: [CECE (Bihar) Pre 2004]
 (a) precipitate (b) sol
 (c) plasma (d) solution
125. On addition of one mL of 10% NaCl solution to 10 mL gold sol in presence of 0.25 gm of starch, the coagulation is just prevented, starch has gold number: [PMT (MP) 2004]
 (a) 0.25 (b) 0.025 (c) 2.5 (d) none of these
126. Which of the following forms cationic micelles above certain concentration? [CBSE (PMT) 2004]
 (a) Sodium dodecyl sulphate
 (b) Sodium acetate
 (c) Urea
 (d) Cetyltrimethyl ammonium bromide
127. The smog is essentially caused by the presence of: (AIEEE 2004)
 (a) O_2 and O_3
 (b) O_2 and N_2
 (c) oxides of sulphur and nitrogen
 (d) O_3 and N_2
128. Which one of the following is most effective in causing the coagulation of an As_2S_3 sol? (EAMCET 2009)
 (a) KCl (b) AlCl_3
 (c) MgSO_4 (d) $\text{K}_3[\text{Fe}(\text{CN})_6]$
129. The fresh precipitate can be transformed in colloidal solution by: [CET (J&K) 2004]
 (a) peptization (b) coagulation
 (c) diffusion (d) none of these
130. Potassium stearate is obtained by the saponification of an oil or a fat. It has formula $\text{CH}_3 - (\text{CH}_2)_{16} - \text{COO}^- \text{K}^+$. The molecule has a lyophobic end (CH_3-) and a lyophilic end $\text{COO}^- \text{K}^+$. Potassium stearate is an example for: [PET (Kerala) 2005]
 (a) lyophobic colloid
 (b) lyophilic colloid
 (c) multimolecular colloid
 (d) macromolecular colloid
 (e) associated colloid or micelle
131. Which one of the following forms micelles in aqueous solution above certain concentration? [CBSE (PMT) 2005]
 (a) Dodecyl trimethyl ammonium chloride
 (b) Glucose
 (c) Urea
 (d) Pyridinium chloride
132. Muddy water can be purified through coagulation using: [CET (J&K) 2005]
 (a) common salt (b) alums
 (c) sand (d) lime
133. The disperse phase in colloidal iron(III) hydroxide and colloidal gold is positively and negatively charged respectively. Which of the following is not correct? (AIEEE 2005)
 (a) Magnesium chloride solution coagulates the gold sol more readily than iron(III) hydroxide sol
 (b) Sodium sulphate solution causes coagulation in both sols
 (c) Mixing of the sols has no effect
 (d) Coagulation in both sols can be brought about by electrophoresis
134. An emulsifier is a substance which: (AIEEE 2005)
 (a) stabilises the emulsion
 (b) homogenises the emulsion
 (c) coagulates the emulsion
 (d) accelerates the dispersion of liquid in liquid
135. Gold number is associated with: [BHU (Mains) 2007; AMU (Engg.) 2010]
 (a) electrophoresis
 (b) purple of cassius
 (c) protective colloid
 (d) amount of pure gold
136. Which one of the following is a false statement? [PMT (Kerala) 2007]
 (a) Cell fluid is an example of sol
 (b) Butter is an example of gel
 (c) Hair cream is an example of emulsion
 (d) Whipped cream is an example of foam
 (e) Cheese is an example of emulsion
137. The presence of electric charge on colloidal particles is indicated by the property, called: [CET (J&K) 2007]
 (a) dialysis (b) solubility
 (c) electrophoresis (d) osmosis
138. Which of the following properties are characteristic of lyophobic sols? (SCRA 2007)
 1. Low viscosity, 2. High viscosity, 3. Reversibility and
 4. Coagulation by electrolytes at low concentration

Select the correct answer using the codes given below:

- (a) 2, 3 and 4 (b) 2 and 3 only
(c) 1 and 4 only (d) 1 and 3 only

139. In an electrical field, the particles of a colloidal system move towards cathode. The coagulation of the same sol is studied using K_2SO_4 (I), Na_3PO_4 (II), $K_4[Fe(CN)_6]$ (III) and $NaCl$ (IV). Their coagulating power should be :

[PMT(Kerala) 2008]

- (a) (I) > (II) > (III) > (IV) (b) (III) > (II) > (I) > (IV)
(c) (III) > (I) > (II) > (IV) (d) (IV) > (III) > (I) > (II)
(e) (IV) > (I) > (II) > (III)

140. Cetyl trimethyl ammonium chloride is which type of detergent ?

[CET (Gujarat) 2008]

- (a) Cationic (b) Anionic (c) Biosoft (d) Non-ionic

141. The effective ion used in clarification of water is:

(KCET 2008)

- (a) Al^{3+} (b) Ca^{2+} (c) SO_4^{2-} (d) PO_4^{3-}

142. The number of moles of lead nitrate needed to coagulate 2 mole of colloidal $[AgI]^-$ is :

[PET (Kerala) 2008]

- (a) 2 (b) 1 (c) $\frac{1}{2}$ (d) $\frac{2}{3}$ (e) $\frac{5}{2}$

[Hint : $2[AgI]^- + Pb^{2+} \longrightarrow PbI_2 + 2AgI$

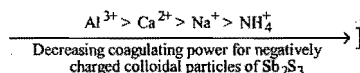
Thus, one mole of $Pb(NO_3)_2$ is required to coagulate 2 mole of $[AgI]^-$]

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

(IIT 2009)

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

[Hint : Sb_2S_3 sol is negative colloid, therefore, $Al_2(SO_4)_3$ will be most effective coagulating agent.



144. A micelle formed during the cleansing action of soap is :

[EAMCET (Engg.) 2010]

- (a) a discrete particle of soap
(b) aggregated particles of soap and dirt
(c) a discrete particle of dust
(d) an aggregated particle of dust and water

145. The dispersed phase and dispersion medium in soap lather are respectively :

[PET (Kerala) 2010]

- (a) gas and liquid (b) liquid and gas
(c) solid and gas (d) solid and liquid

Set-2: The questions given below may have more than one correct answers

- Lysione is not used as:
 - disinfectant
 - germ killer
 - treating eye disease
 - anti-cancer drug
- Which of the following are macromolecular colloids?
 - Starch
 - Soap
 - Detergent
 - Cellulose
- Multimolecular colloids are present in:
 - sol of sulphur
 - sol of proteins
 - sol of gold
 - soap solution
- Methods used for the preparation of colloidal solutions are:
 - peptization
 - hydrolysis
 - ultrasonic dispersion
 - coagulation
- Isoelectric point is the pH at which colloidal particles:
 - coagulate
 - become electrically neutral
 - can move toward either electrode
 - none of the above
- Consider the following statements for micelles, which is/are correct?
 - At critical micelle concentration, several properties of solution of surfactants such as molar conductivity, surface tension and osmotic pressure change
 - Micelles from ionic surfactants can be formed only above a certain temperature called the Kraft temperature
 - Micelle formation is exothermic
 - Micelles are associated colloids
- Which of the following are negative colloids?
 - $Fe(OH)_3$ sol
 - As_2S_3 sol
 - Blood
 - Gold sol
- Which of the following are examples of aerosols?
 - Whipped cream
 - Cloud
 - Fog
 - Soap lather
- Tyndall effect is applicable when:
 - the diameter of the dispersed particles is not much smaller than the wavelength of the light used
 - the diameter of the dispersed particles is much smaller than the wavelength of the light used
 - the refractive indices of the dispersed phase and the dispersion medium must be same
 - the refractive indices of the dispersed phase and the dispersion medium must differ greatly in magnitude

***Assertion-Reason* TYPE QUESTIONS**

The questions given below consist of two statements each printed as 'Assertion' (A) and 'Reason' (R). While answering these questions you are required to choose any one of the following four options:

- (a) If both (A) and (R) are correct and (R) is the correct explanation for (A).
(b) If both (A) and (R) are correct but (R) is not the correct explanation for (A).
(c) If (A) is correct but (R) is incorrect.
(d) If (A) is incorrect but (R) is correct.
- (A) Colloidal silver iodide is prepared by adding silver nitrate in slight excess to potassium iodide solution. When subjected to an electric field, the colloidal particles migrate to the anode.
(R) Colloidal particles absorb ions and thus become electrically charged.
 - (A) Lyophilic colloids such as starch, gelatin, etc., act as protective colloids.
(R) Protective power of lyophilic colloids is expressed in terms of gold number.
 - (A) True solutions do not exhibit Tyndall effect.
(R) In true solutions, size of solute particles is much smaller than the wavelength of light used.
 - (A) The micelle formed by sodium stearate in water has —COO^- groups at the surface.
(R) Surface tension of water is reduced by the addition of stearate. (AIIMS 2003)
 - (A) Lyophilic sols. are more stable than lyophobic sols.
(R) Lyophilic sols. are highly hydrated in the solution.
 - (A) Colloidal sol. of Fe(OH)_3 formed by peptization carries positive charge.
(R) During the formation of positively charged colloidal particles of Fe(OH)_3 , the electrons are lost by the colloidal particles of Fe(OH)_3 .
 - (A) Colloidal solutions are purified by dialysis.
(R) In the process of dialysis, colloidal particles pass through parchment paper.
 - (A) Fe^{3+} can be used for coagulation of As_2S_3 sol.
(R) Fe^{3+} reacts with As_2S_3 to give Fe_2S_3 . (AIIMS 2006)
 - (A) Fat is digested in the intestine by emulsification.
(R) Bile salts stabilize the emulsion so formed.
 - (A) NH_4Cl and RCOONa are colloidal electrolyte.
(R) The substances which behave as electrolyte below a certain concentration limit, beyond this limit colloidal sol. is formed, are called colloidal electrolyte.
 - (A) Sulphide ores are concentrated by froth flotation process.
(R) Pine oil forms emulsion in water.
 - (A) The conversion of fresh precipitate to colloidal state is called peptization.
(R) It is caused by addition of common ions. (AIIMS 2007)
 - (A) Surfactant molecules form micelles above the critical micelle concentration (CMC).
(R) The conductance of solution of surfactant molecules decreases sharply at the (CMC).
 - (A) Soap and detergent are macro-molecular colloids.
(R) Soap and detergent are molecular of large size.
 - (A) Gold sol is hydrophobic and multimolecular.
(R) Gold sol is prepared by Bredig's arc method.

Answers : OBJECTIVE QUESTIONS

● Set-1

- | | | | | | | | |
|----------|----------|----------|----------|----------|----------|----------|----------|
| 1. (a) | 2. (b) | 3. (a) | 4. (c) | 5. (b) | 6. (d) | 7. (d) | 8. (a) |
| 9. (b) | 10. (c) | 11. (a) | 12. (b) | 13. (d) | 14. (a) | 15. (c) | 16. (a) |
| 17. (b) | 18. (c) | 19. (b) | 20. (d) | 21. (d) | 22. (c) | 23. (c) | 24. (a) |
| 25. (a) | 26. (c) | 27. (b) | 28. (d) | 29. (c) | 30. (a) | 31. (c) | 32. (b) |
| 33. (d) | 34. (b) | 35. (c) | 36. (d) | 37. (a) | 38. (d) | 39. (b) | 40. (a) |
| 41. (a) | 42. (d) | 43. (c) | 44. (b) | 45. (a) | 46. (c) | 47. (a) | 48. (d) |
| 49. (d) | 50. (d) | 51. (c) | 52. (b) | 53. (a) | 54. (a) | 55. (a) | 56. (c) |
| 57. (d) | 58. (c) | 59. (c) | 60. (b) | 61. (b) | 62. (b) | 63. (c) | 64. (a) |
| 65. (b) | 66. (d) | 67. (b) | 68. (a) | 69. (a) | 70. (c) | 71. (d) | 72. (d) |
| 73. (b) | 74. (a) | 75. (a) | 76. (b) | 77. (c) | 78. (d) | 79. (c) | 80. (a) |
| 81. (b) | 82. (d) | 83. (a) | 84. (d) | 85. (c) | 86. (d) | 87. (b) | 88. (d) |
| 89. (b) | 90. (c) | 91. (a) | 92. (b) | 93. (b) | 94. (b) | 95. (a) | 96. (a) |
| 97. (d) | 98. (c) | 99. (a) | 100. (c) | 101. (b) | 102. (c) | 103. (c) | 104. (c) |
| 105. (a) | 106. (b) | 107. (b) | 108. (b) | 109. (c) | 110. (a) | 111. (b) | 112. (a) |
| 113. (d) | 114. (a) | 115. (b) | 116. (a) | 117. (d) | 118. (a) | 119. (c) | 120. (a) |
| 121. (d) | 122. (c) | 123. (c) | 124. (b) | 125. (d) | 126. (d) | 127. (c) | 128. (b) |
| 129. (a) | 130. (e) | 131. (a) | 132. (b) | 133. (c) | 134. (a) | 135. (c) | 136. (e) |
| 137. (c) | 138. (c) | 139. (b) | 140. (a) | 141. (a) | 142. (b) | 143. (c) | 144. (b) |
| 145. (a) | | | | | | | |

● Set-2

- | | | | | | | | |
|--------------|-----------|-----------|--------------|--------------|--------------|--------------|-----------|
| 1. (b, c, d) | 2. (a, d) | 3. (a, c) | 4. (a, b, c) | 5. (a, b, c) | 6. (a, b, d) | 7. (b, c, d) | 8. (b, c) |
| 9. (a, d) | | | | | | | |

Answers : ASSERTION-REASON TYPE QUESTIONS

- | | | | | | | | |
|--------|---------|---------|---------|---------|---------|---------|--------|
| 1. (d) | 2. (b) | 3. (a) | 4. (a) | 5. (a) | 6. (c) | 7. (c) | 8. (c) |
| 9. (a) | 10. (a) | 11. (a) | 12. (b) | 13. (b) | 14. (d) | 15. (b) | |

BRAIN STORMING PROBLEMS

OBJECTIVE QUESTIONS for IIT ASPIRANTS

The following questions contain single correct option:

1. Which of the following statements are correct?

1. On the application of an electric field, the particles of lyophobic sol may move in either direction or not move at all.
2. Surface tension of lyophobic sols is similar to that of the dispersion medium.
3. Electro-osmosis is the movement of the particles of dispersion medium under the influence of an electric field.

Select the correct answer using codes given below:

Codes:

- (a) 1, 2 and 3 (b) 1 and 3 (c) 2 and 3 (d) 1 and 2

2. Which of the following statements are correct?

1. The smaller the gold number of lyophobic colloid, the larger will be its protective power.
2. Lyophilic sols, in contrast to lyophobic sols are easily coagulated on addition of small amounts of electrolytes.
3. Ferric chloride solution is used to stop bleeding from a fresh cut because it coagulates the blood.
4. The flocculation value of arsenious sulphide sol is independent of the anion of the coagulating electrolyte.

Codes:

- (a) 1, 2 and 3 (b) 1, 3 and 4 (c) 2, 3 and 4 (d) 1, 2 and 4

3. Match the List-I with List-II and select the correct answer using the codes given below the lists:

List-I

- A. Coagulation
- B. Lyophilization
- C. Peptization
- D. Tyndall effect

List-II

1. Scattering
2. Washing of precipitates
3. Purification of colloids
4. Electrolyte

Codes:

	A	B	C	D
(a)	4	—	2	1
(b)	2	—	3	4
(c)	—	1	2	4
(d)	4	3	1	—

4. The flocculating power of the given ions for the specified colloidal sols will be such that:

Arsenic sulphide sol

Ferric hydroxide sol

- (a) $[\text{Fe}(\text{CN})_6]^{4-} > \text{PO}_4^{3-} > \text{SO}_4^{2-} > \text{Cl}^-$ $\text{Al}^{3+} > \text{Ba}^{2+} > \text{Na}^+$
- (b) $\text{Al}^{3+} > \text{Ba}^{2+} > \text{Na}^+$ $[\text{Fe}(\text{CN})_6]^{4-} > \text{PO}_4^{3-} > \text{SO}_4^{2-} > \text{Cl}^-$
- (c) $\text{Na}^+ > \text{Ba}^{2+} > \text{Al}^{3+}$ $\text{Cl}^- > \text{SO}_4^{2-} > \text{PO}_4^{3-} > [\text{Fe}(\text{CN})_6]^{4-}$
- (d) $\text{Cl}^- > \text{SO}_4^{2-} > \text{PO}_4^{3-} > [\text{Fe}(\text{CN})_6]^{4-}$ $\text{Na}^+ > \text{Ba}^{2+} > \text{Al}^{3+}$

5. The coagulation value in millimoles per litre of electrolytes used for the coagulation of As_2S_3 are as below:

- I. $\text{NaCl} = 52$ II. $\text{KCl} = 51$
 III. $\text{BaCl}_2 = 0.69$ IV. $\text{MgSO}_4 = 0.22$

The correct order of their flocculating power is:

- (a) $\text{I} > \text{II} > \text{III} > \text{IV}$ (b) $\text{I} > \text{II} > \text{III} = \text{IV}$
 (c) $\text{IV} > \text{III} > \text{II} > \text{I}$ (d) $\text{IV} = \text{III} > \text{II} > \text{I}$

6. Cottrell precipitator works on the principle of:

- (a) distribution law
 (b) addition of electrolyte
 (c) neutralisation of charge on colloids
 (d) Le Chatelier's principle

7. The substances involved in micellization are:

- (a) polyphilic in nature (b) non-polar in nature
 (c) diphilic in nature (d) uniphilic in nature

8. The swelling of 'gel' when placed in water is called:

- (a) gelation (b) imbibition (c) thixotropy (d) syneresis

9. A lyophilic sol is at its isoelectric point then it is:

- (a) negatively charged (b) positively charged
 (c) not charged (d) none of these

10. Sedimentation potential is reverse of:

- (a) electro-osmosis (b) electrophoresis
 (c) electrokinetic potential (d) streaming potential

11. The potential difference between the fixed charged layer and the diffused layer having opposite charge is called:

- (a) zeta potential (b) colloidal potential
 (c) Dorn potential (d) streaming potential

12. Silver iodide is used for producing artificial rains because AgI:

- (a) is easy to spray at high altitude
 (b) is insoluble in water
 (c) is easy to synthesize
 (d) has crystals similar to ice

13. All colloidal solutions show:

- (a) very high osmotic pressure
 (b) high osmotic pressure
 (c) low osmotic pressure
 (d) no osmotic pressure

14. Colloidion is a colloidal solution of:

- (a) sucrose in water
 (b) cellulose in water
 (c) cellulose nitrate in water
 (d) cellulose nitrate in ethyl alcohol

15. During micelle formation:

- (a) $\Delta H = +ve$, $\Delta S = +ve$ (b) $\Delta H = -ve$, $\Delta S = -ve$
 (c) $\Delta H = -ve$, $\Delta S = +ve$ (d) $\Delta H = +ve$, $\Delta S = -ve$

16. Which of the following is not the property of hydrophilic solutions?

- (a) High concentration of dispersed phase can be easily obtained

- (b) Coagulation is reversible
 (c) Viscosity and surface tension are nearly same as that of water
 (d) The charge of the particles depends on the pH of the medium and it may be positive, negative or zero
17. The coagulation of 100 mL of colloidal solution of gold is completely prevented by addition of 0.25 g of a substance "X" to it before addition of 1 mL of 10% NaCl solution. The gold number of "X" is:
 (a) 0.25 (b) 25 (c) 250 (d) 2.5
 [Hint: Number of milligrams of protective colloid added in 10 mL of colloidal gold to prevent its coagulation on addition of 1 mL of 10% NaCl solution is called its gold number.
 $\therefore$ Gold number of present colloid = 25]
18. Select the non-elastic gel out of the following:
 (a) starch (b) agar-agar (c) silicic acid (d) gelatin
19. The colligative properties of a colloidal solution compared to the solution of non-electrolyte of same concentration will be:
 (a) same (b) higher
 (c) lower (d) higher or lower
20. 1 mole of AgI/Ag⁺ sol. is coagulated by:
 (a) 1 mole of KI (b) 500 mL of 1 M K₂SO₄
 (c) 300 mL of 1 M Na₃PO₄ (d) 1 mole of AgI
21. Match the List-I (Colloidal dispersion) with List-II (Nature of the dispersion) and select the correct answer using the codes given below the lists: (SCRA 2007)
- | List-I
(Colloidal dispersion) | List-II
(Nature of dispersion) |
|----------------------------------|-----------------------------------|
| A. Milk | 1. Solid in liquid |
| B. Clouds | 2. Liquid in gas |
- C. Paints
 D. Jellies
3. Solids in solid
 4. Liquids in liquid
 5. Liquid in solid
- (a) A-4, B-2, C-1, D-5 (b) A-1, B-5, C-3, D-2
 (c) A-4, B-5, C-1, D-2 (d) A-1, B-2, C-3, D-5
22. At CMC, the surfactant molecules undergo:
 (a) association (b) aggregation
 (c) micelle formation (d) all of these
23. The blue colour of the water of the sea is due to:
 (a) reflection of blue light by salts present in water
 (b) scattering of blue light by sol. particles
 (c) refraction of blue coloured light by the impurities present in seawater
 (d) absorption of radiation of different colours except blue light
24. **Statement :** To stop bleeding from an injury ferric chloride can be applied.
 Which comment about the statement is justified?
 [PMT (Kerala) 2008]
 (a) It is not true, ferric chloride is a poison
 (b) It is true, Fe³⁺ ions coagulate blood which is negatively charged sol
 (c) It is not true, Cl⁻ ions form positively charged sol, profuse bleeding takes place
 (d) It is true, coagulation takes place because of formation of negatively charged sol with Cl⁻ ions
 (e) It is not true, ferric chloride is ionic and gets into blood stream

Answers

- | | | | | | | | |
|---------|---------|---------|---------|---------|---------|---------|---------|
| 1. (c) | 2. (a) | 3. (a) | 4. (b) | 5. (c) | 6. (c) | 7. (c) | 8. (b) |
| 9. (c) | 10. (b) | 11. (a) | 12. (a) | 13. (c) | 14. (c) | 15. (a) | 16. (c) |
| 17. (b) | 18. (c) | 19. (c) | 20. (a) | 21. (a) | 22. (d) | 23. (b) | 24. (b) |

LINKED COMPREHENSION TYPE QUESTIONS

● Passage 1

There are certain substances which behave as normal, strong electrolytes at low concentration but at higher concentration they behave as colloidal solutions due to the formation of aggregated particles. Such colloids are called associated colloids and the aggregated particles are called **micelles**. Soaps and detergents are the examples of associated colloids. The formation of micelles takes place above certain concentration called critical micellization concentration (CMC) and a characteristic temperature.

Answer the following questions:

- Micelles are:
 - emulsions cum gels
 - associated colloids
 - adsorbed catalysts
 - ideal solutions
- What type of molecules form micelles?
 - Non-polar molecules
 - Polar molecules
 - Surfactant molecules
 - Salt of weak acid and weak base
- Micelles are formed only:
 - below the CMC and the Kraft temperature
 - above the CMC and below the Kraft temperature
 - above the CMC and above the Kraft temperature
 - below the CMC and above the Kraft temperature
- Above CMC, the surfactant molecules undergo:
 - dissociation
 - aggregation
 - micelle formation
 - all of these

5. Micelles are used in:

- (a) detergents (b) magnetic separation
(c) petroleum recovery (d) all of these

● Passage 2

Emulsions are also the colloidal solutions in which disperse phase as well as dispersion medium are liquids. It may be oil in water or water in oil type. Bancroft proposed that the phase in which the emulsifier is more soluble becomes the outer phase of the emulsion. Emulsifiers can be used to stabilize the emulsion. Soaps, detergents, proteins and gum, etc., are used as emulsifiers.

Answer the following questions:

- Addition of lyophilic solution to the emulsion forms:
 - a protective film around the dispersed phase
 - a protective film around the dispersion medium
 - an aerosol
 - true solution
- Which of the following examples is/are oil in water type emulsion?
 - Ink
 - Detergent
 - Soap
 - Milk
- Emulsions can be destroyed by:
 - the addition of emulsifier which tends to form another emulsion
 - electrophoresis with high potential
 - freezing
 - all of the above
- Which of the following is homogeneous?
 - Milk
 - Paint
 - Shampoo
 - None of these
- Milk is an emulsion in which:
 - milk fat is dispersed in water
 - a solid is dispersed in water
 - a gas is dispersed in water
 - lactose is dispersed in water

● Passage 3

The process of dialysis finds application in the purification of blood by artificial kidney. In this method, impure blood is introduced in the artificial kidney apparatus, where the waste material (electrolyte) diffuses through the membrane. The membrane used in the dialyser is different from the membrane used in osmosis. These membranes allow the movement of ions through them.

Blood is a negatively charged sol. The haemoglobin particles carry a positive charge. Blood is slightly alkaline (pH 7.36–7.42). Acidic salts like alum and FeCl_3 decrease the pH of the blood and the denaturation of globular proteins present in blood takes place. Due to denaturation, these globular proteins become fibrous which are insoluble and stop bleeding. Blood is lyophobic in nature.

Answer the following questions:

- To stop bleeding, FeCl_3 is applied locally because:
 - FeCl_3 seals the blood vessels
 - FeCl_3 changes the direction of blood flow
 - FeCl_3 reacts with blood to form a solid substance which seals the blood vessel
 - FeCl_3 causes denaturation of proteins present in blood
- Which of the following colloidal solutions does not contain negatively charged particles?
 - $\text{Fe}(\text{OH})_3$
 - As_2S_3
 - Blood
 - Gold sol
- The coagulating power of an electrolyte for blood decreases in the order:
 - Na^+ , Al^{3+} , Ba^{2+}
 - PO_4^{3-} , SO_4^{2-} , Cl^-
 - Al^{3+} , Ba^{2+} , Na^+
 - Cl^- , SO_4^{2-} , PO_4^{3-}
- Which of the following statements is/are not true?
 - Blood is positively charged sol
 - Soap solution contains ionic micelles as the colloidal particles
 - Blood is purified by the process of dialysis
 - Ca^{2+} and K^+ cause coagulation of blood if added in excess
- Which of the following is/are lyophobic colloids?
 - Blood
 - Starch
 - Gelatin
 - Gold

Answers

Passage 1.

1. (b)

2. (c)

3. (c)

4. (b, c)

5. (a, c)

Passage 2.

1. (a)

2. (d)

3. (b, c)

4. (d)

5. (a)

Passage 3.

1. (d)

2. (a)

3. (c)

4. (a)

5. (a, d)

SELF ASSESSMENT

ASSIGNMENT NO. 6

SECTION-I

Straight Objective Type Questions

This section contains 10 multiple choice questions. Each question has 4 choices (a), (b), (c) and (d), out of which only one is correct.

- Dispersed phase and dispersion medium in butter are respectively: [EAMCET (Medical) 2007]
(a) solid and liquid (b) liquid and liquid
(c) liquid and solid (d) solid and solid
- Which one of the following acts as the best coagulating agent for ferric hydroxide sol? [PMT (Kerala) 2007]
(a) Magnesium chloride (b) Hydrochloric acid
(c) Aluminium chloride (d) Potassium oxalate
(e) Potassium ferricyanide
- The colloidal sol found effective in the treatment of eye disease is:
(a) colloidal sulphur (b) colloidal antimony
(c) colloidal silver (d) colloidal gold
- When alcohol is added to the saturated solution of calcium acetate in water then we first of all get sol which changes to gelatinous mass called solid alcohol. Solid alcohol is.....
(a) aerosol (b) gel
(c) solid foam (d) solid sol
- Colloidal solutions of gold prepared by different methods are of different colours because of:
(a) variable valency of gold
(b) impurities produced by different methods
(c) different diameters of colloidal gold particles
(d) different concentration of gold particles
- Emulsions of polyvinyl acetate are used in:
(a) polishes (b) latex paints
(c) fire works (d) rayons
- The outcome of internal liquid of gel on shaking is called:
(a) syneresis (b) imbibition
(c) thixotropy (d) precipitation
- Which of the following shows the maximum hydrophobic behaviour?
(a) Adenine (b) Glucose
(c) Stearic acid (d) Glycine
- The solution of natural rubber in benzene is an example of:
(a) lyophobic colloids (b) macromolecular colloid
(c) multimolecular colloid (d) associated colloid
- When NaCl solution is added to $\text{Fe}(\text{OH})_3$ sol then:
(a) $[\text{Fe}(\text{OH})_3]\text{Fe}^{3+}$ is formed
(b) $[\text{Fe}(\text{OH})_3]\text{Cl}^-$ is formed
(c) $\text{Fe}(\text{OH})_3$ is coagulated
(d) $[\text{Fe}(\text{OH})_3]\text{Na}^+$ is formed

SECTION-II

Multiple Answers Type Objective Questions

- Which of the following are lyophilic in nature?
(a) Gum (b) Sulphur (c) Starch (d) Protein
- Surfactant molecules form micelles in aqueous solution, which:
(a) tend to congregate due to their hydrophobic tails
(b) are colloidal-sized cluster of molecules
(c) provide protection due to their hydrophobic head
(d) none of the above
- Crystalloid and colloid differ with respect to:
(a) Tyndall effect
(b) particle size
(c) diffusion through animal or vegetable membrane
(d) number of particles per unit volume of solution
- Select the correct statements among the following:
(a) Milk is emulsion of fat in water
(b) An emulsifier stabilizes the emulsion
(c) Emulsifier forms a thin film around the droplets of dispersed phase
(d) Milk is an emulsion of protein in water
- Which of the following statements are true?
(a) Flocculation value is inversely proportional to the coagulating power
(b) Colloidal silica is a protective colloid
(c) Alum is used for cleaning muddy water
(d) Gelatin is added in ice cream, it acts as emulsifier

SECTION-III

Assertion-Reason Type Questions

This section contains 5 questions. Each question contains **Statement-1** (Assertion) and **Statement-2** (Reason). Each question has following 4 choices (a), (b), (c) and (d), out of which only one is correct.

- Statement-1 is true; statement-2 is true; statement-2 is a correct explanation for statement-1.
 - Statement-1 is true; statement-2 is true; statement-2 is not a correct explanation for statement-1.
 - Statement-1 is true; statement-2 is false.
 - Statement-1 is false; statement-2 is true.
16. **Statement-1:** Micelles are formed by surfactant molecules above the critical micellar concentration (CMC).

Because

Statement-2: The conductivity of solution having surfactant molecules decreases sharply at the CMC. (IIT 2007)

[Hint: Micellisation takes place above certain minimum concentration called critical micellar concentration (CMC). Each micelle contains at least 100 molecules, therefore conductivity of solution decreases sharply at the CMC.]

17. **Statement-1:** Aqueous gold colloidal solution is red in colour.

Because

Statement-2: The colour arises due to scattering of light by colloidal gold particles.

18. **Statement-1:** An emulsion becomes stable if soap is added to it.

Because

Statement-2: Soap contains hydrophobic and hydrophilic parts.

19. **Statement-1:** Colloidal solutions are electrically neutral.

Because

Statement-2: Dispersed phase and dispersion medium are of same charge.

20. **Statement-1:** Colloidal sol scatter the beam of light while true solutions do not.

Because

Statement-2: The particles in colloidal sol are bigger than those of true solutions.

Answers

- | | | | | | | | |
|---------|---------|---------------|---------------|---------------|---------------|---------------|---------|
| 1. (b) | 2. (e) | 3. (c) | 4. (b) | 5. (c) | 6. (b) | 7. (c) | 8. (a) |
| 9. (b) | 10. (c) | 11. (a, c, d) | 12. (a, b, c) | 13. (a, b, c) | 14. (a, b, c) | 15. (a, c, d) | 16. (b) |
| 17. (b) | 18. (a) | 19. (c) | 20. (a) | | | | |