# DAY SIXTEEN

# Colloidal State

## Learning & Revision for the Day

- Distinction Among True Solutions, Colloids and Suspension
- Classification of Colloids
- Preparation of Colloids
- Purification of Colloidal Solutions
- Properties of Colloidal Solutions
- Emulsions

A **colloid** is a heterogeneous system in which one substance is dispersed as very fine particles in another substance called **dispersion medium**. Colloidal particles are larger than simple molecules but small enough to remain suspended.

## Distinction Among True Solutions, Colloids and Suspension

- Depending upon the size of dispersed particles, there are three different types of solutions *viz*. **true solutions, suspensions** and **colloidal solutions.** In **true solutions,** the dispersed particles are present as single molecule or ion. The size of the dispersed particles is less than 1 nm. True solutions are homogeneous.
- In **colloidal solution,** colloidal particles have an anormous surface area per unit mass as a result of their small size. It is heterogeneous. In **suspension**, the size of dispersed particles is more than 1000 nm. It is also heterogeneous.

## Classification of Colloids

Depending upon whether the dispersed phase and the dispersion medium are solids, liquids or gases, eight types of colloidal systems are possible. These are as follows:

| Colloidal system | Dispersed phase | Dispersion medium | Examples |
|---|---|---|---|
| Foam | Gas | Liquid | Soda water, froth, shaving cream |
| Solid sol | Gas | Solid | Foam, rubber, cork, pumice stone |
| Aerosol | Liquid | Gas | Fog, mist, cloud |
| Emulsion | Liquid | Liquid | Milk, hair cream |
| Solid emulsion (gel) | Liquid | Solid | Butter, cheese |
| Aerosol of solids | Solid | Gas | Dust in air, smoke |
| Sol | Solid | Liquid | Paint, ink, colloidal gold |
| Solid sol | Solid | Solid | Ruby glass, gemstones, alloys, rock salt |

- On the basis of **appearance**, colloids are classified as follows :
  (i) The colloidal systems, in which the dispersion medium is a liquid or gas, are called sols. They are called hydrosol or aquasol, if the dispersion medium is water. When the dispersion medium is alcohol or benzene, they are accordingly called **alcosol** or **benzosol**.
  (ii) The colloidal systems, in which the dispersion medium is gas are called **aerosols.**
  The colloids can be classified into **positive** or **negative colloids** according to the charge present on the dispersed phase particles.
- On the basis of **affinity of phase**, colloids are classified as follows :
  (i) **Lyophilic colloids** represent such colloidal systems in which the particles of dispersed phase have great affinity for the dispersion medium.
  These are reversible colloids, e.g. gum, gelatin, rubber, proteins etc.
  (ii) **Lyophobic colloids** represent such colloidal systems in which particles of the dispersed phase have no affinity for the dispersion medium.
  These are irreversible e.g. sols of metals and their insoluble compounds like sulphides and oxides.
  If water is the dispersion medium, the terms used are **hydrophilic** and **hydrophobic colloids**.
  Lyophobic colloids are less stable due to the presence of electric charge on their particles.
- On the basis of **molecular size**, colloids are classified as follows:
  (i) **Multimolecular colloids** are the colloids in which colloidal particles consist of aggregate of atoms or small molecules with diameter less than $10^{-9}$ m or 1 nm, e.g. a sol of gold, a sol of sulphur.
  (ii) **Macromolecular colloids** are the colloids in which colloidal particles themselves are large molecules, e.g. starch, proteins, enzymes, nylon etc.
  (iii) **Associated colloids** or **micelles** are the substances which behave as normal electrolytes at low concentration but as colloids at higher concentration. This is because at higher concentration, they form associated particles called micelles, e.g. soap and synthetic detergents.
  The concentration above which micelle formation occurs is called **CMC** (Critical Micelle Concentration) and the temperature above which micelle formation occurs is called **Kraft temperature**.

NOTE
- In **polydisperse colloids**, the colloidal particles are of different sizes while in monodisperse colloids, all the colloidal particles are more or less of identical size.
- The colligative properties of colloidal systems are low due to aggregation. Hence, all colloidal solutions exhibit very low osmotic pressure, very small elevation in boiling point and depression in freezing point.

# Preparation of Colloids

Lyophilic colloids may be prepared by simply warming the solid with the liquid dispersion medium. On the other hand, lyophobic colloids have to be prepared by special methods.

Substances are converted into colloidal solutions by the following two methods:

## 1. Dispersion Methods

These methods involve the breaking of bigger particles to the size of colloidal particles.

The various dispersion methods are:

(i) **Electrodisintegration method** (Bredig's arc method), this process involves dispersion as well as condensation. By this method, colloidal solutions of metals like gold, silver etc., are obtained.

(ii) **Peptisation** involves the conversion of freshly prepared precipitate into colloidal solution by adding suitable electrolyte. The suitable electrolyte is known as peptising agent. e.g.

$$\underset{\text{Fresh ppt.}}{Fe(OH)_3} + \underset{\text{Electrolyte}}{FeCl_3} \longrightarrow \underset{\text{Colloid}}{Fe(OH)_3Fe^{3+}} + 3Cl^-$$

## 2. Condensation or Chemical Methods

These methods involve the growing of size of the dispersed phase or the size of colloidal particles.

(i) **By double decomposition**

$$As_2O_3 + 3H_2S \longrightarrow \underset{\text{Colloidal solution}}{As_2S_3} + 3H_2O$$

(ii) **By hydrolysis**

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

(iii) **By oxidation**

$$H_2S + 2HNO_3 \longrightarrow 2H_2O + 2NO_2 + \underset{\text{Colloid}}{S}$$

In periodic precipitation, these reactions are carried out in gel medium. As a result of this, rings or layers of precipitates are formed at definite intervals.

# Purification of Colloidal Solutions

The following methods are commonly used to purify the colloids:

(i) **Dialysis** It is the process of removing small molecules or ions from a sol by diffusion through a semipermeable membrane. In this process, impure colloidal solution is placed in a bag of semipermeable membrane, dipping in water, the ions diffuse through membrane. Ferric hydroxide sol can be purified by this method.

(ii) **Electrodialysis** If dialysis is carried out under the influence of electric field, it is called electrodialysis. This speeds up the migration of ions to the opposite electrodes.

(iii) **Ultrafiltration** Separation of sol particles from the liquid medium and electrolytes by filtration through an ultrafilter is called ultrafiltration.

(iv) **Ultra-centrifugation** In ultra-centrifuge, the colloidal particles settle down at the bottom and impurities remain in the solution.

# Properties of Colloidal Solutions

The important properties of the colloidal solutions are given below:

(i) **Brownian Movement** Colloidal particles are always in a state of rapid random motion (*zig-zag* movement) which is termed as Brownian movement.

(ii) **Tyndall Effect** When a strong and converging beam of light is passed through a colloidal solution, its path becomes visible due to scattering of light by particles. It is called Tyndall effect.

(iii) **Electrophoresis** The phenomenon, involving the migration of colloidal particles under the influence of electric field towards the oppositely charged electrode, is called electrophoresis.

- **Sedimentation potential** or **Dome effect** is the reverse of electrophoresis. It is set up when a particle is forced to move in a resting liquid.
- **Electrophoretic mobility** of colloidal particles is the distance travelled by particles in one second under a potential gradient in one volt per cm. Since, different colloids have different mobilities, so this method is used for separation of proteins, nucleic acids, polysaccharides etc.

(iv) **Coagulation or Flocculation** The precipitation of particles of the dispersed phase in a sol is known as coagulation. The minimum amount of an electrolyte required to cause precipitation of one litre of a colloidal solution is called coagulation value or flocculation value. The reciprocal of coagulation value is regarded as the coagulating power.

(v) **Hardy-Schulze Rule** Higher the valency of the active ion, the greater will be its power to precipitate the sol.

e.g. order of coagulating power is

$$Al^{3+} > Ba^{2+} > Na^{+}$$

$$PO_4^{3-} > SO_4^{2-} > Cl^{-}$$

## Protective Action of Lyophilic Colloids

As lyophobic sols are unstable (e.g. Au, Ag) and get easily precipitated, the addition of lyophilic colloids like gums, soaps etc., makes it difficult to precipitate. The process is known as **protection** and the lyophilic colloids are termed as protective colloids.

NOTE **Gold Number** It is the minimum weight (in mg) which must be added to 10 mL of standard red gold sol so that no coagulation of it takes place when 1 mL of 10% NaCl solution is rapidly added to it.

# Emulsions

These are the colloidal solutions of two immiscible liquids or partially immiscible liquid in which the liquids act as the dispersed phase as well as the dispersion medium.

There are two types of emulsions:

(a) **Oil in water type**, e.g. milk in which tiny droplets of liquid fat are dispersed in water.

(b) **Water in oil type**, e.g. stiff greases, in which water being dispersed in lubricating oil.

During the preparation of emulsion, a small amount of some substances such as soap, gum, agar and protein etc., are added to stabilise the emulsion. These substances are known as **emulsifying agents.**

## Charateristics of Emulsion

- Emulsions can be broken into constituent liquids by heating, freezing, centrifuging or chemical destruction of emulsifying agent.
- They show Brownian movement and Tyndall effect.
- These can be diluted with any amount of the dispersion medium.

NOTE

- **Surfactants** are the substances which get preferentially absorbed at the air-water, oil-water and solid-water interfaces.
- $C_{15}H_{31}COO^{-}Na^{+}$ is an anionic surfactant, $C_{18}H_{37}NH_3^{+}\ Cl^{-}$ is cationic surfactant and $C_nH_{2n+1}(OCH_2CH_2)_xOH$ is **non-ionic surfactant**.

DAY PRACTICE SESSION 1

# FOUNDATION QUESTIONS EXERCISE

**1** Fog is a colloidal solution of
(a) liquid particles dispersed in a gas
(b) gaseous particles dispersed in a liquid
(c) solid particles dispersed in a liquid
(d) solid particles dispersed in a gas

**2** A gel is
(a) a liquid mass of a lyophilic sol in which all the dispersion medium has penetrated into the sol particles
(b) like an emulsion which is stabilised by adding emulsifying agent
(c) a semirigid mass of a lyophobic sol in which all the dispersion medium has penetrated into the sol particles
(d) a semirigid mass of a lyophilic sol in which the dispersion medium has penetrated into the sol particles

**3** Smoke is an example of ➜ JEE Main (Online) 2013
(a) solid dispersed in solid (b) gas dispersed in liquid
(c) solid dispersed in gas (d) gas dispersed in solid

**4** Which one of the following is correctly matched?
(a) Emulsion - smoke (b) Gel - butter
(c) Aerosol - hair cream (d) Sol - whipped cream

**5** Addition of lyophilic solution to the emulsion, forms
(a) a protective film around the dispersed phase
(b) a protective film around the dispersion medium
(c) an aerosol
(d) true solution

**6** Lyophilic solutions are more stable than lyophobic solutions because
(a) the colloidal particles have positive charge
(b) the colloidal particles have negative charge
(c) the colloidal particles are solvated
(d) there is strong electrostatic repulsions between the negatively charged colloidal particles

**7** Lyophilic sols are
(a) irreversible sols
(b) prepared from inorganic compounds
(c) coagulated by adding electrolytes
(d) self-stabilising

**8** 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 the same as that of water
(d) The charge of the particles depend on the pH of the medium and it may be positive, negative or zero

**9** In multimolecular colloidal sols, atoms or molecules are held together by
(a) H-bonding (b) van der Waals' forces
(c) ionic bonding (d) polar covalent bonding

**10** Which type of molecules form micelles?
(a) Non-polar molecules
(b) Polar molecules
(c) Surfactant molecules
(d) Salt of weak acid and weak base

**11** The critical micelle concentration (CMC) is
(a) the concentration at which micellisation starts
(b) the concentration at which the true solution is formed
(c) the concentration at which one molar electrolyte is present per 1000 g of the solution
(d) the concentration at which $\Delta H = 0$

**12** During the micelle formation,
(a) $\Delta H = +ve, \Delta S = +ve$ (b) $\Delta H = -ve, \Delta S = -ve$
(c) $\Delta H = -ve, \Delta S = +ve$ (d) $\Delta H = +ve, \Delta S = -ve$

**13** Micelles form only
(a) below the critical micelle concentration (CMC) and below the Kraft temperature ($T_k$)
(b) above CMC and below the $T_k$
(c) above the CMC and above the $T_k$
(d) below the CMC and above the $T_k$

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

**15.** A freshly prepared $Fe(OH)_3$ precipitate is peptised by adding $FeCl_3$ solution. The charge on the colloidal particles is due to preferential adsorption of
(a) $Br^-$ ion (b) $Fe^{3+}$ ion
(c) $OH^-$ ion (d) $Ba^{2+}$ ion

**16** Peptisation involves
(a) precipitation of colloidal particles
(b) disintegration of colloidal aggregates
(c) evaporation of dispersion medium
(d) impact of molecules of the dispersion medium on the colloidal particles

**17** A particle of radius 1 cm is broken to form colloidal particles of radius 1000 Å. The number of colloidal particles produced are
(a) $10^{15}$ (b) $6.023 \times 10^{23}$
(c) $10^{12}$ (d) $10^{10}$

**18** The colloidal sol formed from $SnO_2$ in acidic and basic medium respectively are

(a) $[SnO_2]SnO_3^{2-}$ : 2 $Na^+$ and $[SnO_2]Sn^{4+}$ : $4Cl^-$
(b) $[SnO_2]Sn^{4+}$ and $[SnO_2]SnO_3^{2-}$ : $2Na^+$
(c) positively and negatively charged
(d) $[SnO_2]SnO_3^{2-}$ : $2Na^+$ in both the media

**19** Separation of colloidal particles from those of molecular dimensions by means of electric current is known as

(a) electroosmosis (b) electrophoresis
(c) electrodialysis (d) electrolysis

**20** The Brownian movement is due to

(a) enthalpy change during the formation of colloids
(b) attractive force between the colloidal particles and the molecules of dispersion medium
(c) the impact of molecules of the dispersion medium on the colloidal particles
(d) the movement of positively charged colloidal particles to negatively charged particle

**21** The migration of dispersion medium under the influence of an electric potential is called ➜ JEE Main (Online) 2013

(a) cataphoresis (b) electroosmosis
(c) electrophoresis (d) gas dispersed in solid

**22** Which of the following statements is correct for Tyndall effect?

(a) Scattering and polarising of light by small suspended particles is called Tyndall effect
(b) Tyndall effect of colloidal particles is due to dispersion of light
(c) Tyndall effect is due to refraction of light
(d) *zig-zag* motion of suspended particles

**23** Which of the following process is responsible for the formation of delta at a place where rivers meet the sea?

(a) Emulsification (b) Colloidal formation
(c) Coagulation (d) Peptisation

**24** Which of the following ions have minimum value of flocculating power?

(a) $PO_4^{3-}$ (b) $SO_4^{2-}$ (c) $SO_3^{2-}$ (d) $NO_3^-$

**25** Match the following and choose the correct option.

| Column I | Column II |
|---|---|
| A. Protective colloid | 1. $FeCl_3$ + NaOH |
| B. Liquid-liquid colloid | 2. Lyophilic colloids |
| C. Positively charged colloid | 3. Emulsion |
| D. Negatively charged colloid | 4. $FeCl_3$ + hot water |

**Codes**

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

**26** Which of the following has maximum coagulation power with ferric hydroxide sol?

(a) Cryolite (b) $K_2C_2O_4$
(c) $K_3[Fe(CN)_6]$ (d) $K_4[Fe(CN)_6]$

**27** The coagulating power of electrolytes having ions $Na^+, Al^{3+}$ and $Ba^{2+}$ for arsenic sulphide solution increases in the order ➜ JEE Main 2013

(a) $Na^+ < Ba^{2+} < Al^{3+}$ (b) $Ba^{2+} < Na^+ < Al^{3+}$
(c) $Al^{3+} < Na^+ < Ba^{2+}$ (d) $Al^{3+} < Ba^{2+} < Na^+$

**28** The coagulation values of $AlCl_3$ and NaCl are 0.093 and 52 respectively. The ratio of coagulating powers of both will be

(a) 0.093 : 1 (b) 52 : 1
(c) 559 : 1 (d) 1.788 : 1

**29** Which of the following will show Tyndall effect?

(a) Aqueous solution of soap below critical micelle concentration
(b) Aqueous solution of soap above critical micelle concentration
(c) Aqueous solution of sodium chloride
(d) Aqueous solution of sugar

**30** Gold number is the index for

(a) protective power of lyophilic colloid
(b) purity of gold
(c) metallic gold
(d) electroplated gold

**31** Hardy-Schulze law states that

(a) larger the charge on the coagulating ions, greater is its coagulating power, having opposite sign of solution
(b) solution must have zero gold number
(c) dispersed phase and dispersion medium must be of the same sign
(d) micelles coagulate in the presence of surfactants

**32** When dilute aqueous solution of $AgNO_3$ (excess) is added to KI solution, positively charged sol particles of AgI are formed due to adsorption of ion

(a) $K^+$ (b) $Ag^+$ (c) $I^-$ (d) $NO_3^-$

**33** Which of the following statements is incorrect?

(a) Emulsions are prepared by shaking two liquid components, say oil and water and adding some emulsifying agent
(b) Water in oil emulsions are formed when the emulsifying agent at the interface is chiefly in the water phase
(c) Water in oil emulsions are formed when the emulsifying agent at the interface is chiefly in the oil phase
(d) Gems and gels mixed together to give emulsions

**Direction** (Q. Nos. 34-38) *In the following questions, Assertion* (A) *followed by a Reason* (R) *is given. Choose the correct option out of the following choices.*

(a) Both A and R are true and R is correct explanation of A
(b) Both A and R are true but R is not correct explanation of A
(c) A is true but R is false
(d) Both A and R are false

**34** **Assertion** (A) An ordinary filter paper impregnated with colloidal solution stops the flow of colloidal particles.

**Reason** (R) Pore size of the filter paper becomes more than the size of colloidal particle.

**35.** **Assertion** (A) The Brownian movement has a stirring affect that does not permit the particles to settle.

**Reason** (R) Brownian motion is responsible for stability of sols.

**36.** **Assertion** (A) Micelles are formed by surfactant molecules above the Critical Micelle Concentration (CMC).

**Reason** (R) The conductivity of a solution having surfactant molecules decreases sharply at the CMC.

**37.** **Assertion** (A) A colloid gets coagulated by addition of an electrolyte.

**Reason** (R) The rate of coagulation depends on the magnitude and sign of the charge of the coagulant ion.

**38.** **Assertion** (A) Colloidal AgI is prepared by adding $AgNO_3$ in slight excess to KI solution. When subjected to an electric field, the colloidal particles migrate to the anode.

**Reason** (R) Colloidal particles adsorb ions and thus, become electrically charged.

DAY PRACTICE SESSION 2

# PROGRESSIVE QUESTIONS EXERCISE

**1** When 9.0 mL of arsenious sulphide sol and 1.0 mL of 0.1 M $BaCl_2$ are mixed, turbidity due to precipitation just appears after 2 h. The effective ion and its coagulation value respectively are

(a) $Cl^-$, 10 millimol $L^{-1}$ (b) $Cl^-$, 20 millimol $L^{-1}$
(c) $Ba^{2+}$, 10 millimol $L^{-1}$ (d) $Ba^{2+}$, 20 millimol $L^{-1}$

**2** The dispersed phase in colloidal iron (III) hydroxide and colloidal gold is positively and negatively charged, respectively. Which of the following statements is not correct?

(a) Coagulation in both sols can be brought about by electrophoresis
(b) Mixing the sols has no effect
(c) Sodium sulphate solution causes coagulation in both sols
(d) Magnesium chloride solution coagulates the gold sol more readily than the iron (III) hydroxide sol

**3** The values of colligative properties of colloidal solution are of small order in comparison to those shown by true solutions of same concentration because colloidal particles

(a) exhibit enormous surface area
(b) remain suspended in the dispersion medium
(c) form lyophilic colloids
(d) are comparatively less in number

**4** In a coagulating experiment, 5 mL of $As_2S_3$ is mixed with distilled water and 0.2 M solution of an electrolyte *AB*, so that the total volume is 20 mL. All solutions containing 5.4 mL of *AB* coagulate within 2 min. The flocculation value of *AB* (in millimole) is

(a) 5 (b) 50
(c) 54 (d) None of these

**5** Which one of the following does not involve coagulation?

(a) Clotting of blood by the use of ferric chloride
(b) Formation of delta region
(c) Treatment of drinking water by potash alum
(d) Peptisation

**6** When $6.0 \times 10^{-5}$ g of a protective colloid was added to 20 mL of a standard gold sol, the precipitation of latter was just prevented on addition of 1 mL of 10% NaCl solution. The gold number of the protective colloid is

(a) 3 (b) $3 \times 10^{-5}$
(c) 0.06 (d) 0.03

**7** Gold numbers of protective colloids *A*, *B*, *C* and *D* are 0.50, 0.01, 0.10 and 0.005, respectively. The correct order of their protective powers is

(a) $D < A < C < B$ (b) $C < B < D < A$
(c) $A < C < B < D$ (d) $B < D < A < C$

**8** Potassium stearate is obtained by the saponification of an oil or fat. It has formula $CH_3—(CH_2)_{16}—COOK$. The molecule has a lyophobic terminal $CH_3$ and a lyophilic terminal—COOK. Potassium stearate is an example of

(a) lyophilic colloid
(b) lyophobic colloid
(c) macromolecular colloid
(d) micelle or associated colloid

**9** The gold number of some colloidal solutions are given below:

| Colloidal solution | Gold number |
|---|---|
| *A* | 0.01 |
| *B* | 2.5 |
| *C* | 20 |

The protective nature of these colloidal solutions follow the order

(a) $C > B > A$ (b) $A > B > C$
(c) $A = B = C$ (d) $B > A > C$

**10** The disperse phase, dispersion medium and nature of colloidal solution (lyophilic or lyophobic) of 'gold sol' respectively are

(a) solid, solid, lyophobic
(b) liquid, liquid, lyophobic
(c) solid, liquid, lyophobic
(d) solid, liquid, lyophilic

# ANSWERS

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| SESSION 1 | **1** (a) | **2** (d) | **3** (c) | **4** (b) | **5** (a) | **6** (c) | **7** (d) | **8** (c) | **9** (b) | **10** (c) |
| | **11** (a) | **12** (c) | **13** (c) | **14** (a) | **15** (b) | **16** (b) | **17** (a) | **18** (c) | **19** (b) | **20** (c) |
| | **21** (b) | **22** (a) | **23** (c) | **24** (a) | **25** (c) | **26** (d) | **27** (a) | **28** (c) | **29** (b) | **30** (a) |
| | **31** (a) | **32** (b) | **33** (d) | **34** (c) | **35** (d) | **36** (b) | **37** (b) | **38** (a) | | |
| SESSION 2 | **1** (c) | **2** (b) | **3** (d) | **4** (c) | **5** (d) | **6** (d) | **7** (c) | **8** (d) | **9** (b) | **10** (c) |

# Hints and Explanations

## SESSION 1

**1** Fog is liquid dispersed in gas, a class of colloidal system.

**2** A gel is liquid dispersed in solid, e.g. cheese. It is a semirigid mass of a lyophilic sol in which the dispersion medium has penetrated into sol particles.

**3** Smoke is a colloid in which dispersed phase is solid and dispersion medium is gas or in other words, in smoke, a solid is dispersed in gas.

**4** Gel-butter
Butter is an example for gel.

**5** Addition of lyophilic solution to the emulsion forms a protective film around the dispersed phase. Surface phase reaction.

**6** Lyophilic colloids are more stable due to solvation.

**7** Lyophilic sols are self-stabilising because these sols are reversible and are highly hydrated in the solution.

**8** Viscosity is higher than that of dispersion medium (water) while surface tension is usually lower than that of dispersion medium (water).

**9** In multimolecular colloidal sols, atoms or molecules are held together by van der Waals' forces.

**10** Surfactant molecules form micelles.

**11** It is the minimum concentration at which surfactant molecules undergo aggregation.

**12** $\Delta H$ = negative, $\Delta S$ = positive

**13** Micelle formation takes place above a particular temperature, called Kraft temperature ($T_k$) and above a particular concentration, called Critical Micelle Concentration (CMC).

**14** Critical concentration for micelle formation decreases as the molecular weight of hydrocarbon chain of surfactant grows. Hexadecyltrimethyl ammonium bromide (CTAB) i.e. $CH_3(CH_2)_{15}N^+(CH_3)_3Br^{\ominus}$, will form micelles in aqueous solution at lowest molar concentration.

**15** Solution particle adsorbs common ion present in the medium. So, charge on colloidal particles is due to preferential adsorption of $Fe^{3+}$ ion.

**16** Peptisation involves disintegration of colloidal aggregates.

**17** Volume of a particle with radius 1 cm

$$= \frac{4}{3}\pi r^3 = \frac{4}{3}\pi\ (1)^3\ cm^3$$

The particle is broken into colloidal particle of radius 1000 Å, i.e. $10^{-5}$ cm.

Hence, volume of the particle

$$= \frac{4}{3}\pi r^3 = \frac{4}{3}\times \pi \times (10^{-5})^3$$

$$= \frac{4}{3}\pi \times 10^{-15}\ cm^3$$

Hence, number of colloidal particles

$$= \frac{\frac{4}{3}\pi\ cm^3}{\frac{4}{3}\pi \times 10^{-15} cm^3} = 10^{15}$$

**18** In acidic medium, $Sn^{4+}$ ion is formed which is preferentially adsorbed on $SnO_2$ giving positively charged colloidal sol.

$$SnO_2 + Sn^{4+} \longrightarrow \underset{\text{Positively charged}}{[SnO_2]Sn^{4+}\ :4Cl^-}$$

In basic medium, $SnO_3^{2-}$ is formed which is preferentially adsorbed on $SnO_2$, giving negatively charged colloidal sol.

$$SnO_2 + SnO_3^{2-} \longrightarrow \underset{\text{Negatively charged}}{[SnO_2]SnO_3^{2-}:2Na^+}$$

**19** In electrophoresis, charged sol particles move towards opposite electrodes.

**20** Brownian movement is *zig-zag* motion of suspended particles. It is due to the impact of molecules of the dispersion medium on the colloidal particles.

**21** Electroosmotic flow is caused by the Coulomb force induced by an electric field on net mobile electric charge in a solution. When an electric field is applied to the fluid, the net charge in the electrical double layer (a layer of mobile ions forms in the region near the interface) is induced to move by the resulting Coulomb force.

**22** When a beam of light is passed through a colloidal solution, its path becomes visible by light scattering and polarising of light by small suspended particles. This is known as Tyndall effect.

**23** The process is responsible for the formation of delta at a place where rivers meet the sea is coagulation.

**24** $PO_4^{3-}$ have minimum value of flocculating power.

**25** A $\longrightarrow$ 2; B $\longrightarrow$ 3; C $\longrightarrow$ 4; D $\longrightarrow$ 1

**26** Ferric hydroxide is a positive solution. Thus, a negative ion cause the precipitation of positively charged sol and *vice-versa*. According to Hardy-Schulze rule, greater is the valency of the coagulating or flocculating ion, greater is its power to bring about coagulation.

Thus, in coagulation of a positive solution ferric hydroxide, the flocculating power is maximum for $[Fe(CN)_6]^{4-}$ ion. Thus, $K_4[Fe(CN)_6]$ possesses the maximum coagulating power form $Fe(OH)_3$ solution.

Hence, the correct increasing order is $Na^+ < Ba^{2+} < Al^{3+}$

**27** $As_2S_3$ is an anionic sol (negative sol) hence, coagulation will depend upon coagulating power of cation which is directly proportional to the valency of cation (Hardy-Schulze rule).

**28** As coagulating power is inversely proportional to coagulation value, the ratio of their coagulating powers will be

$$\frac{\text{Coagulating power of } AlCl_3}{\text{Coagulating power of NaCl}} = \frac{\text{Coagulation value of NaCl}}{\text{Coagulation value of } AlCl_3} = \frac{52}{0.093} = 559:1$$

**29** Aqueous solution of soap above critical micelle concentration show Tyndall effect.

**30** Protective power of various lyophilic substances is expressed in terms of gold number.

**31** Hardy-Schulze law states that larger the charge on the coagulating ions, greater is its coagulating power, having opposite sign of solution.

**32** Sol particles possess the tendency to adsorb preferentially the common ion present in solution. Therefore, AgI are formed due to adsorption of $Ag^+$ ion.

**33** Gems are solid and gels are semisolid. This mixture will not form emulsion.

**34** **Correct Reason** Pore size of the filter paper becomes smaller than the size of the colloidal particles.

**35** The Brownian movement has a stirring affect which does not permit the particles to settle and thus, in responsible for the stability of sols.

**36** At a certain concentration, surfactant molecules start to aggregate and form micelle, the concentration is called Critical Micelle Concentration (CMC).

Aggregation of surfactant molecules (ions; $RCOO^-$), i.e. micelle formation cause effective fall in number of free ions to conduct electricity, thus conductivity decreases at CMC.

**37** Coagulation of sols by addition of electrolytes is explained by Hardy-Schulze rule. For positive sol, negative ion of electrolyte is the effective ion while for negative sol, positive ion of electrolyte is the effective ion. Greater is the valency of effective ion, more is its coagulating power and lesser is the coagulation value.

**38** Colloidal particles are electrically charged, hence they move towards oppositely charged electrode on applying electric field.

## SESSION 2

**1** $As_2S_3$ sol is negatively charged due to preferential adsorption of $S^{2-}$ ions by $As_2S_3$ particles. Hence, cation of largest valency (i.e. $Ba^{2+}$) would be most effective in causing coagulation of the sol.

$$\text{Moles of } Ba^{2+} = \frac{1.0 \times 0.1}{1000} = 1.0 \times 10^{-4} \text{mol}$$

10 mL (9.0 mL of $As_2S_3$ and 1.0 mL $BaCl_2$) of $As_2S_3$ requires $BaCl_2$ for coagulation $= 1.0 \times 10^{-4}$ mol

1000 mL of $As_2S_3$ requires $BaCl_2$ for coagulation (i.e. coagulation value)

$$= \frac{1.0 \times 10^{-4} \times 1000}{10}$$

$$= 1.0 \times 10^{-2} \text{ mol L}^{-1}$$

$$= 10 \text{ millimol L}^{-1}$$

**2** Mixing the sols together can cause coagulation, since the charges are neutralised.

**3** The values of colligative properties of colloidal solution are of small order in comparison to true solutions of same concentration because colloidal particles are comparatively less in number.

**4** Flocculation value is the amount of electrolyte, in millimoles required to bring about complete coagulation of one litre of colloidal solution.

Amount of *AB* in 5.4 mL of 0.2 M *AB*

$$= \frac{5.4 \times 0.2}{1000} = 1.08 \times 10^{-3} \text{ mol}$$

20 mL of $As_2S_3$ requires *AB* for coagulation $= 1.08 \times 10^{-3}$ mol

1000 mL of $As_2S_3$ requires *AB* (i.e. flocculation value)

$$= \frac{1.08 \times 10^{-3}}{20} \times 1000$$

$$= 0.054 \text{ mol}$$

$$= 54 \text{ millimol}$$

**5** Peptisation is the process of converting a precipitate into colloidal sol by shaking it with dispersion medium in the presence of a small amount of electrolyte. It is the method of preparation of colloids.

**6** The protective colloid added to 20 mL of gold sol to completely prevent coagulation by 1 mL of 10 % NaCl solution $= 6.0 \times 10^{-5} \text{g} = 6.0 \times 10^{-2}$ mg.

Hence, the protective colloid required to be added to 10 mL of gold sol to completely prevent coagulation by 1 mL of 10% solution $= \frac{6.0 \times 10^{-2} \times 10}{20}$

$$= 0.03 \text{ mg}$$

Hence, gold number = 0.03

**7** Higher the gold number, lesser will be the protective power of colloid. So, the correct order of their protective power is $A < C < B < D$

**8** Potassium stearate is an example of micelle or associated colloid.

**9** Smaller the value of gold number, greater will be the protecting power of the protective colloid. Hence, protective nature of *A*, *B* and *C* is as

Colloidal solution : $A > B > C$

Gold number : 0.01 2.5 20

**10** Colloidal solution of gold is obtained when dispersed phase is solid and disperstion medium is liquid.

Substances like metals cannot be brought into the colloidal state simply by bringing them in contact with water and therefore, special methods are devised for the purpose.

Hence, they are known as hydrophobic or lyophobic colloids.