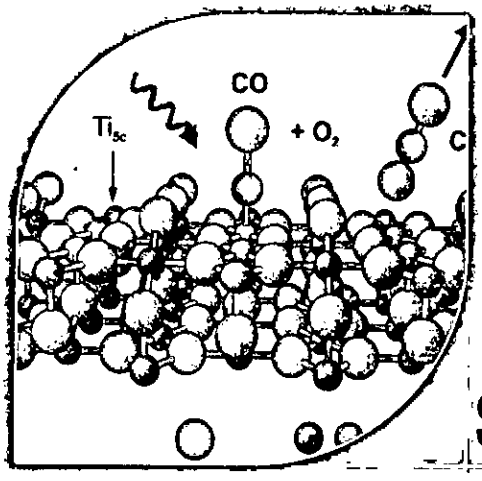



# 11

# SURFACE CHEMISTRY

## Terms Related to Adsorption and Absorption

- **Adsorption :** The accumulation of molecular species at the surface rather than bulk of solid or liquid is known as adsorption.
- **Adsorbate :** The molecular species or substance which accumulates at the surface is known as adsorbate.
- **Adsorbent :** The surface at which accumulation of adsorbate takes place is known as adsorbent.

  **Ex :** Water vapours (adsorbate) adsorb at the surface of silica gel (adsorbent).
- **Desorption :** The process of removing an adsorbed substance from adsorbent is known as desorption. When equilibrium established then rate of adsorption and rate of desorption are equal.
- **Absorption :** When atoms molecules or ions enter in bulk phase of solid or liquid is known as absorption.

  **Ex.** Water vapours absorbed by anhydrous $CaCl_2$.
- **Sorption :** When adsorption and absorption takes place simultaneously then phenomena is known as sorption.

  **Ex.** Dyeing of fabric

## Characteristics of Adsorption

- Adsorption is surface phenomena.
- In adsorption surface energy decreases.
- In adsorption entropy decreases.
- When decrease in free energy takes place then adsorption takes place.

## Types of Adsorption

**(1) Based on concentration :**

- Positive adsorption : If the concentration of adsorbate is more at the surface as compared to its concentration in the bulk phase then it is called positive adsorption
- Negative adsorption : If concentration of adsorbate is less at the surface as compared to its concentration in the bulk phase then it is called negative adsorption

**(2) Based on forces existing between adsorbate molecule and adsorbent :**

- **Physical adsorption :** If the forces of attraction existing between adsorbate and adsorbent are vander Waal's forces, then adsorption is called physical adsorption..
- **Chemical adsorption :** If the forces of attraction existing between adsorbate particles and adsorbent are almost of the same strength as chemical bonds then adsorption is called chemical adsorption.

**Comparison between physisorption and chemisorption**

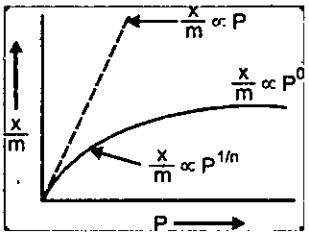
| S.No. | Physisorption | Chemisorption |
|---|---|---|
| 1. | Low heat of adsorption usually in range of 20 – 40 kJ/mol. | High heat of adsorption in the range of 80 – 240 kJ/mol. |
| 2. | Forces of attraction are vander Waal's forces. | Forces of attraction are chemical bond forces. |
| 3. | It is reversible in nature. | It is irreversible in nature. |
| 4. | It usually takes place at low temp and it decreases with increasing temp. | It takes place at high temperature and it increase with increasing temperature. |
| 5. | More easily liquefiable gases are adsorbed readily. | Gases which can react with the adsorbent show chemisorption. |
| 6. | It forms multimolecular layers. | It forms monomolecular layer. |
| 7. | It does not require any activation energy. | It requires activation energy. |
| 8. | It is not specific. | It is highly specific. |
| 9. | It increases with increase the surface of area of adsorbent. | It also increases with increase the surface area of adsorbent. |

## Factors Affecting Adsorption

- **Nature of the gas :** Easily liquefiable gases adsorb to greater extent.
- **Effect of nature of adsorbent :** When adsorbent activated then extent of adsorption increases.
- **Specific area of the solid :** Greater the specific area of the solid, greater would be its adsorbent power. By the activation of adsorbent, surface area increase and adsorption increases.
- **Effect of pressure of the gas :** The adsorption causes a net decrease in pressure as the gas gets adsorbed and thus the increase in pressure favours the process of adsorption.

## Adsorption Isotherm

Graph between extent of the adsorption $\left(\frac{x}{m}\right)$ & pressure ($P$) at a given temperature is called adsorption isotherm. There are two types of adsorption isotherms



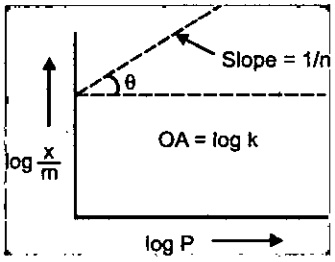

**(i) Freundlich Adsorption isotherm :**

Freundlich's Equation $\frac{x}{m} = k \times P^{1/n}$

where $x$ = mass of adsorbate adsorbs, $m$ = mass of adsorbent, $p$ = pressure

- **At low pressure :** $\frac{x}{m} = k \times P$
- **At intermediate pressure :** $\frac{x}{m} = k \times P^{1/n}$, where $n \geq 1$
- **At high pressure :** $\frac{x}{m}$ = constant

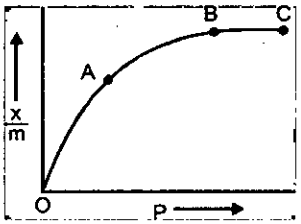
$$\log \frac{x}{m} \log k + \frac{1}{n} \log p$$




**(ii) Langmuir Adsorption isotherm :** According to Langmuir

- There is adsorption of gas molecules on the surface of the solid.
- There is desorption of the adsorbed molecules from the surface of the solid.
- There is formation of unimolecular layer and so it is chemisorption
- A dynamic equilibrium is attained when rate of adsorption = rate of desorption.

$$\frac{x}{m} = \frac{ap}{1 + bp}$$




Where $a$ & $b$ Langmuir parameters.

**Case-I** At very high pressure

$$bp >>> 1,$$

$$\therefore \quad \frac{x}{m} = \frac{ap}{bp} = \frac{a}{b} = \text{constant}$$

**Case-II** At very low pressure

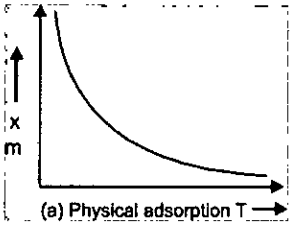
$$bp <<< 1$$

$$\therefore \quad \frac{x}{m} = ap$$

## Adsorption Isobar

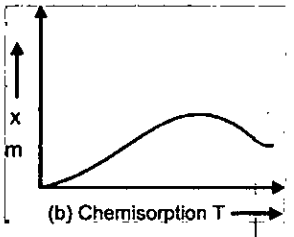
Graph between extent of the adsorption $\left(\frac{x}{m}\right)$ & pressure ($P$) at a given temperature is called adsorption isobar.

A physical adsorption isobar shows a decrease in $x/m$ as the temperature rises.




**Physical adsorption isobar**

The isobar of chemisorption shows an increase in the beginning and then decrease as the temperature rises.




**Chemical adsorption isobar**

## Application of Adsorption

- Activated charcoal is used in gas masks to remove poisonous gases such as $CH_4$, CO etc.
- Animal charcoal is used as decolorizer in manufacture of sugar.
- Silica gel is used for removing moisture and controlling humidity.
- Some industrial processes take place in the presence of catalysts which are based upon adsorption.
- Chromatographic purification of compounds which is based upon adsorption.
- The ion exchange resins used for removing hardness of water are also based upon adsorption.

## Catalyst

**1. Catalyst :** A substance which influence the rate of reaction is known as catalyst provided it remains unchanged in amount a well as in composition.

- **Positive catalyst :** The catalyst which increase the rate of chemical reaction is known as positive catalyst. Fe act as positive catalyst in following reaction.

$$N_2 + 3H_2 \xrightarrow{Fe} 2NH_3$$

- **Negative catalyst :** The catalyst which decrease the rate of chemical reaction is known as negative catalyst. $C_2H_5OH$ act as negative catalyst in following reaction.

$$CHCl_3 + O \xrightarrow{C_2H_5OH} COCl_2 + HCl$$

- **Auto catalyst :** When one of product act as catalyst then such type of catalyst is known as auto catalyst. $Mn^{2+}$ act as auto catalyst in following reactions

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

**2. Catalyst promoters :** Substance which increase the activity of catalyst is known as catalyst promoters. Mo act as catalyst promoters in following reaction.

$$N_2 + 3H_2 \xrightarrow[Mo]{Fe} 2NH_3;$$

**3. Homogenous catalytic reaction :** If catalyst is present in same phase as reactant then it is called homogenous catalytic reaction.

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

**4. Heterogenous catalytic reaction :** If catalyst is present in different phase as reactant then it is called heterogenous catalytic reaction.

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

**5. Adsorption theory of heterogenous catalyst :** The mechanism of heterogenous catalyst involves the following steps :

- Adsorption of reactant molecules on the catalyst surface.
- Occurrence of a chemical reaction through the formation of an intermediate.
- Desorption of products from the catalyst surface.
- Diffusion of products away from the catalyst surface.

## Enzyme Catalyst

Complex nitrogenous compound which are produced by living plants and animals is known as enzymes. The characteristic features of enzyme catalyst are :

- They are highly efficient.
- They are highly specific in nature.
- They are highly active under optimum temperature.
- They are highly active under optimum pH.
- There is increase in their activity in the presence of activators and coenzymes.
- They are influenced by inhibitors and poisons.

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

$$C_{12}H_{22}O_{11} + H_2O \xrightarrow{Maltase} \underset{Glucose}{2C_6H_{12}O_6}$$

$$\underset{Starch}{(C_6H_{10}O_5)_n} + nH_2O \xrightarrow{Diastase} \underset{Maltose}{C_{12}H_{22}O_{11}}$$

$$\underset{Glucose}{C_6H_{12}O_6} \xrightarrow{Zymase} 2C_2H_5OH + 2CO_2$$

## Mechanism of Enzyme Catalyst

**Step 1 :** Binding of enzyme to substrate to form an activated complex $E + S \longrightarrow ES$

**Step 2 :** Decomposition of the activated complex to form products $ES \longrightarrow E + P$

## Colloids

Depending on size of particles solution are divided into three classes In true solution

- **True solution :** Size of particles is less than 1 nm.
- **Suspension :** In suspension size of particles is greater than 1000 nm.
- **Colloidal solution :** In colloidal solution size of particles lies from 1 nm to 1000 nm.

It consists two phase *i.e.,* dispersed phase and dispersion medium.

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

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

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

## Classification of Colloids

### 1. Based on Physical State of Dispersed Phase & Dispersion Medium :

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

### 2. Based on Interaction or Affinity of Phases :

**(a) Lyophilic Colloids :** The colloidal system in which the particle of dispersed phase have great affinity for the dispersion medium, are called lyophilic

**(b) Lyophobic colloids :** The colloidal system in which the dispersed phase have no affinity for the dispersion medium are called lyophobic.

| | Property | Lyophilic sols | Lyophobic sols |
|---|---|---|---|
| 1. | Nature | Reversible | Irreversible |
| 2. | Preparation | They are prepared very easily by shaking or warming the substance with dispersion medium. | They are difficult to prepare, Special methods are used. |
| 3. | Stability | They are very stable and are not easily coagulated by electrolytes. | They are generally unstable and get easily coagulated on addition of electrolytes. |
| 4. | Charge | Particles carry no or very little charge depending upon the pH of the medium. | Colloidal particles have characteristic charge (positive or negative) |
| 5. | Viscosity | Viscosity is much higher than that of the medium. | Viscosity is nearly the same as that of the medium |
| 6. | Surface Tension | Surface tension is usually less than that of the medium. | Surface tension is nearly the same as that of the medium. |

| | | | |
|---|---|---|---|
| **7.** | Migration in electric field | The particles may or may not migrate in an electric field. | The colloidal particles migrate either towards cathode or anode in an electric field. |
| **8.** | Solvation | Particles are heavily solvated. | Particles are not solvated. |
| **9.** | Visibility | The particles can not be seen under ultra microscope. | The particles though invisible, can be seen under ultra microscope. |
| **10.** | Tyndall effect | Less distinct. | More distinct. |
| **11.** | Action of electrolyte | Large amount of electrolyte is required to cause coagulation. | Small amount of electrolyte is sufficient to cause coagulation. |
| **12.** | Examples | Mostly organic substances *e. g.*, starch, gums, proteins, gelatin etc. | Generally inorganic substance e. g., metal sols, sulphides and oxides sols. |

## 3. Based on Type of Particles of the Dispersed Phase

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

  For example, a sol. of gold contains particles of various sizes having several atoms.

- **Macromolecular colloids :** The macromolecular colloidal particles themselves are large molecules. They have very high molecular weights varying from thousands to millions. These substances are generally polymers.

  For example, starch, cellulose and proteins, polyethene, nylone etc.

- **Associated colloids :** Certain substances behave as strong electrolytes at low concentration but at higher concentrations these substances exhibit colloidal characteristics due to the formation of aggregated particles. These aggregated particles are called micelles, which are also known as associated colloids.

**Kraft Temperature :** The formation of micelles takes place only above a particular temperature called Kraft temperature.

**Critical Micelle Concentration :** Formation of micelle takes place above kraft temperature and above a particular concentration called the critical micelle concentration (CMC).

For soaps, the CMC is about $10^{-4}M$ to $10^{-3}M$.

## 4. Method of Preparation of Colloids :

- **Mechanical Dispersion :** In this method the substance is first finely powdered and a suspension is made by shaking the powdered substance with the dispersion medium. This suspension is then passed through a colloidal mill where suspension is converted into colloids. The colloidal solutions of rubber, ink, paints and varnishes are prepared by this method.
- **Electrical Dispersion (Bredig's arc method) :** In this method an electric arc is struck between two metallic rods and kept under the dispersion medium. The particles of the metal break away from the rods and disperse in the liquid. Colloidal solutions of Au, Pt, Ag, Cu and such other metals can be prepared by this method.
- **Peptization :** The process in which freshly formed precipitate converts into a sol by the addition of suitable electrolyte is known as peptization.

(a) Added electrolyte is known as peptizing agent.

(b) The peptization action is due to preferential adsorption of common ion.

**Ex.** $\underset{\text{ppt}}{AgI} + \underset{\text{Peptising agent}}{AgNO_3} \longrightarrow [AgI]\, Ag^+ : NO_3^-$

$\underset{\text{ppt}}{AgI} + \underset{\text{Peptising agent}}{KI} \longrightarrow [AgI]\, I^- : K^+$

❖ **Chemical method :**

Double decomposition : $As_2O_3 + 3H_2S \longrightarrow \underset{\text{Yellow sol}}{As_2S_3} + 3H_2O$

Oxidation : $2H_2S + SO_2 \longrightarrow 2H_2O + \underset{\text{Sol}}{3S}$

Reduction : $2AuCl_3 + 3SnCl_2 \longrightarrow 3SnCl_4 + \underset{\text{Sol}}{2Au}$

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

## 5. Purification of Colloidal Solution :

❖ **Dialysis :** The process of separating the particles of colloid from those of crystalloid, by means of diffusion through a suitable membrane is called dialysis. Its principle is based upon the fact that colloidal particles can not pass through a parchment or cellophane membrane, while the ions of the electrolyte can pass through it.

❖ **Electrodialysis :** The ordinary process of dialysis is slow. To increase the process of purification, the dialysis is carried out by applying electric field. This process is called electrodialysis. The artificial kidney machine works on the principle of dialysis.

## 6. Properties of Colloidal Solution :

### (i) Physical Properties :

❖ **Heterogeneity :** Colloidal solutions are heterogeneous in nature consisting of two phases viz, the dispersed phase and the dispersion medium.

❖ **Filterability :** Colloidal particles readily pass through ordinary filter papers. It is because the size of the pores of the filter paper is larger than that of the colloidal particles.

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

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

(i) Size and shape of colloidal particles.

(ii) Wavelength of the source of light.

(iii) Method of preparation of the colloidal solution.

(iv) Nature of the colloidal solution.

(v) The way an observer receives the light.

❖ **Stability :** Colloidal solutions are quite stable. Only a few solutions of larger particles may settle but very slowly.

**(ii) Mechanical Properties :**

- **Brownian movement :** It involves motion of colloidal particles in zig-zag paths. It is due to the moving molecules of the dispersion medium which are constantly colliding with colloidal particles.
  - (i) It is not observed in ordinary suspension.
  - (ii) It offers a visible proof of the random kinetic motion of molecules in a liquid.
  - (iii) It provides a direct demonstration of ceaseless motion of molecule as postulated by kinetic theory.
  - (iv) It provide stability to colloidal sol by not allowing them to settle down.
- **Sedimentation :** Under the influence of gravity, colloids tends to settle down very slowly. This phenomena is known as sedimentation. It can be accelerated by ultracentrifugation.

**(iii) Optical properties :**

- **Tyndall Effect :** The scattering of light by colloidal particles is known as tyndall effect.

The colloidal particles first absorb light and then a part of the absorbed light is scattered from the surface of the colloidal particles. Maximum scattered intensity is being in a plane at right angles to the plane of incident light. The path becomes visible when seen from that direction.

**(iv) Electrical properties :** Colloidal particles carry an electric charge which is equal and opposite to dispersion medium.

- **Electrophoresis :** The movement of colloidal particles towards a particular electrode in an electric field is known as electrophoresis. It provides information about the nature of the electrical charge on the colloidal particle.
- **Electro-osmosis :** When electrophoresis of dispersed particles in a colloidal system is prevented by suitable means, it is observed that the dispersion medium itself begins to move in an electric field. This phenomenon is called electro-osmosis.

**Electrical charged sols**

| | Positively charged sols | Negatively charged sols |
|---|---|---|
| 1. | Ferric hydroxide, aluminium hydroxide | Metals such as Pt, Cu, Au, Ag, $Sb_2, S_3$, CdS Metals sulphides, *e.g.*, arsenius sulphide |
| 2. | Basic dyes such as methylene blue | Starch, clay, silicic acid, gum, gelatin, charcol |
| 3. | Haemoglobin | Acid dyes, such as eosin, congo Red |

- **Electrical double layer :** The surface of a colloidal particle acquires a positive or a negative charge by selective adsorption of ions carrying +ve or –ve charges respectively. The charged layer attracts counter ions from the medium which forms a second layer. Thus, an electrical double layer is formed on the surface of the particles.

Selective positive adsorption on solid

| | | | |
|---|---|---|---|
| [AgI] $I^-$ | : | $K^+$ | |
| [AgI] $Ag^+$ | : | $NO_3^-$ | |
| $[Fe(OH)_3]$ $Fe^{3+}$ | : | $3Cl^-$ | |
| Solid | + | : | − |
| | + | : | − |
| | + | : | − |
| | + | : | − |

**Electro kinetic potential :** The potential difference between the fixed charge layer and diffused layer of opposite charge is called electro kinetic potential or zeta potential.

- **Coagulation :** The stability of the colloidal system is due to the existence of charged particles. If the charges are neutralised or destroyed, then the colloidal solution gets precipitated. This is called Coagulation or Flocculation. It can be done by
  (i) adding electrolyte
  (ii) mutual action of sols
  (iii) persistent dialysis
  (iv) By cooling
  (v) By electrophoresis

**Coagulation value :** The minimum concentration of the electrolyte required in millimoles per litre of solution to cause coagulation or flocculation is called coagulation value.

**Hardy Schulze Rule :** According to this rule the coagulating power of the active ion increases with the valency of the active ion.

**Coagulating power of cations :** $Al^{3+} > Ba^{2+}$ or $Mg^{2+} > Na^+$ or $K^+$.

**Coagulating power of anion :** $[Fe(CN)_6]^{4-} > PO_4^{3-} > SO_4^{2-} > Cl^-$

- **Isoelectric Point of Colloid :** The hydrogen ion concentration at which the colloidal particles are neither positively charged nor negatively charged (*i. e.*, uncharged) is known as isoelectric point of the colloid.
- **Protective colloids :** In presence of lyophilic colloids like starch no coagulation of lyophobic colloids takes places and lyophilic colloids act as protective colloids. Greater protecting power of a lyophilic colloid lesser would be gold number.

**Gold Number :** It is define as the minimum amount of the protective colloid in milligrams which must be added to 10 mL solution of standard gold sol, which prevents coagulation on adding one mL of 10% NaCl solution.

- **Emulsions :** An emulsion is a colloidal solution of a liquid. It may be defined as a heterogeneous system consisting of more than one immiscible liquids dispersed in one another in the form of droplets

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

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

## Distinction between Two Types of Emulsions

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

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

**Preparation of emulsion (Emulsification) :** Emulsification is the process which involves the preparation of emulsion. Generally, an emulsion is prepared by subjecting a mixture of the immiscible liquid to a distinct layers upon standing. This substance which stabilizes the emulsion is called emulsifier or emulsifying agent. The commonly used emulsifying agents are soaps, detergents and lyophilic colloids. Casein.

**Function of emulsifier :** The main function of emulsifier or emulsifying agents is to lower the interfacial tension between oil and water and thus helps the intermixing of two liquids.

**Demulsification :** The process which involves the breaking of an emulsion into two separate liquid layers is called demulsification.

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

When the gels are allowed to stand for a long time, they give out small quantities of trapped liquids with accumulate on its surface. This action of gels is known as Synresis or Weeping.

- **Uses of Colloids**
  - (i) Medicines
  - (ii) Dyes
  - (iii) Rubber industry
  - (iv) Formation of delta
  - (v) Purification of water
  - (vi) Artificial rain
  - (vii) Smoke precipitation
  - (viii) Sewage disposal
  - (ix) Cleansing action of soap and detergent
  - (x) In Photography

# Level 1

1. The size of particles in suspension, true solution and colloidal solution varies in the order :
   (a) suspension > colloidal > true solution
   (b) true solution > suspension > colloidal
   (c) suspension > colloidal = true solution
   (d) none of these
2. A colloidal system has what size of particles?
   (a) $10^{-4}$ m to $10^{-10}$ m
   (b) $10^{-5}$ m to $10^{-7}$ m
   (c) $10^{-9}$ m to $10^{-12}$ m
   (d) $10^{-6}$ m to $10^{-9}$ m
3. Which are not purely surface phenomena?
   (a) Adsorption, surface tension
   (b) Surface tension, viscosity
   (c) Adsorption, viscosity
   (d) Absorption, viscosity
4. Adsorbed acetic acid on activated carbon is :
   (a) adsorber
   (b) absorber
   (c) adsorbent
   (d) adsorbate
5. Adsorption due to strong chemical forces is called :
   (a) Chemisorption
   (b) Physisorption
   (c) Both (a) and (b)
   (d) None of these
6. Adsorption of gases on solid surface is exothermic because :
   (a) free energy increases
   (b) entropy decreases
   (c) entropy increases
   (d) interaction developed between gas and solid particles
7. The nature of bonding forces in adsorption are :
   (a) purely physical such as van der Waals' forces
   (b) purely chemical
   (c) both chemical and physical are possible
   (d) none of these
8. Which one of the following is not applicable to chemisorption?
   (a) Heat of adsorption is negative
   (b) It takes place at high temperature
   (c) It is reversible
   (d) It forms mono-molecular layer
9. Which one of the following characteristics is correct for physical adsorption?
   (a) It is very specific
   (b) Adsorption on solids is irreversible
   (c) Adsorption decreases with decrease in temperature
   (d) Generally both enthalpy and entropy of adsorption are negative
10. Which of the following statement is not correct?
    (a) Physical adsorption is due to vander Waals' forces
    (b) Physical adsorption is irreversible

(c) Chemical adsorption increases with increase in temperature upto certain limit than decreases

(d) Enthalpy of adsorption ($|\Delta H|$) for a chemical adsorption is greater than that of physical adsorption

**11.** Which gas will be adsorbed on a solid to greater extent?

(a) Having non-polar molecule

(b) Having highest critical temperature

(c) Having lowest critical temperature

(d) Having lowest critical pressure

**12.** Which of the following factors affects the adsorption of a gas on solid?

(a) Critical temperature ($T_c$) (b) Temperature of gas

(c) Pressure of gas (d) All of these

**13.** Which gas is adsorbed to maximum amount by activated carbon?

(a) $H_2(g)$ (b) He(g) (c) CO(g) (d) $CO_2(g)$

**14.** The volume of gases $NH_3$, $CO_2$ and $H_2$ adsorbed by one gram of charcoal at 300 K are in order of:

(a) $H_2 > CO_2 > NH_3$ (b) $NH_3 > H_2 > CO_2$

(c) $NH_3 > CO_2 > H_2$ (d) $CO_2 > NH_3 > H_2$

**15.** Which of the following is used to adsorb water?

(a) Silica gel (b) Calcium acetate

(c) Hair gel (d) Anhydrous $CaCl_2$

**16.** Absorption and adsorptions are respectively:

(a) surface phenomena, bulk phenomena

(b) bulk phenomena, surface phenomena

(c) both are bulk phenomena

(d) both are surface phenomena

**17.** Adsorption is multilayer in case of:

(a) physical adsorption (b) chemisorption

(c) both (a) and (b) (d) none of these

**18.** Reversible adsorption is:

(a) chemical adsorptioin (b) physical adsorption

(c) both (a) and (b) (d) none of these

**19.** The effect of pressure on adsorption is high if:

(a) temperature is low (b) temperature is high

(c) temperature is very high (d) larger charcoal piece is taken

**20.** Sorption is the phenomenon:

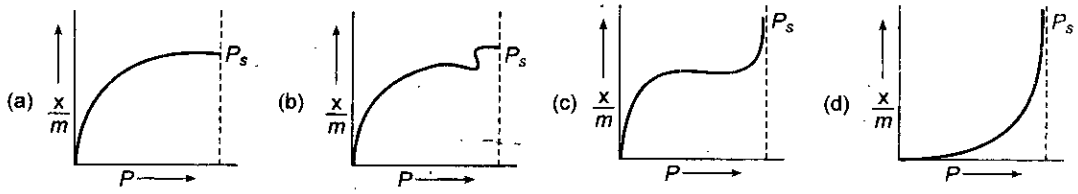
(a) reverse of adsorption

(b) reverse of absorption

(c) when adsorption and absorption takes place simultaneously

(d) none of these

**21.** Which of the following adsorption isotherms represents the adsorption of a gas by a solid involving multilayers of layers? ($P_s$ = saturation pressure)




**22.** A plot of $\log\left(\frac{x}{M}\right)$ against $\log P$ for the adsorption of a gas on a solid gives a straight line with slope equal to:

(a) $\frac{1}{n}$ (b) $n$ (c) $\log K$ (d) K

**23.** The heat evolved in chemisorption lies in the range (in kJ/mol) of :

(a) 80 to 240 (b) 20 to 40

(c) 40 to 80 (d) 20 to 100

**24.** The heat evolved in physisorption lies in the range (in kJ/mol) of :

(a) 20–40 (b) 40–100

(c) 100–200 (d) 200–400

**25.** According to the adsorption theory of catalysis, the speed of the reaction increases because :

(a) in the process of adsorption, the activation energy of the molecules becomes large

(b) adsorption produces heat which increases the speed of the reaction

(c) adsorption lowers the activation energy of the reaction

(d) adsorption increases the activation energy of the reaction

**26.** 3.6 gram of oxygen is adsorbed on 1.2 g of metal powder. What volume of oxygen adsorbed per gram of the adsorbent at 1 atm and 273 K?

(A) $0.19\,L\,g^{-1}$ (b) $1\,L\,g^{-1}$

(C) $2.1\,L\,g^{-1}$ (d) None of these

**27.** A catalytic poison renders the catalyst ineffective because:

(a) It is preferentially adsorbed on the catalyst

(b) It adsorbs the molecules of the reactants

(c) It combines chemically with the catalyst

(d) It combines chemically with one of the reactants

**28.** The catalyst used in the hydrogenation of oils is:

(a) Fe (b) Ni (c) Pt (d) $V_2O_5$

**29.** The function of zymase is to:

(a) Change starch into sugar

(b) Ferment glucose to alcohol and $CO_2$

(c) Change malt sugar into glucose

(d) Change starch into malt sugar and dextrin

**30.** The conversion of maltose to glucose is possible by the enzyme:

(a) Zymase (b) Lactase

(c) Maltase (d) Diastase

**31.** Shape selective catalysis is a reaction catalysed by:

(a) Enzymes (b) Ziegler-Natta Catalyst

(c) Zeolites (d) Platinum

**32.** The process which is catalysed by one of the product is called:
(a) acid-base catalysis (b) autocatalysis
(c) negative catalysis (d) homogeneous catalysis

**33.** An inhibitor is essentially:
(a) a negative catalyst (b) a heterogeneous catalyst
(c) an auto catalyst (d) a homogeneous catalyst

**34.** A catalyst in the finely divided form is most effective because:
(a) less surface area is available
(b) more active sites are formed
(c) more energy gets stored in the catalyst
(d) none of these

**35.** Identify the correct statement regarding enzymes:
(a) Enzymes are specific biological catalysts that normally works at high temperature
(b) Enzymes are normally heterogeneous catalysts decreases reaction rate
(c) Enzymes are specific biological catalysts with low molar masses
(d) Enzymes are specific biological catalysts that are very specific in nature

**36.** A liquid leaves no residue when passed through the ultra-filter paper. The liquid is:
(a) a suspension (b) oil (c) a colloidal sol (d) a true solution

**37.** Crystalloids differ from colloids mainly in respect of :
(a) Electrical behaviour (b) Particle nature
(c) Particle size (d) Solubility

**38.** Surface tension of lyophilic sols is:
(a) lower than water (b) more than water
(c) equal to water (d) none of these

**39.** Which one of the following is not used for preparing lyophilic sols?
(a) Starch (b) Gum
(c) Gelatin (d) Metal sulphide

**40.** Which one of the sols acts as protective colloid?
(a) $As_2S_3$ (b) Gelatin (c) Au (d) $Fe(OH)_3$

**41.** Which one of the following is lyophilic colloid?
(a) Pt (b) Gum (c) Fog (d) Blood

**42.** Small liquid droplets dispersed in another liquid is called:
(a) suspension (b) emulsion
(c) gel (d) true solution

**43.** Which of the following is an example of associated colloid?
(a) Protein in water (b) Soap in water
(c) Rubber in benzene (d) $FeCl_3$ in $H_2O$

**44.** Select the properties which are for lyophilic colloidal sols:
(a) viscosity same as that of the medium
(b) extensive hydration takes place
(c) particles migrate either towards cathode or anode in an electric field
(d) particle cannot be detected even under ultramicroscope

**45.** Fog is an example of colloidal system of:
(a) liquid in a gas (b) gas in a liquid
(c) gas in a solid (d) solid in a liquid

**46.** Colloidal solutions are not classified on the basis of :
(a) molecular size
(b) nature of the particles
(c) surface tension value
(d) interaction between disperse phase and dispersion medium

**47.** All colloids:
(a) are suspensions of one phase in another
(b) are two-phase systems
(c) contain only water-soluble particles
(d) are true solutions

**48.** Which of the following is a lyophobic colloid?
(a) Gelatin (b) Sulphur
(c) Starch (d) Gum arabic

**49.** Which of the following is not a gel?
(a) Cheese (b) Jellies (c) Curd (d) Milk

**50.** Cleaning action of soap occurs because:
(a) non-polar tails of soap molecules dissolve in grease
(b) oil and grease dissolved into hydrophilic centres of soap micelles acid washed away
(c) hydrophilic head dissolve in grease
(d) grease dissolve in soap solution

**51.** Arsenous sulphide sol is prepared by passing $H_2S$ through arsenous oxide solution. The charge developed on the particles is due to adsorption of:
(a) $H^+$ (b) $S^{2-}$ (c) $OH^-$ (d) $O^{2-}$

**52.** Bredig's arc method cannot be used for the preparation of colloidal sol of :
(a) copper (b) gold (c) silver (d) sodium

**53.** $As_2S_3$ sol is:
(a) positive colloid (b) negative colloid
(c) neutral colloid (d) none of the above

**54.** Which of the following electrolyte will be most effective in coagulation of negative sol ?
(A) $KNO_3$ (b) $K_4[Fe(CN)_6]$
(C) $Na_3PO_4$ (d) $MgCl_2$

**55.** The minimum amount of an electrolyte required to cause coagulation of a sol is called :
(a) Coagulation value (b) Gold number
(c) Protective value (d) None of these

**56.** The electrical charge on a colloidal particle is indicated by:
(a) Brownian movement (b) electrophoresis
(c) ultramicroscope (d) molecular sieves

**57.** Colloidal particles in a sol can be coagulated by :
(a) heating (b) adding an electrolyte
(c) adding oppositely charged sol (d) any of the above methods

**58.** Peptization involves:
(a) precipitation of colloidal particles
(b) disintegration of colloidal aggregates
(c) purification of colloids
(d) impact of molecules of the dispersion medium on the colloidal particles

**59.** Hardy-Schulze law states that:
(a) solution must have higher gold number
(b) disperse phase and dispersion medium must be of the same sign
(c) micelles coagulate in presence of surfactants
(d) the ions carrying more opposite charge to that of sol particle are effective in coagulation

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

**61.** The ability of an ion to bring about coagulation of a given colloid depends upon:
(a) its size
(b) the magnitude of its charge only
(c) the sign of its charge alone
(d) both magnitude and sign of its charge

**62.** An emulsifying agent is a substance which?
(a) Stabilizes the emulsion
(b) De-stabilizes the emulsion
(c) Coagulates the emulsion
(d) Break the interfacial film between suspended particle and medium

**63.** Colloidal solution of gold is prepared by:
(a) colloidal mill
(b) double decomposition method
(c) Bredig's method
(d) peptization

**64.** The formation of colloid from suspension is:
(a) peptisation (b) condensation
(c) sedimentation (d) fragmentation

**65.** The method usually employed for the destruction of a colloidal solution is:
(a) dialysis (b) addition of electrolytes
(c) diffusion through animal membrane (d) condensation

**66.** Which of the following has minimum flocculation value for positively charged sol?
(A) $Cl^-$ (b) $SO_4^{2-}$
(C) $PO_4^{3-}$ (d) $[Fe(CN)_6]^{4-}$

**67.** Which of the following will have the highest coagulating power for $Fe(OH)_3$ colloid?
(a) $PO_4^{3-}$ (b) $SO_4^{2-}$ (c) $Ca^{2+}$ (d) $Al^{3+}$

**68.** Artifical rain is caused by spraying:
(a) Opposite charged collidal dust over a cloud
(b) Same charged collidal dust over a cloud
(c) Both
(d) None of these

**69.** Colloids can be purified by :
(a) condensation (b) peptization
(c) coagulation (d) dialysis

**70.** Dialysis can seperate, which of the following in addition to the glucose from the human blood?
(a) Sucrose (b) Fructose
(c) Alcohol (d) Proteins

**71.** Protective sols are:
(a) lyophilic (b) lyophobic
(c) both (a) and (b) (d) none of these

**72.** Electro-osmosis is observed when:
(a) dispersion medium particles begins to move in an electric field
(b) dispersed phase begins to move in an electric field
(c) both (a) and (b)
(d) none of the above

**73.** On adding $AgNO_3$ solution into KI solution, a negatively charged colloidal sol is obtained when they are in:
(a) 50 mL of 0.1 *M* $AgNO_3$ + 50 mL of 0.1 *M* KI
(b) 50 mL of 0.1 *M* $AgNO_3$ + 50 mL of 0.2 *M* KI
(c) 50 mL of 0.2 *M* $AgNO_3$ + 50 mL of 0.1 *M* KI
(d) None of these

**74.** A sol is prepared by addition of excess of $AgNO_3$ solution in KI solution. The charge likely to develop on colloidal particles is:
(a) positive (b) negative
(c) no charge (d) both charges

**75.** The gold numbers of protective colloids *A, B, C* and *D* are 0.04, 0.004, 10 and 40 respectively. The protective powers of *A, B, C* and *D* are in the order:
(A) $A > B > C > D$ (b) $B > A > C > D$
(C) $D > C > A > B$ (d) $D > C > B > A$

**76.** In Brownian motion, the paths of the particles are:
(a) linear (b) curved
(c) zig-zag (d) uncertain

**77.** Which one of the following is not represented by sols?
(a) Adsorption (b) Tyndall effect
(c) Flocculation (d) Paramagnetism

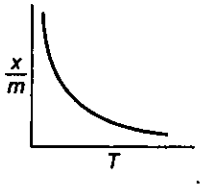
**78.** The Tyndall effect associated with colloidal particles is due to:
(a) presence of electrical charges (b) scattering of light
(c) absorption of light (d) reflection of light

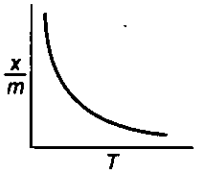
**79.** Blue colour of the sky is due to:
(a) absorption of light by dust particles (b) reflection of light by dust particles
(c) scattering of light by dust particles (d) presence of clouds

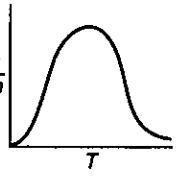
**80.** The apparatus used to coagulate carbon particles from smoke is called:
(a) cottrel smoker (b) cottrell precipitator
(c) cottrell absorber (d) none of these

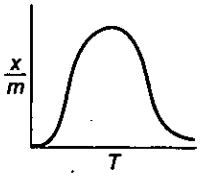
# Level 2

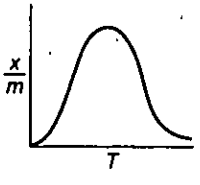
**1.** Select correct adsorption isobars for chemisorption and physisorption respectively :
(where $\frac{x}{m}$ = extent of adsorption, $T$ = temperature)

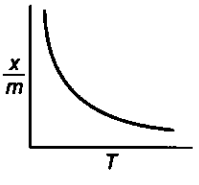
(a) 

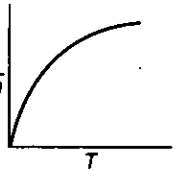


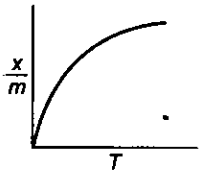

(b) 




(c) 




(d) 




**2.** Which among the following statements is false?
(a) Increase of pressure increases the amount of adsorption
(b) Increase of temperature may decrease the amount of adsorption
(c) Adsorption may be monolayered or multilayered
(d) Particle size of the adsorbent will not affect the amount of adsorption

**3.** Select incorrect statement;
(a) Lyophilic sols are reversible
(b) Lyophilic sols are self stabilized
(c) Lyophobic sols are obtained from inorganic materials
(d) Lyophobic sols particles are hydrated

**4.** Which one of the following statements is not correct in respect of lyophilic sols?
(a) There is a considerable interaction between the dispersed phase and dispersion medium
(b) These are quite stable and are not easily coagulated
(c) They carry charge
(d) The *particles* are hydrated

**5.** Alums purify muddy water by:
(a) dialysis (b) absorption (c) coagulation (d) ultrafiltration

**6.** Lyophilic sols are more stable than lyophobic sols 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 repulsion between the colloidal particles

**7.** Arrange the following electrolytes in the increasing order of coagulation power for the coagulation of $As_2S_3$ sol:

| $K_2SO_4$ | $CaCl_2$ | $Na_3PO_4$ | $AlCl_3$ |
|---|---|---|---|
| (I) | (II) | (III) | (IV) |

(a) I < II < III < IV (b) I = III < II < IV
(c) II < IV < I < II (d) II < III < IV < I

**8.** Equal volume each of two sols of AgI, one obtained by adding $AgNO_3$ to slight excess of KI and another obtained by adding KI to slight excess of $AgNO_3$, are mixed together. Then:
(a) the two sols will stabilize each other
(b) the sol particles will acquire more electric charge
(c) the sols will coagulate each other mutually
(d) a true solution will be obtained

**9.** Which of the following statements is not true about the oil-in-water type emulsion?
(a) Addition of small amount of water, no separate layer of water is formed
(b) Addition of a small amount of oil soluble dye renders the entire emulsion coloured
(c) Addition of oil results in the formation of two layers
(d) Addition of a small amount of an electrolyte increases the conductivity of the emulsion

**10.** Under the influence of an electric field, the particles in a sol migrate towards cathode. The coagulation of the same sol is studied using NaCl, $Na_2SO_4$ and $Na_3PO_4$ solutions. Their coagulating values will be in maximum for:
(a) NaCl (b) $Na_2SO_4$ (c) $Na_3PO_4$ (d) same for all

**11.** Select incorrect statement:
(a) Micelles are macromolecular colloids
(b) The electrical charge on a colloid particle is indicated by electrophoresis
(c) Formation of micelles takes place above kraft temperature
(d) Formation of micelles takes place below CMC

**12.** Bredig's arc method involves:
(a) dispersion of metal (b) condensation of metal
(c) dispersion as well as condensation (d) neither dispersion nor condensation

**13.** A freshly prepared $Fe(OH)_3$ precipitate is peptized by adding $FeCl_3$ solution. The charge on the colloidal particle is due to preferential adsorption of:
(a) $Cl^-$ ions (b) $Fe^{3+}$ ions (c) $OH^-$ ions (d) none of these

**14.** Select incorrect statement :
(a) Gold sol is multimolecular colloid
(b) Large number of atoms of a substance aggregate together and formed multimolecular colloids
(c) Metal sulphides are lyophobic colloids
(d) Sulphur sol is multimolecular colloid and hydrophilic in nature

**15.** Associated colloids :
(a) raise both the surface tension and viscosity of water
(b) lower both the surface tension and viscosity of water
(c) lower the surface tension and raise the viscosity of water
(d) have greater concentration at the surface layer than the bulk of the solution

**16.** Below critical micelle concentration (CMC):
(a) the surfactant molecules of ions undergo association to form clusters
(b) the viscosity of solution increases abruptly
(c) substances like grease, fat, etc. dissolve colloidally
(d) salt behave as normal, strong electrolyte

**17.** During electro-osmosis of $Fe(OH)_3$ sol:
(a) sol particles move towards anode
(b) sol particles move towards cathode
(c) the dispersion medium moves towards anode
(d) the dispersion medium moves towards cathode

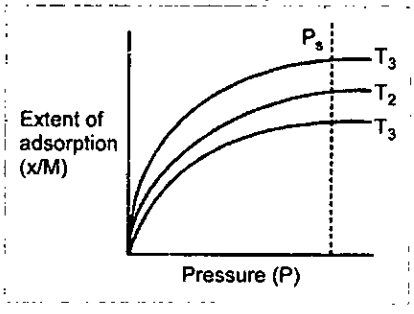
**18.** Select incorrect statement:
(a) Soap and detergent lower the interfacial surface tension between oil and water
(b) Basic principle of peptization is reverse of coagulation
(c) Soap and detergent used as emulsifiers
(d) Lyophilic sols need stabilizing agent

**19.** Smoke precipitator works on the principle of :
(a) centrifugation (b) neutralization of charge on colloids
(c) absorption (d) addition of electrolytes

**20.** What is the correct sequence of the increasing coagulation value of the following electrolyte for the coagulation of ferric hydroxide solution?
(I) $Na_3PO_4$ (II) KCl (III) $K_2SO_4$ (IV) $K_4[Fe(CN)_6]$
(a) IV > I > III > II (b) II > III > I > IV (c) I > II > III > IV (d) IV > III > II > I

**21.** Which of the following is true in respect of chemical adsorption?
(a) $\Delta H < 0, \Delta S > 0, \Delta G > 0$ (b) $\Delta H < 0, \Delta S < 0, \Delta G < 0$
(c) $\Delta H > 0, \Delta S > 0, \Delta G < 0$ (d) $\Delta H > 0, \Delta S < 0, \Delta G > 0$

**22.** For the graph below, select correct order of temperature?




(a) $T_1 > T_2 > T_3$ (b) $T_2 > T_3 > T_1$ (c) $T_3 > T_2 > T_1$ (d) $T_1 = T_2 = T_3$

**23.** Although, nitrogen does not adsorb on a surface at room temperature, it adsorbs on the surface at 83 K. Which one of the following statements is correct ?
(a) At 83 K, there is formation of monolayer
(b) At 83 K, nitrogen is adsorbed as atoms
(c) At 83 K, nitrogen molecules are held by chemical bonds
(d) At 83 K, there is formation of multimolecular layers

**24.** For the coagulation of 50 ml of ferric hydroxide sol. 10 ml of 0.5 M KCl is required. What is the coagulation value of KCl?
(a) 5 (b) 10 (c) 100 (d) None of these

**25.** 100 mL of 0.6 *M* acetic acid is shaken with 2 g activated carbon. The final concentration of the solution after adsorption is 0.5 *M*. What is the amount of acetic acid adsorbed per gram of carbon?
(a) 0.6 g (b) 0.3 g (c) 1.2 g (d) None of these

∴ No. of absorbed molecules of

$$H_2 = 3 \times 10^{-6} \times 6 \times 10^{23}$$

$\Rightarrow \quad 18 \times 10^{17}$

Total no. of surface sites available

$$= 5.4 \times 10^{16} \times 1000$$

$\Rightarrow \quad 5.4 \times 10^{19}\ cm^2$

No. of surface sites that is occupied by adsorption of

$$H_2 = \frac{10}{100} \times 5.4 \times 10^{19}$$

$\Rightarrow \quad 5.4 \times 10^{18}$

No. of surface sites occupied by one molecule

$$H_2 = \frac{5.4 \times 10^{18}}{18 \times 10^{17}} = 3$$

**30.** (b) Final volume of gas, at 608 torr pressure

$$V_2 = \frac{P_1 V_1}{P_2}$$

$$= \frac{760 \times 1}{608}$$

$\Rightarrow \quad 1.25$ or $V_2 = 1250$ mL

Volume occupied by gas = Volume of vessel – Volume occupied by charcoal

$$= 1000 - \frac{16}{1.6} = 990 \text{ mL}$$

Difference of volume is due to adsorption of gas by charcoal.

∴ Volume of gas adsorbed by charcoal

$= 1250 - 990$

$\Rightarrow 260$ mL

Volume of the gas adsorbed per gram of charcoal

$$= \frac{260}{16} = 16.25 \text{ mL/g at 608 torr and } 27°C.$$

# Hints and Solutions

## Level 1

**26.** (c) Mass of $O_2$ per gram of adsorbent $= \frac{3.6}{1.2} = 3$

No. of moles of $O_2$ per gram of adsorbent

$$= \frac{3}{32}$$

Volume of $O_2$ per gram of adsorbent

$$= \frac{3}{32} \times \frac{0.0821 \times 273}{1}$$

$$= 2.10$$

**67.** (a) $Fe(OH)_3$ is a positive sol. Hence, greater the charge on cation, more is the coagulation power.

**75.** (b) Smaller is the 'gold number' of protective colloid, greater is its protective power.

## Level 2

**8.** (c) The sols obtained in the two cases will be oppositely charged so coagulate each other.

**10.** (a) The sol particles migrate towards cathode. So they are positively charged. Hence, anions would be effective in coagulation. Greater is the valence of effective ion, smaller will be its coagulating value.

**17.** (c) In electro-osmosis, the sol particles are prevented from migration whereas the dispersion medium migrates in the direction opposite to those of particles. Here, the medium is negatively charged.

**24.** (c) Coagulation value

$$= \frac{\text{Number of millimoles of electrolyte required}}{\text{Volume of colloidal solution (in litre)}}$$

$$= \frac{10 \times 0.5}{50} \times 1000 = 100$$

**25.** (b) Mass of acetic acid adsorbed by 2 g charcoal

$$= 100 \times 10^{-3} \times (0.6 - 0.5) \times 60$$

$$\Rightarrow \quad 0.6;\ \frac{x}{m} = \frac{0.6}{2} \Rightarrow 0.3$$

**26.** (c) No. of sodium lauryl sulphate $(CH_3(CH_2)_{11}SO_4^-Na^+)$ in 1 litre solution

$$= 10^{-3} \times 6 \times 10^{23}$$

$$= 6 \times 10^{20}$$

No. of sodium lauryl sulphate per $mm^3 = 6 \times 10^{14}$

No. of colloidal particles per $mm^3 = 10^{13}$

No. of molecular per colloidal particle

$$= \frac{6 \times 10^{14}}{10^{13}}$$

$$= 60$$

**27.** (a) Total surface area of carbon $= \frac{44}{7} \times 10^7\ cm^2$

$r = 10^{-8}$ cm

Surface area of $NH_3 = \pi r^2$

$$= \frac{22}{7} \times 10^{-16}\ cm^2$$

$$\text{No. of } NH_3 \text{ molecules adsorbed} = \frac{\frac{44}{7} \times 10^7}{\frac{22}{7} \times 10^{-16}}$$

$$= 2 \times 10^{23}$$

$$\text{Vol. of } NH_3 \text{ adsorbed at STP} = \frac{2 \times 10^{23}}{6 \times 10^{23}} \times 22.4$$

$$= 7.46\ L$$

**28.** (a) No. of molecules per gram of $N_2$ in monolayer

$$= \frac{6 \times 10^{23}}{22{,}400} \times 1.30$$

$$= 3.48 \times 10^{19}$$

Cross-sectional area of a molecule

$$= 1.6 \times 10^{-19}\ m^2$$

$\therefore$ Area covered by molecules per gram

$= 3.48 \times 10^{19} \times 1.6 \times 10^{-19} = 5.568\ m^2$

$\therefore$ Surface area $= 5.568\ m^2 g^{-1}$

**29.** (c) Adsorbed moles of $H_2 = \frac{0.03 \times 2.46 \times 10^{-3}}{0.0821 \times 300}$

$$= 3 \times 10^{-6}$$

## One or More Answers is/are Correct

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.** | (b,d) | **2.** | (b,c,d) | **3.** | (a,c) | **4.** | (a,b,c) | **5.** | (a,c) | **6.** | (b,c,d) | **7.** | (a,b) | **8.** | (b,c) |
| **9.** | (a,b) | **10.** | (a,b) | **11.** | (a,b,c,d) | **12.** | (a,b) | **13.** | (a,b,d) | **14.** | (a,b,c) | **15.** | (a,b,c,d) | **16.** | (b,c) |
| **17.** | (b,c) | **18.** | (b,c) | **19.** | (c) | **20.** | (a,d) | **21.** | (b,c,d) | **22.** | (a,c) | **23.** | (a,c) | **24.** | (a,b,c,d) |
| **25.** | (a,b,c,d) | | | | | | | | | | | | | | |

## Match the Column

| | | | | |
|---|---|---|---|---|
| **1.** | A→ P, S ; | B→ P ; | C→ Q, R ; | D→ Q |
| **2.** | A→ Q ; | B→ P ; | C→ R ; | D→ S |
| **3.** | A→ Q ; | B→ P ; | C→ R ; | D→ S |
| **4.** | A→ R ; | B→ P ; | C→ S ; | D→ Q |
| **5.** | A→ P, R ; | B→ P, R ; | C→ Q ; | D→ S |
| **6.** | A→ R ; | B→ P ; | C→ Q ; | D→ S |
| **7.** | A→ P ; | B→ Q; | C→ Q, S ; | D→ P, R |

## Assertion-Reason Type Questions

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.** | (A) | **2.** | (A) | **3.** | (B) | **4.** | (D) | **5.** | (B) | **6.** | (D) | **7.** | (A) | **8.** | (B) | **9.** | (A) | **10.** | (C) |
| **11.** | (D) | **12.** | (A) | **13.** | (A) | **14.** | (A) | **15.** | (A) | **16.** | (B) | **17.** | (B) | **18.** | (A) | **19.** | (A) | **20.** | (B) |
| **21.** | (A) | **22.** | (B) | **23.** | (C) | **24.** | (A) | **25.** | (B) | | | | | | | | | | |

## Subjective Problems

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1.** | 8 | **2.** | 3 | **3.** | 2 | **4.** | 1 | **5.** | 4 |

# ANSWERS

## Level 1

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1. (a) | 2. (d) | 3. (d) | 4. (d) | 5. (a) | 6. (d) | 7. (c) | 8. (c) | 9. (d) | 10. (b) |
| 11. (b) | 12. (d) | 13. (d) | 14. (c) | 15. (a) | 16. (b) | 17. (a) | 18. (b) | 19. (a) | 20. (c) |
| 21. (a) | 22. (a) | 23. (a) | 24. (a) | 25. (c) | 26. (c) | 27. (a) | 28. (b) | 29. (b) | 30. (c) |
| 31. (c) | 32. (b) | 33. (a) | 34. (b) | 35. (d) | 36. (d) | 37. (c) | 38. (a) | 39. (d) | 40. (b) |
| 41. (b) | 42. (b) | 43. (b) | 44. (b) | 45. (a) | 46. (c) | 47. (b) | 48. (b) | 49. (d) | 50. (a) |
| 51. (b) | 52. (d) | 53. (b) | 54. (d) | 55. (a) | 56. (b) | 57. (d) | 58. (b) | 59. (d) | 60. (c) |
| 61. (d) | 62. (a) | 63. (c) | 64. (a) | 65. (b) | 66. (d) | 67. (a) | 68. (a) | 69. (d) | 70. (a) |
| 71. (a) | 72. (a) | 73. (b) | 74. (a) | 75. (b) | 76. (c) | 77. (d) | 78. (b) | 79. (c) | 80. (b) |

## Level 2

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1. (c ) | 2. (d) | 3. (d) | 4. (c) | 5. (c) | 6. (c) | 7. (b) | 8. (c) | 9. (b) | 10. (a) |
| 11. (d) | 12. (c) | 13. (b) | 14. (d) | 15. (c) | 16. (d) | 17. (c) | 18. (d) | 19. (b) | 20. (b) |
| 21. (b) | 22. (a) | 23. (d) | 24. (c) | 25. (b) | 26. (c) | 27. (a) | 28. (a) | 29. (c) | 30. (b) |

## Level 3

| | | | | |
|---|---|---|---|---|
| **Passage–1** | 1. (b) | 2. (c) | 3. (b) | |
| **Passage–2** | 1. (d) | 2. (b,d) | 3. (a) | |
| **Passage–3** | 1. (d) | 2. (c) | 3. (c) | 4. (d) |
| **Passage–4** | 1. (c) | 2. (d) | | |

25. **STATEMENT-1 :** Gold sol is multimolecular and hydrophobic in nature.
**STATEMENT-2 :** Gold sol is prepared by Bredig's arc method.

## SUBJECTIVE PROBLEMS

1. How many colloidal systems exist in nature ?
2. How many colloidal systems exist in nature in which liquid is dispersed phase ?
3. How many colloidal systems exist in nature in which gas is dispersed phase ?
4. What is the minimum diameter (in nm) of colloidal particles ?
5. For soaps critical micelle concentration (CMC) is $10^{-x}$ (min.) to $10^{-y}$ (max.) mol/L. What is the value of $x$ ?

**11.** **STATEMENT-1 :** When $SnO_2$ is reacted with NaOH, then its sol particles are attracted towards cathode.

**STATEMENT-2 :** When $SnO_2$ is reacted with NaOH, then it gives $SnO_3^{2-}$ which is adsorbed by $SnO_2$, so it is negatively charged sol.

**12.** **STATEMENT-1 :** For coagulation of positively charged sols, $[Fe(CN)_6]^{4-}$ ion has higher coagulating power than that of $PO_4^{3-}$, $SO_4^{2-}$, $Cl^-$.

**STATEMENT-2 :** Because according to Hardy Schulze rule, higher is the valency of ions for the oppositely charged sol particles, better will be the precipitation.

**13.** **STATEMENT-1 :** Dispersed phase particles of colloidal solution cannot pass through ultra-filter paper.

**STATEMENT-2 :** The size of colloidal particles are larger than the size of true solution particles.

**14.** **STATEMENT-1 :** When a finely divided active carbon is stirred into a dilute solution of a dye, the intensity of colour in the solution is decreased.

**STATEMENT-2 :** The dye is adsorbed on the solid surface.

**15.** **STATEMENT-1 :** Silica gel is used for drying air.

**STATEMENT-2 :** Silica gel adsorbs moisture from air.

**16.** **STATEMENT-1 :** ZSM-5 is a type of zeolites used as a catalyst in petrochemical industries.

**STATEMENT-2 :** Zeolites are microporous aluminosilicates three dimensional network silicates in which some silicon atoms are replaced by aluminium atoms.

**17.** **STATEMENT-1 :** Lyophilic colloids are called as reversible sols.

**STATEMENT-2 :** Lyophilic sols are extensively hydrated.

**18.** **STATEMENT-1 :** A catalyst is more effective in finely divided form.

**STATEMENT-2 :** Finely divided form has more surface area.

**19.** **STATEMENT-1 :** Sky appears blue in colour.

**STATEMENT-2 :** Colloidal particles of dust along with water suspended in air scatter blue light.

**20.** **STATEMENT-1 :** The conversion of fresh precipitate to colloidal state is called peptization.

**STATEMENT-2 :** It is caused by addition of common ions.

**21.** **STATEMENT-1 :** Colloidal solutions are stable but colloidal particles do not settle down.

**STATEMENT-2 :** Brownian movement counters the force of gravity act on colloidal particles.

**22.** **STATEMENT-1 :** A colloid gets coagulated by addition of an electrolyte.

**STATEMENT-2 :** Coagulation depends on the valance and sign of the charge of the coagulant ion.

**23.** **STATEMENT-1 :** Suspensions are visible to naked eye.

**STATEMENT-1 :** Size of suspension particles are smaller than collidal particles.

**24.** **STATEMENT-1 :** At pH of isoelectric point, the sol particles of amino acids neither move towards anode nor towards cathode.

**STATEMENT-2 :** Because at the isoelectric point, the concentration of conjugate base and conjugate acid of the Zwitter ions becomes equal and so one's charge is counterbalanced by other.

## ASSERTION-REASON TYPE QUESTIONS

Each questions contains STATEMENT-1 (Assertion) and STATEMENT-2 (Reason).

Examine the statement carefully and mark the correct answer according to the instructions given below:

(A) If both the statement are TRUE and STATEMENT-2 is the correct explanation of STATEMENT-1

(B) If both the statements are TRUE and STATEMENT-2 is NOT the correct explanation of STATEMENT-1

(C) If STATEMENT-1 is TRUE and STATEMENT-2 is FALSE

(D) If STATEMENT-1 is FALSE and STATEMENT-2 is TRUE

1. **STATEMENT-1 :** For adsorption $\Delta G$, $\Delta H$, $\Delta S$ all have –ve values.
   **STATEMENT-2 :** Adsorption is a exothermic process in which randomness decreases due to force of attraction between adsorbent and adsorbate.
2. **STATEMENT-1 :** The extent of adsorption of $CO_2$ is much more higher than of $H_2$.
   **STATEMENT-2 :** $CO_2(g)$ has higher critical temperature and more van der Waals' force of attraction as compare to $H_2(g)$.
3. **STATEMENT-1 :** In absorption, the molecules of a substance are uniformly distributed throughout the body of other substance.
   **STATEMENT-2 :** In some cases, both absorption and adsorption takes place simultaneously.
4. **STATEMENT-1 :** More heat evolved in physisorption than in chemisorption.
   **STATEMENT-2 :** Molecules of adsorbate and adsorbent are held by van der Waals' forces in physisorption and by chemical bonds in chemisorption.
5. **STATEMENT-1 :** Colloidal solution is electrically neutral.
   **STATEMENT-2 :** Due to similar nature of the charge carried by the particles, they repel each other and do not combine to form bigger particles.
6. **STATEMENT-1 :** Soap and detergent are macro-molecular colloids.
   **STATEMENT-2 :** Soap and detergent are molecules of large size.
7. **STATEMENT-1 :** Micelles are formed by surfactant molecules above the critical micelle concentration (CMC).
   **STATEMENT-2 :** The conductivity of a solution having surfactant molecules decrease sharply at the CMC.
8. **STATEMENT-1 :** The micelle formed by sodium stearate in water has —$COO^-$ groups at the surface.
   **STATEMENT-2 :** Surface tension of water is reduced by the addition of stearate.
9. **STATEMENT-1 :** Protein, starch are lyophilic colloids.
   **STATEMENT-2 :** They have strong interaction with the dispersion medium.
10. **STATEMENT-1 :** Colloidal AgI is prepared by adding KI in slight excess to $AgNO_3$ solution, the sol particles migrate toward cathode under electric field.
    **STATEMENT-2 :** Colloidal particles adsorb ions and thus becomes electrically neutral.

**4.**

| Column-I | Column-II |
|---|---|
| (A) Liquid dispersed in gas | (P) Foam |
| (B) Gas dispersed in liquid | (Q) Emulsion |
| (C) Liquid dispersed in solid | (R) Aerosol |
| (D) Liquid dispersed in liquid | (S) Gel |

**5.**

| Column-I | Column-II |
|---|---|
| (A) $As_2S_3$ sol | (P) Lyophobic colloid |
| (B) Sulphur sol | (Q) Macromolecular colloid |
| (C) Starch | (R) Multimolecular colloid |
| (D) Soap | (S) Associated colloid |

**6.**

| Column-I | Column-II |
|---|---|
| (A) Coagulation | (P) Due to presence of charge |
| (B) Electrophoresis | (Q) Due to scattering of light |
| (C) Tyndall effect | (R) Due to neutralization of charge |
| (D) Brownian movement | (S) Due to impact of the molecules of the dispersion medium with colloidal particles |

**7.**

| Column-I | Column-II |
|---|---|
| (A) Peptization | (P) Preparation of sols |
| (B) Ultra centrifugation | (Q) Purification of sols |
| (C) Electrodialysis | (R) Preparation of metal sols |
| (D) Bredig's arc method | (S) Movement of ions across the membrane in presence of electric field |

**24.** Select correct statement(s)
(a) The role of a catalyst in a reversible reaction is to allow the equilibrium to be achieved quickly
(b) Diffusion process is involved in mechanism of heterogeneous catalysis process
(c) Hydrolysis of cane sugar is catalysed by $H^+$
(d) Promotors enhance the activity of a catalyst

**25.** Select correct statement(s)
(a) Blood is a colloidal solution
(b) Alum is used in water purification
(c) River water is a colloidal solution of clay
(d) Colloidal medicines are more effective due to large surface area

## MATCH THE COLUMN

**Column-I** and **Column-II** contains four entries each. Entries of Column-I are to be matched with some entries of Column-II. One or more than one entries of Column-I may have the matching with the same entries of Column-II.

**1.**

| Column-I | Column-II |
|---|---|
| (A) Chemisorption | (P) Exothermic |
| (B) Physical adsorption | (Q) Endothermic |
| (C) Desorption | (R) Removal of adsorbed material |
| (D) Activation of adsorbent | (S) Highly specific in nature |

**2.**

| Column-I | Column-II |
|---|---|
| (A) Chemisorption | (P) Not very specific and decreases with temperature |
| (B) Physisorption | (Q) Specific and increases with temperature |
| (C) Desorption of a solute on liquid surface | (R) Increases the surface tension of the liquid |
| (D) Adsorption of a solute on a liquid surface | (S) Decreases the surface tension of the liquid |

**3.**

| Column-I | Column-II |
|---|---|
| (A) Milk | (P) Aerosol |
| (B) Dust | (Q) Emulsion |
| (C) Cheese | (R) Gel |
| (D) Froth | (S) Foam |

**13.** Colloidal solution can be purified by:
(a) dialysis (b) electrodialysis (c) electrophoresis (d) ultrafiltration

**14.** Coagulation of colloids can be achieved by:
(a) centrifugation (b) adding electrolyte (c) change in pH (d) adding water

**15.** Which are the properties of sols?
(a) Adsorption
(b) Tyndall effect
(c) Flocculation
(d) Depression of freezing point

**16.** In the aqueous solution of soaps above CMC :
(a) the cations associate to form the aggregates
(b) the anions associate to form the clusters of colloidal dimension
(c) the polar ends of the ions forming the clusters are directed towards water
(d) the non-polar (hydrocarbon) ends are directed towards water

**17.** Amongst the following which is/are correct statement about the metal sulphide sols?
(a) The sol particles are positively charged due to preferential adsorption of metal ions
(b) The sol particles are negatively charged due to preferential adsorption of sulphide ions
(c) The cations of added electrolytes are effective in causing the coagulation of the sol
(d) The sol is unstabilized due to both the electric charge and hydration of the particles

**18.** Emulsion can be destroyed by:
(a) the addition of an emulsifier
(b) electrophoresis with a high potential
(c) freezing
(d) all of these

**19.** Which of the following statement is/are correct for electrophoresis?
(a) Colloids are uncharged particles and do not migrate towards the electrodes when electric field is applied
(b) In electrophoresis, solution migrates either to the anode or to the cathode depending on the positively or negatively charged solution
(c) Electrophoresis is useful for finding the charge on a sol
(d) All of these

**20.** Select the false statement(s):
(a) Brownian motion and Tyndall effect are shown by true solutions
(b) Sorption process is combinations of adsorption and adsorption process
(c) Hardy-Schulze law is related with coagulation of a sol
(d) Higher is the gold number greater will be the protective power of a lyophilic colloid

**21.** Select correct statement(s)
(a) Lyophobic colloids are used to protect lyophilic colloids
(b) Dehydrating agent is used to coagulate lyophilic sols
(c) Rubber is obtained by coagulation of latex
(d) Sometimes, the rainfall occurs when two oppositely charged clouds meet

**22.** In which of the followings, Tyndal effect is/are not observed?
(a) Sugar solution
(b) Emulsions
(c) Urea solution
(d) Solution of proteins

**23.** Which of the following reactions are examples for heterogeneous catalysis?
(a) $2H_2O_2(l) \xrightarrow{MnO_2(s)} 2H_2O(l) + O_2(g)$
(b) $2SO_2(g) + O_2(g) \xrightarrow{NO(g)} 2SO_3(g)$
(c) $H_2(g) + C_2H_4(g) \xrightarrow{Ni(s)} CH_3COOH(aq) + C_2H_5OH(aq)$
(d) $CH_3COOC_2H_5(aq) + H_2O(l) \xrightarrow{HCl(aq)} CH_3COOH(aq) + C_2H_5OH(aq)$

**4.** If adsorption of a gas on a solid is limited to monolayer formation, then which of the following statements are true?

(a) At low pressures, $\frac{x}{m}$ varies proportionately with $p$

(b) At moderate pressures, $\frac{x}{m}$ varies less than proportionately with $p$

(c) At high pressures, $\frac{x}{m}$ becomes independent of $p$

(d) At high pressures, $\frac{x}{m}$ varies more than proportionately with $p$

**5.** Which of the following are multimolecular colloids?

(a) Sulphur sol (b) Starch (c) Gold sol (d) Soap solution

**6.** Which of the following is not lyophilic?

(a) Gelatin sol (b) Silver sol

(c) Sulphur sol (d) $As_2S_3$ sol

**7.** Which of the following is/are correct for lyophilic sols?

(a) Its surface tension is lower than that of water

(b) Its viscosity is higher than that of water

(c) Its surface tension is higher than that of water

(d) Its viscosity is equal to that of water

**8.** Select the correct statement(s):

(a) Benzene is dispersed phase in benzosols

(b) Lyophobic sols are irreversible and not so stable

(c) Lyophobic sol can be produce by double decomposition

(d) When a solution of sulphur in alcohol is added in excess of water a sol of alcohol is formed

**9.** When negatively charged colloid like $As_2S_3$ sol is added to positively charged $Fe(OH)_3$ sol in stoichiometric amounts?

(a) Both the sols are precipitated simultaneously

(b) This process is called mutual coagulation

(c) They becomes positively charged colloid

(d) They become negatively charged colloid

**10.** Colloidal gold can be prepared by:

(a) Bredig's arc method (b) reduction of $AuCl_3$

(c) hydrolysis (d) peptization

**11.** The coagulation of sol particles may be brought about by:

(a) boiling (b) persistent dialysis

(c) adding electrolyte (d) adding oppositely charged sol

**12.** Select the correct statement(s) :

(a) A solution is prepared by addition of excess of $AgNO_3$ solution in KI solution. The charge likely to develop on colloidal particle is positive

(b) The effects of pressure on physical adsorption is high if temperature is low

(c) Ultra centrifugation process is used for preparation of lyophobic colloids

(d) Gold number is the index for extent of gold plating done

## PASSAGE 4

Emulsions are normally prepared by shaking the two components together vigorously although some kind of emulsifying agent usually has to added to stabilize the product. This emulsifying agent may be a soap or other surfactant (surface active) species or a lyophilic sol that forms a protective film around the dispersed phase.

Emulsions broadly classified into two types :

(i) Oil in water emulsions (O/W) : Oil acts as dispersed phase and water acts as dispersion medium.

(ii) Water in oil emulsions (W/O) : Water acts as dispersed phase and oil acts as dispersion medium. Dye test, dilution test may be employed for identification of emulsions.

**1.** Read two statements:
(1) Milk is an example of oil in water (O/W) type emulsion
(2) Cold cream is an example of water in oil (W/O) type emulsion
(a) Only statement 1 is correct (b) Only statement 2 is correct
(c) Both are correct (d) None of these

**2.** Select correct statement:
(a) Water in oil emulsions are more viscous than the aqueous emulsions
(b) Electrical conductance of aqueous emulsions is less than that of oil emulsions
(c) Deemulsification can be done by soap or detergent
(d) An emulsion can be diluted with $H_2O$ then it is oil in water (O/W) type

## ONE OR MORE ANSWERS IS/ARE CORRECT

**1.** Select the correct statement(s) :
(a) Physical adsorption is specific in nature
(b) Chemical adsorption highly specific in nature
(c) Physical adsorption is due to free valence of atoms
(d) Chemical adsorption is due to stronger interaction or bond formation

**2.** Select the correct statement(s):
(a) Adsorption is a non-spontaneous process
(b) Surface energy decreases during the process of adsorption
(c) Adsorption takes place with decrease of entropy
(d) In general adsorption is exothermic process

**3.** Select the correct statement(s):
(a) Physisorption is favoured by low temperature
(b) Chemisorption is favoured by very high temperature because the process is endothermic
(c) Chemisorption increases with increase in temperature owing to high activation energy
(d) Oxygen adsorbed by charcoal can be desorbed by lowering pressure and temperature

1. On addition of one mL of solution of 10% NaCl to 10 mL of red gold sol in presence of 0.025 g of starch, the coagulation is just prevented. The gold number of starch is:
   (a) 0.025 (b) 0.25 (c) 2.5 (d) 25
2. Which of the following statement(s) is/are correct?
   (a) Higher the gold number, more protective power of colloid
   (b) Lower the gold number, more the protective power
   (c) Higher the coagulation value, more the coagulation power
   (d) Lower the coagulation value, higher the coagulation power
3. Gold number gives an indication of:
   (a) protective nature of colloids
   (b) purity of gold in suspension
   (c) the charge on a colloidal solution of gold
   (d) gram of gold per litre of solution

**PASSAGE 3**

Coagulation is the process by which the dispersed phase of a colloid is made to aggregate and thereby separate from the continuous phase. The minimum concentration of an electrolyte in milli-moles per litre of the electrolyte solution which is required to cause the coagulation of colloidal sol is called coagulation value.

Therefore higher is the coagulating power of effective ion, smaller will be the coagulation value of the electrolyte.

$$\text{Coagulation value} \propto \frac{1}{\text{coagulating power}}$$

The coagulation values of different electrolytes are different. This behaviour can be easily understood by Hardy-Schulze rule which states.

"The greater is the valency of the effective ion greater is its precipitating power."

1. Which one has the highest coagulating power?
   (a) $K^+$ (b) $Ca^{2+}$ (c) $Al^{3+}$ (d) $Sn^{4+}$
2. $As_2S_3$ sol is negatively charged, capacity to precipitate it is highest in:
   (a) $K_2SO_4$ (b) $Na_3PO_4$ (c) $AlCl_3$ (d) $CaCl_3$
3. The ability of an ion to bring coagulation of a given colloid depends upon:
   (a) the sign of its charge (b) magnitude of its charge
   (c) both magnitude and sign (d) none of these
4. The coagulation of colloidal particles of the sol can be caused by:
   (a) heating
   (b) adding electrolyte
   (c) adding oppositely charged sol
   (d) all of these

# Level 3

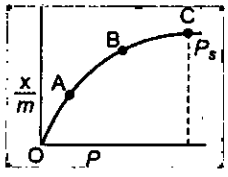
## PASSAGE 1

A graph between $x/m$ and the pressure $P$ of the gas at a constant temperature is called adsorption isotherm. Where $x$ is the no. of moles of the adsorbate and $m$ is the mass of the adsorbent. Adsorption isotherms of different shapes have been experimentally observed. According to Frundlich adsorption isotherm.

$$x/m = kP^{1/n}$$

where $k$ and $n$ are constant parameters depending upon the nature of the solid and gas.

**1.** In the given isotherm select the incorrect statement :



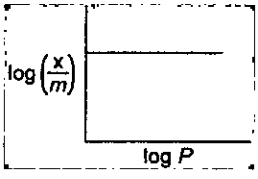

(a) $\frac{x}{m} \propto P^{1/n}$ along $OA$

(b) $\frac{x}{m} \propto P^0$ when point $B$ is reached

(c) $\frac{x}{m}$ does not increase as rapidly with pressure along $BC$ due to less surface area available for adsorption

(d) nature of isotherm is different for two gases for same adsorbent

**2.** Adsorption isotherm of $\log\left(\frac{x}{m}\right)$ and $\log P$ was found of the type :

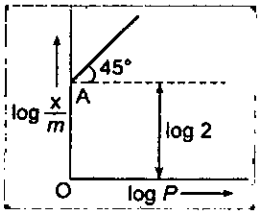



This is true when :

(a) $P = 0$ (b) $P = 1$

(c) $\frac{1}{n} = 1$ (d) $\frac{1}{n} = \infty$

**3.** Graph between $\log\left(\frac{x}{m}\right)$ and $\log P$ is a straight line at angle 45° with intercept $OA$ as shown.




Hence, $\left(\frac{x}{m}\right)$ at a pressure of 2 atm is :

(a) 2 (b) 4

(c) 8 (d) 1

## PASSAGE 2

The protective power of the lyophilic colloids is expressed in terms of gold number, a term introduced by Zsigmondy. Gold number is the number of milli-gram of the protective colloid which prevent the coagulation of 10 mL of red gold sol. When 1 mL of a 10 per cent solution of sodium chloride is added to it. Thus, smaller the gold number of lyophilic colloid, the greater is the protective power.

**26.** A detergent ($C_{12}H_{25}SO_4^-Na^+$) solution becomes a colloidal sol at a concentration of $10^{-3}M$. On an average $10^{13}$ colloidal particles are present in 1 $mm^3$. What is the average number of ions are contain in one colloidal particle (micelle)? [Given: $N_A = 6\times10^{23}$]

(a) $6\times10^7$ (b) 10 (c) 60 (d) None of these

**27.** One gram of activated carbon has a surface area of 1000 $m^2$. Considering complete coverage as well as monomolecular adsorption, how much ammonia at 1 atm and 273 K would be adsorbed on the surface of $\frac{44}{7}$ g carbon if radius of a ammonia molecules is $10^{-8}$ cm.

[Given: $N_A = 6\times10^{23}$]

(a) 7.46 L (b) 0.33 L (c) 44.8 L (d) 23.5 L

**28.** At 1 atm and 273 K the volume of nitrogen gas required to cover a sample of silica gel, assuming Langmuir monolayer adsorption, is found to be 1.30 $cm^3g^{-1}$ of the gel. The area occupied by a nitrogen molecule is 0.16 $nm^2$. What is the surface area per gram of silica gel? [Given: $N_A = 6\times10^{23}$]

(a) 5.568 $m^2\,g^{-1}$ (b) 3.48 $m^2\,g^{-1}$ (c) 1.6 $m^2\,g^{-1}$ (d) None of these

**29.** 10% sites of catalyst bed have absorbed by $H_2$. On heating $H_2$ gas is evolved from sites and collected at 0.03 atm and 300 K in a small vessel of 2.46 $cm^3$.

No. of sites available is $5.4\times10^{16}$ per $cm^2$ and surface area is 1000 $cm^2$. Find out the no. of surface sites occupied per molecule of $H_2$. (Given $N_A = 6\times10^{23}$)

(a) 1 (b) 2 (c) 3 (d) None of these

**30.** A sample of 16 g charcoal was brought into contact with $CH_4$ gas contained in a vessel of 1 litre at 27°C. The pressure of gas was found to fall from 760 to 608 torr. The density of charcoal sample is 1.6 $g/cm^3$. What is the volume of the $CH_4$ gas adsorbed per gram of the adsorbent at 608 torr and 27°C?

(a) 125 mL/g (b) 16.25 mL/g (c) 26 mL/g (d) None of these