SURFACE CHEMISTRY

SYNOPSIS

- Surface chemistry is a branch which deals with the study of the phenomena occuring at the surface or interface, i.e., at the boundary separating the two bulk phases.
- Surface area means the top most layer upto the 100nm depth.

Adsorption: Adsorption is the phenomenon of attracting and retaining the molecules of a substance on the surface of a liquid or a solid resulting into a higher concentration of the molecules on the surface.

- The molecular species or substances, which concentrates or accumulates at the surface is termed as **adsorbate**.
- Adsorbate can be gas, liquid or solid.
- The material or substance on the surface of which the adsorption takes place is called **adsorbent**.
- Adsorbent can be solid or liquid but not gas

Ex : Activated Charcoal adsorbs gases (Cl_2, SO_2, CO_2, Noble gases etc.)

- Ni or Pt adsorbs H_2 gas (hydrogenation of oils).
- Animal charcoal adsorbs acetic acid molecules.
- Coloured particles of molasses gets adsorbed on activated charcoal hence molasses decolourises.
- If a gas like O_2, H_2, CO, Cl_2, NH_3 or SO_2 is taken in a closed vessel containing powdered charcoal, then the pressure of the gas in the vessel decreases due to adsorption of gases on charcoal.
- In a solution of an organic dye say methylene blue, when animal charcoal is added and the solution is well shaken, then the filtrate turns colourless. Because the molecules of the dye are adsorbed on the surface of charcoal.
- The air becomes dry in the presence of silica gel because water molecules get adsorbed on the surface of the gel.
- Adsorption is due to unbalanced molecular forces or vanderwaals forces or valence forces.
- Adsorption is effective when the surface of adsorbent is pure.
- The process of removal of impurities from the surface of adsorbent is called activation.

Ex : Charcoal is activated by heating at 300^0C-1000^0C in vacuum or presence of inert gas.

Absorption: Absorption is the bulk phenomenon i.e., gas, liquid or solid molecules distributed uniformly in solid or liquid.

- Ex: i) Piece of chalk dipped in ink (chalk absorbs ink) Sponge in water (sponge absorbs water)

Sorption: If both adsorption and absorption takes place simultaneously then it is known as **sorption.**

- The term sorption was introduced by MC Bain.

Desorption: The process of removing an adsorbed substance from a surface on which it is adsorbed is called desorption.

Positive and Negative Adsorption:

When the concentration of the adsorbate is more on the surface of the adsorbent than in bulk, it is called **positive adsorption**. On the other hand, if the concentration of the adsorbate is less relative to its concentration in bulk,it is called **negative adsorption**.

Eg : when a concentrated solution of *KCl* is shaken with wood charcoal, it shows positive adsorption but with a dilute solution of *KCl*, it shows negative adsorption.

Mechanism of Adsorption: Adsorption arises due to the fact that the surface particles of the adsorbent are not in the same environment as the particles inside the bulk.adsorption is due to unbalanced forces acting on the surface.

- During adsorption, there is always a decrease in residual forces of surface i.e. there is decrease in surface energy which appears as heat. There fore Adsorption is an exothermic process. $(\Delta H = -ve)$
- During the process of adsorption, free movement becomes restricted i.e. entropy of system decreases. $(\Delta S = -ve)$.

- Adsorption is thus accompanied by decrease in enthalpy $(\Delta H = -ve)$ and entropy $(\Delta S = -ve)$ of the system.
- But adsorption process is spontaneous, the thermodynamic requirement for this is ΔG must be negative $(i.e. \Delta H - T\Delta S = -ve)$.
- On the basis of Thermodynamics $\Delta G = \Delta H - T\Delta S$, ΔG can be negative if ΔH has sufficiently high negative value as $-T\Delta S$ is positive.
- As the adsorption proceeds, ΔH becomes less and less negative ultimately ΔH becomes equal to $T\Delta S$ and ΔG becomes zero. At this state equilibrium is reached.

S.No	Property	Physical adsorption	Chemical adsorption
1.	Nature of adsorption	Due to vanderwall's forces (Weak)	Due to chemical forces (Strong
2.	Enthalpy of adsorption (ΔH) (kJ mol^{-1})	Low 20-40	High 80-240
3.	Reversibility of adsorption	Reversible and occurs rapidly	Irreversible and occurs slowly
4.	Temp. at which adsorption is more pronounced	Low temperature (below the b.p.t of the adsorbate gas)	High temperatures (generally above the b.p.t of the adsorbate gas)
5.	Effect of change in temperature	Decreases with rise in temperature	Increase with rise in temperature
6.	Specificity of adsorption	Not specific generally takes place on all surfaces	Highly specific. Takes place on specified surfaces
7.	Nature of adsorbate layers formed	Multilayered	Only uni-layered
8.	Effect of pressure on adsorption	Increases with rise in pressure of adsorbate gas and finally attains a limiting value	Pressure of the adsorbate has a negligible effect
9.	Energy of activation	Insignificant i.e., very low	Significant i.e., relatively high
10.	Dependence on the nature of the adsorbate & adsorbent	Depends on the adsorbate (gas) only. Easily liquefiable gases are more readily adsorbed	Depends on the adsorbate as well as a adsorbent. No correlation can be given.
11.	Ease of desorption	Easy (vander waal's forces are involved)	Not easy (chemical forces are involved)
12.	Example	Adsorption of H_2 gas on powdered charcoal	Adsorption "H_2" gas "Ni"

The extent of Adsorption of Gases depends on the following factors

i) Surface area of the Adsorbent: With the increase of surface area of the solid, rate of adsorption of gases increases.

- Finely divided transition metals like Co,Ni, Pt act as good adsorbents.
- Greater the surface area, greater is the extent of adsorption.
- The process of increasing the surface area of an adsorbent and making it a better adsorbent is called activation of the Adsorbent.
- Porous charcoal, silica gel contain large surface area.
- Purified adsorbent is called activated adsorbent

ii) Nature of Gas (Adsorbate): Easily liquifiable gases which contain low boiling point adsorb more than non liquifiable gases.

- SO_2, NH_3, HCl and CO_2 adsorb more than H_2, O_2 & N_2
- Higher the critical temperature, greater the ease of liquification of the gas and more is adsorption.
- 1 g. of activated charcoal adsorbs about 400 ml of SO_2 (Tc=430 K), 20 ml of CH_4 (Tc = 356K)

iii) Pressure of the Gas: At constant temperature, increase of pressure of a gas leads to increase of the extent of physical adsorption.

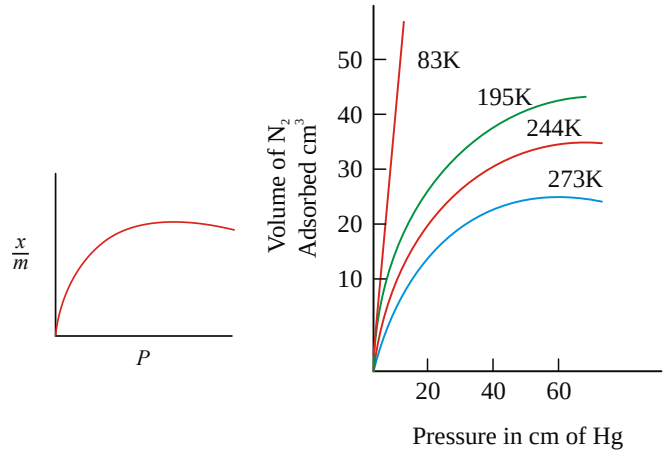
- The effect of pressure on chemisorption is zero.

At low pressure the physically adsorbed gas forms a monolayer.

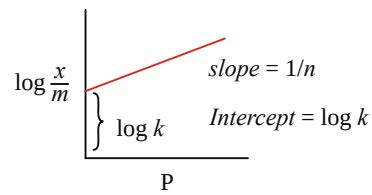
Freundlich isotherm: At constant temperature the amount of the gas adsorbed (x) on given mass of adsorbent (m) is directly proportional to its pressure.

$$\frac{x}{m} = KP^{\frac{1}{n}}$$

k, n are constants of Freundlich adsorption isotherm



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



- Freundlich isotherm explains. the behaviour of adsorption in approximate manner. Here the factor $\frac{1}{n}$ can have value between 0 and 1 (probable range 0.1 to 0.5)
- If $\frac{1}{n} = 0$, then $\frac{x}{m}$ = constant, then adsorption is independent of pressure.
- If $\frac{1}{n} = 1$, then $\frac{x}{m} = K.P$ i.e. $\frac{x}{m} \sim .p$, adsorption varies directly with pressure.
- Both the conditions are supported by experimental results. The experimental isotherms always seem to approach saturation at high pressure. This cannot be explained by Freundlich isotherm. Thus, it fails at high pressure.
- Freundlich theory is applicable to physical adsorption at medium pressures only.

Langmuir Adsorption Isotherm (For Advance) : A solid surface is considered homogeneous. But it contains a fixed number of adsorption sites on the surface of it.

- Each such site adsorbs a single molecule. This means that adsorption is confined to a mono molecular layer.

- Adsorption is considered as an equilibrium process comprising of vapourization and condensation occuring simultaneously at a given temperature.
- At equilibrium the rate of evaporation is equal to rate of condensation
- Rate of evaporation is proportional to the area of the surface covered by the adsorbed gas

  Rate $\propto$ area covered.

  Rate of evaporation = $K_d \times^{-}$
- Rate of condensation is proportional to the product of the pressure of the gas and area uncovered on adsorbent.

  Rate $\propto$ P $\times$ area uncovered.

  Rate of condensation = $K_a p(1-^{-})$

  At equilibrium both rates are equal

  $K_d^{-} = K_a p(1-^{-})$

  If $^{-}$ is covered fraction of the surface.

  $- = \frac{bp}{1+bp}$ where $b = \frac{k_a}{k_d}$

  $\frac{X}{m} = \frac{kbp}{1+bp}; \frac{X}{m} = \frac{ap}{1+bp}$
- where x = mass of a gas adsorbed

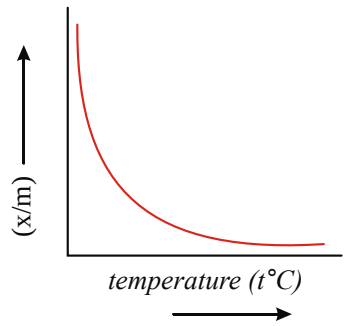
  m = mass of adsorbent

  a = kb, b = ka/kd, p = pressure.

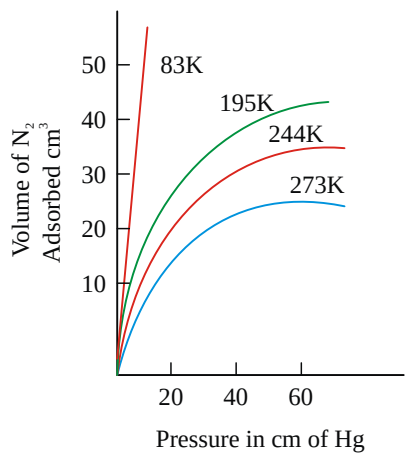
  The above equation is called Langmuir adsorption Isotherm.

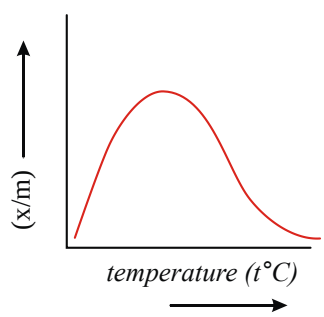
Temperature: Low temperatures favour physical adsorption and high temperatures favour chemical adsorption or chemisorption.

- N_2 is physically adsorbed on iron at 463k but it is chemisorbed at 723k
- When temperature increases, rate of physical adsorption decreases.
- In Chemical adsorption with increase of temperature the magnitude of adsorption first increases and then decreases.
- The graph plotted between x/m vs temperature at constant pressure is called Freundlich adsorption isobars.



a. Physical Adsorption





b. Chemisorption

Adsorption from solutions: Freshly precipitated inorganic precipitates (e.g. metal hydroxides) act as good adsorbents for the dye stuff.

- During the adsorption if the concentration of the solution decreases, it is called positive adsorption.
- The extent of Adsorption (x/m) is related to the concentration of the solution through the mathematical formula $\frac{x}{m} = k.c^{\frac{1}{n}}$

c = concentration of the solution.

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

- Extent of adsorption decreases with an increase in temperature.
- Extent of adsorption depends on concentration of solute in solution, nature of adsorbent, adsorbate and surface area of the adsorbent.

Ex:- **The precipitate of $Mg(OH)_2$ attains blue colour when precipitated in presence of Magneson reagent**. The colour is due to adsorption of Magneson.

W.E-1: ***Per two gram of charcoal, a gas is adsorbed by 0.1g and 0.2g at 10 torr and 80 torr pressure respectively. Calculate the n value in Freundlich adsorption isotherm.***

Sol. $\frac{x}{m} = K.P^{1/n}$ **(or)** $\frac{x_1}{x_2} = \left(\frac{P_1}{P_2}\right)^{1/n}$

Substituting the values,

$\frac{0.1}{0.2} = \left(\frac{10}{80}\right)^{1/n}$ **(or)** $\left(\frac{1}{2}\right)^1 = \left(\frac{1}{2}\right)^{3/n}$

Therefore, the value of n is 3

Applications of Adsorption

- **Production of high vacuum:** The remaining traces of air can be adsorbed by charcoal from a vessel evacuated by a vacuum pump to give a very high vacuum.
- **Gas masks:** Gas mask (a device which consists of activated charcoal or mixture of adsorbents) is usually used for breathing in coal mines to adsorb poisonous gases.
- **Control of humidity:** Silica and aluminium gels are used as adsorbents for removing moisture and controlling humidity.
- **Removal of colouring matter from solutions:** Animal charcoal removes colours of solutions by adsorbing coloured impurities.
- **Heterogeneous catalysis:** Adsorption of reactants on the solid surface of the catalysts increases the rate of reactants.There are many gaseous reactions of industrial importance involving solid catalysts. Manufacture of ammonia using iron as a catalyst, manufacture of H_2SO_4 by contact process Pt/V_2O_5 as catalyst and use of finely divided nickel in the hydrogenation of oils are excellent examples of heterogeneous catalysis.
- **Separation of inert gases:** Due to the difference in degree of adsorption of gases by charcoal, a mixture of noble gases can be separated in Dewar's method by adsorption on coconut charcoal at different temperatures.

Froth floatation process: A low grade sulphide ore is concentrated by separating it from silica and other earthy matter by this method using pine oil and froathing agent.

In curing diseases: A number of drugs are used to kill germs by getting adsorbed on them.

Adsorption indicators: Surfaces of certain precipitates such as silver halides have the property of adsorbing some dyes like eosin, fluorescein, etc. and thereby producing a characteristic colour at the end point.

Chromatographicanalysis:
Chromatographic analysis based on the phenomenon of adsorption finds a number of applications in analytical and industrial fields.

Catalysis: The name catalysis (Kata = wholly, Lysis = to loosen) was first given by Berzelius in 1836.

- A catalyst is that which increases the rate of reaction without itself undergoing any change.

Characteristics of Catalyst:

- A catalyst does not initiate a reaction.
- A catalyst remains chemically uneffected at the end of the chemical reaction.
- Small amount of the catalyst are generally sufficient to speed up a chemical reaction
- A catalyst does not effect the position of equilibrium. It helps to attain the equilibrium quickly. It catalyses both the forward and the backward reactions to the same extent.
- A catalyst generally functions under the optimum conditions only (temperature, pressure, pH etc.,)
- A catalyst may get poisoned (loss of its activity) by the presence of even traces of impurities. **This is called catalytic poison**. H_2S or CO are poison for Fe catalyst (Haber's process). As_2O_3 is poison for Pt catalyst. (contact process).
- Catalytic poison is **specific** for a catalyst.

- The action of catalyst in many instances is selective. Change of catalyst may give changed products. A catalyst gives specific products only. For example.

$$CO + 3H_2 \xrightarrow[catalyst]{Ni} CH_4 + H_2O$$

$$CO + H_2 \xrightarrow[catalyst]{Cu} HCHO$$

- The substance which increases the activity of catalyst is called promoter. Promoter is selective for a catalyst. For example, molybdenum (Mo),Iron oxide,Potassium oxide and Alumina is promoter to the catalyst Fe in the Haber's process.
- Finely divided substances function as more effective catalysts than the coarsely divided substances. For example, finely divided Ni functions as a good catalyst in the hydrogenation of oils.
- If the rate of reaction is decreased in the presence of catalyst then the catalyst is called negative catalyst.

Ex: :Decomposition of H_2O_2 is retarded by the presence of glycerol or acetanilide.

$$2H_2O_2 \xrightarrow{Glycerol} 2H_2O + O_2$$

- Change in temperature may alter the rate of a catalytic action. Bio-catalysts (enzymes) may lose their activity at higher temperatures. Catalysts thus function at optimum temperatures

Types of Catalysis Homogeneous Catalysis: If the reactants and catalyst are present in a same phase, it is called homogeneous catalysis.

Eg: 1) The preparation of SO_3 by lead-chamber process

$$2SO_2(g) + O_2(g) \xrightarrow[+NO_2(g)]{NO(g)} 2SO_3(g)$$

2) The conversion of Carbon monoxide to Carbon dioxide in the presence of NO

$$2CO_{(g)} + O_{2(g)} \xrightarrow{NO_{(g)}} 2CO_{2(g)}$$

3) Hydrolysis of ester in presence of acid.

$$CH_3COOC_2H_{5(l)} + H_2O_{(l)} \xrightarrow{H^+} CH_3COOH_{(l)} + C_2H_5OH_{(l)}$$

4) Hydrolysis of sucrose in presence of mineral acids

$$C_{12}H_{22}O_{11(l)} + H_2O_{(l)} \xrightarrow{H^+} C_6H_{12}O_6 + C_6H_{12}O_6$$

$$glucose \qquad Fructose$$

Heterogeneous Catalysis: If the reactants and catalysts are present in different phases, it is called heterogeneous catalysis

Eg:Preparation of SO_3 by contact process

$$2SO_{2(g)} + O_{2(g)} \xrightarrow{Pt/V_2O_{5(s)}} 2SO_{3(g)}$$

2) The preparation of ammonia by Haber's process

$$N_{2(g)} + 3H_{2(g)} \xrightarrow{Fe+Mo(s)} 2NH_{3(g)}$$

- Oxidation of ammonia into nitric oxide in the presence of platinum gauze in Ostwald's process.

$$4NH_{3(g)} + 5O_{2(g)} \xrightarrow{Pt(s)} 4NO_{(g)} + 6H_2O_{(g)}$$

- Hydrogenation of vegetable oils in the presence of finely divided nickel as catalyst.

$$\text{Vegetableoils}(s) + H_{2(g)} \xrightarrow{Ni(s)} \text{Vegetableghee}(s)$$

One of the reactants is in liquid state and the other in gaseous state while the catalyst is in the solid state.

Auto catalysis: When one of the intermediates formed in a reaction itself acts as a catalyst, it is called auto catalysis.

- Oxidation of oxalic acid by acidified $KMnO_4$

$$2KMnO_4 + 5H_2C_2O_4 + 3H_2SO_4 \rightarrow 2MnSO_4 + K_2SO_4 + 8H_2O + 10CO_2$$

In this reaction Mn^{+2} ions act as autocatalyst

- In Hydrolysis of esters carboxylic acid act as auto catalyst .

$$CH_3COOC_2H_5 + H_2O \rightarrow CH_3COOH + C_2H_5OH$$

W.E-2: ***Why ester hydrolysis is slow in the beginning and becomes faster after some time?***

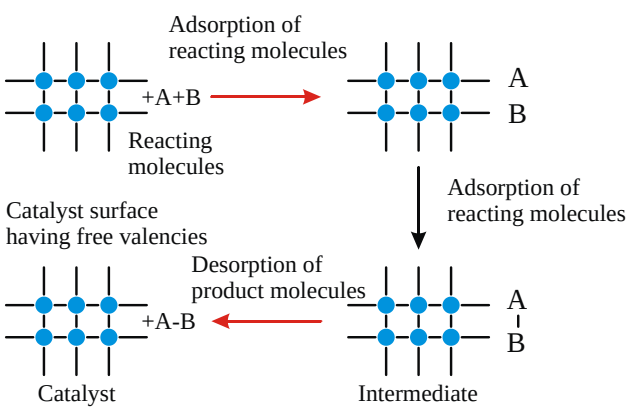
Sol: In the hydrolysis of ester, carboxylic acid formed in the reaction acts as autocatalyst.. Thus the reaction is slow in the begining and becomes faster after some time due to the formation of acid which acts as catalyst..

- Decomposition of arsenic hydride to As and H_2 $(2AsH_3 \rightarrow 2As + 3H_2)$ Arsenic formed initially is acting as autocatalyst

Adsorption theory of Heterogeneous Catalysis (Mechanism)

(Mechanism of heterogeneous catalysis)

- The modern adsorption theory is the combination of Intermediate compound formation theory and the old adsorption theory.
- The catalytic activity is localised on the surface of the catalyst.
- Diffusion of reactants to the surface of the catalyst.
- Adsorption of reactant molecules on the surface of the catalyst.
- Formation of Intermediate due to the chemical reaction on the surface of catalyst.
- Desorption of reaction products from the catalyst surface and there by catalyst whose surface available to further reaction to occur.
- Diffusion of reaction products away from the surface of catalyst.
- This theory explains why the catalyst remains unchanged in mass and chemical composition at the end of the reaction and is effective even in small quantities.
- This theory does not explain the action of catalytic promoters and catalytic poisons.



Solid catalysts possess Two important features

- A) Activity B) Selectivity
- **A) Activity:** The ability of a catalyst to accelerate chemical reactions is called activity of a catalyst.

  Catalytic activity increases from group 5 to group 11.
- Metals with maximum activity being shown by groups 7-9 elements of the periodic table.

$$2H_{2(g)} + O_{2(g)} \xrightarrow{Pt} 2H_2O_{(l)}$$

- **B) Selectivity:** The ability of catalysts to direct reaction to give particular product is called selectivity of that catalyst.

  Ex:- Different catalysts yield different products for the same reacting substances.

i) $CO_{(g)} + 3H_{2(g)} \xrightarrow{Ni} CH_{4(g)} + H_2O_{(g)}$

ii) $CO_{(g)} + 2H_{2(g)} \xrightarrow{Cu/Zno-Cr_2O_3} CH_3OH_{(g)}$

iii) $CO_{(g)} + H_{2(g)} \xrightarrow{Cu} HCHO_{(g)}$

Shape-Selective Catalysis by Zeolites

- The catalytic reaction that depends upon the porestructure of the catalyst and the size of the reactant and product molecules is called **shape-selective catalysis**.
- Zeolites are alumino silicates i.e., three dimensional network silicates in which some silicon atoms are replaced by aluminium atoms giving $Al-O-Si$ frame work.
- Zeolites are good shape-selective catalysts because of their honeycomb-like structures.
- Zeolites, before using as catalysts, are heated in vaccum so that the water of hydration is lost. As a result, zeolite becomes porous i.e., the cavities in the honey-comb like structure which were occupied by the water molecules become vacant.

  The size of the pores generally varies between 260 pm and 740 pm. Thus only those molecules can be adsorbed in these pores whose size is small enough to enter these cavities and also leave easily.
- The reactions taking place in zeolites depend upon the size and shape of reactant and product molecules as well as upon the pores and cavities of the zeolites, that is why these types of reactions are called **'shape-selective catalysis'** reactions.
- Zeolites are being very widely used as catalysts in **petrochemical industries** for cracking of hydrocarbons and isomerisation. An important zeolite catalyst used in the petroleum industry is ZSM-5. It converts alcohols directly into gasoline (petrol) by dehydrating them so that a mixture of hydrocarbons is formed.

Catalysis:

- **Enzyme catalysis:** Enzymes are complex nitrogenous organic compounds which are produced by living plants and animals. They are actually protein molecules of high molecular mass and form colloidal solutions in water. The enzymes are also sometimes called biocatalysts.
- Though enzymes are produced by living beings, they themselves are non-living and can act as catalysts even outside the living bodies.
- Numerous reactions that occur in the bodies of animals and plants to maintain the life process catalysed by enzymes. The enzymes are, thus, termed as biochemical catalysts and the phenomenon is known as biochemical catalysis. Enzymes are capable of bringing about complex reactions at body temperature. Some examples of enzyme catalysed reactions are:

Some enzymatic reactions

Enzyme	Source	Enzymatic reaction
Invertase	Yeast	Sucrose → Glucose+Fructose
Zymase	Yeast	Glucose → Ethylalcohol + CO
Dicstase	Malt	Starch → Maltose
Maltase	Yeast	Maltose → Gloucose
Urease	Soyabean	Urea → Ammonia+CO
Pepsin	Stomach	Proteins → Amino acids
Trypsin	Intestine	Proteins → Peptides
Lactobacilli	Curd	Lactose → Lactic acid

Characteristics of Enzyme Catalysis

- **High Efficiency:** One molecule of an enzyme may transform one million molecules of the reactant per minute.
- **Highly specific nature:** Each enzyme is specific for a given reaction, i.e., one catalyst cannot catalyse more than one reaction. For example, the enzyme urease catalyses the hydrolysis of urea only. It does not catalyse hydrolysis of any other amide.
- **Highly active under optimum temperature:** The rate of an enzyme reaction becomes maximum at a definite temperature, called the optimum temperature. On either side of the optimum temperature, the enzyme activity decreases. The optimum temperature range for enzymatic activity is 298-310K. Human body temperature being 310 K is suited for enzyme catalysed reactions.
- **Highly active under optimum pH:** The rate of an enzyme-catalysed reaction is maximum at a particular pH called optimum pH, which is between pH values 5-7.
- **Increasing activity in presence of activators and co-enzymes:** The enzymatic activity is increased in the presence of a certain small non-protein (vitamin) present along with an enzyme, the catalytic activity is enhanced considerably.

  Activators are generally metal ions such as Na^+, Co^{2+}, Cu^{2+}. etc. These metal ions, when weakly bonded to enzyme molecules, increase their catalytic activity. Amylase in presence of sodium chloride i.e., Na^+ ions are catalytically very active.
- **Influence of inhibitors and poisons :**Like ordinary catalysts, enzymes are also inhibitors or poisons interact with the active functional groups on the enzyme surface and often reduce or completely destroy the catalytic activity of the enzymes. The use of many drugs is related to their action as enzyme inhibitors in the body.

Mechanism of enzyme Catalysed Reaction

- The molecules of the reactant (substrate) which have complementary shape, comparing with the shape of cavities on the surface of colloidal particles of enzymes.
- There fore molecules of reactant fit into cavities of colloidal particles of enzymes just like key fits into lock.

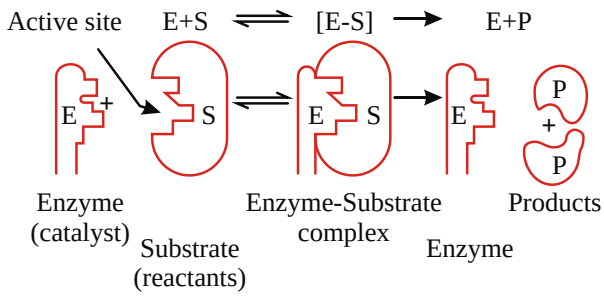
The enzyme-catalysed reactions are considered to proceed in two steps.

Step-I: Binding of enzyme to substrate (reactant) to form an activated complex.

$$E + S \rightarrow ES^*$$

Step-II: Decomposition of the activated complex to form product.

$$ES^{\neq} \rightarrow E(enzyme) + P(product)$$



The Differences Between Enzymes and Catalyst

Enzymes	Catalysts
Enzymes generally have complex structure	Catalysts are very simple, such as metal ions, H^+ ions.
Enzymes are produced by living beings.	Catalysts are not produced by living beings.
Enzymes are highly specific in action.	Catalysts are less specific
Enzymes are active at lower temperatures, close to body temperature.	Catalysts are generally active at higher temperature.

Catalyst in Industry: Some of the important technical catalytic processes are listed in below table.

Process	Catalysts
Haber's process for the manufacture of ammonia $N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$	Finely divided iron, molybdenum as promoter; conditions: 200 bar Pressure and 723-773 K temp
Ostwald's process for the manufacture of nitric acid. $4NH_{3(g)} + 5O_{2(g)} \rightarrow 4NO_{(g)} + 6H_2O$ $2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$ $4NO_{2(g)} + 2H_2O_{(l)} + O_{2(g)} \rightarrow 4HNO_{3(aq)}$	Platinised asbestos temp. 573 K.
Contact process for the manufacture of sulphuric acid. $2SO_{2(g)} + O_{2(g)} \rightarrow + 2SO_{3(g)}$ $SO_{3(g)} + H_2SO_{4(aq)} \rightarrow H_2S_2O_{7(l)}$ $H_2S_2O_{7(l)} + H_2O_{(l)} \rightarrow 2H_2SO_{4(aq)}$	Platinised asbestos (or) vanadium pentoxide (V_2O_5) temp: 673-723K

Colloidal State:

- The substances are classified into crystalloids and colloids by Thomas Graham.
- The substance which passes through the membrane is called crystalloid.
  Eg: Sugar in water, Salt in water, Urea in water, acids and bases etc.,
- . The substance which disperses in a solvent and can not pass through membrane is called colloid.
  Eg: Glue : gum arabic, gelatin, agar etc
- If the particle size of the solute in the binary system is in the range $1m\mu$ - 1μ a colloidal solution is formed.
- Colloidal solutions are - Starch paste, gelatin (or) glue added to hot water.
- The system contains two phases one is "dispersed phase", the other is "dispersion medium".
- Solutions of chemical substances are broadly classified into true solutions and colloidal solutions depending on the particle size.
- If the particle size of the solute in the binary system is less than $1m\ll\left(10^{-9}m\right)$, a true solution is formed.
- Examples for true solutions are - solutions of Common salt, sugar, acids,bases etc.
- Colloidal particles have an enormous surface area per unit mass as a result of their size. Consider a cube with 1cm side. It has a total surface area of $6cm^2$. If it were divided equally into 10^{12} cubes, the cubes would be the size of colloidal particles and will have a total surface area of $60,000cm^2$ or $6m^2$. This large surface area leads to some special properties of colloids to be discussed later in this chapter.
  (Volume of big cube is $1cm^3$. Volume of small cube is $\frac{1}{10^{12}}cm^3$ i.e. $10^{-12}cm^3$. Side is $\sqrt[3]{10^{-12}}=10^{-4}cm$. Total surface area is $6\times10^{-4}\times10^{-4}\times10^{12}=6\times10^{4}cm^2$)

S.No	PROPERTY	COLLIDAL SOLUTIONS	TRUE SOLUTIONS
1	State	Two phase system	One phase system
2	Particle Size	1mμ – 1μ	< 1μ
3	External appearance	Generally clear or opaque partially	Very clear
4	Separation of solute(dispersed phase) particles by filtration	Partially possible	Not possible
5	Separation of solute(dispersed phase) particles by ultra filtration	Possible	Not possible
6	Settling of solute centrifugation	Possible	Not possible
7	Diffusion of particles	Diffuses slowly	Diffuses rapidly
8	Nature of system	Heterogeneous	Homogeneous
9	Tyndall effect	It shows	Does not show

Dispersed Phase: The substance which is in smaller proportion and is distributed as the colloidal particles in the colloidal solution is known as dispersed phase.

The dispersed phase can be a gas, liquid (or) solid.

Dispersion Medium: The continuous phase of the heterogeneous colloidal solution, in which the colloidal particles are dispersed is called dispersion medium.

- Dispersion medium can be a gas or a liquid or a solid
- Gas in gas system doesnot form a colloidal solution.
- The dispersion medium in colloidal solution is named as lyo (solvent), hence the colloidal solutions are named as **lyo sols**.
- If the dispersion medium is air, colloidal solutions are named as **aerosols**.
- If the dispersion medium is water, these are named as **hydrosols** (or) **aqua sols**.
- If the dispersion medium is alcohol the sol is called **"alcosol"**

Types of colloidal system based on Physical state of Dispersed phase and Dispersion medium.

Dispersed Phase	Dispersion Medium	Type of Colloid	Examples Some
Solid	Solid	Solid sol	Coloured glasses and gem stone
Solid	Liquid	Sol	Paints, Cell Fluids
Solid	Gas	Aerosol	Smoke, dust
Liquid	Solid	Gel	Cheese, butter, Jellies
Liquid	Liquid	Emulsion	Mik,hair cream
Liquid	Gas	Aerosol	Fog, mist,Cloud, insecticide sprays
Gas	Solid	Solid Sol	Pumice stone, foam rubber
Gas	Liquid	Foam	Froth, whipped cream, soap lather

Smoke :

- Is a lyophobic sol.
- This is a solid in gas sol.
- dispersed phase : Carbon particles
  dispersion medium : air (Aerosol)

Cloud: It is a lyophobic sol.

- It is liquid in gas sol.
  dispersed phase: water drops dispersion medium : air (Aerosol)

Blood : It is lyophilic sol

- It is a solid in liquid sol.
- dispersed phase is albuminoid substance (RBC: erythrocytes)
  dispersion medium:Water(Aquasol)

Milk: It is lyophilic sol .
It is liquid in liquid type of colloid
Disperse phase : Liquid fat
Dispersion medium : water(Aquasol)

Starch Solution: It is lyophilic sol.

- It is a solid in liquid sol.

Disperse phase : starch
Dispersion medium :water(Aquasol)

Gold sol: It is a lyophobic sol

- It is a solid in liquid sol.

Disperse phase: Gold particles
Dispersion medium : water (aqua sol)

Classification based on Nature of Interaction between dispersed phase and dispersion medium Lyophillic Sol

- If great affinity exists between the dispersed phase and the dispersion medium it is called lyophillic sol.
- These are called solvent -loving collodial solutions.
- High molecular weight carbon compounds form lyophillic sol
- These are very stable and cannot be coagulated easily.
- An important characteristic of these sols is that if the dispersion medium is separated from the dispersed phase (say by evaporation), the sol can be reconstituted by simply remixing the dispersed phase with the dispersion medium. That is why these sols are also called reversible sols.

Eg: starch solution, aqueous protein solutions, polymer solutions.

Lyophobic Sol: If there is low affinity existing between the dispersed phase and dispersion medium it is called **lyophobic sol.**

- These are called solvent hating colloidal solutions.
- Low molecular weight inorganic substances form lyophobic sol.
- These are not very stable
- Lyophobic colloids needs stabilising agents for their preservation.
- These sols are readily precipitated (or coagulated) on the addition of small amounts of electrolytes.
- The precipitate does not give back the colloidal sol by simple addition of the dispersion medium to it. Hence, these sols are also called irreversible sols.

Classification of Colloids based on the type of particles of dispersed Phase

- **a) Multimolecular colloids :** On dissolution, a large number of atoms or smaller molecules of a substance aggregate together to form species having size in the colloidal range (diameter >1nm). The species thus formed are called multimolecular colloids.

Ex: A gold sol many contain particles of various sizes having many atoms, sulphur sol.(S_8)

- **b) Macromolecular colloids :**

Macromolecules in suitable solvents form solutions in which the size of the macromolecules may be in the colloidal range such systems are called macromolecular colloids.

Ex : Starch, cellulose, proteins and enzymes, polythene, nylon, polystyrene, synthetic rubber etc.

- **c) Associated colloids (Micelles):** There are some substances which at low concentrations behave as normal strong electrolytes, but at higher concentration exhibit colloidal behaviour due to the formation of aggregates The aggregated particles thus formed are called micelles. These are also known as associated colloids.The formation of micelles takes place only above a particular temperature called **kraft temperature** (T_k) and above a particular concentration called **critical micelle concentration (CMC).** On dilution, these colloids revert back to individual ions.

Ex : Surface active agents like soaps and synthetic detergents.

- For soaps the CMC is 10^{-4} to 10^{-3} mol L^{-1}.

Micelles : A colloidal sized particle (aggregate) formed in water by the association of normal simple molecules, each having a hydrophobic end and a hydrophillic end is micelle.

- A colloid in which the dispersed phase consists of micelles or aggregated colloidal particles is an associated colloid.
- Substance whose molecules aggregate spontaneously in a given solvent to form large particles of colloid dimensions are called associated colloids.

- Ordinary soap, synthetic detergents dissolved in water belong to this class.
- Micelles contain generally as many as 100 or more molecules of the substance forming the micelle.

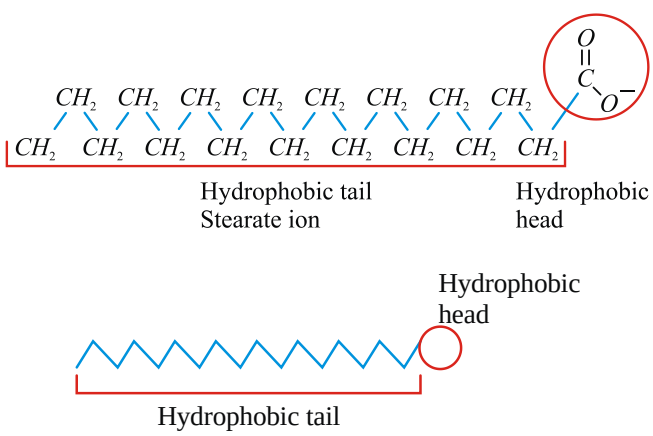
Mechanism Of Micelle Formation

Ex:Soap

- Sodium stearate (soap) with the formula $C_{17}H_{35}COONa$ is one example which forms micelles.
- Stearate ion $\{CH_3(CH_2)_{15}CH_2.COO^-\}$ contains at its ends a hydrophobic group (alkyl group end) and a hydrophilic group (carboxylate ion end)
- **Working of soap (micelles):** The COO^- group has an affinity for water. It is therefore called hydrophilic group and is called head of the stearate anion
- The hydrocarbon chains of the anion has an affinity for grease, oil or dirt. This is the hydrophobic part of the ion and is called tail of the anion. The tail part dissolves the grease or dirt.

Cleaning Action of Soap : The cleaning action of soap is due to the fact that soap molecules form micelle around the oil droplet in such a way that hydrophobic part of the stearate ions is in the oil droplet and hydrophilic part projects out of the grease droplet like the bristles.

- Since the polar groups can interact with water, the oil droplet surrounded by stearate ions is now pulled in water and removed from the dirty surface.
- Thus soap helps in emulsification and washing away of oils and fats. The negatively charged sheath around the globules prevents them from coming together and forming aggregates.



Preparation of colloidal solutions

Lyophobic sols and lyophilic sols are prepared by different methods.

Preparation of lyophobic sols

The methods employed are :

I) Condensation methods

II) Dispersion methods.

III) Chemical method

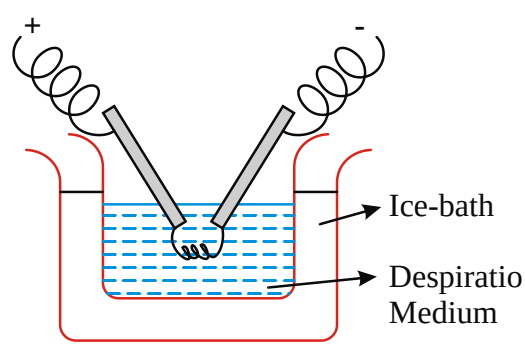
IV) Peptization

I) Condensation methods: In these methods small ions or molecules are induced to combine together to form aggregates of colloidal size either by using chemical or physical methods.

II) Dispersion methods: Here lumps of the substance is broken down to colloidal size in presence of dispersion medium and suitable stabilizer.

- **Mechanical Dispersion:** In this method colloid mill, ball mill or ultrasonic disintegrater are used.

Bredig's arc method (Electrical disintegration)



- An arc is struck between two metal electrodes of silver, gold or platinum held at the surface of cold water containing traces of alkali when sol of metal is obtained.

  Purple of cassius a colloidal sol of gold is obtained.
- Gold sol is prepared by Bredig arc's method
- Alkali stabilises the gold sol, but electrolytes destabilises it.
- The gold sol is coloured blue if the particle size is big and is coloured red when the particle size is small.

III) Chemical methods:

- **Double Decomposition:** An arsenic sulphide (As_2S_3) sol is prepared by passing H_2S through cold solution of As_2O_3 till yellow colour deepens to its maximum

$$As_2O_3 + 3H_2S \rightarrow As_2S_3(sol) + 3H_2O$$

- **Oxidation:** A sol of sulphur is prepared by passing H_2S into solution of SO_2

$$2H_2S + SO_2 \rightarrow 2H_2O + 3S\downarrow$$

- **Reduction:** Gold, platinum and silver sols are prepared by reduction of their compounds in water by using formaldehyde (or) hydrogen or tannic acid.

$AgNO_3$ + Tannic acid $\rightarrow$ Ag Sol

$AuCl_3$ + Tannic acid $\rightarrow$ Au Sol

$$2AuCl_3 + 3HCHO + 3H_2O \rightarrow 2Au + 3HCOOH + 6HCl$$

- **Hydrolysis:** Ferric hydroxide sol is prepared by pouring dilute solution of ferric chloride into boiling water

$$FeCl_3 + 3H_2O \rightarrow \underset{\text{Red sol (Positive in nature)}}{Fe(OH)_3} + 3HCl$$

Sols of chromium and aluminium can also be prepared by this method.

- **Change of solvent:** When ethanolic solution of **sulphur** is added to an excess of water, the sol of **sulphur** is obtained. This is physical method.

IV) Peptization:

The process of conversion of a precipitated substance into colloidal solution by the addition of a small amount of electrolyte is called **peptization.**

- The electrolyte used for the peptization process is called **peptizing agent**.
- During peptization the precepitate adsorbs one of the ions of electrolyte on its surface. This causes the development of positive or negative charge on precipitate which ultimately breakup to colloidal particle.

(i) Ferric hydroxide $Fe(OH)_3$ is peptized by ferric chloride giving positive sol. of $[Fe(OH)_3]Fe^{3+}$

(ii) Silver chloride $AgCl$ is peptized by HCl giving negative sol of $(AgCl)Cl^-$

(iii) Cadmium sulphide CdS is peptized by H_2S giving negative sol of $[CdS]S^{-2}$

(iv) Cellulose nitrate is peptized by a mixture of ethanol and water. The product obtained is called "COLLOIDION".

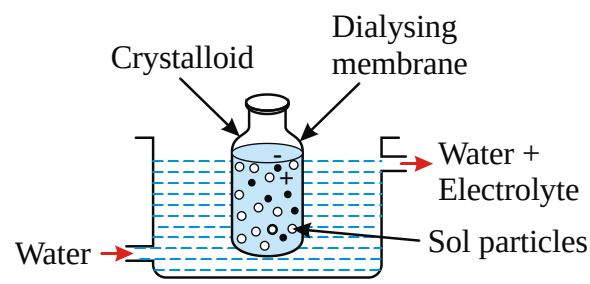
Purificaion of Colloidal Solutions

- Generally colloidal solutions associate with excessive amount of electrolyte and some other soluble substances, which act as impurities.
- The process of removal of impurities from colloidal solution is known as purification of colloids.

Colloidal solutions can be purified by the following methods.

a) Dialysis b) Electrodialysis c) ultrafiltration

a)Dialysis: The process of removal of dissolved substance (Impurities) from a colloidal solution by means of diffusion through a suitable membrane iscalled dialysis.



W.E-3: ***How to save a patient suffering from kidney failure?***

Sol. Blood is a colloidal solution. In case of kidney failure, blood cannot be purified. Under such conditions, the blood is separated from dissolved toxic impurities by dialysis and reintroduced in the blood stream.

b) Electro dialysis: Ordinarily the process of dialysis is slow. It can be made faster by electrodialysis.

- **Definition:** If dialysis is carried out in presence of electric field is called electro dialysis.

This method is used only when colloidal solutions possess electrolytic impurities

c) Ultra filteration: The process of seperating the collidal particles from the solvent and soluble solutes present in the colloidal solution by specially prepared filters (ultra filter) known as ultra filteration.

- The pore size of ordinary filter paper can be reduced by impregnating with **colloidion** solution to stop the flow of colloidal particles
- Colloidion is a 4% solution of nitro cellulose in a mixture of alcohol and ether.
- Ultrafilter paper may be prepared by soaking the filter paper in a colloidion solution, which is then hardened by formaldehyde.

Properties of colloids: The charge on the colloidal particle (disperse phase) is usually taken as the charge of the colloid

Properties are classified into Five types:

A) Optical properties (size of the colloidal particles)

B) Kinetic properties (random motion of the particles)

C) Electrical properties (charge on the colloidal particle)

D) Colour.

E) Colligative properties.

Tyndall Effect: It is an optical property

- The phenomenon of the scattering of light by the colloidal particles is called **Tyndall effect**
- The illuminated beam or cone formed by the scattering of **light by** the sol particles is reffered as Tyndall beam or **tyndall cone.**
- Tyndall effect is observed only when

a) The diameter of the dispersed particles is not much smaller than the wave length of light used

b) The refractive indices of the dispersed phase and dispersion medium differ greatly in magnitude

Examples of Tyndall Effect

a) Blue appearance of sky and sea water

b) Visibility of tails of comets

Brownian Movement (Kinetic Property)

a) The continuous rapid zig - zag movement executed by colloidal particle in a liquid dispersion medium is called Brownian motion.

b) All collodial particles in colloidal solution exhibits Brownian motion.This is due to bombardment of the particles of the dispersion medium on the particles of dispersed phase.

c) Brownian motion is independent of the nature of colloid but depends on the size of the particles and viscosity of solution

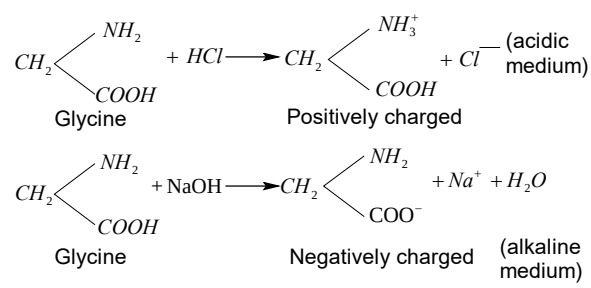
d) Smaller the size and lesser the viscosity, faster is the motion of colloidal particles

e) Brownian movement increases with rise in temperature

Electrical properties

- **Presence of charge:** All the particles of dispersed phase carry a positive or negative charge and dispersion medium carry the opposite charge. sol as a whole is neutral. The origin of the charge may be due to electron capture by sol particles during electrodispersion of metals, due to **preferential adsorption** of ions from solution and / or due to formulation of electrical double layer.
- The charge on the sol particles is due to one or more of the following reasons.

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



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

Examples:

Colloidal sol	Isoelectric pH
Haemoglobin	4.3-5.3
Casein from human milk	4.1-4.7
Gelatin	4.7

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

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

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

iv) Due to preferential adsorption of ions: This is the most accepted view. The sol particles acquire positive or negative charge by preferential adsorption of +ve or -ve ions. **When two or more ions are present in the dispersion medium, preferential adsorption of the ion common to the colloidal particle usually takes place.** This can be explained by taking the following examples.

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

AgI / I^-	AgI / Ag^+
Negatively charged	Positively charged

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

$$\underset{\text{Positively charged}}{Fe_2O_3 xH_2O / Fe^{3+}}$$

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

$$\underset{\text{Negatively charged}}{Fe_2O_3\, xH_2O / OH^-}$$

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

$$SnO_2 + 4H^+ \rightarrow Sn^{4+} + 2H_2O$$

$$SnO_2 + Sn^{4+} \rightarrow \underset{\text{Positive colloid}}{[SnO_2]Sn^{4+}}$$

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

$$SnO_2 + 2OH^- \rightarrow SnO_3^{2-} + H_2O$$

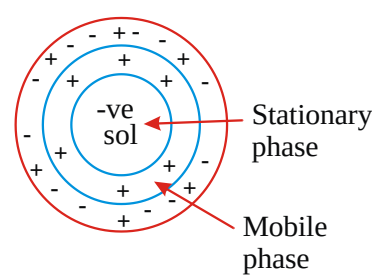
$$SnO_2 + SnO_3^{2-} \rightarrow \underset{\text{Negative colloid}}{[SnO_2]SnO_3^{2-}}$$

- **Frictional electrification** is due to rubbing of particles of dispersed phase with particles of dispersion medium.
- **Positively Charged Sols Negatively Charged Sols**

Positively charged sols	Negatively charged sols
Hydrated metallic oxides, E.g., $Al_2O_3.xH_2O$ $CrO_3.xH_2O$ and $Fe_2O_3.xH_2O$, etc Oxides, e.g., TiO_2 sol	Metals, e.g., copper, silver, gold sols. Metallic sulphides, e.g., As_2O_3, Sb_2S_3, CdS sols
Basic dye stuffs, e.g., methylene blue sol.	Acid dye stuffs, e.g., eosin, congo red sols.
Haemoglobin (blood)	Sols starch, gum, gelatin, clay, charcoal, etc.,

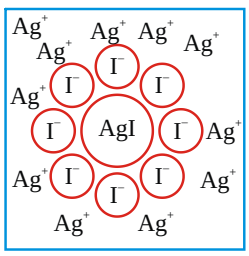
Helmholtz electrical double layer

- The each sol particle is surrounded by either positive or negative ions in the form of fixed layer or compact layer. The second layer is diffuse or mobile layer consisting of ions of both the signs but net charge being equal and opposite to the fixed layer. This is known as Helmholtz electrical double layer.
- **Zeta potential:** The potential difference developed between the two layers is known as zeta potential or electric kinetic potential.

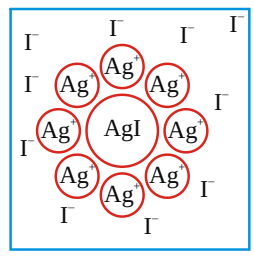


➢ **Electrophoresis:** The movement of sol particles under an applied electric potential is called electrophoresis or *cataphoresis*. The phenomenon helps in

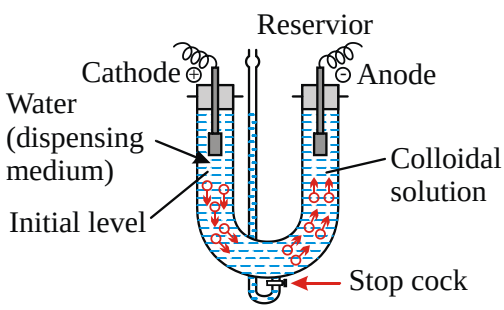
(a) Removing suspended impurities
(b) Removing smoke from chimney gases
(c) Electroplating of rubber
(d) Painting metals with colloidal pigments
(e) Coagulation of sols
(f) determination of charge



AgI / I^- negatively charged sol



AgI / I^+ positively charged sol



➢ **Electro-Osmosis:** The movement of the dispersion medium under the influence of applied electric potential is known as electro osmosis. The phenomenon helps in

(a) removing water from peat (Coal)
(b) dewatering of moist clay
(c) drying dye pastes.

➢ **D) Colour:** The colour of colloidal solution depends on the wavelength of light scattered by the dispersed particles. The wavelength of light scattered further depends on the size and nature of the particles. The colour of colloidal solution also changes with the manner in which the observer receives the light. For example, a mixture of milk and water appears blue when viewed by the reflected light and red when viewed by the transmitted light. Finest gold sol is red in colour; as the size of particles increases, it appears purple, then blue and finally golden.

➢ **E) Colligative Properties:** Colloidal particles being bigger aggregates, the number of particles in a colloidal solution is compartively small as compared to a true solution. Hence, the values of colligative properties (osmotic pressure, lowering in vapour pressure, depression in freezing point and elevation in boiling point) are of small order as compared to values shown by true solutions at same concentrations.

Coagulation of colloidal solution

a. The precipitation of colloidal particles by adding a suitable electrolyte is called coagulation (or) flocculation.
b. The particles of the colloidal solutions possess electrical charge i.e., positive or negative
c. Because of the presence of charge on the colloidal particles, which can be converted into precipitation by the addition of electrolyte (oppositely charged ion)
d. The ion which responsible for the coagulation of colloid solution is known as effective ion or active ion.
e. The effectiveness of an ion or electrolyte in causing coagulation is dependent on the charge sign and charge magnitude. This fact is enunciated by Hardy and Schulze.
f. At lower concentration of electrolyte flocculation takes place and can be reversed by shaking. At higher concentration, **coagulation** takes place and the process cannot be reversed simply by shaking.

Hardy - Schulze law

1. The ion with charge opposite to the charge of the colloidal particles is effective in coagulating the colloid
2. Greater the charge of the ion, greater is the coagulating ability of the ion

➢ Positive colloids are coagulated by negative ions or anions of the salt added.

a) $Cl^- < SO_4^{-2} < PO_4^{-3}$

b) $[Fe(CN)_6]^{4-} > PO_4^{3-} > SO_4^{2-} > C\bar{l}$

Negative colloids are coagulated by positive ions or cations of the salt added. a) $K^+ < Ba^{+2} < Al^{+3}$

➢ Blood is positively charged sol (pH=7.4) and is coagulated by alum, $Al_2(SO_4)_3$ and $FeCl_3$. These salts lower the pH and denaturate globular proteins.

Flocculation value (or) Precipitation value (or) Flocculation value

- It is the minimum amount of the electrolyte in millimoles that must be added to one litre of the colloidal sol to bring about complete coagulation or precipitation

Smaller is the flocculation value of an electrolyte, greater is its coagulating or precipitating power.

Coagulating power is inversely proportional to coagulation or flocculation value.

The relative coagulating powers of two electrolytes for the same colloidal sol, we have the relation

$$\frac{\text{Coagulating power of electrolyte 1}}{\text{Coagulating power of electrolyte 2}} = \frac{\text{Coagulation value of electrolyte 2}}{\text{Coagulation value of electrolyte 1}}$$

Coagulation can also be caused by electrophoresis, mutual precipitation (mixing colloidal sols of opposite charge), prolonged dialysis or by heating or cooling the sol.

Protective colloids & Gold Number

- Lyophobic sols are less stable than lyophilic colloids
- On addition of electrolytes lyophobic colloids are precipitated. This phenomenon is called coagulation or flocculation
- Positively charged colloid is coagulated by negative ion and negatively charged colloid is coagulated by the positive ion of the added salt
- The coagulating effect is more when the charge of the ion is more
- A lyophobic sol can be protected from coagulation by adding a lyophilic colloid to the lyophobic sol
- The lyophilic sol added is called protective colloid or protective agent
- Zigmondy introduced the term gold number to measure the protective power of different colloids
- Weight in milligrams of a protective colloid which prevents the coagulation of 10 ml of a given gold solution on adding 1 ml of a 10 % solution of sodium chloride is called **gold number.**
- Smaller the gold number of a lyophilic colloid, greater is its protective power
- In the given examples

Gelatin is the most effective protective colloid and starch is the least effective protective colloid

- Gold numbers of some protective colloids

Protective colloid	**Gold number**
Gelatin	0.005-0.01
Haemoglobin	0.03 - 0.07
Caesin	0.01 - 0.02
Albumin	0.1 - 0.2
Gum Arabic	0.15 - 0.25
Potato Starch	25

W.E-4: ***One gram of charcoal adsorbs 100ml of 0.5M CH_3COOH to form a monolayer and thereby the molarity of acidic acid is reduced to 0.49M. Calculate the surface area of the charcoal adsorbed by each molecule of acetic acid (surface area of charcoal is $3.01\times10^2 m^2/g$)***

Sol. Number of moles of acetic acid before the adsorption $= 0.5\times\frac{100}{1000} = 0.05$

Number of moles of acetic acid after the adsorption $= 0.49\times\frac{100}{1000} = 0.049$

Number of moles of acetic acid adsorbed $= 0.05 - 0.049 = 0.001$

Number of molecules of acetic acid adsorbed $= 0.001\times6.023\times10^{23} = 6.023\times10^{20}$

Surface area of the charcoal occupied by each acetic acid molecule

$$= \frac{3.01\times10^2}{6.023\times10^{20}} = 5\times10^{-19} m^2$$

W.E-5: ***For the coagulation of 100ml of arsenious sulphide solution, 5ml of 1M NaCl is required. Calculate the flocculation value.***

Sol: Number of millimoles of electrolyte $NaCl$ required to coagulate 100ml of sol $= 1\times5 = 5$

Number of millimoles of electrolyte required to coagulate 1000ml of sol $= 5\times\frac{1000}{100} = 50$

The minimum number of moles of electrolyte per litre required to cause precipitation is called flocculation value. Flocculating value of

$NaCl = 50$milli mole $L^{-1} = 0.05\, mol\, L^{-1}$

Emulsions: The dispersion of finely divided liquid droplets in a immiscible liquid dispersion medium is defined as emulsion.

- Generally, in emulsion one of the liquids is water and the other is a liquid immiscible with water generally oils.
- When a mixture of water and oil is shaken thoroughly, an emulsion is formed
- Milk is a naturally occuring emulsion in which the liquid fat is dispersed in water.
- Milk: Liquid fat (oil) in water
  Vanishing cream: fat in water
- **Oil in water (O/W) type Emulsions:** If the dispersed phase is oil and the dispersion medium is water, it is called oil in water emulsion. milk, vanishing cream are examples.
- **Water Oil (W/O) Emultion:** In these the dispersed phase is water and the dispersion medium is oil. Greases, codliver oil, cold cream, butter and creams are examples.
- Stiff greases: Water in lubrication oils
  Cod liver oil: Water in cod liver oil.
  Cold cream: Water in fat
- The third substance added in small amounts to an emulsion to keep the emulsion stable is known as **emulsifier or emulsifying agent**.

  Eg: Soaps, egg albumin, solid Hg I_2, graphite powder, caesin, gelatin etc.
- For kerosene in water emulsion, soap is emulsifier
- For an olive oil in water emulsion, Egg albumin is emulsifier
- Solid mercuric iodide is emulsifier for water in benzene emulsion.
- Soap emulsifies o/w type emulsion
- **Casein and silica emulsifies oil in water emulsion.**
- **Soaps & Graphite powder act as an emulsifying agent for both types collides.**
- The emulsifier reduces the surface tension on the side of one liquid and this roles into droplets.
- The emulsifying agent forms an interfacial film between suspended particles and the medium.
- The principal emulsifying agents for o/w emulsions are proteins, gums, natural and synthetic soaps etc. & for w/o emulsions, heavy metal salts of fattyacids, long chain alcohols, lamp black etc.
- The droplets in emulsions are often charged and can be precipitated by electrolytes. They also show Brownian movement and Tyndall effect.
- Emulsions can be broken into constituent liquids by heating, freezing, centrifuging etc.

Applications of Emulsions

- In washing process of clothes and crockery.
- In the digestion of fats in intestines. A little amount of fat in the intestines forms a soap with alkaline solution of intestines. This soap emulsifies the rest of the fat.
- As lotions, creams and ointments in pharmaceuticals and cosmetics.
- As drugs of oily type in the form of emulsions to facilitate their easy absorption.
- In the metallurgy, concentration of ores is carried out through emulsification process.
- In the conversion of cream into butter by churning. This is breaking of emulsion of fats in water.
- In natural oil wells, oils and water form emulsions. Hence de-emulsification is necessary.
- **Stability of sols**: It is mainly due to two factors
  (i) Presence of like charge: On sol particles. It prevents them from aggregating and settling down under the influence of gravity.
  (ii) Solvation of sol particles: In case of lyophilic sols a protective layer of solvent is formed around sol particles in addition to charge. Hence they are more stable than lyophobic sols.

Gels: The liquid solid system is called gel. They are of two types

- **(a) Elastic gels:** They can be temporarily deformed by applying force.
  Ex: Gelatin, starch and soaps.
- **(b) Non elastic gels:** They are rigid
  Ex : silica gel.

Applications of colliods

(1) Industrial applications

- **(a) Purification of drinking water:** By adding alum, the suspended impurities in water are coagulated and removed.
- **(b) Electrical precipitation of smoke:** Cottrell's precipitator, Smoke carry negative charge and is removed by the principle of electrophoresis in cottrell's precipitator.

- **(c) Sewage disposal:** It is passed through big tanks fitted with electrodes. The colloidal particles lose their charge and settle down and removed.
- **(d) Electroplating of rubber:** Latex is colloidal suspension of negatively charged rubber particles in water and can be deposited on metals by electrophoresis.
- **(e) Artificial rains:** Clouds are aerosols (water dispersed in air). Aggregates of particles of water cause the rain fall which can be artificially achieved by throwing electrified sand or AgI on clouds and cause the artificial rain. AgI has similar crystal structure as that of ice.
- **(f) Leather tanning:** Skin of animals is positively charged colloidalsystem. Extract of barks, wood leaves is negatively charged colloidal solution of tannin. When latter is applied on the surface of skin (leather). This results in the hardening of leather. This process is called tanning. Chromium salts are used in place of tannin.
- **(g) In warfare:** Animal charcoal is used in gas masks to adsorb poisonous gases. Smoke screens are titanium oxide particles dispersed in air.
- **(h) In everday life:** Blood, milk, butter, cheese, clothes, shoes all are colloidal system.
- **(i) In medicines:** Colloidal medicines are easily adsorbed and assimilated hence are widely used. Colloidal antimony is effective medicine for kalazar. Blood is coagulated by $FeCl_3$. Colloidal sols of Ag (Argyrol and protargol) are used as eye lotions.
- **(j) In nature:** Blue colour of sky, tails of comets are due to scattering of light.
  Formation of deltas in rivers is due to coagulation of negatively charged sand particles by Na^+, Mg^{2+} etc present in sea water.
- **(k) Photographic plates and films:** Photographic plates or films are prepared by coating an emulsion of the light sensitive silver bromide in gelatin over glass plates or celluloid films.
- **(*l*) Blue colour of the sky :** Dust particles along with water vapour suspended in air, scatter blue light which reaches our eyes and hence the sky looks blue to us.
- **(m) Fog, mist and rain :** When a large mass of air containing dust particles, is cooled below its dewpoint, the moisture in the air condenses on the surfaces of these particles forming find droplets. these droplets being colloidal in nature continue to float in air in the form of mist or fog. Clouds are aerosols having small droplets of water suspended in air. On account of condensation in the upper atmosphere, the colloidal droplets of water grow bigger and bigger in size, till they come down in the form of rain. Sometimes, the rainfall occurs when two oppositely charged clouds meet.
  It is possible to cause aritificial rain by throwing electrified sand or spraying a sol carrying charge opposite to the one on clouds from an aeroplane.
- **(n) Blood :**It is a colloidal solution of albuminoid substances. The styptic action of alum and ferric chloride solution is due to coagulation of blood forming a clot which stops further bleeding.
- **(o) Soils :**Fertile soils are colloidal in nature in which humus acts as a protective colloid. On account of colloidal nature, soils adsorb moisture and nourishing materials.
- **(p) Formation of Deltas :**River water is a colloidal solution of clay. Sea water contains a number of electrolytes. When river water meets the sea water, the electrolytes present in sea water coagulate the colloidal solution of clay resulting in its deposition of clay with the formation of delta.
- **(q) Industrial products :**Paints, inks, synthetic plastics, rubber, graphite, lubricants, cement, etc., are all colloidal in nature.

Properties of gels (Additional information)

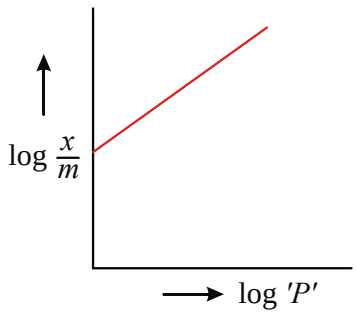
- **(a) Syneresis:** Shrinkage of gels on standing by exudation of solvent is known as syneresis
- **(b) Thixotropy:** Certain gels when shaken form a sol and on standing are converted into the form of gel They are known as thixotropic gels and sol-gel transformation is known as thixotropy.
- **(c) Swelling or Imbibition of gels:** The property of adsorbing definite amount of water and causing the volume of gel to increase is known as swelling or imbibition.

C.U.Q

Adsorption

1. **Activated charcoal is used in separating noble gases in Dewar's method. In this process activated charcoal acts as**
   1) Absorber 2) Adsorbent
   3) Adsorbate 4) Catalyst
2. **In a chemical reaction the solid catalyst function as**
   1) Adsorbent 2)Adsorbate
   3) Makes the reaction mixture homogeneous.
   4) Micelle
3. **Which statement is correct**
   1) Physical adsorption is multi-layered nondirectional and non-specific
   2) Chemical adsorption is unilayered
   3) Chemical adsorption is more stronger than physical adsorption.
   4) all the above
4. **Which of the following gases adsorb more**
   1) H_2 2) N_2 3) O_2 4) NH_3
5. **$\Delta G, \Delta H$ and ΔS for adsorption of a gas on a solid adsorbent are respectively**
   1) -,+,- 2) -,-, + 3) -,-,- 4) -,+,+
6. **Finely divided substance is more effective adsorbent because it has**
   1) Large surface area 2) Low surface area
   3) more liquifying nature 4) Less liquifing nature
7. **Role of Desorption in the process of catalysis**
   1) The surface is not available for the reaction to occur.
   2) Making the surface available again for more reaction to occur.
   3) Half of the surface is available for the reaction to occur.
   4) All of these
8. **Which of the following is correct for the decrease in the physical adsorption with increase of temperature**
   1) Adsorption process is exothermic, and according to Lechatelier principle, the physical adsorption decreases with increase in temperature.
   2) Physical adsorption is endothermic
   3) Physical adsorption occurs at high temperature
   4) All the above
9. **Surface layer of solid means**
   1) atoms present in the upper layer of the solid.
   2) atoms present upto a depth of 100 nm on the surface.
   3) atoms present in the bulk of the solid.
   4) atoms of surface of solid not preoccupied by other substances.
10. **The term sorption for the simultaneous adsorption and absorption is coined by**
    1) Berzelius 2)Mc'Bain
    3) Freundlich 4)Langmuir
11. **The rate of chemisorption**
    1) decrease with increase of pressure
    2) is independent of pressure
    3) is maximum at one atmospheric pressure
    4) increase with decrease of temperature
12. **Physical adsorption is appreciable at**
    1) high temperature 2) low temperature
    3) at room temperature 4) 100^0 C
13. **Chemical adsorption**
    1) decreases with increase of temperature
    2) increase with increase of temperature
    3) first increases and then decreases with increase of temperature
    4) first decreases and then increases with increase of temperature
14. **Pick out the wrong statement**
    1) Sols are homogeneous
    2) Colloids carry +ve or -ve charge
    3) Colloids show Tyndall effect.
    4) The size of colloidal particles range between 10 to 1000A^o
15. **Charcoal is activated**
    1) by cooling it from $143^0 K$ to $127^0 C$ in vacuum
    2) by cooling it to 23K in vacuum
    3) by heating it from 573K to 1273K in vacuum
    4) by heating upto 300K
16. **In adsorption of oxalic acid on activated charcoal, the activated charcoal is called**
    1) adsorbent 2) adsorbate
    3) catalyst 4) absorber

17. Freundlich adsorption isotherm is given by the expression $\frac{x}{m} = kp^{1/n}$. Then the slope of the line in the following plot is



1) $\sqrt{n}$ 2) $1/n$ 3) x/m 4) p

18. The phenomenon of simultaneous absorption and adsorption is called

1) Sorption 2) Desorption
3) Chemisorption 4) Absorption

19. Which of the following is not correct

1) Enthalpy of physical adsorption is less when compared to enthalpy of chemical adsorption
2) Milk is an example of emulsion
3) Physical adsorption increases with increase in temparature
4) Smoke is an aerosol

20. Which of the following cannot act as an adsorbent?

1) Siclica gel 2) Clay
3) Oxygen gas 4) Activated charcoal

21. The correct combination from the following given statements about chemisorption

I) It is unilayered adsorption
II) It is irreversible and takes place slowly
III) It occurs rapidly
The correct combination is

1) Both I and II are correct
2) Both II and III are correct
3) Both I and III are correct
4) All are correct

Catalysis

22. In Lead-Chamber process the catalyst is

1) NO only 2) NO_2 only
3) Mixture of NO & NO_2 4) N_2O_5

23. In Haber's process of Ammonia synthesis, the substance that acts as catalytic poison

1) Fe_2O_3 2) As_2O_3 3) CO_2 4) H_2S

24. Which of the following reactions is an example of heterogeneous catalysis?

1) $2CO_{(g)} + O_{2(g)} \xrightarrow{NO_{(g)}} 2CO_2$

2) $2SO_{2(g)} + O_{2(g)} \xrightarrow{NO_{(g)}} 2SO_3$

3) $2CO_{(g)} + O_{2(g)} \xrightarrow{Pt_{(s)}} 2CO_2$

4) $CH_3CHO_{(g)} \xrightarrow{I_2(g)} CH_4 + CO$

25. The optimum p^H range for the enzyme activity is

1) 4-5 2) 5-7 3) 7-9 4) <4

26. Which of the following reactions is an example of auto catalysis ? (E-M-2008)

1) $2AsH_{3(s)} \rightarrow 2As_{(s)} + 3H_{2(g)}$

2) $N_{2(g)} + 3H_{2(g)} \xrightarrow{Fe(s)} 2NH_{3(g)}$

3) $2SO_{2(g)} + O_{2(g)} \xrightarrow{NO_{(g)}} 2SO_{3(g)}$

4) $C_{12}H_{22}O_{11} + H_2O_{(l)} \xrightarrow{H^+(l)} C_6H_{12}O_{6(l)} + C_6H_{12}O_{6(l)}$

27. When an acid solution of oxalic acid at 80^0C is titrated with $KMnO_4$ solution, the first few drops of $KMnO_4$ are decoloured slowly but decolourisation occurs fast later. This is because

1) of increase in the concentration of CO_2 formed
2) one of the products Mn^{+2} acts as auto catalyst
3) both Mn^{2+} and K^+ ions act as auto catalyst
4) $KMnO_4$ catalyses the reaction at the later stages

28. The catalyst used to increase the dissociaiton of H_2O_2 is

1) Acetanilide 2) Glycerol
3) H_3PO_4 4) Caustic soda

29. Which of the following catalyst is used for preparing toluene by reacting benzene with methyl chloride?

1) Ni 2) Anhydrous $AlCl_3$
3) Pd 4) Pt

Colloids

30. The size of the colloidal particle ranges between

1) $10^{-2} - 10^{-3}$cm 2) $10^{-3} - 10^{-5}$ cm
3) $10^{-4} - 10^{-7}$ cm 4) $10^{-7} - 10^{-9}$ cm

31. Which of the following is a lyophobic colloidal solution [Eamcet -2004E]

1) Aqueous starch solution
2) Aqueous protein solution
3) Gold sol
4) Polymer solution in some organic solvents

32. $As_2O_3 + 3H_2S \rightarrow As_2S_3\,(Sol) + 3H_2O$, **the principle involved in the preparation of above colloidal solution**

1) Oxidation 2) Reduction
3) Double decomposition 4) Hydrolysis

33. A substance which forms micelles the solution contains

1) carboxylic group 2) alkyl groups
3) water insoluble long hydrocarbon groups and water soluble polar group .
4) water soluble hydrocarbon group and water insoluble polar group

34. The coagulation of colloidal particles of the sol can be caused by

1) Heating
2) Adding oppositely charged sol
3) Adding electrolyte
4) All the above methods

35. Finely divided substance is more effective adsorbent because it has

1) Large surface area 2) Low surface area
3) more liquifying nature
4) Less liquifying nature

36. Role of Desorption in the process of catalysis

1) The surface is not available for the reaction to occur.
2) Making the surface available again for more reaction to occur.
3) Half of the surface is available for the reaction to occur.
4) All of these

37. If dispersed phase is a liquid and the dispersion medium is a gas, the colloid is known as

1)aero sol 2)a gel
3)an emulsion 4) a foam

38. If a solid is dispersed in a liquid the colloid is called

1)lyosol 2)Emulsion
3)Gel 4)Aerosol

39. Which one among the following sols is hydrophobic (or lyophobic)

1)Sulphur 2) Gum 3)Starch 4)Gelatin

40. Which of the following is multimolecular colloid

1)Gelatin 2)Gold 3)Starch 4)Rubber

41. Peptization denotes

1) Digestion of food
2) Hydrolysis of proteins
3) Breaking and dispersion into the collodial state
4) Hydrolysis

42. Crystalloid and colloid can be distinguished by

1) Diffusion through membrane
2) Particle size
3) Chemical composition
4) Solubility

43. The number of phases in colloidal system is

1) 1 2) 2 3) 3 4) 4

44. The dispersed phase, dispersion media, and the nature of colloidal solution of gold sol respectively are

1) Solid, solid, Lyophobic
2) Liquid, liquid lyophobic
3) Solid, liquid,lyophobic
4) Solid, liquid, lyophillic

45. The characteristic property of detergent

1) is it contains both hydrophilic and hydrophobic groups
2) is it can act as an emulsifier
3) is it enables water and oily substances to form emulsions
4) all the above

46. During the cleaning action of soap-part of soap dissolves in the dirt and encapsulates to form micelle

1) both hydrophyllic and hydrophobic
2) hydrophyllic
3) hydrophobic 4) Cation

47. The hydrophobic end of lauryl sulphate is

1) $C_{17}H_{35}-$ 2) $C_{17}H_{33}-$
3) $C_{12}H_{25}-$ 4) $-OSO_3^-$

48. The simplest way to check whether a system is colloidal

1) Tyndall effect
2) Brownian movement
3) Electrodialysis
4) Finding out particle size

49. Which of the following is a non electrolytic colloidal sol

1) Starch 2) AgCl sol
3) Arsenic sulphide sol 4) $Sb_2S_3\ sol$

C.U.Q - KEY

1) 2	2) 1	3) 4	4) 4	5) 3
6) 1	7) 2	8) 1	9) 2	10) 2
11) 2	12) 2	13) 3	14) 1	15) 3
16) 1	17) 2	18) 1	19) 3	20)3
21)1	22) 3	23) 4	24) 3	25) 2
26) 1	27) 2	28)4	29)2	30) 3
31) 3	32) 3	33) 3	34) 4	35) 1
36) 2	37) 1	38) 1	39) 1	40) 2
41) 3	42) 1	43)2	44)3	45) 4
46) 3	47) 3	48) 1	49) 1	

C.U.Q- Hints

1. In Dewar's method activated charcoal acts as adsorbent.
2. In chemical reactions solid catalyst acts as adsorbent.
3. Physical adsorption is multi layered, chemisorption is mono layer, it is more stronger than physical adsorption.
4. Gases which can be liquified easily can be adsorbed easily and more.
5. $\Delta G = -ve$
9. Top most layer in which atoms present upto a depth of 100 nm on the surface.
10. MC'Bain
11. Chemical adsorption involves the formation of chemical bonds between adsorbate and adsorbent. Hence its rate is independent of pressure.
12. Physical adsorption is a weak adsorption and is appreciable at low temp.
13. Chemical adsorption first increases and then decreases with increase of temperature.
22. In Lead-chamber process catalyst is mixture of NO and NO_2.
23. Catalytic poison for Fe is H_2S.
24. Catalyst and reactants are different in their physical state.
26. In $2AsH_{3(g)} \rightarrow 2As_{(g)} + 3H_2$ reaction. 'As' acts as auto catalyst.
30. The size of the colloidal particle ranges between $10^{-4} - 10^{-7}$ cm.
31. In gold sol, less affinity exists between gold particle and water, hence it is lyophobic sol.
32. Double decomposition
33. A substance which forms micelles solution contains water insoluble long hydro carbon groups and water soluble polar group.
34. The coagulation of colloidal particles of the sol can be caused by heating (or) by adding oppositely charged sol (or) by adding electrolyte.
37. Aero Sol $\rightarrow$ D.P = liquid
D.M = gas
38. Lyosol in which D.M is liquid. and D.P is solid.
39. Hydrophilic $\rightarrow$ Gum, Starch, gelatin
Hydrophobic $\rightarrow$ Sulphur.
40. On dissolution large no.of atoms or smaller molecules of a substance aggregate together to form species having size in the colloidal range,is called multi molecular colloid. Ex: gold,sulphur
41. The process of conversion of precipitated substance in to colloidal solution is called peptization.

LEVEL-I (C.W)

Introduction-Adsorption

1. Adsorption is the phenomenon in which a substance

1) accumulates on the surface of other substance.
2) goes into the body of the other substances
3) remains close to the other substances
4) oxidises or reduces the other substances.

2. Adsorption is always

1) Endothermic
2) Exothermic
3) Accompanies with increase in entropy
4) accompanies with increase of enthalpy

3. **During adsorption**
   1) $T\Delta S$ is positive
   2) $\Delta H - T\Delta S$ is negative
   3) ΔH is positive
   4) $T\Delta S$ and ΔG becomes zero

4. **Which of the following gas molecules have maximum value of enthalpy of physisorption.**
   1) C_2H_6 2) Ne 3) H_2O 4) H_2

5. **Valence forces cause**
   1) Chemisorption
   2) physical adsorption
   3) sorption
   4) adsorption involving multi layer

6. **The forces operating between the adsorbate and the adsorbent in physical adsorption are**
   1) vander Waals forces 2)Chemical forces
   3) Covalent forces 4) All the three

7. **Which of the following is not a characteristic of chemisorption**
   1) Adsorption is irreversible
   2) ΔH is of the order of 80-240 K.J
   3) Adsorption is specific 4) Multilayered

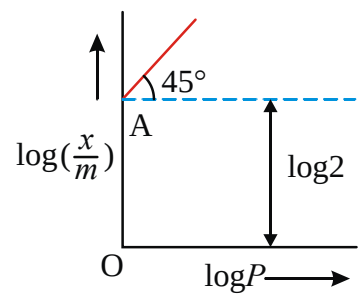
8. **The plot of** $\frac{x}{m}$ **Vs temperature at constant pressure is called**
   1) adsorption isotherm
   2) adsorption isobar
   3) adsorption isochore
   4) Freundlich isotherm

9. **The extent of adsorption from solution increases with**
   1)increasing the temperature
   2) increasing the surface area of the adsorbent
   3) decreasing the surface area of the adsorbent
   4) decreasing the concentration of the solute

10. **According to Freundlich adsorption isotherm, at high pressure, the value of** $\frac{x}{m}$ **is**
   1) directly proportional to pressure
   2) inversely proportional to pressure
   3) directly proportional to square of pressure
   4) independent of pressure

11. **Graph between** $\log\left(\frac{x}{m}\right)$ **and log P is a straight line at angle** 45^0 **with intercept OA as shown.**

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



   1) 2 2) 4 3) 8 4) 1

12. **Which of the following are used as good adsorbents in removing moisture and humidity**
   1) Silica gel 2) Aluminium gel
   3) Charcoal 1 and 2

13. **Heat evolved during chemisorption lies in the range of**
   1) 4-20 kJ/mole 2) 80-240 KJ/mole
   3) 20-40 KJ/mole 4)500-1000KJ/mole

14. **Which of the following can adsorb large volume of hydrogen gas**
   1. Pd 2. Ni 3. $Fe(OH)_3$ 4. Pt

Catalysis

15. **The temperature at which the catalytic activity of the catalyst is maximum is called**
   1) Critical temperature
   2) Room temperature
   3) Optimum temperature
   4) Absolute temperature

16. **The decomposition of** $KClO_3$ **is catalysed by**
   1) HCl 2) MnO_2 3) C_2H_5OH 4) Cl

17. **The efficiency of the catalyst depends upon**
   1) Molecular weight
   2) Physical state
   3) Number of free valencies
   4) Amount of catalyst used

18. $CO + H_2 \xrightarrow{X} CH_4 + H_2O$

$CO + H_2 \xrightarrow{Y} CH_3OH$

$CO + H_2 \xrightarrow{Z} HCHO$

X,Y and Z respectively are

1) $Cu; ZnO, CrO_2; Ni$ 2) $Cu; Ni; Cu$

3) $Ni; Cu$; ZnO, CrO_2 4) $Ni; ZnO, CrO_2; Cu$

19. Which of the following catalyst is sensitive to temperature changes

1)Fe 2) Pt 3)Ni 4) Enzyme

20. Which of the following exhibits specific activity in a catalytic reaction ?

1) Catalyst 2)Promoter

3) Catalyst poison 4)All the three

21. The auto catalyst in the decompostion of Arsene to Arsenic and H_2 is

1) As_2O_3 2) As 3) H_2 4) Ar

22. Which one of the following is not an example of homogeneous catalysis

1) Formation of SO_3 in lead chamber process

2) Formation of SO_3 in contact process

3) Hydrolysis of an ester in presence of an acid

4) Hydrolysis of sugar in presence of sulphuric acid

23. Which of the following is not involved in a heterogeneous catalysis

1) Adsorption of reactants.

2) Diffusion of reactants along the surface

3) Reaction at the active site to form adsorbed product.

4) Decomposition of the catalyst

24. Which is wrong in case of Enzyme Catalyst

1)Enzyme work best at an optimum temperature

2) Enzyme work at an optimum P^H

3) Enzymes are highly specific for substrate

4) an Enzyme raises activation energy

25. One molecule of an enzyme may transfer ___ Number of reactant molecules per second

1) one million 2) 10^{-6}

3) $\frac{10^6}{60}$ 4) 10^4

26. The active groups present in the cavities present on the surface of enzyme is

1) $-COOH$ 2) $-NH_2$

3) $-OH, -SH$ 4) All

27. Activators are generally metal ions, the catalytic activity of amylase increases in presence of

1) Na^+ 2) Co^{2+} 3) Cu^{2+} 4) Mn^{2+}

28. Which of the following is an example of Zeolite

1) ZSM-5 2) $AgNO_3$

3) $Mg(OH)_2$ 4) $Co(OH)_3$

29. The catalytic reaction that depends upon the pore structure of the catalyst and size of the reactant and product molecules is called

1) Size - selective catalyst

2) Shape - selective catalyst

3) Metal oxides

4) Transition metals

30. In the reaction

$2KMnO_4 + 3H_2SO_4 + 5H_2C_2O_4 \rightarrow$

$\text{Product}, Mn^{+2}$ acts as

1) Positive catalyst 2) Negative catalyst

3) Auto Catalyst 4) Induced catalyst

Colloids

31. Methylene bule sol

1)Negatively charged sol 2)Neutral

3)Positively charged sol 4)Both (1) & (3)

32. Which of the following is not a colloid

1) H_2SO_4 solution 2)Solution of urea

3)Chlorophyll 4)All

33. Sulphur sol is

1) Macromolecular colloid

2) Multi molecular colloid

3) Associated colloid 4) Micelle

34. Preparation of gold sol by below method is based on

$2AuCl_3 + 3HCHO + 3H_2O \rightarrow 2Au(sol) + 3HCOOH + 6HCl$

1) Hydrolysis 2) Double decomposition

3) Reduction 4) Oxidation

35. Bredig's arc method cannot be used for the preparation of collodial sol of
1) Copper 2) Gold 3) Silver 4) Sodium

36. In the preparation of ultra filter paper collodion solution is used , collodion is
1) 4% solution nitro cellulose in a mixture of alcohol and ether
2) 4% solution cellulose acetate in phenol
3) 8% solution cellulose acetate in alcohol
4) formaldehyde in water

37. Gold number is used to show
1) Protective power of lyophillic colloids
2) Protective power of lyophobic colloid
3) Peptisation power of a colloid
4) Precipitation power of a colloid

38. Protective sols are
1) lyophilic 2) lyophobic
3) both (1) and (2) 4) None of these

39. Incorrect statement about lyophobic colloids
1) They are readily precipitated by adding small amount of electrolyte
2) They can be prepared by special methods
3) They are irreversible
4) They do not required stabilizing agents for their preservation

40. Example for emulsion is
1)Vanishing cream 2)Curd
3)Ruby glass 4)Foam

41. Which of the following is the emulsifying agent for both O/W type and W/O type of emulsions
1) Soaps 2) Graphite powder
3) Proteins 4) Both 1 & 2

42. The colloidal aggregates of soap molecules formed in the solvent are called
1)Solid foam 2)Gel
3)Jellies 4)Micelles

43. If the dispersed phase is a liquid and the dispersion medium is a solid, the collodial system is known as
1) a Sol 2) an Emulsion
3) a gel 4) a foam

44. The cause of Brownian movement is
1) Heat changes in liquid
2) Conventional currents
3) Impact of molecules of the dispersion medium on the colloidal particles
4) Attractive forces between colloidal particles and molecules of dispersion medium

45. Incorrect statement about tyndall effect
1) It is an optical property
2) The diameter of dispersed particles should be very smaller than the wave length of light used
3) The refractive indices of the disperssed phase and dispersias medium differ greatly in magnitude
4) The apparatus set up based on tyndall effect is ultramicroscope

46. The colour of colloidal particles depends up on
1) Wave length of scattered light
2) size and shape of colloidal particles
3) The manner in which observer recieves the light
4) All

47. The apparatus used to coagulate carbon particles from smoke is called
1) cottrell smoker 2) cottrell precipitator
3) cottrell absorber 4) cottrell breaker

48. Artificial rain is caused by spray of
1) Electrified sand or salt
2) Neutral salt or sand
3) negatively charged sand or salt
4) postively charged sand or salt

49. Which colloid is used for Intramuscular injection.
1) silver sol 2) Gold sol
3) sulphur sol 4) Antimony sol

50. When freshly precipitated $Fe(OH)_3$ is boiled with water in the presence of few drops of $dil\ HCl$, a hydrated ferric oxide sol is obtained. This method is termed
1) Dialysis 2) Peptization
3) Ultrafiltration 4) Electro dispersion

51. On adding $AgNO_3$ solution into KI solution, a negatively charged colloidal sol is obtained when they are in

1) $100ml\ of\ 0.1M\ AgNO_3 + 100ml\ of\ 0.1M\ KI$

2) $100ml\ of\ 0.1M\ AgNO_3 + 100ml\ of\ 0.2M\ KI$

3) $100ml\ of\ 0.2M\ AgNO_3 + 100ml\ of\ 0.1M\ KI$

4) $100ml\ of\ 0.15M\ AgNO_3 + 100ml\ of\ 0.15M\ KI$

52. When lyophilic sols like starch is placed in electric field the sol particle will move

1) either towards anode nor cathode at iso-electric point

2) towards anode at P^H less than that of isoelectric point

3) towards Anode at P^H more than that of isoelectric point

4) Simultaneously towards anode & cathode with equal velocity

53. Stability of emulsions increases by adding

1) electrolyte 2) Acid

3) Base 4) Emulsifying agent

54. Which one has the highest coagulation power?

1) K^+ 2) Ca^{2+} 3) Al^{3+} 4) Sn^{4+}

55. The coagulation of colloidal particles of the sol can be caused by

1) Heating

2) Adding electrolyte

3) Adding oppsitely charged sol

4) All of these

KEY - LEVEL - I (C.W)

1) 1	2) 2	3) 2	4) 3	5) 1	6) 1	7) 4
8) 2	9) 2	10) 4	11) 2	12) 4	13) 2	14) 1
15) 3	16) 2	17) 3	18) 4	19) 4	20) 4	21) 2
22) 2	23) 4	24)4	25) 1	26) 4	27) 1	28) 1
29) 2	30) 3	31) 3	32) 4	33) 2	34) 3	35) 4
36) 1	37) 1	38) 1	39) 4	40) 1	41) 4	42) 4
43) 3	44) 3	45) 2	46) 4	47) 2	48) 1	49) 2
50)2	51) 2	52) 3	53) 4	54) 4	55) 4	

HINTS - LEVEL - I (C.W)

1. The phenomenon in which molecules of adsorbate accumulated on the surface of adsorbent, known as adsorption.
2. The process of adsorption is always exothermic.
3. Adsorption is a spontaneous process hence $\Delta G\, is - ve$ i.e $\Delta H - T\Delta S$ must be -ve
4. H_2O is a polarmolecule, possess more inter molecular force of attraction,and possess more liquifying nature.
5. Chemisorption involves valence forces (or) chemical bonds.
6. In physical adsorption; weak vanderwaals forces exist.
7. Because of the formation of chemical bond, chemisorption is unilayered.
8. Adsorption Isobar.
9. As the surface area of the adsorbent increases, the amount of solute adsorbed also increases.
10. $\frac{x}{m}$ doesn't depends on pressure.
12. Silica gel and aluminium gels act as adsorbents in removing moisture and humidity
13. Enthalphy charge for chemisorptioin is 40-400 kJ/mole.
14. Pd form non-stoichiometric compounds with H_2
15. The temperature at which the catalytic activity of the catalyst is maximum is called optimum temperature.
17. The efficiency of the catalyst depends upon no. of free valencies.
19. Enzymes are the biocatalysts which are sensitive to temperature.
20. The following substances exhibit specific activity in a catalytic reaction (a) catalyst (b) promotor
    (c) catalytic poison
21. Here 'As' is auto catalyst.
    $2AsH_3 \rightarrow 2As + 3H_2$
    n = valency of metal ion
22. $2SO_2(g) + O_2(g) \underset{\longleftarrow}{\overset{pt(s)}{\longrightarrow}} 2SO_3(g)$
23. Decomposition of the catalyst.
24. Enzymes acclerate the speed of reaction by decreasing the activation energy
28. ZSM-5(Zeolite Seive Molecular Porocity)
30. Mn^{2+} acts as a auto catalyst
31. Colloidal particle size $\rightarrow$ 10 - 10000A^0
32. Chlorophyll is not a colloid.
35. Bredig's arc method can not be used in the preparation of alkali or alkaline earth metals.
37. Gold number introduced to describe the protective nature of lyophilic colloids.

38. Lyophilic colloids are more stable.Hence they act as more stable colloids.
40. Vanishing cream.
42. Micelles $\rightarrow$ colloidal aggregates of soap.
43. In gel ,D.M = SOLID , D.P = LIQUID
44. Due to collisions of molecules of dispersion medium on the colloidal particles.
47. The electrically charged carbon particles of smoke can be coagulated by the precipitator called cottrell precipitator
48. Artificial rain is caused by the exposure of colouds to the electrified sand or salt
49. Gold sol
55. Coagulation power $\propto$ charge

LEVEL-I (H.W)

Introduction-Adsorption

1. When adsorption of Oxalic acid is carried out on activated charcoal, the activated charcoal is known as
1. adsorbate 2. adsorbent
3. absorbate 4. absorbent

2. Adsorption plays an important role in
1. Heterogeneous catalysis
2. Homogeneous catalysis
3. Positive catalysis 4. Negative catalysis

3. Adsorption explains all the following except
1. origin of charge on colloids
2. decolourization of sugar solution on charcoal
3. efficiency of finely divided metals as catalyst
4. action of enzymes

4. In a spontaneous adsorption process
1. ΔH is sufficiently negative
2. ΔH is positive
3. ΔH is zero 4. all the above

5. Separation of inert gases involves the process of
1) Absorption 2) Adsorption
3) Sorption 4) Chemisorption

6. Which is used to remove colour from raw cane sugar juice
1) Alumina 2) Silica gel
3) Animal charcoal 4) Nickel powder

7. Gas masks containing activated charcoal removes poisonous gases from atmosphere acts on the principle of
1) occulsion 2) desorption
3) Absorption 4) adsorption

8. Chromatographic analysis finds a number of applications in analytical and Industrial fields, based on the principle of _____
1) Chemical adsorption 2) Physical adsorption
3) Hydrogen bonding 4) Sedimentation

9. Taking up of impurities by charcoal is
1. absorption 2. Physical adsorption
3. Chemisorption 4. desorption

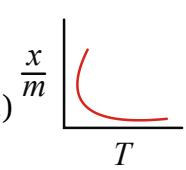
10. Which one of the following characteristics is not correct for physical adsorption?
1. Adsorption on solids is reversible
2. Adsorption increases with increase in temperature.
3. Adsorption is spontaneous
4. Both enthalpy and entropy of adsorption are negative

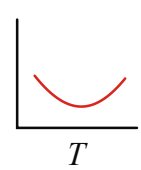
11. The gas which gets easily and extensively adsorbed at low temperature
1. H_2 2. CO_2 3. N_2 4. O_2

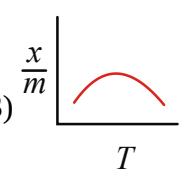
12. The higher the critical temperature of the gas
1) greater is its adsorption
2) lower its adsorption
3) lesser is the case of liquification
4) lesser is its volatile nature.

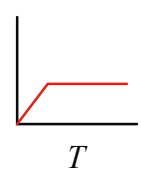
13. 50 ml of 1M oxalic acid is shaken with 0.5g of wood charcoal. The final concentration of the solution after adsorption is 0.5M. What is the amount of oxalic acid adsorbed per gram of charcoal.
1) 3.15 g 2) 3.45 g 3) 6.3 gm 4) 5.20 g

14. Which plot is the adsorption isobar for chemisorption ?

1) 

2) 

3) 

4) 

15. In Freundlich adsorption isotherm, the intercept is equal to
1. k 2. logk 3. $\frac{1}{n}$ 4. $\log\frac{x}{m}$

Catalysis

16. Tetra ethyl lead increases the anti knocking property of petrol. Here it acts as

1) Positive catalyst 2) Negative catalyst
3) Auto catalyst 4) Induced catalyst

17. The substance which reduce or even destroy the activity of a catalyst is called

1) Auto catalyst 2) Catalytic poison
3)Negative catalysis 4) Enzyme catalysis

18. Catalytic poison acts by

1) Its reaction with product
2) Its reaction with reactant
3) Getting adsorbed on the active centres of the catalyst
4) Coagulating the catalyst

19. In contact process of manufacture of H_2SO_4 in presence of Pt as catalyst, As_2O_3 acts as

1) Negative catalyst 2) Inhibitor
3) Catalytic poison 4) promoter

20. In a homogeneous catalysis the catalyst and the reactants are in the same

1)Condition 2) Phase 3)Energy 4)system

21. Catalyst used in the manufacture of HNO_3 by Ostwald's process is

1) Rh 2) Pd 3) Fe 4) Pt

22. The ability of the catalyst to direct the reaction to yield particular product is called

1) reactivity 2) selectivity
3) activity 4) fugacity

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

1) to form an enzyme -substrate complex
2) to decrease the bond energies of the substrate molecule
3) to change the shape of the substrate molecule
4) None of these

24. At what P^H and temp the enzymes are highly effcient.

1) $P^H = 5-7; 298-310K$
2) $P^H = 7-9; 298-310K$
3) $P^H = 7.2; 278-295K$
4) $P^H = 0;\ 273-283K$

25. Zeolites are good shape-selective catalysts because of

1) F.C.C. structure
2) Honey - comb like structure
3) Butterfly structure
4) B.C.C structure

26. Incorrect statement about zeolites is

1) Zeolites are shape selective catalysts
2) They have honeycomb like structure
3) They are 3 – D micro porous silicates containing Al - O-Si frame work
4) ZSM – 5 is used as catalyst for cracking and isomerisation of hydrocarbons

27. Autocatalyst in ester hydrolysis is -

1) C_2H_5OH 2) H^+
3) $C_2H_5COOCH_3$ 4) OH^-

Colloids

28. Peptization involves

1) Precipitation of colloidal particles
2) Disintegration of colloidal aggregates
3) Purification of colloids
4) Impact of molecules of the dispersion medium on the colloidal particles

29. Electro – osmosis is observed when

1) dispersion medium begins to move in an electric field
2) dispersed phase begins to move in an electric field
3) both (a) and (b)
4) No movement of particles

30. 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

1) the two sols will stabilize each other
2) the sol particles will acquire more electric charge
3) the sols will coagulate each other mutually
4) a true solution will be obtained

31. Which of the following has the largest protective power ?

1) Gelatin (Gold no. 0.01)
2) Dextrin (Gold no= 15)
3) Potato starch (Gold no=55)
4) Albumin (Gold no= 0.25)

32. For the preparation of ice cream we use gelatin

1) For stabilisation of mixture
2) For preventing to make a colloid
3) To increase the aroma
4) stabilise the colloid and prevent crystallisation

33. Emulsifier is a substance which

1)Coagulates the emulsion
2)Stabilises the emulsion
3)Homogenises the emulsion
4)Accelerates the dispersion of liquid in liquid

34. Select incorrect statement

1) Soap and detergent lower the interfacial surface tension between oil and water
2) Basic principle of peptization is reverse of coagulation
3) Soap and detergent used as emulsifiers
4) Lyophilic sols need stabilizing agent

35. Detergent is a

1) Soap 2) Drug
3)Catalyst 4) Cleaning agent

36. Which is not a gel ?

1) Cheese 2) Butter
3) Boot polish 4) Blood

37. About froth incorrect statement is

1) Gas in liquid 2) Foam
3) Aerosol 4) Colloid

38. Gelatin protects

1) gold sol 2) As_2S_3 sol
3) $Fe(OH)_3$ sol 4) All

39. In Brownian movement, the path followed by particles is

1) Linear 2) Zig- Zag
3) Circular 4) Curved

40. If a true solution is changed to colloidal solution its freezing point

1) Unchanged 2) Increases
3) decreases 4) May be 2or3

41. Milk can be preserved by adding few drops of

1) Formic acid solution
2)Formaldehyde solution
3) Acetic acid solution
4) Acetaldehyde solution

42. Some times rainfall occurs when oppositely charged clouds meet due to

1) Mutual coagulation 2) Electrophorosis
3) Dialysis 4) electro osmosis

43. Smoke precipitator works on the principle of

1) Centrifugation
2) Neutralization of charge on colloids
3) Absorption 4) Peptisation

44. Which one of the following constitutes irreversible colloidal system with water as dispersion medium?

1) Clay 2) Platinum
3) $Fe(OH)_3$ 4) All of three

45. Bredig's arc method is used for the preparation of colloidal solution of

1) Organic compounds
2) Metals like silver, gold etc
3) Two liquids
4) Inorganic compounds

46. The migration of positively charged colloidal particles, under an electrical field towards the cathode is called

1) cataphoresis 2)Electro-Osmosis
3) Sedimentation 4) Electrodialysis.

47. The coagulating power of an electrolytes for aresenious sulphide sol decreases in the order

1) $Na^+ > Al^{3+} > Ba^{2+}$ 2) $PO_4^{3-} > SO_4^{2-} > Cl^-$
3) $Cl^- > SO_4^{2-} > PO_4^{3-}$ 4) $Al^{3+} > Ba^{2+} > Na^+$

48. Which of the following detergents will be biodegradable?

1) Detergents having linear alkyl chain
2) Detergents having maximum branching
3) Both (a) and (b)
4) Neither (a) nor (b)

KEY - LEVEL - I (H.W)

1) 2	2) 1	3) 4	4) 1	5) 2	6) 3	7) 4
8) 2	9) 2	10) 2	11) 2	12) 1	13) 3	14) 3
15) 2	16) 2	17) 2	18) 3	19) 3	20) 2	21) 4
22) 2	23) 1	24) 1	25) 2	26) 4	27) 2	28) 2
29) 1	30) 3	31) 1	32) 4	33) 2	34) 4	35) 4
36) 4	37) 3	38) 4	39) 2	40) 2	41) 2	42) 1
43) 2	44) 4	45) 2	46)1	47) 4	48) 1	

HINTS - LEVEL - I (H.W)

1. Adsorption of oxalic acid is carried out on activated charcoal, activated charcoal is adsorbent.
2. Adsorption plays an important role in heterogeneous catalysis.
3. Engymes are biological living organisms. so that it is not related to Adsorption.
4. For spontaneous process ΔH is -ve.
5. In Dewar's method, separation of Noble gases involved adsorption.
6. Animal charcoal will decolourise the coloured matter.
7. Adsorption
8. Physical adsorption
9. Adsorption of impurities by the charcoal is due to physical adsorption.
10. Physical adsorption decreases with increase in temperature
11. Since critical temperature of the gas is high.
12. Higher the critical temperature of the gas the greater is the adsorption.
13. $\text{Mass of oxalic acid adsorbed on 0.5gms} = \frac{0.5\times126\times50}{1000} = 3.15\text{gr}$

    $\therefore$ Mass of oxalic acid adsorbed on 1 gram of charcoal = 6.3 grams
14. As the temperature increases, chemisorption increases first and then decreases.
15. Intercept is equal to log k.
16. It decreases the knocking in engines.
17. Catalytic poison
18. Getting adsorbed on the active centres of catalyst.
19. As_2O_3 acts as catalytic poison.
20. The catalysis in which catalyst and the reactants are in the same phase.
21. pt catalyst.
22. The ability of the catalyst to direct the reaction to yield particular product is called selectivity.
23. Enzymes have capacity to form an enzyme-substrate complex
25. Because of Honey-comb like structure
31. Value of gold no $\propto \frac{1}{\text{protective power}}$
32. Gelatin is a more stable lyophilic colloid, which is used to stabilise the unstable colloids and prevent them from crystallisation.
33. Emulsifier is a substance which stabilises the emulsion.
35. Detergent is cleaning agent
36. Blood is a colloidal solution contains D.M is water and D.P = albuminoid substance.
38. Gelatin is a lyophilic colloids which protects all lyophobic colloids.
39. The path followed by colloidal particles is zig-zag.
41. Formaldehyde is used in preserving milk.

5.SURFACE CHEMISTRY

LEVEL-II (C.W)

Adsorption

1. **2.56g of sulphur (colloidal sol) in 100ml solution shows Osmotic pressure of 2.463 atm at 27^0C. How many sulphur atoms are associated in colloidal sol? [Solution constant = 0.0821 atm. $mol^{-1}k^{-1}$]**
   1) 2 2) 4 3) 5 4) 8

2. **In "lake-test" of Al^{3+} ion, there is formation of coloured floating lake. It is due to**
   1) Adsorption of litmus by $Al(OH)_4^-$
   2) Adsorption of litmus by $Al(OH)_3$
   3) Adsorption of litmus by H_2O
   4) Absorption of litmus by $Al(OH)_4^-$

3. **Chromatography is a technique based on**
   1) adsorption and then dispersion of solute
   2) adsorbent's ability for preferential absorption
   3) hydration of solute
   4) evaporation of solute

4. **Calculate the surface area of a catalyst that adsorbs $10^3 cm^3$ of N_2 (reduced to STP) per gram in order to form the monolayer. The effective area occupied by N_2 molecule of the surface is $1.62\times10^{-15} cm^2$**
   1) $2520\times10^5 cm^2$ 2) $4350\ m^2$
   3) $3720\ m^2$ 4) $435\times10^5\ m^2$

5. **The volume of gases H_2, CH_4, CO_2 and NH_3 absorbed by 1g of charcoal at 288K are in the order**
   1) $H_2 > CH_4 > CO_2 > NH_3$
   2) $CH_4 > CO_2 > NH_3 > H_2$
   3) $CO_2 > NH_3 > H_2 > CH_4$
   4) $NH_3 > CO_2 > CH_4 > H_2$

6. **Which of the following processes of metallurgy involves adsorption?**
   1) Magnetic separation method
   2) Electrostatic separation method
   3) Gravity separation method
   4) Froth floatation process

Catalyst

7. **In which of the following process, a catalyst is not used**
   1. Haber process 2. Deacon's process
   3. Solvay process 4. Lead chamber process

8. **According to adsorption theory of catalysis the speed of the reaction increases because**
   1) The concentration of reactant molecules at the active centre of the catalyst becomes high due to adsorption
   2) In the process of adsorption the activation energy of the molecules becomes large
   3) Adsorption produces heat which increases the speed of the reaction
   4) Adsorption lower the reaction temperature

9. **Organic catalysts differ from inorganic catalysts**
   1. By acting at high temperature
   2. By acting at low temperature
   3. Being used up
   4. Being protenious in nature

10. **Which one of the following is not a homogeneous catalytic reaction ?**
    1) manufacture of H_2SO_4 by lead chamber process
    2) acid catalysed hydrolysis of ester
    3) inversion of cane sugar in the presence of mineral acid
    4) manufacture of H_2SO_4 by contact process

11. **Decomposition of urea into NH_3 and CO_2 is followed by the action of enzyme**
    1) urease 2) Pepsin
    3) Invertase 4) All of these

12. Which of the following enzyme is used in the conversion of proteins to Amino acids

1) urease 2) Diastase
3) Maltase 4) Pepsin

13. Zeolites are microporous alumino silicates with general formula

1) $M\ x/n\left[\left(Al_2O_3\right)_x\left(SiO_2\right)_4\right]mH_2O$

2) $M_x\left[\left(SiO_2\right)_4\right]mH_2O$

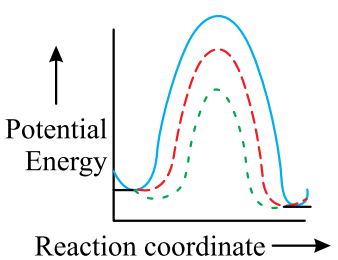
3) $M_x\left[\left(Al_2O_3\right)_x\left(SiO_2\right)_4\right]$

4) $M\left[\left(Al_2O_3\right)_x\right]mH_2O$

14. Zeolites are very important oxide catalyst used in

1) decomposition of Nitramide
2) mutarotation of glucose
3) Petroleum Industry in cracking
4) Hydrolysis of ester

15. In homogeneous catalytic reactions, there are three alternative paths *A*,*B* and *C* (shown in the figure). which one of the following indicates the relative ease with which the reaction can take place?



1) $A > B > C$ 2) $C > B > A$
3) $B > C > A$ 4) $A = B = C$

16. $CH_3COCl + H_2 \xrightarrow{Pd} CH_3CH_2OH$

$\xrightarrow[quinoline]{Pd/BaSO_4} CH_3CHO$ **here quinoline acts as**

1) + ve catalyst 2) Catalyst poison
3) Promoter 4) Medium

17. Air can oxidize sodium sulphite in aqueous soloution but not sodium arsenite. However, if air is passed through a solution containing both, then both are oxidized. This is an example of

1) auto-catalysis 2) positive catalysis
3) negative catalysis 4) induced catalysis

18. An example of auto-catalytic reaction is

1) The decomposition of nitroglycerine
2) Thermal reaction between $KClO_3$ and MnO_2
3) Break down of ^{14}C
4) Hydrogenation of vegetable oil using nickel catalyst

Colloids

19. A colloidal system in which gas bubbles are dispersed in liquid is known as

1) Foam 2) Sol 3) Aerosol 4) Emulsion

20. Butter is

1) Fat dispersed in milk
2) Fat dispersed in water
3) Water dispersed in fat
4) Water dispersed in oil

21. Which is a natural colloid

1) Nacl 2) Urea
3) Cane Sugar 4) Blood.

22. A colloidal system involves.

1) A state of dissolution
2) A state of dispersion
3) A state of suspension
4) Diffused state

23. Colloidal solution of gold prepared by different methods are of different colours because of

1) Variable valency of gold
2) Different concentration of gold particles
3) Impurities produced by different methods
4) different sizes of colloidal gold particles

24. Which of the following is macromolecular colloid

1) Nylon 2) cellulose
3) Proteins 4) all of these

25. Which one of the following is not a property of Hydro sols?

1) High concentration of dispersed phase can be easily attained.
2) Coagulation is reversible.
3) Viscosity and surface tension are about the same as for water.
4) The charge of particle depend upon the P^H values of the medium, it may be positive, negative or even zero.

26. Which reaction gives colloidal solution

1) $2Cu + Cl_2 \rightarrow Cu_2Cl_2$
2) $2HNO_3 + 3H_2S \rightarrow 3S + 4H_2O + 2NO$
3) $2Mg + CO_2 \rightarrow 2Mgo + C$
4) $2Cu + O_2 \rightarrow 2CuO$

27. In both dialysis and osmosis which particles do not pass through semipermeable membrane

1) water 2) Small molecules
3) colloids 4) All of these

28. Water carrying impurities is purified by addition of potash alum. Al^{+3} of the potash alum causes

1) Peptisation of negatively charged turbidity
2) Coagulation of negatively charged turbidity
3) Peptisation of positively charged turbidity
4) Coagulation of positively charged turbidity

29. The minimum concentration of an electrolyte in millimoles per litre required to cause coagulation of sol is called its

1) Flocculation value 2) protective value
3) Gold number 4) Critical value

30. The flocculation values of KC*l*, $MgCl_2$, $CrCl_3$ and $SnCl_4$ for a negatively charged sol are in the order.

1) $KCl < MgCl_2 < CrCl_3 < SnCl_4$
2) $KCl = MgCl_2 = CrCl_3 = SnCl_4$
3) $MgCl_2 < KCl < CrCl_3 < SnCl_4$
4) $SnCl_4 < CrCl_3 < MgCl_2 < KCl$

31. Which one is natural emulsion ?

1) Kerosene in water 2) Benzene in water
3) Vanishing cream 4) Milk

32. Micelles can be formed by

1. Carboxylic acids
2. Sodium stearate solution at low concentration
3. Sodium stearate solution at high concentration
4. Sodium chloride aqueous solution

33. Solutions of soaps and detergents exhibit colloidal properties at

1) low concentrations
2) higher concentrations
3) very low concentrations
4) medium concentrations.

34. When excess of KI solution is added to $AgNO_3$ solution , the charge present on sol is

1) +ve 2) -ve 3) both 4) Neutral

35. When a beam of light is passed through colloidal solution, it

1) Gets scattered 2) Gets adsorbed
3) is refracted 4)Undergoes reflection

36. Which of the following is least effective in causing flocculation of $Fe(OH)_3$ sol

1) $K_3[Fe(CN)_6]$ 2) K_2CrO_4
3) KBr 4) K_2SO_4

37. The ability of an ion to bring about coagulation of a given colloid depends upon

1) Its size
2) The magnitude of its charge only
3) The sign of its charge alone
4) Both magnitude and sign of its charge.

38. Isoelectric point refers to the $[H^+]$ at which the collodial particles.

1) Coagulate
2) become electrically neutral
3) can move to either electrode when subjected to an electric field
4) Reverse their electrical charge.

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

1) Zeta Potential 2) Streaming potential
3) Doru potential 4) colloidal potential

40. Detergent action of synthetic detergents is due to their

1) Inter facial area
2) High molecular weight
3) Ionisation
4) Emulsifying properties

KEY - LEVEL - II (C.W)

1) 4	2) 2	3) 1	4) 2	5) 4	6) 4	7) 3
8) 1	9) 2	10) 4	11) 1	12) 4	13) 1	14) 3
15) 2	16) 2	17)4	18)1	19) 1	20) 3	21) 4
22) 2	23) 4	24) 4	25) 3	26) 2	27) 3	28) 2
29) 1	30) 4	31) 4	32) 3	33) 2	34) 2	35) 1
36) 3	37) 4	38) 2	39) 1	40) 4		

HINTS - LEVEL - II(C.W)

7. No catalyst is used in solvay's process
8. According to adsorption theory of catalysis, the speed of the reaction increase because, the concentration of reactant molecules at the active centre of the catalyst becomes high due to adsorption.
9. Organic catalyst differ from inorganic catalyst by acting at low temperature.
10. $2SO_{2(g)} + O_{2(g)} \xrightarrow{V_2O_{5(s)}} 2SO_3$
11. urease is used in the decomposition of urea
12. Diastase
13. $M\ x/n[(Al_2O_3)_x(SiO_2)_4]mH_2O$
14. Zeolites are used in petroleum industry in cracking
15. Lesser is the activation energy, greater is the ease with which the reaction can take place.
19. In foam, gas bubbles are dispersed in liquid.
20. In butter water dispersed in fat.
21. Blood is a natural colloid.
22. A colloidal system involves a state of dispersion
23. The colour of the gold sol depending on the particle size (or) diameter of gold particles.
24. Macromolecules in a suitable solvent form solution, in which size of macromolecules may be in the range of colloids
    Ex: starch,cellulose,proteins,nylon,etc.
26. $2HNO_3 + 3H_2S \rightarrow 3S + 4H_2O + 2NO$
27. colloids do not pass through the semi permeable membrane
28. Al^{3+} of potash alum causes coagulation of negatively charged turbidity
29. Definition of flocculation value.
30. Flocculation value $\propto \frac{1}{\text{charge an ion}}$

31. Milk is natural emulsion.
32. Sodium stearate solution at high cocentration forms micelles.
33. At high cocentrations soap and detergent solutions exhibits colloidal properites.
34. Excess of KI produces negatively charged sol.
35. When a beam of light is passed through colloidal solution, it gets scattered.
36. Lesser the charge of cation lesser will be the precipitation.
37. The ability of effective ion to bring about coagulation depends upon both magnitude and sign of its charge
38. At isoelectric point colloidal solution do not carry any charge and behave like neutral molecule
39. Zeta potential

LEVEL-II (C.W)

1. Which of the following give linear plots

1) $\frac{x}{m}$ versus $\log C$

2) $\log\frac{x}{m}$ versus $\frac{1}{p}$

3) $\frac{m}{x}$ versus $\log\frac{1}{p}$

4) $P/\left(\frac{x}{m}\right)$ versus P

2. Which of the following relation is correct?
(i) *x/m* = constant at high pressure
(ii) *x/m* = constant $\times$ $p^{1/n}$ at intermediate pressure
(iii) *x/m* = constant $\times$ p^n at lower pressure
1) all are correct 2) all are wrong
3) (i) and (ii) are correct 4) (iii) is correct

3. In Freundlich adsorption isotherm, the value of 1/n is
1) between 0 and 1 in all cases
2) between 2 and 4 in all cases
3) 1 in case of physical adsorption
4) 1 in case of chemisorption

Catalysis

4. A catalyst added to a reversible reaction
1) Changes the position of equilibrium
2) increase the concentration of products
3) increases the equilibrium constant
4) speeds up both the forward and backward reactions

5. Platinum is not used as a catalyst in the
1) Oxidation of CH_3OH *to* $HCHO$
2) Oxidation of SO_2 *to* SO_3
3) Oxidation of ammonia to nitric oxide
4) Synthesis of ammonia from N_2 *and* H_2

6. The rate of a certain biochemical reaction when enzyme is catalysed in the human body is 10^4 times faster than when it carried out in the laboratory. The activation energy of this reaction.
1) Is zero
2) Is different in two cases
3) Is the same in both the cases
4) Can only be determined if temperature of the reaction is known

7. ZSM-5 is an important Zeolite catalyst in petroleum indsutry, which is used to convert.
1) Alcohols to gasoline 2) Alcohols to ethers
3) Alcohols to esters 4) Alcohols to aldehydes

8. What is the role of diphenylamine for the oxidation of benzaldehyde?
1) Positive catalyst 2) Autocatalyst
3) Negative catalyst 4) Promoter

9. What is the catalyst used in Bergius process used for the synthesis of synthetic petrol?
1) Copper chloride 2) Mercury chloride
3) Ferric oxide 4) Zinc oxide

10. Which of the following words means boiling stone in Greek?
1) Catalyst 2) Enzyme
3) Adsorbent 4) Zeolite

Colloid

11. Which of the following is crystalloid
1. Egg Albumin 2. Starch
3. Glucose 4. Gum

12. Which of the following forms a colloidal solution in water
1. NaCl 2. Glucose 3. $Ba(NO_3)_2$ 4. Starch.

13. Which of the following constitute irreversible colloidal system in water as dispersion medium

1. Clay 2. Platinum
3. $Fe(OH)_3$ 4. All of these

14. Which of the following is not a solution

1. Air 2. Smoke
3. Gold ring 4.Salt water

15. In which type of filtration colloidal particles are separated.

1) filtration using convention filter paper
2) filtration using ultra-filters
3) filtration using cloth filters.
4) filtration using quantitative filter paper.

16. Lyophobic colloids show

1) no interaction with the dispersion medium
2) Medium interactions with the dispersion medium.
3. Strong interaction with the dispersion medium.
4) Less interaction with the dispersion medium.

17. Lyophilic and lyophobic colloids are classified depending upon

1) the interaction of two phases.
2) The electrical charge of the dispersed phase.
3) the appearence.
4) the structure of particles

18. Which of the following is hydrophobic

1. Gum 2. Gelatin 3. Starch 4. Sulphur

19. Which is not a property of lyophilic sols.

1) It can be prepared directly by mixing dispersion phase and dispersion medium.
2) It is reversible
3) Viscosity of disperged phase same as that of dispersion medium.
4) Its particles do not carry charge

20. The solution of rubber in benzene is an example of

1) Multimolecular colloid
2) Macromolecular colloid
3) Associated colloid
4) Lyophobic colloid

21. Collodion is a colloidal solution of

1) Starch in water
2) Cellulose in water
3) Cellulose nitrate in water
4) Cellulose nitrate in ethyl alcohol

22. Peptisation is the process in which

1) Suspension is converted into true solution
2) Precipitate dissolve to give true solution
3) Colloidal particles get settled as precipitates
4) Precipitates are converted into colloid

23. On adding few drops of dil HCl of freshly precipitated ferric hydroxide, A red coloured colloidal solution is obtained this phenomenon is known as

1) Peptisation 2) Dialysis
3) protective action 4) Dissolution

24. From which of the following particles can be separated by ultrafiltration but not by ordinary filtration?

1) Gold sol 2) Glucose solution
3) Salt solution 4) sucrose solution

25. The coagulation of 10 ml of gold sol is just prevented on adding 1 ml of 10 % NaCl in the presence of 0.025 g of starch. The gold number of starch is

1) 0.25 2) 0.025 3) 25 4) 250

26. The gold number of three substances A, B and C are 0.05, 0.8 and 0.3. The substance with maximum protective power is

1) A 2) B 3) C 4) All of these

27. The emulsifier of milk is

1. Casein 2. Fat
3. Lactose 4. Lactic acid

28. Soap water removes grease by

1. Adsorption 2. Emulsification
3. Coagulation 4. Absorption

29. Digestion of fats in the intestines is aided by

1. hydrolysis 2. oxidation
3. reduction 4. emulsification

30. Which is not a colloidal solution of a liquid in another liquid ?

1) Photographic emulsions
2) Soap in water
3) Homogenised milk
4) Latex

31. Cold cream is an example of

1) oil in water emulsion
2) solid in a liquid sol
3) water in oil emulsion
4) liquid in a solid sol

32. Detergent action of synthetic detergents is due to their
1) Interfacial area
2) High molecular weight
3) Ionisation
4)Emulsifying properties.

33. Which of the following acts as emulsifier for "water in oil" emulsion
1)soap 2)detergent 3)gelatine 4)egg yolk

34. Gels on standing exude small amount of liquid. This phenomenon is known as
1) Efflorescene 2) Synersis
3) Thixotropy 4) Adsorption

35. Curd is an example of
1) sol 2) foam 3) aerosol 4) gel

36. Which of the following is most effective colloid for coagulation of As_2S_3 Sol.
1) $K_3[Fe(CN)_6]$ 2) $K_4[Fe(CN)_6]$
3) $CaCl_2$ 4) Na_2SO_4

37. Flocculation value of a coagulating electrolyte is expressed in
1) milli moles L^{-1} 2) mol. L^{-1}
3) mg k^{-1} 4) microgram L^{-1}

38. The Arsenic sulphide sol has -ve charge. The maximum power to precipitate it is of
1) H_2SO_4 2) Na_3PO_4 3) $CaCl_2$ 4) $AlCl_3$

39. The coagulation values of $AlCl_3$ and NaCl are 0.093 and 52 respectively. Then coagulating power of $AlCl_3$ as compared to that of NaCl is
1) 52×0.093 times 2) 52/0.093 times
3) 0.093/52 4) 52-0.093 times

40. 10^{-4} g of gelation is required to be added to 100cm^3 of a standard gold solution to just prevent its precipitation by addition of 1 cm^3 of 10% NaCl solution to it. Hence the gold number of gelation in mg is
1) 10 2)1.0 3) 0.1 4) 0.01

41. The number of moles of lead nitrate needed to coagulate 2 moles of colloidal $[AgI]I^-$ is
1) 2 2) 1 3) 1/2 4) 2/3

42. Which colloid is used in treating eye disease
1) colloidal sulphur 2) colloidal antimony
3) colloidal gold 4) colloidal silver

KEY - LEVEL - II (H.W)

1) 4	2) 1	3) 1	4) 4	5) 4	6) 2
7) 1	8) 3	9) 3	10) 4	11) 3	12) 4
13) 4	14) 2	15) 2	16) 4	17) 1	18) 4
19) 3	20) 2	21) 4	22) 4	23) 1	24) 1
25) 3	26) 1	27) 1	28) 2	29) 4	30) 2
31) 3	32) 4	33) 3	34) 2	35) 4	36) 3
37) 1	38) 4	39) 2	40) 4	41) 2	42) 4

HINTS- LEVEL - II(H.W)

4. Catalyst increases rate of both forward and backword reaction.
5. Fe is used as catalyst in Haber's process.
6. The activation energy of a chemical reaction depends on temp of system
7. ZSM-5 is a zeolite is used to convert Alcohols to gasoline

11 Glucose is an example of crystalloid.

12. Starch solution is an example of colloid.
13. In water, clay, platinum and $Fe(OH)_3$ are irreversible colloidal systems.
14. Smoke is a colloid, but not solution.
15. Using ultra-filters, colloidal particles are separated.
16. Lyophobic colloids show less interaction with the dispersion medium.
17. Lyophilic and lyophobic colloids are classified depending on the interaction of two phases
18. Sulphur sol is hydrophobic.
19. Viscosity of dispersed phase and dispersed medium should be different, then only Lyophillic sols are formed.
23. Conversion of precipitation into colloidal solution by the additon of suitable electrolyte is called peptization.
24. colloidal particles (gold sol) can be seperated by ultra filteration
25. According to the definition of gold number, weight of the protective colloid should be taken in milligrams. Hence 0.025 x 1000 = 25.
26. Protective power $\alpha \frac{1}{\text{Gold number}}$
27. Casein is the emulsifier of milk.
28. Soap water removes grease by emulsification.

29. Digestion of fats in the intestine is aided by emulsification.
30. In soap solution, soap particles are dispersed in water.
31. 20% water, 80% oil (water in oil).
32. Detergent action of synthetic detergent is due to their emulsifying properties.
33. Gelatine emulsifies water in oil emulsion.
34. Synersis
35. Curd is a gel.
36. As_2S_3 is a -ve sol which can be effectively coagulated by more positively charged ion
37. Millimoles/L
38 ppt power is directly proportional to magnitude of opposite charge.
39. $$\frac{\text{Coagulation power of } AlCl_3}{\text{Coagulation power of } NaCl} = \frac{\text{Coagulation value of } NaCl}{\text{Coagulation value of } AlCl_3}$$
40. By definition 100 ml gold sol requires 10^{-4}gm

10 ml gold sol requires $= \frac{10}{100} \times 10^{-4} = 10^{-5}$gms

42. Colloidal silver

Assertion and Reason

Note: *1) A and R are correct and R is the correct explanation of A*
2) A and R are correct and R is not the correct explanation of A
3) A is true and R is false
4)A is false and R is true

1. Assertion (A): Physical adsorption is reversible while chemical adsorption is irreversible
Reason (R): Physical adsorption is multilayered while chemical adsorption is unilayered one.

2. Assertion (A): chemical adsorption increases with increase in Temperature and later it decreases
Reason (R): Physical adsorption decreases with increase in Temperature

3. Assertion (A): +Ve catalyst increases the rate of reaction
Reason (R): +Ve catalyst decreases the activation energy of the Reactants.

4. Assertion (A): catalyst must be in a solid state.
Reason (R): small amount of catalyst is enough to change the rate of reaction

5. Assertion (A): gas in gas type of colloidal solution is not possible
Reason (R): colloidal solution is a heterogeneous system

6. Assertion (A): Ethyl Alcohol vapour is passed over anhydrous alumina as catalyst at 350^0 c acetaldehyde is obtained
Reason (R) : Emulsions contain liquid dispersed in liquid.

7. Assertion (A): Cod liver oil is an emulsion of oil in water type.
Reason (R): In oil in water type emulsion. Oil is the dispersed phase and water is the dispersion medium.

8. Assertion (A): Tyndall effect is shown by colloidal solution where as it is not shown by true solution
Reason (R): In colloidal solution particle size is $1m\mu$ to 1μ where in the true solution it is $< 1m\mu$

9. Statement: To stop bleeding from an injury ferric chloride can be applied. Which comment about the statement is justified?
1) It is not true, ferric chloride is a poison
2) It is true, Fe^{3+} ions coagulate blood which is negatively charged sol
3) It is not true, Cl ions form positively charged sol, profuse bleeding takes place
4) It is true, coagulation takes place because of formation of negatively charged sol with Cl ions

Note: *1) A and R are correct and R is the correct explanation of A*
2) A and R are correct and R is not the correct explanation of A
3) A is true and R is false
4) A is false and R is true

10. ASSERTION (A) : Adsorption is a surface phenomenon
Reason (R): Adsorption is an endothermic process

11. Assertion (A): chemical adsorption is unilayered where as physical adsorption is multilayered.
Reason (R): In chemical adsorption strong chemical bonds are formed between adsorbent and adsorbate where as it is not possible in physical adsorption.

12. Assertion (A): catalyst is more effective in the powdered state
Reason (R): In the powdered state surface area is maximum

13. Assertion (A): In Haber's synthesis the rate of formation of NH_3 is increased by adding Fe.
Reason (R): Fe acts as a catalyst for Haber's synthesis.

14. Assertion (A): cloud is a liquid in air type of colloidal solution.
Reason (R): In cloud disperse phase is water drops and Air is dispersion medium

15. Assertion (A): Lyophilic sols are very stable
Reason (R): In these sols, much affinity exists between the disperse phase and the dispersion medium.

16. Assertion (A): Gold sol-is a lyophobic sol.
Reason (R): In gold sol. There is less affinity between gold particle and water.

17. Assertion (A): Milk is an example of water in Oil emulsions
Reason (R): Emulsions contains liquid dispersed in liquid.

PREVIOUS EAMCET QUESTIONS

1. The disperse phase, dispersion medium and nature of colloidal solution (lyophilic or lyopobic) of 'gold sol' respectively are **[EAMCET 2006]**

1) solid, solid,lyophobic
2) liquid, liquid, lyophobic
3) solid, liquid,lyophobic
4) solid, liquid, lyophobic

2. Which of the following biomolecules acts as specific catalysts in biological reaction? **[EAMCET 2007]**

1) Carbohydrates 2) Lipids
3) Vitamins 4) Enzymes

3 Which of the following is not correct?

1) Milk is a naturally occuring emulsion
2) Gold sol is a lyophilic sol
3) Physical adsorption decreases with rise in temperature
4) Chemical adsorption is unilayered

4. Which one of the following graphs represents Freundlisch adsoeption isotherm? **[EAMCET 2008]**

1) $\log(\frac{x}{m})$ vs $\log P$
2) $\log(\frac{x}{m})$ vs $\log P$
3) $\log(\frac{x}{m})$ vs $\log P$
4) $\log(\frac{x}{m})$ vs $\log K$

5. Which one of the following is most effective in causing the coagulation of an As_2S_3 sol? **[EAMCET 2009]**

1) KCl 2) $AlCl_3$
3) $MgSO_4$ 4) $K_3Fe(CN)_6$

6. A micelle formed during the cleansing action by soap is **[EAMCET 2010]**

1) A discrete particle of soap
2) Aggregated particles of soap and dirt
3) A discrete particle of dust
4) An aggregated particle of dust and water

7. According to Langmuir adsorption isotherm, the amount of gas adsorbed by unit surface area is (a,b,k and n are constants; P = pressure of gas) **[EAMCET 2011]**

1) $k.P^n$ 2) $\frac{1+bP}{aP}$ 3) $k.P^{1/n}$ 4) $\frac{aP}{1+bP}$

8. Gelly is a colloidal solution of **[EAMCET 2012]**

1) Solid in liquid 2) Liquid in solid
3) Liquid in liquid 4) Solid in solid

9. Match the following **[EAMCET 2013]**

LIST-I	LIST-II
A) Solid dispersed in liquid	I) Emulsion
B) Liquid dispersed in liquid	II)Foam
C) Gas dispersed in liquid	III) Gel
D) Liquid dispersed in solid	IV) Sol
	V) Aerosol

The correct match is

	A	B	C	D
1)	IV	I	II	III
2)	III	I	V	II
3)	III	I	II	IV
4)	IV	I	V	III

10. Assertion(A): Vander Waal's force are responsible for chemisorption
Reason(R): High temperature is favourable for chemisorption
The correct answer is **[EAMCET 2014]**

1) A and R are correct but R is not the correct explanation of A
2) A is correct but R is not correct
3) A is not correct but R is correct
4) A and R are correct and R is the correct explanaiton of A

PREVIOUS EAMCET - KEY

1) 3 2) 4 3) 2 4)3 5) 2 6) 2
7) 2 8) 2 9) 4 10) 2

LEVEL-III

Adsorption

1. Based on Langmuir adsorption isotherm, the interceot in the graph ($\frac{m}{x}$ versus $\frac{1}{p}$) is equal to

1) $\frac{1}{a}$ 2) $\frac{b}{a}$ 3) $\frac{a}{b}$ 4) $\frac{1}{slope}$

2. 3.6 gram of oxygen is adsorbed on 1.2g of metal powder, What volume of oxygen adsorbed per gram of the adsorbent at S.T.P.

1) 0.19 Lg^{-1} 2) 1 Lg^{-1}
3) 2.1 Lg^{-1} 4) 3.2 Lg^{-1}

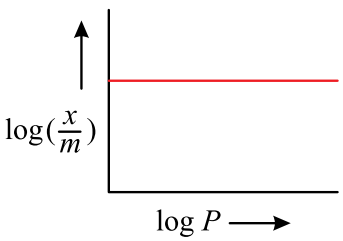
3. 100 ml of 0.6 M acetic acid is shaken with 2gm activated carbon. The final connetration of the solution after adsorption is 0.5M. What is the amount of acetic acid adsorbed per gram of carbon?

1) 0.6g 2) 0.3g 3) 1.2 g 4) 2 g

4. Plot of $\log\left(\frac{x}{m}\right)$ against $\log P$ is a straight line inclined at an angle of 45^0. When the pressure is 0.5 atm and freundlich parameter, k is 10, the amount of solute adsorbed per gram of adsorbent will be:(log 5 = 0.6990)

1) 1g 2) 2g 3) 3g 4) 5g

5. Following graph will be true when



1) $P=0$ 2) $P=1$ 3) $\frac{1}{n}=0$ 4) $\frac{1}{n}=\infty$

6. 1g charcoal adsorbs 100ml of 0.5M CH_3COOH to form a monolayer. As a result molarity of acetic acid reduces to 0.49M. What will be the surface area covered by each molecule of acetic acid? Given that surface area of charcoal= $3.01\times10^2 m^2/g$.

1) $2.5\times10^{-19}m^2$ 2) $5.0\times10^{-19}m^2$
3) $10^{-18}m^2$ 4) $2.0\times10^{-18}m^2$

7. $1.30cm^3$ of N_2 gas at STP is adsorbed per gram of silica gel. The area occupied by nitrogen molecule is $0.16nm^2$. What is the surface area per gram of silica gel? $\left(N_A=6.023\times10^{23}\right)$

1) $1.6m^2g^{-1}$ 2) $5.568m^2g^{-1}$
3) $3.48m^2g^{-1}$ 4) $4.42m^2g^{-1}$

8. Elastic gels when placed in contact with water, they absorb water and swell. This property is called

1) Thixotropy 2) Weeping
3) Syneresis 4) Imbibition

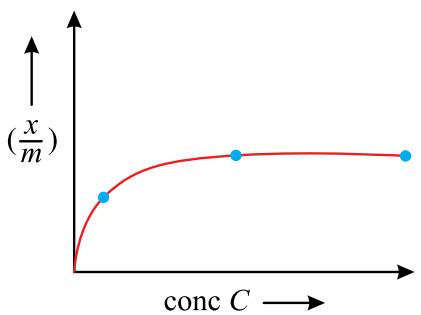
9. **Graph between $\log\frac{x}{m}$ and log P is a straight line inclined at an angle $\theta = 45^0$. When pressure of 0.5 atm and logk = 0.699, the amount of solute adsorbed per g of adsorbent will be**

1) 1 g/g adsorbent 2) 1.5 g/g adsorbent
3) 2.5 g/g adsorbent 4) 0.25 g/g adsorbent

10. **3.6gram of oxygen is adsorbed on 1.2g of metal powder. What volume of oxygen adsorbed per gram of the adsorbent at STP?**

1) 0.19 L 2) 1L 3) 2.1 L 4) 3.1 L

11. **Adsorption also takes place in the solution when solid surface is saturated by adsorption, then variation of $\left(\frac{x}{m}\right)$ and concentration (C) is given by which of the following b portion?**



1) OA 2) AB 3) OB 4) BC

12. **Based on Langmuir adsorption isotherm, the intercept in the graph of (*m/x*) vs 1/P, is equal to**

1) $\frac{1}{a}$ 2) $\frac{b}{a}$ 3) $\frac{a}{b}$ 4) $\frac{1}{slope}$

Catalyst

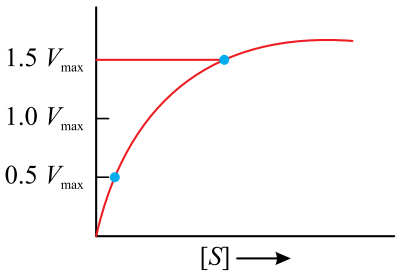
13. **An enzyme[E] is combined with the substrate [S] as follows:**

$$E + S \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} ES$$

$$ES \xrightarrow{k_2} P + E$$

The overall reaction rate is given by:

$Rate = \frac{V_{max}[S]}{K_m + [S]}$ **and the rate of reaction varies with substrate concentration as**



The order of reaction at point A is

1)one 2)two 3) three 4) zero

14. **The kinetics of enzyme catalysed reactions are studied by**

1) Eyring equation
2) Michaelis-Menten equation
3) Arrhenius equation
4) Lindemann hyporthesis

15. **Enzyme-catalysed reactions have the order**

1) one at low concentraiton of substrate and two at high concentration of the substrate
2) one at high concentraiton of substrate and two at low concentration of the substrate
3) one at low as well as high concentrations
4) two at low as well as high concentrations

Colloids

16. **1 mol of $[AgI]Ag^+$ sol is coagulated by**

1) 1 mole of KI 2) 500ml of 1M K_2SO_4
3) both 1 and 2 4) 2 mole of KI

17. **On adddig $AgNO_3$ solution into KI solution, a negatively charged colloidal sol is obtained when they are in**

1) 50ml of $0.1M\ AgNO_3 + 50ml\ of\ 0.1M\ KI$
2) 50ml of $0.1M\ AgNO_3 + 50ml of\ 0.2M\ KI$
3) 50ml of $0.2M\ AgNO_3 + 50ml\ of\ 0.1M\ KI$
4) All of there

18. **400ml of standard sol is just prevented from coagulation by the addition of 0.96gm of starch before adding 1ml of 10% Nacl solution, the gold number will be**

1) 2.4 2) 7.6 3) 240 4) 24

19. **In the stoichiometry of Natural faujasita a Zeolite with formula**

$Na_{x/n}[(AlO_2)_{56}(SiO_2)_{136}]250H_2O$ the value of x is

1) 12 2) 56 3) 136 4) 256

20. **A detergent $\left(C_{12}H_{25}SO_4^-Na^+\right)$ solution becomes a colloidal sol at a conc of $10^{-3}M$. On an average 10^{13} colloidal particles present in $1mm^3$. What is the average number of ions are contain in one colloidal particle micelle**

1) 6×10^{-7} 2) 10 3) 60 4) 4×10^5

21. **If a freshly formed PPt of SnO_2 is peptised by a small amount of NaOH, these colloidal particles may be represented as**

1) $\left[SnO_2\right]SnO_3^{2-}:2Na^+$

2) $\left[SnO_2\right]Sb^{+4}:O_2^{2-}$

3) $\left[SnO_2\right]Na^+:OH^-$ 4) $\left[SnO_2\right]Sn^{+4}:OH^-$

22. **Among the electrolytes $Na_2SO_4, CaCl_2, Al_2\left(SO_4\right)_3$ and NH_4Cl, the most effective coagulating agent for Sb_2S_3 sol is**

1) Na_2SO_4 2) $CaCl_2$ 3) $Al_2\left(SO_4\right)_3$ 4) NH_4Cl

23. **The dispersed phase and dispersion medium in soap lather are respectively**

1) gas and liquid 2) liquid and gas
3) solid and gas 4) solid and liquid

24. **Silver iodide is used for producing artificial rains because AgI**

1) is easy to spray at high altitude
2) is insoluble in water
3) is easy to synthesize
4) has crystals similar to ice

25. **During micelle formation**

1) $\Delta H=+ve,\ \Delta S=+ve$

2) $\Delta H=-ve,\ \Delta S=-ve$

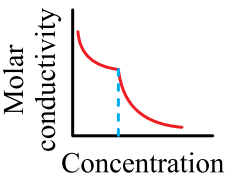
3) $\Delta H=-ve,\ \Delta S=+ve$

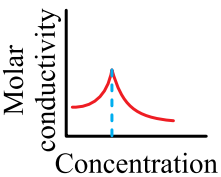
4) $\Delta H=+ve,\ \Delta S=-ve$

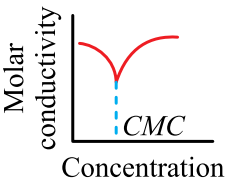
26. **The volume of a colloidal particle, V_c as compared to the volume of a solute particle in a true solution V_s could be (AIEEE 2005)**

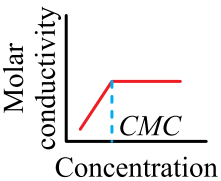
1) $\frac{V_C}{V_S}=1$ 2) $\frac{V_C}{V_S}=10^{23}$ 3) $\frac{V_C}{V_S}=10^{-3}$ 4) $\frac{V_C}{V_S}=10^3$

27. **Which of the following plot correctly represents the variation of concentgration of a surfactant (e.g. sodium dodecyl sulphate) versus molar conductivity with regard to behaviour at CMC?**

1) 

2) 

3) 

4) 

28. **The coagulation of 200mL of a positive colloid took place when 0.73g *HCl* was added to it without changing the volume much. The flocculation value of *HCl* for the colloid is**

1) 0.365 2) 36.5 3) 100 4) 150

29. **Sedimentation potential is the reverse of**

1) Electroomosis 2) Electrophoresis
3) Electrokinetic potential
4) Dorn potential

30. **Cloud bursts due to**

1) strong attraction towards the earth due to opposite charges
2) high density of clouds at higher altitudes
3) dark grey colour of some dense clouds
4) opposite charge on the clouds resulting into coagulation

31. **Multimolecular colloids are present in**

1) Sol of sulphur 2) Sol of Proteins
3) Sol of gold 4) Both 1 & 3

32. **SnO_2 is shaken with a small amount of NaOH solution to form a colloidal sol of sodium stannate. The sol thus obtained can be coagulated most easily by**

1) Na_3PO_4 2) $AlCl_3$

3) $K_4\left[Fe\left(CN\right)_6\right]$ 4) HCl

33. Among the following, the surfactant that will form micelles in aqueous solution at the lowest molar concentration at ambient conditions, is

1) $CH_3(CH_2)_{15}N^+Br^-$ 2) $CH_3(CH_2)_{11}OSO_3^-Na^+$

3) $CH_3(CH_2)_6COO^-Na^+$

4) $CH_3(CH_2)_{11}N^+(CH_3)_3Br^-$

34. During electro-osmosis of $Fe(OH)_3$ sol

1) Sol particles move towards anode
2) Sol particles move towards cathode of a sol
3) Higher is the gold number, greater will be the protective power of a lyophilic colloid
4) The dispersion medium moves towards anode

35. Colloidal gold can be prepared by

1) Bredig's arc method 2) Reduction of $AuCl_3$
3) Hydrolysis 4) Both 1&2

KEY - LEVEL - III

1) 2	2) 3	3) 2	4) 4	5) 3	6) 2
7) 2	8) 4	9) 3	10) 3	11) 4	12) 3
13) 1	14) 2	15) 2	16) 3	17) 2	18) 4
19) 2	20) 3	21) 1	22) 3	23) 1	24) 1
25) 1	26) 4	27) 1	28) 3	29) 2	30) 4
31) 4	32) 2	33) 3	34) 3	35) 4	

HINTS - LEVEL - III

1. Osmotic pressure (π)

$$\frac{nRT}{V}=\frac{w}{m}X\frac{RT}{V}$$

$$2.463=\frac{2.56}{m}X\frac{0.0821X300}{100X10^{-3}}$$

$$m=256$$

No of S atoms $=\frac{256}{32}=8$

2. 3.6gm of O_2 is adsorbed per 1.2gms of adsorbent mass of O_2 adsorbed per gram of adsorbent = ? $=\frac{3.6}{1.2}=3$

No of moles O_2 per gram adsorbent $=\frac{3}{32}$

1mole of $O_2 \rightarrow 22.4$ lits at STP

$\frac{3}{32}$ moles O_2 ? $= 2.10$

3. mass of acetic acid adsorbed by 2gm of char coal $=\frac{(0.6\text{-}0.5)X\ 60X100}{1000}=0.6$

mass of acetic acid adsorbed per gram of char coal = ?

$=\frac{0.6}{2}=0.3$

4. According to Freundlich Adsorption Isotherm

$$\log\left(\frac{x}{m}\right)=\log k+\frac{1}{n}\log p$$

When $\log\left(\frac{x}{m}\right)$ is plotted against log P, we get straight line of slope $(1/n)$ and intercept $(\log k)$.

$\frac{1}{n}=\tan 45^0=1 \quad \log k=\log 10=1$

$$\frac{x}{m}=k(P)^{1/n}=10(0.5)^1=5$$

When $m=1g, x=5g$

6. Acetic acid adsorbed = 0.5 - 0.49 M = 0.01 M
$\therefore$ Acetic acid adsorbed from 100mL solution = 0.001 mole

Acetic acid adsorbed by 1g of charcoal = $0.001 mole=6.02\times10^{20}$ molecules

Surface area of 1g of charcoal = $3.01\times10^2 m^2$

$\therefore$ Surface area of charcoal covered by each molecule = $(3.01\times10^2 m^2)/(6.02\times10^{20})$

$= 5\times10^{-19}m^2$

7. Number of N_2 molecules adsorbed per gram of silica gel $=\frac{6.023\times10^{23}\times1.30}{22400}=3.48\times10^{19}$

Area of cross-section of N_2 molecule

$= 0.16\ nm^2=1.6\times10^{-19}m^2$

$\therefore$ Surface area covered per gram of silica gel

$=1.6\times10^{-19}\times3.48\times10^{19}=5.568m^2$

8. By definition

9. $\log k=0.699$

$$\therefore K=5, slope=\frac{1}{n}=\tan 45^0=1$$

$$\frac{x}{m}=5(0.5)^1$$

10. $n_{0_2} = \frac{3.6}{32} = 0.112$ (on 1.2 gm of metal)

$\therefore n_{0_2}$ adsorbed on 1gm metal = $\frac{0.112}{1.2} = 0.094$

Volume of O_2 adsorbed at
S.T.P = 0.094 × 22.4 = 2.1

14. The kinetics of enzyme catalysed reactions is studied by Michaelis-Menten equation.
15. Enzyme catalysed reactions are of first order at high concentration of substrate and of second order at low concentration of substrate.
16. $[AgI]Ag^+ + KI \rightarrow AgI\downarrow + AgI\downarrow + K^+$

$1mol \qquad 1mol$

$2[AgI]Ag^+ + K_2SO_4 \rightarrow [AgI] + Ag_2SO_4$

$1mol \qquad 0.5mol$

17. Negatively charged colloidal sol is obtained when KI solution must be in excess

$KI + AgNO_3 \rightarrow [AgI]I^-$

i.e $\underset{excess}{} \qquad \underset{-ve\ sol}{}$

50 ml of 0.1M $AgNO_3$ + 50 ml of 0.2M KI contains excess of KI.

18. 400ml of gold sol require starch = 0.96 gm=960 mg 10 ml of gold sol require starch=?

$= \frac{960X10}{400} = 24$

We always calculate gold number for 10 ml of gold sol.

19. Formula of a zeolite is

$M_{x/n}\left[(AlO_2)_x(SiO_2)_y\right]mH_2O$

given $Na_x\left[(AlO_2)_{56}(SiO_2)_{136}\right]250H_2O$

$\therefore$ x = 56

20. No. of detergent molecules present in one litre solution

$= 10^{-3} X 6X10^{23} = 6X10^{20}$

i.e, 1000 ml $\rightarrow 6X10^{20}$ detrgent molecule

$1mm^3 = ?$

$= 6X10^{14}$

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

No of molecules per colloidal particles

$= \frac{6X10^{14}}{10^{13}} = 60$

21. SnO_2 dissolved in NaoH forming Na_2SnO_3

$SnO_2 + 2NaOH \rightarrow Na_2SnO_3 + H_2O$

SnO_3^- is adsorbed by SnO_2 forming negatively charged colloidal sol

$[SnO_2]SnO_3^{2-} : 2Na^+$

22. Order of coagulating power is

$Al^{+3} > Ca^{+2} > Na^+ > NH_4^+$

26. For a true solution the diameter range is 1-10A^0 For a collodial sol Diameter range is 10-1000 A^0 taking the lower limit

$\frac{V_c}{V_s} = \frac{\frac{4}{3}\pi r_c^3}{\frac{4}{3}\pi r_s^3}$

$= \left(\frac{r_c}{r_s}\right)^3 = \left(\frac{10}{1}\right)^3 = 10^3$

27. The molar conductivity varies as shown in plot (a). With increase in concentraion below CMC, molar conductivity keeps on decrasing. After CMC, the decrease becomes steeper and a discontinuity is observed at CMC.
28. 200mL of the sol require = 0.73g HCl

$= \frac{0.73}{36.5} = 0.02mol = 20mmol$

$\therefore 1000mL(1L)$ of the sol will require

$\frac{20}{200} \times 1000 = 100\,mmol$

29. Sedimentation potential is the reverse of electrophoresis.
30. Cloud bursts when oppositely charged clouds meet resulting into their coagulation.
31. 1 and 3 represent multimolecular colloids.
32. $SnO_2 + 2NaOH \rightarrow Na_2SnO_3 + H_2O$

$SnO_2 + SnO_3^{2-} \rightarrow [SnO_2] : SnO_3^{2-}$

As they from negatively charged particles, they are easily coagulated by $AlCl_3$ in which Al^{3+} carry maximum positive charge.

33. $m.wt \propto \frac{1}{micelle\ \ formation\ at\ low\ conc.}$

PREVIOUS MAIN QUESTIONS

1. **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 [MAINS 2008]**

   1) D < A < C < B 2) C < B < D < A

   3) A < C < B < D 4) B < D < A < C

2. **Which of the following statements is incorrect regarding physissorptions ? [MAINS 2009]**

   1) It occurs because of vander Waal's forces.

   2) More easily liquefiable gases are adsorbed readily.

   3) Under high pressure it results into multi molecular layer on adsorbent surface.

   4) Enthalpy of adsorption $\left(\Delta H_{adsorption}\right)$ is low and positive.

3. **According to Freundlich adsorption isotherm, which of the following is correct ? [MAINS 2012]**

   1) $\frac{x}{m} \propto P^0$ 2) $\frac{x}{m} \propto P^1$ 3) $\frac{x}{m} \propto P^{1/n}$

   4)All the above are correct for different ranges of pressure

4. **The coagulating power of electrolytes having ions Na^+ , $Al3^+$ and $Ba2^+$ for arsenic sulphide solincreases in the order [MAINS 2013]**

   1) $Al^{3+} < Ba^{2+} < Na^+$ 2) $Na^{3+} < Ba^{2+} < Al^{3+}$

   3) $Ba^{2+} < Na^+ < Al^{3+}$ 4) $Al^{3+} < Na^+ < Ba^{2+}$

PREVIOUS MAIN - KEY

1)3 2) 4 3) 4 4) 2

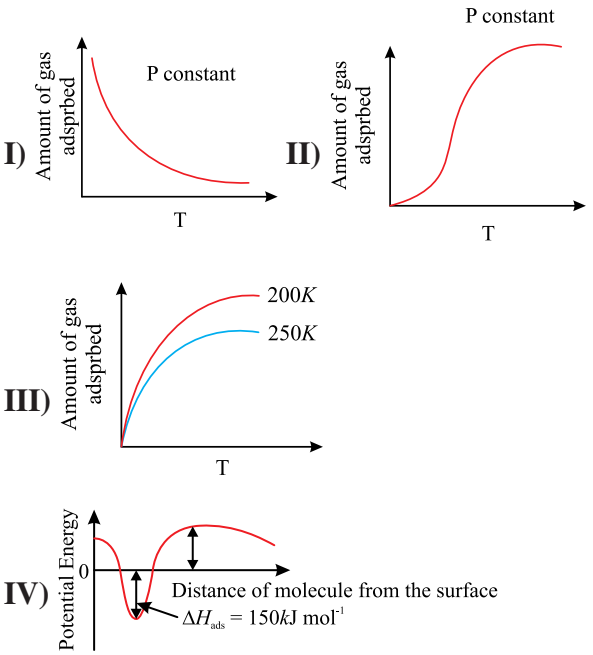
PREVIOUS MAIN - HINTS

1. Higher the gold number lesser will be the protective power of colloid.
2. Enthalpy of adsorption regarding physissorption is not positive and it is negative.
3. $\frac{x}{m} \propto P^0$ is true at extremely high pressures

   $\frac{x}{m} \propto P^1$; $\frac{x}{m} \propto P^{1/n}$ are true at low and moderate pressures

LEVEL-IV

1. **The given graphs/data I,II,III and IV represent general trends observed for different physisorption and chemisorption processes under mild conditions of temperature and pressure. Which of the following choice(s) about I,II,III and IV is (are) correct**



   1) I is physisorption and II is chemisorption

   2) I is physisorption and III is chemisorption

   3) IV is chemisorption and II is physisorption

   4) IV is chemisorption and III is chemisorption

2. **For the coagulation of 100mL of arsenious sulphide solution, 5mL of $1M\ NaCl$ is required. The coagulation power of $NaCl$**

   1) 48.1 2) 38.1 3) 49.5 4) 47.6

3. **Following are the terms about activity and selectivity**

   I. Activity is the ability of catalysts to accelerate chemical reactions and selectivity is the ability of catalysts to direct reaction to yield particular products.

   II.Activity is the ability of catalysts to direct reaction to yield particular products and selectivity is the ability of catalysts to accelerate chemical reactions.

   Select correct term

   1) I 2) II

   3) I and II both 4) None of these

4. Match the following

Colum-I	Column-II
A)Occlusion	p) $CaCl_2 + H_2O$ vapour
B) Sorption	q)Hydrated chabazite+ H_2O vapour
C) Persorption	r) Dil.KCl solution+ Blood charcoal
D) Negative	s) Dyes on cotton fibres adsorption
E) Absorption	t) H_2 on palladium surface

1) $A-t, B-r, C-q, D-s, E-p$

2) $A-t, B-s, C-q, D-r, E-p$

3) $A-p, B-s, C-q, D-r, E-t$

4) $A-s, B-t, C-q, D-r, E-p$

5. Match the following

List - I	List - II
A) physical adsorption	1) $\frac{x}{m} = kp^{1/n}$
B) chemisorption	2)Bulk phenomenon
C) Fruendlich adsorption isotherm	3) multilayered
D) Absorption	4) unilayered

	A	B	C	D		A	B	C	D
1)	1	2	3	4	2)	3	4	1	2
3)	2	3	1	4	4)	3	4	2	1

6. Match the following

List - I	List - II
A) Ammonia preparation	1. Bio catalysed
B) Hydrogenation	2. Fe
C) Fermentation	3. Ni
D) $SO_2 + \frac{1}{2}O_2 \xrightarrow{NO} SO_3$	4)Homogeneous catalysis

	A	B	C	D		A	B	C	D
1)	4	3	1	2	2)	3	2	1	4
3)	1	2	4	3	4)	2	3	1	4

7. Match the following

List - I	List - II
A) blood	1) liquid in liquid sol
B) milk	2) solid in liquid sol
C) smoke	3) Gas in Gas sol
D) cloud	4) liquid in air sol
	5) solid in air sol

	A	B	C	D		A	B	C	D
1)	1	3	2	5	2)	2	1	5	4
3)	5	3	2	4	4)	4	5	2	1

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

List-I	List-II
A) Coagulation	1) Scattering
B) Lyophilization	2) Washing of precipitates
C) Peptization	3) Purification of colloids
D) Tyndall effect	4) Electrolyte

	A	B	C	D		A	B	C	D
1)	4	3	2	1	2)	2	1	3	4
3)	3	1	2	4	4)	4	3	1	2

9. Match the List-I (Colloidal dispersion) with List-II (Nature of the dispersion) and select the correct answer using the codes given below the lists.

List-I (Colloidal dispersion)	List-II (Nature of dispersion)
A. Milk	1. Solid in liquid
B.Clouds	2. Liquid in gas
C. Paints	3. Solid in solid
D.Jellies	4. Liquid in liquid
	5. Liquid in solid

1) A-4,B-2,C-1,D-5 2) A-1,B-5,C-3,D-2

3) A-4,B-5,C-1,D-2 4) A-1,B-2,C-3,D-5

10. Match the following

Colum-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

1) $A \to S, B \to Q, C \to R, D \to P$

2) $A \to Q, B \to S, C \to R, D \to P$

3) $A \to P, B \to R, C \to Q, D \to S$

4) $A \to R, B \to S, C \to Q, D \to P$

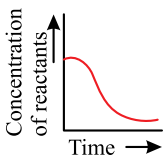
11. Statement-1: At P^H of isoelectric point, the sol particles of amino acids neither move towards anode nor towards cathode.
Statement-2: At the isoelectric point, the cocentration of conjugate base and conjugate acid of the Zwitter ions becomes equal and so charge are counterbalanced.

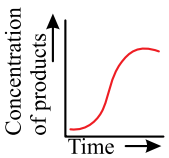
1) Both the statements are True & Statement -2 is the correct explanation of Statement-1.
2) Both the statements are True & Statement-2 is not the correct explanation of Statement-1
3) Statement -1 is True and Statement-2 is False
4) Statement -1 is False and Statement-2 is True

12. Statement - I : The silver halides shows a characteristic colour change at the end point in argento metric titrations
Statement - II : The surface of precipitate of silver halide have the property of adsorbing some dyes like eosin, fluores cein
1. Both (I) and (II) are true and (II) is the correct explanation of (I)
2. Both (I) and (II) are true and (II) is not the correct explanation of (I)
3. (I) is true but (II) is false
4. (I) is false but (II) is true

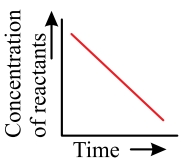
13. Which of the following is (are) correct statement(s) for methyl acetate (ester) hydrolysis
1. Acetic acid formed in the reaction acts as auto catalyst
2. It is an example of heterogenous catalysis
3. Ester hydrolysis is slow at the begining and becomes faster after some time
4. Both 1 and 3 are correct.

14. In the reaction of autocatalysis, the variation of concentration with time is correctly represented by which of the following plots?

1) 

2) 

3) Both 1 & 2

4) 

15. The activity and selectivity of zeolites as catalysts is based on
1) Their pore size
2) Size of their cavities on the surface
3) Both 1 & 2
4) Muta rotation

16. Bleeding of blood is stopped due to
1) the coagulation of blood by applying $FeCl_3$ and blood vessel is sealed
2) the coagulation of blood by applying Alum and blood vessel is sealed
3) Both 1 & 2
4) blood combines with Alum

17. Which of the following are macromolecular colloids?
1) Starch
2) Egg albumen
3) Cellulose
4) All the above

LEVEL-IV - KEY

1) 1	2) 4	3) 1	4) 2	5) 2	6) 4	7) 2
8) 1	9) 1	10) 3	11) 1	12) 1	13) 4	14) 3
15) 3	16) 3	17) 4				

LEVEL-IV - HINTS

1. In graphs I and III, the amount of adsorption decreases with increase of temperature and increases with increase of pressure. Hence, they represent physisorption.
In graph II, amount of adsorption increases with increase of temperature. Hence, it represents chemisorption. Graph IV shows the formation of a chemical bond. Hence, it again represents chemisorption.
Thus I and III are correct while II and IV are incorrect.
2. Total volume after addition of 5mL of 1M NaCl solution = 105 mL
Thus 105 x molarity of NaCl in colloidal solution = 5×1
Molarity of NaCl in colloidal solution = 5/105
Concentraiton in millimole = 5/105x1000 = 47.6
3. Activity is the abilityof catalyst to accelerate chemical reactions.
Selectivity is the ability of catalyst to direct the reaction to yield particular products
4. Occulsion is adsorption of gases on metal surface. Hence, $A \to t$
Sorption is the case where absorption as well as adsorption occurs. e.g. dyes on cotton fabrics. Hence, $B \to s$
Persorption is the adsorption of gases in cavities of substnaces like zeolites or chabazite.
Hence $C \to q$
Negative adsorption is the case of adsorption of solvent from the solution by adsorbent, e.g., water from dil. KCl solution by blood charcoal.
Hence, $D \to r$
Absorption is not a surface phenomenon but a bulk phenomenon, e.g., H_2O combines with $CaCl_2$ to form $CaCl_2.2H_2O$.
Hence, $E \to p$
5. (A) Ammonia preparation - Fe
(B) Hydrogenation - Ni
(C) Fermentation - Bio catalysed
(D) Oxidation of SO_2 to SO_3 - Homogenous catalysis
6. (A) Physical adsorption - multi layered
(B) Chemisorption - unilayer
(C) Fruendlich adsorption isotherm - $\frac{x}{m} = kp^{1/n}$
(D) Absorption - Bulk phenomenon