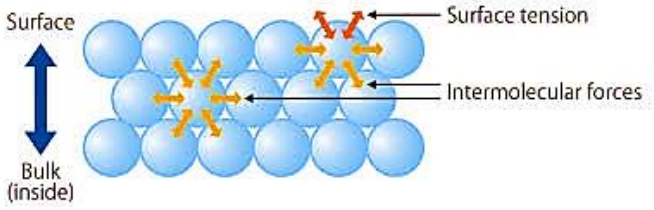
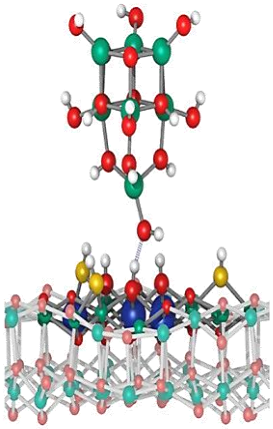
CHAPTER – 5

SURFACE CHEMISTRY

Surface chemistry deals with the phenomenon that occur at the surface or interface.
The surface or interface is represented by separating the bulk phases by a hypen or slash. For example: (i) Interface between a solid and gas → solid-gas or solid/gas
(ii) Interface between liquid and liquid → Liquid-liquid or liquid/liquid
(iii) But there is no interface between two gases, due to complete miscibility

- Molecules on surface experiences unbalanced attracted forces resulting in a net inward pull. This produces surface tension.
- Molecules in bulk phases experiences balanced forces from all the directions and are in state of equilibrium.

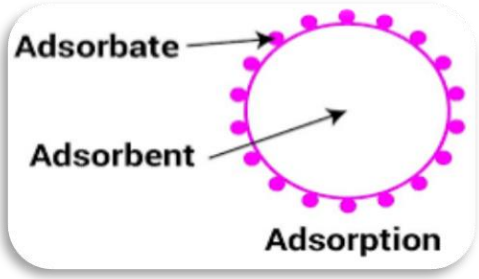




Adsorption

Adsorption is a process that involves the accumulation of a substance in molecular species in higher concentrations on the surface. If we look at Hydrogen, Nitrogen and Oxygen, these gases adsorb on activated charcoal. Meanwhile, we have to note that adsorption is different from absorption. The two processes involve totally different mechanisms.

Adsorbate: Substance that is deposited on the surface of another substance. For example, H_2, N_2 and O_2 gases.



Adsorbent: Surface of a substance on which adsorbate adsorbs. For example, Charcoal, Silica gel, Alumina.

Important features of adsorption:

(i) It is straightforward and selective in nature.

(ii) Adsorption is associated with a reduction (free power switch) of the system in which, the adsorption balance is said to be established.

Desorption:

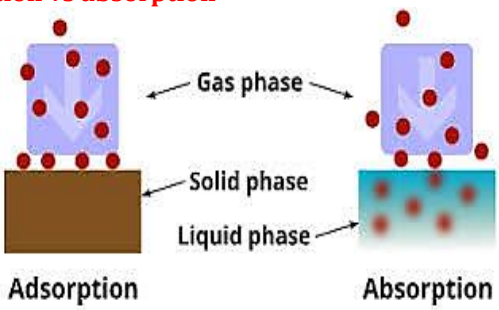
The process of removing an adsorbed substance from a surface. [Reverse of adsorption]

An example of desorption is when a container full of water is exposed to heat, oxygen is released from the water, leading to a decrease in the oxygen content of the container.

Absorption:

It is different from adsorption. In absorption, the substance is evenly distributed throughout the body of solid or liquid.

Adsorption vs absorption



Adsorption	Absorption
Accumulation of molecular species at the bottom instead of the liquid or solid.	Assimilation of the molecular system throughout the bulk of the solid or liquid medium.
A surface phenomenon.	A bulk phenomenon.
Exothermic process	Endothermic process
The Concentration at the bottom of adsorbent is different from that in bulk.	It is constant throughout the medium.
Influenced by low temperature	The temperature has no effect.
Increases steadily and reaches equilibrium.	Occurs at a uniform rate.

Sorption:

When adsorption and absorption occur simultaneously, it is called sorption.

Thermodynamics of adsoption: [Why is adsorption always exothermic?]

During adsorption there is always a decrease in residual forces of surface, there is a decrease in surface energy, which appears as heat. That's why adsorption is an exothermic process.
After adsorption randomness of the system decreases. So far adsorption ΔS = -ve

For adsorption, thermodynamics requirement is that at constant T and P, ΔG must be negative. [$\Delta G = -ve$]
$\Delta G = \Delta H - T\,\Delta S$

Enthalpy or adsorption heat:

As such, adsorption occurs by the release of energy, i.e. naturally exothermic. The enthalpy change of advertising for one adsorbate mole on the adsorbent surface is called enthalpy or adsorption heat.

Types of adsorption:

Physical adsorption or physisorption

When the particles of adsorbate are held to the surface by physical forces such as van der Waal's forces. Then adsorption is called physical adsorption.

Features of physical adsorption

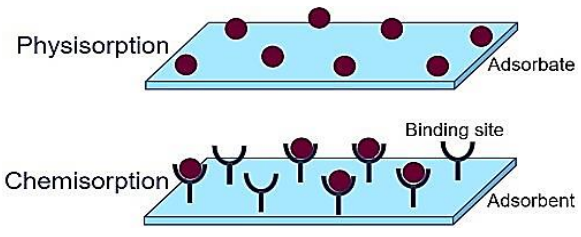
- Renewable environment
- Low adsorption enthalpy
- Multimolecular layers of adsorption

Chemical Adsorption or Chemisorption:

When the molecules of adsorbate are held together to the surface of the adsorbent by chemical forces, the adsorption is known as chemical adsorption.

Features of chemical adsorption

- Forming a chemical bond between molecules
- High initial energy
- High adsorption temperature
- Unimolecular adsorption layer



Difference between physisorption and chemisorption

Physisoption	Chemisorption
It is due to the formation of van der Waals forces.	It is due to the formation of chemical bonds.
It is reversible in nature.	It is irreversible in nature.
Physisorption is not specific in nature.	It is very specific in nature.
It has low adsorption enthalpy nearly 20 to 40 kJ/mol.	Chemisorption has high adsorption enthalpy nearly 80 to 240 kJ/mol.
It favours low temperature.	It favours high temperature.
Physisorption decreases with increase in temperature.	Chemisorption increases with increase in temperature.
It results in a multimolecular layer.	It results in a unimolecular layer.

Factors affecting extent of adsorption

Nature of adsorbent

The adsorption of the gas depends on the nature of the adsorbent. A gas can be adsorbed on different absorbent surfaces in different amounts. For example, Hydrogen is weakly adsorbed on the alumina surface whereas it is strongly adsorbed on the nickel surface under certain conditions.

Surface area

When we increase the surface area of the adsorbent there is an increase in the adsorption of gases. This is because when we increase the surface area there is more number of adsorbing sites. So finely divided solids and some porous substances are good adsorbents.

Nature of the gas

In general, if a gas is more liquefiable it will be more easily absorbed. For example, gases like NH_3, HCl, Cl_2, CO_2, which can be liquefied easily are more readily adsorbed on the solids surface rather than permanent gases like O_2, H_2, etc.

Exothermic nature

The heat of adsorption can be defined as the energy liberated when 1 g mol of a gas is adsorbed on a solid surface. When the temperature is increased the kinetic energy of the gas molecules also increases which results in more number of collisions between the molecules and the surface.

Pressure

On the solid surface, there is a fixed number of adsorption sites where gas molecules can be adsorbed. Initially when the pressure has increased the rate of adsorption increases due to an increase in the gas molecules striking on the surface. Thus, an increase in the pressure increases the rate of adsorption linearly. But after sometime, it will reach a point when the pressure has no effect on the rate of adsorption as the number of adsorption sites is fixed and no more adsorption can happen in those sites. Hence, at that point, the extent of adsorption will be independent of the pressure.

Adsorption isotherm:

The graph between amount of gas absorbed and pressure at constant temperature is known as adsoption isotherm.

x – mass of gas adsorbed

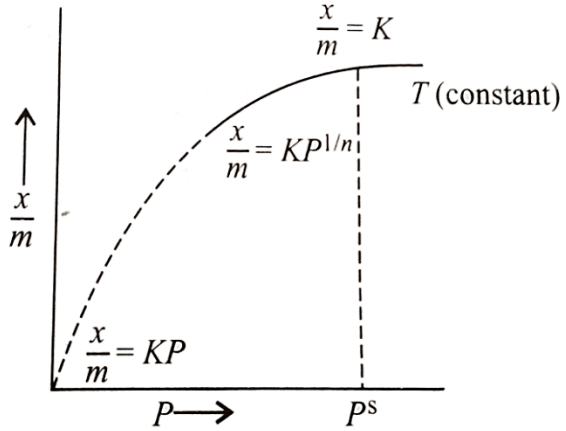
m – mass of adsorbent

Freundlich Adsorption isotherm:

Freundlich adsorption gives the variation in the quantity of gas adsorbed by a unit mass of solid adsorbent with the change in pressure of the system for a given temperature. The expression for the Freundlich isotherm can be represented by the following equation:

$x / m = k \times P^{1/n}$ $(n > 1)$

where n>1



Where x is the mass of the gas adsorbed, m is the mass of the adsorbent, P is the pressure and n is a constant which depends upon the nature of the adsorbent and the gas at a given temperature. Taking the logarithm on both the sides of the equation, we get,

$\log x / m = \log k + 1 / n \log P$

Observation

(i) **At low pressure**, the graph is almost straight line which indicates that x/m is directly proportional to the pressure.

$x/m \propto p_z$

$x/m = K_p$

where K is constant.

(ii) **At high pressure**, the graph becomes almost constant which means that x/m becomes independent of pressure. This may be expressed as:

x/m = constant

$x/m \propto p^0$

$x/m = K p^0$

(iii) Thus, in the intermediate range of pressure, x/m will depend upon the power of pressure which lies between 0 to l i.e., fractional power of pressure (probable range 0.1 to 0.5).

This may be expressed as

$x/m \propto p^{1/n}$

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

where n can take any whole number value which depends upon the nature of adsorbate and adsorbent. The above relationship is also called Freundlich's adsorption isotherm.

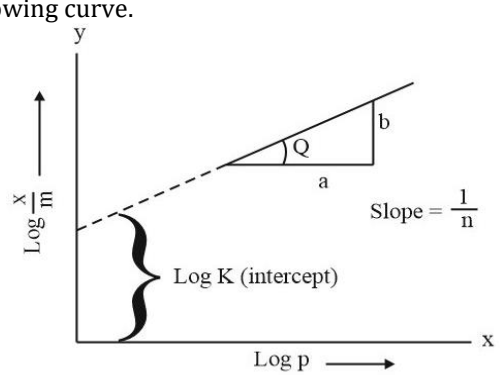
Adsorption from solution phase: solids can adsorb from solutions. Freundlich equation approximately describes the behaviour of adsorption from solution with a difference that instead of pressure, concentration of solution is taken into account.

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

$\log x/m = 1/n \log c + \log k$

$y = mx + c$

The plot of this equation is a straight line as represented by the following curve.



Freundlich isotherm

Limitations of Freundlich Isotherm

Freundlich isotherm only approximately explains the behaviour of adsorption. The value of 1/n can be between 0 and 1, therefore the equation holds good only over a limited range of pressure.

When 1/n = 0, x/m is constant, the adsorption is independent of pressure.

When 1/n =1, $x/m = k_p$, i.e. $x/m \propto P$, adsorption is directly proportional to pressure.

Adsorption isobars:

With the increase in temperature at constant pressure the extent of adsorption (x/m) will decrease. The graph between extent of adsorption and temperature at constant pressure is called adsorption isobar.

In case of chemisorption, the adsorption initially increases with rise in temperature and then decreases. Like all chemical reactions, some activation energy is required for chemisorption.

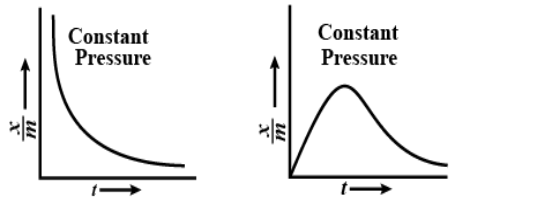
(a) At low temperature, x/m is small.

(b) As temperature is increased the molecules of the adsorbate gain energy and become equal to activation energy so that proper bonds are formed with the adsorbent molecules.

(c) Therefore, initially amount of gas adsorbed increases with rise in temperature. Further increase of temperature will increase the energy of molecules which have already been adsorbed.

(d) This would increase the rate of desorption and, therefore, decrease the extent of adsorption.

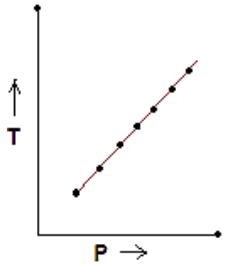
The adsorption isobar graphs can be used to distinguish between physical and chemical adsorptions. In physical adsorption, there is a regular decrease as temperature increases. However, in chemisorption, there is initial increase and then it decreases.



Physical adsorption osobar Chemical adsorption osobar

Adsorption Isostere:

It is a plot of temperature versus pressure for a given amount of adsorption. In this graph amount of gas adsorbed is kept constant. It shows that linear relationship exists between temperature and pressure

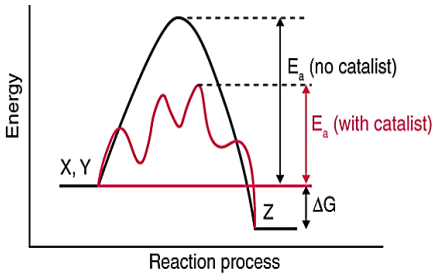


Adsorption Isostere

Catalysis:

All reactants need to overcome certain energy, better known as activation energy in order to form products. This activation energy is the difference between the energy of transition state and the reactant species. Some reactant molecules have enough kinetic energy to overcome this energy barrier whereas others don't.

Hence, not all the reactions happen at the same rate in general conditions. Therefore, certain reagents are added which lower the required activation energy for the conversion of reactants to products. These reagents are known as catalysts and this process of lowering the activation energy is known as catalysis.

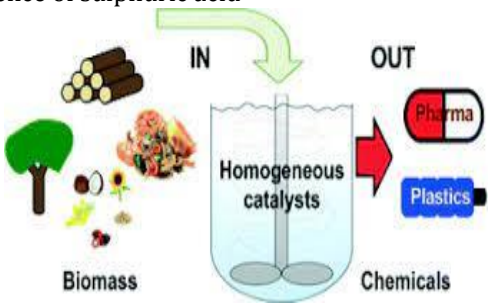


Types of catalysis:

Homogeneous catalysis:

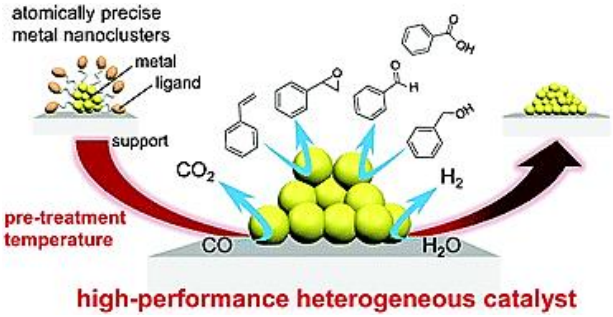
Homogeneous catalysis of chemical reactions is a process where the reactants involved in the reaction and the catalyst

are in the same phase. For example - hydrolysis of sugar in the presence of sulphuric acid



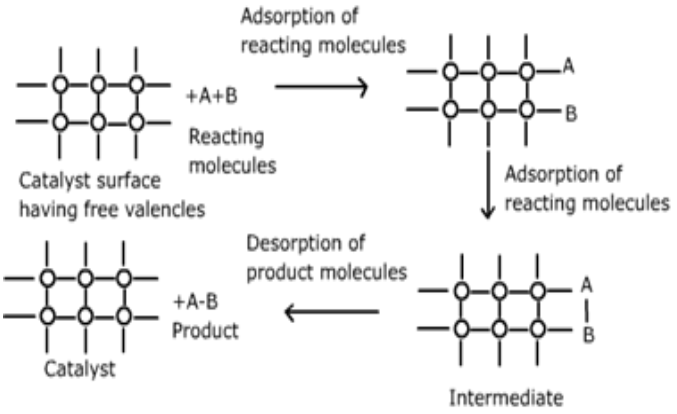
Heterogeneous catalysis:

Heterogeneous catalysis of chemical reactions is a process where the reactants involved in the reaction and the catalyst are in different phases. For example reaction of hydrogen and nitrogen in the presence of finely divided iron to form ammonia.



Adsorption Theory of Heterogeneous catalyst:

1. The reactants diffuse to the surface of the catalysts. In this process, the reactants first get in contact with the external surface out of which some of them get enter into interior through the cracks on the external surface.
2. These molecules then get adhered to the suitable sites available for adsorption.
3. The reactants, when bound to the surface have a higher probability of reacting with each other, and after the reaction, they form an intermediate compound.
4. After this process, the intermediate compound gets desorbed from the surface, which again becomes available for adsorption for other molecules to come.
5. The intermediate compound then disintegrates to form the final products, which then diffuse out of the internal pores and the external surface of the catalyst.



Catalyst features:

- Catalyst may change physically but not chemically.
- Small amounts of catalyst are sufficient for catalysis.
- Catalyst activates the reaction rate but cannot activate it.
- Catalytic activity at high temperature.

Activity of Catalyst:

Catalyst has an ability to increase the rate of reaction. This ability of catalyst is known as the activity of catalyst. It depends upon adsorption of reactants on the surface of catalyst. Chemisorption is the main factor governing the activity of catalysts. The bond formed during adsorption between the catalytic surface and the reactants must not be too strong or too weak.

It must be strong enough to make the catalyst active whereas, not so strong that the reactant molecules get immobilized on the catalytic surface leaving no further space for the new reactants to get adsorbed. Generally for the hydrogenation reaction, from Group 5 to Group 11 metals, the catalytic activity increases. The catalytic activity is found to be highest for group 7-9 elements of the periodic table.

$$2H_2(g) + O_2(g) \xrightarrow{Pt} 2H_2O(l)$$

Selectivity of Catalyst:

Catalysts are highly specific compounds. They have an ability to direct the reaction to yield a particular product. The reaction with same reactants but different catalyst may yield different products. This is termed as the selectivity of catalyst. Catalysts are highly selective in nature. They can accelerate a particular reaction while inhibit another reaction. Hence, we can say a particular catalyst can catalyse one particular reaction only. It may fail to catalyse another reaction of the same type. For example: reaction of hydrogen and carbon monoxide yields methane when nickel is used as catalyst, methanol when a mixture of zinc oxide and chromium oxide is used as catalyst and methanal when only copper is used as catalyst.

$CO\ (g) + 3H_2\ (g) \xrightarrow{Ni} CH_4\ (g) + H_2O\ (g)$

$CO\ (g) + 2H_2\ (g) \xrightarrow{Cu,\ ZnO.Cr2O3} CH_3OH\ (l)$

$CO\ (g) + H_2\ (g) \xrightarrow{Cu} HCHO\ (g)$

Shape selective catalyst:

A catalytic reaction which depends upon the pore structure of the catalyst and on the size of the reactant and the product molecules is called shape-selective catalysis. For example, catalysis by zeolites is a shape-selective catalysis.

Poisons and promoters:

Promoters are substances that enhance the activity of a catalyst. For example in the manufacture of ammonia, iron acts as a catalyst. Molybdenum acts as a promoter in this case. Poisons are substances that decrease the activity of a catalyst.

Role of promoters and poisons in catalysis

Promoter increases the activity of catalyst and poison decreases the activity of catalyst.

For example:

In the formation of ammonia along with finely divided Fe as a catalyst we also use Mn as a promoter.

$N_2 + 3H_2 \rightarrow 2NH_3$

Enzyme catalysis:

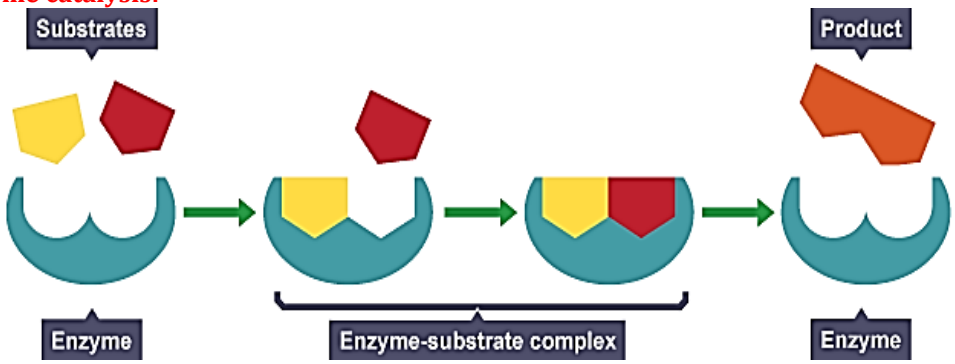
It refers to the various reactions (caused by enzymes) that occur in the bodies of animals and plants in order to maintain life processes. An example of an enzyme catalysis is the conversion of sugarcane sugar.

This is also known as biochemical catalysis.

Steps for Enzyme catalysis:

- The enzyme and the substrate are in the same area. Some situations have more than one substrate molecule that the enzyme will change.
- The enzyme grabs on to the substrate at a special area called the active site.
- A process called catalysis happens.
- The enzyme releases the product.

The process of enzyme catalysis:



Symptoms of enzyme catalysis:

(1) High efficiency. Enzyme catalysts increase reaction reactions 10^8 to 10^{22} times compared to random reactions.
(2) Very small values.
(3) Clarification.
(5) Very good pH.
(6) Regulation of enzyme activity.
(7) Controlled activity.
(9) Influence of inhibitors and toxins.

True solution:

A true solution is a mixture of solute and solvent that is homogeneous. Filtration cannot separate the solute from the solution in a true solution. The solute's particle size is around the same as the solvent's, and the solvent and solute move through the filter paper together.

Colloids:

Any substance consisting of particles substantially larger than atoms or ordinary molecules but too small to be visible to the unaided eye; more broadly, any substance, including thin films and fibres, having at least one dimension in this general size range, which encompasses about 10^{-7} to 10^{-3} cm.

Alternatively, we can also say that colloids are basically solutions in which solute particle size ranges from 1nm – 1000 nm. Colloids are heterogeneous in nature.

Dispersed phase and dispersion medium

The phase that is dispersed or present in colloidal particle shape is called the dispersed phase. The medium the colloidal particles are distributed is called the medium of dispersion. Example: Starch represents the dispersed phase in a starch solution, while water is the dispersing medium.

Classification of colloids:

Dispersed phase	Dispersion medium	Type of colloid	Example
Solid	Solid	Solid sol	Some coloured glasses, and gem stones
Solid	Liquid	Sol	Paints, cell fluids
Solid	Gas	Aerosol	Smoke, dust
Liquid	Solid	Gel	Cheese butter, jellies
Liquid	Liquid	Emulsion	Milk, 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

Colloids are classified into many types.

Classification Based on Physical State

(a) Solid Solution
In this dispersed phase solid and the dispersion medium.
Eg: gemstones.

(b) Aerosol
These colloids consist of air as the dispersion medium.

Example

1. Cloud. This contains air as dispersion medium and water drops as the dispersed phase.
2. Dust. This contains air is dispersion medium and dent particle as the dispersed phase.
3. Smoke. This contains carbon particles in the air.

(c) Gels: These contain solid dispersion medium and liquid dispersed phase

Example

Cheese, butter.

(d) Emulsion: These are liquid-liquid solutions in which the dispersed phase is liquid and liquid dispersed medium. Emulsion mainly consists of two aspects.
Oil in water type:
Oil is dispersed phase and water is dispersion medium

Example

Milk

Water in oil type:
Water is the dispersed phase and oil/fat is dispersion medium.

Example

Vanishing cream

Sols and gels are reversible and interconvertible. This is known as thixotropy.
Classification Based on Dispersion Medium

On the basis of dispersion medium sol are classified as;

(a) Hydrosol: In these colloids water act as a dispersion medium.

Example

Starch

(b) Alcosol: In this type, alcohol acts as a dispersion medium.

(c) Acrosol: These contain a dispersed phase particle in the air.

Example

Smoke

Classification Based on Interaction Forces

On the basis of interaction forces between the dispersion medium and dispersed phase.

Lyophobic Sols: [Emulsoid]

(a) Surface Tension: It is same as that of the medium.
(b) Viscosity: It is the same as that of the medium.
(c) Irreversible: These are irreversible colloids when once dispersion medium is evaporated and again when the solvent is added no new sol is formed.
(d) Stability: There is weak interaction between the dispersed phase and dispersion medium hence lyophobic sols are unstable.
(e) Visibility: Particle can be detected using ultramicroscope.
(f) Migration: Particle migrates either colloid an anode depending upon the charge of sol particle.
(g) Action of electrolyte: When the electrolyte is added to sol, coagulation takes place.
(h) Hydration: No hydration of sol takes place.

Example

Metallic sols like Ag, gold etc.

Lyophilic Sols

These are stable strong sols. A strong interaction is present between the dispersed phase and the dispersion medium. Following are the characteristics of lyophilic sols.

(a) Surface tension: Lower than that of the medium.
(b) Viscosity: Higher than medium.
(c) Reversibility: These are reversible sols. When dispersion medium is evaporated and the solvent is added again the same type of sol is formed.
(d) Stability: More stable due to strong interaction between the dispersed phase and the dispersion medium.
(e) Visibility: The particles are visible under an electron microscope.
(f) Addition of electrolyte: Small amount of electrolyte is required for the formation of sol.
(g) Hydration: Extensive hydration takes place.
(h) Example: gum, gelatin, starch.

Classification Based on Properties of Sol Particle

Classification of sols on the basis of properties are given as;

Multi Molecular Colloids

When a dissolution occurs atoms or smaller molecules of substance [having a diameter less than 1nm] aggregate together to form particles of colloidal dimensions. The particles thus formed are called multimolecular colloids.

In these sols, the dispersed phase consists of aggregates of atoms or molecules with a molecular size less than 1 atm. For example sols of gold atoms and sulphur (S) molecules. In these colloids, the particles are held together by physical forces called Van der Waals forces. Metallic sols are usually multimolecular sols prepared by Bredig's are melted. These are usually lyophobic unstable, and separation is early possible.

Macromolecular Colloids

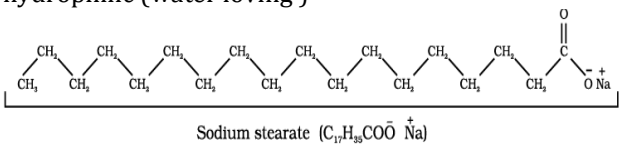
These are substances having big size molecular called macromolecular which on demolition form size in the colloidal ran such substance are called macromolecular colloids. Thus macromolecule forming the dispersed phase are generally polymers having very high molecular masses.

Naturally occurring macromolecular are starch, cellulose proteins, enzyme gelatin etc. Artificial macromolecular and synthetic polymers such as nylon, polyester, plastics, polishers etc. They have usually lyophobic sols.

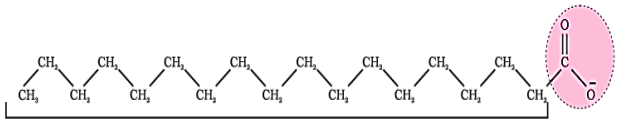
Mechanism of miscelle formation:

Soap is the sodium or potassium salt of fatty acid and may be represented as RCOO- Na (e.g. sodium stearate, (CH3(CH2)16COO-Na+]) . Whendissolved into water , it dissociates into $RCOO^-$ and Na^+ ions

The $RCOO^-$ ion consists of two parts – long hydrocarbon chain (also called non – polar tail) which is hydrophobic (water repelling) and a polar group COO^- (polar head) which is hydrophilic (water loving)



Sodium stearate ($C_{17}H_{35}COO^- Na$)



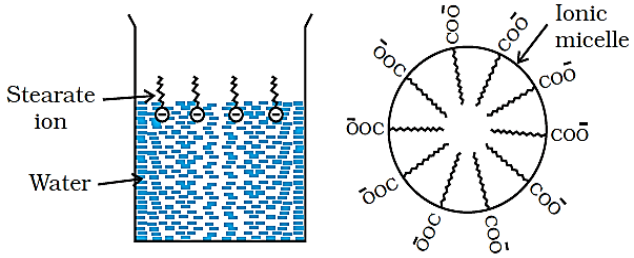
Hydrophobic tail
Stearate ion

Hydrophilic head

Hydrophilic head

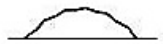
Hydrophobic tail

At higher concentrations (CMC) $RCOO^-$ ions form an aggregate of spherical shape with the hydrocarbon chains pointing towards the centre and the COO^- part facing outward on the surface of the sphere. This aggregate is called ionic micelle. It may have as many as 100 ions

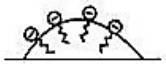


Cleansing action of soaps:

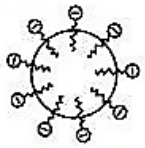
The cleansing action of soap is due to the formation of micelle by the soap molecules in such a way that the hydrophobic part is in the oil droplet(dirt) and the hydrolphilic part projects out. Since the polar groups interact with water surrounded by soap ions is pulled from the surface and pulled into water.



(i) Grease on cloth



(II) Stearate ions arranging around the grease droplet



(III) Grease droplet surrounded by stearate ions (micelle formed)

Lyphobic Sols can be prepared as follows:

Chemical method

- On Oxidation
- Reduction
- Hydrolysis
- Double decomposition method

Physical Modes:

- Solvent exchange.
- Excessive cooling: colloidal sol ice in organic solvent can be obtained by dissolving the aqueous solution in the solvent.

Dispersion method:

- Dispersion of equipment
- Bredig's arc method
- Peptization Method.

Preparation methods of colloidal solution:

Lyophilic & Lyophobic Colloids:

Lyophilic colloids can be prepared by just heating the solid with the liquid dispersion medium.

Whereas the lyophobic colloids cannot be prepared just by heating, they need to be prepared by some special methods.

The two methods by which the lyophobic colloids can be prepared are as follows:
Dispersion method
Aggregation method

Dispersion Method:

In this type of preparation method, the larger particles are broken down into particles of the range of colloidal particle size.

Some dispersion methods are:

Mechanical Dispersion:

In this method, solid and liquid dispersion mediums are poured into the colloidal mill to form a colloidal sol.

Bredig's Arc method (Electrodispersion):
Hydrosols of metals e.g., platinum, silver, and gold are prepared by this method. The metal electrodes are kept at the two sides of the arc which is enclosed by deionised water. The excessive heat provided by the spark vaporises some traces of the metal and water gets condensed by vapour. Some amount of KOH is added to water as a stabilising agent.

Peptisation:
In the peptisation method, some electrolytes are added to form a colloidal sol from a freshly prepared precipitate.

Example

Ferric chloride is added to a freshly prepared precipitate of ferric hydroxide which converts it into a colloidal sol of reddish brown.

Aggregation methods:
In this method, small particles are aggregated to form colloidal-size particles.

Double Decomposition:

Example

Arsenious oxide is mixed with hydrogen sulphide to form arsenic sulphide sol. The excess amount of hydrogen sulphide is removed by passing a stream of hydrogen.
$As_2O_3 + 3H_2S \rightarrow As_2S_3$ (sol) $+ 3H_2O$

Reduction:

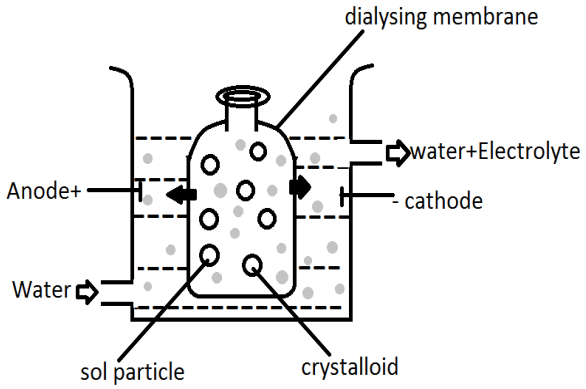
Example

Noble gases are reacted with organic reducing agents like ethanol, tannic acid, and formaldehyde to form their respective sol.
$AgNO_3$ + tannic acid → Ag-sol

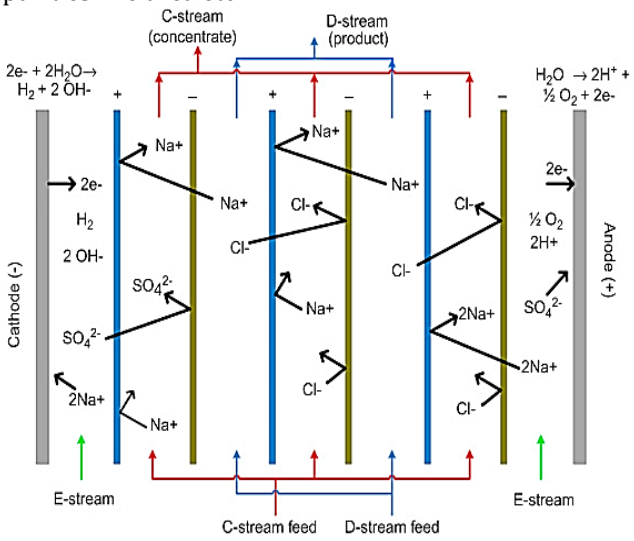
Oxidation:
When hydrogen sulphide is passed through a solution of sulphur dioxide it forms a sulphur sol.
$2\ H_2S + SO_2 \rightarrow 2H_2O + S$

Purification of colloidal solution

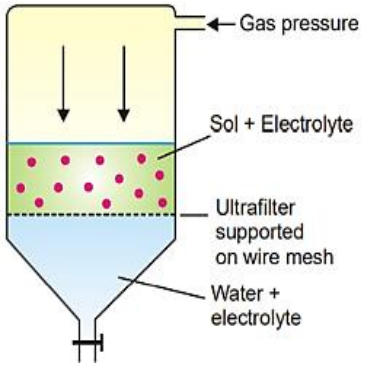
Dialysis:
The process in which the ions are removed from the solution by the phenomenon of diffusion through a permeable membrane is known as dialysis. In this process, a sol consisting of ions or molecules is filled in a permeable membrane bag and dipped in the water. The ion from the solution diffuses through the permeable membrane. Because of the continuous flow of water, the concentration of electrolytes outside the membrane is neutralized. For e.g.: Ferric hydroxide sol is purified by using this method.



Electrodialysis:
In this process dialysis of the colloidal solution is carried out under the effect of the electric field. Some potential is applied between the metal screens that support the membranes. Due to this potential, the speed of the ions moving in the direction of opposite electrodes is increased. Thus, the rate of dialysis is increased. This method is not useful for non-electrolyte impurities like urea etc.



Ultrafiltration:
If filter paper is made with colloidal or some regenerated cellulose like cellophane, the size of the pores is decreased. This modified form of filter paper is known as ultrafilter. The process in which the particles of the solution are removed from the liquid medium by electrolysis and by using this ultrafilter is known as ultrafiltration. It is a slow process. To speed up the process some external gas pressure has to be applied.



Properties of Colloids

Colligative Properties-

The particles in colloids are bigger aggregates than those in a true solution. So, the number of particles in a colloid is lesser than a true solution of the same concentration. The values of colligative properties (osmotic pressure, lowering of vapour pressure, depression in freezing point, elevation in boiling point) are of small order as compared to values shown by true solution at same concentration.

Tyndall effect-

Tyndall effect is the scattering of the light by the particles present in the colloidal solution when viewed at right angles to the passage of light.

It is observed only when-

The diameter of the dispersed particles is not much smaller than the wavelength of light used

The refractive indices of the dispersed phase and dispersed medium have a large difference

This effect was used to make an ultramicroscope and differentiate between true solution and colloids.

Colour-

The colour of the colloidal solution depends on the wavelength of the light scatter by the dispersed particles, size and nature of the dispersed particles and the manner in which it is viewed. Example- Finest gold sol is red in colour and as the size of the particle keeps increasing its colour changes to blue, then purple and finally gold.

Coagulation value: Minimum concentration of an electrolyte required to cause precipitation of a sol is called coagulation value.

Coagulation Power α 1/coagulation value

Physical features of colloidal solution:

Stability: Colloids are naturally stable. The particles of the dispersed phase are in a state of continuous motion and remain suspended in solution.

Filterability: Colloids require special filters known as ultrafilters to filter. They easily pass through standard filter papers without removing residues.

Heterogenous Nature: As colloids consist of two phases, the dispersed phase and the dispersion medium, known as heterogeneous in nature.

Homogeneous appearance: Even though colloids have a set of particles and have different textures, they appear to be a drought-like solution. This is because the suspended particles are so small that they cannot be seen with the naked eye.

Emulsion:

An emulsion can be defined as a colloid consisting of two or more non-homogenous type of liquids wherein one of the liquid contains the dispersion of the different form of liquids.

Emulsification: The process of converting a liquid mixture into an emulsion is called emulsification.

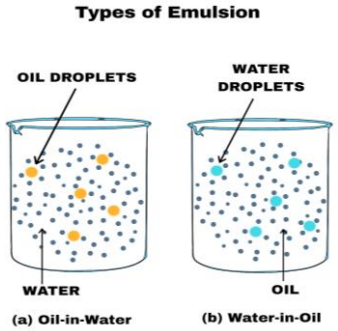
Types of emulsion:

(1) Oil in water (O/W):

In this type of emulsion, the oil will be the dispersed phase and water will be the dispersion medium. The best example for o/w emulsion is milk. In milk, the fat globules (which act as the dispersed phase) are suspended in water (which acts as the dispersion medium).

2) Water in oil (w/o):

In this type, water will be the dispersed phase and oil will be the dispersion medium. Margarine (a spread used for flavouring, baking and working) is an example of water in oil emulsion.



Emulsifying Agent

Generally, an emulsion is stabilized by introducing third substances like emulsifying agents. These agents are three types,

Soap and detergents

Lyophilic sols

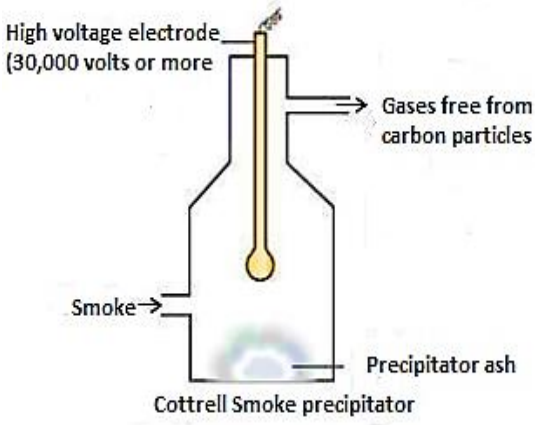
Insoluble powder

Demulsification:

The process of decomposition of an emulsion into its constituent liquids is called demulsification. Examples of demulsifiers are surfactants, ethylene oxide, etc.

Applications of Colloids

Electro precipitation of smoke – The smoke is led through a chamber containing plates having a charged opposite to that carried by smoke particles. The particles on coming in contact with these plates lose their charge and get precipitated. The particles settle down on the floor of the chamber. The precipitator is called Cottrell precipitator.



Purification drinking water – Alum is added to impure water to coagulate the suspended impuritiesand make water fit for drinking.

Medicines – Most of the medicines are colloidal in nature. Colloidal medicines are more effective because they have a larger surface area and are more easily absorbed by the body. Eg- Argyrol is a silver sol used as an eye lotion, milk of magnesia is used to cure stomach disorders

Tanning – Animal hides are colloidal in nature. When a hide that has positively charged particles is soaked in tannin/chromium salts, which contains negatively charged particles , mutual coagulation takes place. This results in the hardening of leather. This process is termed as tanning.

Photographic plates and films – Photographic plates and films are prepared by coating an emulsion of the light sensitive silver bromide in gelatin over glass plates or celluloid films.

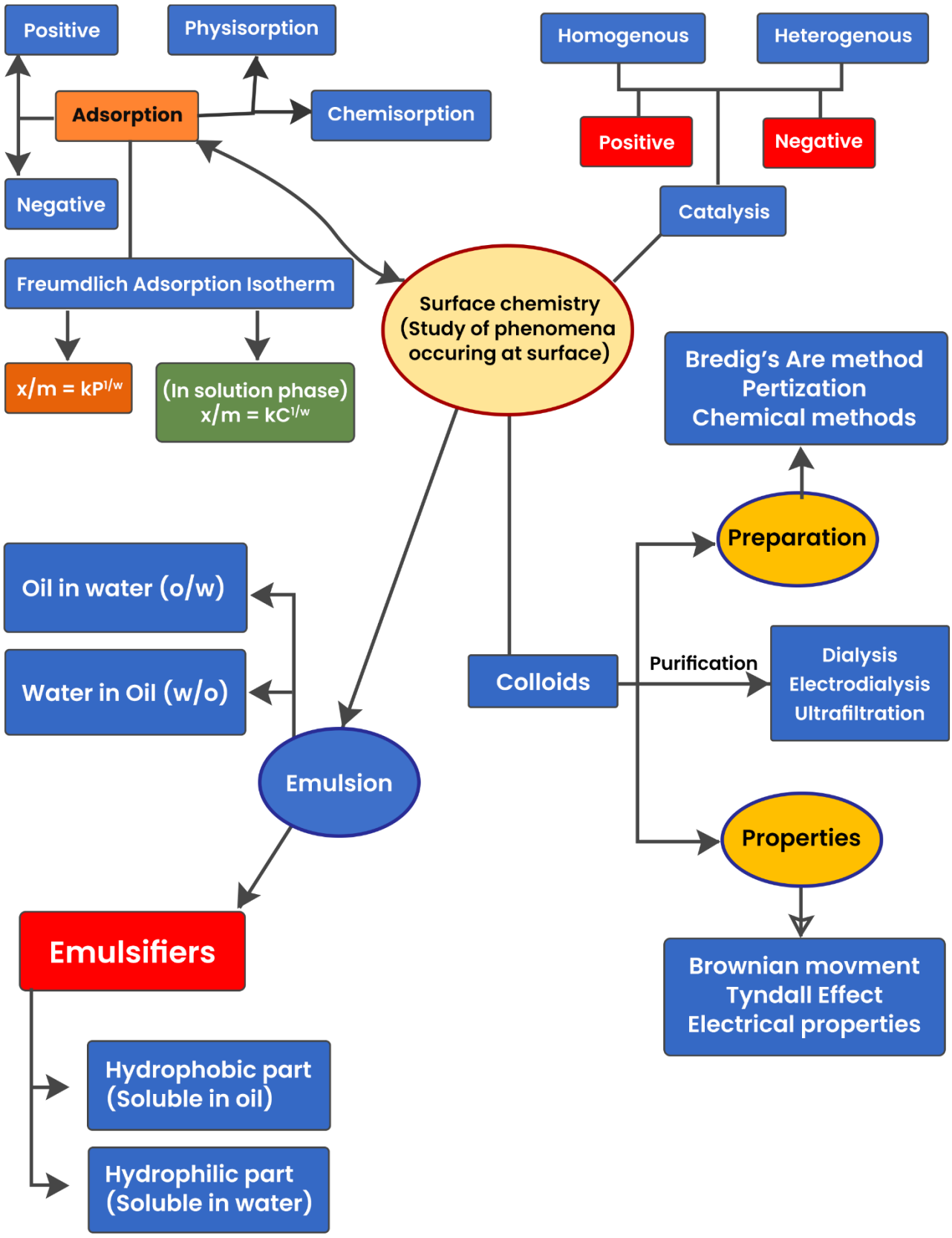
Rubber industry- Latex is a colloidal solution of rubber particles which are negatively charged. Rubber is obtained by coagulation of latex.

Industrial products - Paints, inks, synthetic plastics, rubber, cement, graphite lubricants are all colloids

SUMMARY

Adsorption is the phenomenon of attracting and retaining the molecules of a substance on the surface of a solid resulting into a higher concentration on the surface than in the bulk. The substance adsorbed is known as adsorbate and the substance on which adsorption takes place is called adsorbent. In physisorption, adsorbate is held to the adsorbent by weak van der Waals forces, and in chemisorption, adsorbate is held to the adsorbent by strong chemical bond. Almost all solids adsorb gases. The extent of adsorption of a gas on a solid depends upon nature of gas, nature of solid, surface area of the solid, pressure of gas and temperature of gas. The relationship between the extent of adsorption (x/m) and pressure of the gas at constant temperature is known as adsorption isotherm. A catalyst is a substance which enhances the rate of a chemical reaction without itself getting used up in the reaction. The phenomenon using catalyst is known as catalysis. In homogeneous catalysis, the catalyst is in the same phase as are the reactants, and in heterogeneous catalysis the catalyst is in a different phase from that of the reactants. Colloidal applications in industry as well as in daily life solutions are intermediate between true solutions and suspensions. The size of the colloidal particles range from 1 to 1000 nm. A colloidal system consists of two phases - the dispersed phase and the dispersion medium. Colloidal systems are classified in three ways depending upon (i) physical states of the dispersed phase and dispersion medium (ii) nature of interaction between the dispersed phase and dispersion medium and (iii) nature of particles of dispersed phase. The colloidal systems show interesting optical, mechanical and electrical properties. The process of changing the colloidal particles in a sol into the insoluble precipitate by addition of some suitable electrolytes is known as coagulation. Emulsions are colloidal systems in which both dispersed phase and dispersion medium are liquids. These can be of: (i) oil in water type and (ii) water in oil type. The process of making emulsion is known as emulsification. To stabilise an emulsion, an emulsifying agent or emulsifier is added. Soaps and detergents are most frequently used as emulsifiers. Colloids find several

MIND MAP


Positive
Physisorption
Adsorption
Chemisorption
Negative
Freumdlich Adsorption Isotherm
x/m = kP1/w
(In solution phase)
x/m = kC1/w
Homogenous
Heterogenous
Positive
Negative
Catalysis
Surface chemistry
(Study of phenomena
occuring at surface)
Bredig's Are method
Pertization
Chemical methods
Preparation
Oil in water (o/w)
Water in Oil (w/o)
Emulsion
Colloids
Purification
Dialysis
Electrodialysis
Ultrafiltration
Properties
Emulsifiers
Brownian movment
Tyndall Effect
Electrical properties
Hydrophobic part
(Soluble in oil)
Hydrophilic part
(Soluble in water)

QUESTIONS FOR PRACTICE

Q1. Which of the following process does not occur at the interface of phases?
(a) crystallization
(b) heterogenous catalysis
(c) homogeneous catalysis
(d) corrosion

Q2. Which of the following interface cannot be obtained?
(a) liquid-liquid (b) solid-liquid
(c) liquid-gas (d) gas-gas

Q3. The term 'sorption' stands for
(a) absorption
(b) adsorption
(c) both absorption and adsorption
(d) desorption

Q4. Extent of physisorption of a gas increases with
(a) increase in temperature.
(b) decrease in temperature.
(c) decrease in surface area of adsorbent.
(d) decrease in strength of van der Waals forces.

Q5. Extent of adsorption of adsorbate from solution phase increases with
(a) increase in amount of adsorbate in solution.
(b) decrease in surface area of adsorbent.
(c) increase in temperature of solution.
(d) decrease in amount of adsorbate in solution.

Q6. Which of the following is not a favourable condition for physical adsorption?
(a) high pressure
(b) negative ΔH
(c) higher critical temperature of adsorbate
(d) high temperature

Q7. Physical adsorption of a gaseous species may change to chemical adsorption with
(a) decrease in temperature
(b) increase in temperature
(c) increase in surface area of adsorbent
(d) decrease in surface area of adsorbent

Q8. In physisorption adsorbent does not show specificity for any particular gas because
(a) involved van der Waals forces are universal.
(b) gases involved behave like ideal gases.
(c) enthalpy of adsorption is low.
(d) it is a reversible process.

Q9. Which of the following is an example of absorption?
(a) Water on silica gel
(b) Water on calcium chloride
(c) Hydrogen on finely divided nickel
(d) Oxygen on metal surface

Q10. At high concentration of soap in water, soap behaves as
(a) molecular colloid
(b) associated colloid
(c) macromolecular colloid
(d) lyophilic colloid

Q11. Which of the following will show Tyndall effect?
(a) Aqueous solution of soap below critical micelle concentration.
(b) Aqueous solution of soap above critical micelle concentration.
(c) Aqueous solution of sodium chloride.
(d) Aqueous solution of sugar.

Q12. Method by which lyophobic sol can be protected.
(a) By addition of oppositely charged sol.
(b) By addition of an electrolyte.
(c) By addition of lyophilic sol.
(d) By boiling.

Q13. Freshly prepared precipitate sometimes gets converted to colloidal solution by
(a) coagulation (b) electrolysis
(c) diffusion (d) peptisation

Q14. A colloidal system having a solid substance as a dispersed phase and a liquid as a dispersion medium is classified as
(a) solid sol (b) gel
(c) emulsion (d) sol

Q15. The values of colligative properties of colloidal solution are of small order in comparison to those shown by true solutions of same concentration because of colloidal particles
(a) exhibit enormous surface area.
(b) remain suspended in the dispersion medium.
(c) form lyophilic colloids.
(d) are comparatively less in number.

Q16. Which of the following is a lyophobic colloid?
(a) gelatin (b) sulphur
(c) starch (d) gum arabic.

Q17. The nature of bonding forces in adsorption are
(a) purely physical such as Van der Waal's forces
(b) purely chemical
(c) both chemical and physical
(d) sometimes physical and sometimes chemical.

Q18. The protective power of a lyophilic sol is
(a) defined by Hardy-Schulze rule
(b) proportional to the quantity of electrical charge on it
(c) measured in terms of gold number
(d) determined by the size of its colloidal particles.

Q19. The Tyndall effect associated with colloidal particles is due to
(a) presence of electrical
(b) scattering of light charge

(c) absorption of light
(d) reflection of light

Q20. Which one of the following is not applicable to chemisorption?
(a) Its heat of adsorption is high
(b) It takes place at high temperature
(c) It is reversible
(d) It forms mono-molerular layers.

Q21. In the colloidal state the particle size ranges
(a) below 1 nm
(b) between 1nm to 100 nm
(c) more than 100nm
(d) none of the above.

Q22. All colloids
(a) are suspension of one phase in another
(b) are two-phase systems
(c) contain only water-soluble particles
(d) are true solutions.

Q23. Colloids can be purified by
(a) condensation (b) peptization
(c) coagulation (d) dialysis.

Q24. Milk is an example of
(a) emulsion (b) suspension
(c) foam (d) sol.

Q25. Emulsifier is an agent which
(a) accelerates the dispersion
(b) homogenizes an emulsion
(c) stabilizes an emulsion
(d) aids the flocculation of an emulsion.

Q26. Fog is colloidal system of
(a) gas in liquid (b) liquid in gas
(c) gas in gas (d) gas in solid.

Q27. When a colloidal solution is observed under ultramicroscope, we can see
(a) light scattered by colloidal particles
(b) size of the colloidal particles
(c) shape of the colloidal particles
(d) relative size of the colloidal particles

Q28. Colloidal solutions are classified on the basis of:
(a) molecular size (b) organic or inorganic
(c) surface tension value (d) pH value.

Q29. Surface tension of lyophilic sols is:
(a) lower than that of H_2O
(b) more than that of H_2O
(c) Equal to that of H_2O (d) none.

Q30. Blood may be purified by:
(a) Dialysis (b) electro-osmosis
(c) coagulation (d) Alteration.

Q31. Which of the following characteristics is not correct for physical adsorption?
(a) Adsorption increases with increase in temperature.
(b) Adsorption is spontaneous
(c) Both enthalpy and entropy of adsorption are negative
(d) Adsorption on solids is reversible.

Q32. A colloidal system in which gas bubbles are dispersed in a liquid is known as:
(a) foam (b) aerosol
(c) sol (d) emulsion.

Q33. Which one of the following forms micelles in aqueous solution above certain concentration?
(a) Glucose
(b) Urea
(c) Dodecyl trimethyl ammonium chloride
(d) Pyridinium chloride

Q34. Adsorption of gases on solid surface is generally exothermic because
(a) enthalpy is positive
(b) entropy decreases
(c) entropy increases
(d) free energy increases.

Q35. Which of the following forms cationic micelles above certain concentration?
(a) sodium dodecyl sulphate
(b) sodium acetate
(c) urea
(d) cetyl trimethyl ammonium bromide.

Q36. Which one of the following statements about the zeolites is false?
(a) They are used as cation exchangers
(b) Some of the SiO44- units are replaced by AlO45- and AlO69- ions is zeolites.
(c) They have open structure which enables them to take up small molecules.
(d) Zeolites are alumino silicates having three dimensional network.

Q37. The dispersed phase in colloidal iron (III) hydroxide and colloidal gold is positively and negatively charged respectively. Which of the following statements is not correct?
(a) Magnesium chloride solution coagulates the gold sol more readily than the iron (III) hydroxide sol
(b) Sodium sulphate solution causes coagulation in both sols.
(c) Mixing the sols has no effect
(d) Coagulation of both sols can be brought about by electrophoresis.

Q38. Which of the following is correct about lyophilic sols?
(a) They are irreversible
(b) They are formed by inorganic substance
(c) They are readily coagulated by addition of electrolytes
(d) They are self-stabilized.

Q39. Which one of the following is correctly matched?
(a) Emulsion-curd (b) Foam-mist
(c) Aerosol-smoke (d) Solid sol-cake.

Q40. Cellulose dispersed in ethanol is called:
(a) Emulsion (b) Micelle
(c) Collodion (d) Hydrophilic sol.

Q41. The correct ascending order of adsorption of the following gases on the same mass of charcoal at same temperature and pressure is
(a) $CH_4 < H_2 < SO_2$ (b) $H_2 < CH_4 < SO_2$
(c) $SO_2 < CH_4 < H_2$ (d) $H_2 < SO_2 < CH_4$

Q42. The formation of micelles takes place only above
(a) Inversion temperature
(b) Boyle's temperature
(c) Critical temperature
(d) Kraft temperature

Q43. The protective power of lyophilic colloidal sol is expressed in terms of
(a) coagulation value
(b) gold number
(c) CMC (Critical Micelle Concentration)
(d) oxidation numbers

Q44. The coagulation values in millimoles per litre of the electrolyte for the coagulation of As2S3 sol are given
I. NaCl (52)
II. $BaCl_2$ (0.69)
III. $MgSO_4$ (0.22)
The correct order of coagulating power is
(a) I > II > III (b) II > I > III
(c) III > II > I (d) III > I > II

Q45. 3g of activated charcoal was added to 50 ml of acetic acid solution (0.06 M) in a flask. After an hour it was filtered and the strength of filtrate was found to be 0.042 M. The amount of acetic acid adsorbed per gram of charcoal is
(a) 42 mg (b) 54 mg
(c) 18 mg (d) 36 mg

Q46. Which is favourable for physical adsorption?
(a) High T and high P (b) High T and low P
(c) Low T and high P (d) T and P do not affect

Q47. The stability of lyophobic sols is due to
(a) adsorption of covalent molecules on the colloid
(b) the size of the particles
(c) the charge on particles
(d) Tyndall effect.

Q48. The term 'sorption' stands for
(a) absorption
(b) adsorption
(c) both absorption and adsorption
(d) desorption

Q49. Extent of adsorption of adsorbate from solution phase increases with
(a) increase in amount of adsorbate in solution.
(b) decrease in surface area of adsorbent.
(c) increase in temperature of solution.
(d) decrease in amount of adsorbate in solution.

Q50. Physical adsorption of a gaseous species may change to chemical adsorption with
(a) decrease in temperature
(b) increase in temperature
(c) increase in surface area of adsorbent
(d) decrease in surface area of adsorbent

Q51. According to adsorption theory of catalysis, the speed of the reaction increases because
(a) the concentration of the reactant molecules at the active centres of the catalyst becomes high due to adsorption.
(b) in the process of adsoption, the activation energy of the molecules becomes large.
(c) adsorption produces heat which increases the speed of the reaction.
(d) adsorption lowers the activation energy of the reaction.

Q52. Lyophillic colloids are stable due to
(a) charge on the particles.
(b) large size of the particles.
(c) small size of the particles.
(d) layer of dispersion of medium on the particles.

Q53. Cottrell precipitator is used to
(a) precipitate mud from muddy water.
(b) precipitate carbon particles from smoke.
(c) purify the ordinary drinking water.
(d) precipitate salts in qualitative analysis.

ASSERTION AND REASONING

Q1. **Assertion:** Detergents with low CMC are more economical to use.
Reason: Cleansing action of detergents involves the formation of micelles. These are formed when the concentration of detergents becomes equal to CMC.
(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

Q2. **Assertion:** Soap and detergents are macro-molecules colloids.
Reason: Soap and detergent are molecules of large size.
(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.
(e) Assertion is incorrect and Reason is correct

Q3. **Assertion:** Micelles are formed by surfactant molecules above the critical micellar concentration because
Reason: The conductivity of a solution having surfactant molecules decreases sharply at the CMC
(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.
(e) Assertion is incorrect and Reason is correct

Q4. Assertion: An ordinary filter paper impregnated with collodion solution stops the flow of colloidal particles.
Reason: Pore size of the filter paper becomes more than the size of colloidal particle.
(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.
(e) Assertion is incorrect and Reason is correct.

TRUE/FALSE

Q1. The movement of tiny particles in a gas or liquid is called Tyndall effect.
(a) True
(b) False

Q2. Chemical adsorption is irreversible.
(a) True
(b) False

Q3. Chemical adsorption increases with an increase in temperature.
(a) True
(b) False

QUESTIONS FOR PRACTICE

Q1. Tyndall effect confirms the
(a) gravity effect on the sol. particles
(b) light scattering by the sol. particles
(c) heterogeneous nature of sols
(d) Brownian motion of the sol particles

Q2. Alum helps in purifying water by:
(a) Forming Si complex with clay particles
(b) Sulphate part which combines with the dirt and removes it
(c) Aluminium which coagulates the mud particles
(d) Making mud water soluble

Q3. Negative catalyst or inhibitor is one:
(a) which retards the rate of reaction
(b) takes the reaction in forward direction
(c) promotes the side reaction
(d) none of the above

Q4. Butter is a colloid form in which:
(a) fat is dispersed in solid casein
(b) fat globules are dispersed in water
(c) water is dispersed in fat
(d) suspension of casein is in water

Q5. Purple of cassius is colloidal solution of:
(a) Silver
(b) Lead
(c) Gold
(d) Mercury

Q6. The electrical charge on a colloidal particle is observed by:
(a) Ultramicroscope
(b) Scattering
(c) Brownian movement
(d) Electrophoresis

Q7. Movement of dispersion medium under the influence of electric field is known as
(a) electrodialysis (b) electrophoresis
(c) electroosmosis (d) cataphoresis

Q8. Which of the following can adsorb larger volume of hydrogen gas?
(a) Finely divided platinum
(b) Colloidal solution of palladium
(c) Small pieces of palladium
(d) A single metal surface of platinum

Q9. Which of the following types of metals make the most efficient catalyst?
(a) Alkali metals
(b) Transition metals
(c) Inner transition metals
(d) Alkaline earth metals

Q10. Shape selective catalysis is a reaction catalysed by
(a) zeolite
(b) enzymes
(c) platinum
(d) Ziegler-Natta catalyst

Q11. When hit by light, what happens to a colloidal mixture?
(a) Passes through (b) Absorbed
(c) Reflected (d) Diffracted

Q12. Under which category is colloidal system?
(a) True solution
(b) Homogeneous mixture
(c) Heterogeneous mixture
(d) Suspensions

Q13. What is the colloidal solution of a gas in liquid called?
(a) Solution (b) Aerosol
(c) Gel (d) Foam

Q14. Which of the following is not an example of lyophilic colloids?
(a) Starch solution
(b) Gelatin
(c) Gum
(d) Silver solution

Q15. Which of the following is not an example of lyophobic colloids?
(a) Blood
(b) Gold solution
(c) Sulphur solution
(d) NaCl solution

Q16. Which of the following is a characteristic of a multi-molecular colloid?
(a) Multi-molecular colloids are normally of the lyophilic type
(b) Large number of molecules combine to form a particle of colloidal size
(c) A large number of atoms aggregate to form a particle of colloidal size
(d) Starch solution is an example of multi-molecular colloid

Q17. Which of the following is false regarding macro-molecular colloids?
(a) These are normally of lyophilic type
(b) Protein solution is an example for macro-molecular colloids
(c) Man-made macro-molecules like polythene can form such colloids
(d) Silver solution can form macro-molecular colloids

Q18. Which of the following is not an example of associated colloids?
(a) Sodium stearate
(b) Potassium stearate
(c) Gum
(d) Detergents

Q19. Which of the following colloids cannot be formed by direct mixing?
(a) Associated colloids
(b) Lyophilic colloids
(c) Lyophobic colloids
(d) Macro-molecular colloids

Q20. Which of the following colloids is most stable?
(a) Starch solution
(b) Blood
(c) Sulphur solution
(d) Silver solution

Q21. In which of the following, the dispersed phase and medium can be separated by evaporation?
(a) Ferric hydroxide solution
(b) Sulphur solution
(c) Metal in water
(d) Starch solution

Q22. Which of the following is incorrect for a catalyst?
(a) Bio-chemical reactions are mostly catalysed by enzymes
(b) Catalyst does not start a reaction
(c) Catalyst changes the equilibrium constant of a reaction
(d) Co-enzymes increase the activity of an enzyme

Q23. How does a catalyst increase the rate of a reaction?
(a) By forming an intermediate complex
(b) By increasing activation energy
(c) By lowering the activation energy
(d) By changing equilibrium constant

Q24. Which of the following is known as Lindlar's catalyst?
(a) Na in liquid NH_3
(b) Pt in ethanol
(c) Pd with $BaSO_4$
(d) Ni in ethanol

Q25. Which of the following enzymes catalyses the hydrolysis of triglycerides to fatty acids and glycerol?
(a) Pepsin
(b) Maltase
(c) Zymase
(d) Lipase

Q26. Ziegler Natta catalyst is associated with
(a) polymerisation of alkenes
(b) hydrogenation of alkenes
(c) hydroformylation of alkenes
(d) none of the above

Q27. Which of the following is changed in a chemical reaction due to a catalyst?
(a) Internal energy
(b) Entropy
(c) Enthalpy
(d) Activation energy

Q28. Which of the following is used as a catalyst in the lead chamber process?
(a) Nitrogen oxides (b) Pt
(c) Ni (d) V2O5

Q29. Which of the following is incorrect for enzymes?
(a) Enzymes are specific
(b) Most of the enzymes are protein
(c) Reactivity of enzymes is least at optimum temperature
(d) High temperature and UV rays can denature enzymes

Q30. What is the effect of enzymes on the rate of biochemical reactions?
(a) The rate increases (b) It does not change
(c) The rate decreases (d) either (b) or (c)

ASSERTION AND REASONING

Q1. **Assertion:** Colloidal solutions show colligative properties.
Reason: Colloidal particles are large in size.
(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.
(e) Assertion is incorrect and Reason is correct

Q2. **Assertion:** Colloidal solutions do not show Brownian motion.
Reason: Brownian motion is responsible for the stability of sols.
(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.
(e) Assertion is incorrect and Reason is correct

Q3. **Assertion:** The values of colligative properties are of smaller order as compared to values shown by true solutions at same concentrations.
Reason: Colloidal particles show Brownian movement.
(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.
(e) Assertion is incorrect and Reason is correct

Q4. **Assertion:** Colloidal solution exhibit Tyndall effect while true solution particles.
Reason: Because the size of the colloidal particles is large enough to scatter light as compared to size of the true solution particles.
(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.
(e) Assertion is incorrect and Reason is correct.

TRUE/FALSE

Q1. The size of colloidal particles is usually less than 10 A°.
(a) True (b) False

Q2. Colloidal solutions are usually transparent but they may also show transluscene.
(a) True (b) False

Q3. True solutions do not exhibit Tyndall effect.
(a) True (b) False

SOLUTIONS

S1. **(c)** In homogeneous catalysis, only, the reactant and product are in same phase and composition is uniform throughout.

S2. **(d)** Because gas-gas forms homogeneous composition.

S3. **(c)** When adsorption and absorption occur simultaneously it is known as sorption.

S4. **(b)** Since the adsorption (Solid+ Gas=Gas/Solid+ Heat) process is exothermic, the physical adsorption occurs readily at low temperature and decreases with increasing temperature as the equilibrium will shift in backward direction. (Le-Chatelier's principle).

S5. **(a)** The extent of adsorption depends on the concentration of the solute in solution as the concentration of adsorbate increase interaction between adsorbate and adsorbent increases thus the extent of adsorption increases.

S6. **(d)** High temperature is not favourable for physical adsorption since it is an exothermic process.

S7. **(b)** On increasing the temperature activation energy of the adsorbate molecule increases. Which can convert physical adsorption into chemisorptions.

S8. **(a)** Involved van der waals forces are universal.
This phenomenon involves the use of weak Van der Waal forces by means of which gas molecules get adsorbed on a solid surface.
There is no specificity as any gas can be adsorbed onto the surface.

S9. **(b)** Absorption implies that a substance is uniformly distributed, through the body of the solid or liquid.

S10. **(b)** There are some substances which at low concentrations behave as normal strong electrolytes, but at higher concentrations exhibit colloidal behavior due to the formation of aggregates. The aggregated particles thus formed are called micelles. These are also known as associated colloids.

S11. **(b)** Tyndall effect is the optical property shown by the colloidal particle. Above critical micelle concentration, a solution of soap behave as associated colloid that is why it shows tyndall effect.

S12. **(c)** Lyophilic colloids have a unique property of protecting lyophobic colloids. When a lyophilic sol is added to the lyophobic sol, the lyophilic particles form a layer around lyophobic particles and thus protect the latter from electrolytes. Lyophilic colloids used for this purpose are called protective colloids.

S13. **(d)** Peptisation is the process in which freshly prepared precipitate can be converted into colloidal solution.

S14. **(d)** Explanation: Solid + liquid= sol (here solid is the dispersed phase and liquid is the dispersion medium.)

S15. **(d)** Colloidal particles being bigger aggregates, the number of particles in a colloidal solution is comparatively 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 concentration.

S16. **(b)** Gelatin, starch and gum all are examples of lyophilic colloids and sulphur is an example of lyophobic colloids.

S17. **(c)** The exact nature of the bonding depends on the details of the species involved, but the adsorption process is generally classified as physisorption (characteristic of weak van der Waals forces) or chemisorption (characteristic of covalent bonding). It may also occur due to electrostatic attraction.

S18. **(c)** It is expossed in terms of gold number

S19. **(b)** Colloidal particles due to their bigger size, scatters the light. Hence, they show Tyndall effect. When the colloidal solution is watched from perpendicular to the light-plane, colloidal particles look like stars in sky.

S20. **(c)** Chemical adsorption is strong, unilayer, directional and strong. It generally happens at high temperature as it requires activation energy. Chemisorption happens due to specific forces so, it is not reversible generally. It happens due to strong attraction forces and hence its heat of adsorption is high.

S21. **(b)**

S22. **(b)** A colloid is a substance in which microscopically dispersed insoluble particles are suspended throughout another substance. So, all colloids are two phase systems.

S23. **(d)** Colloidal solutions can be purified by dialysis. It may be defined as the process of separating a crystalloid from a colloid by diffusion or

filtration through a fine membrane. The process of dialysis can be quickened by using hot water (hot dialysis) or by applying an electric field (electrodialysis).

S24. **(a)** Milk is an example of emulsion. These are formed when both the dispersed phase and dispersion medium are liquids in a colloidal system. If a mixture of two immiscible or partially miscible. liquids is shaken, coarse dispersion of one liquid on the other is obtained, which is known as emulsion. They also show Brownian movement and Tyndall effect.
They can be broken into their constituent liquids by freezing, heating and centrifuging etc.

S25. **(c)** In order to prepare stable emulsions, it is important to add a third component known as emulsifier or emulsifying agent in suitable amounts. Several types of emulsifiers are listed below:
(i) Long chain compounds with polar groups such as soap, sulphonic acid, sulphates etc.
(ii) Most of the lyophilic colloids also act as emulsifiers such as glue, gelatin etc.
(iii) Certain insoluble powders as clay, lamp, black etc.
(iv) Soluble substances like iodine also act as emulsifiers.

S26. **(b)** Fog is a class of colloidal system where liquid (liquid aerosol) is dispersed in gas medium.

S27. **(a)** Scattering of light from the surface of colloidal particles-tyndall effect is observed. When a colloidal solution is observed under an ultramicroscope.

S28. **(a)** One criterion for classifying colloids is the physical state of the dispersed phase and dispersion medium. Depending upon the type of the dispersed phase and dispersion medium (solid, liquid, or gas), there can be eight types of colloidal systems. The dispersed-phase particles have a diameter between approximately 1 and 1000 nanometers. Homogeneous mixtures with a dispersed phase in this size range are colloidal aerosols, colloidal emulsions, colloidal foams, colloidal dispersions or hydrosols.

S29. **(a)** Lyophilic sols are those where the substances have a high affinity for the dispersion medium and thus easily form colloidal solutions. As they are highly hydrated, the viscosity decreases, and so they have a lower surface tension than the dispersion medium.
As the lyophilic colloids have a great affinity towards the water solvent, which lowers the surface tension, the surface tension of lyophilic sols is lower than that of the surface tension of water.

S30. **(a)** Blood is a Colloidal which Contain Crystalloids as impurity hence Con be Separated by Dialysis

S31. **(a)** Physical adsorption increases with decrease in temperature as easily liquifiable gases can adsob more.
So option A is false statement.

S32. **(a)** A colloidal system in which gas bubbles are dispersed in a liquid is known as foam.

S33. **(c)** **Hint:** Micelles are generated in an aqueous solution, with the polar part facing the micelle's exterior surface and the nonpolar region forming the micelle's core.
Explanation:
Above a certain concentration, dodecyl trimethyl ammonium chloride forms micelles in an aqueous solution. A cationic detergent is dodecyl trimethyl ammonium chloride. Above a certain concentration, soaps and detergents form micelles in an aqueous solution.

S34. **(b)** When a gas is adsorbed on the surface, the freedom of movement of its molecules becomes restricted. This causes a decrease in the entropy of the gas after adsorption, i.e, ΔS becomes negative.

S35. **(d)** Cetyl trimethyl ammonium bromide forms cationic micelles above a certain concentration. In the molecule of detergents and soap, the negative ions aggregate to form a micelle of colloidal size. In polar medium (like water), the negative ion has a long hydrocarbon chain and a polar group($-COO^-$) at one end and on other end, it has N^+ ion, thus cationic micelle is formed.

S36. **(b)** **(a)** Zeolites are natural ion exchangers. For example, permutit water softeners are sodium zeolites. They take up calcium ions from hard water and release sodium ions in water.
Thus, the statement A is correct.

(b) In zeolites, some of the the Si^{4+} ions may be replaced by Al^{3+}. This results in unbalanced anionic charge. To maintain electrical neutrality, positive ions must be introduced. Thus, the statement B is incorrect.

(c) Zeolites are like molecular sieves. They trap small molecules such as water, ammonia and carbon dioxide in their interstices.
Thus, the option c is correct.

(d) zeolites are aluminosilicates having three dimensional network. They are termed aluminosilicates because, some of the the Si^{4+} ions may be replaced by Al^{3+}.

S37. **(c)** Opposite charges attract each other. Hence on mixing coagulation of two sols may be take place.

S38. **(d)** Lyophilic sols are reversible in nature, formed by organic substances are self-stabilized. Hence, they are not readily coagulated by addition of electrolytes.

S39. **(c)** Curd-Gel
Mist-Aerosol
Smoke-Aerosol
Cake-Foam, an emulsion and a complex colloidal dispersion

S40. **(c)** Cellulose dispersed in ethanol is called collodion. It used as an adhesive to close small wounds and hold surgical dressings, in topical medications, and for making photographic plates.

S41. **(b)** The extent of adsorption increases with increase in polarity and molar mass.

S42. **(d)** The temperature above which micelles formation takes place is called Kraft temperature.

S43. **(b)** **(b)** Gold number measures protective power of colloids. Lower the gold number more will be protective power, e.g., gelatin.

S44. **(c)** ∵ Lesser the coagulation value, more is coagulating power.

S45. **(b)** Molarity of CH_3COOH adsorbed
= 0.06 – 0.042 = 0.018
Number of millimoles of CH_3COOH
adsorbed = 0.018 × 50 ml = 0.90
Amount = 0.90 × 60 = 54 mg
[∵ molar mass of CH_3COOH = 60 g mol-1]

S46. **(c)** Low temperature and high pressure favours physical adsorption because van der Waals' forces of attraction will increase.

S47. **(c)** same charge on particles cause repulsion and does allow particles to settle down.

S48. **(c)** When both adsorption and absorption takes place, it is called sorption, e.g., dying of cotton fibre.

S49. **(a)** x/m = k C1/n [where 'C' is concentration of solution]

S50. **(b)** **(a)** At high temperature, covalent bond will be formed as activation energy will be provided. Physical adsorption of a gaseous species may change to chemical adsorption with increase in temperature.
As temperature increases, the energy possessed by reactant molecules increases. At a certain temperature, this energy becomes greater than or equal to the activation energy. This results in the formation of a chemical bond.

S51. **(d)** According to the adsorption theory of catalysis, the speed of the reaction increases because adsorption lowers the activation energy of the reaction.

S52. **(d)** Lyophilic sols are more stable than lyophobic sols. This is due to the fact that lyophilic colloids are extensively solvated, i.e., colloidal particles are covered by a sheath of the liquid in which they are dispersed.
Forces of interaction between colloidal particles and liquid are quite strong. Hence, lyophilic sols are very stable and do not precipitate/coagulate easily.

S53. **(b)** Cottrell precipitator is used to precipitate carbon particles from smoke. So, option B is correct.
Cottrell's precipitator neutralizes charges on colloidal particles.
The smoke particles released from industries have charged colloidal carbon particles, which are precipitated by Cottrell's precipitator.
Carbon particles are introduced into the opposite charged plate so that carbon loses its charge and precipitate. This type of precipitation is called Cottrell's smoke precipitator.

ASSERTION AND REASONING

S1. **(a)** Detergents with low CMC are more economical to use as they involve the formation of micelle which is used for cleaning oil and dirt from our cloth. Micelle formation takes place when the concentration of detergent becomes equal to CMC.

S2. **(e)** Macromolecular solutions are polymers dissolved in a solvent, starch, proteins, enzymes and cellulose are the naturally occurring macromolecular colloids. Colloids, due to the formation of aggregate or associated colloids. Soaps and detergents are an example of associated colloids. Thus, assertion is incorrect.

S3. **(b)** At a certain concentration surfactant molecules start to aggregate and form micelle, the concentration is called critical micellisation concentration (CMC). Aggregation of surfactant molecules (ions; RCOO-) ie. micelle formation cause effective fall in number of free ions to conduct electricity, thus conductivity decreases at CMC.

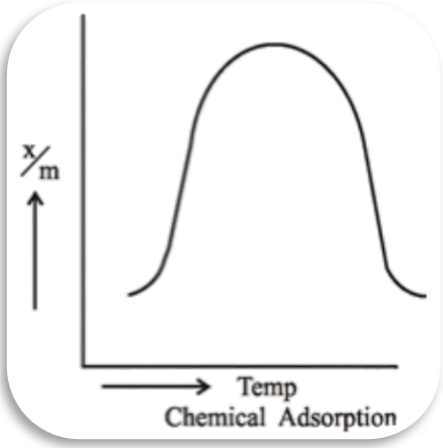
S4. **(c)** Colloidal particles can pass through ordinary filter paper because the pores are too large. However, the pores of filter paper can be reduced in size by impregnating with a colloidal solution to stop the flow of colloidal particles.

TRUE/FALSE

S1. **(b)** The movement of tiny particles in a gas or liquid is called the flow of particles. The property can be also called as "fluidity".
Tyndall effect is the phenomenon of light scattering by particles in a colloid.

S2. **(a)** Chemical adsorption involves a chemical reaction in between surface and adsorbate. The force operating between the adsorbate and adsorbent is strong and similar to chemical bonds. The enthalpy of the adsorbent is high. Chemical adsorption occurs at relatively high temperatures and high pressure. It is also irreversible in nature. So, the given statement is true.

S3. **(b)** Chemical adsorption involves a chemical reaction in between surface and adsorbate. The force operating between the adsorbate and adsorbent is strong and similar to chemical bonds. The enthalpy of the adsorbent is high. Chemical adsorption occurs at relatively high temperatures and high pressure. Where chemical adsorption first increases with temperature and gradually decreases the temperature.



SOLUTION FOR PRACTICE QUESTIONS

MCQ

S1. **(c)** Tyndall effect confirms the heterogeneous nature of the colloidal solution.it is observed due to the scattering of dust particles. Tyndall effect is used to distinguish between the true solution and the colloidal solution.

S2. **(c)** Alum is added to water in order to destabilize the mud particles suspended in it. This process is known as coagulation. Alum helps in purifying water by aluminium which helps to coagulate the mud particles.

S3. **(a)** The catalyst which decreases the rate of reaction is known as inhibitor or negative catalyst and the process is known as negative catalysis or inhibition. Negative catalysts are useful to slow down or stop any unwanted reactions.

S4. **(c)** A colloid is a mixture where a particular substance is trapped in a given dispersion medium but do not get mixed chemically. Butter is a colloidal formed when water is dispersed in fat.

S5. **(c)** Gold is dissolved in the aqua medium and it further reduces to give a purple precipitate. Therefore, purple of cassius is a colloidal sol of gold.

S6. **(d)** Colloidal particles possess some type of electric charge. The migration of colloidal particles under the influence of an electric field is known as electrophoresis.

S7. **(c)** When movement of particles (electrophoresis) is prevented by some suitable means, it is observed that the dispersion medium begins to move in an electric field. This phenomenon is termed as electroosmosis.

S8. **(b)** An excellent absorbed hydrogen gas is palladium. Therefore, colloidal solutions of palladium could adsorb greater volume of hydrogen gas as the surface area of palladium is the most colloidal solution of palladium.

S9. **(b)** The transition metals are considered to make the most efficient catalysts. This is because, when these metals are with suitable reactants, they form unstable intermediate products that can lower the activation energy and thereby making the reaction faster.

S10. **(a)** The shape-selective catalysis is a reaction catalysed by Zeolites. Because the structure of Zeolites is like a honeycomb. Hence it is used as the catalyst in the chemical reaction. Zeolites are especially used as Shape-selective catalysis.

S11. **(d)** When light strikes a colloidal mixture, it is reflected off the large particles and spreads out. It is so because the colloidal particles move rapidly and randomly. This is what happens when light hits a mixture.

S12. **(c)** Colloidal sols form heterogeneous mixtures consisting of particles of dispersed phase and the dispersion medium. The dispersed particles are spread evenly throughout the dispersion medium, which can be a solid, liquid, or gas.

S13. **(d)** Depending upon whether the dispersed phase and the dispersion medium are solids, liquids or gases, eight types of colloidal systems are possible. The colloidal solution wherein gas is the dispersed phase and liquid is the dispersion medium is called foam.

S14. **(d)** Starch solution, gelatin and gum are colloids in which the dispersed phase has very high affinity for the dispersion medium and therefore they are categorized as lyophilic colloids. Silver solution on the other hand is an example of lyophobic colloids.

S15. **(d)** Gold solution, Sulphur solution and blood are colloids in which the dispersed phase has very low affinity for the dispersion medium and once the dispersed phase and dispersion medium are separated we cannot get the solution directly by remixing the two phases. Therefore they are categorized under lyophobic colloids.

S16. **(c)** In this type of colloidal solution, a large number of atoms or small molecules aggregate to form a particle of colloidal size, these are normally of lyophobic type. Starch solution is an example of lyophilic colloids and hence is not an example for multi-molecular colloids.

S17. **(d)** Macro-molecules dissolve in a suitable solvents, gives rise to particles of colloidal size. These are normally of lyophilic type and silver solution is an example for lyophobic and multi-molecular colloids.

S18. **(c)** Some substances at low concentration behave as true solutions. As the concentration of the solution increases, it turns to be a colloidal solution. These type of colloids are knows as associated solution. Soaps like sodium stearate potassium stearate and detergents are examples of associated colloids whereas gum is an example for lyophilic colloids.

S19. **(c)** Lyophobic colloids such as metal solutions like gold and silver solution, sulphur solution and blood cannot be prepared directly by mixing. These are prepared by special methods and are irreversible in nature. Once the dispersed phase and medium are separated it is not possible to get the solution by remixing the two phases.

S20. **(a)** Starch solution is most stable among the following because it is a lyophilic colloid and the solutions are highly stable due to the high interaction between the dispersed phase and the dispersion medium.

S21. **(d)** In starch solution, if the dispersed phase and the dispersion medium are separated by evaporation, the colloidal solution can be regained by remixing the dispersed phase and dispersion medium. Hence these are called reversible solutions are highly stable because of the high interaction between the dispersed phase and medium.

S22. **(c)** The value of equilibrium constant is not changed in the presence of a catalyst in the reaction at equilibrium. The catalyst increases the rate of forward and reverse reaction to same extent. It does not affect the value of the equilibrium constant.

S23. **(c)** Catalysts lower the activation energy for reactions. The lower the activation energy for a reaction, the faster the rate. Thus enzymes speed up reactions by lowering activation energy.

S24. **(c)**

S25. **(d)** Lipase has the tendency to hydrolyse the ester bonds that are present which connect the fatty acids to the glycerol. This action in turn enables the release of fatty acids and glycerol form the adipose tissue to wherever any given active tissue needs energy.

S26. **(a)**

S27. **(d)** Catalyst lowers the threshold point by making a short intermediate path so activation energy decreases

S28. **(a)** The process of producing sulphuric acid by oxidising sulphur dioxide with moist air, using gaseous nitrogen oxides as catalysts, is known as Lead chamber process. This reaction takes place primarily in a series of large, box-like chambers of sheet lead.

S29. **(c)** At optimum temperature (25 to 35^0C), enzyme activity is maximum. Most of the enzymes have proteinous nature. They are highly specific and are denatured at high temperature

S30. **(a)** Enzymes are the very efficient catalyst for the enzymatic biochemical reaction and Enzymes speed up the reaction by providing lower activation energy.

ASSERTION AND REASONING

S1. **(b)** Colloidal solutions show colligative properties as colloidal particles have large size so colloidal particles have small value of colligative properties because number of particle so are small in comparison to normal solution.

S2. **(e)** Colloidal particle shows the Brownian movement. The Brownian movement has a stirring effect that does not permit the particles to settle and thus, is responsible for the stability of sols.

S3. **(b)** Colloidal particles being bigger aggregates, the number of particles in a colloidal solution is comparatively 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.

Colloidal particles show Brownian movement. The Brownian movement has been explained to be due to the unbalanced bombardment of the particles by the molecules of the dispersion medium.

Hence, both assertion and reason are correct but the reason is not the correct explanation for the assertion.

S4. **(a)** Size of colloidal particle is sufficient to scatter light and true solution particle size is smaller.

TRUE/FALSE

S1. **(b)** Colloidal particles are particles that are dispersed in a suspension. The colloidal particles formed due to the saturation or instability of the solution. These colloidal particles are differ according to the dispersion medium. For example: In milk, the colloidal particles are fat globulous. The size of colloidal particles ranges from 1−1000nm.

S2. **(a)** Colloidal particles are particles that are dispersed in a suspension. Colloidal solutions are heterogeneous in nature. Colloidal solution appearance generally transparent and may also show transluscene. So, the given statement is true.

S3. **(a)** True solutions are the solution they are homogeneous in nature. True solution particles are invisible particles. The appearance of the true solution is transparent. True solution particles do not settle. The true solution does not scatter the light where is Tyndall effect does not exist. So, the given statement is true where the true solution does not exhibit the Tyndall effect.