HINTS & SOLUTIONS

EXERCISE - 1

Single Choice

1. As temperature increases, physical adsorption decreases because physical adsorption is exothermic and reversible process.

3. Total surface area of eight cubes $= 8 \times 6 \times \left(\frac{1}{2} \times \frac{1}{2}\right)$

Apply the formula

Surface area on n split of a cube $= 8^n \times 6 \times \left(\frac{1}{2}\right)^{2n}$

$$6291456 = 8^n \times 6 \times \left(\frac{1}{2}\right)^{2n}$$

5. The volume of N_2 at STP required to cover the iron surface with monolayer $= 8.15$ ml gm^{-1}

Area occupied by single molecule $= 16 \times 10^{-18}$ cm^2

22400 ml of N_2 at STP contains $= N_A$ molecule of N_2

$$\therefore \quad 8.15 \ldots\ldots\ldots\ldots = \frac{8.15 \times N_A}{22400}$$

$$= 2.19 \times 10^{20} \text{ molecule of } N_2$$

Area occupied by 2.19×10^{20} molecule of N_2 $= 2.19 \times 10^{20} \times 16 \times 10^{-18}$ $cm^2 = 35.06 \times 10^2$ cm^2

surface area of the iron adsorbed $= 0.35$ m^2 gm^{-1}

In short

$$A = \frac{\text{Volume covered by the } N_2 \text{ molecule} \times N_A \times \text{Area occupied by single molecule}}{22400}$$

6. Physical adsorption decreases as temperature increases.

7. Softening of hard water : Ion exchange resins used for softening of hard water is based upon selective and competitive adsorption of ions on resins.

$$Na_2Z + Ca^{+2} \longrightarrow CaZ + 2\,Na^+$$

The organic polymers containing groups like –COOH, $–SO_3H$ and $–NH_2$ etc. possess the property of selective adsorption of ions from solution. These are quite useful in the softening of water.

10. Catalyst provides new path to the chemical reaction which has lower value of activation energy. Reactant and product with not be affected, so there will not be any change in state parameter like enthalpy and internal energy.

11. Different colloidal particle will provide different colour to the sol.

12. Process by which precipitate is converted into colloid is known as peptisation.

14. Blood is a colloidal solution containing a –ve charge colloidal particle (Albuminoid), bleeding can be stopped by use of alum or $FeCl_3$ solution. The addition of Al^{3+} or Fe^{3+} causes coagulation of blood, so bleeding stops.

15. Effectiveness of ion in coagulation $\propto$ charge on coagulating ion.

17. Gold number $\propto \frac{1}{\text{Protecting power}}$.

19. 10 ml of 1 M NaCl contains NaCl $= 10 \times 1 = 10$ milli mole

200 ml of As_2S_3 required NaCl for the coagulation $= 10$ milli mole

$\therefore$ 1000 ml of As_2S_3 required NaCl for the coagulation $= 10 \times 1000/200 = 50$ milli mole

20. Association occurs at CMC so colloid is formed.

22. Loss of water from gel is known as syneresis.

24. Lyophilic solution is easily solvated and quite stable in solvent.

26. $V_2 = \frac{P_1V_1}{P_2} = \frac{720 \times 1000}{480} = 1500$ ml

Volume of gas in the flask $= 1000 -$ volume of charcoal $=$

$$1000 - \frac{5}{1.25} = 996 \text{ ml}$$

Total volume of gas adsorbed by charcoal $= 1500 - 996 =$ 504 ml

Volume of gas adsorbed by per gram of charcoal $= \frac{504}{5}$

$=$ **100.08 ml**

28. $\log \frac{x}{M} = \log k + \frac{1}{n} \log P$

$\frac{1}{n} = \tan 45°$ $\qquad$ $\ln k = 0.69$

$n = 1$ $\qquad$ $k = 2$

$\frac{x}{m} = 2\,x\,(0.5)^1$

$x = 1$

30. Silver sol in water is an example of lyophobic solution.

31. Colloidal particle has size range of 1 to 1000 nm.

34. Reddish brown sol is prepared by adding $FeCl_3$ in $Fe(OH)_3$ precipitate.

36. Higher the charge on coagulating ion, lesser the flocculation value.

37. Cellulose is macromolecular colloid.

39. Lower the gold number, higher the producing power of lyophillic colloid.

40. 0.03 = weight of Hb in mg × 10 / 100
weight of Hb in mg = 0.30.

42. Smoke is blue because of scattering of light.

43. Micelles have large molar mass so less colligative property.

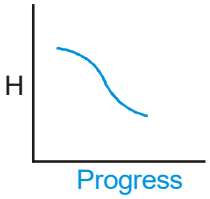
45. More the charge on cation, more the effectiveness of the electrolyte.

46. Similar charged colloidal particles will repel each other so colloidal system will not be suspended.

47. Viscosity of lyophilic colloid is less than water.

49. Sponge will be completely soaked by water, so it is absorption.

50.



For physical adsorption, activation energy is low and ΔH is negative.

53. Monolayer is formed during chemisorption.

54. Colloidal particles scatter light because of their larger size.

55. Blood is colloidal solution which can be purified by dialysis.

56. – ve charged sol is coagulated by cation of electrolyte. More the charge on cation, higher the precipitating power.

57. $\frac{x}{m} = KP^{1/n}$, $\log\frac{x}{m} = \log K + \frac{1}{n}\log P$

58. That's why lyophilic colloid has affinity for water.

59. Scattering of light by colloidal particles is known as Tyndall effect.

60. Tyndall effect is shown by colloidal solution.

61. More the charge on cation, higher the coagulating power.

62. In milk, liquid fat particles are dispersed in water.

63. Lyophilic colloid is solvated by dispersion medium and becomes more stable.

64. Coagulating power ∝ charge on coagulating ion.

65. Effectiveness of coagulation by electrolyte ∝ charge on coagulating ion.

66. Higher the charge on coagulating ion, higher the coagulating power.

67. Gold sol is – ve sol, so coagulating ion is cation.

68. Lyophilic colloidal particles are solvated by dispersion medium.

69. Blood is colloid solution.

70. Fog is an example of liquid dispersed in gas.

EXERCISE - 2

Part # I : Multiple Choice

1. Physisorption is reversible and its extent increases with pressure.

2. Gold sol and $Fe(OH)_3$ sol are hydrophobic.

4. Colloidal particle diameter is 10^{-9} m to 10^{-6} m.

5. $Fe(OH)_3$ is positive sol, remaining all three are negative sol.

8. Delta formation is because of coagulation.

9. Positive and negative sol will precipitate each other.

10. Gel is liquid in solid dispersion.

11. Egg albumin is macromolecular colloid and soap solution is associated colloid.

12. Size of colloidal particle is 10 Å to 10^4 Å.

13. Efficiency of a heterogeneous catalyst increases with its surface area.
Catalyst provides a path of lower activation energy but enthalpy of reaction is not affected.

14. Catalyst may appear in rate expression. But it is not consumed in the reaction.

15. Milk is an emulsion of fat in water.

16. Colloidal particle shows Tyndall effect because of it's larger size.

17. Brownian motion is due to impact of molecules of the dispersion medium on the colloidal particles.

18. As_2S_3 is negatively charged sol so more positively charged ion will have minimum coagulating value .

19. As_2S_3 colloidal sol is obtained when As_2O_3 is saturated with H_2S :

$$As_2O_3 + 3H_2S \rightarrow As_2S_3 + 3H_2O.$$

As_2S_3 adsorbs S^{2-} ions (common between H_2S and As_2S_3 and thus is negatively charged).

$$As_2S_3 + H_2S \rightarrow As_2S_3 \mid S^{2-} : 2H^+.$$

20. Light is scattered by colloidal particles present in environment so sky looks blue.

21. Higher the protecting power of lyophilic colloid, lesser the gold number and gelatin has highest protecting power among the given options.

22. Size of colloidal particles 10Å to 10^4Å which is 10^{-9} m (1 mμ) to 10^{-6} m (1μ).

23. Ferric hydroxide sol is + vely charged sol.

24. Gold number is minimum amount of protective colloid when can protect 10 ml standard gold sol from coagulation when 1 ml of 10% NaCl is added.

25. Sulphur is a lyophobic colloid.

26. Smoke is an example of solid dispersed in gas.

27. Colloidal particles are large sized so they scatter light.

28. Pure air is air in air type of homogeneous mixture.

29. As_2S_3 is – ve charged colloidal solution. Coagulation power $\propto$ charge on cation

30. Gelatin is positive sol.

31. Arsenious sulphide is negatively charged sol so more the charge on cation of electrolyte, more the efficiency of electrolyte for coagulation.

32. Colloid is heterogeneous, biphasic solution.

33. Colloidal sol of less reactive metal such as gold, silver, platinum, copper, lead etc. can be prepared by Bredig's method.

34. $\Delta H = 20 - 40$ kJ mol^{-1} for physisorption and $\Delta H = 200 - 400s$ kJ mol^{-1} for chemisorption.

35. Easily liquefiable gases like CO_2 are adsorbed to a greater extent than gases like O_2, N_2 and H_2

36. Electrophoresis means movement of colloidal particles under the influence of electric field.

37. Lyophobic colloids are irreversible colloids.

38. Smaller the charge on coagulating ion, higher the flocculation value.

39. Power of precipitating $\propto$ charge on cation.

40. According Hardy-Schulze rule

41. Conversion of a freshly prepared ppt. into a colloidal solution by application of a suitable electrolyte is called peptization.

42. (i) NH_3 is easily liquifiable, so ordered more than H_2.
(ii) This phenomenon is known as electrophoresis, not Brownian movement.

43. Adsorption theory is given for heterogeneous catalyst. Example : adsorption of gas on solid surface.

44. According to Freundlich adsorption isotherm,

$$\frac{x}{m} \propto kp^{1/n} \; (n > 1).$$

45. Chromatography is based upon adsorption theory.

46. Negative catalyst provides a path of higher activation energy

47. $\log \frac{x}{M} = \log k + \frac{1}{n} \log P$

$\frac{1}{n} = \tan 45°$ $\quad \log k = 0.3010$

$n = 1$ $\quad k = 2$

$\frac{x}{m} = 2 \times (0.3)^1 \quad \Rightarrow \quad x = 0.6$

48. These are the properties of colloidal solution.

49. Physical adsorption is due to vander waals forces.

50. According to Freundlich isotherm : $\frac{x}{m} = Kp^{1/n}$ or $\log \frac{x}{m}$

$= \log K + \frac{1}{n} \log P$ (For solution, P = C).

51. Enzymes are highly specific heterogeneous catalyst.

56. As_2S_3 is negatively charged.

Part # II : Assertion & Reason

1. Gold number $\propto \frac{1}{\text{Protective power of lyophilic colloid}}$

2. Extent of adsorption increases with surface area of adsorbent.

4. Colloidal particles have high molar mass, so their mole fraction is very less causing low colligative properties.

5. On the basis of Brownian movement, we can say that molecules are in continuous motion.

7. At isoelectric point, colloid particles will not move towards either of electrode because they will come chargeless
8. Gas with higher critical temperature will be liquefied easily and adsorbed more.
9. $AgNO_3 + KI\,(excess) \longrightarrow AgI \xrightarrow{KI\ (remaining)} AgI/I^-$
11. Physisorption decreases with increase in temperature.
14. Medicines are easily accepted by body because of larger size of colloidal medicines.

EXERCISE - 3

Part # I : Matrix Match Type

1. **(A)** Coagulation is known as accumulation of colloidal sols.
   (B) Dialysis is purification of colloids.
   (C) Peptization is formation of colloidal solution from precipitates.
   (D) Tyndall effect is scattering of light by colloidal particle
2. **(A)** Mechanical property of colloid particle is known as Brownian movement.
   (B) Purification of colloids is done by dialysis.
   (C) Gold number $\propto \dfrac{1}{\text{protection power}}$
   (D) Formation of a sol is done by peptization.
3. **(A)** Gold sol is prepared by Bredig's Arc method and it is negatively charged
   (B) Purification of colloidal solution is done by Ultra centrifugation
   (C) As_2S_3 sol is prepared by Double decomposition reaction and it is negatively charged
   (D) Zeta potential- potential difference between stable layer and disperse layer. (Electro kinetic potential)
   (E) Casein is lyophilic Protective colloid.
4. **(A)** Tyndall effect is scattering of light by colloidal particle
   (B) Brownian movement is Zig-zag motion of colloidal particle
   (C) Electrophoresis movement of colloidal particles under the effect of electric field
   (D) According to Hardy schulze rule, coagulation power $\propto$ charge on coagulating ion
   (E) Froth floatation is based on concept of Emulsion (formation) of pine oil

Part # II : Comprehension

Comprehension # 1 :

1. $AgNO_3\,(excess) + KI \longrightarrow AgI$
   $AgI \xrightarrow{+AgNO_3\ (remaining)} AgI/Ag^+$
3. Smoke screen is cloud of smoke. It consists of fine particles of TiO_2.

Comprehension # 2 :

2. The process of imbibing water when elastic gel are placed in water is called as imbibition.
3. Interconversion of sol and gel is known as thixotropy.

Comprehension # 3 :

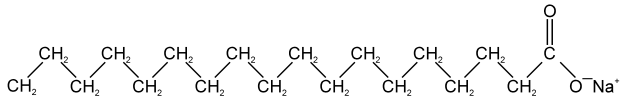
1. At low pH the basic group will be ionized (protonated) so will have positive charge and hence sol particles will move towards cathode.
2. Minimum coagulating value will be for the ion with maximum charge and since the sol particles are negatively charged, hence positively charged ions are required for coagulations
3. We want to prepare sol of AgI having positively charged particles, so a little excess of Ag^+ should be added to KI.
4. Conc. of $Ba^{2+} = \dfrac{10^{-4}}{10\times10^{-3}}\ M = 10^{-2}\ M = 10\ mmole/L.$
5. The sols will neutralise each other so will coagulate each other.
6. Greater the charge on negative ions of salt used (since sol is positively charged) smaller will be its coagulating value.

EXERCISE - 4

Subjective Type

1. Gelatin is added in the preparation of ice cream to protect the particle of ice.
2. By making their surface rough
3. (i) & (iii) are based upon concept of coagulation of colloidal sol.
   (ii) Tail of comet is visible because of Tyndall effect.
   (iv) The Cleansing Action of Soaps :
   It has been mentioned earlier that a micelle consists of a hydrophobic hydrocarbon like central core. The

cleansing action of soap is due to these micelles, because oil and grease can be solubilised in their hydrocarbon, like centres which are not otherwise soluble in water. This is shown diagrammatically in Fig. The dirt goes out along with the soap micelles.



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

4. Gold sol which is lyophobic starts behaving like a lyophilic colloid.

5. Ne, because of greater vander Waal's forces of attraction in Ne than that of He.

6. (i) Haber's process : $N_2 + 3H_2 \xrightarrow{Fe\ (Mo)\ \Delta} 2NH_3$

   (ii) Contact's process : $2SO_2 + O_2 \xrightarrow{V_2O_5} 2SO_3$

7. CO_2 froth made by mixing solutions of $NaHCO_3$ and alum is called fire foam. It is used in fire extinguishers. A protective colloid such as glue or dextrin is added to stabilise the foam.

8. **(a)** Positively charged colloidal particles of $Fe(OH)_3$ get coagulated by the oppositely charged Cl^- ions provided by NaCl.

   (b) Constituent liquids of the emulsion separate out i.e., demulsification occurs.

   (c) Colloidal particles move towards the oppositely charged electrodes, where they lose their charge and get coagulated.

   (d) Scattering of light by the colloidal particles takes place and the path of light becomes visible (Tyndall effect).

9. Micelles are associated colloid, they have low colligative property than normal colloidal solution.

10. The colloidal dispersions of liquids in solid media are called gel.

11. **(i)** Random motion of colloidal particle is known as Brownian movement

    (ii) Scattering of light by colloidal particle is known as Tyndall effect

    (iii) Movement of colloidal particle under the effect of electric field is known as Electrophoresis.

12. **(i)** **Multimolecular colloids :** In this type, the particles consist of an aggregate of atoms or small molecules size less than 1 nm. For example, sols of gold atoms and sulphur (S_8) molecules. In these colloids, the particles are held together by van der Waal's forces.

    (ii) Movement of ions across the membrane can be expedited by applying electric potential through two electrodes as shown in fig. This method is faster than simple dialysis and is known as **Electrodialysis.**

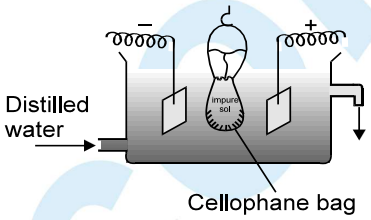


Fig. : An apparatus for electrodialysis.

13. **Associated colloids (Micelles):** These are the substances which behave as normal strong electrolytes at low concentration but behave as colloidal particles at higher concentration. These associated particles are also called micelles. Ex. Soap.

14. The zig–zag motion of colloidal particles is called Brownian movement.

15. Refer Freundlich adsorption isotherm for effect of pressure and adsorption.

16. Scattering of light occurs (Tyndall effect).

17. Solvent loving colloid is known as lyophilic colloid. They are stable and reversible where as solvent hating colloid is known as lyophobic colloid they are less stable and irreversible.

18. **Multimolecular colloids :** In this type, the particles consist of an aggregate of atoms or small molecules size less than 1 nm. For example, sols of gold atoms and sulphur (S_8) molecules. In these colloids, the particles are held together by van der Waal's forces.

    Macromolecular colloids : In this types, the particles of the dispersed phase are sufficiently big in size (macro) to be of colloidal dimensions. These macromolecules forming the dispersed phase are generally polymers having very high molecular masses. These colloids are quite stable and resemble true solutions in many respects. Naturally occurring macromolecules are starch, cellulose, proteins, enzymes, gelatin, etc.

19. Homogeneous, NO in lead chamber process, heterogeneous, finely divided nickel in hydrogenation reactions.

20. Shape selective catalyst. These catalyst catalyses the reaction because of their specific shape so that reactant is get attached in the pores of shape selective catalyst.

21. Random motion of colloidal particle is known as 'Brownian movement'

Conversion of precipitate into colloidal sol is known as 'peptization'

EXERCISE - 5

Part # I : AIEEE/JEE-MAIN

1. On mixing, they will coagulate each other being +ve and – ve charged.

2. For true solution the diameter range is 1 to 10 Å and for colloidal solution diameter range is 10 to 10,000 Å.

$$\frac{V_c}{V_s}=\frac{(4/3)\pi r_c^3}{(4/3)\pi r_s^3}=\left(\frac{r_c}{r_s}\right)^3$$

Ratio of diameters $=(10/1)^3=10^3$ $\quad V_c/V_s=10^3$.

3. The adsorption of a gas is directly proportional to the pressure of gas.

4. Higher the gold number, lesser will be the protective power of colloid.

5. CO is oxidised to CO_2 with steam in the presence of a catalyst followed by absorption of CO_2 in alkali.

$$CO+H_2 \xrightarrow[\text{catalyst}]{\text{steam}} CO_2+2H_2 \xrightarrow{KOH} K_2CO_3$$

6. Since adsorption is exothermic process so ΔH of adsorption is always negative.

7. $\frac{x}{m}\propto P^{1/n}$ where $n\geq 1$

8. According to Hardy Schulze rule, greater the charge on cation, greater is its coagulating power for negatively charged solution. So, order of coagulating power : $Na^+ < Ba^{2+} < Al^{3+}$.

9. Theoritical

$$\frac{x}{m}=k\,p^{1/n}$$

$$\text{Log}(x/m)=\log(k)+\frac{1}{n}\log(p)$$

Only $\left(\frac{1}{n}\right)$ appears as slope

10. 2

11. NO_3^- : The maximum limit of nitrate in drinking water is 50 ppm. Excess nitrate in drinking water can cause disease. Such as methemoglobinemia.

SO_4^{2-} : above 500 ppm of SO_4^{2-} ion in drinking water causes laxative effect otherwise at moderate levels it is harmless.

F^- : Above 2ppm concentration of F^- in drinking water cause brown mottling to teeth.

$\therefore$ The concentration given in question of SO_4^{2-} & NO_3^- in water is suitable for drinking but the concentration of F^- (i.e. 10 ppm) make water unsuitable for drinking purpose.

Part # II : IIT-JEE ADVANCED

1. In adsorption there in bond formation between the gases and solid surface which decreases the entropy so to make it spontaneous the enthalpy change must be negative.

2. In lyophilic sols the dispersed phase have great affinity (attraction) towards dispersion medium. So they are self stabilizing.

3. Longer the hydrophobic part of the molecule easy will be the formation of micelle.

4. Most effective coagulating agent for Sb_2S_3 is $Al_2(SO_4)_3$ because of high charge.

5. Volume of one mole of silver atoms $=\frac{108}{10.5}$ cm^3/mole

volume of one silver atom $=\frac{108}{10.5}\times\frac{1}{6.022\times10^{23}}$ cm^3

so, $\frac{4}{3}\pi R^3=\frac{108}{10.5}\times\frac{1}{6.022\times10^{23}}=1.708\times10^{-23}$

[neglecting the void space]

$R^3=0.407\times10^{-23}$ cm^3

$R^3=0.407\times10^{-29}$ m^3

Area of each silver atom

$\pi R^2=\pi\times(0.407\times10^{-29}\ m^3)^{2/3}$

so, number of silver atoms in given area.

$$= \frac{10^{-12}}{(0.407\times10^{-29}\,m^3)^{2/3}} = \frac{10^8}{(\pi\times2)} = 1.6\times10^7 = y\times10^x$$

$x = 7$

6. **(A)** ΔH = –ve for adsorption

(B) fact

(D) chemical bonds are stronger than vander waal's forces so chemical adsorption is more exothermic.

7. **(A)** due to preferential adsorption of common ions

(C) due to repulsion not due to attraction

(D) The layer of oppositely charged particles around any colloidal particles will decrease the potential energy of system as a whole.

8. In physisorption on increasing temperature at constant pressure, adsorption decreases while in chemical adsorption on increasing temperature due to requirement of activation energy adsorption will increase at same pressure. So, I is physisorption while II is chemisorption. III is physical adsorption as on increasing temperature, extent of adsorption is decreasing .

IV is representing enthalpy change (which is high) during chemical adsorption (due to bond formation) So, is valid for chemical adsorption. So, answer is **(A)** and **(C)**

9. As the adsorption of methylene blue over activated charcoal is physisorption (Reference : NCERT), it is accompanied by decrease in enthalpy.

MOCK TEST

1 **(B)**

$$\log\frac{x}{M} = \log K + \frac{1}{n}\log P \Rightarrow \frac{1}{n} = \tan 45°$$

$\Rightarrow n = 1 \quad \Rightarrow \quad \log K = 0.3010, K = 2.$

2 **(A)**

Physical adsorption is a multilayer phenomenon

3 **(C)**

Total surface area of eight cubes $= 8\times6\times\left(\frac{1}{2}\times\frac{1}{2}\right)^2$

Apply the formula

Surface area on n split of a cube $= 8^n\times6\times\left(\frac{1}{2}\right)^{2n}$

$6291456 = 8^n\times6\times\left(\frac{1}{2}\right)^{2n}$

4 **(C)**

Chemical adsorption is a mono layer phenomenon.

5 **(A)**

6 **(C)**

Lower is the value gold number, greater will be the protecting power.

7 **(C)**

10 ml of 1 M NaCl contains NaCl = 10 × 1= 10 milli mole

200 ml of As_2S_3 required NaCl for the coagulation = 10 milli mole

$\therefore$ 1000 ml of As_2S_3 required NaCl for the coagulation = 10 × 1000/200 = 50 milli mole

8 **(A)**

9 **(C)**

$$\frac{\text{coagulation power of } AlCl_3}{\text{coagulation power of NaCl}} = \frac{\text{coagulation value of NaCl}}{\text{coagulation value of } AlCl_3}$$

10 (D)

11 (C)

0.03 = weight of Hb in mg × 10 /100

12 (A)

It is because of more stable surface area of colloidal Pd

13 (A)

14 (A, C)

(A) $\Delta G = \Delta H - T\Delta S < O$ as $\Delta S < O$ so ΔH has to be negative

(B) micelles formation will take place above T_k and above CMC.

(C) this solution will be negatively charged.

(D) Fe^{+3} ions will have a greater flocculability power so smaller flocculating value.

15 (C, D)

In gel, liquid is dispersed in solid.

16 (ABC)

17 (B)

18 (B)

19 (B)

20 (B)

21 (A)

22 (A)

23 (C)

24 (A)

25 (A) → (s) ; (B) → (r) ; (C) → (q) ; (D) → (p)

26 (A) → (s) ; (B) → (r) ; (C) → (q) ; (D) → (p)