Exercise-1

Marked Questions may have for Revision Questions.

OBJECTIVE QUESTIONS

Section (A) : Adsorption

A-1. Sol. It involves's vanderwall's interaction b/w adsorbent and adsrobate that's why its enthalpy is quite law (20–40 kJ mol^{-1}) this is only due to weak vanderwall's foroes b/w gas molecules and solid surface. It is all reversible in nature. Solid + gas $\rightleftharpoons$ gas /solid + heat.

A-2. Sol. It involves on the basis of equation $\Delta G = \Delta H - T\Delta S$
So it is dependent on temperature.

A-3. Sol Physical adsorption decreases as temperature increases.

A-4. Sol On increasing pressure more molecule will into contact with the surface of solid adsorbent.

A-5. Sol. It's activation energy is high (80–240 kJ mol^{-1})

Section (B) : Catalysts

B-1. Sol. Molybdnum acts as a promoter for iron which is used as a catalyst

$$N_2(g) + 3H_2(g) \overset{\overset{Fe(s)}{\rightleftharpoons}}{Mo(s)} 2NH_3(g)$$

B-2. Sol. A catalyst increases rate of reaction by decreasing activation energy.

B-3. Sol. $2SO_2 + O_2 \rightarrow V_2O_5 \xrightarrow{V_2O_5} 2SO_3$

B-5. Sol. Catalyst affects the rate of chemical reactions.

B-7. Sol. Numereous reaction that occur in the bodies of animals and plants to maintain the life process are catalysed by enzymes. So an enzyme acts as a biological catalyst.

Section (C) : Classification, Preparation & Purification of Colloid

C-1. Sol. Egg albumin is an solvent attraction (lyophilic colloid).

C-3. Sol. Peptisation is conversion of precipitate into colloidal sol by shaking it with dispersion medium in the presence of a small amount of electrolyte.

C-6. Sol. Liquid (disperesed phase) & gas (dispersion medium) type of colloid (Aerosol) example is cloud.

Section (D) : Coagulation, Protection & Application of colloid

D-3. Sol. The grater the valence of the floculating ion added, the greater its power to cause precipitation. In the coagulation of a (–ve) sol, the flocculating power is in the order $Al^{3+} > Ba^{2+} > Na^{+}$.

Section (E) : Emulsion, Micelle & Gel

E-1. Sol. If a mixture of two immiscible or partially miscible liquid is shaken, a coarse dispersion of one liquid in the other is obtained which is called emulsion.

Exercise-2

PART - I : OBJECTIVE QUESTIONS

5. **Sol.** $\frac{\text{coagulation power of } AlCl_3}{\text{coagulation power of NaCl}} = \frac{\text{coagulation value of NaCl}}{\text{coagulation value of } AlCl_3} = \frac{52}{0.093} = 559.8$

6. **Sol.** $\log \frac{x}{M} = \log k + \frac{1}{n} \log P$

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

$n = 1$ $k = 2$

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

$x = 1.$

7. **Sol.** Lyophilic means liquid loving or solvent attracting so it is quite stable in solvent.

9. **Sol.** Gel (liquid in solid)

14. **Sol.** Impurities present in a solution makes it more unstable.

15. **Sol.** In hydrophilic colloid : there is a strong attraction b/w the dispersed phase and water but in hydrophobic lack of attraction between dispersed phase and water.

18. **Sol.** For lyophilic sol

Gold number $\downarrow$ protective power $\uparrow$

19. **Sol.** The greater the valence of the flocculating ion added, the greater is its power to cause precipitation.

21. **Sol.** When light fall on smoke particles, the blue colour of light scattared.

23. **Sol.** For hydrophilic sols when compared to water viscosity is greater than water.

24. **Sol.** Brownian movement is independent of nature but depand on the size of particles and viscosity of the solution. Smallest the size and lesser the viscosity faster is the motion.

27. **Sol.** Physisorption is of endothermic nature and it occurs at low temperature and decreases with increasing temperature (Le chateleir's principle).

Exercise-3

PART - I : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

OFFLINE JEE-MAIN

1. **Sol.** Since the physical adsorption process is exothermic, the physical adsorption occurs readily at low temperature and decreases with increasing temperature. (Le Chatelier's principle).

2. **Sol.** On mixing, they will coagulate each other being +ve and – ve charged.

3. **Sol.** 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 = $(10/1)^3 = 10^3$ $V_c / V_s = 10^3$.

4. **Sol.** The adsorption of a gas is directly proportional to the pressure of gas.

5. **Sol.** Higher the gold number, lesser will be the protective power of colloid.

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

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

8. **Sol.** 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. **Sol.** Initial mmoles of $CH_3COOH = 0.06 \times 50$
Final mmoles of $CH_3COOH = 0.042 \times 50$
Hence, mass of CH_3COOH adsorbed per gram of charcoal $= \frac{(0.06-0.042)\times 50\times 10^{-3}\times 60\times 10^{3}}{3} = 18$ mg

10. **Sol.** According to the Freundlich adsorption isotherm

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

$$\log\frac{x}{m} = \log K + \frac{1}{n}\log P$$

11. **Sol.** Theory based

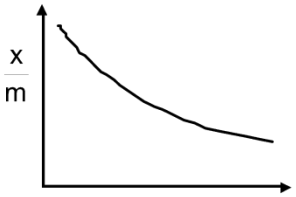
ONLINE JEE-MAIN

1. **Sol.** Adsorption takes place due to the presence of residual forces on the surface. After adsorption, these are decreased.

2. **Sol.** Longer hydrophobic chain, lesser CMC

3. **Sol.** Only the transparent part of egg has albumin.

4. **Sol.** Adsorption aries due to Vander waal forces & reversible, hence it should be physisorption (physical adsorption).
(i) Enthalpy of physisorption is low (20 – 40 kJ/mol)
(ii) In physisorption multimolecular layer form.



(iii) Physisorption decreases with increase in temperature.
(iv) Physisorption required number activation energy.
Hence answer is (4)

5. **Sol.** Lower the gold number, more will be protective power of colloid.

6. **Sol.** Brownian movement more pronounced for smaller particles.

7. **Sol.** $\frac{x}{m} = KP^{1/n}$

$\therefore \log\left(\frac{x}{m}\right) = \log K = \frac{1}{n} \log P$

slop = $\frac{1}{n} = 0.5 \therefore n = 2$

so, adsorption is proportional to square root of pressure.

PART - II : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

*** Marked Questions may have more than one correct option.**

1. **Sol.** Physical adsorption is exothermic process so its rate decreases with increase in temperature.

2. **Sol.** 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.

3. **Sol.** In lyophilic sols the dispersed phase have great affnity (attraction) towards dispersion medium. So they are self stabilizing.

4. **Sol.** Longer the hydrophobic part of the molecule easy will be the formation of micelle. (Longest hydrocarbon chain)

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

6. **Sol.** As the adsorption of methylene blue over activated characoal is physisorption (Reference : NCERT), it is accompanied by decrease in enthalpy.

7. **Sol.** Impurities affect surface tension appreciably. It is observed that impurities which tend to concentrate on surface of liquids, compared to its bulk lower the surface tension.
Substance like detergents, soaps ($CH_3(CH_2)_{11}SO_3^-Na^+$) decreases the surface tension sharply.
Those like alcohol (eg. $-CH_3OH$, C_2H_5OH) lower the surface tension slightly. This can also be related to the fact that CH_3OH has smaller dielectric constant. Dielectric constant is directly proportional to surface tension. So, on adding CH_3OH in water, overall dielectric constant decreases and surface tension decreases.
Inorganic impurities present in bulk of a liquid such as KCl tend to increase the surface tenstion of water.

8. **Ans. (AC)**

Sol. ⇒ Higher the critical temperature, higher will be extent of adsorption.
⇒ Cloud is an arosol, imulsions are liquid-liquid colloidal system.
⇒ For adsorption ΔH ⇒negative : ΔS ⇒ negative
⇒ Brownian movement of colloidal particals depends on size of particles.

Additional Problems For Self Practice (APSP)

PART - I : PRACTICE TEST PAPER

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

2. **Sol.** That's why lyophilic colloid has affinity for water.

3. **Sol.** Scattering of light by colloidal particles is known as Tyndall effect.

4. **Sol.** Tyndall effect is shown by colloidal solution.

5. **Sol.** In milk, liquid fat particles are dispersed in water.

6. **Sol.** Higher the charge on coagulating ion, higher the coagulating power.

7. **Sol.** Gold sol is – ve sol, so coagulating ion is cation.

8. **Sol.** Lyophilic colloid is solvated by dispersion medium and becomes more stable.

9. **Sol.** Coagulating power $\propto$ charge on coagulating ion.

10. **Sol.** Effectiveness of coagulation by electrolyte $\propto$ charge on coagulating ion.

11. **Sol.** Fog is an example of liquid dispersed in gas.

12. **Sol.** 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).

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

13. **Sol.** Light is scattered by colloidal particles present in environment so sky looks blue.

14. **Sol.** Colloidal particle shows Tyndall effect because of it's larger size.

15. **Sol.** Brownian motion is due to impact of molecules of the dispersion medium on the colloidal particles.

16. **Sol.** As_2S_3 is negatively charged sol so more positively charged ion will have minimum coagulating value .

17. **Sol.** Gelatin is positive sol.

18. **Sol.** Sulphur is a lyophobic colloid.

19. **Sol.** Smoke is an example of solid dispersed in gas.

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

21. **Sol.** Colloid is heterogeneous, biphasic solution.

22. **Sol.** Smaller the charge on coagulating ion, higher the flocculation value.

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

24. **Sol.** Electrophoresis means movement of colloidal particles under the influence of electric field.

25. **Sol.** Negative catalyst provides a path of higher activation energy

26. **Sol.** A colloidal solution this is done by using ultrafilter paper and the process is known as ultra-filtration process.It is a process of separating the colloidal particles from the solvent & soluble solutes present in the colloidal solution by especially prepared filters.

27. **Sol.** Adsorption of reactants on the solid surface of the catalysts affects the rate of reaction between the reactants. The reaction proceeds more rapidly after adsorption and adsorption being an enothermic process the heat of adsorption is utilisedin enhancing the rate of reaction.
eg. Manufacture of NH_3 using iron as a catalyst.

& Manufacture of H_2SO_4 by contact process

28. **Sol.** According to Freundlich adsorption isotherm, $\frac{x}{m} \propto kp^{1/n}$ (n > 1).

29. **Sol.** The foces between the adsorbate molecules & adsorbent molecules of solids are weak vanderwall's forces & usually occours at low temp. & decreases with increase in temp.

30. **Sol.** According to Freundlich isotherm :

$= \left(\frac{x}{m}\right) Kp^{1/n}$ or $\log\left(\frac{x}{m}\right) = \log K + \frac{1}{n}\log P$ (For solution, P = C).

PART - II : PRACTICE QUESTIONS

Practice Questions: 20-50 depending on chapter length.

1. **Sol.** Low temperature is favourable for adsorption. It decreases with increase of temperature.

2. **Sol.** $CH_3COOCH_3(aq) + H_2O(l) \xrightarrow{H_2SO_4\ (\ell)} C_6H_{12}O_6(aq) + C_6H_{12}O_6(aq)$

solution

Both the reactants and the catalyst are in same phase.

3. **Sol.** Some substance which at low concentration behave as normal strong electrolytes but at higher concentraiton exhibit colloidal behaviour due to the formation of aggregates. The aggreated particles thus formed are called associated colloid (Miselles).

4. **Sol.** Purificaiton of blood in the body is an example of removing a dissolved substance from a colloidal solution by means of diffustion through a suitable membrane.

5. **Sol.** Metallic sulphides e.g. As_2S_3, Sb_2S_3 and CdS are (–ve) charged solution.

6. **Sol.** Emulsion of oil in water are unstable and sometimes they seperate into two layer on standing. For stabilization of an emulsion a third component emulsifying agent is usually added.

9. **Sol.** Smoke is an aerosol (solid carbon particles dispersed in air).

13. **Sol.** Particle size of the adsorbent affects the amount of adsorption.

16. **Sol.** In (4), Mn^{2+} ions produced in the reaction act as autocatalyst.

17. **Sol.** 200 mL of the sol require = 0.73 g HCl

$\frac{0.73}{36.5}$ = mol = 0.02 mol = 20 m mol.

So, flocculation value of HCl = $\frac{20\text{mmole}}{0.2\text{lit}}$ = 100

18. **Sol.** As adsorption is an enothermic process and is invariable accompanied by evolution of heat i.e. ΔH is always –ve. When a gas is adsorbed , the freedom of movement of molecules becomes restricted &

$\therefore$ entropy of gas decreases after adsorptioni.e. ΔS is –ve.

$\because$ $\Delta G = \Delta H - T\Delta S$ ...(i)

$\therefore$ ΔG will also be–ve from eq^n (i)

19. **Sol.** According to langmuir Adsorption Isotherm " a dynamics equilibrium is established between the two opposing process.

(i) Adsorption of the gas molecules on the surface of the solid.

(ii) Desorption of the adsorbed molecules from the surface of solid.

∴ It is represented by relation

$$\frac{x}{m} = \frac{ap}{1+bp} \quad \text{....(i)}$$

Where a & b are constant

At very high pressure $\frac{x}{m} = \frac{a}{b}$ ...(ii)

& At very low pressure $\frac{x}{m} = ap$ .... (iii)

For determination of parmaters 'a' and 'b' equation (i) may be writtern in its inverse form

$$\frac{m}{x} = \frac{1+bp}{ap} = \frac{b}{a} + \frac{1}{p} \quad \text{...(iv)}$$

or $$\frac{1}{m/x} = \frac{b}{a} + \frac{1}{ap}$$

20. **Sol.** Kraft temperature
(NCERT definition based)
Some substances which at low concetration behave as normal strong electrolytes but at higher concetrations exhibit collidal behaviour due to the formation of aggregates & these aggregated particles thus formed are called miscels & these are also known as associated colloids on dilution these collides revert back to individual ions.

21. **Sol.** At 83 K, there is physisorption and hence multimolecular.

22. **Sol.** Less the gold number of a colloid, greater is its protective nature.

23. **Sol.** Fe $(OH)_3$ sol is positively charged. Hence , anion with highest valency will be best coagulating agent, i.e., $[Fe(CN)_6]^{3-}$.

24. **Sol.** According to Freundlich iostherm, $\frac{x}{m} = kp^{1/n}$. According to Langmuir isotherm, $\frac{x}{m} = \frac{aP}{1+bP}$.

25. **Sol.** Pesticide spray is a colloidal dispersion of liquid in gas (an aerosol).

26. **Sol.** Milk = Liquid in liquid, Clouds = Liquid in gas Paints = Solid in liquid, Jellies = Liquid in solid.

27. **Sol.** According to Freundlich equation , $\frac{x}{m} = KP^{1/n}$

or $\log \frac{x}{m} = \log K + \frac{1}{n} \log P$

∴ Plot of log x/m vs log P is straight line with slope = $\frac{1}{n}$ and intercept = log K. Thus.

$\frac{1}{n} = \tan\theta = \tan 45^\circ = 1$ or n = 1

At P = 0.5 atm and K = 10, $\frac{x}{m} = 10 \times (0.5) = 5$

∴ x (i.e. amount adsorbed per gram) = 5 g.

28. **Sol.** $2[AgI]I^- + Pb^{2+} - PbI_2 + 2AgI$
Thus, 2 moles of [AgI] I^- are coagulated by 1 mole of Pb^{2+} , i.e., 1 mole of $Pb(NO_3)_2$.

29. **Sol.** In Cottrell's precipitator, the charged plates neutralise the charge on the smoke particles which get precipitated..

30. **Sol.** It is method for seperation of component &is based on preferential adsorption column & is widely used in operations.

31. **Sol.** Colloidal particles are larger than simple molecules but small enough to remains suspended. Their range of diameter is between 1& 1000 nm i.e.

10^{-6} to 10^{-9}m.
Colloidal particle have an enormous surface area per unit mass as a result of their small size.

32. **Sol.** Enzymes are highly specific heterogeneous catalyst.

34. **Sol.** **S_1 :** Valency of effective ion $\uparrow$ cogulating power $\uparrow$
S_3 : The Brownain movement has beeen explained to be due to the unbalanced bombardment of the particles by the molecules of the dispersion medium.

35. **Sol.** **S_2 :** An important characterstic of lyophilic sol is that if the dispersion medium is seperated from the dispersed phase the sol can be reconstituted by simply remixing with the dispersion medium. That is why these sols are also called reversible sol/hydrophilic sol.