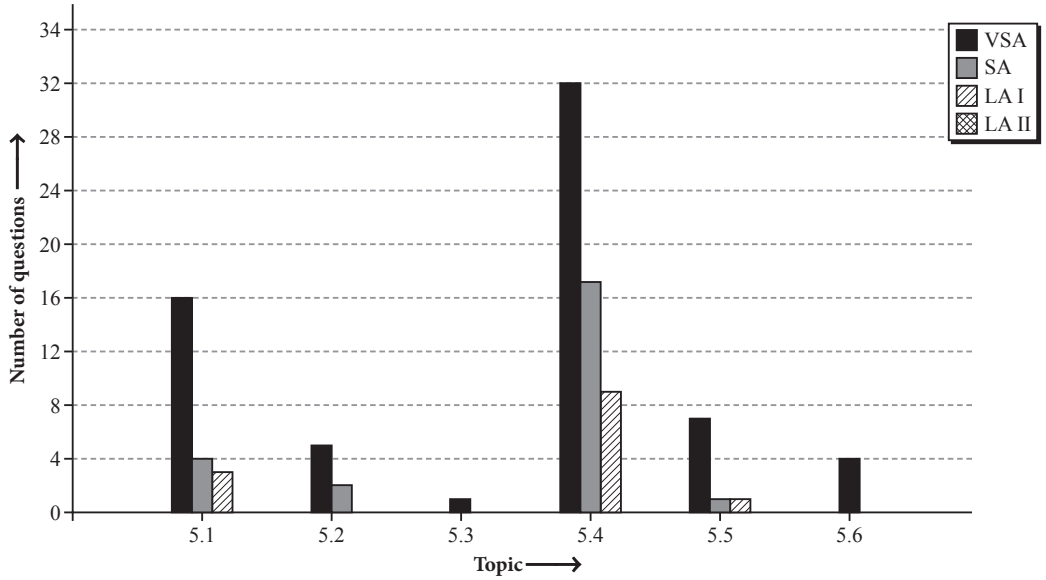
CHAPTER
5

Surface Chemistry

Topicwise Analysis of Last 10 Years' CBSE Board Questions (2020-2011)



- Maximum total weightage is of *Classification of Colloids.*
- Maximum VSA type questions were asked from *Classification of Colloids.*
- Maximum SA and LA I type questions were asked from *Classification of Colloids.*

QUICK RECAP

- **Surface chemistry :** It deals with phenomena that occur at the surfaces or interfaces.
- **Adsorption :** It is the process of accumulation of molecular species at the surface rather than in the bulk of a solid or liquid.
- **Adsorbate :** The molecular species or substance, which concentrates or accumulates at the surface.
- **Adsorbent :** The material on the surface of which the adsorption takes place.

Distinction between adsorption and absorption

Adsorption	Absorption
It is a surface phenomenon, *i.e.*, it occurs only at the surface of the adsorbent.	It is a bulk phenomenon, *i.e.*, occurs throughout the body of the material.
In this phenomenon, the concentration on the surface of adsorbent is different from that in the bulk.	In this phenomenon, the concentration is same throughout the material.
Its rate is high in the beginning and then decreases till equilibrium is attained.	Its rate remains same throughout the process.

- **Desorption :** The process of removing an adsorbed substance from the surface.
- **Sorption :** The term used when both absorption and adsorption occur simultaneously.
- ΔG, ΔH and ΔS all are – ve for adsorption.
- **Types of adsorption :** Depending on forces which hold the adsorbate on the surface of adsorbent, adsorption is divided into two classes :
  - **Physical adsorption :** When the particles are held to the surface by the physical forces like van der Waals forces, the adsorption is called *physical adsorption* or *physisorption*.
  - **Chemical adsorption :** When the particles are held to the surface by the chemical forces or by chemical bonds, the adsorption is called *chemical adsorption* or *chemisorption*.

Differences between physisorption and chemisorption

Property	Physisorption	Chemisorption
Enthalpy	Low enthalpy, is the order of 20-40 kJ mol^{-1}	High enthalpy, is the order of 80-240 kJ mol^{-1}
Reversibility	Reversible process	Irreversible process
Effect of temperature	With the increase in temperature, extent of adsorption decreases because adsorption is a exothermic process and kinetic energy of gas molecules increases with temperature.	Chemisorption first increases with temperature upto a certain extent and then decreases. A gas adsorbed at low temperature by physical adsorption may change into chemisorption at high temperature.
Selectivity	Not selective in nature. Does not depend upon the nature or chemical properties of gas and adsorbent.	Highly selective in nature. Depends upon the nature of gas and adsorbent.
Nature and state of adsorbate	The extent of adsorption depends upon the ease of liquefaction of the gas.	The state of adsorbed molecules may be different from that in the bulk.
Activation energy	No appreciable energy needed	High activation energy needed
Pressure	Increase in pressure increases adsorption	Increase in pressure decreases adsorption
Layers	Multimolecular layer	Mono-molecular layer

- **Factors affecting adsorption of gases on solids :**
  - **Nature of adsorbent :** Greater the strained forces on the surface, more is the ease with which adsorption takes place on the surface. The activated adsorbents have high adsorbing power.
  - **Surface area of adsorbent :** Greater the surface area, more is the adsorption.
  - **Nature of gas being adsorbed :** Easily liquefiable gases like NH_3, HCl, Cl_2, SO_2, CO_2, etc. (whose critical temperature is high) are adsorbed to greater extent.

- **Pressure :** At constant temperature, adsorption increases with increase in pressure. The effect of pressure is large at low temperature.
- **Temperature :** Since adsorption is an exothermic process so according to Le-Chatelier's principle adsorption decreases with increase in temperature.

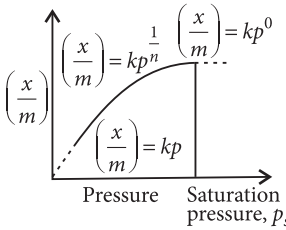
Freundlich adsorption isotherm : The plot of $\frac{x}{m}$ *vs* pressure at constant temperature is called *Freundlich adsorption isotherm*,

where, m = mass of the adsorbent, x = mass of the adsorbate

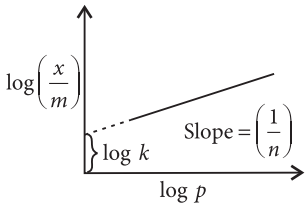
For low pressure, $\frac{x}{m} \propto p$

For high pressure, $\frac{x}{m} \propto p^0$

For intermediate pressures, $\frac{x}{m} \propto p^{1/n}$ $(n > 1)$



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



Similarly, for adsorption of solutes from solutions, $\frac{x}{m} = k.C^{1/n}$ where, C is the equilibrium concentration, *i.e.*, when adsorption is complete.

Plot of $\log\frac{x}{m}$ *vs* log C is linear.

Promoters : The substances that enhance the activity of a catalyst *e.g.*, Mo acts as a promoter in Haber's process.

Poisons : The substances that decrease the activity of a catalyst.

- **Activity :** It is the capacity of a catalyst to increase the speed of the chemical reaction.
- **Selectivity :** It is the ability of a catalyst to direct a reaction to yield a particular product.

Catalysis : Substances which accelerate the rate of a chemical reaction and themselves remain chemically and quantitatively unchanged after the reaction, are known as *catalysts*, and the phenomenon is known as *catalysis*.

Homogeneous Catalysis

The process in which the reactants and the catalyst are in the same phase.
e.g., oxidation of SO_2 to SO_3 by NO as catalyst (lead chamber process), hydrolysis of methyl acetate by HCl, hydrolysis of sugar by H_2SO_4.

Shape-selective Catalysis

The catalytic reaction that depends upon the pore structure of the catalyst and the size of the reactant and product molecules, *e.g.,* Zeolites (have honey–comb like structures).

Heterogeneous Catalysis

The process in which the reactants and the catalyst are in different phases. *e.g.,* oxidation of SO_2 to SO_3 by Pt, manufacture of NH_3 from N_2 and H_2 by Fe (Haber's process), oxidation of NH_3 to NO by Pt (Ostwald's process), hydrogenation of vegetable oils by Ni.

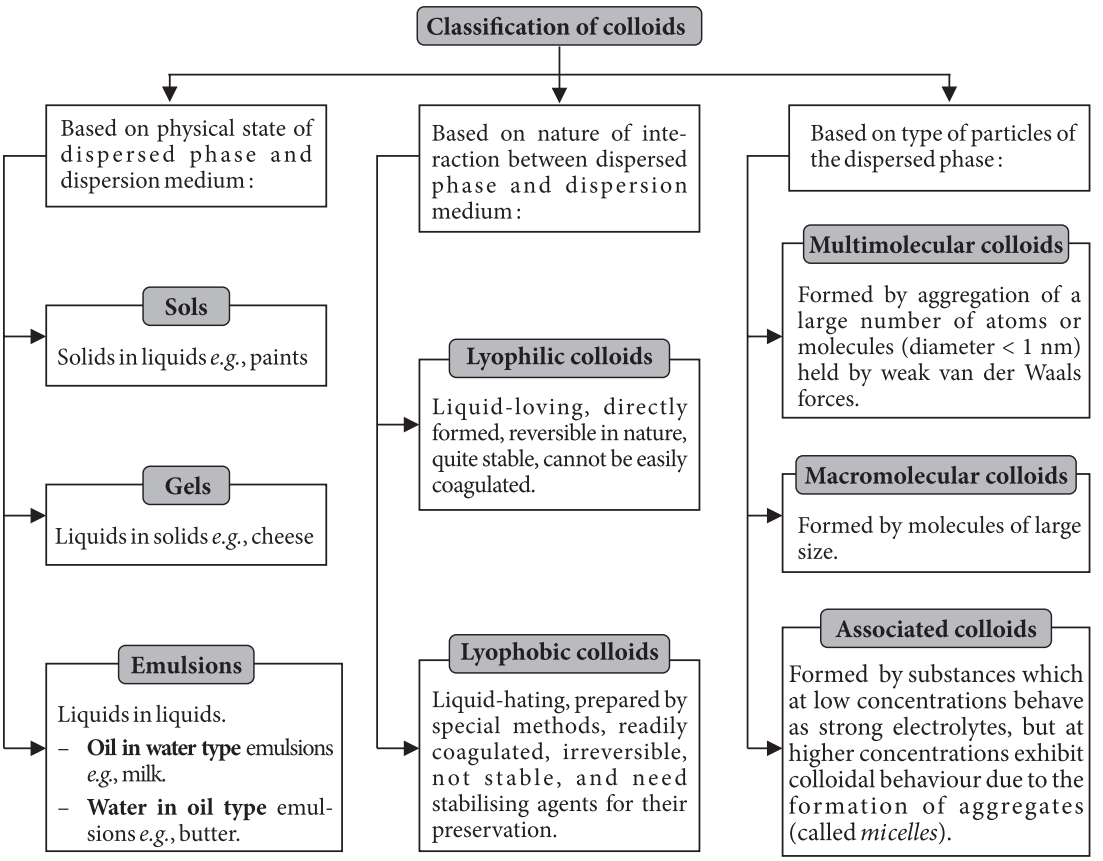
Enzyme Catalysis

Many biochemical reactions are catalysed by complex nitrogeneous organic compounds (proteins or enzymes) which are also called *biochemical catalysts* and the phenomenon is known as *biochemical catalysis*.

Some Enzymatic Reactions

	Enzyme	Source	Enzymatic reaction
1.	Invertase	Yeast	Sucrose → glucose and fructose
2.	Zymase	Yeast	Glucose → ethyl alcohol and carbon dioxide
3.	Diastase	Malt	Starch → maltose
4.	Maltase	Yeast	Maltose → glucose
5.	Urease	Soyabean	Urea → ammonia and carbon dioxide
6.	Pepsin	Stomach	Proteins → Peptides

Colloid : A colloid is a heterogeneous system in which one substance (*dispersed phase*) is dispersed as very fine particles in another substance called *dispersion medium*. The range of diameters of colloidal particles is between 1 and 1000 nm (10^{-9} to 10^{-6} m).



Properties of colloidal solutions :

- **Colligative properties :** Colloids show colligative properties like relative lowering of vapour pressure, elevation of boiling point, etc. and magnitude of colligative properties of colloids is much less than true solutions due to larger size of colloidal particles.
- **Tyndall effect (Optical property) :** Scattering of light by colloidal particles due to which the path of light beam becomes visible.
- **Brownian movement (Mechanical property):** Zig-zag movement of colloidal particles due to the unbalanced bombardment by the molecules of dispersion medium.
- **Charge on colloidal particles :** Colloidal particles always carry an electric charge and nature of charge (+ve or –ve) is same on all the particles in a given colloidal solution. The charge is due to preferential adsorption of ions from solution.

Positively charged sols	Negatively charged sols
Hydrated metallic oxides, *e.g.*, $Al_2O_3 \cdot xH_2O$, $Fe_2O_3 \cdot xH_2O$, metal hydroxides, *e.g.*, $Fe(OH)_3$, $Al(OH)_3$, basic dye stuff like Prussian blue, haemoglobin (blood), etc.	Metallic particles, *e.g.*, Cu, Ag, Au Metal sulphides, *e.g.*, As_2S_3, CdS, Acidic dyes like eosin, congo red etc, sols of gelatin, gum, starch, etc.

- **Electrophoresis (Electrical property) :** Movement of colloidal particles towards one of the electrodes on passage of electricity through colloidal solution. The direction depends on the type of charge on colloidal particles.
- **Coagulation of colloids :** Precipitation of colloidal solution by induced aggregation of colloidal particles.
  - **Lyophobic sols:** They can be coagulated by electrophoresis, boiling, persistent dialysis, mixing of oppositely charged sols and addition of electrolytes.
  - **Hardy–Schulze rules :**
    - In case of electrolytes, the ion carrying charge opposite to that of colloidal particles is effective in causing coagulation and greater the valency of the ion causing coagulation, greater is the coagulating power.
    - The minimum concentration of an electrolyte in millimoles per litre required to cause precipitation of a sol in two hours is called *coagulating value*. The smaller the quantity needed, the higher will be the coagulating power of an ion.
  - **Lyophilic sols :** They can be coagulated by addition of electrolytes or addition of a suitable solvent.

Emulsions : Colloids in which both dispersed phase and dispersion medium are in liquid state.

- **Types of emulsions :**
  - **Oil in water :** Dispersed phase is oil, *e.g.*, milk, body lotion.
  - **Water in oil :** Dispersed phase is water, *e.g.*, butter, cold cream.
- **Emulsification :** Process of making an emulsion.
- **Emulsifying agent :** Used to stabilize the emulsion *e.g.*, soaps and detergents.
- **Demulsification :** Separating the two components of an emulsion. Methods used are boiling, freezing, changing pH.

Previous Years' CBSE Board Questions

5.1 Adsorption

VSA (1 mark)

1. Why are powdered substances more effective adsorbents than their crystalline forms? *(AI 2019)*

2. Why is adsorption always exothermic? *(2018C, AI 2014)*

3. Why is a finely divided substance more effective as an adsorbent? *(1/3, 2018C, AI 2011C)*

4. Write one similarity between physisorption and chemisorption. *(Delhi 2017)*

5. Differentiate between adsorption and absorption. *(1/3, Delhi 2016)*

6. Physisorption is reversible while chemisorption is irreversible. Why ? *(Foreign 2015)*

7. Define the following term :
Adsorption *(1/3, Delhi 2015C, 2014C, 1/2, AI 2013)*

8. In reference to Freundlich adsorption isotherm write the expression for adsorption of gases on solids in the form of an equation. *(1/3, Delhi 2014, 1/3, Foreign 2014)*

9. What is the effect of temperature on chemisorption? *(AI 2014)*

10. What type of forces are responsible for the occurrence of physisorption? *(1/3, Foreign 2014)*

11. Define the following term :
Sorption *(1/3, Delhi 2014C)*

12. Of physisorption or chemisorption, which has a higher enthalpy of adsorption? *(AI 2013)*

13. Out of NH_3 and CO_2, which gas will be adsorbed more readily on the surface of activated charcoal and why? *(Delhi 2012C)*

14. Adsorption of a gas on surface of solid is generally accompanied by a decrease in entropy, still it is a spontaneous process. Explain. *(1/3, Delhi 2012C)*

15. Physisorption is multi-layered, while chemisorption is mono-layered. *(1/3, Delhi 2012C)*

16. Write two applications of adsorption. *(AI 2012C)*

SA (2 marks)

17. Write two differences between physisorption and chemisorption. *(2020)*

18. (i) What is the role of activated charcoal in gas mask?
(ii) How does chemisorption vary with temperature? *(2/3, Delhi 2019)*

19. Give reasons for the following observations :
(i) NH_3 gas absorbs more readily than N_2 gas on the surface of charcoal.
(ii) Powdered substances are more effective adsorbents. *(2/3, Foreign 2015)*

20. Write the differences between physisorption and chemisorption with respect to the following :
(i) Specificity
(ii) Temperature dependence
(iii) Reversibility and
(iv) Enthalpy change *(Delhi 2013)*

LA I (3 marks)

21. Give three points of difference between physisorption and chemisorption. *(2020)*

22. Giving appropriate examples, explain how the two types of processes of adsorption (physisorption and chemisorption) are influenced by the prevailing temperature, the surface area of adsorbent and the activation energy of the process? *(AI 2014C)*

23. What is an adsorption isotherm? Describe Freundlich adsorption isotherm. *(Delhi 2013, AI 2012C)*

5.2 Catalysis

VSA (1 mark)

24. Define the following term :
Shape-selective catalysis
(1/3, 2020, 1/3, Delhi 2015C, 1/2, AI 2012, 2011)

25. $CO_{(g)}$ and $H_{2(g)}$ react to give different products in the presence of different catalysts. Which ability of the catalyst is shown by these reactions? *(2018)*

26. Write one difference of the following :
Homogeneous catalysis and heterogeneous catalysis *(1/3, Delhi 2017)*

27. Give reason for the following observation :
It is necessary to remove CO when ammonia is prepared by Haber's process.
(1/3, Delhi 2015)

28. What are biocatalysts ? Give an example.
(Foreign 2014)

SA (2 marks)

29. Name the two groups into which phenomenon of catalysis can be divided. Give an example of each group with the chemical equation involved. *(Delhi 2012)*

30. Explain how the phenomenon of adsorption find application in the following processes :
(i) Production of vaccum
(ii) Heterogeneous catalysis *(Foreign 2011)*

5.3 Colloids

VSA (1 mark)

31. Write one difference of the following :
Solution and colloid *(1/3, Delhi 2017)*

5.4 Classification of Colloids

VSA (1 mark)

Read the given passage and answer the questions number (32 - 36) that follow.

Colloidal particles always carry an electric charge which may be either positive or negative. For example, when $AgNO_3$ solution is added to KI solution, a negatively charged colloidal sol is obtained. The presence of equal and similar charges on colloidal particles provide stability to the colloidal sol and if, somehow, charge is removed coagulation of sol occurs. Lyophobic sols are readily coagulated as compare to lyophilic sols. *(2020)*

32. What is the reason for the charge on sol particles?

33. Why the presence of equal and similar charges on colloidal particles provide stability?

34. Why a negatively charged sol is obtained on adding $AgNO_3$ solution to KI solution?

35. Name one method by which coagulation of lyophobic sol can be carried out.

36. Out of KI or K_2SO_4, which electrolyte is better in the coagulation of positive sol?

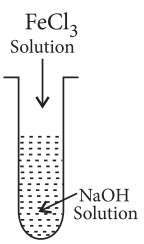
37. Define the following term.
Kraft temperature *(1/3, 2020)*

38. Define the following term.
Peptization *(1/3, 2020, AI 2012)*

39. Define the following term with a suitable example :
Associated colloids *(1/2, 2020)*

40. What is difference between an emulsion and a gel? *(Delhi 2019)*

41. A colloidal sol is prepared by the given method in figure. What is the charge on hydrated ferric oxide colloidal particles formed in the test tube? How is the sol represented?



(1/3, Delhi 2019)

42. Write one difference between the following :
Lyophobic sol and lyophilic sol
(1/3, Delhi 2017, Delhi 2014C)

43. What type of colloid is formed when a liquid is dispersed in a solid? Give an example.
(AI 2017)

44. What type of colloid is formed when a solid is dispersed in a liquid? Give an example.
(AI 2017)

45. What type of colloid is formed when a gas is dispersed in a liquid? Give an example. *(AI 2017)*

46. Define the term 'Tyndall effect'. *(1/3, AI 2017C)*

47. Write the main reason for the stability of colloidal sols. *(Delhi, AI 2016)*

48. Out of $BaCl_2$ and KCl, which one is more effective in causing coagulation of a negatively charged colloidal sol? Give reason. *(Delhi 2015)*

49. Write the dispersed phase and dispersion medium of butter. *(AI 2015, Foreign 2014)*

50. In reference to surface chemistry, define dialysis. *(Delhi 2015C, 2014C, AI 2014C)*

51. Define the following term :
Electrophoresis *(1/3, Delhi 2015C)*

52. Give one example each of sol and gel. *(Delhi 2014)*

53. Give one example each of lyophobic sol and lyophilic sol. *(Delhi 2014)*

54. What are the dispersed phase and dispersion medium in milk? *(Delhi 2014)*

55. Name the temperature above which the formation of micelles takes place. *(Foreign 2014)*

56. Based on the type of dispersed phase, what type of colloid is micelles? *(Foreign 2014)*

57. Which aerosol depletes ozone layer? *(AI 2013)*

58. To which colloidal system does milk belong? *(AI 2013C)*

59. Which complex ion is formed when undecomposed AgBr is washed with hypo solution in photography ? *(AI 2013C)*

60. How can a colloidal solution and true solution of the same colour be distinguished from each other? *(Delhi 2012C)*

61. How is a sol different from an emulsion ? *(AI 2012C)*

62. What are lyophobic colloids? Give an example for them. *(AI 2011)*

63. Define the following term giving an example :
Hydrosol *(1/3, Foreign 2011)*

SA (2 marks)

64. What happens when
(a) a freshly prepared precipitate of $Fe(OH)_3$ is shaken with a small amount of $FeCl_3$ solution?
(b) persistent dialysis of a colloidal solution is carried out? *(2/3, 2018)*

65. Write one difference between each of the following :
(i) Multimolecular colloid and macromolecular colloid
(ii) Sol and gel *(2/3, Delhi 2017)*

66. Write one difference in each of the following :
(a) Multimolecular colloid and associated colloid
(b) Coagulation and peptization *(2/3, AI 2017)*

67. (a) Write the dispersed phase and dispersion medium of milk.
(b) Write the chemical method by which $Fe(OH)_3$ sol is prepared from $FeCl_3$. *(2/3, AI 2017)*

68. (i) Out of $MgCl_2$ and $AlCl_3$, which one is more effective in causing coagulation of negatively charged sol and why ?
(ii) Out of sulphur sol and proteins, which one forms multimolecular colloids? *(2/3, Delhi 2016)*

69. Give reasons for the following observations :
(i) Leather gets hardened after tanning.
(ii) Lyophilic sol is more stable than lyophobic sol. *(2/3, Delhi 2015)*

70. (i) Based on type of particles of dispersed phase, give one example each of associated colloid and multimolecular colloid
(ii) Write an important characteristic of lyophilic sols. *(2/3, Delhi 2014)*

71. Define the following terms :
(i) Peptization
(ii) Sol *(2/3, Delhi 2014C)*

72. Define the following terms :
(i) Tyndall effect
(ii) Electrophoresis *(2/3, Delhi 2014C)*

73. Write the dispersed phase and dispersion medium of the following colloidal systems :
(i) Smoke
(ii) Milk *(Delhi 2013)*

74. What is the difference between multimolecular and macromolecular colloids? Give one example of each. *(Delhi 2013)*

75. What are the characteristics of the following colloids? Give one example of each.
(i) Multimolecular colloids
(ii) Lyophobic sols *(2/3, AI 2013)*

76. How are the following colloidal solutions prepared?
(a) Sulphur in water (b) Gold sol *(Delhi 2013C)*

77. Explain the following terms giving one example for each.
(i) Micelles (ii) Aerosol *(Delhi, AI 2012)*

78. Explain the cleaning action of soap. Why do soaps not work in hard water? *(AI 2012)*

79. (i) Same substances can act both as colloids and crystalloids. Explain
(ii) What will be the charge on AgI colloidal particles when it is prepared by adding small amount of $AgNO_3$ solution to KI solution in water? What is responsible for the development of this charge ? *(2/3, Delhi 2012C)*

80. Define the following terms :
(i) Aerosol
(ii) Coagulation of colloids *(Foreign 2011)*

LA I (3 marks)

81. Define lyophobic and lyophilic sol with a suitable example of each. Why is coagulation of lyophilic sol difficult as compared to lyophobic sol? *(2020)*

82. Give reasons for the following :
(a) Brownian movement provides stability to the colloidal solution.
(b) True solution does not show Tyndall effect.
(c) Addition of alum purifies water. *(AI 2019)*

83. Define the following terms :
(i) Lyophilic colloid
(ii) Zeta potential
(iii) Associated colloids *(AI 2016)*

84. Define the following terms :
(i) Brownian movement
(ii) Peptization
(iii) Multimolecular colloids *(AI 2015)*

85. Describe the following processes :
(i) Dialysis
(ii) Electrophoresis
(iii) Tyndall effect *(AI 2015C, 2011C)*

86. Explain what is observed when :
(i) A beam of light is passed through a colloidal solution.
(ii) NaCl solution is added to hydrated ferric oxide sol.
(iii) Electric current is passed through a colloidal solution. *(AI 2013C)*

87. What is meant by coagulation of a colloidal solution? Describe briefly any three methods by which coagulation of lyophobic sols can be carried out. *(Delhi 2012)*

88. Classify colloids where the dispersion medium is water. State their characteristics and write an example of each of these classes. *(AI 2011)*

89. Distinguish between multimolecular, macromolecular and associated colloids. Give one example of each. *(Delhi 2011C)*

5.5 Emulsions

VSA (1 mark)

90. Define the following term with a suitable example :
O/W emulsion *(1/2, 2020)*

91. What happens when an emulsion is centrifuged? *(1/3, 2018)*

92. Write one difference between the following :
O/W emulsion and W/O emulsion *(1/3, Delhi 2017)*

93. What are emulsions? Give an example. *(AI 2017C, Delhi 2015C)*

94. Give one example each of 'oil in water' and 'water in oil' emulsion. *(Delhi 2014)*

95. What is an emulsion? *(Delhi 2014C, AI 2012, Foreign 2011)*

96. What are emulsions? Name an emulsion in which water is a dispersed phase. *(AI 2014C)*

SA (2 marks)

97. What is the difference between oil/water (O/W) type and water/oil (W/O) type emulsions? Given an example of each type. *(Delhi 2013)*

LA I (3 marks)

98. What are emulsions? What are their different types? Give one example of each type. *(AI 2014, Delhi 2013C)*

5.6 Colloids Around Us

VSA (1 mark)

99. Hardening of leather in tanning industry is based on
(a) electrophoresis
(b) electro-osmosis
(c) mutual coagulation
(d) Tyndall effect. *(2020)*

100. Why are medicines more effective in colloidal state? *(Delhi 2019)*

101. Give reasons for the following observations :
A delta is formed at the meeting point of sea water and river water. *(1/3, Foreign 2015, 2014)*

102. Explain the following :
Artificial rain is caused by spraying salt over clouds. *(1/3, Delhi 2012C)*

Detailed Solutions

1. A finely divided substance is more effective as adsorbent because
(i) it has more surface area so more adsorption occurs.
(ii) the number of active sites (active centres) and the extent of adsorption increases.

2. In adsorption, there is always a decrease in residual unbalanced forces on the surface. This results in decrease in surface energy which appears as heat. Hence, adsorption is unconditionally an exothermic process.

3. *Refer to answer 1.*

4. Physical adsorption and chemical adsorption both increase with increase in surface area of the adsorbent.

5. Adsorption is a surface phenomenon. In this process the adsorbate is concentrated on the surface of the adsorbent and does not penetrate into the bulk whereas, absorption of a substance takes place throughout the bulk of the material. In adsorption, concentration of adsorbate is high on the surface of adsorbent, while during absorption concentration is uniform throughout. *e.g.*, water vapour is adsorbed by silica gel whereas absorbed by anhydrous calcium carbide.

6. Physisorption takes place with the help of non-covalent bonding between an adsorbate and an adsorbent; it makes the process reversible. Chemisorption, on the other hand, takes place with the help of covalent bonding; it makes the process irreversible.

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

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

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

where, $\frac{x}{m}$ is the mass of gas adsorbed per gram of the adsorbent and p is the pressure of gas.

9. Effect of temperature : Chemisorption is an exothermic process. Hence, according to Le Chatelier principle, rate of adsorption decreases with rise in temperature. Rate of adsorption is low at lower temperature because of high energy of activation hence, with increasing temperature rate of adsorption increases initially.

10. The forces operating in these cases are weak van der Waals' forces.

11. The term sorption is used to describe both the processes adsorption and absorption.

12. Chemisorption has higher enthalpy of adsorption.

13. NH_3 gas will be adsorbed more readily on the surface because it has higher critical temperature than CO_2 gas.

Higher the critical temperature, more easily the gas can be liquified, *i.e.*, greater are the attraction of the gas molecules on the surface of the adsorbent, hence greater will be the adsorption.

14. For the process to be spontaneous, ΔG must be negative.

As ΔS is negative, ΔG can be negative only if ΔH is negative and greater than $T\Delta S$.

15. Physical adsorption occurs due to intermolecular attractive forces between the adsorbate and adsorbent. If the size of the adsorbent pores is close to the size of adsorbate molecules, multilayer adsorption takes place, *i.e.,* adsorption takes place until all the pores are filled with adsorbate molecules, whereas in chemisorption chemical bonds are formed between adsorbate and adsorbent molecules. Therefore, it is monolayered.

16. Applications of adsorption :

(i) Deionisation of water

(ii) In chromatographic analysis.

17.

S. No.	Criteria	Physisorption	Chemisorption
(i)	Specificity	It is not specific in nature.	It is highly specific in nature.
(ii)	Temperature dependence	It decreases with increase in temperature. Thus, low temperature is favourable for physisorption.	It increases with increase in temperature. Thus, high temperature is favourable for chemisorption.
(iii)	Reversibility	Reversible in nature.	Irreversible in nature.
(iv)	Enthalpy change	Low enthalpy of adsorption.	High enthalpy of adsorption.

(Any two)

18. (i) Activated charcoal in gas mask adsorb the poisonous gases present in air and thus purify the air for breathing.

(ii) *Refer to answer 9.*

19. (i) Higher the critical temperature of gas, more readily it can get adsorbed on the surface of an adsorbent due to stronger van der Waals' forces.

NH_3 (132°C) has a higher critical temperature than dinitrogen (–147°C). Thus, NH_3 gas adsorbs more readily than N_2 gas on the surface of charcoal.

(ii) *Refer to answer 1.*

20. *Refer to answer 17.*

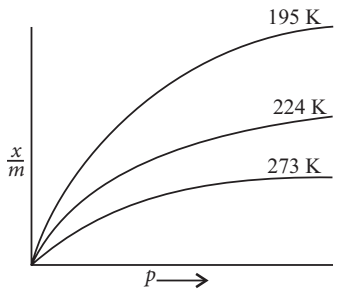
21. *Refer to answer 17.*

22. Effect of temperature : Physisorption decreases with increase of temperature and chemisorption first increases then decreases with increase of temperature.

Surface area : Greater the surface area, greater is the physisorption and chemisorption.

Activation energy : In physisorption, no appreciable activation energy is needed. In chemisorption, sometimes high activation energy is needed.

23. Adsorption isotherm : It is the variation in the amount of gas adsorbed by the adsorbent with pressure at constant temperature.



Adsorption isotherm

These curves indicate that on increasing temperature, physical adsorption decreases at a fixed pressure.

Freundlich adsorption isotherm : It is an empirical relationship between the quantity of gas adsorbed by unit mass of solid adsorbent and pressure at a particular temperature.

$$\frac{x}{m} = kp^{1/n} (n > 1) \quad \ldots(i)$$

when, $n = 1, \Rightarrow \frac{x}{m} = kp$ or $\frac{x}{m} \propto p$

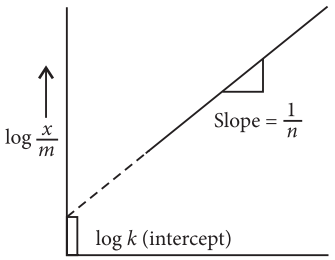
where, x is the mass of gas adsorbed on mass m of the adsorbent at pressure p. k and n are constants which depend on the nature of the adsorbent and the gas at the particular temperature.

Taking log in Eq. (i), gives

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

The validity of Freundlich isotherm can be verified by plotting $\frac{x}{m}$ on y-axis and log p on x-axis.

If it comes to be a straight line, the Freundlich isotherm is valid.



Freundlich isotherm

24. The catalytic reaction that depends upon the pore structure of the catalyst and the size of the reactant and product molecules is called shape selective catalysis.

25. The selectivity of a catalyst is its ability to yield a particular product in the reaction *e.g.*,

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

$$CO + 2H_2 \xrightarrow{Cu/ZnO\text{-}Cr_2O_3} CH_3OH$$

26. Homogeneous catalysis : Catalyst is present in the same phase as reactants.

Heterogeneous catalysis : Catalyst is present in different phase as that of reactants.

27. CO is a catalytic poison. It reacts with iron to form iron carbonyl thus inhibiting the activity of catalyst.

28. Enzymes are termed as biocatalysts as they help in catalysis of biological reactions.

For example, inversion of cane sugar with the help of invertase enzyme :

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11(aq)}} + H_2O_{(l)} \xrightarrow{\text{Invertase}} \underset{\text{Glucose}}{C_6H_{12}O_{6(aq)}} + \underset{\text{Fructose}}{C_6H_{12}O_{6(aq)}}$$

29. Catalysis is divided into following two groups:

Homogeneous catalysis : When reactants and the catalysts are in the same phase, *i.e.,* liquid or gas, the catalysis is known as homogeneous catalysis.

$$e.g., 2C_2H_5OH_{(l)} \xrightarrow{\text{conc. } H_2SO_{4(l)}} C_2H_5OC_2H_{5(l)} + H_2O_{(l)}$$

$$\text{or } \frac{3}{2}O_{2(g)} \xrightarrow{NO_{(g)}} O_{3(g)}$$

Heterogeneous catalysis : When reactants and the catalysts are in different phases, the catalysis is known as heterogeneous catalysis. In most cases, the catalyst is solid, while reactants are either liquids or gases. Here, the catalyst is usually a metal or an oxide in finely divided form *e.g.,*

$$\text{Vegetable oils}_{(l)} + H_{2(g)} \xrightarrow{Ni_{(s)}} \text{Vegetable ghee}_{(s)}$$

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

30. (i) **Production of vacuum :** Adsorption can be applied to create condition of high vacuum. Vessel which has already been exhausted by vacuum pump is connected to a bulb containing charcoal. The remaining traces of air inspite of low pressure are adsorbed by the charcoal almost completely.

(ii) **Role of adsorption in heterogeneous catalysis :** The reactant molecules in gaseous state or in solutions are adsorbed on the surface of the solid catalyst by physisorption or chemisorption. As result, the concentration of the reactant molecules on the surface increases and hence, the rate of reaction increases.

31. Solution : In true solution, the size of the particles is about 10^{-10} m.

Colloid : In a colloid, the size of the particles is in between 10^{-7} to 10^{-9} m.

32. The charge on sol particles is due to preferential adsorption of ions from solution.

33. The main reason for the stability of colloids is the electrostatic stabilisation *i.e.,* equal and same type of charge on the colloidal particles which causes repulsion between them and prevents the coagulation of the sol.

34. When $AgNO_3$ solution is added to aqueous KI solution, a negatively charged sol of AgI is formed. This is due to selective adsorption of I^- ions from the dispersion medium.

$$AgI + \underset{\text{Dispersion medium}}{I^-} \longrightarrow \underset{\text{Negative sol}}{[AgI]I^-}$$

35. Coagulation is usually done by adding electrolytes. Coagulation also occurs on electrophoresis or prolonged dialysis or mixing two oppositely charged colloidal sols.

36. K_2SO_4 is more effective in causing coagulation of positively charged colloidal sol.
Because greater the valency of the coagulating ion, greater is its power to bring about coagulation.

37. The formation of micelles takes place only above a particular temperature called Kraft temperature (T_k).

38. Peptization is the process of conversion of a precipitate into colloidal state in the presence of some electrolyte.

39. The substances which when dissolved in a medium at low concentrations behave as normal, strong electrolytes but at higher concentrations exhibit colloidal state properties due to formation of aggregated particles are called associated colloids *e.g.,* soap.

40. In an emulsion both the dispersed phase and dispersion medium are liquids while in a gel the dispersed phase is a liquid and dispersion medium is a solid.

41. $FeCl_3 + NaOH \longrightarrow \underset{\text{Negatively charged sol}}{Fe_2O_3 \cdot xH_2O \vdots OH^-}$

42. Difference between lyophilic and lyophobic sol :

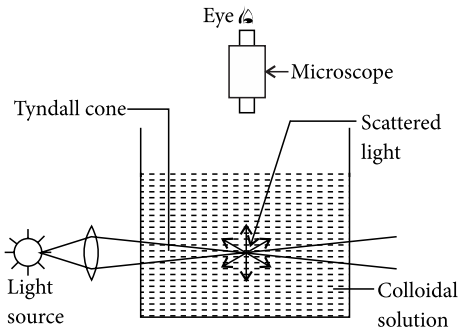
Lyophobic sol	Lyophilic sol
These are solvent repelling.	These are solvent attracting.

43. When a liquid is dispersed in a solid, 'gel' is formed, *e.g.*, jellies.

44. When a solid is dispersed in a liquid, a colloid is formed which is known as 'sol' *e.g.,* paints.

45. When a gas is dispersed in a liquid, foam is formed, *e.g.,* froth.

46. When a beam of light is passed through a colloidal solution and viewed perpendicular to the path of incident light, the path of beam is illuminated by a bluish light. This phenomenon is called Tyndall effect. This is due to the fact that colloidal particles scatter light in all the directions in space.



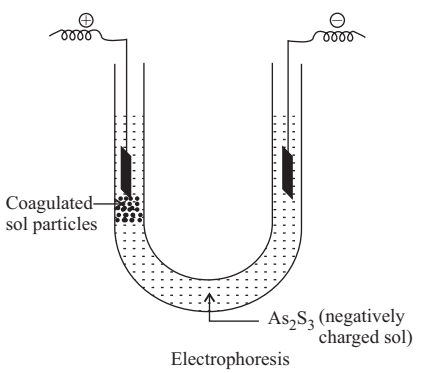
47. The main reason for the stability of colloids is the Brownian movement and electrostatic stabilisation, *i.e.,* equal and same type of charge on the colloidal particles which causes repulsion between them and prevents the coagulation of the sol.

48. $BaCl_2$ is more effective in causing coagulation of negatively charged colloidal sol.
Because greater the valency of the coagulating ion, greater is its power to bring about coagulation.

49. Dispersed phase : Liquid
Dispersion medium : Solid

50. Dialysis : It is the process of removing a dissolved substance from a colloidal solution by means of diffusion through a suitable membrane.
A bag of suitable membrane containing the colloidal solution is suspended in a vessel through which fresh water is continuously flowing.
The molecules and ions diffuse through membrane into the water and pure colloidal solution is left behind.

51. The movement of colloidal particles under an applied electric potential is called electrophoresis.
Positively charged colloidal particles move towards the cathode, while negatively charged particles move towards the anode.



52.

Type of colloid	Dispersed phase	Dispersion medium	Examples
Sol	Solid	Liquid	Paints or Cell fluids
Gel	Liquid	Solid	Cheese or Jellies

53. A colloidal sol in which dispersed phase and dispersion medium attract each other is called lyophilic colloid. *e.g.*, gum. A colloidal sol in which dispersed phase and dispersion medium repel each other is called lyophobic colloid. *e.g.*, gold solution.

54. Liquid fat is the dispersed phase and water is the dispersion medium.

55. When the formation of micelles takes place only above a particular temperature called Kraft temperature (T_k).

56. Associated colloids

57. CFC (Chlorofluorocarbon)

58. Emulsion

59. When the developed film is immersed in sodium thiosulphate (hypo) solution it removes unchanged silver bromide as a complex ion (sodium argentothisoluphate).
This is known as fixing.

$$AgBr + 2Na_2S_2O_3 \rightarrow Na_3[Ag(S_2O_3)_2] + NaBr$$

After fixing, the film is not sensitive to light.

60. When a powerful beam of light is passed through true and colloidal solutions each kept in a glass vessel then, colloidal solution exhibits tyndall effect whereas true solution does not.

61. Sol is a type of colloid in which the dispersed phase is solid and the dispersion medium is a liquid. Examples include mud, milk of magnesia.
Emulsion is a type of colloid in which the dispersed phase is liquid and dispersion medium is also a liquid. Examples include milk, face cream, etc.

62. *Refer to answer 53.*

63. Hydrosol : It is a colloidal solution of a solid in water as the dispersion medium. *e.g.*, starch solution.

64. (a) On treating a precipitate of iron (III) oxide with a small amount of $FeCl_3$ solution, a reddish brown coloured colloidal solution is formed. In this case, Fe^{3+} ions from ferric chloride are adsorbed by $Fe(OH)_3$ precipitate.

$$\underset{\text{ppt.}}{Fe(OH)_3} + \underset{\text{Electrolyte}}{Fe^{3+}} \longrightarrow \underset{\text{Colloidal sol}}{Fe(OH)_3.\ Fe^{3+}}$$

(b) When dialysis is persistent and prolonged, the traces of electrolyte are also removed. These electrolytes stabilise the colloid and when removed completely, make the colloid unstable and the colloid gets coagulated.

65.

(i)	**Multimolecular Colloids**	**Macromolecular Colloids**
	When a large number of small molecules or atoms (diameter < 1 nm) of a substance combine together in a dispersion medium to form aggregates, having size in the colloidal range, the colloidal solutions thus, formed are known as multimolecular colloids, *e.g.*, gold sol, sulphur sol, etc.	When substances which possess very high molecular masses are dispersed in suitable dispersion medium, the colloidal solutions thus, formed are called macromolecular colloids, *e.g.*, cellulose, starch, etc.
(ii)	**Sol**	**Gel**
	Dispersed phase is solid whereas dispersion medium is liquid.	Dispersed phase is liquid whereas dispersion medium is solid.

66. (a) Difference between multimolecular colloid and associated colloid :

Multimolecular colloid	Associated colloid
The particles of this type of colloids are aggregates of atoms or molecules with diameter less than 1 nm. *e.g.*, sulphur sol consists of colloidal particles which are aggregate of S_8 molecules.	They are substances which at low concentration behave as true solution and at higher concentration exhibit colloidal behaviour due to formation of aggregated particles.

(b) Difference between coagulation and peptization :

Coagulation	Peptization
It is the process of settling of colloidal particles.	It is the process responsible for the formation of stable dispersion of colloidal particles in dispersion medium.

67. (a) *Refer to answer 54.*

(b) Hydrolysis is the chemical method by which $Fe(OH)_3$ sol is prepared from $FeCl_3$.

$$FeCl_3 + 3H_2O \longrightarrow Fe(OH)_{3(sol)} + 3HCl$$

68. (i) According to Hardy-Schulze rule, for negatively charged sol greater the valency of positive ion added to it, greater is its coagulation power.

In $AlCl_3$, Al has +3 charge which is more than Mg with +2 charge in $MgCl_2$. Thus, $AlCl_3$ is more effective in causing coagulation of negatively charged sol.

(ii) Proteins are macromolecules which cannot form multimolecular colloids while sulphur sol have smaller S_8 molecules which can form multimolecular colloids.

69. (i) Animal hides are colloidal in nature. When a hide, which has positively charged particles is soaked in tannin, containing negatively charged colloidal particles, mutual coagulation takes place. This results in the hardening of leather.

(ii) Lyophilic sol is more stable than lyophobic sol because it is highly hydrated in the solution.

70. (i) Associated colloid : Soap

Multimolecular colloid : Sulphur sol

(ii) Lyophilic sols are reversible sols. These are quite stable and cannot be easily precipitated.

71. (i) *Refer to answer 38.*

(ii) *Refer to answer 61.*

72. (i) *Refer to answer 46.*

(ii) *Refer to answer 51.*

73. (i) Dispersed phase of smoke = Solid

Dispersion medium of smoke = Gas

(ii) Dispersed phase of milk = Fat (liquid)

Dispersion medium of milk = Water (liquid)

74. *Refer to answer 65(i)*

75. (i) *Refer to answer 65(i).*

(ii) *Refer to answer 53.*

76. (a) Sulphur sol is prepared by the oxidation of H_2S with SO_2.

$$SO_2 + 2H_2S \xrightarrow{\text{Oxidation}} \underset{\text{(Sol)}}{3S} + 2H_2O$$

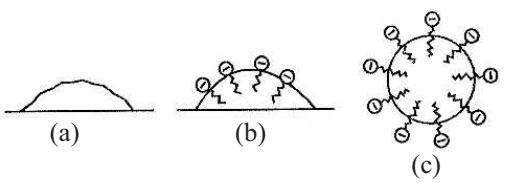
(b) Gold sol is prepared by the reduction of $AuCl_3$ with HCHO.

$$2AuCl_3 + 3HCHO + 3H_2O \xrightarrow{\text{Oxidation}} 2Au\ \text{(Sol)} + 3HCOOH + 6HCl$$

77. (i) Aggregated particles of associated colloids at high concentration are called micelles, *e.g.,* soaps.

(ii) Colloid of a liquid in a gas is called aerosol, *e.g.,* fog, sprays, etc.

78. The cleansing action of soap is due to the fact that soap molecules form micelle around the oil droplet in such a way that hydrophobic part is in the oil droplet and hydrophilic part interact with water, the oil droplet surrounded by stearate ions is now pulled in water and removed from the dirty surface. Thus, soap helps in emulsification and washing away of oils and fats. The negatively charged sheath around the globules prevents them from coming together and forming aggregates.



Hard water contains calcium and magnesium ions. These ions form insoluble calcium and magnesium salts when sodium or potassium soaps are dissolved in hard water. These insoluble soaps separate as scum in water and are useless as cleansing agent.

79. (i) The same substance can act as both colloid and crystalloid. It depends on the size of the particles.

When the size of the particles lies between 1 to 1000 nm, it behaves as a colloid. If particle size is less than 1 nm, it exists as a true solution and behave like a crystalloid.

(ii) When small amount of $AgNO_3$ solution is added to excess aqueous KI solution, a negatively

charged sol of AgI is formed. This is due to selective adsorption of I^- ions from the dispersion medium.

$$AgI + \underset{\text{Dispersion medium}}{I^-} \longrightarrow$$

80. (i) *Refer to answer 77(ii).*
(ii) **Coagulation :** The process of aggregating together the colloidal particles into large sized particle which ultimately settle down under the force of gravity as a precipitate is called coagulation.

81. A colloidal sol in which dispersed phase and dispersion medium attract each other is called lyophilic colloid. *e.g.*, gum. A colloidal sol in which dispersed phase and dispersion medium repel each other is called lyophobic colloid. *e.g.*, gold solution.
In lyophobic sol, there is hardly and affinity between the particles of dispersion medium and dispersed phase. Therefore, it is unstable and can be easily coagulated. Since there is strong affinity between the particles in case of lyophilic sol, so coagulation is rather difficult.

82. (a) The Brownian movement has a stirring effect which does not permit the particles to settle and thus, it is responsible for the stability of colloidal solutions.
(b) Tyndall effect is not observed in true solution as the diameter of dispersed particles is much smaller as compared to wavelength of the light used.
(c) The water obtained from natural sources often contains suspended impurities. Alum is added to such water to coagulate the suspended impurities and make water fit for drinking purposes.

83. (i) *Refer to answer 53.*
(ii) The difference of potential between fixed layer and diffused layer of a colloidal sol is known as electrokinetic or zeta potential.
(iii) *Refer to answer 39.*

84. (i) **Brownian movement :** When the colloidal particles are observed under the ultramicroscope, the particles are seen to be in constant motion in zig-zag path.
This zig-zag motion of colloidal particles is called Brownian movement.
(ii) *Refer to answer 38.*
(iii) *Refer to answer 65(i).*

85. (i) *Refer to answer 50.*
(ii) *Refer to answer 51.*
(iii) *Refer to answer 46.*

86. (i) Scattering of light by the colloidal particles takes place and the path of light becomes visible (Tyndall effect).
(ii) The positively charged colloidal particles of ferric hydroxide sol get coagulated by the oppositely charged Cl^- ions provided by NaCl.
(iii) On passing electric current through a sol, colloidal particles start moving towards oppositely charged electrodes where they lose their charge and get coagulated (electrophoresis).

87. The process of setting of colloidal particles is called coagulation of the sol. It is also known as precipitation. Following are the three methods by which coagulation of lyophobic sols can be carried out :
(i) **Electrophoresis :** In this process, the colloidal particles move towards oppositely charged electrodes and get discharged resulting in coagulation.
(ii) **Mixing of two oppositely charged sols :** When equal proportions of oppositely charged sols are mixed, they neutralise each other resulting in coagulation.
(iii) **Prolonged dialysis :** By prolonged dialysis, electrolytes present in sol are removed completely and colloid becomes unstable resulting in coagulation.

88. (i) **Hydrosol :** When solids is dispersed in water, it is called hydrosol, *e.g.*, gold sol, starch sol.
(ii) **Emulsion:** When liquid is dispersed in water, it is called emulsion, *e.g.*, milk.
(iii) **Foam :** When gas is dispersed in water, it is called foam or froth, *e.g.*, soap lather, whipped cream.

89. *Refer to answers 65(i) and 66(a).*

90. The emulsion in which oil is the dispersed phase and water is the dispersion medium is known as O/W emulsion *e.g.,* milk.

91. On centrifugation, emulsion is decomposed back into its constituent liquids. This process is called demulsification.

92.

O/W emulsion	W/O emulsion
Oil is dispersed phase and water is the dispersion medium.	Water is dispersed phase and oil is the dispersion medium.

93. Emulsion : It is a colloidal system when both the dispersed phase and the dispersion medium are in the liquid state, *e.g.*, milk.

94. Oil in water emulsion : Milk
Water in oil emulsion : Butter

95. *Refer to answer 93.*

96. *Refer to answer 93.*
Butter is an emulsion in which water acts a dispersed phase and oil acts as the dispersion medium.

97. The two types of emulsions are :
(i) Oil-in-water type in which small droplets of an oil are dispersed in water.
Example : Milk, cod liver oil.
(ii) Water-in-oil type in which water droplets are dispersed in an oil.
Example : Butter.

98. *Refer to answer 93 and 97.*

99. (c) : Hardening of leather in tanning industry is based on mutual coagulation.

100. Medicines are more effective in colloidal form because in this form, these are more easily assimilated due to large surface area.

101. Sea water contains a lot of electrolytes. River contains colloids of sand and clay. When they meet the electrolytes neutralise the charge on colloidal particles which results in the precipitation of sand, clay etc. thus, resulting in a delta formation.

102. Clouds are colloidal dispersion of water particles in air. These water particles carry some charge over them. On spraying oppositely charged colloidal dust or sand particles over a cloud from an aeroplane, the colloidal water particles present in the cloud will get neutralized and as a result they will come closer and will grow in size to form bigger water drops and ultimately will coagulate or precipitate causing artificial rain.