
UNIT : 10 SURFACE CHEMISTRY

Important Points

- ^ The study of chemistry regarding the boundary separating two bulk states or phases is called surface chemistry. This boundary surface is known as interface. It is expressed as hyphen (–) or slash (/). Dissolution, crystallization, catalysis, metallic corrosion are surface phenomena.
- ^ The surface should be completely pure which can be obtained by vacuum generating method and can be stored also.
- ^ In this unit, surface phenomena like adsorption, catalysis, colloid and emulsion are studied.
- ^ In adsorption, the substance which is in solid form and on which other gas or liquid is adsorbed is called adsorbent. The substance that is adsorbed is called adsorbate and the whole phenomenon is called adsorption. The phenomenon opposite to adsorption is called desorption.
- ^ Absorption is such a phenomenon in which there is homogeneous system viz. any coloured solution but if solid adsorbent like charcoal is added to it then there is decrease in intensity of the colour which is adsorption. The combined phenomenon of adsorption and absorption is called sorption. In adsorption the concentration of adsorbate is more than that in the bulk. More porous the adsorbent more will be adsorption. Adsorption is an exothermic phenomenon.
- ^ In adsorption, the residual particles on the surface are responsible for the adsorption that is due to difference in forces of attraction.
- ^ Adsorption is of two types– Physical and Chemical. The points of difference between them are given in the unit.
- ^ Adsorption is used in many fields as well as in everyday life viz. To wear gas mask in which there is adsorbent to save from the poisonous gas like chlorine. Silica gel is used as adsorbent for keeping the electronic instruments moisture free. In the removal of yellow colour from sugar, the phenomenon of adsorption is used.
- ^ The factors affecting adsorption are (1) nature of adsorbate (2) nature of adsorbent (3) specific area of adsorbent surface (4) pressure of adsorbed gas (5) temperature. The detailed discussion about each one is included in the unit.
- ^ At constant temperature the graph of pressure of gas adsorbed or concentration is called adsorption isotherm. There are five different types of isotherms. The study of adsorption isotherm was done by scientist Freundlich and gave the equation $\frac{x}{m} = Kp^{\frac{1}{n}}$ or $\log \frac{x}{m} = \log K + \frac{1}{n} \log p$ (for pressure (p)) and $\frac{x}{m} = KC^{\frac{1}{n}}$ or $1 \log \frac{x}{m} = \log K + \frac{1}{n} \log C$ (for concentration (C)) where K and n are constants. This was an empirical isotherm and had no scientific base.

^ Langmuir on the basis of kinetic theory of gases gave isotherm equation.

$$\frac{x}{m} = \frac{ap}{1 + bp}, \quad \frac{x}{m} = \frac{aC}{1 + bC} \quad (\text{where } a \text{ and } b \text{ are constants})$$

^ The study of Freundlich isotherm can be understood by the study of demonstration experiment in practicals book. There are many uses of adsorption which are described in the unit.

^ Catalysis is also a surface phenomenon. Some chemical reactions are slow. To increase their rates, the substance used in small proportion is called catalyst. This phenomenon is called catalysis. The catalyst is obtained back in original form at the end of the reaction.

^ There are two types of catalysis (1) Homogeneous and (2) Heterogeneous. In homogeneous catalysis, catalyst and the reactant are in one phase e.g. hydrolysis of methyl acetate in presence of H^+ (2) In heterogeneous catalysis the catalyst and the reactants are in different phases e.g. Production of sulphuric acid in presence of V_2O_5 by contact process. There are many uses of homogeneous and heterogeneous catalysis as shown in the unit.

^ The characteristics of catalysis are activity, selectivity that is specific reaction; selection of specific catalyst e.g. zeolite. The zeolite named ZSM-5 is used to obtain gasoline from alcohol. Catalyst increases the rate of reaction but does not affect the equilibrium because it affects equally both the forward and the reverse reaction. Hence, more product is not obtained.

^ Enzymes are proteins and are necessary for biochemical reaction. For every reaction separate and specific enzyme works viz. invertase can transform sugar into glucose and fructose. Urease can decompose urea into ammonia and carbon dioxide.

^ For enzyme catalysis the lock and key model or induced fit model are proposed. As the lock can be opened by suitable key, similarly for a particular reaction suitable enzyme will be required. The enzymes work at the temperature of the body i.e. 298-310 K temperature is considered the best.

^ Colloid chemistry is also a surface phenomenon. The colloidal solution is called sol. There are two components called dispersing phase and dispersion medium in it. The particles are of some particular size so this is a heterogeneous system. Colloids are of two types-Lyophilic and Lyophobic. The colloid which has attraction for solvent (dispersion medium) is used called lyophilic colloid e.g. gum. The colloid which has repulsion towards the solvent (dispersion medium) is called lyophobic colloid. If water is as a medium then they are respectively called hydrophilic and hydrophobic. Colloids are of eight types which depend on the dispersing phase and dispersion medium. This is shown in the unit. Multimolecular, macromolecular and associated colloids are also known. In associated colloids molecules come nearer and form an association which is called micelle.

^ The certain temperature, at which the micelle is formed is called Kraft's temperature (T_K). Below the critical micelle concentration (CMC), it remains in colloidal state and at higher than that concentration it is changed to solid in the form of precipitates. The formation micelle is obtained in the cleansing action of soap. Molecules like soap are shown as $RCOONa$, and their ionization form will be $RCOO^-Na^+$. From this $RCOO^-$, R part combines with organic impurity and drags inside. It is called tail. The upper charged part COO^- attracts dust etc. and removes the dirt. It is called head.

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- ^ The methods of preparation of colloids are as follows :
- ^ **Condensation method** : In these methods, oxidation, reduction, decomposition etc. types of reactions are associated. In physical methods, excessive cooling is used, and in dispersion methods-mechanical dispersion (use of colloid mill), electrical dispersion (Bredig arc method) and peptization are used.
- ^ For purification of prepared colloidal solution, a method like dialysis and better method like electrodialysis can be used. On addition of certain electrolytes to colloid solutions, precipitation occurs which is called coagulation. The order of concentration for coagulation for iron sol having positive charge is trivalent > divalent > monovalent for negative ions (anions). Similarly for arsenious sulphide colloid having negative charge, the order of coagulation remains the same but positive ions (cations) are used. Amongst the other methods used for purification of colloids are ultrafiltration and ultracentrifugation.
- ^ The properties of colloidal solutions-sol are as follows : (1) Colligative properties (2) Optical properties (3) Mechanical and (4) Electrical properties.
- ^ In colligative properties determination of molecular masses is by osmosis method. In optical properties- Tyndall effect and in mechanical properties Brownian movement and in electrical properties, instrument called electrophoresis is used for determination of electrical charge of colloid. There are two laws given by Hardy and Schulze for the study of coagulation of colloids. The electrolytes having electric charge opposite to that on the colloid are required for coagulation of colloid. For colloid having positive or negative electric charge negative or positive ions of the electrolyte respectively are useful. In concentration, highest concentration of monovalent and less than that concentration of divalent ion and the least concentration of trivalent produces coagulation.
- ^ Emulsions are also colloids, in which both the dispersion medium and the dispersed phase are in liquid form. They are of two types- Oil / water and water/oil. The examples of water/oil emulsion are cold cream, butter etc; while in oil/water emulsion the examples are milk, vanishing cream etc. There are two methods for the test of emulsions (1) Dye test and (2) Dilution test. Demulsification is the opposite phenomenon.
- ^ There are many uses of colloids. Its specific uses are rubber plating, sewage disposal, Cottrell smoke precipitator, preparation of nano-substances, medicines, as germicides in metallurgy, construction of roads etc. which are described in detail in the unit.

M.C.Q.

- (1) On which factors interface depends ?
- Size of the molecules in the bulk phase.
 - Weight of the molecules in the bulk phase.
 - Numbers of molecules in the bulk phase.
 - Physical state of molecules in the bulk phase.
- (2) Which of the following phenomenon is not involved in surface chemistry ?
- Electrode reactions
 - Dissolution
 - Heterogeneous catalysis
 - Liquid and its vapour taken in closed vessel.
- (3) How much pascal high vacuum is required to achieve completely pure surface of metal?
- 10^{-8} to 10^{-9}
 - 10^{-8} to 10^{-10}
 - 10^{-6} to 10^{-9}
 - 10^{-8} to 10^{-7}
- (4) Due to adsorption
- surface energy increases
 - surface energy becomes zero
 - surface energy decreases
 - no change occurs in surface energy
- (5) Which of the following processes is adsorption phenomenon ?
- Soak of rayon clothes in coloured solution
 - Contact between silica gel and vapour of water
 - Contact between anhydrous CaCl_2 and vapour of water
 - H_2S gas in contact to water.
- (6) Which of the following is good adsorbent ?
- Silica gel
 - Alumina
 - Clay
 - All the given
- (7) Which type of process adsorption is ?
- Isotonic
 - Isochoric
 - Endothermic
 - Exothermic
- (8) When adsorption phenomenon occurs complete ?
- $\Delta H < 0, \Delta G < 0, \Delta S < 0$
 - $\Delta G < 0, \Delta H < 0, \Delta S > 0$
 - $\Delta H > 0, \Delta S > 0, \Delta G < 0$
 - $\Delta G < 0, \Delta S < 0, \Delta H > 0$
- (9) Which is correct for adsorption ?
- $\Delta H - T \Delta S$ is negative
 - ΔH is positive
 - $\Delta H - T \Delta S$ is positive
 - $T \Delta S$ and $\Delta G = 0$
- (10) Which of the following statement is not true ?
- The value of adsorption enthalpy of physical adsorption is less than chemical adsorption.
 - Physical adsorption occurs due to van der Waals' forces
 - Chemical adsorption decreases at high temperature and low pressure.
 - Physical adsorption is reversible.

- (11) At which temperature chemical adsorption occurs ?
- (a) At high temperature (b) At very low temperature
(c) At low temperature (d) Temperature does not affect.
- (12) Whose value is less than zero during adsorption ?
- (a) ΔG (b) ΔH (c) ΔS (d) All the given
- (13) How molecules of gases are deposited on the surface of solid during physical adsorption ?
- (a) By electrostatic forces (b) By chemical forces
(c) By gravitational forces (d) By van der waals' forces
- (14) What is used to prevent electronic instruments damaged by the moisture ?
- (a) Silica gel (b) Zeolite
(c) Chromatographic plate (d) All the given
- (15) On which factor adsorption of gas on solid adsorption depend ?
- (a) On temperature (b) On pressure of gas
(c) On nature of adsorbent (d) All the given
- (16) If H_2, CH_4, CO_2 and NH_3 gases are adsorbed by 1 gram charcoal at 290 K temperature than decreasing order of their volume is
- (a) $H_2 > CH_4 > CO_2 > NH_3$ (b) $CO_2 > NH_3 > H_2 > CH_4$
(c) $NH_3 > CO_2 > CH_4 > H_2$ (d) $CH_4 > CO_2 > NH_3 > H_2$
- (17) Which gaseous molecule has highest value of physical adsorption enthalpy ?
- (a) H_2 (b) N_2 (c) H_2O (d) He
- (18) How magnitude of adsorption gas is expressed ?
- (a) $\frac{m}{x}$ (b) $m \cdot \Delta x$ (c) $\frac{x}{m}$ (d) $x+m$
- (19) Which is Freundlich adsorption isotherm equation ?
- (a) $\frac{m}{x} \alpha p^{1/n}$ (b) $\frac{m}{x} \alpha p^n$ (c) $\frac{x}{m} \alpha p^{1/n}$ (d) None of these
- (20) What will be the value of slope after drawing graph of $\log \frac{x}{m} \rightarrow \log p$ in Freundlich adsorption isotherm?
- (a) $\frac{1}{p}$ (b) $\frac{1}{n}$ (c) $\frac{1}{a}$ (d) -k
- (21) What will be the intercept⁺ in a graph of Freundlich adsorption isotherm ?
- (a) k (b) $\log k$ (c) $\frac{1}{a}$ (d) $\frac{1}{n}$
- (22) Whose value we can get from intercept in the graph of adsorption isotherm ?
- (a) a and b (b) n and k (c) $\frac{1}{a}$ (d) $\log k$

- (23) Which of the following is not true regarding to Freundlich adsorption isotherm ?
- (a) This isotherm is applicable in certain limit of pressure
 (b) Constant k and n change with temperature
 (c) It shows deviation at low pressure
 (d) Freundlich isotherm is empirical, there is no theoretical proof of it.
- (24) If the value of $\frac{1}{n}$ becomes zero in Freundlich adsorption isotherm then adsorption is independent to
- (a) pressure (b) temperature (c) quantity (d) a and b
- (25) If the value of $\frac{1}{n}$ is 1 in Freundlich adsorption isotherm then $\frac{x}{m} = \dots\dots\dots$
- (a) $\frac{k}{p}$ (b) kp (c) k (d) none of these
- (26) On basis of which theory Langmuir derived isotherm equation ?
- (a) Thermodynamics (b) Kinetic theory of gases
 (c) Collision theory (d) Wave mechanic theory
- (27) Which of the following is Langmuir adsorption isotherm ?
- (a) $\frac{m}{x} = \frac{1+bp}{ab}$ (b) $\frac{x}{m} = \frac{ab}{1+bp}$ (c) $\frac{x}{m} = \frac{ap}{1+bp}$ (d) $\frac{x}{m} = \frac{ap}{1+bc}$
- (28) How will be Langmuir equation at high pressure ?
- (a) $\frac{x}{m} = \frac{a}{b}$ (b) $\frac{x}{m} = ap$ (c) $\frac{x}{m} = \frac{ap}{1+bp}$ (d) $\frac{x}{m} = \frac{b}{a}$
- (29) What will be the value of slope in graph of $\frac{m}{x} \rightarrow \frac{1}{p}$ according to Langmuir equation ?
- (a) $\frac{1}{a}$ (b) $\frac{b}{a}$ (c) $\frac{a}{b}$ (d) k
- (30) In Endothermic reaction with the increase of temperature adsorption will be
- (a) constant (b) increase (c) decrease (d) none of these
- (31) Which adsorbent is used in separation of inert gases by Dewar's method ?
- (a) Vanadium pentoxide (b) Silica gel
 (c) Activated charcoal (d) Alumina
- (32) Which of the following are adsorption indicators ?
- (a) eosin (b) fluorescein (c) methylene blue (d) (a) and (b)
- (33) What is not true for catalytic reaction ?
- (a) Catalyst increases equally both the rate of forward and reverse reactions.
 (b) Catalyst does not effect to equilibrium constant.
 (c) Catalyst decreases activation energy
 (d) Catalyst increases activation energy of chemical equation.
- (34) Which catalyst forms NH_3 and CO_2 from urea ?
- (a) Invertase (b) Cellulase (c) Urease (d) Pepsin

- (35) Which of the following is an example of surface catalysis ?
- (a) Inversion of sucrose
 (b) Production of ammonia by Haber's process
 (c) Production of H_2SO_4 by lead chamber process
 (d) Hydrolysis of ester
- (36) Which catalyst is used in inversion of sucrose ?
- (a) $Fe_{(s)}$ (b) $NO_{(g)}$ (c) H_2SO_4 (d) $Cl_{(g)}$
- (37) Which catalyst is used to obtain methanal from water gas ?
- (a) Cu (b) $ZnO-Cr_2O_3$ (c) (a) and (b) (d) FeO
- (38) Which catalyst is used in the decomposition of ozone ?
- (a) $Cl_{2(g)}$ (b) $Cl_{(g)}$ (c) $O_{2(g)}$ (d) all the given
- (39) Which catalyst is used to prepare propylene oxide from the reaction between propylene and dioxygen ?
- (a) Rh-Pd complex (b) $[Rh(CO)_2I_2]$ complex (c) Mo(VI) complex (d) Ni-Pd complex
- (40) On which factor activity of catalyst depends ?
- (a) On the strength of chemical adsorption. (b) On the concentration of products.
 (c) On the concentration of reactants. (d) On the physical state of catalyst
- (41) By which name this reaction is also known ?
- reaction: $2SO_2 + O_{2(g)} \rightarrow 2SO_{3(g)}$
- (a) Shape-selective catalysis (b) Homogeneous catalysis
 (c) Enzyme catalysis (d) Surface catalysis
- (42) $CO_{(g)} + H_{2(g)} \rightarrow x$. What is x ?
- (a) Methane (b) Methanal (c) Formic acid (d) Formaldehyde
- (43) On which factor shape-selective catalysis depends ?
- (a) Size of reactant molecules (b) Pore structure of catalyst
 (c) Size of product molecules (d) All the given
- (44) How many times reaction rate increase by catalyst ?
- (a) 10^{10} to 10^{20} (b) 10^2 to 10^4
 (c) 10^6 to 10^8 (d) 10^8 to 10^{20}
- (45) What is called colloid system in which dispersing phase and dispersion medium, both are in solid state ?
- (a) Gel (b) Emulsion (c) Sol (d) Aerosol
- (46) What is called colloid system in which dispersing phase is gas and dispersion medium is liquid ?
- (a) Gel (b) Aerosol (c) Emulsion (d) Foam

- (47) Milk is example of which type of colloid ?
 (a) Emulsion (b) Suspension (c) Gel (d) Aerosol
- (48) Smoke is which type of colloidal system ?
 (a) Gas in solid (b) Solid in gas (c) Gas in gas (d) Gas in liquid
- (49) Which of the following is reversible sol ?
 (a) Cellulose (b) (c) Mist (d) Gelatin
- (50) Which type of sol sulphur is ?
 $Na^+ > Ba^{2+} > Fe^{3+}$
 (a) Multimolecular colloid (b) Micelle
 (c) Associated colloid (d) Macromolecular colloid
- (51) Which of the following is macromolecular colloid ?
 (a) Artificial rubber (b) Protein (c) Nylon (d) All the given
- (52) What is called to that temperature at which the formation of micelle takes place ?
 (a) Zero temperature (b) Kraff temperature
 (c) Kelvin temperature (d) Absolute temperature
- (53) At which condition micelle is formed ?
 (a) At concentration higher than critical micelle concentration and lower than kraff temperature.
 (b) At concentration higher than critical micelle concentration and higher than kraff temperature.
 (c) At concentration lower than critical micelle concentration and lower than kraff temperature.
 (d) At concentration lower than critical micelle concentration and higher than kraff temperature.
- (54) Which of the following condition is true during the formation of micelle ?
 (a) $\Delta H = -ve, \Delta S = -ve$ (b) $\Delta H = +ve, \Delta S = -ve$
 (c) $\Delta H = +ve, \Delta S = +ve$ (d) $\Delta H = -ve, \Delta S = +ve$
- (55) What is approximate value of CMC for soap ?
 (a) $10^{-9}M$ to $10^{-4}M$ (b) $10^{-3}M$ to $10^{-4}M$ (c) $10^{-9}M$ to $10^{-14}M$ (d) 10^3M to 10^5M
- (56) Which of the following is physical method for the preparation of colloidal sol ?
 (a) coagulation (b) peptization (c) fusion (d) excessive cooling
- (57) Which sol is formed due to hydrolysis of $FeCl_3$?
 (a) $FeCl_2$ (b) $Fe(OH)_2$ (c) Fe_2O_3 (d) $Fe(OH)_3$
- (58) Which of the following is double decomposition ?
 (a) $SO_2 + 2H_2S \rightarrow 3S + 2H_2O$ (b) $FeCl_3 + 2H_2O \rightarrow Fe(OH)_2 + 3HCl$
 (c) $As_2O_3 + 3H_2S \rightarrow As_2S_3 + 3H_2O$ (d) All the given
- (59) By which method As_2S_3 sol can be obtained by the reaction between As_2O_3 and H_2S ?
 (a) Reduction (b) Oxidation (c) Hydrolysis (d) Double decomposition
- (60) In which of the following method condensation and dispersion are associated ?
 (a) Excessive cooling (b) Hydrolysis (c) Bredig's arc (d) Peptization

- (61) Which method is used to obtain sol of gold and silver ?
 (a) Electric dispersion (b) Peptization (c) Excessive cooling (d) Mechanical dispersion
- (62) Whose membranes are used in dialysis ?
 (a) Parchment paper (b) Plastic (c) Filter paper (d) Ultrafilter paper
- (63)Phenomenon is called reverse to coagulation ?
 (a) Flocculation (b) Tyndall (c) Brownian (d) Dialysis
- (64) Which of the following is correct order of coagulations for the coagulation of As_2S_3 ?
 (a) $Fe^{3+} > Ba^{2+} > Na^+$ (b) $Na^+ > Ba^{2+} > Fe^{3+}$
 (c) $Fe^{3+} > Na^{2+} > Ba^{2+}$ (d) $Ba^{2+} > Na^+ > Fe^{3+}$
- (65) Which of the following is correct order of coagulation ions for the coagulation of $Fe(OH)_3$?
 (a) $Cl^- > SO_4^{2-} > PO_4^{3-}$ (b) $PO_4^{3-} > SO_4^{2-} > Cl^-$
 (c) $SO_4^{2-} > Cl^- > PO_4^{3-}$ (d) $SO_4^{2-} > PO_4^{3-} > Cl^-$
- (66) Which is correct order of coagulation of ion necessary for coagulation of colloid sol ?
 (a) Monovalent ion < divalent ion < trivalent ion
 (b) Divalent ion < trivalent ion < monovalent ion
 (c) Trivalent ion < monovalent ion < divalent ion
 (d) Trivalent ion < divalent ion < monovalent ion
- (67) Which of the following substances contain negative charge in their colloidal solution ?
 (a) Arsenious sulphide (b) Platinum
 (c) Gold-Silver (d) All the given
- (68) Which peptizing agent is used to obtain sol of $Fe(OH)_3$?
 (a) HCl (b) $FeCl_2$ (c) KCl (d) $FeCl_3$
- (69) By the use of which colligative property molecular mass of colloid can be determined ?
 (a) Decrease in vapour pressure (b) Elevation in boiling point
 (c) Depression in freezing point (d) Osmotic pressure
- (70) Which of the following is oil/water emulsion ?
 (a) Milk (b) Vanishing cream (c) Butter (d) All the given
- (71) Which of the following substance is used as stabilizer in emulsion ?
 (a) Protein (b) Gum (c) Agar (d) All the given
- (72) Tyndall effect is associated with which property of colloid ?
 (a) Mechanical (b) Colligative (c) Optical (d) Electrical
- (73) Which method is used for demulsification ?
 (a) Sublimation (b) Distillation (c) Filtration (d) Centrifugation
- (74) Surface-tension of lyophobic sol is
 (a) less than water (b) greater than water (c) equal to water (d) can not be predicted

- (87) Surface tension of lyophilic sol is
 (a) greater than H_2O (b) equal to H_2O (c) less than H_2O (d) none of these
- (88) Which of the following is an example of homogeneous catalysis ?
 (a) Acidic hydrolysis of methyl acetate
 (b) Catalytic conversion in methanol from water gas
 (c) Catalytic conversion in SO_3 from SO_2 by contact process
 (d) Synthesis of NH_3 by Haber's process
- (89) In peptization reaction
 (a) colloid converts in precipitates
 (b) precipitates convert in colloid
 (c) true solution is formed from suspension particles.
 (d) true solution is formed by dissolving precipitates.
- (90) From which of the following effects is a colloidal system free ?
 (a) gravitational (b) Concentration of electrolyte
 (c) heat (d) applied electrical field.

ANSWER KEY

1	A	16	C	31	C	46	D	61	A	76	C
2	D	17	C	32	D	47	A	62	A	77	C
3	A	18	C	33	D	48	A	63	A	78	A
4	B	19	C	34	C	49	D	64	A	79	B
5	B	20	B	35	B	50	A	65	C	80	D
6	D	21	B	36	B	51	D	66	D	81	C
7	D	22	B	37	C	52	B	67	D	82	C
8	A	23	C	38	B	53	B	68	D	83	B
9	A	24	A	39	C	54	C	69	D	84	C
10	C	25	B	40	A	55	B	70	A	85	C
11	A	26	B	41	D	56	D	71	D	86	D
12	D	27	C	42	D	57	D	72	C	87	B
13	D	28	A	43	D	58	C	73	D	88	A
14	A	29	A	44	D	59	D	74	A	89	B
15	D	30	B	45	C	60	C	75	B	90	C