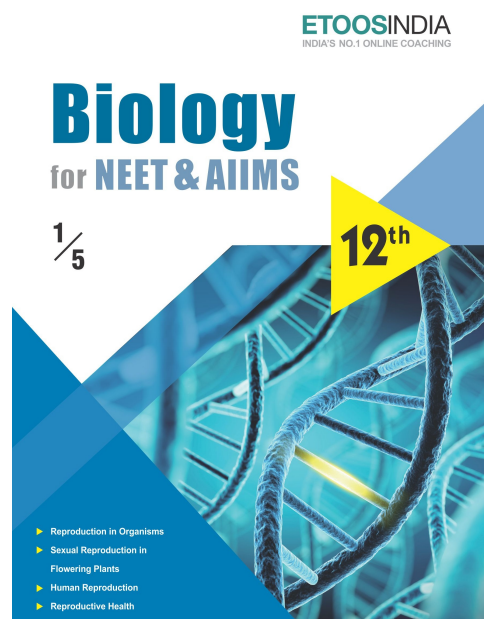
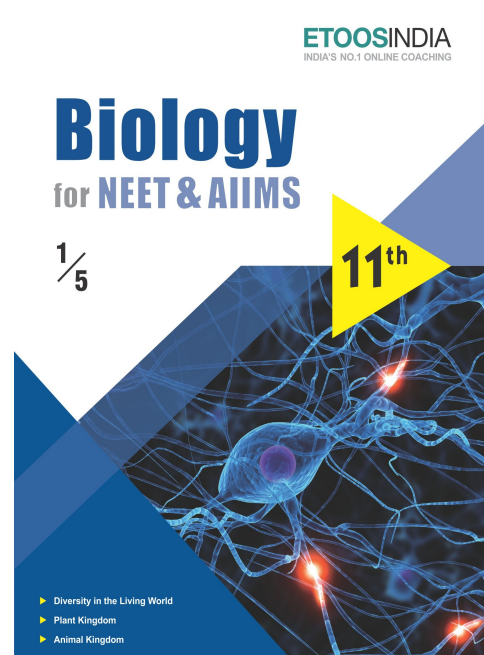
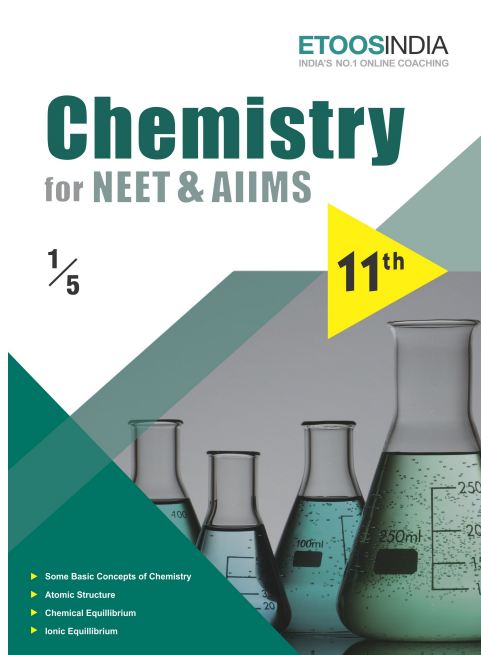
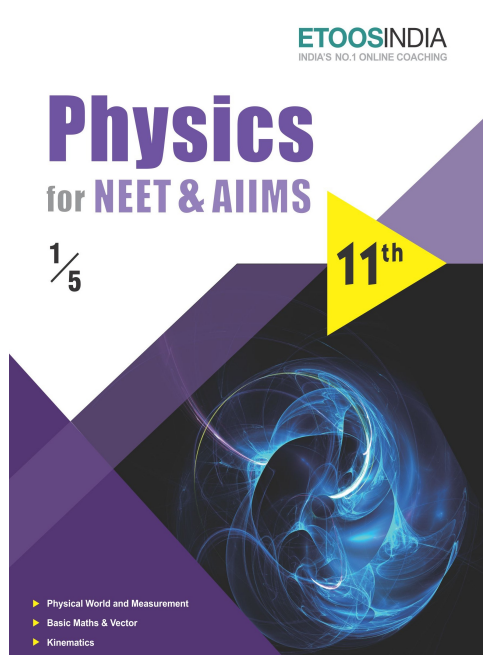


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SURFACE CHEMISTRY

The nature of the chemical bond is the problem at the heart of all chemistry.

"BRYCE CRAWFORD"

INTRODUCTION

The properties of substances are different at the surfaces and in the bulk, because the molecules present in the bulk are equally attracted in all direction having net force zero but the molecules present at surface experience attraction unequally. Due to unbalanced forces these molecules present at surface tends to take up molecules of a gas or any other substance in order to release the surface tension which they are experiencing. This tendency is more prominent in transition metals. The surface is more activated in case of finely divided state or rough surface. In this unit we will study phenomenon related to surface.

Surface chemistry is the branch of chemistry which deals with the study of nature of surface and the species present on it. This phenomenon is studied with the help of adsorption and colloidal state which are quite useful to understand the physical and chemical characteristics of the substance.



ETOOS KEY POINTS

Actually every substance irrespective of its nature can be crystalloid or colloid under suitable conditions. For example:

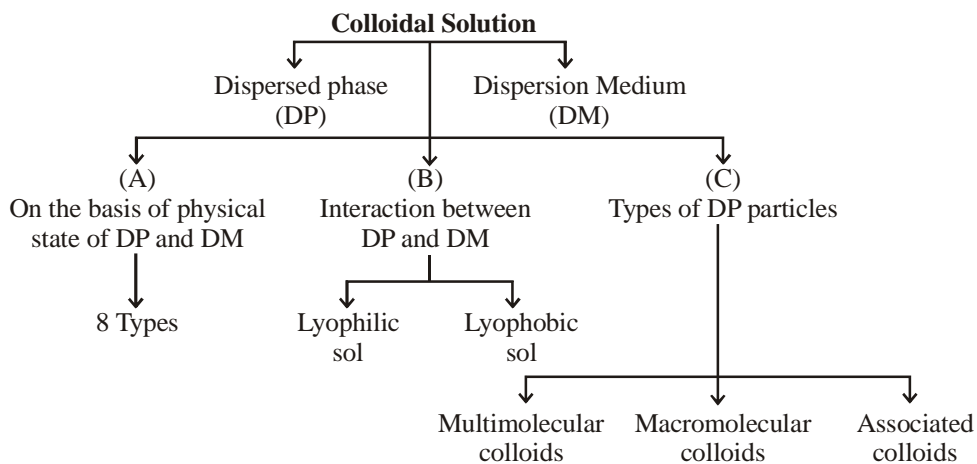
- (I) NaCl though a crystalloid in water behaves like a colloid in benzene.
- (II) Soap is a colloid in water, while it behaves like a crystalloid in benzene.

Therefore colloidal state now a days may be defined as following "A substance is said to be in the colloidal state, when it is dispersed in another medium in the form of very small particles having diameter between 10^{-4} to 10^{-7} cm (100 m μ to 1 m μ).

Molecular size in true solution	Colloidal particle size	Coarse suspension particle size
10^{-7} to 10^{-8} cm	10^{-5} to 10^{-7} cm	10^{-3} to 10^{-5} cm

TYPES OF COLLOIDAL SOLUTIONS

They considered as a heterogeneous system consisting of the following three essential components:



- (i) **A dispersed phase:** It is also known as discontinuous or inner phase. It consists of discrete particles significantly larger than ordinary molecules and in this small particles of solute is diffused in solvent.
- (ii) **A dispersion medium or continuous phase or the outer phase :** It is the medium in which dispersed phase is present. This consists of continuously interlinked molecules.
- (iii) **A stabilising agent:** This is a substance which tends to keep the colloidal particles apart. Some colloids are self stabilizers.

Dispersed phase + Dispersion medium = Dispersion system (Colloidal solution)

Each of the two phases constituting a colloidal system may be a gas, a liquid or a solid. For example, in milk, the fat globules are dispersed in water. Hence fat globules form a dispersed phase and water is the dispersion medium.

- (iv) **Sol :** If dispersion of a solid in a liquid, solid or gaseous medium, the resulting solution is called sol.

Etoos Tips & Formulas

(COLLOIDAL SOLUTION)

Classification based on interaction of phases :-

(1) LYOPHILIC AND LYOPHOBIC SOLS

Colloidal solution in which the dispersed phase has considerable affinity for the dispersion phase, are called Lyophilic sols (solvent - liking)

For example - dispersion of gelatin, starch, gum and proteins in water.

Colloidal solutions in which the dispersed phase has no affinity or attraction for the medium or for the solvent are called Lyophobic colloidal (Solvent hating) solutions.

COMPARISON OF LYOPHOBIC AND LYOPHILIC SOLS

General Characteristics of Catalysts :-

- (i) A catalyst remains unchanged in mass and chemical composition but can change their physical state.
- (ii) Only a very small amount of catalyst is sufficient to catalyse a reaction.
- (iii) A catalyst does not initiate a reaction.
- (iv) Solid catalyst is more efficient when used in finely divided form.
- (v) Generally catalyst does not change the nature of products.
- (vi) A catalyst does not change the equilibrium state of a reversible reaction but helps to achieve the equilibrium state or position of equilibrium in lesser time.
- (vii) The catalyst is generally specific in nature.
- (viii) Change rate constant of reaction.
- (ix) Does not change free energy of reaction.
- (x) Participate in mechanism of reaction.

SOLVED EXAMPLE

- Ex. 1** Which of the following process does not occur at the interface of phases
 (A) Crystallisation
 (B) Heterogeneous catalysis
 (C) Homogeneous catalysis
 (D) Corrosion

Sol. (C) Homogeneous catalysis does not at the interface of phases as in case of homogenous catalysis reactant and catalyst have same phase and their distribution is uniform throughout.

- Ex. 2** At the equilibrium position in the process of adsorption ...

- (A) $\Delta H > 0$ (B) $\Delta H = T \Delta S$
 (C) $\Delta H > T \Delta S$ (D) $\Delta H < T \Delta S$

Sol. (B) As we know that, at equilibrium $\Delta G = 0$

$$\Delta H - T \Delta S = 0$$

$$\Delta H = T \Delta S$$

Hence, at equilibrium enthalpy change is equal to product of temperature and entropy change.

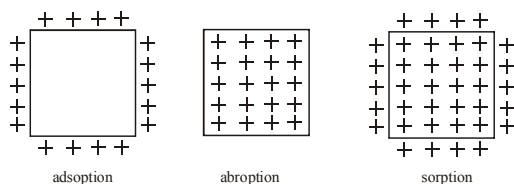
- Ex. 3** Which of the following interface cannot be obtained
 (A) Liquid-liquid (B) Solid-liquid
 (C) Liquid-gas (D) Gas-gas

Sol. (A) Gas-gas interface can not be obtained as they are completely miscible in nature. e.g., air is a mixture of various gases such as. O_2 , N_2 , CO_2 etc.

- Ex. 4** The term 'sorption' stands for.....

- (A) Absorption
 (B) Adsorption
 (C) Both absorption and adsorption
 (D) Desorption

Sol. (C) Sorption stands for both absorption and adsorption. We can understand this by using following figures.



- Ex. 5** Extent of physisorption of a gas increases with.....
 (A) Increase in temperature
 (B) Decrease in temperature
 (C) Decrease in surface area of adsorbent
 (D) Decrease in strength of van der Waal's forces

Sol. (B) Extent of physisorption of a gas increases with decreases in temperature. Because in physisorption particles are held to the surface by weak van der Waal's force of attraction hence on increasing temperature they get desorbed easily.

- Ex. 6** Extent of adsorption of adsorbate from solution phase increases with.....

- (A) Increase in amount of adsorbate in solution
 (B) Decrease in surface area of adsorbent
 (C) Increase in temperature of solution
 (D) Decrease in amount of adsorbate in solution

Sol. (A) Extent of adsorption of adsorbate from solution phase increase with increase in amount of adsorbate in solution. As amount of adsorption in the solution increase interaction of adsorption with adsorbent increase which lead to increase in extent of adsorption.

- Ex. 7** Which one of the following is not applicable to the phenomenon of adsorption

- (A) $\Delta H > 0$ (B) $\Delta G < 0$
 (C) $\Delta S < 0$ (D) $\Delta H < 0$

Sol. (A) For phenomenon of adsorption $\Delta H < 0$. i.e., enthalpy change during phenomenon of adsorption is negative because during adsorption, there is always a decrease in residual forces of the surface which lead to decrease in surface energy which appears as heat.

So, adsorption is an exothermic process and $\Delta H < 0$

- Ex. 8** Which of the following is not a favourable condition for physical adsorption

- (A) High pressure
 (B) Negative ΔH
 (C) Higher critical temperature of adsorbate
 (D) High temperature

Sol. (D) Physisorption is a process in which adsorbate get adsorbed on the adsorbent surface by weak van der Waal's force of attraction. On increasing temperature the interaction between adsorbate and adsorbent becomes weak and adsorbate particles get desorbed.

- Ex. 9** Physical adsorption of a gaseous species may change to chemical adsorption with....

- (A) Decrease in temperature
 (B) Increase in temperature
 (C) Increase in surface area of adsorbent
 (D) Decrease in surface area of adsorbent

Sol. (B) On increasing temperature physisorption changes to chemisorption. As temperature increases, energy of activation of adsorbate particles increase which lead to formation of chemical bond between adsorbate and adsorbent.

Hence, physisorption transform into chemisorption.

Exercise # 1

SINGLE OBJECTIVE

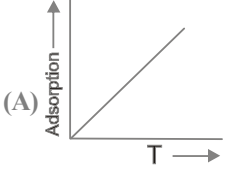
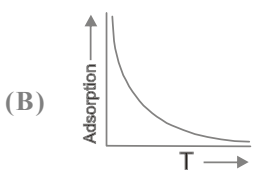
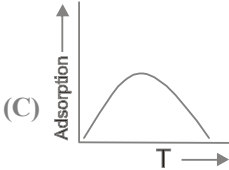
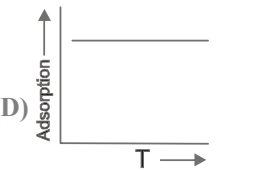
NEET LEVEL

1. Chemisorption
 - (A) Involves the weak attractive interactions between adsorbent and adsorbate
 - (B) Is irreversible in nature
 - (C) Decreases with increase of temperature
 - (D) Involves multilayer formation of adsorbent on adsorbate
2. Chemisorption
 - (A) Increases with temperature
 - (B) Decreases with temperature
 - (C) Remains unaffected by change of temperature
 - (D) Either increases or decreases with temperature
3. Which among the following statement is false
 - (A) The adsorption may be monolayered or multilayered
 - (B) Particle size of adsorbent will not affect the amount of adsorption
 - (C) Increase of pressure increases amount of adsorption
 - (D) Increase of temperature may decrease the amount of adsorption
4. Wood charcoal is used to decolourise sugar because it
 - (A) Adsorbs coloured material
 - (B) Absorbs decolorised material
 - (C) Reduces coloured material
 - (D) None of these
5. If the adsorbate is held on a surface by weak Vander Waal's forces, the adsorption process is called
 - (A) Physical adsorption
 - (B) Chemical adsorption
 - (C) Heat of adsorption
 - (D) Enthalpy of adsorption
6. When the temperature is raised, the viscosity of liquid decreases, this is because
 - (A) Decreased volume of the solution
 - (B) Increase in temperature increases the average kinetic energy of molecules, which overcome the attractive force between them
 - (C) Decreased covalent and hydrogen bond forces
 - (D) Increased attraction between molecules
7. A solid acts as an adsorbent because it has
 - (A) A definite shape
 - (B) Small pores in it
 - (C) Unsaturated valencies
 - (D) A high lattice energy
8. Point out the wrong statement :
Physical adsorption is characterised by
 - (A) Attraction due to weak Vander Waal's forces
 - (B) Irreversible nature of adsorption
 - (C) Multimolecular adsorption layers
 - (D) Decrease in adsorption with increase in temperature
9. When the temperature is lowered and pressure is raised, the adsorption of a gas on a solid
 - (A) Decreases
 - (B) Increases
 - (C) Remains unaffected
 - (D) Decreases first then increases
10. In physical adsorption, the gas molecules are held on solid surface by
 - (A) Chemical forces
 - (B) Electrostatic forces
 - (C) Gravitational forces
 - (D) Vander Waal's forces
11. Adsorption is multilayer in the case of
 - (A) Physical adsorption
 - (B) Chemisorption
 - (C) Both
 - (D) None of both
12. Physical adsorption
 - (A) Involves the weak attractive interaction between the adsorbent and adsorbate
 - (B) Involves the chemical interactions between the adsorbent and adsorbate
 - (C) Is irreversible in nature
 - (D) Increases with increase of temperature
13. The charge on sol is due to the adsorbed
 - (A) H^+
 - (B) OH^-
 - (C) O^{2-}
 - (D) S^{2-}
14. In the adsorption of acetic acid on activated charcoal, the acetic acid is an
 - (A) Adsorber
 - (B) Absorber
 - (C) Adsorbent
 - (D) Adsorbate
15. Sticking of one substance at the surface of another is called
 - (A) Absorption
 - (B) Chemisorption
 - (C) Adsorption
 - (D) Desorption
16. The charge on colloidal particles is due to
 - (A) Presence of electrolyte
 - (B) Very small size of particles
 - (C) Adsorption of ions from the solution
 - (D) None of these

Exercise # 2

SINGLE OBJECTIVE

AIIMS LEVEL

1. Following is the variation of physical adsorption with temperature:
- (A)  (B) 
- (C)  (D) 
2. Adsorption is the phenomenon in which a substance:
- (A) accumulates on the surface of the other substance
(B) goes into the body of the other substances
(C) remains close to the other substance
(D) none of these
3. Finely divided catalyst has greater surface area and has greater catalytic activity than the compact solid. If a total surface area of 6291456 cm^2 is required for adsorption in a catalysed gaseous reaction, then how many splits should be made to a cube of exactly 1 cm in length to achieve required surface area. (Given : One split of a cube gives eight cubes of same size)
- (A) 60 (B) 80
(C) 20 (D) 22
4. Which of the following statements about chemisorption is not applicable?
- (A) It involves chemical forces between adsorbent and adsorbate
(B) It is irreversible in nature
(C) It involves high heat of adsorption
(D) It does not require activation energy
5. Volume of N_2 at NTP required to form a mono layer on the surface of iron catalyst is 8.15 ml/gram of the adsorbent. What will be the surface area of the adsorbent per gm if each nitrogen molecule occupies $16 \times 10^{-22} \text{ m}^2$.
- (A) $16 \times 10^{-16} \text{ cm}^2$ (B) $0.35 \text{ m}^2/\text{g}$
(C) $39 \text{ m}^2/\text{g}$ (D) 22400 cm^2
6. There is desorption of physical adsorption when:
- (A) temperature is increased
(B) temperature is decreased
(C) pressure is increased
(D) concentration is increased
7. Softening of hard water is done using sodium aluminium silicate (zeolite). The causes :
- (A) adsorption of Ca^{2+} and Mg^{2+} ions of hard water replacing Na^+ ions.
(B) adsorption of Ca^{2+} and Mg^{2+} ions of hard water replacing Al^{3+} ions
(C) both (A) and (B)
(D) none of these
8. The rate of chemisorption :
- (A) decreases with increase of pressure
(B) increases with increase of pressure
(C) is independent of pressure
(D) is independent of temperature
9. Which one is false in the following statement ?
- (A) A catalyst is specific in its action
(B) A very small amount of the catalyst alters the rate of a reaction
(C) The number of free vacancies on the surface of the catalyst increases on sub-division
(D) Ni is used as a catalyst in the manufacture of ammonia
10. A catalyst increases rate of reaction by :
- (A) Decreasing enthalpy
(B) Decreasing internal energy
(C) Decreasing activation energy
(D) Increasing activation energy
11. Colloidal solution of gold prepared by different methods of different colours because of :
- (A) different diameters of colloidal gold particles
(B) variable valency of gold
(C) different concentration of gold particles
(D) impurities produced by different methods
12. Peptisation is :
- (A) conversion of a colloidal into precipitate form
(B) conversion of precipitate into colloidal sol
(C) conversion of metal into colloidal sol by passage of electric current
(D) conversion of colloidal sol into macromolecules

Exercise # 3

PART - 1

MATRIX MATCH COLUMN

1. Match list I with list II and select the correct answer :

List I

- (A) Coagulation
- (B) Dialysis
- (C) Peptization
- (D) Tyndall effect

List II

- (p) Scattering of light
- (q) Formation of colloidal solution from precipitates.
- (r) Purification of colloids
- (s) Accumulation of colloidal sols

2. Match list I with list II and select the correct answer :

List I

- (A) Mechanical property of colloid
- (B) Purification
- (C) Gold number
- (D) Formation of a sol

List II

- (p) Dialysis
- (q) Peptization
- (r) Brownian movement
- (s) Protection

3. **Column (I)**

- (A) Gold sol
- (B) Purification of colloidal solution
- (C) As_2S_3 sol
- (D) Zeta potential
- (E) Casein

Column (II)

- (p) Bredig's Arc method
- (q) Negatively charged
- (r) Ultra centrifugation
- (s) Electro kinetic potential
- (t) Double decomposition reaction
- (u) Protective colloid

4. **Column (I)**

- (A) Tyndall effect
- (B) Brownian movement
- (C) Electrophoresis
- (D) Hardy schulze rule
- (E) Froth floatation

Column (II)

- (p) Zig-zag motion
- (q) Sky is blue
- (r) Coagulation of colloids
- (s) Charge on colloidal solution
- (t) Emulsion of pine oil
- (u) Gold number

5. Match the entries Listed in Column I with appropriate entries listed in Column II.

Column (I)

- (A) Silicic acid
- (B) Arsenic sulphide
- (C) Gum arabic
- (D) Gold

Column (II)

- (p) Forms negatively charged sol
- (q) Forms macromolecular colloid
- (r) Forms lyophobic sol
- (s) Forms a non-elastic gel

6. Match the entries Listed in Column I with appropriate entries Listed in Column II.

Column (I)

- (A) Lyophilic colloids
- (B) Lyophobic colloids
- (C) Macromolecular colloids
- (D) Associated colloids

Column (II)

- (p) Scatter light
- (q) Irreversible in nature
- (r) Can act as protective colloids
- (s) Can act as emulsifiers

Exercise # 4

PART - 1

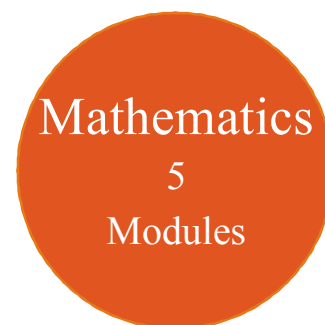
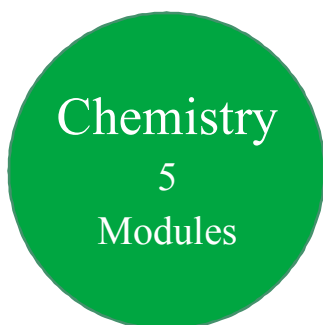
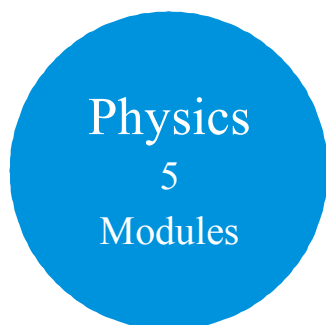
PREVIOUS YEAR (NEET/AIPMT)

- The method usually employed for the precipitation of a colloidal solution is [CBSE ALPMT 2000]
 - Dialysis
 - Addition of electrolytes
 - Adsorption is more for some specific substance
 - Condensation
- Which is not correct regarding the adsorption of a gas on surface of solid? [CBSE ALPMT 2001]
 - On increasing temperature adsorption increases continuously
 - Enthalpy and entropy change is negative
 - Adsorption is more for some specific substance
 - Reversible
- Position of non-polar and polar parts in micelle is [CBSE ALPMT 2002]
 - Polar at outer surface but non-polar at inner surface
 - Polar at inner surface but non-polar at outer surface
 - Distributed all over the surface
 - Present in the surface only
- According to the adsorption theory of catalysis, the speed of the reaction increases because [CBSE ALPMT 2003]
 - Adsorption produces heat which increases the speed of the reaction
 - Adsorption lowers the activation energy of the reaction
 - The concentration of reactant molecules at the active centres of the catalyst becomes high due to adsorption
 - In the process of adsorption, the activation energy of the molecules becomes large
- Which of the following forms cationic micelles above certain concentration? [CBSE ALPMT 2004]
 - Sodium ethyl sulphate
 - Sodium acetate
 - Urea
 - Cetyl trimethyl ammonium bromide
- Which one of the following forms micelles in aqueous solution above certain concentration? [CBSE ALPMT 2005]
 - Urea
 - Dodecyl trimethyl ammonium chloride
 - Pyridinium chloride
 - Glucose
- For adsorption of a gas on a solid, the plot of $\log \frac{x}{m}$ vs $\log p$ is linear with slope equal to (n being a whole number) [CBSE ALPMT 2006]
 - k
 - $\log k$
 - n
 - $\frac{1}{n}$
- The Langmuir adsorption isotherm is deduced by using the assumption that [CBSE ALPMT 2007]
 - the adsorption takes place in multilayers
 - the adsorption sites are equivalent in their ability to adsorb the particles
 - the heat of adsorption varies with coverage
 - the adsorbed molecules interact with each other
- If x is amount of adsorbate and m is amount of adsorbent, which of the following relations is not related to adsorption process? [CBSE ALPMT 2011]
 - $\frac{x}{m} = f(T)$ at constant P
 - $p = f(T)$ at constant $\left(\frac{x}{m}\right)$
 - $\frac{x}{m} = p \times T$
 - $\frac{x}{m} = f(p)$ at constant T
- The protecting power of lyophilic colloidal sol is expressed in terms of [CBSE ALPMT 2012]
 - Coagulation value
 - Gold number
 - Critical micelle concentration
 - Oxidation number

STRAIGHT OBJECTIVE TYPE

- According to the adsorption theory of catalysis, the speed of the reaction increases because
 - Adsorption lowers the activation energy of the reaction
 - The concentration of reactant molecules at the active centres of the catalyst becomes high due to adsorption
 - In the process of adsorption, the activation energy of the molecules becomes large
 - Adsorption produces heat which increases the speed of the reaction
- In Freundlich adsorption, isotherm adsorption is proportional to pressure P as
 - P^0
 - P
 - P^n
 - $P^{1/n}$
- Which one of the following characteristics is not correct for physical adsorption
 - Adsorption on solids is reversible
 - Adsorption increases with increase in temperature
 - Adsorption is spontaneous
 - Both enthalpy and entropy of adsorption are negative
- Which of the following is not a characteristic of chemisorption
 - ΔH is of the order of 400 kJ
 - Adsorption is irreversible
 - Adsorption may be multimolecular layer
 - Adsorption is specific
- The viscosity of the solvent depends on
 - Isothermic nature
 - Solute - solute interaction
 - Solute - solvent interaction
 - Density of the liquid
- The transition metal used as a catalyst is
 - Nickel
 - Platinum
 - Cobalt
 - All of these
- Which of the following is true about catalyst
 - It initiates reaction
 - It changes equilibrium point
 - It increase average kinetic energy
 - It accelerates the rate of reaction
- Which of the following types of metals form the most efficient catalysts
 - Alkali metals
 - Alkaline earth metals
 - Transition metals
 - All of these
- Formation of ammonia from H_2 and N_2 by Haber's process using Fe is an example of
 - Heterogeneous catalysis
 - Homogeneous catalysis
 - Enzyme catalysis
 - Non-catalytic process
- Paste is
 - Suspension of solid in a liquid
 - Mechanical dispersion of a solid in liquid
 - Colloidal solution of a solid in solid
 - None of these
- A precipitate is changed to colloidal solution by the following process
 - Dialysis
 - Ultrafiltration
 - Peptization
 - Electrophoresis
- An aerosol is a
 - Dispersion of a solid or liquid in a gas
 - Dispersion of a solid in a liquid
 - Dispersion of a liquid in a liquid
 - Solid solution
- Lyophilic sols are
 - Irreversible sols
 - They are prepared from inorganic compound
 - Coagulated by adding electrolytes
 - Self stabilizing
- The volume of a colloidal particle, V_c as compared to the volume of a solute particle in a true solution V_s could be
 - $\frac{V_c}{V_s} \approx 1$
 - $\frac{V_c}{V_s} \approx 10^{23}$
 - $\frac{V_c}{V_s} \approx 10^{-3}$
 - $\frac{V_c}{V_s} \approx 10^3$
- The disperse phase in colloidal iron (III) hydroxide and colloidal gold is positively and negatively charged, respectively. Which of the following statements is NOT correct
 - Magnesium chloride solution coagulates, the gold sol more readily than the iron (III) hydroxide sol
 - Sodium sulphate solution causes coagulation in both sols
 - Mixing the sols has no effect
 - Coagulation in both sols can be brought about by electrophoresis

11th Class Modules Chapter Details



PHYSICS	CHEMISTRY	BIOLOGY
<p>Module-1</p> <ol style="list-style-type: none"> 1. Physical World & Measurements 2. Basic Maths & Vector 3. Kinematics <p>Module-2</p> <ol style="list-style-type: none"> 1. Law of Motion & Friction 2. Work, Energy & Power <p>Module-3</p> <ol style="list-style-type: none"> 1. Motion of system of particles & Rigid Body 2. Gravitation <p>Module-4</p> <ol style="list-style-type: none"> 1. Mechanical Properties of Matter 2. Thermal Properties of Matter <p>Module-5</p> <ol style="list-style-type: none"> 1. Oscillations 2. Waves 	<p>Module-1(PC)</p> <ol style="list-style-type: none"> 1. Some Basic Concepts of Chemistry 2. Atomic Structure 3. Chemical Equilibrium 4. Ionic Equilibrium <p>Module-2(PC)</p> <ol style="list-style-type: none"> 1. Thermodynamics & Thermochemistry 2. Redox Reaction 3. States Of Matter (Gaseous & Liquid) <p>Module-3(IC)</p> <ol style="list-style-type: none"> 1. Periodic Table 2. Chemical Bonding 3. Hydrogen & Its Compounds 4. S-Block <p>Module-4(OC)</p> <ol style="list-style-type: none"> 1. Nomenclature of Organic Compounds 2. Isomerism 3. General Organic Chemistry <p>Module-5(OC)</p> <ol style="list-style-type: none"> 1. Reaction Mechanism 2. Hydrocarbon 3. Aromatic Hydrocarbon 4. Environmental Chemistry & Analysis Of Organic Compounds 	<p>Module-1</p> <ol style="list-style-type: none"> 1. Diversity in the Living World 2. Plant Kingdom 3. Animal Kingdom <p>Module-2</p> <ol style="list-style-type: none"> 1. Morphology in Flowering Plants 2. Anatomy of Flowering Plants 3. Structural Organization in Animals <p>Module-3</p> <ol style="list-style-type: none"> 1. Cell: The Unit of Life 2. Biomolecules 3. Cell Cycle & Cell Division 4. Transport in Plants 5. Mineral Nutrition <p>Module-4</p> <ol style="list-style-type: none"> 1. Photosynthesis in Higher Plants 2. Respiration in Plants 3. Plant Growth and Development 4. Digestion & Absorption 5. Breathing & Exchange of Gases <p>Module-5</p> <ol style="list-style-type: none"> 1. Body Fluids & Its Circulation 2. Excretory Products & Their Elimination 3. Locomotion & Its Movement 4. Neural Control & Coordination 5. Chemical Coordination and Integration

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5
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5
Modules

PHYSICS	CHEMISTRY	BIOLOGY
<p>Module-1</p> <ol style="list-style-type: none"> 1. Electrostatics 2. Capacitance <p>Module-2</p> <ol style="list-style-type: none"> 1. Current Electricity 2. Magnetic Effect of Current and Magnetism <p>Module-3</p> <ol style="list-style-type: none"> 1. Electromagnetic Induction 2. Alternating Current <p>Module-4</p> <ol style="list-style-type: none"> 1. Geometrical Optics 2. Wave Optics <p>Module-5</p> <ol style="list-style-type: none"> 1. Modern Physics 2. Nuclear Physics 3. Solids & Semiconductor Devices 4. Electromagnetic Waves 	<p>Module-1(PC)</p> <ol style="list-style-type: none"> 1. Solid State 2. Chemical Kinetics 3. Solutions and Colligative Properties <p>Module-2(PC)</p> <ol style="list-style-type: none"> 1. Electrochemistry 2. Surface Chemistry <p>Module-3(IC)</p> <ol style="list-style-type: none"> 1. P-Block Elements 2. Transition Elements (d & f block) 3. Co-ordination Compound 4. Metallurgy <p>Module-4(OC)</p> <ol style="list-style-type: none"> 1. HaloAlkanes & HaloArenes 2. Alcohol, Phenol & Ether 3. Aldehyde, Ketone & Carboxylic Acid <p>Module-5(OC)</p> <ol style="list-style-type: none"> 1. Nitrogen & Its Derivatives 2. Biomolecules & Polymers 3. Chemistry in Everyday Life 	<p>Module-1</p> <ol style="list-style-type: none"> 1. Reproduction in Organisms 2. Sexual Reproduction in Flowering Plants 3. Human Reproduction 4. Reproductive Health <p>Module-2</p> <ol style="list-style-type: none"> 1. Principles of Inheritance and Variation 2. Molecular Basis of Inheritance 3. Evolution <p>Module-3</p> <ol style="list-style-type: none"> 1. Human Health and Disease 2. Strategies for Enhancement in Food Production 3. Microbes in Human Welfare <p>Module-4</p> <ol style="list-style-type: none"> 1. Biotechnology: Principles and Processes 2. Biotechnology and Its Applications 3. Organisms and Populations <p>Module-5</p> <ol style="list-style-type: none"> 1. Ecosystem 2. Biodiversity and Conservation 3. Environmental Issues

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