#### Objective Questions I (Only one correct option)

- Among the following, the incorrect statement about colloids is (2019 Main, 12 April II)
  - (a) They can scatter light
  - (b) They are larger than small molecules and have high molar mass
  - (c) The osmotic pressure of a colloidal solution is of higher order than the true solution at the same concentration
  - (d) The range of diameters of colloidal particles is between 1 and 1000 nm
- 2. Peptisation is a (2019 Main, 12 April I)
  - (a) process of bringing colloidal molecule into solution
  - (b) process of converting precipitate into colloidal solution
  - (c) process of converting a colloidal solution into precipitate
  - (d) process of converting soluble particles to form colloidal solution
- **3.** The correct option among the following is

#### (2019 Main, 10 April II)

- (a) colloidal medicines are more effective, because they have small surface area.
- (b) brownian motion in colloidal solution is faster if the viscosity of the solution is very high.
- (c) addition of alum to water makes it unfit for drinking.
- (d) colloidal particles in lyophobic sols can be precipitated by electrophoresis.
- **4.** A gas undergoes physical adsorption on a surface and follows the given Freundlich adsorption isotherm equation  $\frac{x}{2} K p^{0.5}$

Adsorption of the gas increases with (2019 Main, 10 April I)

- (a) increase in p and increase in T
- (b) increase in p and decrease in T
- (c) decrease in p and decrease in T
- (d) decrease in p and increase in T
- Match the catalysts Column I with products Column II. (2019 Main, 9 April I)

	Column I (Catalyst)		Column II (Product)
(A)	V <sub>2</sub> O <sub>5</sub>	(i)	Polyethlyene
(B)	TiCl <sub>4</sub> / Al(Me) <sub>3</sub>	(ii)	Ethanal
(C)	PbCl <sub>2</sub>	(iii)	H <sub>2</sub> SO <sub>4</sub>
(D)	Iron oxide	(iv)	NH <sub>3</sub>

- (a) (A)-(ii), (B)-(iii), (C)-(i), (D)-(iv)
- (b) (A)-(iv), (B)-(iii), (C)-(ii), (D)-(i)
- (c) (A)-(iii), (B)-(i), (C)-(ii), (D)-(iv)
- (d) (A)-(iii), (B)-(iv), (C)-(i), (D)-(ii)
- 6. The number of water molecule(s) not coordinated to copper ion directly in CuSO<sub>4</sub> 5H<sub>2</sub>O, is (2019 Main, 9 April I) (a) 2 (b) 3 (c) 1 (d) 4
- 7. The aerosol is a kind of colloid in which (2019 Main, 9 April I)
  (a) gas is dispersed in liquid
  (b) gas is dispersed in solid
  (c) liquid is dispersed in water
  (d) solid is dispersed in gas
- **8.** Adsorption of a gas follows Freundlich adsorption isotherm. *x* is the mass of the gas adsorbed on mass *m* of the adsorbent.

The plot of  $\log \frac{x}{m}$  versus  $\log p$  is shown in the given graph.  $\frac{x}{m}$ 

is proportional to

(2019 Main, 8 April I)



- **9.** Among the following, the false statement is
  - (2019 Main, 12 Jan II)
  - (a) Tyndall effect can be used to distinguish between a colloidal solution and a true solution
  - (b) It is possible to cause artificial rain by throwing electrified sand carrying charge opposite to the one on clouds from an aeroplane
  - (c) Lyophilic sol can be coagulated by adding an electrolyte
  - (d) Latex is a colloidal solution of rubber particles which are positively charged

**10.** Given, Gas :  $H_2$ ,  $CH_4$ ,  $CO_2$ ,  $SO_2$ 

Critical temperature/K 33 190 304 630 On the basis of data given above, predict which of the following gases shows least adsorption on a definite amount of charcoal? (2019 Main, 12 Jan I) (a)  $CH_4$  (b)  $SO_2$  (c)  $CO_2$  (d)  $H_2$ 

- **11.** Among the colloids cheese (*C*), milk (*M*) and smoke (*S*), the correct combination of the dispersed phase and dispersion medium, respectively is (2019 Main, 11 Jan II) (a) *C* : liquid in solid; *M* : liquid in liquid; *S* : solid in gas (b) C: solid in liquid; M: liquid in liquid; S: gas in solid (c) C: liquid in solid; M: liquid in solid; S: solid in gas (d) C: solid in liquid; M: solid in liquid; S: solid in gas **12.** An example of solid sol is (2019 Main, 11 Jan I) (a) gem stones (b) hair cream (c) butter (d) paint 13. Haemoglobin and gold sol are examples of (2019 Main, 10 Jan II)
  - (a) negatively and positively charged sols, respectively
  - (b) negatively charged sols
  - (c) positively charged sols
  - (d) positively and negatively charged sols, respectively
- **14.** Which of the following is not an example of heterogeneous catalytic reaction? (2019 Main, 10 Jan I)
  - (a) Haber's process
  - (b) Combustion of coal
  - (c) Hydrogenation of vegetable oils
  - (d) Ostwald's process
- 15. The correct match between item-I and Item-II is

(2019 Main, 9 Jan II)

Р.	Dynamic phase
Q.	Adsorbent
R.	Adsorbate
(Q); (C)	(P)
(R); (C)	(Q)
(P); (C)	(R)
(R); (C)	(P)
	P. Q. R. (Q); (C) (R); (C) (P); (C) (R); (C)

- **16.** Which of the salt-solution is most effective for coagulation of arsenious sulphide? (2019 Main, 9 Jan II) (a) BaCl<sub>2</sub> (b) AlCl<sub>3</sub> (c) Na<sub>3</sub>PO<sub>4</sub> (d) NaCl
- **17.** Adsorption of a gas follows Freundlich adsorption isotherm. In the given plot, x is the mass of the gas adsorbed on mass m

of the adsorbent at pressure  $p \frac{x}{m}$  is proportional to

(2019 Main, 9 Jan I)



- **18.** The Tyndall effect is observed only when following conditions are satisfied (2017 Main)
  - 1. The diameter of the dispersed particles is much smaller than the wavelength of the light used.

- 2. The diameter of the dispersed particle is not much smaller than the wavelength of the light used.
- 3. The refractive indices of the dispersed phase and dispersion medium are almost similar in magnitude.
- 4. The refractive indices of the dispersed phase and dispersion medium differ greatly in magnitude.
- (a) 1 and 4 (b) 2 and 4 (c) 1 and 3 (d) 2 and 3
- **19.** For a linear plot of  $\log (x/m)$  versus  $\log p$  in a Freundlich adsorption isotherm, which of the following statements is correct? (*k* and *n* are constants) (2016 Main)
  - (a) 1/n appears as the intercept

(b) Only 1/n appears as the slope

(c) log  $\frac{1}{n}$  appears as the intercept

(d) Both k and 1/n appear in the slope term

- 20. Methylene blue, from its aqueous solution, is adsorbed on activated charcoal at 25°C. For this process, the correct statement is (2013 Adv.)
  - (a) the adsorption requires activation at 25°C
  - (b) the adsorption is accompanied by a decreases in enthalpy
  - (c) the adsorption increases with increase of temperature
  - (d) the adsorption is irreversible
- **21.** The coagulating power of electrolytes having ions  $Na^+$ ,  $Al^3$ and Ba<sup>2+</sup> for arsenic sulphide sol increases in the order

			1			(2013 Main)
(a) Al <sup>3+</sup>	$\mathrm{Ba}^2$	$Na^+$		(b) Na <sup>+</sup>	$\mathrm{Ba}^{2+}$	Al <sup>3+</sup>
(c) $Ba^{2+}$	Na <sup>2+</sup>	$Al^{3+}$		(d) Al <sup>3+</sup>	$Na^+$	Ba <sup>2+</sup>

- **22.** Among the electrolytes  $Na_2SO_4$ ,  $CaCl_2$ ,  $Al_2(SO_4)_3$  and  $NH_4Cl$ , the most effective coagulating agent for  $Sb_2S_3$  sol is (2009, 1M) (a) Na<sub>2</sub>SO<sub>4</sub> (b) CaCl<sub>2</sub>
  - (d) NH<sub>4</sub>Cl (c)  $Al_2(SO_4)_3$
- **23.** Among the following, the surfactant that will form micelles in aqueous solution at the lowest molar concentration at ambient conditions, is (2008, 3M) (a)  $CH_3(CH_2)_{15}N^+(CH_3)_3Br$ (b)  $CH_3(CH_2)_{11}OSO_3Na^4$ (c) CH<sub>3</sub>(CH<sub>2</sub>)<sub>6</sub>COO Na<sup>+</sup> (d)  $CH_3(CH_2)_{11}N^+(CH_3)_3Br$

(2005, 1M)

(a) irreversible sols (b) prepared from inorganic compounds (c) coagulated by adding electrolytes (d) self-stabilising

**24.** Lyophilic sols are

- 25. Spontaneous adsorption of a gas on solid surface is an exothermic process, because (2004, 1M) (a) *H* increases for system (b) S increases for gas
  - (c) S decreases for gas (d) G increases for gas
- **26.** Rate of physisorption increases with (2003, 1M) (a) decrease in temperature (b) increase in temperature (d) decrease in surface area (c) decrease in pressure
- **27.** When the temperature is increased, surface tension of water (2002, 1M)

(a) increases	(b) decreases
(c) remains constant	(d) shows irregular behaviour

#### **Objective Questions II**

#### (One or more than one correct option)

- **28.** The correct statement(s) about surface properties is(are)
  - (a) The critical temperatures of ethane and nitrogen are 563 K and 126 K, respectively. The adsorption of ethane will be more than that of nitrogen of same amount of activated charcoal at a given temperature

(2017 Adv.)

- (b) Cloud is an emulsion type of colloid in which liquid is dispersed phase and gas is dispersion medium
- (c) Adsorption is accompanied by decrease in enthalpy and decrease in entropy of the system
- (d) Brownian motion of colloidal particles does not depend on the size of the particles but depends on viscosity of the solution
- When O<sub>2</sub> is adsorbed on a metallic surface, electron transfer occurs from the metal to O<sub>2</sub>. The true statement(s) regarding this adsorption is (are) (2015 Adv.)
  - (a)  $O_2$  is physisorbed
  - (b) heat is released
  - (c) occupancy of 2p of  $O_2$  is increased
  - (d) bond length of  $O_2$  is increased
- 30. The given graph/data I, II, III and IV represent general trends observed for different physisorption and chemisorption processes under mild conditions of temperature and pressure. Which of the following choice(s) about I, II, III and IV is (are) correct? (2012)



- (a) I is physisorption and II is chemisorption
- (b) I is physisorption and III is chemisorption
- (c) IV is chemisorption and II is chemisorption
- (d) IV is chemisorption and III is chemisorption
- **31.** Choose the correct reason(s) for the stability of the lyophobic colloidal particles. (2012)
  - (a) Preferential adsorption of ions on their surface from the solution
  - (b) Preferential adsorption of solvent on their surface from the solution
  - (c) Attraction between different particles having opposite charges on their surface
  - (d) Potential difference between the fixed layer and the diffused layer of opposite charges around the colloidal particles
- **32.** The correct statement(s) pertaining to the adsorption of a gas on a solid surface is (are) (2011)
  - (a) Adsorption is always exothermic
  - (b) Physisorption may transform into chemisorption at high temperature
  - (c) Physisorption increases with increasing temperature but chemisorption decreases with increasing temperature
  - (d) Chemisorption is more exothermic than physisorption, however it is very slow due to higher energy of activation

#### Assertion and Reason

Read the following questions and answer as per the direction given below:

- (a) Statement I is true; Statement II is true; Statement II is a correct explanation of Statement I.
- (b) Statement I is true; Statement II is true; Statement II is not the correct explanation of Statement I.
- (c) Statement I is true; Statement II is false.
- (d) Statement I is false; Statement II is true.
- **33. Statement I** Micelles are formed by surfactant molecules above the critical micelle concentration (CMC).

**Statement II** The conductivity of a solution having surfactant molecules decreases sharply at the CMC(2007)

### Answers

<b>1.</b> (c)	<b>2.</b> (b)	<b>3.</b> (d)	<b>4.</b> (b)	21.
<b>5.</b> (c)	<b>6.</b> (c)	7. (d)	<b>8.</b> (a)	25.
<b>9.</b> (d)	<b>10.</b> (d)	<b>11.</b> (a)	<b>12.</b> (a)	29.
<b>13.</b> (d)	<b>14.</b> (b)	<b>15.</b> (a)	<b>16.</b> (b)	33.
<b>17.</b> (c)	<b>18.</b> (b)	<b>19.</b> (b)	<b>20.</b> (b)	

. (b)	<b>22.</b> (c)	<b>23.</b> (a)	<b>24.</b> (d)
. (c)	<b>26.</b> (a)	<b>27.</b> (b)	<b>28.</b> (a, c)
(b, c, d)	<b>30.</b> (a, c)	<b>31.</b> (a, d)	<b>32.</b> (a, b, d)
. (b)			

# **Hints & Solutions**

- **1.** Statement (c) is incorrect about colloids. Colligative properties such as relative lowering of vapour pressure, elevation in boiling point, depression in freezing point and osmotic pressure of a colloidal solution is of low order than the true solution at the same concentration.
- **2.** Peptisation is a process of converting precipitate into colloidal solution. This process involves the shaking of precipitate with the dispersion medium in the presence of small amount of electrolyte. The electrolyte added is called **peptising agent**.

During peptisation, the precipitate adsorbs one of the ions of the electrolyte on its surface. This causes the development of positive or negative charge on precipitates, which ultimately breakup into smaller particles of the size of a colloid.

- 3. The explanation of the given statements are as follows :
  - (a) Colloidal medicines are more effective because they (dispersed phase) have larger surface area.

Thus, option (a) is incorrect.

- (b) Brownian motion of dispersed phase particles in colloidal solution is faster if the viscosity of the solution is very low. Thus, option (b) is incorrect.
- (c) Addition of alum(K<sub>2</sub>SO<sub>4</sub> Al<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub> 24H<sub>2</sub>O), an electrolyte to water makes it fit for drinking purposes because alum coagulates mud particles from water. Thus, option (c) is incorrect.
- (d) Precipitation of lyophobic solution particles by electrophoresis is called cottrell precipitation. Thus, option (d) is correct.
- 4. For physisorption or physical adsorption,

Adsorption isotherm (Temperature, T constant) is shown below:



where, x amount of adsorbate, m amount of adsorbent,

$$\frac{x}{m} \quad \text{degree of adsorption}$$

$$\frac{1}{n} \quad \text{order of the reaction, where, } 0 \quad \frac{1}{n} \quad 1 \text{ and so,}$$

$$1 \quad n$$
Here, 
$$\frac{x}{m} \quad Kp^{\frac{1}{2}},$$

 $\frac{x}{m}$   $p^{\frac{1}{2}}$ 

i.e.

Adsorption isobar (Pressure, p = constant)



So, the rate of physical adsorption of the gas, increases with p (when, T is constant) and decreases with T (when p is constant).

- **5.** Correct match is
  - (A) (iii); (B) (i); (C) (ii); (D) (iv)
  - (i) TiCl<sub>4</sub> AlCl<sub>3</sub> (*Ziegler- Natta* catalyst) is used to prepare polyethylene from ethene.

$$n \operatorname{CH}_2 \longrightarrow \operatorname{CH}_2 \xrightarrow{Zieglar-Natta} (\operatorname{CH}_2 \longrightarrow \operatorname{CH}_2)_n$$
Ethene Polyethylene

(ii)  $V_2O_5$  (Vanadium pentoxide) is used as catalyst to prepare  $H_2SO_4$  from contact process. Reaction involved is

$$2SO_2(g) O_2(g) \overset{V_2O_5}{=} 2SO_3(g)$$

It is the key step in the manufacture of  $H_2SO_4$ .

(iii) Fe (Iron) is used as catalyst in Haber's process for the manufacture of ammonia.

$$N_2(g) = 3H_2(g) = Fe(s) = 2NH_3(g)$$

(iv) Pd (Palladium) is used to prepare ethanal. Reaction involved is

$$H_2C = CH_2 + O_2 \xrightarrow{PdCl_2/CuCl_2} CH_3CHO$$

This reaction is also known as Wacker's process.

6. In  $CuSO_4$  5H<sub>2</sub>O, one molecule of water is indirectly connected to Cu. In this molecule, four water molecules form coordinate bond with Cu<sup>2</sup> ion while one water molecule is associated with H-bond with  $SO_4^2$ .

Structure of CuSO<sub>4</sub> 5H<sub>2</sub>O



 $[Cu(H_2O)_4]SO_4$  H<sub>2</sub>O

**7.** The aerosol is a kind of colloid in which solid is dispersed in gas. e.g. smoke, dust.

8.

Key Idea According to Freundlich,

 $\frac{x}{m} \quad Kp^{1/n} [n \quad 1]$ where, *m* mass of adsorbent, *x* mass of the gas adsorbed,  $\frac{x}{m}$  amount of gas adsorbed per unit mass of

solid adsorbent, p pressure, K and n constants.

The logarithm equation of Freundlich adsorption isotherm is

$$\log \frac{x}{m} - \log K - \frac{1}{n} \log p$$

On comparing the above equation with straight line equation, (y mx c)

we get

÷

m slope 
$$\frac{1}{n}$$
 and  $c \log K$   
From the given plot,  
$$m \quad \frac{y_2 \quad y_1}{x_2 \quad x_1} \quad \frac{1}{n} \quad \frac{2}{3}$$
$$\frac{x}{x_1} \quad Kp^{2/3}$$

9. Statement given as statement (d) is incorrect. Latex is a stable dispersion, i.e. emulsion of polymer microparticles in an aqueous medium.

m

These microparticles belong to rubber and are negatively charged in nature. Natural latex contains some amount of sugar, resin, protein and ash as well.

The closest synthetic latex that can be associated with the properties of natural latex is SBR, i.e. Styro Butane Rubber.

Rest of all the statements are correct.

10. Same adsorbant (charcoal in this case) at same temperature will adsorb different gases to different extent. The extent to which gases are adsorbed is proportional to the critical temperature of gas.

$$T_c = \frac{8a}{27Rb}$$

where, a is the magnitude of intermolecular forces between gaseous molecules.

Thus, higher the cirtical temperature more is the gas adsorbed. Among the given gases, H<sub>2</sub> has the minimum critical temperature, i.e. 33K thus, it shows least adsorption on a definite amount of charcoal.

11.	Dispersed phase	Dispersion medium	Type of colloid	Examples
	Liquid	Solid	Gel	Cheese (C), butter, jellies
	Liquid	Liquid	Emulsion	Milk (M), hair cream
	Solid	Gas	Aerosol	Smoke (S), dust

Thus, C: liquid in solid, M: liquid in liquid and S: solid in gas.

12. Solid sol consists of solid as both dispersed phase and dispersion medium. In gemstones, metal crystals (salt and oxides of metals) are dispersed in solid (stone) medium. Hair cream is an emulsion (liquid in liquid). Butter is a colloidal solution of liquid in solid. Paint is also sol (solid in liquid).

13. Haemoglobin and gold sol both are colloids and always carry an electric charge. Haemoglobin is a positively charged sol, because in haemoglobin,  $Fe^2$  ion is the central metal ion of the octahedral complex.

All metal sols like, Au-sol, Ag-sol etc; are negatively charged sols.

14. In heterogeneous catalytic reactions, physical state of reactants and that of catalyst(s) used are different.

Haber's process, hydrogenation of vegetable oils and Ostwald's process all are heterogeneous process. Combustion of coal is not a heterogeneous catalytic reaction.

• In Haber's process

$$N_2(g) = 3H_2(g) \xrightarrow{Fe(s), Mo(s)} 2NH_3(g)$$

· Hydrogenation of vegetable oils,

Vegetable oil(
$$l$$
)[(Ph<sub>3</sub> P)<sub>3</sub> Rh] Cl  
or Ni ( $s$ )Vanaspati( $s$ )

· Ostwald's process,

$$4\mathrm{NH}_3(g) \quad 5\mathrm{O}_2(g) \quad \frac{\mathrm{Pt}(s)}{\mathrm{V}_2\mathrm{O}_5(s)} \quad 4\mathrm{NO}(g) \quad 6\mathrm{H}_2\mathrm{O}(g)$$

• No catalyst is used in combustion of coal. The reaction is highly spontaneous in nature.

$$\begin{array}{cc} C & O_2 & CO_2 \\ Coal) \end{array}$$

- 15. Using the principle of adsorption chromatography, qualitative and quantitative analysis of benzaldehyde can be done from its mixture with acetonitrile. Here, a mobile phase moves over a stationary phase (adsorbent). Adsorbents used are alumina  $(Al_2O_3)$  and silica gel. The sample solution of benzaldehyde and acetonitrile when comes in contact with the adsorbent, benzaldehyde gets adsorbed on the surface of the adsorbent. So, benzaldehyde acts as absorbate whereas acetonitrile starts moving as mobile phase over the stationary phase of the adsorbate. Hence, act as dynamic phase.
- **16.** Arsenious sulphide sol is a negative colloid,  $As_2S_3$ .( $S^2$ ). So, it will be coagulated by the cation of an electrolyte. According to the Hardy-Schulze rule, the higher the charge of the ion, the more effective it is in bringing about coagulation. Here, the cations available are  $Al^3$  (from AlCl<sub>3</sub>),  $Ba^2$  (from BaCl<sub>2</sub>) and Na (from Na<sub>3</sub>PO<sub>4</sub> and NaCl). So, their power to coagulate  $As_2S_3$ . (S<sup>2</sup>) will follow the order as

$$Al^{3+} > Ba^{2+} > Na^{+}$$

17. According to Freundlich adsorption isotherm,

$$\frac{x}{m}$$
  $p^{1/n}$   $\frac{x}{m}$   $Kp^{1/n}$ 

On taking log on both sides, we get

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

On comparing with equation of straight line, y mx c, plot of  $\log \frac{x}{m} vs \log p$  gives,

Slope 
$$\frac{(y_2 \ y_1)}{(x_2 \ x_1)} \frac{1}{n} \frac{2}{4} \frac{1}{2}$$
  
 $\frac{x}{m} p^{1/2}$ 

- **18.** Colloidal solutions show Tyndall effect due to scattering of light by colloidal particles in all directions in space. It is observed only under the following conditions.
  - (i) The diameter of the colloids should not be much smaller than the wavelength of light used.
  - (ii) The refractive indices of the dispersed phase and dispersion medium should differ greatly in magnitude.

**19.** According to Freundlich adsorption isotherm, 
$$\frac{x}{m} = kp^{1/4}$$

$$\log \frac{x}{m} \log k \log p^{1/n}$$
or  $\log \frac{x}{m} \log k \frac{1}{n} \log p$ 

$$y c mx$$

$$y \log \frac{x}{m},$$

$$c \text{ intercept } \log k$$

$$m \text{ slope } \frac{1}{n} \text{ and } x \log p$$

**20.** Physical adsorption takes place with decrease in enthalpy thus exothermic change. It is physical adsorption and does not require activation. Thus, (*a*) is incorrect.

Being physical adsorption H = 0 thus, (b) is correct. Exothermic reaction is favoured at low temperature thus (c) is incorrect. Physical adsorption is always reversible, thus (d) is incorrect.

- **21.** According to Hardy Schulze rule, greater the charge on oppositely charged ion, greater is its coagulating power. Since arsenic sulphide is a negatively charged sol, thus, the order of coagulating power is Na<sup>+</sup> Ba<sup>2+</sup> Al<sup>3+</sup>.
- **22.**  $Sb_2S_3$  is a negative (anionic) sol. According to Hardy Schulze rule, greater the valency of cationic coagulating agent, higher its coagulating power. Therefore,  $Al_2(SO_4)_3$  will be the most effective coagulating agent in the present case.
- **23.** Larger the hydrophobic fragment of surfactant, easier will be the micellisation, smaller the crticial micelle concentration. Therefore,  $CH_3(CH_2)_{15}N^+$  ( $CH_3$ )<sub>3</sub>Br will have the lowest crticial micelle concentration.
- **24.** Lyophilic sols are reversible, not easily coagulated because it is self-stabilising.
- 25. G H T S
  As gas is adsorbed on surface of solid, entropy decreases, i.e. S 0. Therefore, for G 0, H must be negative.
- **26.** It is an exothermic process, according to Le-Chatelier's principle, lowering temperature drive the process in forward direction.

- 27. As temperature increases surface tension of liquid decreases.
- **28.** (a) Higher the critical temperature, greater the extent of adsorption.
  - (c) P(s) Q(g) PQ(s)Adsorbent Adsorbate

As gaseous adsorbate is adsorbed on solid surface, entropy decreases, S = 0. Also formation of bond between P and Q results in release of energy, hence H = 0.

- **29.** Since, adsorption involves electron transfer from metal to  $O_2$ , it is chemical adsorption not physical adsorption, hence (*a*) is incorrect. Adsorption is spontaneous which involves some bonding between adsorbent and adsorbate, hence exothermic. The last occupied molecular orbital in  $O_2$  is \*2*p*. Hence, electron transfer from metal to oxygen will increase occupancy of \*2*p* molecular orbitals. Also increase in occupancy of \*2*p* orbitals will decrease bond order and hence increase bond length of  $O_2$ .
- 30. Graph-I represents physisorption as in physisorption, absorbents are bonded to adsorbate through weak van der Waals' force. Increasing temperature increases kinetic energy of adsorbed particles increasing the rate of desorption, hence amount of adsorption decreases.

**Graph-II** represents chemisorption as it is simple activation energy diagram of a chemical reaction.

Graph-III also represents physical adsorption as extent of adsorption increasing with pressure.

**Graph-IV** represents chemisorption as it represents the potential energy diagram for the formation of a typical covalent bond.

- **31.** Lyophobic sol, which is otherwise unstable, gets stabilised by preferential adsorption of ions on their surface, thus developing a potential difference between the fixed layer and the diffused layer. Thus, option (a) and (d) are correct.
- **32.** (a) In the process of adsorption, a bond is formed between adsorbate and adsorbent, hence always exothermic.
  - (b) Physisorption require very low activation energy while chemisorption require high activation energy. Therefore a physisorption may transform into chemisorption but only at high temperature.
  - (c) It is wrong statement as at higher temperature, physically adsorbed substance starts desorbing.
  - (d) In physical adsorption, van der Waals' force hold the adsorbate and adsorbent together which is a weak electrostatic attraction. In chemisorption, strong chemical bond binds the adsorbate to the adsorbent. Therefore, chemisorption is more exothermic than physical adsorption.
- **33.** Both statements are independently correct but Statement II does not explain Statement I. Critical micelle concentration is the minimum concentration of surfactant at which micelle formation commences first. At critical micelle concentration, several molecules of surfactant coalesce together to form one single micelle molecule. This decreases the apparent number of molecule suddenly lowering conductivity sharply.