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Surface Chemistry

TOPIC 1

Adsorption and Various Isotherms

01 The correct option representing a Freundlich adsorption isotherm is **[NEET (Odisha) 2019]**

(a) $\frac{x}{m} = kp^{0.3}$ (b) $\frac{x}{m} = kp^{2.5}$

(c) $\frac{x}{m} = kp^{-0.5}$ (d) $\frac{x}{m} = kp^{-1}$

Ans. *(a)*

According to Freundlich adsorption isotherm,

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

where, $\frac{x}{m}$ = amount of the gas adsorbed per unit mass of adsorbent

p = pressure k and n = constants.

The value of n lies in between 0 to 1.

Thus, $\frac{x}{m} = kp^{0.3}$ and option (a) is correct.

02 Which one of the following characteristics is associated with adsorption? **[NEET 2016, Phase I]**

(a) ΔG, ΔH and ΔS all are negative

(b) ΔG and ΔH are negative but ΔS is positive

(c) ΔG and ΔS are negative but ΔH is positive

(d) ΔG is negative but ΔH and ΔS are positive

Ans. *(a)*

Adsorption is a spontaneous process that occurs with release in energy and decrease in the randomness (i.e. entropy) of the adsorbed substance.

For a spontaneous process, ΔG must be negative.

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

As the process is exothermic and randomness of molecule (entropy) decreases hence, both ΔH and ΔS will be negative as well.

03 Which of the following statements is correct for the spontaneous adsorption of a gas? **[CBSE AIPMT 2014]**

(a) ΔS is negative and therefore, ΔH should be highly positive

(b) ΔS is negative and therefore, ΔH should be highly negative

(c) ΔS is positive and therefore, ΔH should be negative

(d) ΔS is positive and therefore, ΔH should also be highly positive

Ans. *(b)*

ΔS [change in entropy] and ΔH [change in enthalpy] are related by the equation

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

[Here, ΔG = change in Gibbs free energy]

For adsorption of a gas, ΔS is negative because randomness decreases. Thus, in order to make ΔG negative [for spontaneous reaction], ΔH must be highly negative because reaction is exothermic. Hence, for the adsorption of a gas, if ΔS is negative, therefore, ΔH should be highly negative.

04 In Freundlich adsorption isotherm, the value of $1/n$ is **[CBSE AIPMT 2012]**

(a) between 0 and 1 in all cases

(b) between 2 and 4 in all cases

(c) 1 in case of physical adsorption

(d) 1 in case of chemisorption

Ans. *(a)*

In Freundlich adsorption isotherm,

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

Where, x = amount of adsorbent

m = amount of adsorbate

The value of n is always greater than 1. So, the value of $1/n$ lies between 0 and 1 in all cases.

05 If x is amount of adsorbate and m is amount of adsorbent, which of the following relations is not related to adsorption process? **[CBSE AIPMT 2011]**

(a) $\frac{x}{m} = f(T)$ at constant p

(b) $p = f(T)$ at constant $\left(\frac{x}{m}\right)$

(c) $\frac{x}{m} = p \times T$

(d) $\frac{x}{m} = f(p)$ at constant T

Ans. *(c)*

$\frac{x}{m} = p \times T$ is the incorrect relation. The correct relation is amount of adsorption $\frac{x}{m} \propto \frac{p}{T}$

06 The Langmuir adsorption isotherm is deduced by using the assumption that **[CBSE AIPMT 2007]**

(a) the adsorption takes place in multilayers

(b) the adsorption sites are equivalent in their ability to adsorb the particles

(c) the heat of adsorption varies with coverage

(d) the adsorbed molecules interact with each other

Ans. *(b)*

The main points of Langmuir's theory of adsorption are as

(i) Adsorption takes place on the surface of the solid only till the whole of the surface is completely covered with a unimolecular layer of the adsorbed gas.

(ii) Adsorption consist of two opposing processes (a) condensation and (b) evaporation.

(iii) The rate of condensation depend upon the uncovered surface of the adsorbent available for condensation.

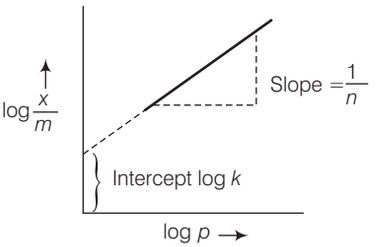
07 For adsorption of a gas on a solid, the plot of $\log \frac{x}{m}$ *vs* $\log p$ is linear with slope equal to (n being a whole number) **[CBSE AIPMT 2006, 1994]**

(a) k (b) $\log k$

(c) n (d) $\frac{1}{n}$

Ans. ***(d)***

If we plot a graph between $\log\left(\frac{x}{m}\right)$ and $\log p$, a straight line will be obtained. The slope of the line is equal to $\frac{1}{n}$ and the intercept is equal to $\log k$.



where, $\frac{x}{m}$ = amount of adsorption

According to Freundlich adsorption isotherm

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

Taking log of both sides,

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

from $y = zx + c$

$$z = \frac{1}{n}(\text{slope})$$

08 Which is not correct regarding the adsorption of a gas on surface of solid? **[CBSE AIPMT 2001]**

(a) On increasing temperature adsorption increases continuously

(b) Enthalpy and entropy change is negative

(c) Adsorption is more for some specific substance

(d) Reversible

Ans. ***(a)***

Adsorption is the ability of a substance to concentrate or hold gases, liquids upon its surface.

Solids adsorb greater amounts of substances at lower temperature. In general adsorption decreases with increasing temperature.

TOPIC 2
Catalyst

09 Which one of the following statements is incorrect about enzyme catalysis? **[CBSE AIPMT 2012]**

(a) Enzymes are mostly proteinous in nature

(b) Enzyme action is specific

(c) Enzymes are denaturated by UV-rays and at high temperature

(d) Enzymes are least reactive at optimum temperature

Ans. ***(d)***

Most of the enzymes have proteinous nature. They are highly specific and get denaturated by high temperature or UV-rays. At optimum temperature, which is generally in between 25°-35°C, enzyme activity is maximum.

10 According to the adsorption theory of catalysis, the speed of the reaction increases because **[CBSE AIPMT 2003]**

(a) adsorption produces heat which increases the speed of the reaction

(b) adsorption lowers the activation energy of the reaction

(c) the concentration of reactant molecules at the active centres of the catalyst becomes high due to adsorption

(d) in the process of adsorption, the activation energy of the molecules becomes large

Ans. ***(b)***

According to adsorption theory of catalysis, the speed (rate) of the reaction increases because adsorption lowers the activation energy of the reaction.

$$\left(\therefore \text{ Rate of reaction} \propto \frac{1}{\text{activation energy}}\right)$$

TOPIC 3
Colloids, Micelles and Emulsions

11 The right option for the statement "Tyndall effect is exhibited by", is **[NEET 2021]**

(a) NaCl solution (b) glucose solution

(c) starch solution (d) urea solution

Ans. ***(c)***

Tyndall effect is shown by colloidal solution in which particles having larger size scatters the light.

NaCl, glucose and urea do not form a colloidal solution. Only starch solution is colloidal solution. So, Tyndall effect is exhibited by starch solution.

12 In which of the sols, the colloidal particles are with negative charge? **[NEET (Oct.) 2020]**

(a) TiO_2 (b) Haemoglobin

(c) Starch (d) Hydrated Al_2O_3

Ans. ***(c)***

(a) In TiO_2 sol, TiO_2 particles are positively charged.

(b) In blood, haemoglobin is positively charged.

(c) In starch sol, starch is negatively charged.

(d) In hydrated Al_2O_3, $Al_2O_3 \cdot xH_2O$ is positively charged.

Hence, option (c) is the correct.

13 Measuring zeta potential is useful in determining which property of colloidal solution? **[NEET (Sep.) 2020]**

(a) Solubility

(b) Stability of the colloidal particles

(c) Size of the colloidal particles

(d) Viscosity

Ans. ***(b)***

Stability of a colloidal solution is explained by zeta potential.

The particles of colloid carry an electric charge, i.e. acquire positive or negative charge by preferential adsorption of positive or negative ions from dispersion medium. The combination of two layer of positive and negative charges around the colloid is called Helmholtz electrical double layer and the potential difference of this double layer is called zeta potential.

14 Which mixture of the solutions will lead to the formation of negatively charged colloidal $[AgI]I^-$ sol ?

[NEET (National) 2019]

(a) 50 mL of 1 M $AgNO_3$ + 50 mL of 2 M KI
(b) 50 mL of 2 M $AgNO_3$ + 50 mL of 1.5 M KI
(c) 50 mL of 1 M $AgNO_3$ + 50 mL of 0.1 M KI
(d) 50 mL of 1 M $AgNO_3$ + 50 mL of 1.5 M KI

Ans. *(d)*

Key Idea The colloidal particles acquire positive or negative charge by preferential adsorption of positive ions on negative ions.

When silver nitrate ($AgNO_3$) solution is added to potassium iodide (KI) solution, the precipitated silver iodide (AgI) adsorbs iodide ions (I^-) from the dispersion medium and negatively charged colloidal solution results. Among the given options, in option (a) and option (b) millimole of KI is higher than $AgNO_3$. Hence, both the mixture will lead to the formation of negatively charged colloidal $[AgI]I^-$ sol.

Note The most appropriate option is (a) because millimole of KI
(50 mL × 2 M = 100 mmol) is maximum in this option.

15 On which of the following properties does the coagulating power of an ion depend?

[NEET 2018]

(a) Both magnitude and sign of the charge on the ion
(b) Size of the ion alone
(c) The magnitude of the charge on the ion alone
(d) The sign of charge on the ion alone

Ans. *(a)*

The process of settling of colloidal particles due to the neutralisation of their charge by any means is called coagulation.

Coagulation power of an ion depends both on **magnitude and sign of the charge** (positive or negative) **on the ion**. This fact can be explained by **Hardy Schulze rule**.

According to this rule "greater the valency of the coagulating ion/flocculating ion (oppositely charged ion) added, the greater is its power to cause coagulation.

To coagulate a positively charged sol, the order of coagulating power of negative ion is

$I^- < SO_4^{2-} < PO_4^{3-} < [Fe(CN)_6]^{4-}$.

Similarly, to coagulate a negatively charged sol, the order of coagulating power of positive ions is

$Ag^+ < Pb^{2+} < Fe^{3+} < Si^{4+}$

16 Fog is a colloidal solution of

[NEET 2016, Phase I]

(a) Gas in liquid (b) Solid in gas
(c) Gas in gas (d) Liquid in gas

Ans. *(d)*

Fog is a colloidal solution of liquid in a gas, in which liquid is the dispersed phase whereas gas is the dispersion medium. Examples of other options are as follows:

Gas in liquid : Shaving cream, soda water, froth

Solid in gas : Dust in air

Gas in gas : Atmospheric air.

17 The coagulation values in millimoles per litre of the electrolytes used for the coagulation of As_2S_3 are given below

I. (NaCl) = 52,
II. ($BaCl_2$) = 0.69
III. ($MgSO_4$) = 0.22

The correct order of their coagulating power is

[NEET 2016, Phase II]

(a) I > II > III (b) II > I > III
(c) III > II > I (d) III > I > II

Ans. *(c)*

Lower the coagulating power, higher is the coagulation value in millimoles per litre, i.e. coagulating power is inversely proportional to coagulation values. Thus, correct order of coagulating power is

$MgSO_4 > BaCl_2 > NaCl$ or III > II > I

18 The suspension of slaked lime in water is known as

[NEET 2016, Phase II]

(a) limewater
(b) quicklime
(c) milk of lime
(d) aqueous solution of slaked lime

Ans. *(c)*

Aqueous solution of slaked lime is called lime water whereas suspension solution of slaked lime is called milk of lime.

19 Which property of colloidal solution is independent of charge on the colloidal particles?

[CBSE AIPMT 2015, 2014]

(a) Coagulation
(b) Electrophoresis
(c) Electroosmosis
(d) Tyndall effect

Ans. *(d)*

Coagulation is generally brought about by the addition of electrolytes. When an electrolyte is added to a colloidal solution, the particles of the sol take up the ions which are oppositely charged. As a result their charge gets neutralised.

Electrophoresis The movement of colloidal particles under an applied electric potential is called electrophoresis.

Electroosmosis may be defined as a phenomenon in which the molecules of the dispersion medium are allowed to more under the influence of an electric field whereas colloidal particles are not allowed to more.

Tyndall effect is the scattering of light by sol particles, which cannot be affected by charge on them.

20 The protecting power of lyophilic colloidal sol is expressed in terms of **[CBSE AIPMT 2012]**

(a) coagulation value
(b) gold number
(c) critical micelle concentration
(d) oxidation number

Ans. *(b)*

Lyophobic sols are unstable, so they are stabilised by adding some lyophilic colloids which protect them from precipitation. Thus, lyophilic colloids are called **protecting colloids**. Their protecting power is expressed in terms of gold number. In other words, gold number can be defined as the minimum amount of lyophilic colloid in milligrams, which prevent the flocculation of 10 mL gold sol by the addition of 1 mL of 10% NaCl solution.

NOTE Lesser the gold number, higher is the protecting power.

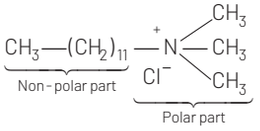
21 Which one of the following forms micelles in aqueous solution above certain concentration?

[CBSE AIPMT 2005]

(a) Urea
(b) Dodecyl trimethyl ammonium chloride
(c) Pyridinium chloride
(d) Glucose

Ans. *(b)*

Surfactants like detergents, form micelles in aqueous solution above to their critical micelle concentration (CMC). Dodecyl trimethyl ammonium chloride is an example of surfactant (cationic surfactant),



22 Which of the following forms cationic micelles above certain concentration? **[CBSE AIPMT 2004]**

(a) Sodium ethyl sulphate
(b) Sodium acetate
(c) Urea
(d) Cetyl trimethyl ammonium bromide

Ans. *(d)*

Cetyltrimethylammonium bromide forms cationic micelles above a certain concentration. In the molecule of detergents and soap, the negative ions aggregate to form a micelle of colloidal size. In polar medium (like water), the negative ion has a long hydrocarbon chain and a polar group ($-COO^-$) at one end and on other end, it has N^+ ion, thus cationic micelle is formed.

23 Position of non-polar and polar parts in micelle is **[CBSE AIPMT 2002]**

(a) polar at outer surface but non-polar at inner surface
(b) polar at inner surface but non-polar at outer surface
(c) distributed all over the surface
(d) present in the surface only

Ans. *(a)*

Micelles are the clusters formed by the association of colloids. They are formed by lyophilic and lyophobic groups. As the concentration increases, the lyophobic parts receding away from the solvent approach each (non-polar part) other and form a cluster, the lyophobic ends are in the interior, lyophilic groups (polar part) projecting outward in contact with the solvent.

24 The method usually employed for the precipitation of a colloidal solution is

(a) dialysis **[CBSE AIPMT 2000]**
(b) addition of electrolytes
(c) diffusion through animal membrane
(d) condensation

Ans. *(b)*

On addition of electrolyte charge of colloidal particles will neutralise and hence, coagulation or precipitation of colloidal solution will occur.

25 At the critical micelle concentration (CMC) the surfactant molecules **[CBSE AIPMT 1998]**

(a) decompose
(b) dissociate
(c) associate
(d) become completely soluble

Ans. *(c)*

The soap concentration at which micelles first appear is called **critical micelle concentration** (CMC). At this condition the surfactant molecules associate with each other.

26 The ability of anion to bring about coagulation of a given colloid depends upon

(a) its charge **[CBSE AIPMT 1997]**
(b) the sign of the charge alone
(c) the magnitude of its charge
(d) both magnitude and sign of its charge

Ans. *(d)*

According to Hardy-Schulze law,

coagulation $\propto$ charge of ion

So, coagulation is affected by both magnitude of charge and nature of charge. For coagulation of a positive sol, negative ions are required and for coagulation of negative sol, positive ions are required.

Greater the magnitude of charge, quicker will be the coagulation.

The ions having opposite charge to sol particle causes coagulation.

Coagulating power of an electrolyte is directly proportional to the fourth power of the valence of the ions causing the coagulation.

27 During dialysis **[CBSE AIPMT 1996]**

(a) only solvent molecules can diffuse
(b) solvent molecules, ions and colloidal particles can diffuse
(c) all kinds of particles can diffuse through the semipermeable membrane
(d) solvent molecules and ions can diffuse

Ans. *(d)*

The principle of dialysis is based upon the fact that colloidal particles cannot pass through a parchment or cellophane membrane while the ions of the electrolyte can pass through it.

28 If a beam of light is passed through true solution, then it is

(a) visible **[CBSE AIPMT 1995]**
(b) scatter
(c) not visible
(d) None of the above

Ans. *(c)*

When a beam of light is passed through true solution, then the path of light is invisible due to fact that the size of particles in true solution is below 1 nm, so they cannot scatter the light that means cannot show Tyndall effect.