Chapter 5

Surface Chemistry

Solutions

SECTION - A

Objective Type Questions (One option is correct)

1. 5 g of a gas is adsorbed on 2.5 g of metal powder at 300 K and 0.7 atm. Calculate the volume of gas adsorbed per gram of adsorbent. (Molar mass of gas = 4 g mole^{-1})

   (1) 17.6 dm^3 (2) 24.5 dm^3 (3) 31.6 dm^3 (4) 37.0 dm^3

Sol. Answer (1)

$$V_{gas} = \frac{nRT}{P} = \frac{5/2.5}{4} \times \frac{0.0821 \times 300}{0.7}$$

$$= \frac{2 \times 0.0821 \times 300}{2.8}$$

$$= \frac{2 \times 8.21 \times 3}{2.8}$$

$$= \frac{24.63}{1.4} = 17.6 \text{ L}$$

2. Acidified $KMnO_4$ solution is titrated against oxalic acid solution, colour of $KMnO_4$ first fades slowly and then faster. This is an example of

   (1) Heterogeneous catalysis (2) Induced catalysis

   (3) Autocatalytic reactions (4) All of these

Sol. Answer (3)

Mn^{2+} act as catalyst.

3. Which of the following is incorrect?

   (1) Acid dye are negatively charged colloids

   (2) The colour of colloidal solution depends on the wavelength of light scattered by the dispersed particle

   (3) Lyophobic colloids are more stable than lyophillic colloids

   (4) Lyophobic colloids are irreversible colloids

Sol. Answer (3)

Lyophilic colloids is more stable than lyophobic colloids.

4. Consider the reaction

$$N_2(g) + 3H_2(g) \xrightarrow[Mo(s)]{Fe(s)} 2NH_3(g)$$

The correct statement is

(1) In the above reaction Fe used as a catalyst
(2) In the above reaction Fe used as a promoter
(3) In the above reaction Mo used as a promoter
(4) Both (1) & (3) are correct

Sol. Answer (4)

5. Which of the following statement is/are related to Tyndall effect?

(1) Headlights of vehicles works on Tyndall effect
(2) Determination of concentration strengths
(3) Visibility of sunlight in dense forests
(4) All of these

Sol. Answer (4)

Fact.

6. Which of the following statements is correct?

(1) Charge on colloidal particle is the main reason of stability of lyophilic sol
(2) The charge on colloidal particle is due to preferential adsorption of the ion which is related chemically to the colloidal particle
(3) A freshly formed precipitate of stannic oxide when peptised with HCl carries a positive charge due to adsorption of H^+ ions on the colloidal particle
(4) Metal sols prepared by Bredig's arc method are positively charged

Sol. Answer (2)

Lyophobic sols are stabilised due to charge. Preferential adsorption of common ion generally occurs.

SnO_2 sol is positively charged due to adsorption of Sn^{+4} ions.

7. Select the correct statement.

(1) Particles in true solution do not show brownian motion
(2) Color of colloidal solution changes with the manner in which the observer views the solution
(3) For Tyndall effect, the speed of light in the dispersion medium should not be much different than that in the dispersed phase
(4) Colloidal solution show colligative properties of greater magnitude than that of true solutions

Sol. Answer (2)

Brownian motion is generally shown by all type of solutions for Tyndall effect, refractive indices should differ greatly.

8. $A(g)+M(surface) \underset{K_b}{\overset{K_f}{\rightleftharpoons}} AM$, $K = \frac{K_f}{K_b}$ for the above adsorption process, Langmuir proposed the following relation:

$\theta = \frac{KP_A}{1+KP_A}$ where θ is the fraction of active sites occupied and P_A is the pressure of gas A.

Consider the following statements:

S1 : At very low pressures, the adsorption varies almost linearly with pressure.

S2 : At very high pressures, the adsorption becomes independent of pressure.

S3 : Multilayered physisorption follows the above expression.

The correct statement is/are

(1) S1 and S2 Only
(2) S1 and S3 Only
(3) S2 and S3 Only
(4) S1, S2 and S3

Sol. Answer (1)

Langmuir adsorption isotherm is applicable for monolayered.

9. Which of the following has the least flocculating value for a sol whose particles move towards the cathode in the presence of an electric field?

(1) NaCl (2) Na_2SO_4 (3) Na_3PO_4 (4) $Na_2C_2O_4$

Sol. Answer (3)

Oppositely charged particles bring about coagulation, their flocculating value increases as the charge on the ion decreases.

10. Identify the incorrect statement among following.

(1) $CH_3 – (CH_2)_{10} – CH_2 – NH_2$ is not a surfactant

(2) Surfactants are positively adsorbed at interfaces between two phases and they lower interfacial tension

(3) Quaternary ammonium salts cannot act as surfactants

(4) Surfactants can be neutral, positive or negative in charge

Sol. Answer (3)

Quaternary ammonium salts can act as surfactants.

11. 40% of the sites on a metal surface have adsorbed H_2. Upon heating, desorption takes place and the H_2 gas collected at 76 mm Hg and 298 K was found to occupy a volume of X cm^3. If the surface area of the solid is 1 m^2 and the density of active sites is 6×10^{15} cm^{-2}. If the number of H_2 molecule adsorbed per active site is 2, find the value of X. (use $N_A = 6 \times 10^{23}$)

(1) 4 cm^3 (2) 19 cm^3 (3) 33 cm^3 (4) 46 cm^3

Sol. Answer (2)

Number of active sites occupied $= \frac{40}{100} \times 10000 \times 6 \times 10^{15} = 4 \times 6 \times 10^{18} = 24 \times 10^{18}$

$\therefore$ Number of hydrogen molecules $= 48 \times 10^{18}$

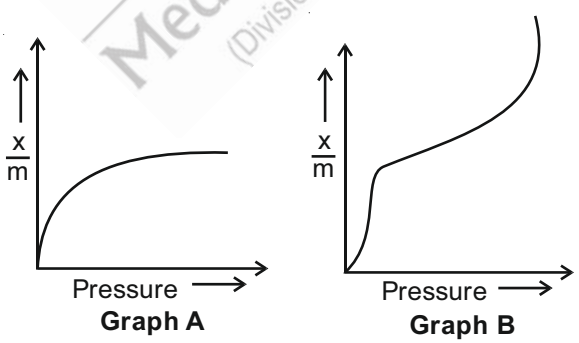
$\therefore$ Moles of $H_2 = \frac{48 \times 10^{18}}{6 \times 10^{23}} = 8 \times 10^{-5}$

$\therefore$ PV = nRT

$\Rightarrow 0.1\ V = 8 \times 10^{-5} \times (0.0821) \times 298$

V = 0.019 lit = 19 cm^3

12. Consider following graph of adsorption [x $\rightarrow$ mass of gas absorbed on mass m of adsorbent]



Select the correct statement.

(1) Graph A is for multilayered adsorption (2) Graph B is for monolayered adsorption

(3) Graph A is for chemisorption (4) Graph B is for chemisorption

Sol. Answer (3)

Chemisorption is monolayered.

13. Anhydrous calcium chloride and silica gel have an affinity for water vapour when brought in contact with water. The processes taking place respectively are

(1) Adsorption only in both cases (2) Absorption only in both cases

(3) Adsorption, Absorption respectively (4) Absorption, Adsorption respectively

Sol. Answer (4)

Anhydrous $CaCl_2$ show absorption.

14. In a container, 1L of aqueous CH_3COOH ispresent and pH of this solution is 3. Now 2g charcoal is added in this container and pH of CH_3COOH solution become 4. The mass of CH_3COOH adsorbed per gram of charcoal is [K_a of CH_3COOH is 10^{-5} and no volume change due to addition of charcoal]

(1) 5.94 g (2) 2.97 g (3) 1.27 g (4) 6.3 g

Sol. Answer (2)

Initial pH = 3

$[H^+] = 10^{-3} = \sqrt{K_a \times c}$

Mol of CH_3COOH = 0.1

Mol of CH_3COOH after addition of charcoal = 0.001

15. Select the correct combination.

	Dispersed phase	**Dispersion medium**	**Types of colloid**	**Examples**
(1)	Liquid	Liquid	Emulsion	Butter
(2)	Gas	Solid	Solid sol	Pumice Stone
(3)	Solid	Gas	Aerosol	Fog
(4)	Solid	Liquid	Sol	Mist

Sol. Answer (2)

Pumice stone is example of gas in solid.

16. The gold number of three protective colloid A, B and C are 0.1, 0.5 and 0.9 respectively. Then the amount of these protective colloid required for protection of fixed amount of lyophobic sol

(1) A > B > C (2) C > B > A (3) B > A > C (4) A > C > B

Sol. Answer (2)

Greater the gold number, greater is its amount required.

17. The process of converting a precipitate into a colloidal solution by shaking it with dispersion medium in presence of small amount of electrolyte is

(1) Bredig's method (2) Peptization (3) Dialysis (4) Ultrafiltration

Sol. Answer (2)

In peptisation, a freshly prepared precipitate is converted into colloidal solution by addition of suitable electrolyte (peptising agent).

SECTION - B

Objective Type Questions (More than one options are correct)

1. Which is/are correct statements?

(1) Physical adsorption always increases when temperature increases

(2) Physical adsorption decreases when temperature increases

(3) Chemical adsorption is reversible

(4) Monolayer is formed in chemical adsorption

Sol. Answer (2, 4)

Physical adsorption decreases with the rise in temperature It is an endothermic process and it is higher at lower temperature.

In chemical adsorption, a monolayer is formed which further results in the decrease of adsorption.

2. Which forms multilayers during adsorption?

(1) Physical adsorption (2) van der Waals' adsorption

(3) Chemical adsorption (4) All of these

Sol. Answer (1, 2)

Multilayer are formed in case of physical adsorption or van der Waals adsorption.

3. Langmuir's adsorption isotherm for a gas - solid system is/are

(1) $\frac{x}{m} = KP^{\frac{1}{n}}$ (2) $\frac{x}{m} = \frac{K_1 + P}{K_2 P}$ (3) $\frac{x}{m} = \frac{aP}{1+bP}$ (4) $\frac{m}{x} = 1 + cP$

Sol. Answer (3)

For a gas-liquid system it is the well know relation that

$\frac{x}{m} = \frac{aP}{1+bP}$ and $\frac{m}{x} = \frac{1+bP}{aP} = \frac{1}{aP} + \frac{b}{a}$

4. Which act as poison for Pd-charcoal in Lindlar's catalyst?

(1) $BaSO_4$ (2) Quinoline (3) V_2O_5 (4) Fe

Sol. Answer (1, 2)

In Lindlar's catalyst, the substance acting as poisons are $BaSO_4$ and Quinoline.

5. Which is an example of auto-catalysis?

(1) Hydrolysis of methyl acetate (2) Oxidation of Na_2SO_3 in presence of Na_2AsO_3

(3) Oxidation of oxalic acid by $KMnO_4$ (4) None of these

Sol. Answer (1, 3)

In autocatalysis product formed acts as a catalyst.

6. Which is/are application(s) of adsorption?
   (1) Humidity can be controlled by adsorption
   (2) Inert gases cannot be separated by adsorption
   (3) Softening of hard water takes place by adsorption
   (4) Colouring matter can be removed from the solution by adsorption

Sol. Answer (1, 3, 4)

Facts about adsorption.

7. Which is/are correct statement?
   (1) Lyophilic colloids are irreversible
   (2) Lyophilic colloids do not migrate in electric field or migrate in any direction
   (3) In lyophobic colloids no hydration takes place
   (4) Lyophilic are more stable and lyophobic less stable

Sol. Answer (2, 3, 4)

Lyophilic are stable, do not migrate in electric field and no hydration takes place in lyophobic colloids.

8. Which colloid can be coagulated by Al^{+3}?
   (1) Haemoglobin (2) TiO_2 (3) As_2S_3 (4) CdS

Sol. Answer (3, 4)

As_2S_3 and CdS are negatively charged sol, hence can be coagulated by Al^{3+}.

9. Which is/are correct statement about gold number?
   (1) Larger its value, the greater is the protecting power
   (2) Lower its value, the greater is the protecting power
   (3) It is always expressed in mg of protective colloids
   (4) Milligrams of gold sol is also known as gold number

Sol. Answer (2, 3)

Gold number is the amount of protective colloid in mg that prevents coagulation of 10 ml gold sol on addition of 1 ml of 10% NaCl solution. Lower is its value greater is the protecting power.

10. When a hydrophilic sol like gelatin is subjected to electric field, the sol particle moves
    (1) Towards anode when pH > isoelectric point
    (2) In both directions at isoelectric pH
    (3) Towards cathode when pH < isoelectric point
    (4) All of these

Sol. Answer (1, 3)

When gelatin is subjected to an electric field, the sol particles move towards anode when pH > Isoelectric point and towards cathode when pH < Isoelectric point.

11. Which is/are correct about emulsions?
    (1) Demulsification can take place by chemical methods only
    (2) Small amount of water cannot be mixed in water-in-oil emulsion
    (3) Sodium oleate is used to prepare oil-in-water emulsion
    (4) Calcium oleate is used to prepare water-in-oil emulsion

Sol. Answer (2, 3, 4)

Sodium oleate and calcium oleate are used to prepare oil-in-water or water-in-oil emulsion and small amount of H_2O cannot mix in water-in-oil emulsion.

12. An oil in water emulsion has

(1) High electrical conductivity (2) Easy dilution with water

(3) Easy dilution with oil soluble (4) No response to oil soluble dye test

Sol. Answer (1, 2)

It is a well know fact that O/W emulsion has high electrical conductivity and are easily diluted with water.

13. Associated colloids

(1) Behave as electrolytes at low concentration

(2) Behave as colloids at low concentration

(3) $C_{17}H_{35}COONa$ is an example of associated colloid

(4) Associated colloids are formed below Kraft's temperature

Sol. Answer (1, 3)

Associated colloids behave as electrolytes at low concentration.

14. Coagulation value is

(1) Minimum concentration of electrolyte required to cause coagulation

(2) Expressed in millimoles per litre

(3) Expressed in milligram

(4) Also known as flocculation value

Sol. Answer (1, 2, 4)

Coagulation value or flocculation value is the minimum concentration of electrolyte in millimoles/L to cause coagulation.

15. Which is/are correct about protective colloids?

(1) Haemoglobin cannot be used as a protective colloids

(2) Protective colloids are responsible for the stability of paints, ink etc.

(3) Lyophobic colloids act as protective colloids

(4) Gelatin is a better protective colloid than gum arabic

Sol. Answer (2, 4)

Information based.

SECTION - C

Linked Comprehension Type Questions

Comprehension-I

The colloidal solution of two immiscible liquids in which one of the liquids acts as a dispersed phase and the other as dispersion medium is called emulsion. Milk is an example of emulsion in which fat globules are dispersed in water. Emulsions resemble lyophobic sols in some properties. Emulsions are prepared by high speed mixer. Emulsion are of two types i.e. O/W and W/O type emulsion, identified by dilution test, conductivity test and dye test.

1. The conductivity test is positive for

(1) O/W (2) W/O

(3) Both (1) & (2) (4) None of these

Sol. Answer (1)

Conductivity test is positive for oil in water emulsion & negative for water in oil emulsion.

2. Which property is observed in an emulsion?

(1) Tyndall effect (2) Brownian motion

(3) Both (1) & (2) (4) None of these

Sol. Answer (3)

Emulsion is a colloidal solution. Tyndall effect & Brownian movement are the properties of colloidal solution.

3. In milk which acts as an emulsifier?

(1) Gelatin (2) Albumin

(3) Casein (4) None of these

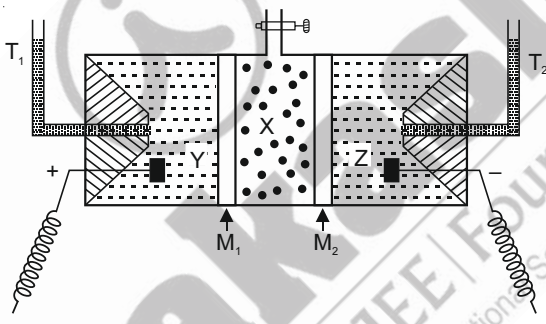
Sol. Answer (3)

Casein acts as an emulsifier.

Comprehension-II

The electrophoresis of dispersed particle in a colloidal system is prevented by some suitable means (e.g using membrane M_1 and M_2) it is observed that the dispersion medium itself begins to move in an electric field. This phenomenon is known as electro-osmosis.

Consider the apparatus for studying electro-osmosis given below:



$X \rightarrow$ contains the colloidal system

M_1, $M_2 \rightarrow$ Membranes that prevent the movement of colloidal particle but water can pass through it

Y and $Z \rightarrow$ Contain water

T_1 and $T_2 \rightarrow$ Contain water

1. When current is applied (Polarity of battery is shown) the level of water inside the tube T_1 is increased, then colloidal particles may be

(1) Congo red sol (2) Methylene blue sol (3) Sb_2S_3 sol (4) Copper sol

Sol. Answer (2)

If water moves towards anode it means water contains negative charge so colloidal sol must contain positive charge.

2. X contains colloidal sol of 'P'. If current is applied (according to shown polarity) then water level in tube T_2 increases. Select the ion which has highest coagulation power for sol 'P'.

(1) Na^+ (2) Cl^- (3) $[Fe(CN)_6]^{4-}$ (4) Al^{3+}

Sol. Answer (4)

Water moves towards negative electrode it means it is positively charged and sol is negatively charged.

SECTION - D

Matrix-Match Type Quesitons

1. Match the following :

Column-I	Column-II
(A) Aerosol	(p) Optical property
(B) Emulsion	(q) Electrical property
(C) Tyndall effect	(r) Smoke
(D) Dialysis	(s) Medicines

Sol. Answer A(r), B(s), C(p), D(q)

Aerosol contains smoke particles in air. Emulsion contains liquids in liquids. Tyndall effect is the optical property, which is related to scattering of light. Dialysis is an electrical property for the purification of colloids.

2. Match the following :

Column-I	Column-II
(A) Adsorption	(p) Removal of adsorbed substance
(B) Absorption	(q) Fermentation of glucose
(C) Desorption	(r) Bulk phenomenon
(D) Zymase	(s) Surface phenomenon

Sol. Answer A(s), B(r), C(p), D(q)

Adsorption is a surface phenomenon but absorption is a bulk phenomenon. In desorption some adsorbed substance is released.

The energy released in physical adsorption is 20–40 kJ/mol, as it is an exothermic process.

3. Match the following :

Column-I	Column-II
(A) Fog	(p) Gel
(B) Gem stones	(q) Emulsion
(C) Cheese	(r) Aerosol
(D) Milk	(s) Solid sol

Sol. Answer A(r), B(s), C(p), D(q)

In paint & milk, liquid is dispersed phase and liquid is dispersion medium.

In cheese, liquid is dispersed phase & solid is dispersion medium.

In gemstones, solid is dispersed phase and solid is dispersion medium.

4. Match the following :

Column-I	Column-II
(A) Physisorption	(p) Multilayer adsorption
(B) Chemisorption	(q) Plot of T vs P for a given amount of adsorption
(C) Desorption	(r) Strong covalent forces
(D) Adsorption isotherm	(s) Occurs at high temperature

Sol. Answer A(p), B(r), C(s), D(q)

SECTION - E

Assertion-Reason Type Questions

1. STATEMENT-1 : During adsorption, ΔH, ΔG and ΔS decreases i.e., its value becomes negative.

   and

   STATEMENT-2 : Adsorption is a spontaneous process as well as randomness or disorderedness decreases during adsorption.

Sol. Answer (1)

Entropy decreases because randomness decreases and energy is released therefore ΔH is –ve.

Hence statement (2) is the correct explanation of statement (1).

2. STATEMENT-1 : Colloids can be purified by dialysis.

   and

   STATEMENT-2 : Colloidal particles does not pass through parchment paper or animal membrane.

Sol. Answer (3)

The purification of colloids takes place by dialysis as they can easily pass through parchment paper or animal membrane.

Statement (1) and statement (2) both are correct and statement (2) is also the correct explanation.

3. STATEMENT-1 : Al^{3+} ions have greater precipitating power for As_2S_3 than Na^+ ions.

   and

   STATEMENT-2 : As_2S_3 sol is a negatively charged sol.

Sol. Answer (2)

As_2S_3 is –vely charged sol, hence, gets precipitated by +vely charged ions. Al^{3+} has greater charge as compared to Na^+.

Statement (1) & (2) both are correct but statement (2) is not the correct explanation.

4. STATEMENT-1 : An electrolyte having greater coagulating power has greater flocculation value.

   and

   STATEMENT-2 : Flocculation value of an electrolyte for different colloidal solutions is different.

Sol. Answer (4)

Flocculation value of an electrolyte is the minimum concentration in millimoles/L required to cause coagulation of a sol and is different for different colloidal sols.

5. STATEMENT-1 : Tyndall effect is due to scattering of light by the particles.

   and

   STATEMENT-2 : Colloidal particles due to charge scatter the light to the maximum extent.

Sol. Answer (1)

Colloidal particles scatter the light to maximum amount because of charge and is known as Tyndall effect.

Statement (2) is the correct explanation of statement (1).

SECTION - F

Integer Answer Type Questions

1. Find the value of $\log\left(\frac{\text{Size of colloidal particles}}{\text{Size of solute particles in true solution}}\right)$ (In case of limiting value).

Sol. Answer (3)

$$\frac{V_c}{V_s} = \frac{\frac{4}{3}\pi r_c^3}{\frac{4}{3}\pi r_s^3} = \frac{r_c^3}{r_s^3} = 10^3$$

$= 3$

2. Find the number of phases involved in thermal decomposition of $KClO_3$ in presence of MnO_2(s).

Sol. Answer (3)

Heterogeneous systems has $p \geq 2$

In this case, S + S has p = 2

3. On addition of one ml solution of 10% NaCl to 10 ml gold solution in the presence of 0.009 g of an anticoagulant, the coagulation is prevented. What is the gold number of anticoagulant?

Sol. Answer (9)

Follow definition of gold number = 9

4. How many of the statements given below are correct?
   (a) Physisorption may be converted into chemisorption at higher temperature.
   (b) Fog is example of colloid in which dispersed phase is liquid.
   (c) TiO_2 is positive charged colloid.
   (d) ΔS for adsorption of gas on Pt and for micelle formation is negative (for both).
   (e) Brownian motion of colloid particle depend on viscosity of dispersion medium.
   (f) Latex is a colloidal solution of rubber particles which are negatively charged.
   (g) Lyophilic sols are more stable than lyophobic sols.

Sol. Answer (6)

$(\Delta S)_{ads}$ = –ve

$(\Delta S)_{micellation}$ = +ve

5. How many of following represent surface phenomenon?
   (a) Addition of charcoal to acetic acid.
   (b) Purification of sugar using charcoal.
   (c) Silica gel in the presence of moisture.
   (d) Surface tension
   (e) Viscosity
   (f) Mixture of O_2, N_2, CO, NH_3 in contact wtih charcoal in closed vessel.

Sol. Answer (5)

6. 1.3 litres N_2 gas at 2 atm and 300 K in 1.3 litre container is exposed to 4 g of solid surface. After complete adsorption the pressure of N_2 is reduced by 30%, if value of x/m is P then 10 P is

Sol. Answer (22)

$P_{N_2} = 2$ atm, P_{N_2} left $= \frac{2\times 70}{100} = 1.4$ atm

$\therefore \quad w_{N_2}$ adsorbed $= \frac{PV\times m}{RT} = \frac{(2-1.4)\times 1.3\times 28}{0.0821\times 300} = 0.89$ g

$\therefore \quad \frac{x}{m} = \frac{0.89}{4} = 0.22$ g

7. One gram of activated charcoal has a surface area of 10^3 m^2. If complete coverage by monolayer is assumed, how much NH_3 in cm^3 at STP (to nearest integer) would be adsorbed on the surface of 25 g of the charcoal? (Given diameter of NH_3 molecule = 0.3 nm)

Sol. Answer (13)

Total surface area to be covered = 25×10^3 m

2r for $NH_3 = 0.3 \times 10^{-9}$ nm

$= 0.3 \times 10^{-9} \times 10^2$ cm

$= 0.3 \times 10^{-7}$ cm

$r = 1.5 \times 10^{-8}$ cm

$\therefore$ Surface area of 1 molecule $= \pi r^2 = 3.14 \times (1.5 \times 10^{-8})^2$

$= 7.065 \times 10^{-16}$ cm^2

No. of NH_3 molecules adsorbed $= \frac{25\times 10^3}{7.065\times 10^{-20}} = 3.539\times 10^{23}$

$\therefore$ Mole of NH_3 adsorbed $= \frac{3.539\times 10^{23}}{6.023\times 10^{23}} = 0.5875$

Now using PV = nRT,

$$V = \frac{0.05875\times 0.0821\times 273}{1}$$

V = 13.168 litre

8. 1 g of charcoal adsorbs 100 mL of 0.5 M CH_3COOH to form a monolayer and thereby the molarity of CH_3COOH reduces to 0.49. The surface area of charcoal adsorbed by each molecule of acetic acid is 5×10^{-x} m^2. Then value of x is (Surface area of charcoal = 3.01×10^2 m^2/g)

Sol. Answer (19)

Millimole of acetic acid taken = $100 \times 0.5 = 50$

Millimole of acetic acid left = $100 \times 0.49 = 49$

Millimole of acetic acid adsorbed = $50 - 49 = 1$

Molecules of acetic acid adsorbed = $1 \times 10^{-3} \times 6.023 \times 10^{23} = 6.023 \times 10^{20}$

Total area of 1 g charcoal covered by these molecules = 3.01×10^2 m^2

$\therefore$ Area covered by 1 molecule $= \frac{3.01\times 10^2}{6.023\times 10^{20}}$ ($\because$ unilayer adsorption)

$= 5 \times 10^{-19}$ m^2

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