Important questions on Surface Chemistry

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Important Questions on Surface Chemistry

1. In Freundlich Adsorption Isotherm, value of 1/n can be defined as-
A. 1 in case of chemisorption
B. 1 in case of physical Adsorption
C. Between o to 1 in all the cases
D. 0 in all the cases

2. Adsorption is
A. An exothermic process hence increases in temperature decrease adsorption in case where Vander Waals forces exist between adsorbate and adsorbent.
B. An endothermic process hence increase in temperature increases adsorption.
C. An exothermic process hence increase in temperature increases adsorption.
D. None of the above.
3. A graph plotted log x/m vs log p shows a straight line with slope = 1 and intercept = 0.4771 . The extent of adsorption of gas at p= 2 atm is:
A.1.4
B. 6
C. 4.1
D. 3.2

4. For 1.0×10^{-4} M aqueous solutions of n-butanoic acid $\frac{d\gamma}{dC} = -0.080\ Nm^2mol^{-1}$ at 25°C. By using Gibb's adsorption equation, determine the average surface area available to each molecule.
A. 5.2×10^{-19} m^2
B. 3.9×10^{-19} m^2
C. 4.7×10^{-19} m^2
D. 6.7×10^{-19} m^2

5. The adsorption of a gas on a solid surface follows a Langmuir isotherm with k = 3.76 kPa^{-1}, at a temperature of 25°C. Calculate the pressure of gas required to achieve a fractional surface coverage of 10^{-1}.
A. 32 Pa
B. 27 Pa
C. 30 Pa
D. 45 Pa

6. Which gas is adsorbed to maximum extent on the given surface?
A. NH_3
B. H_2
C. N_2
D. O_2

7. The time for which the oxygen atom remains adsorbed on a tungsten surface is 0.36 s at 2550 K and 3.49 s at 2360 K. Determine the activation of desorption of oxygen atoms.
A. 432.42 kJ/mol
B. 532.30 kJ/mol
C. 326.43 kJ/mol
D. 598.29 kJ/mol

8. The mass x of a solute adsorbed per gram of a solid adsorbed is given by the Freundlich adsorption isotherm as $x = kc^n$, here k and n are 0.160 and 0.431, respectively. Calculate the amount of acetic acid (M_m = 60.05 g mol^{-1}) that 1 kg of charcoal would adsorb from a 0.837 M vinegar solution.
A. 4.32 mol
B. 2.47 mol
C. 1.57 mol
D. 3.26 mol

9. An organic fatty acid forms a surface film on water that obeys the two-dimensional ideal gas law. If the surface tension lowering is 10 mN m^{-1} at 25°C, calculate the surface excess concentration.
A. 4.04×10^{-5} mol m^{-2}
B. 4.04×10^{-6} mol m^{-2}
C. 4.04×10^{-4} mol m^{-2}
D. 4.04×10^{-3} mol m^{-2}

10. For adsorption process, the correct thermodynamic condition is:
A. ΔH must be negative
B. ΔS must be negative
C. ΔG must be negative
D. ΔH, ΔS and ΔG must be negative.

ANSWER KEY

1. C	2. A	3. B	4. A	5. C	6. A
7. D	8. B	9. B	10. D		

SOLUTIONS

Solution 1. Freundlich equation is given as:

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

Or,

$$\frac{x}{m} \propto P^{1/n}$$

Taking log on both sides of equation,

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

Case I $\rightarrow$ at low pressure,

$$\frac{1}{n} = 1$$

Case II $\rightarrow$ at high pressure,

$$\frac{x}{m} = \text{constant}$$

Case III $\rightarrow$ at intermediate range of pressure,

$$\frac{x}{m}$$

Depends on power P which is between 0 to 1.

Solution 2. Adsorption is a Surface Phenomenon and an exothermic process hence increase in temperature decrease adsorption in case where Vander Walls's forces exist between adsorbate and adsorbent.

Solution 3. According to Freundlich Adsorption Isotherm,

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

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

Given,

$$\frac{1}{n} = 1 \log k = 0.4771$$

k = $10^{0.4771}$ =3

$$\frac{x}{m} = 3 \times 2 = 6$$

Solution 4. From Gibbs adsorption equation,

$$\Gamma_2 = -\frac{C}{RT}\cdot\frac{d\gamma}{dC}$$

$$\Gamma_2 = \frac{(1.0\times10^{-4}\,\text{mol dm}^{-3})(10^3\,\text{dm}^3\text{m}^{-3})}{(8.314\,\text{JK}^{-1}\text{mol}^{-1})(298\,\text{K})(-0.080\,\text{Nm}^2\,\text{mol}^{-1})}$$

$$\Gamma_2 = 3.2\times10^{-6}\,\text{mol m}^{-2}$$

Average surface area available to each molecule

$$= \frac{1}{3.2\times10^{-6}\times6.02\times10^{23}} = 5.2\times10^{-19}\,\text{m}^2$$

Solution 5. The expression to calculate pressure is:

$$Q = \frac{kp}{1+kp}$$

Rearrange the above expression for p,

$$p = \frac{\theta}{(1-\theta)k} = \frac{0.10}{(1-0.10)\times3.76\times\text{kPa}^{-1}} = 30\text{Pa}$$

Solution 6. Extent of adsorption is maximum for a polar gas over a non-polar gas due to stronger interaction in polar species than in non-polar gas.

NH_3→ Polar

H_2, N_2, O_2→ non-polar

Solution 7. The expression to calculate desorption of oxygen atom is:

$$E_a = \frac{R\ln(\tau_2/\tau_1)(T_1T_2)}{T_1 - T_2}$$

$$= \frac{(8.314\,\text{J K}^{-1}\,\text{mol}^{-1})\ln(3.49\,\text{s}/0.36\text{s})(2550\,\text{K})(2360\,\text{K})}{(2550-2360)\,\text{K}}$$

= 598.29 kJ mol^{-1}

Solution 8. $x = k\,c^n = (0.160)\,(0.837)^{0.431}$ per gram of charcoal
= (0.148 g acetic acid) (g charcoal)$^{-1}$ = (148 g acetic acid) (kg charcoal)$^{-1}$

$$= \frac{(148\text{ g acetic acid})(\text{kg charcoal})^{-1}}{60.05\text{ mol}^{-1}} = 2.47\text{ mol acetic acid (kg charcoal)}^{-1}$$

Solution 9. Γ_2 is equal to *N/ (N_A A)* where N is the number of molecules contained in a film of area A.

$$\Gamma_2 = \frac{\pi}{RT} = \frac{10\times10^{-3}\,\text{Nm}^{-1}}{(8.314\text{ J K}^{-1}\text{ mol}^{-1})(298\text{ K})} = 4.04\times10^{-6}\text{ mol m}^{-2}$$

Solution 10. According to the equation,
$\Delta G = \Delta H - T\Delta S$
can be negative if ΔH has sufficiently high negative value as $-T\Delta S$ is positive. Thus, in adsorption which is a spontaneous process, ΔS is negative, ΔH is sufficiently negative and as a result, ΔG is also negative.