Sample Chemistry Question (Ch. 15, 16, 17) - CH 223

Questions for Chapters Seventeen Part II, Nineteen and Twenty:

1. What is the concentration of F^- in a saturated solution of BaF_2 if $K_{sp} = 1.7*10^{-6}$?

   a. $7.5*10^{-3}$ M
   b. $8.2*10^{-4}$ M
   c. $1.5*10^{-2}$ M
   d. $4.3*10^{-7}$ M
   e. $1.5*10^{-6}$ M

2. For $BaSO_4$, $K_{sp} = 1.1*10^{-10}$. What is the molar solubility of $BaSO_4$ in a solution which is 0.018 M in Na_2SO_4?

   a. 0.018 M
   b. $7.8*10^{-5}$ M
   c. $1.1*10^{-5}$ M
   d. $6.1*10^{-9}$ M
   e. $1.1*10^{-10}$ M

3. In which of the following reactions do you expect to have the largest increase in entropy?

   a. $I_{2(s)} \rightarrow I_{2(g)}$
   b. $2\ IF_{(g)} \rightarrow I_{2(g)} + F_{2(g)}$
   c. $Mn_{(s)} + O_{2(g)} \rightarrow MnO_{2(s)}$
   d. $Hg_{(l)} + S_{(s)} \rightarrow HgS_{(s)}$
   e. $CuSO_{4(s)} + 5\ H_2O_{(l)} \rightarrow CuSO_4 \cdot 5H_2O_{(s)}$

4. For a particular reaction the equilibrium constant is $1.50*10^{-2}$ at 370 °C. ΔH° is +16.0 kJ. What is ΔS° for the reaction?

   a. -18.8 J/K
   b. +18.8 J/K
   c. -10.0 J/K
   d. +10.0 J/K
   e. None of the above

5. How many electrons are transferred in the following reaction:
   $2\ ClO_3^- + 12\ H^+ + 10\ I^- \rightarrow 5\ I_2 + Cl_2 + 6\ H_2O$

   a. 12
   b. 5
   c. 2
   d. 30
   e. 10

6. If a current of 6.0 amps is passed through a solution of $Ag^+_{(aq)}$ for 1.5 hours, how many grams of silver are produced?

a. 0.60 g
b. 36 g
c. 0.34 g
d. 3.0 g
e. 1.0 g

Here are the answers to the previous questions:

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1. What is the concentration of F^- in a saturated solution of BaF_2 if $K_{sp} = 1.7*10^{-6}$?

a. $7.5*10^{-3}$ M
b. $8.2*10^{-4}$ M
c. $1.5*10^{-2}$ M
d. $4.3*10^{-7}$ M
e. $1.5*10^{-6}$ M

Answer: Recall that the K_{sp} expression can be written as $K_{sp} = [Ba^{2+}][F^-]^2$ for BaF_2. One mole of BaF_2 creates two moles of F^- and one mole of Ba^{2+} per mol of BaF_2 dissolved. If x represents the amount of Ba^{2+} dissolved, then 2x represents the F^-, and we can re-write the K_{sp} expression as $K_{sp} = 1.7*10^{-6} = (x)(2x)^2 = (x)(4x^2) = 4x^3$. x represents the solubility of the BaF_2, and here $x = (1.7*10^{-6}/4)^{1/3} = 7.5*10^{-3}$ M. The concentration of $[F^-]$ will be twice as much as the solubility (since there are two F^- ions per BaF_2 molecule); hence, the concentration of F^- in a saturated BaF_2 solution will be $2(7.5*10^{-3}$ M$)$ = **$1.5*10^{-2}$ M**, answer **c**.

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2. For $BaSO_4$, $K_{sp} = 1.1*10^{-10}$. What is the molar solubility of $BaSO_4$ in a solution which is 0.018 M in Na_2SO_4?

a. 0.018 M
b. $7.8*10^{-5}$ M
c. $1.1*10^{-5}$ M
d. $6.1*10^{-9}$ M
e. $1.1*10^{-10}$ M

Answer: If we have a 0.018 M Na_2SO_4 solution, we have, therefore, a solution with $[SO_4^{2-}] = 0.018$ M and $[Na^+] = 0.036$ M.

K_{sp} for $BaSO_4 = [Ba^{2+}][SO_4^{2-}]$, and normally we would write $K_{sp} = x*x$ since both ions dissociate in a 1:1 ratio. x here is the solubility of the $BaSO_4$.

Here, however, we have a common ion present - namely sulfate. We can re-write the equation for K_{sp} as following:

$K_{sp} = [Ba^{2+}][SO_4^{2-}] = (x)(x+0.018)$ since the sulfate has contributions from both the $BaSO_4$ and the Na_2SO_4.

Normally x is much smaller than 0.018, and (x+0.018) will likely be approximately equal to 0.018 using significant figures. We can re-write the equation as:

$K_{sp} = [Ba^{2+}][SO_4^{2-}] = (x)(x+0.018) = (x)(0.018)$

Solving for x gives the solubility: $x = K_{sp}/0.018 = 1.1*10^{-10}/0.018 = 6.1*10^{-9}$

Note that x is much less than 0.018, making the assumption valid. Answer = **$6.1*10^{-9}$**, answer **d**.

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3. In which of the following reactions do you expect to have the largest increase in entropy?

a. $I_{s(s)} \rightarrow I_{2(g)}$
b. $2\ IF_{(g)} \rightarrow I_{2(g)} + F_{2(g)}$
c. $Mn_{(s)} + O_{2(g)} \rightarrow MnO_{2(s)}$
d. $Hg_{(l)} + S_{(s)} \rightarrow HgS_{(s)}$
e. $CuSO_{4(s)} + 5\ H_2O_{(l)} \rightarrow CuSO_4 \cdot 5H_2O_{(s)}$

Answer: Entropy will increase upon an increase in disorder. This can occur through several methods, including solids going to liquids and/or liquids going to gases. Another disorder enhancement comes about when a large molecule splits into many particles.

Option a shows a solid going to a gas. This would increase disorder; hence, this would increase the entropy.

Option b shows two gas molecules rearranging to make two more gas molecules. There is no disorder here except possibly in the fact that a mixed molecule (IF) is dissociating to "pure" elements (I_2 and F_2), which might lead to a decrease in entropy (less randomness in the elements than in the molecules.) Hence, this option will probably lead to a decrease in entropy instead of an increase.

Option c has a solid and gas combining to make a solid. Anytime gases become solids there is usually a decrease in entropy, not an increase. Also, two molecules are changing into one product: this is less disorder, and a lowering of entropy.

Option d is similar to option c except that a liquid is being forced to become a solid. This will also lead to a decrease in entropy. Also, two molecules are changing into one product: this is less disorder, and a lowering of entropy.

Option e is similar to option d in that a liquid is being turned into a solid. Note also how six reactant molecules are converting to one product molecule: this is a more ordered product state, which defeats entropy. Entropy will diminish here.

The only option which should increase the entropy is option **a**, the correct **answer** for this problem.

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4. For a particular reaction the equilibrium constant is $1.50*10^{-2}$ at 370 °C. ΔH° is +16.0 kJ. What is ΔS° for the reaction?

a. -18.8 J/K
b. +18.8 J/K
c. -10.0 J/K
d. +10.0 J/K
e. None of the above

Answer: To solve this problem we need two equations: $\Delta G = \Delta H - T\Delta S$, and $\Delta G = -RT \ln K$. Combining the equations leads to:

$\Delta G = \Delta H - T\Delta S = -RT \ln K$, or

$\Delta S = (RT \ln K + \Delta H)/T$

Converting °C to K and kJ to J gives:

$\Delta S = ((8.314 * 643\ K) \ln (1.50*10^{-2}) + (16.0*10^{3}\ J))/643\ K =$ **-10.0 J/K**, answer **c**.

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5. How many electrons are transferred in the following reaction:
$2\ ClO_3^- + 12\ H^+ + 10\ I^- \rightarrow 5\ I_2 + Cl_2 + 6\ H_2O$

a. 12
b. 5
c. 2
d. 30
e. 10

Answer: To solve this equation, we need to break the oxidizing and reducing portions into half reactions. Cl in chlorate changes its oxidation number upon going to Cl_2; I^- also changes its oxidation number upon going to I_2.

For the Cl:

$12\ H^+ + 2\ ClO_3^- \rightarrow Cl_2 + 6\ H_2O$

gives a balanced reaction for mass, but not for charge. The product side has no charge, the reactant side has a net +10 charge; hence, add 10 electrons to the reactant side to balance charge. The result:

$10\ e^- + 6\ H^+ + 2\ ClO_3^- \rightarrow Cl_2 + 3\ H_2O$

For the I^- side,

$2\ I^- \rightarrow I_2$

This equation is balanced for mass, but not charge: the reactant side has a net -2 charge, and the product side has no charge. Add 2 electrons to balance the equation for both mass and charge to get:

$2\ I^- \rightarrow I_2 + 2\ e^-$

We can now clearly see that the I^- is being oxidized (losing electrons) and the ClO_3^- is being reduced (gaining electrons.)

To balance the reaction, multiple the I^- equation by five to cancel the electrons. This results in ten net electrons being transferred from the I^- to the ClO_3^-, meaning that **10 electrons are being transferred**, answer **e**.

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6. If a current of 6.0 amps is passed through a solution of $Ag^{+}_{(aq)}$ for 1.5 hours, how many grams of silver are produced?

a. 0.60 g
b. 36 g
c. 0.34 g
d. 3.0 g
e. 1.0 g

Answer: Remember that an amp equals a Coulomb per second. In addition, the Faraday (96485 C/mol e^-) will be helpful, and each Ag^+ will need one electron to become $Ag_{(s)}$. Unit analysis will help to solve this problem:

6.0 amps = 6.0 C/s * (60 s/minute) * (60 minutes/hour) * 1.5 hours = 32400 C delivered to the Ag^+.

To find out the quantity of silver produced, use the Faraday constant and the atomic mass of silver.

32400 C * (mol e^- / 96485 C) * (mol Ag^+ / mol e^-) * (108 g Ag / mol Ag) = **36 g** of silver, answer **b**.