PLI 39

Tuesday July 26, 2016

Chapter 17 (Solubility) and Chapter 18 (Entropy)

1. What mass of ZnS (K_{sp} = 2.5 x 10^{-22}) will dissolve in 300.0 mL of 0.050 M $Zn(NO_3)2$? Ignore the basic properties of S^{2-}

$ZnS(s) \rightleftharpoons Zn^{2+}(aq) + S^{2-}(aq)$

I: 0.050, 0

C: +s, +s

E: 0.050+s, s

$K_{sp} = 2.5\times10^{-22} = s(0.050+s)$ ignore

$5.0\times10^{-21} = s$

$\frac{5.0\times10^{-21}\ mol\ S^{2-}}{1\ L} \times 0.300\ L =$

$1.5\times10^{-21}\ mol\ S^{2-} =$

$1.5\times10^{-21}\ mol\ ZnS$ dissolved $= 1.5\times10^{-19}$ g

2. If you add sodium sulfate to a solution containing these metal cations, each with a concentration of 0.13 M, what will be the concentration of the first ion that precipitates (Ba^{2+} or Sr^{2+}) when the second, more soluble salt begins to precipitate? (K_{sp} for $BaSO_4$ is 1.1×10^{-10}, K_{sp} for $SrSO_4$ is 3.4×10^{-7})? $BaSO_4$ precipitates first, so use use $SrSO_4$ for first step.

$K_{sp}\ SrSO_4 = 3.4\times10^{-7} = [Sr^{2+}][SO_4^{2-}]$

$3.4\times10^{-7} = [0.13][SO_4^{2-}]$

$2.6\times10^{-6} = SO_4^{2-}$

$K_{sp}\ BaSO_4 = [Ba^{2+}][2.6\times10^{-6}] = 1.1\times10^{-10}$

$[Ba^{2+}] = 4.2\times10^{-5}$ → concentration Ba^{2+} that remains in solution

3. The Ca^{2+} ion in hard water can be precipitated as $CaCO_3$ by adding soda ash, Na_2CO_3. If the calcium ion concentration in hard water is 0.017 M and if the Na_2CO_3 is added until the carbonate ion concentration is 0.048 M, what percentage of the calcium ions had been left in the water? (You may neglect carbonate ion hydrolysis.) K_{sp} = 3.4 × 10^{-9}

$K_{sp}\ CaCO_3 = 3.4\times10^{-9} = [Ca^{2+}][CO_3^{2-}]$

$3.4\times10^{-9} = [Ca^{2+}][0.048\ M]$

$7.08\times10^{-8} = [Ca^{2+}]$

concentration of Ca^{2+} that can remain in the solution. Therefore only $\frac{7.08\times10^{-8}}{0.017} \times 100\% = 4.2\times10^{-4}\%$ is left from the original amount.

4. In principle, the ions Ba^{2+} and Ca^{2+} can be separated by the difference in solubility of their fluorides, BaF_2 and CaF_2. If you have a solution that is 0.17 M in both Ba^{2+} and Ca^{2+}, CaF_2 will begin to precipitate first as fluoride ion is added slowly to the solution. What concentration of fluoride ion will precipitate the Ca^{2+} ion without precipitating BaF_2? What concentration of Ca^{2+} remains in solution when BaF_2 just begins to precipitate? ($K_{sp}(BaF_2) = 1.7 \times 10^{-6}$ and $K_{sp}(CaF_2) = 3.9 \times 10^{-11}$)

1) $K_{sp}\ BaF_2 = 1.7\times10^{-6} = [0.17][F^-]^2$

$3.2\times10^{-3} = [F^-]$

at this concentration of F^-, BaF_2 begins to precipitate. Any F^- concentration less than 3.2×10^{-6} will only precipitate CaF_2

2) $K_{sp}\ CaF_2 = [Ca^{2+}][3.16\times10^{-3}]^2$

$\frac{3.9\times10^{-6}}{} = [Ca^{2+}]$ ← concentration Ca^{2+} that remains in solution

5. For which of the following reactions is $\Delta S° > 0$?

a. $2NO(g) + 2H_2(g) \leftrightarrow N_2(g) + 2H_2O(l)$

b. $2NH_3(g) + 3N_2O(g) \leftrightarrow 4N_2(g) + 3H_2O(g)$

c. $NH_4I(s) \leftrightarrow NH_3(g) + HI(g)$

d. $2H_2O(g) + 2Cl_2(g) \leftrightarrow 4HCl(g) + O_2(g)$

e. $C_2H_4(g) + H_2O(g) \leftrightarrow CH_3CH_2OH(g)$

} qualitatively, $S°>0$ if more moles gas exist on product side than reactant side

6. Using standard absolute entropies at 298K, calculate the entropy change for the **system** when **1.94** moles of **N_2(g)** react at standard conditions.

$$N_2(g) + 3H_2(g) \leftrightarrow 2NH_3(g)$$

$S°\ N_2(g) = 191.6 \frac{J}{mol\cdot K}$ $S°\ H_2(g) = 130.7 \frac{J}{mol\cdot K}$ $S°\ NH_3(g) = 192.5 \frac{J}{mol\cdot K}$

$\Delta S° = \Delta S°_{products} - \Delta S°_{reactants}$

$= [2(192.5) - (191.6 + 3(130.7))]$

$\Delta S° = -198.7 \frac{J}{mol\cdot K}$

$1.94\ mol\ N_2 \left(\frac{1\ mol\ rxn}{1\ mol\ N_2}\right)\left(\frac{-198.7 \frac{J}{mol\cdot K}}{1\ mol\ rxn}\right) = -385.5 \frac{J}{K}$

7. Repeat the above calculations for 2.28 moles of liquid H_2O:

$$2H_2O(l) \leftrightarrow 2H_2(g) + O_2(g)$$

$S°\ H_2O(l) = 69.9 \frac{J}{mol\cdot K}$ $S°\ H_2(g) = 130.7 \frac{J}{mol\cdot K}$ $S°\ O_2(g) = 205.1 \frac{J}{mol\cdot K}$

$\Delta S° = (2(130.7) + 205.1) - (2((69.9)) = 326.7 \frac{J}{mol\cdot K}$

$2.28\ mol\ H_2O \left(\frac{1\ mol\ rxn}{2\ mol\ H_2O}\right)\left(\frac{326.7 \frac{J}{mol\cdot K}}{1\ mol\ rxn}\right) = 372.4 \frac{J}{K}$