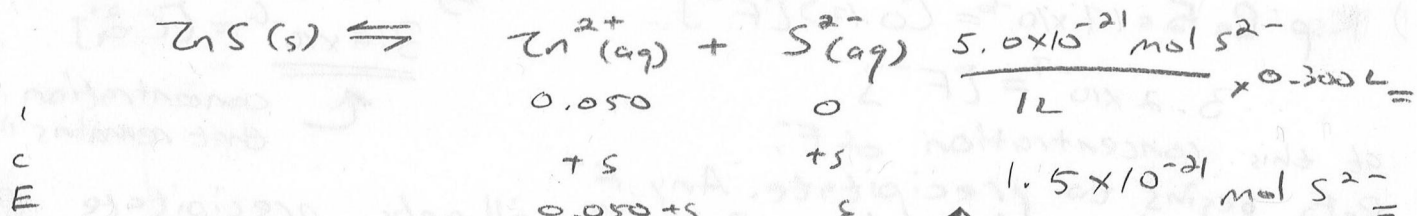


Tuesday July 26, 2016

Chapter 17 (Solubility) and Chapter 18 (Entropy)

1. What mass of ZnS ($K_{sp} = 2.5 \times 10^{-22}$) will dissolve in 300.0 mL of 0.050 M $\text{Zn}(\text{NO}_3)_2$?
Ignore the basic properties of S^{2-}



$K_{sp} = 2.5 \times 10^{-22} = \text{S}(0.050 + S)$ ignore $5.0 \times 10^{-21} = S$ $\uparrow$ $1.5 \times 10^{-21} \text{ mol ZnS dissolved} = 1.5 \times 10^{-19} \text{ g}$

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 SrSO_4 for first step.

$$K_{sp} \text{ SrSO}_4 = 3.4 \times 10^{-7} = [\text{Sr}^{2+}][\text{SO}_4^{2-}]$$

$$3.4 \times 10^{-7} = [0.13] \text{SO}_4^{2-}$$

$$2.6 \times 10^{-6} = \text{SO}_4^{2-}$$

$$K_{sp} \text{ BaSO}_4 = [\text{Ba}^{2+}][2.6 \times 10^{-6}] = 1.1 \times 10^{-10}$$

$$[\text{Ba}^{2+}] = 4.2 \times 10^{-5}$$

concentration Ba^{2+} that

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.) $K_{sp} = 3.4 \times 10^{-9}$ remains in solution

$$K_{sp} \text{ CaCO}_3 = 3.4 \times 10^{-9} = [\text{Ca}^{2+}][\text{CO}_3^{2-}]$$

$$3.4 \times 10^{-9} = [\text{Ca}^{2+}][0.048 \text{ M}]$$

$$7.08 \times 10^{-8} = [\text{Ca}^{2+}]$$

concentration of Ca^{2+} that can remain in the solution. Therefore only

$$\frac{7.08 \times 10^{-8}}{0.017} \times 100\% = 4.2 \times 10^{-4}\%$$

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? ($K_{\text{sp}}(\text{BaF}_2) = 1.7 \times 10^{-6}$ and $K_{\text{sp}}(\text{CaF}_2) = 3.9 \times 10^{-11}$)

$$1) K_{\text{sp}} \text{BaF}_2 = 1.7 \times 10^{-6} = [0.17][\text{F}^-]^2$$

$$3.2 \times 10^{-3} = [\text{F}^-]$$

at this concentration of F^- ,

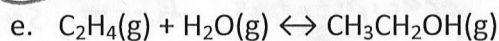
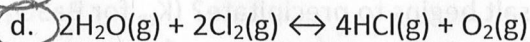
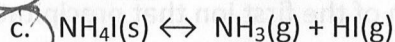
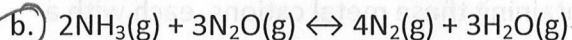
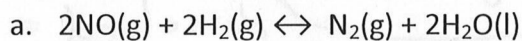
BaF_2 begins to precipitate. Any F^- concentration less than 3.2×10^{-3} will only precipitate CaF_2

$$2) K_{\text{sp}} \text{CaF}_2 = [\text{Ca}^{2+}][3.16 \times 10^{-3}]^2$$

$$3.9 \times 10^{-11} = [\text{Ca}^{2+}]$$

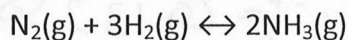
concentration Ca^{2+} that remains in solution

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



qualitatively, $S^\circ > 0$ 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 $\text{N}_2(\text{g})$ react at standard conditions.



$$S^\circ \text{N}_2(\text{g}) = 191.6 \frac{\text{J}}{\text{mol} \cdot \text{K}} \quad S^\circ \text{H}_2(\text{g}) = 130.7 \frac{\text{J}}{\text{mol} \cdot \text{K}} \quad S^\circ \text{NH}_3(\text{g}) = 192.5 \frac{\text{J}}{\text{mol} \cdot \text{K}}$$

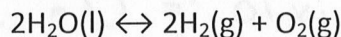
$$\Delta S^\circ = \Delta S^\circ \text{products} - \Delta S^\circ \text{reactants}$$

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

$$\Delta S^\circ = -198.7 \frac{\text{J}}{\text{mol} \cdot \text{K}}$$

$$1.94 \text{ mol N}_2 \left(\frac{1 \text{ mol rxn}}{1 \text{ mol N}_2} \right) \left(\frac{-198.7 \frac{\text{J}}{\text{mol} \cdot \text{K}}}{1 \text{ mol rxn}} \right) = -385.5 \frac{\text{J}}{\text{K}}$$

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



$$S^\circ \text{H}_2\text{O}(\text{l}) = 69.9 \frac{\text{J}}{\text{mol} \cdot \text{K}} \quad S^\circ \text{H}_2(\text{g}) = 130.7 \frac{\text{J}}{\text{mol} \cdot \text{K}} \quad S^\circ \text{O}_2(\text{g}) = 205.1 \frac{\text{J}}{\text{mol} \cdot \text{K}}$$

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

$$2.28 \text{ mol H}_2\text{O} \left(\frac{1 \text{ mol rxn}}{2 \text{ mol H}_2\text{O}} \right) \left(\frac{326.7 \frac{\text{J}}{\text{mol} \cdot \text{K}}}{1 \text{ mol rxn}} \right) = 372.4 \frac{\text{J}}{\text{K}}$$