Session #25: Homework Solutions

Problem #1

Bi_2S_3 dissolves in water according to the following reaction:

$$Bi_2S_3\ (s) \Leftrightarrow 2\ Bi^{3+}\ (aq) + 3\ S^{2-}\ (aq)$$

for which the solubility product, K_{sp}, has the value of 1.6×10^{-72} at room temperature.

(a) At room temperature how many moles of Bi_2S_3 will dissolve in 3.091×10^6 liters of water?

(b) How many Bi^{3+} ions will be found in the solution described in part (a)?

Solution

(a) $Bi_2S_3 = 2\ Bi^{3+}(aq) + 3\ S^{2-}(aq)$

$\therefore\ [Bi^{3+}] = 2\ C_s$ and $[s^2] = 3\ C_s$

$\therefore\ K_{sp} = (2\ C_s)^2\ (3\ C_s)^3 = 4\ C_s^2 \bullet 27\ C_s^3 = 108\ C_s^5$

$$\therefore\ C_s = \left(\frac{K_{sp}}{108}\right)^{1/5} = 1.715 \times 10^{-15}\ \text{mol/L}$$

$\therefore$ in 3.091×10^6 L $\Rightarrow$ 5.3×10^{-9} mol Bi_2S_3

(b) $[Bi^{3+}] = 2\ C_s = 1.06 \times 10^{-8}$ mol

N_{Av} ions/mol $\Rightarrow$ 6.38×10^{15} Bi^{3+} ions in the 3.091×10^6 liters of water of part (a)

Problem #2

Calculate the volume of 0.25 M NaI that would be needed to precipitate all the g^{2+} ion from 45 mL of a 0.10 M $Hg(NO_3)_2$ solution according to the following reaction:

$$2\ NaI(aq) + Hg(NO_3)_2(aq) \rightarrow HgI_2(s) + 2\ NaNO_3(aq)$$

Solution

$$2\ NaI(aq) + Hg(NO_3)_2(aq) \rightarrow HgI_2(s) + NaNO_3(aq)$$

$$\frac{0.10\ mol\ Hg(NO_3)_2}{1\ L} \times 0.045\ L = 4.5 \times 10^{-3}\ mol\ Hg(NO_3)_2$$

$$4.5 \times 10^{-3}\ mol\ Hg(NO_3)_2 \times \frac{2\ mol\ NaI}{1\ mol\ Hg(NO_3)_2} = 9.00 \times 10^{-3}\ mol\ NaI$$

$$\frac{9.00 \times 10^{-3}\ mol\ NaI}{0.25 \frac{mol\ NaI}{L}} = 3.6 \times 10^{-2}\ L \times \frac{1000ml}{1\ L} = 36\ mL\ NaI$$

Problem #3

(a) Strontium fluoride, SrF_2, has a K_{sp} value in water of 2.45×10^{-9} at room temperature.
Calculate the solubility of SrF_2 in water. Express your answer in units of molarity.

(b) Calculate the solubility of SrF_2 in 0.03 M NaF *(aq)*. Express your answer in units of molarity.
Assume that NaF is completely dissociated in water.

Solution

(a) $SrF_2 = Sr^{2+} + 2\ F^-$ $\quad K_{sp} = [Sr^{2+}][F^-]^2$, $\quad$ but $[F] = 2\ [Sr^{2+}] = 2c_s$

$$\therefore\ K_{sp} = c_s(2\ c_s)^2 = 4\ c_s^3 \quad \therefore \quad c_s = \left(\frac{K_{sp}}{4}\right)^{1/3} = 8.49 \times 10^{-4}\ M$$

(b) $NaF = Na^+ + F^-$

$\therefore [F] = 0.003$ M, which dominates the other equilibrium

$$\therefore\ K_{sp} = [Sr^{2+}][F^{-}]^2 \ \Rightarrow\ [Sr^{2+}] = \frac{K_{sp}}{[F^{-}]^2} = \frac{2.45x10^{-9}}{(0.03)^2} = 2.72x10^{-6}\ M$$

$$\therefore\ [Sr^{2+}] = c_s = 2.72x10^{-6}\ M$$

3.091SC Introduction to Solid State Chemistry
Fall 2009