Question 1
(10 points)

Answer the following questions about the solubility of some fluoride salts of alkaline earth metals.

(a) A student prepares 100. mL of a saturated solution of MgF_2 by adding 0.50 g of solid MgF_2 to 100. mL of distilled water at 25°C and stirring until no more solid dissolves. (Assume that the volume of the undissolved MgF_2 is negligibly small.) The saturated solution is analyzed, and it is determined that $[F^-]$ in the solution is $2.4 \times 10^{-3}\ M$.

(i) Write the chemical equation for the dissolving of solid MgF_2 in water.

$MgF_2(s) \rightleftarrows Mg^{2+}(aq) + 2\,F^-(aq)$	1 point is earned for the correct equation.

(ii) Calculate the number of moles of MgF_2 that dissolved.

$\frac{2.4 \times 10^{-3}\text{ mol } F^-}{1.0\text{ L}} \times 0.100\text{ L} \times \frac{1\text{ mol } MgF_2}{2\text{ mol } F^-} = 1.2 \times 10^{-4}\text{ mol } MgF_2$	1 point is earned for the correct calculation of moles from concentration. 1 point is earned for the correct stoichiometry.

(iii) Determine the value of the solubility-product constant, K_{sp}, for MgF_2 at 25°C.

$[Mg^{2+}] = \frac{1}{2}[F^-] = \frac{1}{2}(2.4 \times 10^{-3}\ M) = 1.2 \times 10^{-3}\ M$ $K_{sp} = [Mg^{2+}][F^-]^2 = (1.2 \times 10^{-3})(2.4 \times 10^{-3})^2$ $= 6.9 \times 10^{-9}$	1 point is earned for the correct value of $[Mg^{2+}]$ 1 point is earned for the correct setup for determining the value of K_{sp}. 1 point is earned for the correct value of K_{sp}.

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Question 1 (continued)

(b) A beaker contains 500. mL of a solution in which both $Ca^{2+}(aq)$ and $Ba^{2+}(aq)$ are present at a concentration of 0.10 M at 25°C. A student intends to separate the ions by adding 0.20 M NaF solution one drop at a time from a buret. At 25°C the value of K_{sp} for CaF_2 is 3.5×10^{-11}; the value of K_{sp} for BaF_2 is 1.8×10^{-6}.

(i) Which salt will precipitate first, CaF_2 or BaF_2 ? Justify your answer.

CaF_2 will precipitate first. Its K_{sp} value is smaller, thus the ion-concentration product $[Ca^{2+}][F^-]^2$ will be the first to exceed the K_{sp} value.	1 point is earned for the correct choice with its justification.

For parts (b)(ii) and (b)(iii) below, assume that the addition of the NaF solution does not significantly affect the total volume of the liquid in the beaker.

(ii) Calculate the minimum concentration of $F^-(aq)$ necessary to initiate precipitation of the salt selected in part (b)(i).

$K_{sp} = 3.5 \times 10^{-11} = [Ca^{2+}][F^-]^2 = (0.10)[F^-]^2$ $3.5 \times 10^{-10} = [F^-]^2$ $[F^-] = \sqrt{3.5 \times 10^{-10}} = 1.9 \times 10^{-5}\ M$	1 point is earned for the correct value of $[F^-]$.

(iii) Calculate the minimum volume of 0.20 M NaF that must be added to the beaker to initiate precipitation of the salt selected in part (b)(i).

Assuming that the volume of added $NaF(aq)$ is negligible, the total volume of the solution at the point of precipitation is 500. mL. $(0.20\ M)(V) = (1.9 \times 10^{-5}\ M)(0.500\ L)$ $V = 4.7 \times 10^{-5}$ L (or 4.8×10^{-5} L) $= 4.7 \times 10^{-2}$ mL (or 4.8×10^{-2} mL)	1 point is earned for the correct volume.

(c) There are several ways to dissolve salts that have limited solubility. Describe one procedure to redissolve the precipitate formed in part (b).

Valid procedures include adding water, adding acid (H^+), heating (i.e., increasing the temperature), and any valid statement that implies a shifting of the equilibrium toward the products side of the dissolution equation.	1 point is earned for a description of a valid procedure.

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