AP® CHEMISTRY
2010 SCORING GUIDELINES

Question 1
(10 points)

Several reactions are carried out using AgBr, a cream-colored silver salt for which the value of the solubility-product-constant, K_{sp}, is 5.0×10^{-13} at 298 K.

(a) Write the expression for the solubility-product constant, K_{sp}, of AgBr.

$K_{sp} = [Ag^+][Br^-]$	One point is earned for the correct expression (ion charges must be present; parentheses instead of square brackets not accepted).

(b) Calculate the value of $[Ag^+]$ in 50.0 mL of a saturated solution of AgBr at 298 K.

Let x = equilibrium concentration of Ag^+ (and of Br^-). Then $K_{sp} = 5.0 \times 10^{-13} = x^2 \Rightarrow x = 7.1 \times 10^{-7}\ M$	One point is earned for the correct value with supporting work (units not necessary).

(c) A 50.0 mL sample of distilled water is added to the solution described in part (b), which is in a beaker with some solid AgBr at the bottom. The solution is stirred and equilibrium is reestablished. Some solid AgBr remains in the beaker. Is the value of $[Ag^+]$ greater than, less than, or equal to the value you calculated in part (b) ? Justify your answer.

The value of $[Ag^+]$ after addition of distilled water is equal to the value in part (b). The concentration of ions in solution in equilibrium with a solid does <u>not</u> depend on the volume of the solution.	One point is earned for the correct answer with justification.

(d) Calculate the minimum volume of distilled water, in liters, necessary to completely dissolve a 5.0 g sample of AgBr(*s*) at 298 K. (The molar mass of AgBr is 188 g mol^{-1}.)

$5.0\text{ g AgBr} \times \frac{1\text{ mol AgBr}}{188\text{ g AgBr}} = 0.0266\text{ mol AgBr}$ $\frac{0.0266\text{ mol}}{\text{V}} = 7.1 \times 10^{-7}\text{mol L}^{-1} \Rightarrow \text{V} = 3.7 \times 10^{4}\text{ L}$	One point is earned for the calculation of moles of dissolved AgBr. One point is earned for the correct answer for the volume of water

Question 1 (continued)

(e) A student mixes 10.0 mL of $1.5 \times 10^{-4}\ M$ $AgNO_3$ with 2.0 mL of $5.0 \times 10^{-4}\ M$ NaBr and stirs the resulting mixture. What will the student observe? Justify your answer with calculations.

$[Ag^+] = \frac{(10.0\text{ mL})(1.5 \times 10^{-4}\ M)}{12.0\text{ mL}} = 1.3 \times 10^{-4}\ M$ $[Br^-] = \frac{(2.0\text{ mL})(5.0 \times 10^{-4} M)}{12.0\text{ mL}} = 8.3 \times 10^{-5}\ M$ $Q = [Ag^+][Br^-] = (1.3 \times 10^{-4}\ M)(8.3 \times 10^{-5}\ M) = 1.1 \times 10^{-8}$ $1.1 \times 10^{-8} > 5.0 \times 10^{-13}$, $\therefore$ a precipitate will form.	One point is earned for calculation of concentration of ions. One point is earned for calculation of Q and conclusion based on comparison between Q and K_{sp}. One point is earned for indicating the precipitation of AgBr.

(f) The color of another salt of silver, AgI(*s*), is yellow. A student adds a solution of NaI to a test tube containing a small amount of solid, cream-colored AgBr. After stirring the contents of the test tube, the student observes that the solid in the test tube changes color from cream to yellow.

(i) Write the chemical equation for the reaction that occurred in the test tube.

$AgBr(s) + I^-(aq) \rightarrow AgI(s) + Br^-(aq)$ ***OR*** $AgBr(s) + NaI(aq) \rightarrow AgI(s) + NaBr(aq)$	One point is earned for the correct equation.

(ii) Which salt has the greater value of K_{sp}: AgBr or AgI ? Justify your answer.

AgBr has the greater value of K_{sp}. The precipitate will consist of the less soluble salt when both $I^-(aq)$ and $Br^-(aq)$ are present. Because the color of the precipitate in the test tube turns yellow, it must be AgI(*s*) that precipitates; therefore K_{sp} for AgBr must be greater than K_{sp} for AgI. ***OR*** K_{eq} for the displacement reaction is $\frac{K_{sp}\text{ of AgBr}}{K_{sp}\text{ of AgI}}$. Because yellow AgI forms, $K_{eq} > 1$; therefore K_{sp} of AgBr > K_{sp} of AgI.	One point is earned for the correct choice with justification.