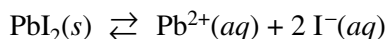


**AP[®] CHEMISTRY
2006 SCORING GUIDELINES**

Question 1

1. Answer the following questions that relate to solubility of salts of lead and barium.

- (a) A saturated solution is prepared by adding excess $\text{PbI}_2(s)$ to distilled water to form 1.0 L of solution at 25°C . The concentration of $\text{Pb}^{2+}(aq)$ in the saturated solution is found to be $1.3 \times 10^{-3} M$. The chemical equation for the dissolution of $\text{PbI}_2(s)$ in water is shown below.



- (i) Write the equilibrium-constant expression for the equation.

$K_{sp} = [\text{Pb}^{2+}][\text{I}^{-}]^2$	One point is earned for the correct expression.
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- (ii) Calculate the molar concentration of $\text{I}^{-}(aq)$ in the solution.

By stoichiometry, $[\text{I}^{-}] = 2 \times [\text{Pb}^{2+}]$, thus $[\text{I}^{-}] = 2 \times (1.3 \times 10^{-3}) = 2.6 \times 10^{-3} M$	One point is earned for the correct concentration.
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- (iii) Calculate the value of the equilibrium constant, K_{sp} .

$K_{sp} = [\text{Pb}^{2+}][\text{I}^{-}]^2 = (1.3 \times 10^{-3})(2.6 \times 10^{-3})^2$ $= 8.8 \times 10^{-9}$	One point is earned for a value of K_{sp} that is consistent with the answers in parts (a)(i) and (a)(ii).
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- (b) A saturated solution is prepared by adding $\text{PbI}_2(s)$ to distilled water to form 2.0 L of solution at 25°C . What are the molar concentrations of $\text{Pb}^{2+}(aq)$ and $\text{I}^{-}(aq)$ in the solution? Justify your answer.

The molar concentrations of $\text{Pb}^{2+}(aq)$ and $\text{I}^{-}(aq)$ would be the same as in the 1.0 L solution in part (a) (i.e., $1.3 \times 10^{-3} M$ and $2.6 \times 10^{-3} M$, respectively). The concentrations of solute particles in a saturated solution are a function of the constant, K_{sp} , which is independent of volume.	One point is earned for the concentrations (or stating they are the same as in the solution described in part (a)) and justification.
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Question 1 (continued)

- (c) Solid NaI is added to a saturated solution of PbI_2 at 25°C . Assuming that the volume of the solution does not change, does the molar concentration of $\text{Pb}^{2+}(\text{aq})$ in the solution increase, decrease, or remain the same? Justify your answer.

<p>$[\text{Pb}^{2+}]$ will decrease.</p> <p>The $\text{NaI}(\text{s})$ will dissolve, increasing $[\text{I}^-]$; more $\text{I}^-(\text{aq})$ then combines with $\text{Pb}^{2+}(\text{aq})$ to precipitate $\text{PbI}_2(\text{s})$ so that the ion product $[\text{Pb}^{2+}][\text{I}^-]^2$ will once again attain the value of 8.8×10^{-9} (K_{sp} at 25°C).</p>	<p>One point is earned for stating that $[\text{Pb}^{2+}]$ will decrease.</p> <p>One point is earned for justification (can involve a Le Chatelier argument).</p>
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- (d) The value of K_{sp} for the salt BaCrO_4 is 1.2×10^{-10} . When a 500. mL sample of $8.2 \times 10^{-6} M$ $\text{Ba}(\text{NO}_3)_2$ is added to 500. mL of $8.2 \times 10^{-6} M$ Na_2CrO_4 , no precipitate is observed.

- (i) Assuming that volumes are additive, calculate the molar concentrations of $\text{Ba}^{2+}(\text{aq})$ and $\text{CrO}_4^{2-}(\text{aq})$ in the 1.00 L of solution.

<p>New volume = 500. mL + 500. mL = 1.000 L, therefore $[\text{Ba}^{2+}]$ in 1.000 L is one-half its initial value:</p> $[\text{Ba}^{2+}] = \frac{500. \text{ mL}}{1,000. \text{ mL}} \times (8.2 \times 10^{-6} M) = 4.1 \times 10^{-6} M$ $[\text{CrO}_4^{2-}] = \frac{500. \text{ mL}}{1,000. \text{ mL}} \times (8.2 \times 10^{-6} M) = 4.1 \times 10^{-6} M$	<p>One point is earned for the correct concentration.</p>
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- (ii) Use the molar concentrations of $\text{Ba}^{2+}(\text{aq})$ ions and $\text{CrO}_4^{2-}(\text{aq})$ ions as determined above to show why a precipitate does not form. You must include a calculation as part of your answer.

<p>The product $Q = [\text{Ba}^{2+}][\text{CrO}_4^{2-}]$</p> $= (4.1 \times 10^{-6} M)(4.1 \times 10^{-6} M)$ $= 1.7 \times 10^{-11}$ <p>Because $Q = 1.7 \times 10^{-11} < 1.2 \times 10^{-10} = K_{sp}$, no precipitate forms.</p>	<p>One point is earned for calculating a value of Q that is consistent with the concentration values in part (d)(i).</p> <p>One point is earned for using Q to explain why no precipitate forms.</p>
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