

Worksheet 8 Addendum—More Solubility Problems

1. A solution is made with NaI and NaCl such that it is 0.01 M in both I^- and Cl^- . To 1 L of this solution 0.01 moles $\text{Ag}(\text{NO}_3)$ are added (you can ignore any volume change). The NaI, NaCl, and $\text{Ag}(\text{NO}_3)$ are completely soluble (as is NaNO_3 but you already knew that). The K_{SP} for AgI is 8.3×10^{-17} and for AgCl is 1.8×10^{-10} .

After the solution has reached equilibrium what are the concentrations of the following?

Will anything precipitate?

Initial concentration of $[\text{Ag}^+]$ is 0.01 M, $[\text{I}^-] = 0.01 \text{ M}$, $[\text{Cl}^-] = 0.01 \text{ M}$

$$Q_{\text{sp}} = [\text{Ag}^+][\text{I}^-] = (.01)(.01) = 10^{-4} \quad \text{AgI could precipitate}$$

$$Q_{\text{sp}} = [\text{Ag}^+][\text{Cl}^-] = (.01)(.01) = 10^{-4} \quad \text{AgCl could precipitate}$$

However AgI is much less soluble than AgCl. Assume the AgI precipitates completely to equilibrium

Then you have a saturated solution of AgI

Concentration of Ag^+ will be

$$K_{\text{sp}} = [\text{Ag}^+][\text{I}^-] \quad [\text{Ag}^+] = \sqrt{K_{\text{sp}}} = \sqrt{8.3 \times 10^{-17}} = 9.11 \times 10^{-9}$$

Given this concentration will the AgCl precipitate?

$$Q_{\text{sp}} = [\text{Ag}^+][\text{Cl}^-] = (9.11 \times 10^{-9})(.01) = 9.11 \times 10^{-11}$$

$$Q_{\text{sp}} < K_{\text{sp}} \text{ so no AgCl will precipitate}$$

$$[\text{Ag}^+] \quad 9.11 \times 10^{-9} \text{ M}$$

$$[\text{I}^-] \quad 9.11 \times 10^{-9} \text{ M}$$

$$[\text{Cl}^-] \quad 0.01 \text{ M}$$

Are there any solid precipitates? If so how many grams of each.

Only AgI will precipitate. Essentially all the silver will precipitate as AgI. That is 0.01 moles. $(0.01 \text{ mol})(234.8 \text{ g mol}^{-1}) = 2.35 \text{ g}$

2. The K_{sp} of $PbCl_2$ is 1.7×10^{-5} . How many grams of $PbCl_2$ will dissolve in 100 mL of a 0.1 M NaCl solution?

| | | |
|---|-----------|--------|
| | Pb^{2+} | Cl^- |
| I | 0 | .1 |
| C | +x | +2x |
| E | +x | .1+2x |

$$K_{sp} = [Pb^{2+}][Cl^-]^2 = (x)(.1 + 2x)^2 \sim (x)(.1)^2$$

$$[Pb^{2+}] = K_{sp}/[Cl^-]^2 = (1.7 \times 10^{-5})/(.1)^2 = 1.7 \times 10^{-3}$$

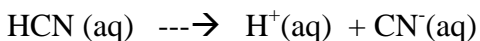
that will be $(1.7 \times 10^{-3} \text{ M})(.1 \text{ L}) = 1.7 \times 10^{-4}$ moles $PbCl_2$

$$(1.7 \times 10^{-4} \text{ moles})(278.1 \text{ g mol}^{-1}) = 0.047 \text{ g}$$

3. Will CaF_2 be more soluble in acid or base?

F^- is the conjugate base of the weak acid HF. In acid, F^- will form HF allowing more CaF_2 to dissolve.

4. Consider the following reactions



You a saturated solution of $AgCN$, what will the effect of each of the following (nothing, more $AgCN$ dissolves, some $AgCN$ precipitates)

What is the concentration of

A. Adding HNO_3

Increasing H^+ will cause more HCN to form lowering the CN^- concentration. More $AgCN$ will dissolve. (also the Cl^- concentration will increase. If it get high enough $AgCl$ will precipitate causing more $AgCN$ to dissolve)

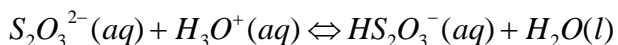
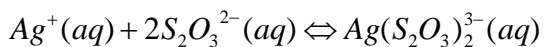
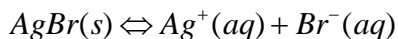
B. Adding KCN

Adding CN^- will cause some $AgCN$ to precipitate

C. Adding KNO_3

Adding K^+ and NO_3^- will do nothing

5. A blast from the past



What is the effect of each of these on the solubility of $AgBr(s)$

1. Adding the soluble salt KBr

This will decrease the solubility of the $AgBr$ as the concentration of Br^- will increase

2. Adding the soluble salt $Na_2S_2O_3$

This increase the solubility of the $AgBr$. The $S_2O_3^{2-}$ will react with the silver to form $Ag(S_2O_3)_2^{3-}$. This will decrease the Ag^+ concentration leading to more $AgBr$ dissolving.

3. Adding HCl

Adding HCl will casue the $S_2O_3^{2-}$ to form $HS_2O_3^-$. This will decrease in $S_2O_3^{2-}$. This will cause $Ag(S_2O_3)_2^{3-}$ to dissolve forming more Ag^+ . This will decrease the solubility of the $AgBr$

4. Adding solid $AgBr$

This will have no effect.