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 $Ag(NO_3)$ are added (you can ignore any volume change). The NaI, NaCl, and $Ag(NO_3)$ 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 $[Ag^+]$ is 0.01 M, $[I^-] = 0.01$ M, $[Cl^-] = 0.01$ M

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

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

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

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

Given this concentration will the AgCl precipitate?

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

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

$[Ag^+]$ 9.11×10^{-9} M

$[I^-]$ 9.11×10^{-9} M

$[Cl^-]$ 0.01 M

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

Only AgI will precipitate. Essentially all the silver will precipate as AgI. That is 0.01 moles. (0.01 mol)(234.8 g mol^{-1}) = 2.35 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 $(1.7 \times 10^{-3}$ M$)(.1$ L$) = 1.7 \times 10^{-4}$ moles $PbCl_2$

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

$AgCN(s) \longrightarrow Ag^+(aq) + CN^-(aq)$

$HCN(aq) \longrightarrow H^+(aq) + CN^-(aq)$

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

$$AgBr(s) \Leftrightarrow Ag^+(aq) + Br^-(aq)$$
$$Ag^+(aq) + 2S_2O_3^{2-}(aq) \Leftrightarrow Ag(S_2O_3)_2^{3-}(aq)$$
$$S_2O_3^{2-}(aq) + H_3O^+(aq) \Leftrightarrow HS_2O_3^-(aq) + H_2O(l)$$

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 $S_2O_3^-$ 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 $Ag(S_2O_3)^{3-}$ to dissolve forming more Ag^+. This will decrease the solubility of the AgBr

4. Adding solid AgBr

This will have no effect.