wkst 7d - Solubility + K_{sp}

① a) $Pb(NO_3)_2(aq) + 2HCl(aq) \rightarrow PbCl_2(s) + 2HNO_3(aq)$

$Pb^{2+}(aq) + 2Cl^-(aq) \rightarrow PbCl_2(s)$

b) $AgNO_3(aq) + LiOH(aq) \rightarrow AgOH(s) + LiNO_3(aq)$

$Ag^+(aq) + OH^-(aq) \rightarrow AgOH(s)$

c) $CuSO_4(aq) + K_2CO_3(aq) \rightarrow K_2SO_4(aq) + CuCO_3(s)$

$Cu^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CuCO_3(s)$

② a) $Ca_3(PO_4)_2(s) \rightleftharpoons 3Ca^{2+}(aq) + 2PO_4^{3-}(aq)$

b) $K_{sp} = [Ca^{2+}]^3[PO_4^{3-}]^2$

c) $Ca_3(PO_4)_2 \rightleftharpoons 3Ca^{2+} + 2PO_4^{3-}$

$3x \quad 2x$

$3(7.1\cdot10^{-7}M) \quad 2(7.1\cdot10^{-7}M)$

$2.1\cdot10^{-6} \quad 1.4\cdot10^{-6}M$

$K_{sp} = (2.1\cdot10^{-6})^3(1.4\cdot10^{-6})^2$

$= \boxed{1.8\cdot10^{-29}}$

③ a) $BaF_2(s) \rightleftharpoons Ba^{2+}(aq) + 2F^-(aq)$

$x \quad 2x$

$K_{sp} = [Ba^{2+}][F^-]^2 \qquad 1.7\cdot10^{-6} = (x)(2x)^2 = 4x^3$

$\boxed{x = .0075M}$

b) $\frac{.0075\,mol\ BaF_2}{L} \left| \frac{175.33g}{1\,mol} \right. = \boxed{1.3g/L}$

④ $AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq)$

$x \quad x$

$K_{sp} = [Ag^+][Cl^-]$

$1.8\cdot10^{-10} = x^2 \qquad x = 1.3\cdot10^{-5}M$

$Ag_2CO_3(s) \rightleftharpoons 2Ag^+(aq) + CO_3^{2-}(aq)$

$2x \quad x$

$K_{sp} = [Ag^+]^2[CO_3^{2-}]$

$8.1\cdot10^{-12} = (2x)^2(x) \qquad x = 1.3\cdot10^{-4}M$

NO, because $[Ag^+]$ is squared in K_{sp} expression for Ag_2CO_3, the actual molar solubility of Ag_2CO_3 is greater

* optional challenge *

⑤ 75mL .060M NaF

$M_1V_1 = M_2V_2$

$(.060M)(75mL) = (M_2)(100mL)$

$M_2 = [NaF] = .045M$

25 mL .15M $Sr(NO_3)_2$

$M_1V_1 = M_2V_2$

$(.15M)(25mL) = (M_2)(100mL)$

$M_2 = [Sr(NO_3)_2] = .038M$

$2NaF_{(aq)} + Sr(NO_3)_{2(aq)} \rightarrow 2NaNO_{3(aq)} + SrF_{2(s)}$

$SrF_{2(s)} \rightleftharpoons Sr^{2+}_{(aq)} + 2F^-_{(aq)}$

$K_{sp} = [Sr^{2+}][F^-]^2$

$2.0 \cdot 10^{-10} = (x)(2x)^2 = 4x^3$

$x = 3.7 \cdot 10^{-4} M$

$2x = 7.4 \cdot 10^{-4} M$

$[NO_3^-] = 2 \cdot .038M = .076M$

$[Na^+] = .045M$

$[F^-] = 7.4 \cdot 10^{-4} M$

$[Sr^{2+}] = .015M$

$Sr^{2+} + 2F^- \rightarrow SrF_2$

.038M .045M

.0038 mol + .0045 mol → .0023 mol produced

(.0038 mol: ER; .0045 mol: LR)

.0015 mol Sr^{2+} left over

⑥ $CaCO_{3(s)} \rightleftharpoons Ca^{2+} + CO_3^{2-}$

I	0	.010M
C	+x	+x
E	x	.010 + x ← x is negligible b/c of small K_{sp} (.010)

$K_{sp} = [Ca^{2+}][CO_3^{2-}]$

$4.9 \cdot 10^{-9} = (x)(.010)$

$x = 4.9 \cdot 10^{-7} M$

⑦ $SrCrO_{4(s)} \rightleftharpoons Sr^{2+} + CrO_4^{2-}$ $K_{sp} = 3.6 \cdot 10^{-5}$

$K_{sp} = [Sr^{2+}][CrO_4^{2-}]$

$Q = (1.0 \cdot 10^{-3} M)(3.0 \cdot 10^{-5} M) = 3.0 \cdot 10^{-8}$

$Q < K_{sp}$

no precipitate

⑧ $SrSO_4$ precipitate 1st

$PbSO_{4(s)} \rightleftharpoons Pb^{2+}_{(aq)} + SO_4^{2-}_{(aq)}$

$K_{sp} = [Pb^{2+}][SO_4^{2-}]$

$6.3 \cdot 10^{-7} = (1.0 \cdot 10^{-4})[SO_4^{2-}]$

$[SO_4^{2-}] = 6.3 \cdot 10^{-3} M$

$SrSO_{4(s)} \rightleftharpoons Sr^{2+}_{(aq)} + SO_4^{2-}_{(aq)}$

$K_{sp} = [Sr^{2+}][SO_4^{2-}]$

$3.4 \cdot 10^{-7} = (2.0 \cdot 10^{-3} M)[SO_4^{2-}]$

$[SO_4^{2-}] = 1.7 \cdot 10^{-4} M$

once $[SO_4^{2-}] > 1.7 \cdot 10^{-4} M$, $SrSO_4$ will precipitate

$6.3 \cdot 10^{-3} M > [SO_4^{2-}] > 1.7 \cdot 10^{-4} M$, only $SrSO_4$ will precipitate