KEY

Solubility Constant Product Calculations Practice

Part 2

1.) Will a precipitate form if $1.0\ L$ of $3.0 \times 10^{-10}\ M\ Fe^{+2}$ is added to $1.0\ L$ of $1.2 \times 10^{-8}\ M\ S^{-2}$?

Answer - $FeS_{(s)} \leftrightarrow Fe^{+2}{}_{(aq)} + S^{-2}{}_{(aq)}$ $K_{sp} = 6.0 \times 10^{-19}$

Do dilution first $C_cV_c = C_dV_d$ $[Fe^{+2}] = \frac{3.0\times10^{-10}\ M}{2.0\ L}$ $[S^{-2}] = \frac{1.2\times10^{-8}\ M}{2.0\ L}$

$K_{trial} = (Fe^{+2})(S^{-2})$ $K_{trial} = (1.5 \times 10^{-10})(6.0 \times 10^{-9})$ $K_{trial} = 9.0 \times 10^{-19}$

$K_{trial} > K_{sp}$ $\therefore$ *a precipitate will form.*

2.) What concentration of S^{-2} is required to just start precipitation of CuS from a $0.20\ M$ solution of $CuCl_2$?

Answer - $CuS_{(s)} \leftrightarrow Cu^{+2}{}_{(aq)} + S^{-2}{}_{(aq)}$ $K_{sp} = 6.0 \times 10^{-37}$

$CuCl_{2\,(s)} \leftrightarrow Cu^{+2}{}_{(aq)} + 2\ Cl^{-}{}_{(aq)}$ $1:1$ *ratio for* $CuCl_2 : Cu^{+2}$

$K_{sp} = (Cu^{+2})(S^{-2})$ $6.0 \times 10^{-37} = (0.20)(S^{-2})$ $S^{-2} = 3.0 \times 10^{-36}\ M$

3.) What F^{-} concentration is required to just start precipitating CaF_2 from a $3.0 \times 10^{-3}\ M$ solution of $CaNO_3$?

$K_{sp} = 1.5 \times 10^{-10}$ for CaF_2. $CaF_{2\,(s)} \leftrightarrow Ca^{+2}{}_{(aq)} + 2\ F^{-2}{}_{(aq)}$ $[Ca^{+2}] = 3.0 \times 10^{-3}\ M$

Answer - $K_{sp} = (Ca^{+2})(F^{-})^2$ $1.5 \times 10^{-10} = (3.0 \times 10^{-3})(F^{-})^2$ $F^{-} = 2.2 \times 10^{-4}\ M$

4.) Will a precipitate form when $10.0\ mL\ of\ 1.0 \times 10^{-3}\ M$ $Pb(NO_3)_2$ is added to $40.0\ mL\ of\ 1.5 \times 10^{-4}\ M$ Na_2SO_4?

Answer - $Pb^{+2}{}_{(aq)} + SO_4^{-2}{}_{(aq)} \leftrightarrow PbSO_{4\,(s)}$ $K_{sp}[PbSO_4] = 1.8 \times 10^{-8}$

Do dilution *both are* $1:1$ $C_cV_c = C_dV_d$ $[Pb^{+2}] = \frac{1.0\times10^{-3}\ M \times 0.010\ L}{0.050\ L}$ $[SO_4^{-2}] = \frac{1.5\times10^{-4}\ M \times 0.040\ L}{0.050\ L}$

$K_{trial} = (Pb^{+2})(SO_4^{-2})$ $K_{trial} = (2.0 \times 10^{-4})(1.2 \times 10^{-4})$ $K_{trial} = 2.4 \times 10^{-8}$

$K_{trial} > K_{sp}$ $\therefore$ *a precipitate will form.*

5.) A precipitate barely forms when $20.0\ mL\ of\ 3.0 \times 10^{-3}\ M\ Ni^{+2}$ is added to $60.0\ mL\ of\ 2.52 \times 10^{-4}\ M\ CO_3^{-2}$.

What is K_{sp} for $NiCO_3$? $Ni^{+2}{}_{(aq)} + CO_3^{-2}{}_{(aq)} \leftrightarrow NiCO_{3\,(s)}$

Answer - Do dilution $C_cV_c = C_dV_d$ $[Ni^{+2}] = \frac{3.0\times10^{-3}\ M \times 0.020\ L}{0.080\ L}$ $[CO_3^{-2}] = \frac{2.52\times10^{-4}\ M \times 0.060\ L}{0.080\ L}$

$K_{trial} = (Ni^{+2})(CO_3^{-2})$ $K_{sp} = (7.5 \times 10^{-4})(1.89 \times 10^{-4})$ $K_{sp} = 1.4175 \times 10^{-7}$

$K_{sp} = 1.4 \times 10^{-7}$

6.) Does a precipitate form when $25.0\ mL\ of\ 1.0 \times 10^{-4}\ M$ $Zn(NO_3)_2$ is added to $45.0\ mL\ of\ 2.4 \times 10^{-5}\ M$ $Ca(OH)_2$? $K_{sp} = 4.1 \times 10^{-17}$ for $Zn(OH)_2$. $Pb^{+2}{}_{(aq)} + SO_4^{-2}{}_{(aq)} \leftrightarrow PbSO_{4\,(s)}$

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Answer - $C_cV_c = C_dV_d$ $1:1\ ratio$ $[Zn^{+2}] = \frac{1.0\times10^{-4}\ M \times 0.025\ L}{0.070\ L}$ $= 3.5714 \times 10^{-5}\ M$

$1:2\ ratio$ $[OH^-] = \frac{2.4\times10^{-5}\ M \times 0.045\ L}{0.070\ L}$ $= 1.5429 \times 10^{-5} \times 2$ $= 3.09 \times 10^{-5}\ M$

$K_{trial} = (Zn^{+2})(OH^-)^2$ $K_{trial} = (3.5714 \times 10^{-5})(3.09 \times 10^{-5})^2$ $K_{trial} = 3.4 \times 10^{-14}$

$K_{trial} > K_{sp}$ $\therefore$ *a precipitate will form.*

7.) When $100.0\ mL\ of\ 4.0 \times 10^{-2}\ M$ $CaCl_2$ is added to $150.0\ mL\ of\ 2.9 \times 10^{-2}\ M$ NaOH, A precipitate of $Ca(OH)_2$ just starts to form. What is K_{sp} for $Ca(OH)_2$? $Ca^{+2}{}_{(aq)} + 2\ OH^{-2}{}_{(aq)} \leftrightarrow Ca(OH)_2{}_{(s)}$

Answer - $C_cV_c = C_dV_d$ $1:1\ ratio$ $[Ca^{+2}] = \frac{4.0\times10^{-2}\ M \times 0.100\ L}{0.250\ L}$ $= 1.60 \times 10^{-2}\ M$

$1:1\ ratio$ $[OH^-] = \frac{2.9\times10^{-2}\ M \times 0.150\ L}{0.250\ L}$ $= 1.74 \times 10^{-2}\ M$

$K_{trial} = (Ca^{+2})(OH^-)^2$ $K_{sp} = (1.6 \times 10^{-2})(1.74 \times 10^{-2})^2$ $K_{sp} = 4.84416 \times 10^{-6}$

$K_{sp} = 4.8 \times 10^{-6}$

8.) Does a precipitate form when $20.0\ mL\ of\ 5.0 \times 10^{-5}\ M\ Ca^{+2}$ is added to $35.0\ mL\ of\ 2.5 \times 10^{-4}\ M\ C_2O_4{}^{-2}$ and the resulting solution is boiled down to a total volume of $25.0\ mL$.

Answer – $Ca^{+2}{}_{(aq)} + C_2O_4{}^{-2}{}_{(aq)} \leftrightarrow CaC_2O_4{}_{(s)}$ $K_{sp}[CaC_2O_4] = 2.3 \times 10^{-9}$

$[Ca^{+2}] = \frac{5.0\times10^{-5}\ mol}{1\ L} \times \frac{0.020\ L}{0.025\ L}$ $= 4.0 \times 10^{-5}\ M$ $[C_2O_4{}^{-2}] = \frac{2.5\times10^{-4}\ mol}{1\ L} \times \frac{0.035\ L}{0.025\ L}$ $= 3.5 \times 10^{-4}\ M$

$K_{trial} = (Ca^{+2})(C_2O_4{}^{-2})$ $K_{trial} = (4.0 \times 10^{-5})(3.5 \times 10^{-4})$ $K_{trial} = 1.4 \times 10^{-8}$

$K_{trial} > K_{sp}$ $\therefore$ *a precipitate will form.*

9.) If $0.10\ M\ Pb^{+2}$ is added dropwise to a solution having $0.10\ M\ Cl^-$, $0.10\ M\ I^-$, and $0.10\ M\ SO_4{}^{-2}$, which precipitate will form first?

Answer – Solve which mixture needs the least amount of Pb^{+2} added.

1.) $Pb^{+2}{}_{(aq)} + 2\ Cl^-{}_{(aq)} \leftrightarrow PbCl_2{}_{(s)}$ $K_{sp}[PbCl_2] = 1.2 \times 10^{-5}$

$1.2 \times 10^{-5} = (Pb^{+2})(0.10)^2$ $[Pb^{+2}] = 1.2 \times 10^{-3}\ M$

2.) $Pb^{+2}{}_{(aq)} + 2\ I^-{}_{(aq)} \leftrightarrow PbI_2{}_{(s)}$ $K_{sp}[PbI_2] = 8.5 \times 10^{-9}$

$8.5 \times 10^{-9} = (Pb^{+2})(0.10)^2$ $[Pb^{+2}] = 8.5 \times 10^{-7}\ M$

3.) $Pb^{+2}{}_{(aq)} + SO_4{}^{-2}{}_{(aq)} \leftrightarrow PbSO_4{}_{(s)}$ $K_{sp}[PbSO_4] = 1.8 \times 10^{-8}$

$1.8 \times 10^{-8} = (Pb^{+2})(0.10)$ $[Pb^{+2}] = 1.8 \times 10^{-7}\ M$

$\therefore$ *$PbSO_4$ requires the smallest amount of lead.*