X) Type C Problems: Trial K_{sp}

When two soluble solutions are mixed, a cation from one solution is introduced to an anion from the other solution, and *visa versa*. One or both of the new ion combinations (cation and anion) could have low solubility. If this is the case, and there are too many of the low solubility ions present (more than what is necessary for a saturated solution), a precipitate will result. If there are not enough of the low solubility ions present to reach the saturation concentration, a precipitate will not form and the ions will stay dissolved in solution.

A Trial K_{sp} (same concept as a trial K_{eq}) can be calculated for these mixtures to deduce whether a precipitate will form or not when the two solutions are mixed.
If the trial K_{sp} is larger than the actual K_{sp}, the concentrations of low solubility ions is greater than saturation, so a precipitate will result. If the trial K_{sp} is smaller than the actual K_{sp}, the concentrations of low solubility ions has not yet reached saturation, therefore a precipitate will not form.

Example:

1. Will a precipitate form if 40.0mL of 8.0×10^{-3}M $Mg(NO_3)_2$ is mixed with 60.0mL of 1.0×10^{-2}M K_2CO_3?

V_i m_i V_i m_i

① $Mg(NO_3)_{2(aq)} + K_2CO_{3(aq)} \Rightarrow MgCO_{3(s)}$ (possible ppt) $+ KNO_{3(aq)}$

Mg^{2+} NO_3^- K^+ CO_3^{-2}

② mixing 2 solutions, effectively its a dilution: $40.0mL + 60.0mL = 100.0mL$

$m_i V_i = m_f V_f$ $V_f = 0.1000L$

$[Mg(NO_3)_2]_f = \frac{(8.0\times10^{-3}M)(0.0400L)}{(0.1000L)} \Rightarrow$

$= 3.2 \times 10^{-3}M$

③ $Mg(NO_3)_{2(aq)} \rightleftharpoons Mg^{2+}_{(aq)} + 2NO_{3(aq)}^-$ (possible ppt.)

$3.2\times10^{-3}M$ $\therefore 3.2\times10^{-3}M$

$[K_2CO_3]_f = \frac{(1.0\times10^{-2}M)(0.0600L)}{(0.1000L)} \Rightarrow$

$= 6.0\times10^{-3}M$

$K_2CO_{3(aq)} \rightleftharpoons 2K^+_{(aq)} + CO_3^{-2}{}_{(aq)}$

$6.0\times10^{-3}M$ $\therefore 6.0\times10^{-3}M$

④ Possible PPt.

$MgCO_{3(s)} \rightleftharpoons Mg^{2+}_{(aq)} + CO_3^{-2}{}_{(aq)}$

? $3.2\times10^{-3}M$ $6.0\times10^{-3}M$

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

$= (3.2\times10^{-3}M)(6.0\times10^{-3}M)$

"Actual" $K_{sp} = 6.8\times10^{-6}$ (table)

⑤ Trial $K_{sp} = 1.9\times10^{-5}$

A: Trial K_{sp} > actual K_{sp} ∴ solubility [ion] are greater than saturation, so a ppt will form

Example:

2. Will a precipitate form if 50.0mL of 0.00100M $CaCl_2$ is added to 50.0mL of 0.0100M Na_2SO_4?

① $CaCl_{2(aq)} + Na_2SO_{4(aq)} \rightarrow 2NaCl_{(aq)} + CaSO_{4(s)}$ possible ppt

② Since 2 solutions are mixed, a dilution occurs:

$50.0mL + 50.0mL = 100.0mL$

$= 0.1000L$

$[CaCl_2]_f = \frac{(0.00100M)(0.0500L)}{(0.1000L)} \Rightarrow$

$= 5.00\times10^{-4}M$

③ Calculate ion [conc.]

$CaCl_{2(aq)} \rightleftharpoons Ca^{2+}_{(aq)} + 2Cl^-_{(aq)}$

$\therefore [Ca^{2+}] = 5.00\times10^{-4}M$

$[CaCl_2]_f = \frac{\ldots}{(0.1000 L)}$

$= 5.00 \times 10^{-4} M$

$\therefore [Ca^{2+}] = 5.00 \times 10^{-4} M$

$[Na_2SO_4]_f = \frac{(0.0100 M)(0.0500 L)}{(0.1000 L)}$

$= 5.00 \times 10^{-3} M$

$\Rightarrow$ $Na_2SO_{4(aq)} \rightleftharpoons 2Na^+_{(aq)} + SO_4^{2-}{}_{(aq)}$ (1 : 2 : 1)

$\therefore [SO_4^{2-}] = 5.00 \times 10^{-3} M$

A: Trial Ksp < actual Ksp

∴ NO ppt formed

[ion] have NOT reached saturation

(4) Possible PPt:

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

$5.00 \times 10^{-4} M$, $5.00 \times 10^{-3} M$

$\therefore$ Trial $K_{sp} = [Ca^{2+}][SO_4^{2-}]$

$= (5.00 \times 10^{-4} M)(5.00 \times 10^{-3} M)$

Trial $K_{sp} = 2.5 \times 10^{-6}$

(5) "Actual" $K_{sp} = 7.1 \times 10^{-5}$

Assignment 8: Type C Exercises

1. Will a precipitate form when 1.0L of 3.0×10^{-10}M $Zn(NO_3)_2$ is added to 1.0L of 2.0×10^{-11}M Na_2S ?
2. Will a precipitate form when 2.0L of 6.7×10^{-3}M SrS is added to 1.0L of 4.3×10^{-4}M K_2SO_4 ?
3. Will a precipitate form when 1.0L of 5.0×10^{-4}M $MgCl_2$ is added to 1.0L of 2.0×10^{-2}M Na_2CO_3 ?

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