

[TP] K_{sp} for $M_2X(s) \rightleftharpoons 2\,M^+(aq) + X^{2-}(aq)$ is 8×10^{-11}. Assume a maximum of y moles of $M_2X(s)$ can dissolve in one liter. What is true for y?

25% 1. $K_{sp} = (2\,y)\,(y)$
25% 2. $K_{sp} = (2\,y)^2\,(y)$
25% 3. $K_{sp} = (y)^2\,(y)$
25% 4. None of the above

Response Counter

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Lecture 24 CH102 A1 (MWF 9:05 am)

Monday, March 27, 2017

- Complete Ch15: Solubility, precipitation, and complexation

Next lecture: Begin ch16: Electron transfer reactions and electrochemistry. For oxidation numbers and balancing redox equations, please work through http://goo.gl/MMEUCs.

Ch15: Solubility, precipitation, and complexation

Solubility equilibria

$$MX_2(s) \rightleftharpoons M^{2+}(aq) + 2\,X^-(aq),\ K = K_{sp}$$

Five kinds of problems

1. From solubility → get K_{sp}
2. From K_{sp} → get solubility
3. Solubility in presence of common ion
4. Will precipitation occur?
5. What remains after precipitation?

3. Solubility in presence of common ion

The molar solubility of CaF_2, $K_{sp} = 3.9 \times 10^{-11}$, is 0.00021 mol/L.
Calculate the molar solubility in a solution of 0.015 M NaF.

$$CaF_2(s) \rightleftharpoons Ca^{2+}(aq) + 2\,F^-(aq)$$

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3. Solubility in presence of common ion

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Calculate the molar solubility in a solution of 0.015 M NaF.

$$CaF_2(s) \rightleftharpoons Ca^{2+}(aq) + 2\,F^-(aq)$$

	MX_2	M^{2+}	X^-
Initial			
Change			
Equilibrium			

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Calculate the molar solubility in a solution of 0.015 M NaF.

$$CaF_2(s) \rightleftharpoons Ca^{2+}(aq) + 2\,F^-(aq)$$

	MX_2	M^{2+}	X^-
Initial	excess	0	c_{ion}
Change			
Equilibrium			

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3. Solubility in presence of common ion

The molar solubility of CaF_2, $K_{sp} = 3.9 \times 10^{-11}$, is 0.00021 mol/L.
Calculate the molar solubility in a solution of 0.015 M NaF.

$$CaF_2(s) \rightleftharpoons Ca^{2+}(aq) + 2\,F^-(aq)$$

	MX_2	M^{2+}	X^-
Initial	excess	0	c_{ion}
Change	$-\,x$	$+\,x$	$+\,2\,x$
Equilibrium	excess	x	$c_{ion} + 2\,x \approx c_{ion}$

$$K_{sp} = (M^{2+})(X^-)^2 = (x)(c_{ion})^2$$

Large c_{ion} makes x smaller

Answer: 1.7×10^{-7}, 0.08 % of the value in pure water!

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4. Will precipitation occur?

0.2 mmol of NaF and 10 mmol of $Ca(NO_3)_2$ are combined in a total volume of 1 L of water. Will a precipitate form? The K_{sp} of CaF_2 is 3.9×10^{-11}.

$$CaF_2(s) \rightleftharpoons Ca^{2+}(aq) + 2\ F^-(aq)$$

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$$CaF_2(s) \rightleftharpoons Ca^{2+}(aq) + 2\ F^-(aq)$$

	MX_2	M^{2+}	X^-
Initial			

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4. Will precipitation occur?

0.2 mmol of NaF and 10 mmol of $Ca(NO_3)_2$ are combined in a total volume of 1 L of water. Will a precipitate form? The K_{sp} of CaF_2 is 3.9×10^{-11}.

$$CaF_2(s) \rightleftharpoons Ca^{2+}(aq) + 2\ F^-(aq)$$

	MX_2	M^{2+}	X^-
Initial	0	c_M	c_X

Is $(M^{2+})(X^-)^2 = (c_M)(c_X)^2 = Q_{sp} > K_{sp}$?

If no, then no precipitation.

If yes, then a precipitate will form.

Answer: $Q_{sp} = 4 \times 10^{-10} > K_{sp}$, so $CaF_2(s)$ will precipitate

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5. What remains after precipitation

When 0.2 mmol of NaF and 10 mmol of $Ca(NO_3)_2$ are combined in 1 L of water, $CaF_2(s)$ precipitates. How much Ca^{2+} and F^- remain in solution? The K_{sp} of CaF_2 is 3.9×10^{-11}.

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5. What remains after precipitation

When 0.2 mmol of NaF and 10 mmol of $Ca(NO_3)_2$ are combined in 1 L of water, $CaF_2(s)$ precipitates. How much Ca^{2+} and F^- remain in solution?
The K_{sp} of CaF_2 is 3.9 x 10^{-11}.

	MX_2	M^{2+}	X^-
Initial mol			
Revised M			
Change			
Equilibrium			

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5. What remains after precipitation

When 0.2 mmol of NaF and 10.0 mmol of $Ca(NO_3)_2$ are combined in 1 L of water, $CaF_2(s)$ precipitates. How much Ca^{2+} and F^- remain in solution?
The K_{sp} of CaF_2 is 3.9 x 10^{-11}.

	MX_2	M^{2+}	X^-
Initial mol	0	0.0100 mol	0.0002 mol
Revised M			
Change			
Equilibrium			

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When 0.2 mmol of NaF and 10.0 mmol of $Ca(NO_3)_2$ are combined in 1 L of water, $CaF_2(s)$ precipitates. How much Ca^{2+} and F^- remain in solution?
The K_{sp} of CaF_2 is 3.9 x 10^{-11}.

	MX_2	M^{2+}	X^-
Initial mol	0	0.0100 mol	0.0002 mol
Revised M	0.0001 mol	0.0099 mol/V	0
Change			
Equilibrium			

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When 0.2 mmol of NaF and 10.0 mmol of $Ca(NO_3)_2$ are combined in 1 L of water, $CaF_2(s)$ precipitates. How much Ca^{2+} and F^- remain in solution?
The K_{sp} of CaF_2 is 3.9 x 10^{-11}.

	MX_2	M^{2+}	X^-
Initial	0	0.0100 mol	0.0002 mol
Revised	0.0001 mol	0.0099 mol/V	0
Change	$-y$	$+y$	$+2y$
Equilibrium			

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5. What remains after precipitation

When 0.2 mmol of NaF and 10.0 mmol of $Ca(NO_3)_2$ are combined in 1 L of water, $CaF_2(s)$ precipitates. How much Ca^{2+} and F^- remain in solution?
The K_{sp} of CaF_2 is 3.9 x 10^{-11}.

	MX_2	M^{2+}	X^-
Initial	0	0.0100 mol	0.0002 mol
Revised	0.0001 mol	0.0099 mol/V	0
Change	$-y$	$+y$	$+2y$
Equilibrium	≈ 0.0001 mol	≈ 0.0099 mol/V	$2y$

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5. What remains after precipitation

When 0.2 mmol of NaF and 10.0 mmol of $Ca(NO_3)_2$ are combined in 1 L of water, $CaF_2(s)$ precipitates. How much Ca^{2+} and F^- remain in solution?
The K_{sp} of CaF_2 is 3.9 x 10^{-11}.

	MX_2	M^{2+}	X^-
Initial	0	0.0100 mol	0.0002 mol
Revised	0.0001 mol	0.0099 mol/V	0/V
Change	$-y$	$+y$	$+2y$
Equilibrium	≈ 0.0001 mol	≈ 0.0099 mol/V	$2y$

$K_{sp} = (M^{2+})(X^-)^2 \approx (0.0099)\ (2\,y)^2$

Answer: $[Ca^{2+}] = 0.0099$ M, $[F^-] = 2$ y $= 0.000063$ M

Check: $Q_{sp} = (0.0099)(0.000063)^2 = 3.9 \times 10^{-11} = K_{sp}$

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Practice with solubility equilibria

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[TP] The expression for the equilibrium constant for the solubility equilibrium $M_2X(s) \rightleftharpoons 2\ M^+(aq) + X^{2-}(aq)$ is …

25% 1. $K_{sp} = (2\ M^+)\ (X^{2-})\ /\ (M_2X)$
25% 2. $K_{sp} = (2\ M^+)^2\ (X^{2-})\ /\ (M_2X)$
25% 3. $K_{sp} = (2\ M^+)^2\ (X^{2-})$
25% 4. $K_{sp} = (M^+)^2\ (X^{2-})$

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[TP] K_{sp} for $M_2X(s) \rightleftharpoons 2\ M^+(aq) + X^{2-}(aq)$ is 8×10^{-11}. Assume a maximum of y moles of $M_2X(s)$ can dissolve in one liter. What is true for y?

25% 1. $K_{sp} = (2\ y)\ (y)$
25% 2. $K_{sp} = (2\ y)^2\ (y)$
25% 3. $K_{sp} = (y)^2\ (y)$
25% 4. None of the above

Response Counter

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[Quiz] K_{sp} for $M_2X(s) \rightleftharpoons 2\ M^+(aq) + X^{2-}(aq)$ is 8×10^{-11}. Assume a maximum of y moles of $M_2X(s)$ can dissolve in one liter. What is true for y if $M^+(aq)$ is initially 0.1 M (that is, M^+ is a common ion)?

20% 1. $K_{sp} \approx (2 \times 0.1)\ (y)$
20% 2. $K_{sp} \approx (2 \times 0.1)^2\ (y)$
20% 3. $K_{sp} \approx (0.1)^2\ (y)$
20% 4. $K_{sp} \approx (0.1)\ (y)$
20% 5. None of the above

Response Counter

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