

Lecture 24 CH102 A1 (MWF 9 am) Spring 2017 Copyright © 2016 Dan Dill dan@bu.edu

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

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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>.

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Ch15: Solubility, precipitation, and complexation

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Solubility equilibria

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

Five kinds of problems

- From solubility \rightarrow get K_{sp}
- From $K_{sp} \rightarrow$ get solubility
- Solubility in presence of common ion
- Will precipitation occur?
- What remains after precipitation?

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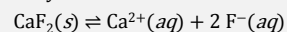
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3. Solubility in presence of common ion

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



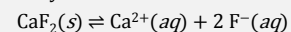
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Calculate the molar solubility in a solution of 0.015 M NaF.



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



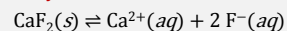
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Calculate the molar solubility in a solution of 0.015 M NaF.



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



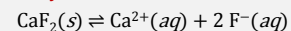
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Calculate the molar solubility in a solution of 0.015 M NaF.



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

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

Large c_{ion} makes x smaller

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



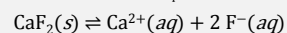
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4. Will precipitation occur?

0.2 mmol of NaF and 10 mmol of $\text{Ca}(\text{NO}_3)_2$ 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} .



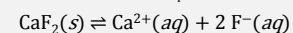
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	MX_2	M^{2+}	X^-
Initial			



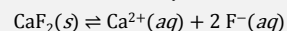
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0.2 mmol of NaF and 10 mmol of $\text{Ca}(\text{NO}_3)_2$ are combined in a total volume of 1 L of water. **Will a precipitate form?** The K_{sp} of CaF_2 is 3.9×10^{-11} .



	MX_2	M^{2+}	X^-
Initial	0	c_{M}	c_{X}

$$\text{Is } (\text{M}^{2+})(\text{X}^-)^2 = (c_{\text{M}})(c_{\text{X}})^2 = Q_{\text{sp}} > K_{\text{sp}}?$$

If no, then no precipitation.

If yes, then a precipitate will form.

Answer: $Q_{\text{sp}} = 4 \times 10^{-10} > K_{\text{sp}}$, so $\text{CaF}_2(s)$ will precipitate



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5. What remains after precipitation

When 0.2 mmol of NaF and 10 mmol of $\text{Ca}(\text{NO}_3)_2$ are combined in 1 L of water, $\text{CaF}_2(s)$ 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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The K_{sp} of CaF_2 is 3.9×10^{-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 $\text{Ca}(\text{NO}_3)_2$ are combined in 1 L of water, $\text{CaF}_2(s)$ precipitates. **How much Ca^{2+} and F^- remain in solution?**
The K_{sp} of CaF_2 is 3.9×10^{-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 $\text{Ca}(\text{NO}_3)_2$ are combined in 1 L of water, $\text{CaF}_2(s)$ precipitates. **How much Ca^{2+} and F^- remain in solution?**
The K_{sp} of CaF_2 is 3.9×10^{-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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5. What remains after precipitation

When 0.2 mmol of NaF and 10.0 mmol of $\text{Ca}(\text{NO}_3)_2$ are combined in 1 L of water, $\text{CaF}_2(s)$ precipitates. **How much Ca^{2+} and F^- remain in solution?**
The K_{sp} of CaF_2 is 3.9×10^{-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 $\text{Ca}(\text{NO}_3)_2$ are combined in 1 L of water, $\text{CaF}_2(s)$ precipitates. **How much Ca^{2+} and F^- remain in solution?**
The K_{sp} of CaF_2 is 3.9×10^{-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 $\text{Ca}(\text{NO}_3)_2$ are combined in 1 L of water, $\text{CaF}_2(s)$ precipitates. **How much Ca^{2+} and F^- remain in solution?**
The K_{sp} of CaF_2 is 3.9×10^{-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	$2y$

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

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

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



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Practice with solubility equilibria



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[TP] The expression for the equilibrium constant for the solubility equilibrium $\text{M}_2\text{X}(s) \rightleftharpoons 2 \text{M}^+(aq) + \text{X}^{2-}(aq)$ is ...

- 25% 1. $K_{\text{sp}} = (2 \text{M}^+) (\text{X}^{2-}) / (\text{M}_2\text{X})$
- 25% 2. $K_{\text{sp}} = (2 \text{M}^+)^2 (\text{X}^{2-}) / (\text{M}_2\text{X})$
- 25% 3. $K_{\text{sp}} = (2 \text{M}^+)^2 (\text{X}^{2-})$
- 25% 4. $K_{\text{sp}} = (\text{M}^+)^2 (\text{X}^{2-})$



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

Response
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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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