[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. $K_{sp} = (M^+)^2\ (X^{2-})$

Response Counter

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Lecture 23 CH102 A1 (MWF 9:05 am)

Friday, March 24, 2017

- Review: Buffer action
- Ch15: Solubility, precipitation, and complexation

Next lecture: Complete ch15. Begin ch16: Electron transfer reactions and electrochemistry.
Please work through the notes “Balancing redox equations” http://goo.gl/MMEUCs”

Different amounts of “not enough” base

At 25 °C, the pH of a 1.0 L solution pure water, $K_a = 1 \times 10^{-14}$ is …
pH = 7.00

Add 100. mL of 0.100 M HCl …
$[H_3O^+] = 0.010$ mol/1.10 L = 0.0091
pH = 2.04 (huge change!)

Buffers

Mixtures of a weak acid and its conjugate base (or weak base and its conjugate acid) exhibit the special property that they resist changes to pH.

For this reason such mixtures are known as buffers.

Buffers resist change in pH

Added strong base (say, OH^-) is gobbled up ...

↓$HA(aq) + OH^-(aq) \rightarrow H_2O(l) +$ ↑$A^-(aq)$

c_a lowered, c_b raised, c_a/c_b lowered

Added strong acid (say, HCl) is gobbled up ...

$HCl(aq) +$ ↓$A^-(aq) \rightarrow$ ↑$HA(aq) + Cl^-(aq)$

c_b lowered, c_a raised, c_a/c_b raised

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Buffers resist change in pH

The relative amounts of weak acid (weak base) and conjugate acid (conjugate base) do not have to be equal.

The closer they are, the closer the pH will be to pKa.

The closer they are, the greater the amount strong base or strong base that can be "buffered."

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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

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?

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[TP] At 25 °C, K_{sp} of CaF_2 3.9×10^{-11} . What is the maximum number of moles of CaF_2 that can dissolve in water at 25 °C?

17% 1. 0.002
17% 2. 0.01
17% 3. 0.0002
17% 4. 0.001
17% 5. 0.00002
17% 6. 0.0001

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Response Counter

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1. From K_{sp} → get solubility

What is the molar solubility of CaF_2? $K_{sp} = 3.9 \times 10^{-11}$

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

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1. From K_{sp} → get solubility

What is the molar solubility of CaF_2? $K_{sp} = 3.9 \times 10^{-11}$

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

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

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1. From K_{sp} → get solubility

What is the molar solubility of CaF_2? $K_{sp} = 3.9 \times 10^{-11}$

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

	MX_2	M^{2+}	X^-
Initial	excess	0	0
Change	$-x$	$+x$	$+2x$
Equilibrium	excess	x	$2x$

$$K_{sp} = (M^{2+})(X^-)^2 = (x)(2x)^2 = 4x^3$$

Answer: 0.00021 mol/L

Check: $0.00021 \times (2 \times 0.00021)^2 = 3.9 \times 10^{-11} = K_{sp}$

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2. From solubility → get K_{sp}

The solubility of magnesium phosphate is 0.000259 g/(100 g) of water at 20 °C. Calculate its K_{sp} at this temperature.

$$Mg_3(PO_4)_2 \rightleftharpoons 3\ Mg^{2+}(aq) + 2\ PO_4^{3-}(aq)$$

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2. From solubility → get K_{sp}

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$$Mg_3(PO_4)_2 \rightleftharpoons 3\ Mg^{2+}(aq) + 2\ PO_4^{3-}(aq)$$

	M_3X_2	M^{2+}	X^{3-}
Initial	excess	0	0
Change			
Equilibrium			

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$$Mg_3(PO_4)_2 \rightleftharpoons 3\ Mg^{2+}(aq) + 2\ PO_4^{3-}(aq)$$

	M_3X_2	M^{2+}	X^{3-}
Initial	excess	0	0
Change	$-\ x$	$+\ 3\ x$	$+\ 2\ x$
Equilibrium	excess	$3\ x$	$2\ x$

0.000259 g/100 g → mol/L = x

$$K_{sp} = (M^{2+})^3(X^{3-})^2 = (3\ x)^3(2\ x)^2 = 108\ x^5$$

Answer: 1.00×10^{-23}

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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.

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

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Initial			
Change			
Equilibrium			

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Change			
Equilibrium			

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	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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