18.2 Using Ksp in Calculations

Estimating Solubility

Which of the following salts is the **least soluble** in water?

a) AgBr Ksp = 3.3×10^{-13} @25°C

b) $Cu(OH)_2$ ✓ Ksp = 1.6×10^{-19} @25°C

c) $Ca_3(PO_4)_2$ Ksp = 1.0×10^{-25} @25°C

	$AgBr_{(s)}$	⇌	Ag^+	+	Br^-
I	Some		0		0
C	-s		s		s
E			s		s

$K_{sp} = [Ag^+][Br^-]$: $3.3 \times 10^{-13} = (s)(s)$

$s^2 = 3.3 \times 10^{-13}$

$s = \sqrt{3.3 \times 10^{-13}} = 5.47 \times 10^{-7}$

	$Cu(OH)_{2\,(s)}$	⇌	Cu^{2+}	+	$2\,OH^-$
I	Some		0		0
C	-s		s		2s
E			s		2s

$K_{sp} = [Cu^{2+}][OH^-]^2$

$1.6 \times 10^{-19} = (s)(2s)^2$

$4s^3 = 1.6 \times 10^{-19}$

$s^3 = 4.0 \times 10^{-20}$

$s = \sqrt[3]{4.0 \times 10^{-20}} = 3.42 \times 10^{-7}$

	$Ca_3(PO_4)_{2\,(s)}$	⇌	$3\,Ca^{2+}$	+	$2\,PO_4^{3-}$
I	Some		0		0
C	-s		3s		2s
E			3s		2s

$K_{sp} = [Ca^{2+}]^3[PO_4^{3-}]^2$

$1.0 \times 10^{-25} = (3s)^3(2s)^2$

$108s^5 = 1.0 \times 10^{-25}$

$s^5 = 9.3 \times 10^{-28}$

$s = \sqrt[5]{9.3 \times 10^{-28}} = 3.9 \times 10^{-6}$

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Estimating Solubility

General Formula	Example	K_{sp} Expression	K_{sp} as a Function of Molar Solubility (x)	Solubility (x) as a Function of K_{sp}
MY	AgCl	$K_{sp} = [M^+][Y^-]$	$K_{sp} = (x)(x) = x^2$	$x = \sqrt{K_{sp}}$
MY_2	HgI_2	$K_{sp} = [M^{2+}][Y^-]^2$	$K_{sp} = (x)(2x)^2 = 4x^3$	$x = \sqrt[3]{\frac{K_{sp}}{4}}$
MY_3	BiI_3	$K_{sp} = [M^{3+}][Y^-]^3$	$K_{sp} = (x)(3x)^3 = 27x^4$	$x = \sqrt[4]{\frac{K_{sp}}{27}}$
M_2Y_3	$Fe_2(SO_4)_3$	$K_{sp} = [M^{3+}]^2[Y^{2-}]^3$	$K_{sp} = (2x)^2(3x)^3 = 108x^5$	$x = \sqrt[5]{\frac{K_{sp}}{108}}$

Instead of memorizing these simply use the ICE method.

Note that in the ICE table for solubility we use 's' instead of 'x' simply because by solving for s, we have determined the solubility in mol. L^{-1} ... M

18.2 Using Ksp in Calculations

Predicting Whether a Solid Will Precipitate or Dissolve

$$AgCl_{(s)} \Leftrightarrow Ag^+ + Cl^-$$

$$Q = [Ag^+][Cl^-]$$

Compare Q to Ksp