

18.2 Using K_{sp} in Calculations

Estimating Solubility

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



- a) AgBr $K_{sp} = 3.3 \times 10^{-13}$ @25°C
 b) Cu(OH)₂ ✓ $K_{sp} = 1.6 \times 10^{-19}$ @25°C
 c) Ca₃(PO₄)₂ $K_{sp} = 1.0 \times 10^{-25}$ @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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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 ₂ Y ₃	Fe ₂ (SO ₄) ₃	$K_{sp} = [M^{3+}]^2[Y^{2-}]^3$	$K_{sp} = (2x)^2(3x)^3 = 108x^5$	$x = \sqrt[5]{\frac{K_{sp}}{108}}$

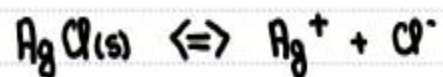
Instead of MEMORIZING these simply use the ICE method.

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



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Predicting Whether a Solid Will Precipitate or Dissolve



$$Q = [\text{Ag}^+][\text{Cl}^-]$$

Compare Q to K_{sp}

