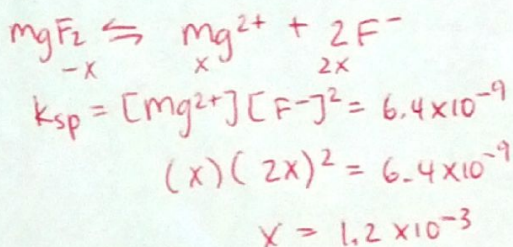
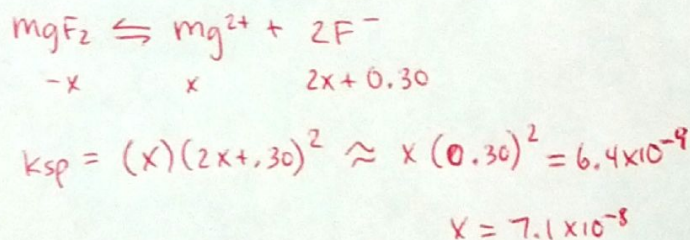


16 • Solubility Equilibria**STUDY QUESTIONS**

- Predict, on the basis of the solubility rules, which of the following salts are soluble and which are insoluble. For those that are "insoluble" look up their solubility products.
 - AgI *insoluble, 1.5×10^{-16}*
 - Na₃PO₄ *soluble*
 - BaSO₄ *insoluble, 1.5×10^{-9}*
 - (NH₄)₂SO₄ *soluble*
 - NiCO₃ *insoluble, 1.4×10^{-7}*
 - Cu(OH)₂ *insoluble, 1.6×10^{-19}*
- Write solubility product expressions for the following salts:
 - PbSO₄
 $K_{sp} = [Pb^{2+}][SO_4^{2-}]$
 - Ca₃(PO₄)₂
 $K_{sp} = [Ca^{2+}]^3[PO_4^{2-}]^2$
 - CuS
 $K_{sp} = [Cu^{2+}][S^{2-}]$
 - CaF₂
 $K_{sp} = [Ca^{2+}][F^-]^2$
- If the molar concentration of lead bromide, PbBr₂, in an aqueous solution is 1.6×10^{-6} M, what is [Pb²⁺] and [Br⁻]?
 $PbBr_2 \rightleftharpoons Pb^{2+} + 2Br^-$
 If [PbBr₂] = 1.6×10^{-6} M, then $\left\{ \begin{array}{l} [Pb^{2+}] = 1.6 \times 10^{-6} \text{ M} \\ [Br^-] = 3.2 \times 10^{-6} \text{ M} \end{array} \right.$
- If the molar solubility of silver iodide is 1.22×10^{-8} M, what is the solubility product for AgI?
 $K_{sp} = [Ag^+][I^-]$
 $= (1.22 \times 10^{-8})(1.22 \times 10^{-8}) = 1.49 \times 10^{-16}$
- What is the molar solubility of cadmium sulfide, CdS, if its $K_{sp} = 3.6 \times 10^{-29}$?
 $K_{sp} = [Cd^{2+}][S^{2-}] = 3.6 \times 10^{-29}$
 $(x)(x) = 3.6 \times 10^{-29}$
 $x = 6.0 \times 10^{-15}$
 molar solubility of CdS = 6.0×10^{-15} M
- K_{sp} of strontium fluoride, SrF₂, is 2.5×10^{-9} . What is the [Sr²⁺] and [F⁻] in a saturated solution of SrF₂? What is the molar solubility of SrF₂?
 $SrF_2 \rightleftharpoons Sr^{2+} + 2F^-$
 $-x \quad x \quad 2x$
 $K_{sp} = [Sr^{2+}][F^-]^2$
 $2.5 \times 10^{-9} = (x)(2x)^2$
 $x = 8.6 \times 10^{-4}$
 $[Sr^{2+}] = 8.6 \times 10^{-4}$ M
 $[F^-] = 1.7 \times 10^{-3}$ M
 Solubility SrF₂ = 8.6×10^{-4} M
- What is the [Mg²⁺] in a saturated solution of magnesium fluoride, MgF₂ if its solubility product constant is 6.4×10^{-9} ? What is the [Mg²⁺] if the solution also contains 0.30 M sodium fluoride?



$$[Mg^{2+}] = 1.2 \times 10^{-3} \text{ M}$$



$$[Mg^{2+}] = 7.1 \times 10^{-8} \text{ M}$$

(*) NOTE = solubility is reduced in the presence of the common ion.

8. From which of the following mixtures of silver nitrate and sodium sulfite would silver sulfite precipitate?

The K_{sp} for silver sulfite = 1.5×10^{-14} . $K_{sp} = [Ag^+]^2 [SO_3^{2-}] = 1.5 \times 10^{-14}$

- a. 50 mL of 1.0×10^{-4} M Ag^+ and 50 mL of 1.0×10^{-4} M SO_3^{2-} .

$$[Ag^+] = \frac{5.0 \times 10^{-6} \text{ mol}}{.100 \text{ L}} = 5.0 \times 10^{-5} \text{ M}$$

$$Q_{sp} = (5.0 \times 10^{-5})^2 (5.0 \times 10^{-5}) = 1.3 \times 10^{-13}$$

$$[SO_3^{2-}] = 5.0 \times 10^{-5} \text{ M}$$

$$Q_{sp} > K_{sp}$$

$\therefore$ precipitates

- b. 25 mL of 1.0×10^{-3} M Ag^+ and 25 mL of 1.0×10^{-5} M SO_3^{2-} .

$$[Ag^+] = 5.0 \times 10^{-4}$$

$$Q_{sp} = (5.0 \times 10^{-4})^2 (5.0 \times 10^{-6}) = 1.3 \times 10^{-12}$$

$$[SO_3^{2-}] = 5.0 \times 10^{-6}$$

$$Q_{sp} > K_{sp}$$

precipitates

- c. 50 mL of 1.0×10^{-5} M Ag^+ and 100 mL of 1.0×10^{-3} M SO_3^{2-} .

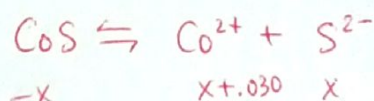
$$[Ag^+] = \frac{(.05)(1.0 \times 10^{-5}) \text{ mol}}{(.100 + .050) \text{ L}} = 3.3 \times 10^{-6}$$

$$Q_{sp} = (3.3 \times 10^{-6})^2 (6.7 \times 10^{-4}) = 7.4 \times 10^{-15}$$

$$[SO_3^{2-}] = \frac{(.100)(1.0 \times 10^{-3}) \text{ mol}}{(.100 + .050) \text{ L}} = 6.7 \times 10^{-4}$$

$$Q_{sp} < K_{sp} \quad \text{no precipitate}$$

9. Calculate the solubility in moles per Liter of cobalt(II) sulfide in a solution that contains 0.030 M cobalt(II) chloride. K_{sp} for cobalt sulfide $CoS = 5.9 \times 10^{-21}$.



$$K_{sp} = (x + 0.030)(x) \approx (.030)(x) = 5.9 \times 10^{-21}$$

$$x = 2.0 \times 10^{-19}$$

$$[S^{2-}] = 2.0 \times 10^{-19} \text{ M}$$

$$[CoS] = 2.0 \times 10^{-19} \text{ M}$$

10. Addition of a strong acid would increase the solubility of which of the following salts?

AgCl

CaSO₄

CdS

CaCO₃

PbBr₂

CaHPO₄

Cd(OH)₂

AuCl

Look for = anion that is a conjugate base of a weak acid

