Culver City H.S. • AP Chemistry

Name KEY
Period ___ Date ___/___/___

16 • Solubility Equilibria

STUDY QUESTIONS

1. 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.
   a. AgI insoluble, 1.5×10^{-16}
   b. Na_3PO_4 soluble
   c. $BaSO_4$ insoluble, 1.5×10^{-9}
   d. $(NH_4)_2SO_4$ soluble
   e. $NiCO_3$ insoluble, 1.4×10^{-7}
   f. $Cu(OH)_2$ insoluble, 1.6×10^{-19}

2. Write solubility product expressions for the following salts:
   a. $PbSO_4$ $K_{sp} = [Pb^{2+}][SO_4^{2-}]$
   b. $Ca_3(PO_4)_2$ $K_{sp} = [Ca^{2+}]^3[PO_4^{2-}]^2$
   c. CuS $K_{sp} = [Cu^{2+}][S^{2-}]$
   d. CaF_2 $K_{sp} = [Ca^{2+}][F^-]^2$

3. If the molar concentration of lead bromide, $PbBr_2$, in an aqueous solution is 1.6×10^{-6} M, what is $[Pb^{2+}]$ and $[Br^-]$?

   $PbBr_2 \rightleftharpoons Pb^{2+} + 2Br^-$

   If $[PbBr_2] = 1.6 \times 10^{-6}$ m, then $[Pb^{2+}] = 1.6 \times 10^{-6}$ M, $[Br^-] = 3.2 \times 10^{-6}$ M

4. If the molar solubility of silver iodide is 1.22×10^{-8} M, what is the solubility product for AgI?

   $K_{sp} = [Ag^+][I^-]$
   $= (1.22 \times 10^{-8})(1.22 \times 10^{-8}) = 1.49 \times 10^{-16}$

5. 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

6. K_{sp} of strontium fluoride, SrF_2, is 2.5×10^{-9}. What is the $[Sr^{2+}]$ and $[F^-]$ in a saturated solution of SrF_2? What is the molar solubility of SrF_2?

   $SrF_2 \rightleftharpoons Sr^{2+} + 2F^-$
   $-x \quad x \quad 2x$

   $K_{sp} = [Sr^{2+}][F^-]^2$
   $2.5 \times 10^{-9} = (x)(2x)^2$
   $x = 8.6 \times 10^{-4}$

   $[Sr^{2+}] = 8.6 \times 10^{-4}$ M
   $[F^-] = 1.7 \times 10^{-3}$ M
   Solubility $SrF_2 = 8.6 \times 10^{-4}$ M

7. What is the $[Mg^{2+}]$ in a saturated solution of magnesium fluoride, MgF_2 if its solubility product constant is 6.4×10^{-9}? What is the $[Mg^{2+}]$ if the solution also contains 0.30 M sodium fluoride?

   $MgF_2 \rightleftharpoons Mg^{2+} + 2F^-$
   $-x \quad x \quad 2x$

   $K_{sp} = [Mg^{2+}][F^-]^2 = 6.4 \times 10^{-9}$
   $(x)(2x)^2 = 6.4 \times 10^{-9}$
   $x = 1.2 \times 10^{-3}$

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

   $MgF_2 \rightleftharpoons Mg^{2+} + 2F^-$
   $-x \quad x \quad 2x + 0.30$

   $K_{sp} = (x)(2x + .30)^2 \approx x(0.30)^2 = 6.4 \times 10^{-9}$
   $x = 7.1 \times 10^{-8}$

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

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

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

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

$Q_{sp} > K_{sp}$

∴ precipitates

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

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

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

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

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

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

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

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

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

$= 7.4 \times 10^{-15}$

$Q_{sp} < K_{sp}$ 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 = 5.9×10^{-21}.

$CoS \rightleftharpoons Co^{2+} + S^{2-}$

$-x \quad x+.030 \quad x$

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

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

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

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

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

AgCl	$CaSO_4$	CdS	$CaCO_3$
$PbBr_2$	$CaHPO_4$	$Cd(OH)_2$	AuCl

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

HPO_4^{2-}, S^{2-}, OH^-, CO_3^{2-}