AP Chemistry

Name CALVIN
Period ___ Date ___/___/___

16 • Precipitation Reactions

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.

I a. AgI 1.5×10^{-16} I c. $BaSO_4$ 1.5×10^{-9} I e. $NiCO_3$ 1.4×10^{-7}

S b. Na_3PO_4 S d. $(NH_4)_2SO_4$ I f. $Cu(OH)_2$ 1.6×10^{-19}

2. Write solubility product expressions for the following salts:

a. $PbSO_4$ $K_{sp} = [Pb^{2+}][SO_4^{2-}]$

c. CuS $K_{sp} = [Cu^{2+}][S^{2-}]$

b. $Ca_3(PO_4)_2$ $K_{sp} = [Ca^{2+}]^3[PO_4^{3-}]^2$

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 $[Br^-]$?

$PbBr_{2(s)} \rightleftharpoons Pb^{2+} + 2Br^-$

$[Pb^{2+}] = 1.6\times10^{-6}M$ $[Br^-] = 3.2\times10^{-6}M$

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

$AgI \rightleftharpoons Ag^+ + I^-$ 1:1

	0	0
−	+s	+s
−	s	s

$K_{sp} = [1.22\times10^{-8}][1.22\times10^{-8}] = \boxed{1.49\times10^{-16}\,M^2}$

5. What is the molar solubility of cadmium sulfide, CdS, if its $K_{sp} = 3.6 \times 10^{-29}$?

$CdS \rightarrow Cd^{2+} + S^{2-}$ $3.6\times10^{-29} = s^2$

$K_{sp} = 3.6\times10^{-29} = [Cd^{2+}][S^{2-}]$ $\boxed{6.0\times10^{-15}M} = s$

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?

$SrF_2 \rightarrow Sr^{2+} + 2F^-$

	0	0
−	+x	+2x
−	x	2x

$K_{sp} = 2.5\times10^{-9} = [Sr^{2+}][F^-]^2$

$2.5\times10^{-9} = s\cdot(2s)^2$ $[Sr^{2+}] = \boxed{8.5\times10^{-4}M}$

$2.5\times10^{-9} = 4s^3$ $[F^-] = \boxed{1.7\times10^{-3}M}$

$s = 8.5\times10^{-4}M$

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?

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

	0	0
−	+x	+2x
−	x	2x

$K_{sp} = 6.4\times10^{-9} = [Mg^{2+}][F^-]^2$

$6.4\times10^{-9} = s\cdot(2s)^2$

$s = 1.2\times10^{-3}$

$[Mg^{2+}] = \boxed{1.2\times10^{-3}}$

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

	0	0.30
−	+x	+2x
−	x	0.30 + ~~2x~~ 0

$K_{sp} = 6.4\times10^{-9} = [Mg^{2+}][F^-]^2$

$6.4\times10^{-9} = (s)(0.30)^2$

$s = 7.1\times10^{-8}M$

$[Mg^{2+}] = \boxed{7.1\times10^{-8}M}$

$AgNO_3 \rightleftharpoons Ag^+ + NO_3^-$ $Na_2SO_3 \rightleftharpoons 2Na^+ + SO_3^{2-}$

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}.

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

$[Ag^+] = 0.050\,L \left| \frac{1.0\times10^{-4}\ mol}{1\ L} \right| \frac{1}{0.1\ L} = 5.0\times10^{-5}\ M$

$[SO_3^{2-}] = 0.050\,L \left| \frac{1.0\times10^{-4}\ mol}{1\ L} \right| \frac{1}{0.1\ L} = 5.0\times10^{-5}\ M$

$Ag_2SO_3 \rightleftharpoons 2Ag^+ + SO_3^{2-}$

$K_{sp} = 1.5\times10^{-14} = [Ag^+]^2[SO_3^{2-}]$

$Q = 1.3\times10^{-13} > K_{sp}$ yes

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

$[Ag^+] = 5.0\times10^{-4}\ M$ $[SO_3^{2-}] = 5.0\times10^{-6}\ M$

$Q = 1.3\times10^{-12} > K_{sp}$ yes

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

$[Ag^+] = 3.3\times10^{-6}\ M$ $[SO_3^{2-}] = 6.7\times10^{-4}\ M$

$Q = 7.3\times10^{-15} < K_{sp}$ no

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}.

$CoCl_2 \rightarrow Co^{2+} + 2Cl^-$

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

		Co^{2+}	S^{2-}
I	–	0.030	0
C	–	+s	+s
E	–	0.030 + s	s

$K_{sp} = [Co^{2+}][S^{2-}]$

$5.9\times10^{-21} = (0.030)(s)$

$s = 2.0\times10^{-19}\ M$

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~~

$AgCl \rightleftharpoons Ag^+ + Cl^-$

$Cl^- + H^+ \not\rightleftharpoons HCl$

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

$Br^- + H^+ \not\rightleftharpoons HBr$

$CaSO_4 \rightleftharpoons Ca^{2+} + SO_4^{2-}$

$SO_4^{2-} + H^+ \not\rightleftharpoons H_2SO_4$

$CaHPO_4 \rightleftharpoons Ca^{2+} + HPO_4^{2-}$

$HPO_4^{2-} + H^+ \rightleftharpoons H_2PO_4^-$

$CdS \rightleftharpoons Cd^{2+} + S^{2-}$

$S^{2-} + H^+ \rightleftharpoons HS^-$

$CaCO_3 \rightleftharpoons Ca^{2+} + CO_3^{2-}$

$CO_3^{2-} + H^+ \rightleftharpoons HCO_3^-$

$AuCl \rightleftharpoons Au^+ + Cl^-$

$Cl^- + H^+ \not\rightleftharpoons HCl$

Solubility of slightly soluble salts containing basic anions increases as $[H^+]$ increases (pH ↓)

Go Vikings!!