Solubility Equilibrium – Practice **Name:** Key

1) Write the balanced equation and solubility product expressions for the following solubility equilibria for the following compounds.
   a) Ag_2CrO_4 $\rightleftharpoons 2Ag^+ + CrO_4^{2-}$ $K_{sp} = [Ag^{\oplus}]^2[CrO_4^{2-}]$

   b) $AuCl_3$ $\rightleftharpoons Au^{3+} + 3Cl^{\ominus}$ $K_{sp} = [Au^{3+}][Cl^{\ominus}]^3$

2) Calculate the concentration of ions in the following saturated solutions:
   a) $[I^-]$ in AgI solution with $[Ag^+] = 9.1 \times 10^{-9}$ M. (K_{sp} : 8.3×10^{-17}) $AgI \rightleftharpoons Ag^{\oplus} + I^{\ominus}$

$8.3 \times 10^{-17} = [I^{\ominus}](9.1 \times 10^{-9})$

$[I^{\ominus}] = \frac{8.3 \times 10^{-17}}{9.1 \times 10^{-9}} = \boxed{9.1 \times 10^{-9}\ M}$

   b) $[Al^{3+}]$ in $Al(OH)_3$ solution with $[OH^-] = 2.9 \times 10^{-9}$ M. (K_{sp} : 1.8×10^{-33}) $Al(OH)_3 \rightleftharpoons Al^{3+} + 3OH^{\ominus}$

$K_{sp} = [Al^{3+}][OH^{\ominus}]^3$

$[Al^{3+}] = \frac{K_{sp}}{[OH^{\ominus}]^3} = \frac{1.8 \times 10^{-33}}{(2.9 \times 10^{-9})^3} = \boxed{7.4 \times 10^{-8} M}$

3) Calculate the solubility products (K_{sp}) for the following compounds:
   a) SrF_2 7.3×10^{-2} g/L

$7.3 \times 10^{-2} g/L \times \frac{1 mol\ SrF_2}{125.6 g} = 5.8 \times 10^{-4} mol/L\ (x)$

$SrF_2 \rightleftharpoons \underset{x}{Sr^{2+}} + \underset{2x^2}{2F^{\ominus}}$

$K_{sp} = (x)(2x)^2 = 4x^3 = 4(5.8 \times 10^{-4})^3 = \boxed{7.8 \times 10^{-10}}$

   b) Ag_3PO_4 6.7×10^{-3} g/L

$6.7 \times 10^{-3} g/L \times 1 mol/418.7 g = 1.6 \times 10^{-5} mol/L\ (x)$

$Ag_3PO_4 \rightleftharpoons \underset{3x}{3Ag^{\oplus}} + \underset{x}{PO_4^{3-}}$

$K_{sp} = (3x)^3(x) = 27x^4 = 27(1.6 \times 10^{-5})^4 = \boxed{1.8 \times 10^{-18}}$

4) The molar solubility of $MnCO_3$ is 4.2×10^{-6} M. What is the K_{sp} for this compound?

$MnCO_3 \rightleftharpoons \underset{x}{Mn^{2+}} + \underset{x}{CO_3^{2-}}$ $x = 4.2 \times 10^{-6} M$

$K_{sp} = (x)(x) = x^2 = (4.2 \times 10^{-6})^2 = \boxed{1.8 \times 10^{-11}}$

5) The solubility of an ionic compound MX (mol mass = 346 g/mol) is 4.63 x 10^{-3} g/L. What is the K_{sp} for this compound?

$4.63 \times 10^{-3} \frac{g}{L} \times \frac{1 mol}{346 g} = 1.34 \times 10^{-5} = s$

$MX \rightleftharpoons M^{\oplus} + X^{\ominus}$

$s \quad s$

$K_{sp} = (s)(s) = (1.34 \times 10^{-5})^2 = \boxed{1.8 \times 10^{-10}}$

6) What is the pH of a saturated zinc hydroxide solution? $Zn(OH)_2$. $K_{sp} = 1.8 \times 10^{-14}$.

$Zn(OH)_2 \rightleftharpoons Zn^{2+} + 2OH^{\ominus}$

$x \quad 2x$

$1.8 \times 10^{-14} = (x)(2x)^2$

$x = 1.65 \times 10^{-5} \equiv [OH^{\ominus}]$

$pOH = 4.48 \quad pH = 14 - 4.48 = \boxed{9.52}$

7) The solubility product of $PbBr_2$ is 8.9 x 10^{-6}. Determine the molar solubility in:

a) pure water,

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

$x \quad 2x$

$8.9 \times 10^{-6} = (x)(2x)^2$

$\boxed{x = 1.3 \times 10^{-2} M}$

b) 0.20 M KBr

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

0.20

$-\cancel{x} \quad +x \quad +2x$

$8.9 \times 10^{-6} = (x)(0.20 + 2x)^2$ ignore.

$\frac{8.9 \times 10^{-6}}{(0.2)^2} = x = \boxed{2.2 \times 10^{-4} M}$

c) 0.20 M $Pb(NO_3)_2$.

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

$0.2 \quad 0$

$+x \quad +2x$

$8.9 \times 10^{-6} = (0.2 + x)(2x)^2$ ignore.

$\frac{8.9 \times 10^{-6}}{0.2} = (2x)^2, \quad \boxed{x = 3.3 \times 10^{-3} M}$

8) If 20.0 mL of 0.10 M $Ba(NO_3)_2$ is added to 50.0 mL of 0.10 M Na_2CO_3, will $BaCO_3$ precipitate?

$K_{sp} = 8.1 \times 10^{-9}$.

$20\,mL \times \frac{0.1\,mol}{1000\,mL} = 2 \times 10^{-3}\,mol\ Ba^{2+}$

$50\,mL \times \frac{0.1\,mol}{1000\,mL} = 5 \times 10^{-3}\,mol\ CO_3^{2-}$

added. total vol. $20 + 50 = 70\,mL$

$\frac{2 \times 10^{-3}}{0.07L} = 2.9 \times 10^{-2}\,M\ Ba^{2+}$ $\quad \frac{5 \times 10^{-3}}{0.07L} = 7.1 \times 10^{-2}\,M\ CO_3^{2-}$

$BaCO_3 \rightleftharpoons \underset{s}{Ba^{2+}} + \underset{s}{CO_3^{2-}}$

$Q_{sp} = (2.9 \times 10^{-2})(7.1 \times 10^{-2}) = 2.1 \times 10^{-3}$

$\boxed{Q_{sp} > K_{sp}}$ | yes ppt forms.

9) Which of the following ionic compounds will be more soluble in acid solution than pure water: a) $BaSO_4$, $PbCl_2$, $Fe(OH)_3$, $CaCO_3$.

a) $BaSO_4$	b) $PbCl_2$	c) $Fe(OH)_3$	d) $CaCO_3$
little bit more in acid b/c SO_4^{2-} conj base of strong acid so weak base.	unaffected. Cl^{-} conj base of strong acid	more sol. in acid OH^{-} more sol. in acid	more sol. in H^{+} CO_3^{2-} is weak base