Practice/Solubility Equilibrium – Molar Solubility and K_{sp} ***DO NOT SUBMIT***

1) Write the balanced dissociation equation and solubility product expressions for the following compounds.

a) Ag_2CrO_4

$$Ag_2CrO_4 \rightleftharpoons 2\,Ag^{+}_{(aq)} + CrO_{4(aq)}^{2-}$$

$$K_{sp} = [Ag^{+}]^2[CrO_4^{2-}]$$

b) $AuCl_3$

$$\rightleftharpoons Au^{3+}_{(aq)} + 3Cl^{-}_{(aq)}.$$

$$K_{sp} = [Au^{3+}][Cl^{-}]^3$$

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}) (Ans: 9.1×10^{-9} M)

$$AgI \rightleftharpoons \underset{x}{Ag^{+}_{(aq)}} + \underset{x}{I^{-}_{(aq)}}$$

$$8.3\times10^{-17} = [I^-][9.1\times10^{-9}]$$

$$I^- = \frac{8.3\times10^{-17}}{9.1\times10^{-9}} = \boxed{9.1\times10^{-9}\ M}$$

b) $[Al^{3+}]$ in $Al(OH)_3$ solution with $[OH^-] = 2.9 \times 10^{-9}$ M. (K_{sp}: 1.8×10^{-33}) (Ans: 97.4×10^{-8} M)

$$Al(OH)_3 \rightleftharpoons \underset{x}{Al^{3+}_{(aq)}} + \underset{3x \;\to\; 2.9\times10^{-9}}{3OH^{-}_{(aq)}}$$

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

$$[Al^{3+}] = \frac{1.8\times10^{-33}}{(2.9\times10^{-9})^3} = \boxed{7.4\times10^{-8}\ M}$$

3) Calculate the molar solubility of $Mg_3(AsO_4)_2$. (K_{sp}: 2.0×10^{-20}) (Ans: 4.5×10^{-5} M)

$$Mg_3(AsO_4)_2 \rightleftharpoons \underset{3x}{3Mg^{2+}} + \underset{2x}{2AsO_4^{2-}}$$

$$K_{sp} = (3x)^3(2x)^2 = 108x^5$$

$$x = \sqrt[5]{\frac{2.0\times10^{-20}}{108}} = \boxed{4.5\times10^{-5}\ M}$$

4) Calculate the K_{sp} in the problems below.

a) $MnCO_3$ when its molar solubility is 4.2×10^{-6} M. (Ans: 1.8×10^{-11})

$MnCO_3 \rightleftharpoons Mn^{2+} + CO_3^{2-}$

$x \quad x$

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

b) CaF_2 when the molar solubility is 3.32×10^{-4} M. (Ans: 1.46×10^{-10})

$CaF_2 \rightleftharpoons Ca^{2+} + 2F^-$

$x \quad 2x$

$K_{sp} = (x)(2x)^2 = (3.32 \times 10^{-4})(2 \times 3.32 \times 10^{-4})^2$

$\boxed{K_{sp} = 1.46 \times 10^{-10}}$

c) The solubility of an ionic compound MX (mol mass = 346 g/mol) is 4.63×10^{-3} g/L. (Ans: 1.79×10^{-10})

$4.63 \times 10^{-3} \text{ g/L} \times \frac{1 \text{ mol}}{346 \text{ g}} = 1.34 \times 10^{-5} = x.$

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

$x \quad x$

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

5) What is the pH of a saturated zinc hydroxide solution? (K_{sp}: 1.8×10^{-14}) (Ans: 9.52)

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

$x \quad 2x$

$1.8 \times 10^{-14} = (x)(2x)^2 = 4x^3$

$x = \sqrt[3]{\frac{1.8 \times 10^{-14}}{4}} = 1.65 \times 10^{-5}$

$\times 2 \quad (\text{for } 2OH^{\ominus})$

3.3×10^{-5}

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

Practice/Solubility Equilibrium – Solubility and Predicting Precipitation ***DO NOT SUBMIT***

6) 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 x 10^{-9}) (Ans: Q_{sp} = 2.1 x 10^{-3} > K_{sp}, yes ppt occurs)

$\frac{20\,mL \times 0.1M}{(20+50)\,mL} = 2.9\times10^{-2}\,Ba^{2+}$ || $\frac{50\,mL \times 0.1M}{(20+50)\,mL} = 7.2\times10^{-2}\,CO_3^{2-}$

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

$x \quad x$

$Q_{sp} = (2.9\times10^{-2})(7.1\times10^{-2}) = 2.1\times10^{-3}$

$Q_{sp} > K_{sp}$ = yes ppt

7) Will there be a precipitation of $CaSO_4$ when 200 mL of a 0.0250 M calcium nitrate solution is mixed with 150 mL of 0.0750 M magnesium sulfate? (K_{sp} = 9.1 x 10^{-6}) (Ans: Q_{sp} is 4.59 x 10^{-4}, > K_{sp}, yes ppt occurs)

$\frac{200\,mL \times 0.025M}{(200+150)\,mL} = 0.0143M\ Ca^{2+}$ || $\frac{150\,mL \times 0.075M}{(200+150)\,mL} = 0.0321M\ SO_4^{2-}$

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

$x \quad x$

$Q_{sp} = (0.0143)(0.0321) = 4.596\times10^{-4}$

$Q_{sp} > K_{sp}$ = yes ppt

8) Which of the following ionic compounds will be more soluble in acid solution than pure water:

a) $BaSO_4$ ✓ Lithmore since SO_4^{2-} is CB of SA.

b) $PbCl_2$

c) $Fe(OH)_3$ ✓ OH^- will react with acid

d) $CaCO_3$. ✓ CO_3^{2-} is CB of WA so will react with acid.