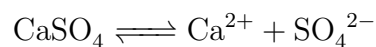


Ksp Problems (SCH 4U) - ANSWERS

1. Calculate the Ksp for each of the salts whose solubility is listed below.

(a) CaSO_4 solubility = 5.0×10^{-3} mol/L



$$[\text{Ca}^{2+}] = 5 \times 10^{-3} \text{ M}$$

$$[\text{SO}_4^{2-}] = 5 \times 10^{-3} \text{ M}$$

$$K_{\text{sp}} = [\text{Ca}^{2+}][\text{SO}_4^{2-}]$$

$$K_{\text{sp}} = (5 \times 10^{-3})^2$$

$$K_{\text{sp}} = 2.5 \times 10^{-5}$$

(b) MgF_2 solubility = 2.7×10^{-3} mol/L



$$[\text{Mg}^{2+}] = 2.7 \times 10^{-3} \text{ M}$$

$$[\text{F}^{1-}] = 2 \times (2.7 \times 10^{-3} \text{ M})$$

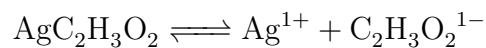
$$[\text{F}^{1-}] = 5.4 \times 10^{-3} \text{ M}$$

$$K_{\text{sp}} = [\text{Mg}^{2+}][\text{F}^{1-}]^2$$

$$K_{\text{sp}} = (2.7 \times 10^{-3})(5.4 \times 10^{-3})^2$$

$$K_{\text{sp}} = 7.87 \times 10^{-8}$$

(c) $\text{AgC}_2\text{H}_3\text{O}_2$ solubility = 10.2 p.p.m.



$$\frac{10.2 \text{ mg AgC}_2\text{H}_3\text{O}_2}{1 \text{ L}} \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ mol AgC}_2\text{H}_3\text{O}_2}{166.92 \text{ g AgC}_2\text{H}_3\text{O}_2} = 6.11 \times 10^{-5} \text{ mol/L}$$

$$[\text{Ag}^{1+}] = 6.11 \times 10^{-5} \text{ M}$$

$$[\text{C}_2\text{H}_3\text{O}_2^{1-}] = 6.11 \times 10^{-5} \text{ M}$$

$$K_{\text{sp}} = [\text{Ag}^{1+}][\text{C}_2\text{H}_3\text{O}_2^{1-}]$$

$$K_{\text{sp}} = (6.11 \times 10^{-5})^2$$

$$K_{\text{sp}} = 3.73 \times 10^{-9}$$

(d) SrF_2 solubility = 122 p.p.m.



$$\frac{122 \text{ mg SrF}_2}{1 \text{ L}} \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ mol SrF}_2}{125.62 \text{ g SrF}_2} = 9.71 \times 10^{-4} \text{ mol/L}$$

$$[\text{Sr}^{2+}] = 9.71 \times 10^{-4} \text{ M}$$

$$[\text{F}^{1-}] = 2 \times (9.71 \times 10^{-4}) \text{ M}$$

$$[\text{F}^{1-}] = 1.94 \times 10^{-3} \text{ M}$$

$$K_{\text{sp}} = [\text{Sr}^{2+}][\text{F}^{1-}]^2$$

$$K_{\text{sp}} = (9.71 \times 10^{-4})(1.94 \times 10^{-3})^2$$

$$K_{\text{sp}} = 3.66 \times 10^{-9}$$

2. Calculate the solubility in mol/L of each of these salts, determine the concentration of all ions and find the concentration of each cation in p.p.m. in each of the saturated solutions



Let s represent the solubility of AgCN

$$[\text{Ag}^{1+}] = s$$

$$[\text{CN}^{1-}] = s$$

$$K_{sp} = [\text{Ag}^{1+}][\text{CN}^{1-}]$$

$$2 \times 10^{-12} = s^2$$

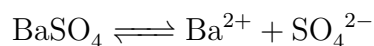
$$s = 1.41 \times 10^{-6} \text{ mol/L}$$

$$[\text{Ag}^{1+}] = 1.41 \times 10^{-6} \text{ M}$$

$$[\text{CN}^{1-}] = 1.41 \times 10^{-6} \text{ M}$$

$$\frac{1.41 \times 10^{-6} \text{ mol Ag}^{1+}}{1 \text{ L}} \times \frac{107.87 \text{ g Ag}^{1+}}{1 \text{ mol Ag}^{1+}} \times \frac{1000 \text{ mg}}{1 \text{ g}} = \frac{0.151 \text{ mg Ag}^{1+}}{1 \text{ L}}$$

$$\therefore 0.152 \text{ p.p.m. Ag}^{1+}$$



Let s represent the solubility of BaSO₄

$$[\text{Ba}^{2+}] = s$$

$$[\text{SO}_4^{2-}] = s$$

$$K_{sp} = [\text{Ba}^{2+}][\text{SO}_4^{2-}]$$

$$1.9 \times 10^{-9} = s^2$$

$$s = 3.87 \times 10^{-5} \text{ mol/L}$$

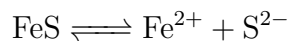
$$[\text{Ba}^{2+}] = 3.87 \times 10^{-5} \text{ M}$$

$$[\text{SO}_4^{2-}] = 3.87 \times 10^{-5} \text{ M}$$

$$\frac{3.87 \times 10^{-5} \text{ mol Ba}^{2+}}{1 \text{ L}} \times \frac{137.33 \text{ g Ba}^{2+}}{1 \text{ mol Ba}^{2+}} \times \frac{1000 \text{ mg}}{1 \text{ g}} = \frac{5.31 \text{ mg Ba}^{2+}}{1 \text{ L}}$$

$$\therefore 5.31 \text{ p.p.m. Ba}^{2+}$$

(c) FeS $K_{sp} = 3.7 \times 10^{-19}$



Let s represent the solubility of FeS

$$[\text{Fe}^{2+}] = s$$

$$[\text{S}^{2-}] = s$$

$$K_{sp} = [\text{Fe}^{2+}][\text{S}^{2-}]$$

$$3.7 \times 10^{-19} = s^2$$

$$s = 6.08 \times 10^{-10} \text{ mol/L}$$

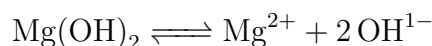
$$[\text{Fe}^{2+}] = 6.08 \times 10^{-10} \text{ M}$$

$$[\text{S}^{2-}] = 6.08 \times 10^{-10} \text{ M}$$

$$\frac{6.08 \times 10^{-10} \text{ mol Fe}^{2+}}{1 \text{ L}} \times \frac{55.85 \text{ g Fe}^{2+}}{1 \text{ mol Fe}^{2+}} \times \frac{1000 \text{ mg}}{1 \text{ g}} = \frac{0.0000340 \text{ mg Fe}^{2+}}{1 \text{ L}}$$

$$\therefore 0.0000340 \text{ p.p.m. Fe}^{2+}$$

(d) Mg(OH)₂ $K_{sp} = 9 \times 10^{-12}$



Let s represent the solubility of Mg(OH)₂

$$[\text{Mg}^{2+}] = s$$

$$[\text{OH}^{1-}] = 2s$$

$$K_{sp} = [\text{Mg}^{2+}][\text{OH}^{1-}]^2$$

$$9 \times 10^{-12} = (s)(2s)^2$$

$$9 \times 10^{-12} = (s)(4s^2)$$

$$9 \times 10^{-12} = 4s^3$$

$$s = 1.31 \times 10^{-4} \text{ mol/L}$$

$$[\text{Mg}^{2+}] = 1.31 \times 10^{-4} \text{ M}$$

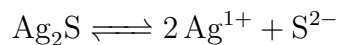
$$[\text{OH}^{1-}] = 2 \times (1.31 \times 10^{-4} \text{ M})$$

$$[\text{OH}^{1-}] = (2.62 \times 10^{-4} \text{ M})$$

$$\frac{1.31 \times 10^{-4} \text{ mol Mg}^{2+}}{1 \text{ L}} \times \frac{24.31 \text{ g Mg}^{2+}}{1 \text{ mol Mg}^{2+}} \times \frac{1000 \text{ mg}}{1 \text{ g}} = \frac{3.18 \text{ mg Mg}^{2+}}{1 \text{ L}}$$

$$\therefore 3.18 \text{ p.p.m. Mg}^{2+}$$

$$(e) \text{Ag}_2\text{S} \quad K_{sp} = 1.6 \times 10^{-49}$$



Let s represent the solubility of Ag_2S

$$[\text{Ag}^{1+}] = 2s$$

$$[\text{S}^{2-}] = s$$

$$K_{sp} = [\text{Ag}^{1+}]^2[\text{S}^{2-}]$$

$$1.6 \times 10^{-49} = (2s)^2(s)$$

$$1.6 \times 10^{-49} = (4s^2)(s)$$

$$1.6 \times 10^{-49} = 4s^3$$

$$s = 3.42 \times 10^{-17} \text{ mol/L}$$

$$[\text{Ag}^{1+}] = 2 \times (3.42 \times 10^{-17} \text{ M})$$

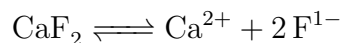
$$[\text{Ag}^{1+}] = 6.84 \times 10^{-17} \text{ M}$$

$$[\text{S}^{2-}] = 3.42 \times 10^{-17} \text{ M}$$

$$\frac{6.84 \times 10^{-17} \text{ mol Ag}^{1+}}{1 \text{ L}} \times \frac{107.87 \text{ g Ag}^{1+}}{1 \text{ mol Ag}^{1+}} \times \frac{1000 \text{ mg}}{1 \text{ g}} = \frac{7.38 \times 10^{-12} \text{ mg Ag}^{1+}}{1 \text{ L}}$$

$$\therefore 7.38 \times 10^{-12} \text{ p.p.m. Ag}^{1+}$$

$$(f) \text{CaF}_2 \quad K_{sp} = 4.9 \times 10^{-11}$$



Let s represent the solubility of CaF_2

$$[\text{Ca}^{2+}] = s$$

$$[\text{F}^{1-}] = 2s$$

$$K_{sp} = [\text{Ca}^{2+}][\text{F}^{1-}]^2$$

$$4.9 \times 10^{-11} = (s)(2s)^2$$

$$4.9 \times 10^{-11} = (s)(4s^2)$$

$$4.9 \times 10^{-11} = 4s^3$$

$$s = 2.31 \times 10^{-4} \text{ mol/L}$$

$$[\text{Ca}^{2+}] = 2.31 \times 10^{-4} \text{ M}$$

$$[\text{F}^{1-}] = 2 \times (2.31 \times 10^{-4} \text{ M})$$

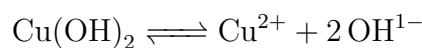
$$[\text{F}^{1-}] = (4.61 \times 10^{-4} \text{ M})$$

$$\frac{2.31 \times 10^{-4} \text{ mol Ca}^{2+}}{1 \text{ L}} \times \frac{40.08 \text{ g Ca}^{2+}}{1 \text{ mol Ca}^{2+}} \times \frac{1000 \text{ mg}}{1 \text{ g}} = \frac{9.26 \text{ mg Ca}^{2+}}{1 \text{ L}}$$

$$\therefore 9.26 \text{ p.p.m. Ca}^{2+}$$

3. For each of these substances, calculate the concentration of metallic ion in p.p.m. that can remain at equilibrium in a solution having a $[\text{OH}^{-}] = 1.0 \times 10^{-4} \text{ mol/L}$

(a) $\text{Cu}(\text{OH})_2$ $K_{\text{sp}} = 1.6 \times 10^{-19}$



$$[\text{Cu}^{2+}] = ?$$

$$[\text{OH}^{1-}] = 1.0 \times 10^{-4} \text{ M}$$

$$K_{\text{sp}} = [\text{Cu}^{2+}][\text{OH}^{1-}]^2$$

$$[\text{Cu}^{2+}] = \frac{K_{\text{sp}}}{[\text{OH}^{1-}]^2}$$

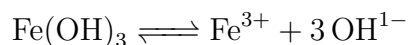
$$[\text{Cu}^{2+}] = \frac{1.6 \times 10^{-19}}{(1 \times 10^{-4})^2}$$

$$[\text{Cu}^{2+}] = 1.6 \times 10^{-11} \text{ M}$$

$$\frac{1.6 \times 10^{-11} \text{ mol Cu}^{2+}}{1 \text{ L}} \times \frac{63.55 \text{ g Cu}^{2+}}{1 \text{ mol Cu}^{2+}} \times \frac{1000 \text{ mg}}{1 \text{ g}} = \frac{1.02 \times 10^{-6} \text{ mg Cu}^{2+}}{1 \text{ L}}$$

$\therefore 1.02 \times 10^{-6} \text{ p.p.m. Cu}^{2+}$

(b) $\text{Fe}(\text{OH})_3$ $K_{\text{sp}} = 6.0 \times 10^{-38}$



$$[\text{Fe}^{3+}] = ?$$

$$[\text{OH}^{1-}] = 1.0 \times 10^{-4} \text{ M}$$

$$K_{\text{sp}} = [\text{Fe}^{3+}][\text{OH}^{1-}]^3$$

$$[\text{Fe}^{3+}] = \frac{K_{\text{sp}}}{[\text{OH}^{1-}]^3}$$

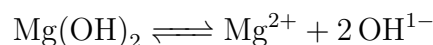
$$[\text{Fe}^{3+}] = \frac{6.0 \times 10^{-38}}{(1 \times 10^{-4})^3}$$

$$[\text{Fe}^{3+}] = 6.0 \times 10^{-26} \text{ M}$$

$$\frac{6.0 \times 10^{-26} \text{ mol Fe}^{3+}}{1 \text{ L}} \times \frac{55.85 \text{ g Fe}^{3+}}{1 \text{ mol Fe}^{3+}} \times \frac{1000 \text{ mg}}{1 \text{ g}} = \frac{3.35 \times 10^{-21} \text{ mg Fe}^{3+}}{1 \text{ L}}$$

$\therefore 3.35 \times 10^{-21} \text{ p.p.m. Fe}^{3+}$

(c) $\text{Mg}(\text{OH})_2$ $K_{\text{sp}} = 9.0 \times 10^{-12}$



$$[\text{Mg}^{2+}] = ?$$

$$[\text{OH}^{1-}] = 1.0 \times 10^{-4} \text{ M}$$

$$K_{\text{sp}} = [\text{Mg}^{2+}][\text{OH}^{1-}]^2$$

$$[\text{Mg}^{2+}] = \frac{K_{\text{sp}}}{[\text{OH}^{1-}]^2}$$

$$[\text{Mg}^{2+}] = \frac{9.0 \times 10^{-12}}{(1 \times 10^{-4})^2}$$

$$[\text{Mg}^{2+}] = 9.0 \times 10^{-4} \text{ M}$$

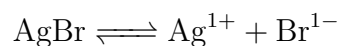
$$\frac{9.0 \times 10^{-4} \text{ mol Mg}^{2+}}{1 \text{ L}} \times \frac{24.31 \text{ g Mg}^{2+}}{1 \text{ mol cu}^{2+}} \times \frac{1000 \text{ mg}}{1 \text{ g}} = \frac{21.9 \text{ mg Mg}^{2+}}{1 \text{ L}}$$

$\therefore 21.9 \text{ p.p.m. Mg}^{2+}$

4. Calculate the $[\text{Ag}^+]$ in mol/L (M) needed to begin precipitation of each of these anions from solutions containing a concentration of 500 p.p.m. for each anion.

Please note that for each of the following, precipitation will begin once equilibrium concentrations are achieved, therefore calculations are done as equilibrium conditions

(a) Br^{1-}



$$[\text{Ag}^{1+}] = ?$$

$$[\text{Br}^{1-}] = \frac{500 \text{ mg Br}^{1-}}{1 \text{ L}} \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ mol Br}^{1-}}{79.90 \text{ g Br}^{1-}} = 6.25 \times 10^{-3} \text{ M}$$

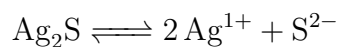
$$K_{\text{sp}} = [\text{Ag}^{1+}][\text{Br}^{1-}]$$

$$[\text{Ag}^{1+}] = \frac{K_{\text{sp}}}{[\text{Br}^{1-}]}$$

$$[\text{Ag}^{1+}] = \frac{7.7 \times 10^{-13}}{6.25 \times 10^{-3}}$$

$$[\text{Ag}^{1+}] = 1.23 \times 10^{-10} \text{ M}$$

(b) S^{2-}



$$[Ag^{1+}] = ?$$

$$[S^{2-}] = \frac{500 \text{ mg } S^{2-}}{1 \text{ L}} \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ mol } S^{2-}}{32.07 \text{ g } S^{2-}} = 1.56 \times 10^{-2} \text{ M}$$

$$K_{sp} = [Ag^{1+}]^2[S^{2-}]$$

$$[Ag^{1+}] = \sqrt{\frac{K_{sp}}{[S^{2-}]}}$$

$$[Ag^{1+}] = \sqrt{\frac{1.6 \times 10^{-49}}{1.56 \times 10^{-2}}}$$

$$[Ag^{1+}] = 3.20 \times 10^{-24} \text{ M}$$

(c) BrO_3^{1-}



$$[Ag^{1+}] = ?$$

$$[BrO_3^{1-}] = \frac{500 \text{ mg } BrO_3^{1-}}{1 \text{ L}} \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ mol } BrO_3^{1-}}{127.91 \text{ g } BrO_3^{1-}} = 3.91 \times 10^{-3} \text{ M}$$

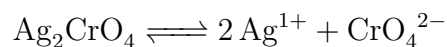
$$K_{sp} = [Ag^{1+}][BrO_3^{1-}]$$

$$[Ag^{1+}] = \frac{K_{sp}}{[BrO_3^{1-}]}$$

$$[Ag^{1+}] = \frac{6.0 \times 10^{-5}}{3.91 \times 10^{-3}}$$

$$[Ag^{1+}] = 1.53 \times 10^{-2} \text{ M}$$

(d) CrO_4^{2-}



$$[\text{Ag}^{1+}] = ?$$

$$[\text{CrO}_4^{2-}] = \frac{500 \text{ mg CrO}_4^{2-}}{1 \text{ L}} \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ mol CrO}_4^{2-}}{116.00 \text{ g CrO}_4^{2-}} = 4.31 \times 10^{-3} \text{ M}$$

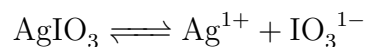
$$K_{\text{sp}} = [\text{Ag}^{1+}]^2[\text{CrO}_4^{2-}]$$

$$[\text{Ag}^{1+}] = \sqrt{\frac{K_{\text{sp}}}{[\text{CrO}_4^{2-}]}}$$

$$[\text{Ag}^{1+}] = \sqrt{\frac{1.1 \times 10^{-12}}{4.31 \times 10^{-3}}}$$

$$[\text{Ag}^{1+}] = 1.60 \times 10^{-5} \text{ M}$$

(e) IO_3^{1-}



$$[\text{Ag}^{1+}] = ?$$

$$[\text{IO}_3^{1-}] = \frac{500 \text{ mg IO}_3^{1-}}{1 \text{ L}} \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ mol IO}_3^{1-}}{174.90 \text{ g IO}_3^{1-}} = 2.86 \times 10^{-3} \text{ M}$$

$$K_{\text{sp}} = [\text{Ag}^{1+}][\text{IO}_3^{1-}]$$

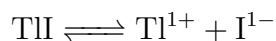
$$[\text{Ag}^{1+}] = \frac{K_{\text{sp}}}{[\text{IO}_3^{1-}]}$$

$$[\text{Ag}^{1+}] = \frac{3.1 \times 10^{-8}}{2.86 \times 10^{-3}}$$

$$[\text{Ag}^{1+}] = 1.08 \times 10^{-5} \text{ M}$$

5. How many mg of TlI can dissolve in 500 mL of:

(a) water



Let s represent the solubility of TlI

$$[\text{Tl}^{1+}] = s$$

$$[\text{I}^{1-}] = s$$

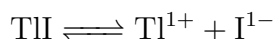
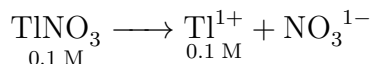
$$K_{\text{sp}} = [\text{Tl}^{1+}][\text{I}^{1-}]$$

$$8.9 \times 10^{-8} = s^2$$

$$s = 2.98 \times 10^{-4} \text{ mol/L}$$

$$500 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{2.98 \times 10^{-4} \text{ mol TlI}}{1 \text{ L}} \times \frac{331.27 \text{ g TlI}}{1 \text{ mol TlI}} \times \frac{1000 \text{ mg}}{1 \text{ g}} = 49.4 \text{ mg TlI}$$

(b) 0.1 mol/L TlNO₃



Let s represent the solubility of TlI

$$[\text{Tl}^{1+}] = s + 0.1$$

$$[\text{I}^{1-}] = s$$

$$K_{\text{sp}} = [\text{Tl}^{1+}][\text{I}^{1-}] *$$

$$8.9 \times 10^{-8} = (s + 0.1)(s)$$

$$\text{assume } s \lll 0.1$$

$$\therefore (s + 0.1) \simeq 0.1$$

$$8.9 \times 10^{-8} \simeq (0.1)(s)$$

$$s \simeq 8.9 \times 10^{-7} \text{ mol/L}$$

$$\therefore 8.9 \times 10^{-7} \lll 0.1 \quad \therefore \text{the assumption is valid}$$

$$500 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{8.9 \times 10^{-7} \text{ mol TlI}}{1 \text{ L}} \times \frac{331.27 \text{ g TlI}}{1 \text{ mol TlI}} \times \frac{1000 \text{ mg}}{1 \text{ g}} = 0.147 \text{ mg TlI}$$

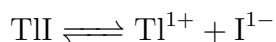
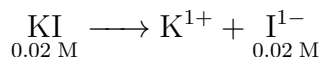
for exact solution see next page *

The exact solution requires using the quadratic formula starting from the K_{sp} expression. Please note the * above.

$$\begin{array}{l}
 K_{sp} = [Tl^{1+}][I^{1-}] * \\
 8.9 \times 10^{-8} = (s)(s + 0.1) \\
 8.9 \times 10^{-8} = s^2 + 0.1s \\
 0 = s^2 + 0.1s - 8.9 \times 10^{-8} \\
 s = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}
 \end{array}
 \quad \left| \quad
 \begin{array}{l}
 s = \frac{-0.1 \pm \sqrt{(0.1)^2 - 4(1)(-8.9 \times 10^{-8})}}{2(1)} \\
 s = \frac{-0.1 \pm 0.10000178}{2} \quad \begin{array}{l} \text{Be careful.} \\ \text{These digits} \\ \text{matter!!} \end{array} \\
 s = \underset{\text{extraneous}}{-0.1 \text{ mol/L}} \text{ or } s = 8.89992 \times 10^{-7} \text{ mol/L}
 \end{array}$$

This result is only slightly different than the result obtained using the assumption. The error generated through the assumption is only 0.0009 %. Assumptions are used to make the math easier. Checking the assumption validates its use. As a general rule, a 10 % error is acceptable!

(c) mol/L KI



Let s represent the solubility of TII

$$[\text{Tl}^{1+}] = s$$

$$[\text{I}^{1-}] = s + 0.02$$

$$K_{sp} = [\text{Tl}^{1+}][\text{I}^{1-}]$$

$$8.9 \times 10^{-8} = (s)(s + 0.02)$$

$$\text{assume } s \lll 0.02$$

$$\therefore (s + 0.02) \simeq 0.02$$

$$8.9 \times 10^{-8} \simeq (s)(0.02)$$

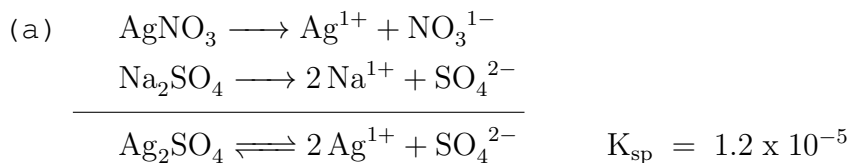
$$s \simeq 4.45 \times 10^{-6} \text{ mol/L}$$

$$\therefore 4.45 \times 10^{-6} \lll 0.02 \quad \therefore \text{the assumption is valid}$$

$$500 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{4.45 \times 10^{-6} \text{ mol TII}}{1 \text{ L}} \times \frac{331.27 \text{ g TII}}{1 \text{ mol TII}} \times \frac{1000 \text{ mg}}{1 \text{ g}} = 0.737 \text{ mg TII}$$

6. These questions require a comparison of the "solubility product constant" to the "solubility product". If:

$$\begin{aligned} K_{sp} &> [A^+][B^-] && \text{unsaturated, more can dissolve} \\ K_{sp} &= [A^+][B^-] && \text{saturated, at equilibrium} \\ K_{sp} &< [A^+][B^-] && \text{supersaturated, ppte is imminent} \end{aligned}$$



For $[\text{Ag}^{1+}]$:

$$10.0 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{0.01 \text{ mol}}{1 \text{ L}} = 1 \times 10^{-4} \text{ mol Ag}^{1+}$$

$$[\text{Ag}^{1+}] = \frac{n}{V}$$

$$[\text{Ag}^{1+}] = \frac{1 \times 10^{-4} \text{ mol Ag}^{1+}}{0.020 \text{ L}}$$

$$[\text{Ag}^{1+}] = 0.005 \text{ M}$$

For $[\text{SO}_4^{2-}]$:

$$10.0 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{0.10 \text{ mol}}{1 \text{ L}} = 1 \times 10^{-3} \text{ mol SO}_4^{2-}$$

$$[\text{SO}_4^{2-}] = \frac{n}{V}$$

$$[\text{SO}_4^{2-}] = \frac{1 \times 10^{-3} \text{ mol SO}_4^{2-}}{0.020 \text{ L}}$$

$$[\text{SO}_4^{2-}] = 0.05 \text{ M}$$

$$K_{sp} = [\text{Ag}^{1+}][\text{SO}_4^{2-}]$$

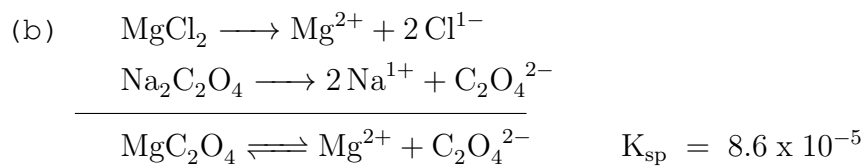
$$[\text{Ag}^{1+}][\text{SO}_4^{2-}] = (0.005)(0.05)$$

$$[\text{Ag}^{1+}][\text{SO}_4^{2-}] = 2.5 \times 10^{-4}$$

$$K_{sp} = 1.2 \times 10^{-5}$$

$$K_{sp} < [\text{Ag}^{1+}][\text{SO}_4^{2-}]$$

∴ therefore precipitate forms



For $[\text{Mg}^{2+}]$:

$$1 \text{ mg MgCl}_2 \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ mol MgCl}_2}{95.21 \text{ g MgCl}_2} \times \frac{1 \text{ mol Mg}^{2+}}{1 \text{ mol MgCl}_2} = 1.050 \times 10^{-5} \text{ mol Mg}^{2+}$$

$$[\text{Mg}^{2+}] = \frac{n}{V}$$

$$[\text{Mg}^{2+}] = \frac{1.050 \times 10^{-5} \text{ mol Mg}^{2+}}{1 \text{ L}^*}$$

$$[\text{Mg}^{2+}] = 1.050 \times 10^{-5} \text{ M}$$

* assume the 1 mg addition of MgCl_2 has a negligible effect on volume

For $[\text{C}_2\text{O}_4^{2-}]$:

$$1 \text{ L} \times \frac{0.01 \text{ mol Na}_2\text{C}_2\text{O}_4}{1 \text{ L}} \times \frac{1 \text{ mol C}_2\text{O}_4^{2-}}{1 \text{ mol Na}_2\text{C}_2\text{O}_4} = 0.01 \text{ mol C}_2\text{O}_4^{2-}$$

$$[\text{C}_2\text{O}_4^{2-}] = \frac{n}{V}$$

$$[\text{C}_2\text{O}_4^{2-}] = \frac{0.01 \text{ mol C}_2\text{O}_4^{2-}}{1 \text{ L}}$$

$$[\text{C}_2\text{O}_4^{2-}] = 0.01 \text{ M}$$

$$K_{\text{sp}} = [\text{Mg}^{2+}][\text{C}_2\text{O}_4^{2-}]$$

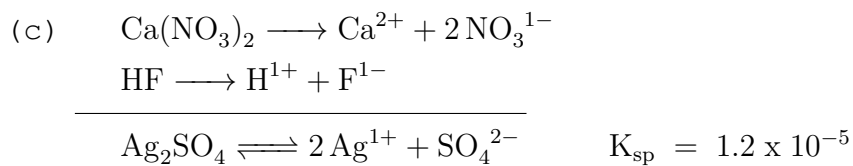
$$[\text{Mg}^{2+}][\text{C}_2\text{O}_4^{2-}] = (1.050 \times 10^{-5})(0.01)$$

$$[\text{Mg}^{2+}][\text{C}_2\text{O}_4^{2-}] = 1.050 \times 10^{-7}$$

$$K_{\text{sp}} = 8.6 \times 10^{-5}$$

$$K_{\text{sp}} > [\text{Mg}^{2+}][\text{C}_2\text{O}_4^{2-}]$$

\therefore therefore no precipitate forms



For $[\text{Ag}^{1+}]$:

$$10.0 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{0.01 \text{ mol}}{1 \text{ L}} = 1 \times 10^{-4} \text{ mol Ag}^{1+}$$

$$[\text{Ag}^{1+}] = \frac{n}{V}$$

$$[\text{Ag}^{1+}] = \frac{1 \times 10^{-4} \text{ mol Ag}^{1+}}{0.020 \text{ L}}$$

$$[\text{Ag}^{1+}] = 0.005 \text{ M}$$

For $[\text{SO}_4^{2-}]$:

$$10.0 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{0.01 \text{ mol}}{1 \text{ L}} = 1 \times 10^{-4} \text{ mol SO}_4^{2-}$$

$$[\text{SO}_4^{2-}] = \frac{n}{V}$$

$$[\text{SO}_4^{2-}] = \frac{1 \times 10^{-4} \text{ mol SO}_4^{2-}}{0.020 \text{ L}}$$

$$[\text{SO}_4^{2-}] = 0.005 \text{ M}$$

$$K_{\text{sp}} = [\text{Ag}^{1+}][\text{SO}_4^{2-}]$$

$$[\text{Ag}^{1+}][\text{SO}_4^{2-}] = (0.005)^2$$

$$[\text{Ag}^{1+}][\text{SO}_4^{2-}] = 2.5 \times 10^{-5}$$

$$K_{\text{sp}} = 1.2 \times 10^{-5}$$

$$K_{\text{sp}} < [\text{Ag}^{1+}][\text{SO}_4^{2-}]$$

\therefore no precipitate forms

(d) dddddddd

(e) xxxxxxxx