

# KSP PROBLEM SHEET



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

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

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

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

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



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

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

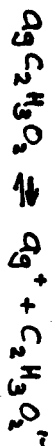
$$= 5.4 \times 10^{-3} \text{ M}$$

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

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

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

c)  $\frac{1.02 \text{ g}}{100 \text{ mL}} \times \frac{1000 \text{ mL}}{1 \text{ L}} \times \frac{1 \text{ mol}}{166.92 \text{ g}} = 6.11 \times 10^{-2} \text{ M}$



$$[\text{Ag}^+] = 6.11 \times 10^{-2} \text{ M}$$

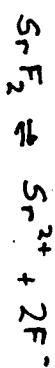
$$[\text{C}_2\text{H}_3\text{O}_2^-] = 6.11 \times 10^{-2} \text{ M}$$

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

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

$$K_{sp} = 3.73 \times 10^{-3}$$

d)  $\frac{12.2 \text{ mg}}{100 \text{ mL}} \times \frac{1000 \text{ mL}}{1 \text{ L}} \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ mol}}{125.62 \text{ g}} = 9.71 \times 10^{-4} \text{ M}$



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

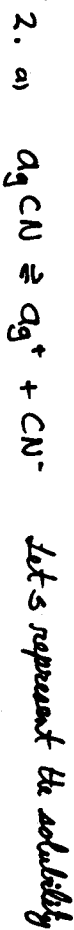
$$[\text{F}^-] = 2 \times 9.71 \times 10^{-4} \text{ M}$$

$$= 1.94 \times 10^{-3} \text{ M}$$

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

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

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



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

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

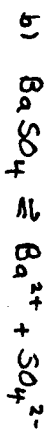
$$K_{sp} = [\text{Ag}^+][\text{CN}^-]$$

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

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

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

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



let  $s$

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

$$[SO_4^{2-}] = s$$

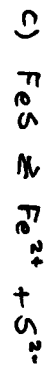
$$K_{sp} = [Ba^{2+}][SO_4^{2-}]$$

$$1.5 \times 10^{-9} = s^2$$

$$s = 3.87 \times 10^{-5}$$

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

$$[SO_4^{2-}] = 3.87 \times 10^{-5} M$$



let  $s$

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

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

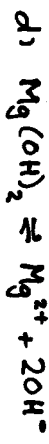
$$K_{sp} = [Fe^{2+}][S^{2-}]$$

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

$$s = 6.08 \times 10^{-10}$$

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

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



let  $s$  represent

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

$$[OH^-] = 2s$$

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

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

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

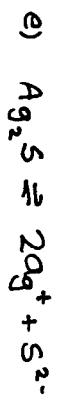
$$4s^3 = 9 \times 10^{-12}$$

$$s = 1.31 \times 10^{-4}$$

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

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

$$= 2.62 \times 10^{-4} M$$



let  $s$

$$[Ag^+] = 2s$$

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

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

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

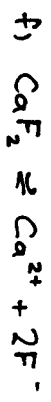
$$4s^3 = 1.6 \times 10^{-49}$$

$$s = 3.42 \times 10^{-17}$$

$$\therefore [Ag^+] = 2 \times 3.42 \times 10^{-17} M$$

$$= 6.84 \times 10^{-17} M$$

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



let  $s$

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

$$[F^-] = 2s$$

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

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

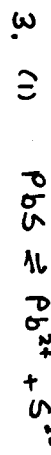
$$4s^3 = 4.9 \times 10^{-11}$$

$$s = 2.31 \times 10^{-4}$$

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

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

$$= 4.61 \times 10^{-4} M$$



let  $s$

$$[Pb^{2+}] = s$$

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

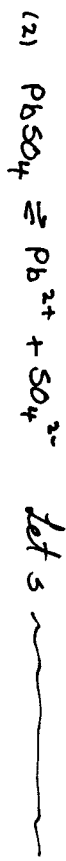
$$K_{sp} = [Pb^{2+}][S^{2-}]$$

$$8.4 \times 10^{-28} = s^2$$

$$s = 2.90 \times 10^{-14} M$$

$\therefore$  the solubility of

$PbS$  is  $2.90 \times 10^{-14} \text{ mol/L}$



$$[Pb^{2+}] = s$$

$$[SO_4^{2-}] = s$$

$\therefore$  the solubility of

$$K_{sp} = [Pb^{2+}][SO_4^{2-}] \quad PbSO_4 \text{ is } 1.26 \times 10^{-4} \text{ mol/L}$$

$$1.6 \times 10^{-8} = s^2$$

$$s = 1.26 \times 10^{-4} M$$



$$[Pb^{2+}] = s$$

$$[IO_3^-] = 2s$$

$$K_{sp} = [Pb^{2+}][IO_3^-]^2 \quad \therefore \text{the solubility of}$$

$$2.6 \times 10^{-13} = s(2s)^2 \quad Pb(IO_3)_2 \text{ is } 4.02 \times 10^{-5} \text{ mol/L}$$

$$4s^3 = 2.6 \times 10^{-13}$$

$$s = 4.02 \times 10^{-5} M$$

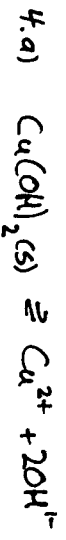
a)  $PbSO_4$

b) see above

c)  $1L \times \frac{1.26 \times 10^{-4} \text{ mol}}{1L} \times \frac{303.25g}{1 \text{ mol}} = 0.0384g$

d) - add a soluble sulphate such as  $Na_2SO_4$   
- the  $\uparrow [SO_4^{2-}]$  will force the equilibrium to the left

e)  $\frac{2.90 \times 10^{-14} \text{ mol}}{1L}$  from (1) above



$$[Ca^{2+}] = ?$$

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

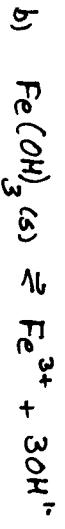
$$K_{sp} = [Ca^{2+}][OH^-]^2$$

$$[Ca^{2+}] = \frac{K_{sp}}{[OH^-]^2}$$

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

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

$$\frac{1.6 \times 10^{-11} \text{ mol}}{1L} \times \frac{63.54g Ca}{1 \text{ mol Ca}} \times \frac{1000 \text{ mg}}{1g} \times \frac{1L}{1000 \text{ mL}} = 1.02 \times 10^{-9} \text{ mg/mL}$$



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

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

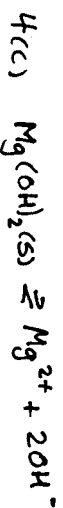
$$K_{sp} = [Fe^{3+}][OH^-]^3$$

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

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

$$[Fe^{3+}] = 6 \times 10^{-26} M$$

$$\frac{6 \times 10^{-26} \text{ mol}}{1L} \times \frac{55.85g Fe}{1 \text{ mol Fe}} \times \frac{1000 \text{ mg}}{1g} \times \frac{1L}{1000 \text{ mL}} = 3.35 \times 10^{-24} \text{ mg/mL}$$



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

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

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

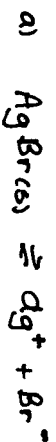
$$[Mg^{2+}] = \frac{K_{sp}}{[OH^-]^2}$$

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

$$[Mg^{2+}] = 9 \times 10^{-4} M$$

$$\frac{9 \times 10^{-4} \text{ mol}}{1 L} \times \frac{24.31 \text{ g}}{1 \text{ mol}} \times \frac{1000 \text{ mg}}{1 \text{ g}} \times \frac{1 L}{1000 \text{ mL}} = 2.19 \times 10^{-2} \text{ mg/mL}$$

5. Precipitation will begin once equilibrium conditions are obtained



$$[Ag^+] = ?$$

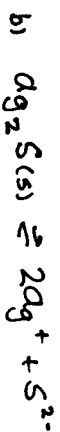
$$[Br^-] = \frac{1 \text{ mg}}{1 \text{ mL}} \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1000 \text{ mL}}{1 L} \times \frac{1 \text{ mol}}{79.91 \text{ g}} = 0.0125 M$$

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

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

$$[Ag^+] = \frac{7.7 \times 10^{-13}}{0.0125}$$

$$[Ag^+] = 6.15 \times 10^{-11} M$$



$$[Ag^+] = ?$$

$$[S^{2-}] = 0.0312 M \text{ (see 5a)}$$

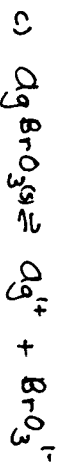
$$K_{sp} = [Ag^+]^2 [S^{2-}]$$

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

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

$$[Ag^+] = \sqrt{\frac{1.6 \times 10^{-49}}{0.0312}}$$

$$[Ag^+] = 2.26 \times 10^{-24} M$$



$$[Ag^+] = ?$$

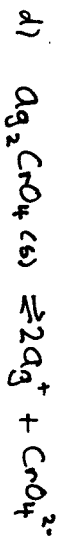
$$[BrO_3^-] = \frac{1 \text{ mg}}{1 \text{ mL}} \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1000 \text{ mL}}{1 L} \times \frac{1 \text{ mol}}{127.91 \text{ g}} = 7.82 \times 10^{-3} M$$

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

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

$$[Ag^+] = \frac{6.0 \times 10^{-5}}{7.82 \times 10^{-3}}$$

$$[Ag^+] = 7.67 \times 10^{-3} M$$



$$[Ag^+] = ?$$

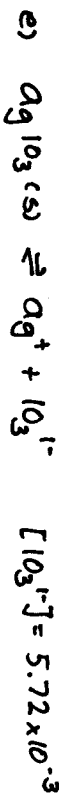
$$[CrO_4^{2-}] = 8.61 \times 10^{-3} M$$

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

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

$$[Ag^+] = \sqrt{\frac{1.1 \times 10^{-12}}{8.61 \times 10^{-3}}}$$

$$[Ag^+] = 1.13 \times 10^{-5}$$



$$[Ag^+] = 5.42 \times 10^{-6} M$$



$$[Tl^+] = s$$

$$[I^-] = s$$

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

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

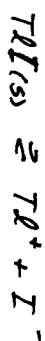
$$s = 2.98 \times 10^{-4} M$$

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



$$\therefore \text{a } 0.1 M TlNO_3 \text{ solution has } [Tl^+] = 0.1 M$$

After some  $TlI$  dissolves and reaches equilibrium



$$[Tl^+] = 0.1 + s$$

$$\begin{matrix} \text{from} & \text{from} \\ TlNO_3 & TlI \end{matrix}$$

$$[I^-] = s$$

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

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

$$s^2 + 0.1s - 8.9 \times 10^{-8} = 0$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$s = \frac{-0.1 \pm \sqrt{0.1^2 - 4(1)(-8.9 \times 10^{-8})}}{2(1)}$$

$$s = \frac{-0.1 \pm 0.1000018}{2} \leftarrow \text{careful, these digits matter}$$

$$s = 9 \times 10^{-7} M$$

$$500 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{9 \times 10^{-7} \text{ mol}}{\text{L}} \times \frac{331.27 \text{ g}}{\text{mol}} \times \frac{1000 \text{ mg}}{\text{g}} = 0.149 \text{ mg}$$

$$c) [Tl^+] = s$$

$$[I^-] = s + 0.02$$

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

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

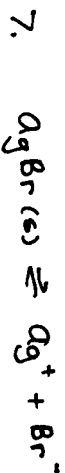
$$s^2 + 0.02s - 8.9 \times 10^{-8} = 0$$

$$s = \frac{-0.02 \pm \sqrt{0.02^2 - 4(1)(-8.9 \times 10^{-8})}}{2(1)}$$

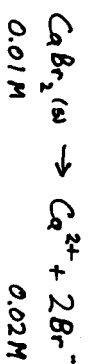
$$s = \frac{-0.02 \pm 0.0200089}{2}$$

$$s = \frac{-0.02}{2} \text{ or } 4.45 \times 10^{-6} M$$

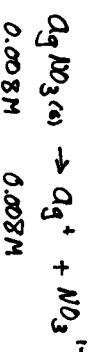
$$\text{stoichiometry} \frac{4.45 \times 10^{-6} \text{ mol}}{0.750 \text{ L}} \times \frac{331.27 \text{ g}}{1 \text{ mol}} = 0.737 \text{ mg}$$



n) Determine  $[Br^-]$  from  $CaBr_2$  2)  $[Ag^+]$  from  $AgNO_3$



$$0.01 M \quad 0.02 M$$



$$0.008 M \quad 0.008 M$$

$$C_2 = \frac{C_1 V_1}{V_2}$$

$$C_2 = \frac{0.02 M \times 50.0 \text{ mL}}{100 \text{ mL}}$$

$$C_2 = 0.01 M \quad Br^-$$

$$C_2 = \frac{C_1 V_1}{V_2}$$

$$C_2 = \frac{0.008 M \times 50 \text{ mL}}{100 \text{ mL}}$$

$$C_2 = 0.004 M \quad Ag^+$$

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

$$[Ag^+][Br^-] = (0.004)(0.01)$$

$$[Ag^+][Br^-] = 4 \times 10^{-5}$$

$$K_{sp} = 7.7 \times 10^{-13}$$

$\therefore K_{sp} < [Ag^+][Br^-] \therefore$  a ppte forms and the solubility of additional  $AgBr$  is gone



$$0.1 M \quad 0.1 M$$

$$0.1 M$$

$$0.2 M$$

$$C_2 = \frac{C_1 V_1}{V_2}$$

$$C_2 = \frac{C_1 V_1}{V_2}$$

$$C_2 = \frac{0.1 M \times 50 \text{ mL}}{200 \text{ mL}}$$

$$C_2 = \frac{0.2 M \times 150 \text{ mL}}{200 \text{ mL}}$$

$$C_2 = 0.025 M$$

$$C_2 = 0.15 M$$

$$\therefore [Ag^+] = 0.025 M$$

$$\therefore [Cl^-] = 0.15 M$$

n) with these concentrations an  $AgCl$  ppte will definitely form (i.e.  $[Ag^+][Cl^-] > K_{sp}$ )

Let  $x$  represent the amount of  $AgCl$  ppte that forms

	$AgCl(s)$	$\rightleftharpoons$	$Ag^+$	+	$Cl^-$
Initial Amount	$\emptyset$		$n = 0.1 \times 0.05$ 0.005 mol		0.03 mol
Final Amount	$x$		$0.005 - x$		$0.03 - x$
Final [ ]	$x$		$\frac{0.005 - x}{0.2}$		$\frac{0.03 - x}{0.2}$

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

$$1.8 \times 10^{-10} = \left( \frac{0.005 - x}{0.2} \right) \left( \frac{0.03 - x}{0.2} \right)$$

$$7.2 \times 10^{-12} = (0.005 - x)(0.03 - x)$$

$$7.2 \times 10^{-12} = 1.5 \times 10^{-4} - 0.035x + x^2$$

$$x^2 - 0.035x + 1.5 \times 10^{-4} = 0$$

$$= \frac{0.035 \pm \sqrt{(0.035)^2 - 4(1)(1.5 \times 10^{-4})}}{2(1)}$$

$$= \frac{0.035 \pm 2.5 \times 10^{-2}}{2} \quad \therefore \text{discriminant } x = 5 \times 10^{-3} \text{ M}$$

→ this root also appears extraneous (gives  $[Ag^+] = 0$ )  
However, the actual value is  $0.004999999712$

$$\therefore [Ag^+] = \frac{0.005 - 0.004999999712}{0.2}$$

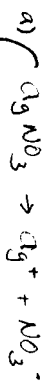
$$[Ag^+] = 1.44 \times 10^{-9} \text{ M}$$

$$[Cl^-] = \frac{0.03 - 0.005}{0.2}$$

$$[Cl^-] = 0.125 \text{ M}$$

Note  $[Ag^+][Cl^-] = (1.44 \times 10^{-9})(0.125) = 1.8 \times 10^{-10}$  !!  
 $K_{sp} = 1.8 \times 10^{-10}$  ∴

q a ppte will form if the solubility product exceeds  $K_{sp}$

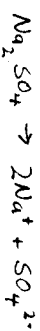


$$\left\{ \begin{array}{l} 10.0 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{0.01 \text{ mol}}{1 \text{ L}} = 1 \times 10^{-4} \text{ mol } Ag^+ \\ \therefore [Ag^+] = 5 \times 10^{-3} \text{ M} \end{array} \right.$$

$$C = \frac{n}{V}$$

$$C = \frac{1 \times 10^{-4} \text{ mol}}{0.020 \text{ L}}$$

$$C = 5 \times 10^{-3} \text{ mol/L}$$

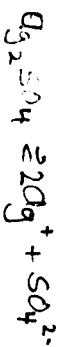


$$\left\{ \begin{array}{l} 10.0 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{0.01 \text{ mol}}{1 \text{ L}} = 1 \times 10^{-4} \text{ mol } SO_4^{2-} \\ \therefore [SO_4^{2-}] = 5 \times 10^{-3} \text{ M} \end{array} \right.$$

$$C = \frac{n}{V}$$

$$C = \frac{1 \times 10^{-4} \text{ mol}}{0.020 \text{ L}}$$

$$C = 5 \times 10^{-3} \text{ mol/L}$$



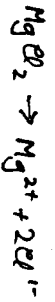
$$K_{sp} = [Ag^+]^2 [SO_4^{2-}]$$

$$[Ag^+]^2 [SO_4^{2-}] = (5 \times 10^{-3})^2 \times 5 \times 10^{-3} = 1.25 \times 10^{-7}$$

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

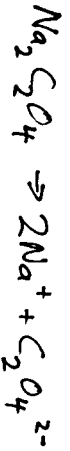
$$\therefore K_{sp} > [Ag^+]^2 [SO_4^{2-}] \therefore \text{no ppte forms}$$

b) From the table 16-1  $MgC_2O_4 \rightleftharpoons Mg^{2+} + C_2O_4^{2-}$   $K_{sp} = 8.6 \times 10^{-5}$   
 is the equilibrium in question:

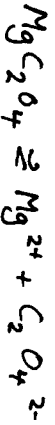


$$1 \text{ mg } Mg^{2+} \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ mol } Mg^{2+}}{95.21 \text{ g } Mg^{2+}} \times \frac{1 \text{ mol } Mg^{2+}}{1 \text{ mol } Mg^{2+}} = 1.0503 \times 10^{-5} \text{ mol}$$

$$C = \frac{n}{V} \quad C = \frac{1.0503 \times 10^{-5} \text{ mol}}{1 \text{ L (assume no change in volume)}} \therefore [Mg^{2+}] = 1.0503 \times 10^{-5} M$$



$$\therefore [C_2O_4^{2-}] = 0.01 M$$



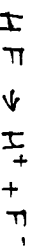
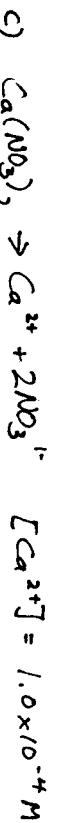
$$K_{sp} = [Mg^{2+}][C_2O_4^{2-}]$$

$$[Mg^{2+}][C_2O_4^{2-}] = (1.0503 \times 10^{-5})(0.01)$$

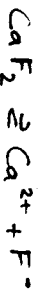
$$= 1.0503 \times 10^{-7}$$

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

$\therefore K_{sp} > [Mg^{2+}][C_2O_4^{2-}] \therefore$  no ppte forma



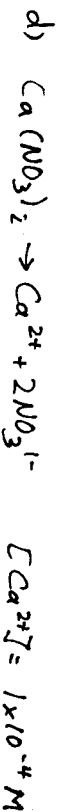
$$[F^-] = 1.0 \times 10^{-2} M$$



$$K_{sp} = 4.9 \times 10^{-11}$$

$$[Ca^{2+}][F^-]^2 = (1 \times 10^{-4})(1.0 \times 10^{-2})^2 = 1 \times 10^{-8}$$

$\therefore K_{sp} < [Ca^{2+}][F^-]^2 \therefore$  a ppte forma

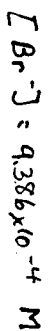
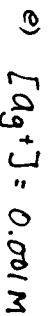


$$[F^-] = 1.0 \times 10^{-2} M$$



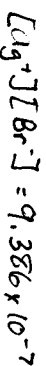
$$[Ca^{2+}][F^-]^2 = (1 \times 10^{-4})(1 \times 10^{-2})^2 = 1 \times 10^{-8}$$

$\therefore K_{sp} < [Ca^{2+}][F^-]^2 \therefore$  a ppte forma



$$15 \text{ mg} \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ mol}}{79.91 \text{ g}} = 1.88 \times 10^{-5} \text{ mol}$$

$$C = \frac{n}{V} \quad C = \frac{1.88 \times 10^{-5} \text{ mol}}{0.020 \text{ L}} \quad C = 9.39 \times 10^{-4}$$



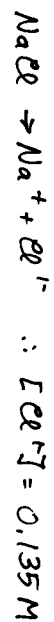
$$K_{sp} = 7.7 \times 10^{-13}$$

$\therefore K_{sp} < [Ag^+][Br^-] \therefore$  a ppte forma

GOOD EXAM QUESTION  
 am over simplification  
 This is \*



10. For a precipitate to form  $K_{sp} < \text{solubility product actual}$



$$K_{sp} = [\text{Pb}^{2+}][\text{Cl}^-]^2$$

for ppt

$$K_{sp} < [\text{Pb}^{2+}][\text{Cl}^-]^2$$

$$[\text{Pb}^{2+}] > \frac{K_{sp}}{[\text{Cl}^-]^2}$$

$$[\text{Pb}^{2+}] > \frac{1.6 \times 10^{-5}}{(0.135)^2}$$

$$[\text{Pb}^{2+}] > 8.78 \times 10^{-4} \text{ M}$$

$$n = CV$$

$$n = 8.78 \times 10^{-4} \times 0.010 \text{ L}$$

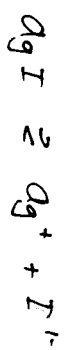
$$n = 8.78 \times 10^{-6} \text{ mol}$$

$$8.78 \times 10^{-6} \text{ mol} \times \frac{207.19 \text{ g}}{1 \text{ mol}} \times \frac{1000 \text{ mg}}{1 \text{ g}} = 1.82 \text{ mg}$$

$\therefore$  more than 1.82 mg of  $\text{Pb}^{2+}$  must be added

11. a)  $\text{TlI} \rightleftharpoons \text{Tl}^+ + \text{I}^-$

$$K_{sp} = 8.9 \times 10^{-8}$$



$$K_{sp} = 8.3 \times 10^{-17}$$

Since both equilibrium are of similar form and  $K_{sp}$  is exceeded the  $\text{AgI}$  should ppt first (i.e.  $K_{sp}$  is exceeded for  $\text{AgI}$  before  $\text{TlI}$ )

b) Find  $[\text{I}^-]$  when  $\text{TlI}$  begins to ppt



$$K_{sp} = 8.9 \times 10^{-8}$$

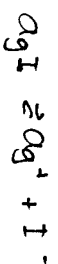
$$[\text{Tl}^+] = 0.01 \text{ M}$$

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

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

$$[\text{I}^-] = \frac{8.9 \times 10^{-8}}{0.01}$$

$$[\text{I}^-] = 8.9 \times 10^{-6} \text{ M}$$



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

$$[\text{Ag}^+] = \frac{8.3 \times 10^{-17}}{8.9 \times 10^{-6}}$$

$$[\text{Ag}^+] = 9.32 \times 10^{-12} \text{ M}$$

$$100 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{9.32 \times 10^{-12} \text{ mol}}{1 \text{ L}} \times \frac{107.87 \text{ g Ag}^+}{1 \text{ mol Ag}^+} \times \frac{1000 \text{ mg}}{1 \text{ g}} = 1 \times 10^{-7} \text{ mg Ag}^+$$