

3. Use the fact that 53.9 mg of Ag_2CrO_4 will saturate 2.50 L of solution, to determine the K_{sp} value for this salt. Use the table of K_{sp} values to check your answer.



$$\checkmark \frac{53.9 \text{ mg}}{2.50 \text{ L}} \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ mol}}{331.74 \text{ g}} = \frac{6.50 \times 10^{-5} \text{ mol}}{1 \text{ L}} \quad \checkmark$$

$$\therefore [\text{Ag}^+] = 2 \times 6.50 \times 10^{-5} \text{ M} \quad \checkmark$$

$$= 1.30 \times 10^{-4} \text{ M}$$

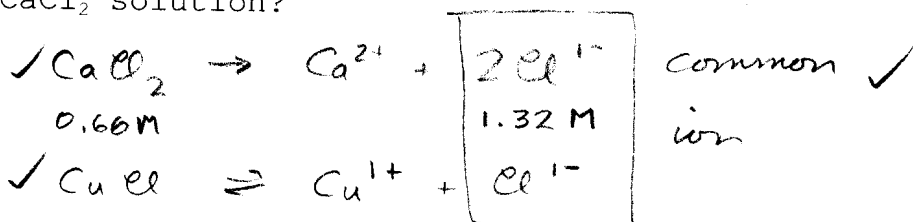
$$[\text{CrO}_4^{2-}] = 6.50 \times 10^{-5} \text{ M} \quad \checkmark$$

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

$$K_{sp} = (1.30 \times 10^{-4})^2 \times 6.50 \times 10^{-5}$$

$$K_{sp} = 1.10 \times 10^{-12} \quad \text{😊} \quad \checkmark$$

4. What mass of CuCl in mg will dissolve in 750 mL of 0.66 M CaCl_2 solution?



Let s represent the solubility of CuCl \checkmark

$$[\text{Cu}^+] = s \quad \checkmark$$

$$[\text{Cl}^-] = s + 1.32 \quad \checkmark$$

$$K_{sp} = [\text{Cu}^+][\text{Cl}^-] \quad \checkmark$$

$$3.2 \times 10^{-7} = s(s + 1.32)$$

assume $s \ll 1.32$

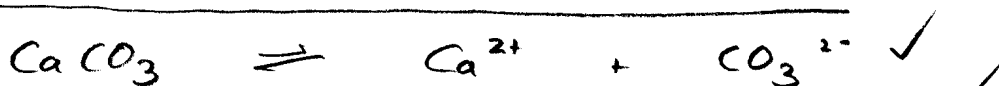
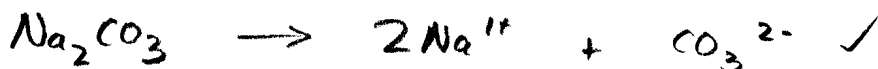
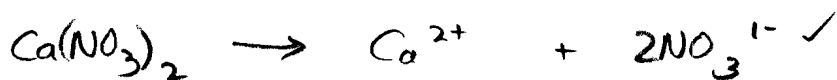
$$\therefore 3.2 \times 10^{-7} = s(1.32)$$

$$s = 2.42 \times 10^{-7} \text{ mol/L} \quad \checkmark \checkmark$$

\therefore assumption is valid $\checkmark \checkmark$

$$750 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{2.42 \times 10^{-7} \text{ mol}}{1 \text{ L}} \times \frac{99.00 \text{ g}}{1 \text{ mol}} \times \frac{1000 \text{ mg}}{1 \text{ g}} = 0.0180 \text{ mg} \quad \text{CuCl}$$

5. Determine the identity and mass of precipitate that will form when 250 mL of $2.8 \times 10^{-4} \text{ M Ca(NO}_3)_2$ is mixed with 500 mL of $1.0 \times 10^{-4} \text{ M Na}_2\text{CO}_3$. Express your mass answer in mg.



Initial [?]	N.A	/	/	250 mL 500 mL
Initial amount	0	$n = CV$ $n = 2.8 \times 10^{-4} \frac{\text{mol}}{\text{L}} \times 0.250 \text{ L}$ $n = 7 \times 10^{-5} \text{ mol} \checkmark$	$n = CV$ $n = 1.0 \times 10^{-4} \frac{\text{mol}}{\text{L}} \times 0.5 \text{ L}$ $n = 5 \times 10^{-5} \text{ mol} \checkmark$	750 mL ↳ 0.750 L ✓
Final amount	$x \checkmark$	$7 \times 10^{-5} - x$	$5 \times 10^{-5} - x$	
Final [?]	N.A	$\frac{7 \times 10^{-5} - x}{0.750}$	$\frac{5 \times 10^{-5} - x}{0.750 \text{ L}}$	

Let x represent the amount of CaCO_3 that forms ✓

$$K_{sp} = [\text{Ca}^{2+}][\text{CO}_3^{2-}] \checkmark$$

$$4.8 \times 10^{-9} = \left(\frac{7 \times 10^{-5} - x}{0.750} \right) \left(\frac{5 \times 10^{-5} - x}{0.750} \right)$$

$$2.7 \times 10^{-9} = x^2 - 1.2 \times 10^{-4} x + 3.5 \times 10^{-9}$$

$$0 = x^2 - 1.2 \times 10^{-4} x + 8 \times 10^{-10}$$

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

$$\rightarrow x = \frac{1.2 \times 10^{-4} \pm \sqrt{(1.2 \times 10^{-4})^2 - 4(1)(8 \times 10^{-10})}}{2(1)}$$

$$x = \frac{1.2 \times 10^{-4} \pm 1.058 \times 10^{-4}}{2}$$

$$x = 1.129 \times 10^{-4} \text{ mol extraneous (too large)}$$

$$x = 7.085 \times 10^{-6} \text{ mol} \checkmark$$

$$7.085 \times 10^{-6} \text{ mol} \times \frac{100.09 \text{ g}}{1 \text{ mol}} \times \frac{1000 \text{ mg}}{1 \text{ g}} = 0.709 \text{ mg CaCO}_3 \text{ ppte!!}$$

Bonus Question: Chloride ion is often used to test for the presence of Ag^+ ion through a precipitation reaction (i.e. formation of AgCl precipitate). The problem is that other ions can form precipitates with chloride ion as well. Suppose you had a solution with the following composition:

$$[\text{Cu}^{2+}] = 35 \text{ p.p.m.}$$

$$[\text{Ag}^+] = 0.05 \text{ p.p.m.}$$

What $[\text{Cl}^-]$ will cause precipitation with Cu^{2+} ? What $[\text{Cl}^-]$ will cause precipitation with Ag^+ ? What range of $[\text{Cl}^-]$ will cause precipitation of one ion and not the other. What mass of NaCl would be required to initiate precipitation of the second ion for a 1L solution?

$$\text{CuCl}_2 \rightleftharpoons \text{Cu}^{2+} + 2\text{Cl}^- \quad [\text{Cu}^{2+}] = \frac{35 \text{ mg Cu}}{1 \text{ L}} \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ mol}}{63.55 \text{ g}} = 5.507 \times 10^{-4} \text{ M}$$

$$K_{sp} = [\text{Cu}^{2+}][\text{Cl}^-]^2 \quad [\text{Cl}^-] = \frac{K_{sp}}{[\text{Cu}^{2+}]} \quad [\text{Cl}^-] = \frac{3.2 \times 10^{-7}}{5.507 \times 10^{-4}} \quad [\text{Cl}^-] = 5.810 \times 10^{-4} \text{ M} \quad \text{with stand CuCl}_2 \text{ ppte } \checkmark$$

$$\text{AgCl} \rightleftharpoons \text{Ag}^+ + \text{Cl}^- \quad [\text{Ag}^+] = \frac{0.05 \text{ mg Ag}}{1 \text{ L}} \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ mol}}{107.87 \text{ g}} = 4.635 \times 10^{-7} \text{ M}$$

$$K_{sp} = [\text{Ag}^+][\text{Cl}^-] \quad [\text{Cl}^-] = \frac{K_{sp}}{[\text{Ag}^+]} \quad [\text{Cl}^-] = \frac{1.8 \times 10^{-10}}{4.635 \times 10^{-7}} \quad [\text{Cl}^-] = 3.883 \times 10^{-4} \text{ M} \checkmark$$

$\therefore 3.883 \times 10^{-4} \text{ M} < [\text{Cl}^-] < 5.810 \times 10^{-4} \text{ M}$ is the range where AgCl ppte and CuCl_2 does not! \checkmark

Before CuCl_2 will ppte there is an amount of Cl^- that is consumed by the formation of AgCl ppte that must be taken into account!

① Determine amount Cl^- consumed by AgCl ppte when CuCl_2 starts to form (i.e. $[\text{Cl}^-] = 5.810 \times 10^{-4} \text{ M}$)

$$\textcircled{2} [\text{Ag}^+] = \frac{K_{sp}}{[\text{Cl}^-]} \quad [\text{Ag}^+] = \frac{1.8 \times 10^{-10}}{5.810 \times 10^{-4}} \quad [\text{Ag}^+] = 3.098 \times 10^{-7} \text{ M}$$

$$\textcircled{3} n = \frac{C}{V} \quad n_{\text{AgCl}} = \frac{(4.635 \times 10^{-7} - 3.098 \times 10^{-7}) \text{ M}}{1.0 \text{ L}} \quad n_{\text{AgCl}} = 1.537 \times 10^{-7} \text{ mol}$$

$\therefore 1.537 \times 10^{-7} \text{ mol NaCl}$ require

$$\textcircled{4} \text{NaCl require to reach } [\text{Cl}^-] = 5.81 \times 10^{-4} \text{ M} \Rightarrow 5.81 \times 10^{-4} \text{ mol for 1L}$$

$$\textcircled{5} \text{Total amount } 5.810 \times 10^{-4} + 1.537 \times 10^{-7} = 5.813 \times 10^{-4} \text{ mol}$$

$$\textcircled{6} \text{Convert to mass } 5.813 \times 10^{-4} \text{ mol} \times \frac{58.44 \text{ g}}{1 \text{ mol}} = 3.397 \times 10^{-2} \text{ g} \checkmark$$

$\hookrightarrow 33.97 \text{ mg}$