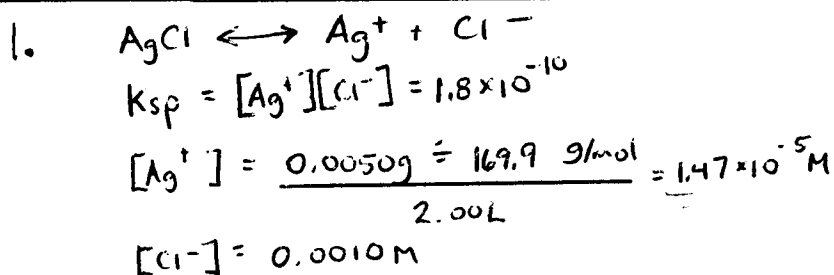
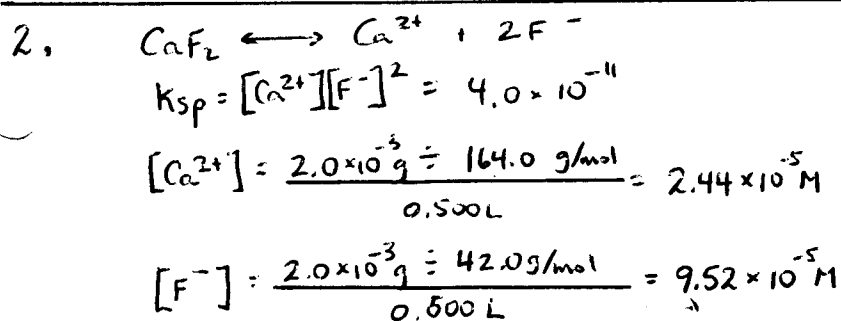


**Solubility #6**

1. Show whether or not a precipitate would be expected to form when 0.0050 g  $\text{AgNO}_3$  crystals are added to 2.00 L of 0.0010 M  $\text{NaCl}$ .
2. 2.0 mg of  $\text{Ca}(\text{NO}_3)_2$  and 2.0 mg  $\text{NaF}$  are dissolved and made up to 500 mL of solution. If the  $K_{sp}$  for  $\text{CaF}_2$  is  $4.0 \times 10^{-11}$ , will a precipitate form?
3. Will a precipitate of  $\text{AgCl}$  form when 5.1 mg of  $\text{AgNO}_3$  crystals are added to 3.0 L of  $2.0 \times 10^{-3}$  M  $\text{NaCl}$ ?
4. Show whether or not a precipitate of silver acetate forms when 15 mL of 1.0 M  $\text{AgNO}_3$  is added to 45 mL of acetic acid in which the  $[\text{CH}_3\text{COO}^-]$  is  $5.2 \times 10^{-3}$  M.  
 $K_{sp} \text{CH}_3\text{COOAg} = 3.7 \times 10^{-3}$
5. Determine whether or not a precipitate of  $\text{BaSO}_4$  will form when 0.15 g of  $\text{K}_2\text{SO}_4$  solid is added to 2.0 L of  $1.7 \times 10^{-5}$  M  $\text{BaCl}_2$ .
6. Explain why a precipitate of silver chloride will not be produced when 20 mL of  $3.0 \times 10^{-6}$  M  $\text{AgNO}_3$  is mixed with 30 mL of  $1.0 \times 10^{-4}$  M  $\text{NaCl}$ .
7. When  $\text{AgNO}_3$  crystals dissolve in a solution containing 0.010 M  $\text{NaCl}$  and 0.010 M  $\text{Na}_2\text{CrO}_4$ ,  $\text{AgCl}$  precipitates before the  $\text{Ag}_2\text{CrO}_4$ . Explain this behavior.
8. A 0.010 M solution of  $\text{AgNO}_3$  is added dropwise to a solution containing a mixture of carbonate and iodate ions, in which  $[\text{CO}_3^{2-}] = 3.0 \times 10^{-3}$  M and  $[\text{IO}_3^-] = 5.0 \times 10^{-3}$  M. Which substance precipitates first?
9. Will a precipitate of  $\text{Al}(\text{OH})_3$  form when 0.50 L of  $2.0 \times 10^{-3}$  M  $\text{AlCl}_3$  and 0.50 L of  $4.0 \times 10^{-2}$  M  $\text{NaOH}$  are mixed and diluted to 1000 L with water?  $K_{sp} \text{Al}(\text{OH})_3 = 3.7 \times 10^{-15}$
10. Will a precipitate form when 400 mL of 0.0020 M  $\text{Ba}(\text{OH})_2$  are mixed with 200 mL of 0.0020 M  $\text{H}_2\text{SO}_4$ ?



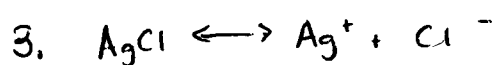
TIP =  $(1.47 \times 10^{-5})(0.0010)$   
 $= 1.5 \times 10^{-8}$   
 Since TIP >  $K_{sp}$  a ppt will form.



TIP =  $(2.44 \times 10^{-5})(9.52 \times 10^{-5})^2$   
 $= 2.2 \times 10^{-13}$   
 Since TIP <  $K_{sp}$  no ppt will form.

## Solubility #6

## Answer key



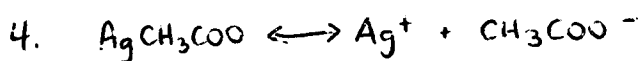
$$K_{sp} = [\text{Ag}^+][\text{Cl}^-] = 1.8 \times 10^{-10}$$

$$[\text{Ag}^+] = \frac{5.1 \times 10^{-3} \text{ g} \div 169.9 \text{ g/mol}}{3.0 \text{ L}} = 1.00 \times 10^{-5} \text{ M}$$

$$[\text{Cl}^-] = 2.0 \times 10^{-3} \text{ M}$$

$$\begin{aligned} \text{TIP} &= (1.00 \times 10^{-5})(2.0 \times 10^{-3}) \\ &= 2.0 \times 10^{-8} \end{aligned}$$

TIP >  $K_{sp}$  a ppt will form.



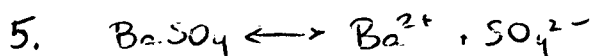
$$K_{sp} = [\text{Ag}^+][\text{CH}_3\text{COO}^-] = 3.7 \times 10^{-3}$$

$$[\text{Ag}^+] = \frac{15 \text{ mL} \times 1.0 \text{ M}}{15 \text{ mL} + 45 \text{ mL}} = 0.25 \text{ M}$$

$$[\text{CH}_3\text{COO}^-] = \frac{45 \text{ mL} \times 5.2 \times 10^{-3} \text{ M}}{45 \text{ mL} + 15 \text{ mL}} = 3.9 \times 10^{-3} \text{ M}$$

$$\begin{aligned} \text{TIP} &= (0.25)(3.9 \times 10^{-3}) \\ &= 9.8 \times 10^{-4} \end{aligned}$$

TIP <  $K_{sp}$  no ppt will form.



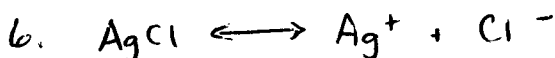
$$K_{sp} = [\text{Ba}^{2+}][\text{SO}_4^{2-}] = 1.1 \times 10^{-10}$$

$$[\text{Ba}^{2+}] = 1.7 \times 10^{-5} \text{ M}$$

$$[\text{SO}_4^{2-}] = \frac{0.15 \text{ g} \div 174.3 \text{ g/mol}}{2.0 \text{ L}} = 4.3 \times 10^{-4} \text{ M}$$

$$\begin{aligned} \text{TIP} &= (1.7 \times 10^{-5})(4.3 \times 10^{-4}) \\ &= 7.3 \times 10^{-9} \end{aligned}$$

TIP >  $K_{sp}$  a ppt will form



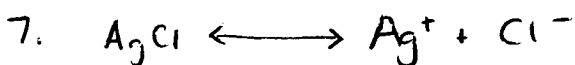
$$K_{sp} = [\text{Ag}^+][\text{Cl}^-] = 1.8 \times 10^{-10}$$

$$[\text{Ag}^+] = \frac{20 \text{ mL} \times 3.0 \times 10^{-6} \text{ M}}{20 \text{ mL} + 30 \text{ mL}} = 1.2 \times 10^{-6} \text{ M}$$

$$[\text{Cl}^-] = \frac{30 \text{ mL} \times 1.0 \times 10^{-4} \text{ M}}{20 \text{ mL} + 30 \text{ mL}} = 6.0 \times 10^{-5} \text{ M}$$

$$\begin{aligned} \text{TIP} &= (1.2 \times 10^{-6})(6.0 \times 10^{-5}) \\ &= 7.2 \times 10^{-11} \end{aligned}$$

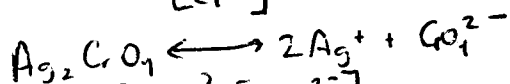
TIP <  $K_{sp}$  no ppt will form



$$K_{sp} = [\text{Ag}^+][\text{Cl}^-] = 1.8 \times 10^{-10}$$

$$[\text{Cl}^-] = 0.010 \text{ M}$$

$$[\text{Ag}^+] = \frac{K_{sp}}{[\text{Cl}^-]} = 1.8 \times 10^{-8} \text{ M to ppt AgCl}$$



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

$$[\text{CrO}_4^{2-}] = 0.010 \text{ M}$$

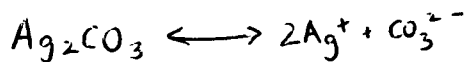
$$[\text{Ag}^+] = \sqrt{\frac{K_{sp}}{[\text{CrO}_4^{2-}]}} = 1.05 \times 10^{-5} \text{ M to ppt Ag}_2\text{CrO}_4$$

When adding the  $\text{AgNO}_3$ , the lower  $[\text{Ag}^+]$  is reached before to higher one, thus the  $\text{AgCl}$  precipitates first.

## Solubility #6

## Answer key

8. For a precipitate of  $\text{Ag}_2\text{CO}_3$

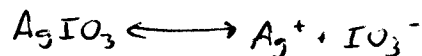


$$K_{sp} = [\text{Ag}^+]^2 [\text{CO}_3^{2-}] = 8.5 \times 10^{-12}$$

$$[\text{CO}_3^{2-}] = 3.0 \times 10^{-3}$$

$$[\text{Ag}^+] = \sqrt{\frac{K_{sp}}{[\text{CO}_3^{2-}]}} = 5.3 \times 10^{-5} \text{ M}$$

For a precipitate of  $\text{AgIO}_3$



$$K_{sp} = [\text{Ag}^+][\text{IO}_3^-] = 3.2 \times 10^{-8}$$

$$[\text{IO}_3^-] = 5.0 \times 10^{-3} \text{ M}$$

$$[\text{Ag}^+] = \frac{K_{sp}}{[\text{IO}_3^-]} = 6.4 \times 10^{-6} \text{ M}$$

The  $\text{AgIO}_3$  ppt's first

9.  $\text{Al}(\text{OH})_3 \rightleftharpoons \text{Al}^{3+} + 3\text{OH}^-$

$$K_{sp} = [\text{Al}^{3+}][\text{OH}^-]^3 = 3.7 \times 10^{-15}$$

$$[\text{Al}^{3+}] = \frac{0.50 \text{ L} \times 2.0 \times 10^{-3} \text{ M}}{1000 \text{ L}} = 1.0 \times 10^{-6} \text{ M}$$

$$[\text{OH}^-] = \frac{0.50 \text{ L} \times 4.0 \times 10^{-2} \text{ M}}{1000 \text{ L}} = 2.0 \times 10^{-5} \text{ M}$$

$$\begin{aligned} \text{TIP} &= (1.0 \times 10^{-6})(2.0 \times 10^{-5})^3 \\ &= 8.0 \times 10^{-21} \end{aligned}$$

$\text{TIP} < K_{sp}$  so no ppt will form

10.  $\text{BaSO}_4 \rightleftharpoons \text{Ba}^{2+} + \text{SO}_4^{2-}$

$$K_{sp} = [\text{Ba}^{2+}][\text{SO}_4^{2-}] = 1.1 \times 10^{-10}$$

$$[\text{Ba}^{2+}] = \frac{0.0020 \text{ M} \times 400 \text{ mL}}{400 \text{ mL} + 200 \text{ mL}} = 1.33 \times 10^{-3} \text{ M}$$

$$[\text{SO}_4^{2-}] = \frac{0.0020 \text{ M} \times 200 \text{ mL}}{400 \text{ mL} + 200 \text{ mL}} = 6.67 \times 10^{-4} \text{ M}$$

$$\begin{aligned} \text{TIP} &= (1.33 \times 10^{-3})(6.67 \times 10^{-4}) \\ &= 8.9 \times 10^{-7} \end{aligned}$$

$\text{TIP} > K_{sp}$  so a ppt will form