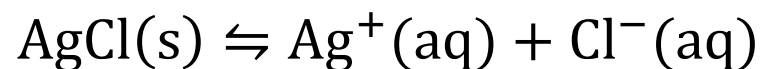


# Chapter 15 Part 2

Dr. Turner

# $Q_{sp}$



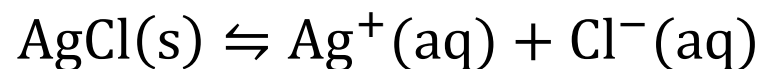
If for the equilibrium concentrations,

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

Then for any concentrations,

$$Q_{sp} = [\text{Ag}^+][\text{Cl}^-]$$

# Precipitation



If

$$K_{\text{sp}} = [\text{Ag}^+][\text{Cl}^-] = 1.77 \times 10^{-10}$$

and for a particular set of conditions,

$$Q_{\text{sp}} = [\text{Ag}^+][\text{Cl}^-] = 5.3 \times 10^{-8}$$

Will a precipitant form?

# Precipitation

- If  $Q_{sp}$  is smaller than  $K_{sp}$ , a precipitant will not form.
- If  $Q_{sp}$  is larger than  $K_{sp}$ , a precipitant will form.

# Precipitation

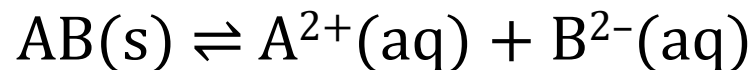
A solution containing  $\text{Pb}(\text{NO}_3)_2$  is mixed with one containing  $\text{NaBr}$  to form a solution that is  $0.0150 \text{ M}$  in  $\text{Pb}(\text{NO}_3)_2$  and  $0.00350 \text{ M}$  in  $\text{NaBr}$ . Will a precipitant form in the newly mixed solution? The  $K_{\text{sp}}$  of  $\text{PbBr}_2 = 4.67 \times 10^{-6}$ .

# Precipitation

The first step in a commercial process in which magnesium is obtained from seawater involves precipitating  $\text{Mg}^{2+}$  as  $\text{Mg}(\text{OH})_2(\text{s})$ . The magnesium ion concentration in seawater is about 0.059 M. If a seawater sample is treated so that its  $[\text{OH}^-]$  is maintained at  $2.0 \times 10^{-3}$  what will be  $[\text{Mg}^{2+}]$  remaining in solution when precipitation stops ( $K_{\text{sp}} = 1.8 \times 10^{-11}$ )?

# Precipitation, $Q_{sp}$ , and $K_{sp}$

Consider the generic reaction:



Under which condition will a precipitate form?

- A.  $Q_{sp} < K_{sp}$
- B.  $Q_{sp} = K_{sp}$
- C.  $Q_{sp} > K_{sp}$
- D. a precipitate forms under all conditions

# Fractional Precipitation

- When two anions form slightly soluble compounds with the same cation, the less soluble compound (usually, the compound with the lower  $K_{sp}$ ) precipitates first when adding the cation to a solution of both anions



# Fractional Precipitation

$\text{AgNO}_3(\text{aq})$  is slowly added to a solution that has  $[\text{CrO}_4^{2-}] = 0.010 \text{ M}$  and  $[\text{Br}^-] = 0.010 \text{ M}$ .  $K_{\text{sp}}$  of  $\text{Ag}_2\text{CrO}_4 = 1.1 \times 10^{-12}$ , and  $K_{\text{sp}}$  of  $\text{AgBr} = 5.0 \times 10^{-13}$ .

- A. Show that  $\text{AgBr}(\text{s})$  should precipitate before  $\text{Ag}_2\text{CrO}_4(\text{s})$  does by finding  $[\text{Ag}^+]$  at both equilibria.
- B. When  $\text{Ag}_2\text{CrO}_4(\text{s})$  begins to precipitate, what is  $[\text{Br}^-]$  remaining in solution?

# Fractional Precipitation

A solution contains  $1.0 \times 10^{-2} \text{ M Ag}^+$  and  $2.0 \times 10^{-2} \text{ M Pb}^{2+}$ . When  $\text{Cl}^-$  is added, both  $\text{AgCl}$  ( $K_{\text{sp}} = 1.8 \times 10^{-10}$ ) and  $\text{PbCl}_2$  ( $K_{\text{sp}} = 1.7 \times 10^{-5}$ ) can precipitate. (A) What concentration of  $\text{Cl}^-$  is necessary to begin the precipitation of each salt? (B) Which salt precipitates first? (C) When the second salt begins to precipitate, what is will be the concentration of the cation of the first salt remaining in solution?

# Fractional Precipitation

Addition of which salt will selectively precipitate lead from a mixture of  $\text{Pb}^{2+}$  and  $\text{Mg}^{2+}$ ?

- A.  $\text{Na}_2\text{CO}_3$
- B.  $\text{NaF}$
- C. both  $\text{Na}_2\text{CO}_3$  and  $\text{NaF}$
- D. neither  $\text{Na}_2\text{CO}_3$  nor  $\text{NaF}$

Formula	$K_{\text{sp}}$
$\text{PbCO}_3$	$7.4 \times 10^{-14}$
$\text{MgCO}_3$	$6.82 \times 10^{-6}$
$\text{PbF}_2$	$3.3 \times 10^{-8}$
$\text{MgF}_2$	$5.16 \times 10^{-11}$

# Solubility and pH

Should  $\text{Mg}(\text{OH})_2(\text{s})$  precipitate from a solution that is 0.010 M  $\text{MgCl}_2$  and also 0.10 M  $\text{NH}_3$ ? The  $K_{\text{sp}}$  of  $\text{Mg}(\text{OH})_2$  is  $K_{\text{sp}} = 1.8 \times 10^{-11}$ . The  $K_{\text{b}}$  of  $\text{NH}_3$  is  $1.8 \times 10^{-5}$ .