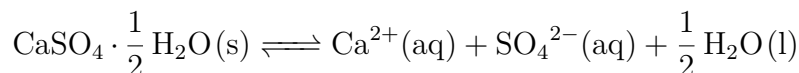


1. How much water would it take to dissolve 3.0 g of  $\text{CaSO}_4 \cdot \frac{1}{2} \text{H}_2\text{O}$  if its  $K_{sp} = 3.1 \times 10^{-7}$ ? You may disregard the water formed in the dissolving process.



	$\text{CaSO}_4$	$\text{Ca}^{2+}$	$\text{SO}_4^{2-}$
I	—	0	0
C	—	+x	+x
E	—	x	x

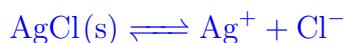
$$K_{sp} = [\text{Ca}^{2+}][\text{SO}_4^{2-}] = x^2$$

$$x = \sqrt{3.1 \times 10^{-7}} = 5.57 \times 10^{-4} \frac{\text{mol}}{\text{L}}$$

$$V = 3.0 \text{ g} \times \frac{1 \text{ mol}}{145.15 \text{ g}} \times \frac{1 \text{ L}}{5.57 \times 10^{-4} \text{ mol}}$$

$$= \boxed{37.1 \text{ L}}$$

2. (a) The solubility of  $\text{AgCl}(\text{s})$  in  $6.5 \times 10^{-3} \text{ M AgNO}_3$  is  $2.5 \times 10^{-8} \text{ M}$  at 298 K. What is the  $K_{sp}$  of  $\text{AgCl}$ ?



	$\text{AgCl}$	$\text{Ag}^+$	$\text{Cl}^-$
I	-	$6.5 \times 10^{-3}$	0
C	-	+x	+x
E	-	$6.5 \times 10^{-3} + x$	x

$$[\text{Ag}^+] = 6.5 \times 10^{-3} \text{ M}$$

$$[\text{Cl}^-] = 2.5 \times 10^{-8} \text{ M}$$

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

$$= (6.5 \times 10^{-3} \text{ M})(2.5 \times 10^{-8} \text{ M})$$

$$= 1.6 \times 10^{-10}$$

- (b) Find the  $\Delta S^\circ$  for dissolving  $\text{AgCl}$  in water, given a reported  $\Delta H_{\text{sol}}^\circ$  of 61 kJ/mol.

$$\Delta H^\circ - T\Delta S^\circ = -RT \ln K_{sp}$$

$$\Delta S^\circ = \frac{\Delta H^\circ + RT \ln K_{sp}}{T}$$

$$\Delta S^\circ = \frac{61 \frac{\text{kJ}}{\text{mol}} \cdot \frac{1,000 \text{ J}}{1 \text{ kJ}} + (8.314 \frac{\text{J}}{\text{mol}\cdot\text{K}})(298 \text{ K}) \ln(1.6 \times 10^{-10})}{298 \text{ K}}$$

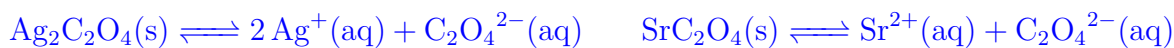
$$= 17.2 \frac{\text{J}}{\text{mol}\cdot\text{K}}$$

- (c) True or False: “As the salt dissolves, heat is released, which increases the temperature of the solution, causing more salt to dissolve in solution.” Briefly justify your answer.

False, the reaction is endothermic not exothermic

3. A small amount of  $\text{Ag}_2\text{C}_2\text{O}_4(\text{s})$  is added to 100 mL of a solution that is  $4 \times 10^{-3} \text{ M Sr}(\text{NO}_3)_2(\text{aq})$ . A single precipitate is present after the addition of  $\text{Ag}_2\text{C}_2\text{O}_4(\text{s})$ . What is the precipitate?

$$K_{sp}(\text{Ag}_2\text{C}_2\text{O}_4) = 3.5 \times 10^{-11} \quad K_{sp}(\text{SrC}_2\text{O}_4) = 5 \times 10^{-8}$$



	$\text{Ag}_2\text{C}_2\text{O}_4$	$\text{Ag}^+$	$\text{C}_2\text{O}_4^{2-}$
I	—	0	0
C	—	+2x	+x
E	—	2x	x

	$\text{SrC}_2\text{O}_4$	$\text{Sr}^{2+}$	$\text{C}_2\text{O}_4^{2-}$
I	—	$4.0 \times 10^{-3}$	0
C	—	+x	+x
E	—	$4.0 \times 10^{-3} + x$	x

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

$$3.5 \times 10^{-11} = (2x)^2x$$

$$x = 2.06 \times 10^{-4} \text{ M}$$

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

$$5 \times 10^{-8} = (4.0 \times 10^{-3} + x)(x)$$

$$x = 1.25 \times 10^{-5} \text{ M}$$

$\text{SrC}_2\text{O}_4$  precipitates out first. Cannot compare  $K_{sp}$

4.  $\text{AgBr}(\text{s})$  (MW = 187.77 g/mol) is used in black and white film. Once an image is formed, excess  $\text{AgBr}(\text{s})$  needs to be removed but it is not very soluble in water ( $K_{sp} = 5.3 \times 10^{-13}$ ).

(a) What is the solubility of  $\text{AgBr}$ ?

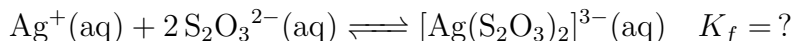
	$\text{AgBr}(\text{s})$	$\text{Ag}^+$	$\text{Br}^-$
I	—	0	0
C	-s	+s	+s
E	—	s	s

$$K_{sp} = [\text{Ag}^+][\text{Br}^-] = s^2$$

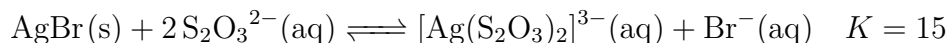
$$s = \sqrt{5.3 \times 10^{-13}}$$

$$= 7.3 \times 10^{-7} \text{ M}$$

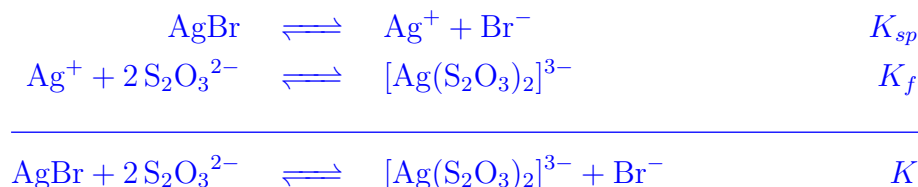
- (b) To increase the solubility of  $\text{AgBr}$ ,  $\text{Na}_2\text{S}_2\text{O}_3$  is added to water and the following equilibrium takes place:



This leads to an overall equilibrium of:

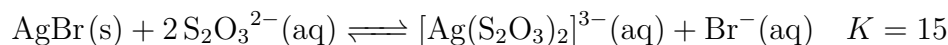


Determine the value of  $K_f$ .



$$K = K_{sp} \cdot K_f \implies K_f = \frac{K}{K_{sp}} = \frac{15}{5.3 \times 10^{-13}} = \boxed{2.8 \times 10^{13}}$$

5.



This system is at equilibrium, and  $\text{AgBr}(s)$  is added. Immediately:

- (a)  $Q$ :  increases  decreases  stays the same  
(b)  $K$ :  increases  decreases  stays the same  
(c)  $\Delta G_{\text{toeq}}$ :  is positive  is negative  equals 0

This system is at equilibrium, and  $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}(s)$  is added. Immediately:

- (a)  $Q$ :  increases  decreases  stays the same  
(b)  $K$ :  increases  decreases  stays the same  
(c)  $\Delta G_{\text{toeq}}$ :  is positive  is negative  equals 0

### Homework Problem 26

1. The  $K_{sp}$  of  $\text{Ba}(\text{NO}_3)_2$  at 298 K is  $4.63 \times 10^{-3}$ . At 350 K it is  $9.96 \times 10^{-3}$ .

(a) What is the solubility of  $\text{Ba}(\text{NO}_3)_2$  at 350 K?

(b) What is the sign of  $\Delta H_{\text{sol}}$  of  $\text{Ba}(\text{NO}_3)_2$ ?

(c) 10.0 mL of a solution that is 0.005 M  $\text{Ba}^{2+}(\text{aq})$  is mixed with 20.0 mL of 0.25 M  $\text{NO}_3^{-}(\text{aq})$  at 298 K. Then a single crystal of solid  $\text{Ba}(\text{NO}_3)_2$  is added. Will  $\text{Ba}(\text{NO}_3)_2$  dissolve, precipitate, or do nothing? Show work to justify your answer.