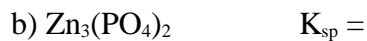


CHEM 2
Problem Set Ch.17

Key begins on page 3.

1. Write the **solubility product expression** for the following compounds.



2. The molar solubility of AgSCN is 1.0×10^{-6} . **Calculate its K_{sp} .**

3. The K_{sp} for bismuth sulfide, Bi_2S_3 is 1.6×10^{-72} . Calculate its solubility in **g/L**.

4. A volume of 75.0 mL of 0.060 M NaF is mixed with 25.0 mL of 0.15 M $\text{Sr}(\text{NO}_3)_2$. Calculate the **concentrations in the final solution** of NO_3^- , Na^+ , Sr^{+2} and F^- . (K_{sp} for SrF_2 is 2.0×10^{-10})

5. Solid NaI is slowly added to a solution that is 0.010 M in Cu^{+1} and 0.010 M in Ag^{+1} . (the K_{sp} 's for CuI and AgI are 5.1×10^{-12} and 8.3×10^{-17} , respectively)

a) **Which compound will begin to precipitate first?**

b) **Calculate $[\text{Ag}^+]$ when CuI just begins to precipitate.**

c) **What percent of Ag^+ remains in solution at this point?**

6. The K_{sp} of $PbBr_2$ is 8.9×10^{-6} . Calculate its **molar solubility** in:

a) pure water.

b) in 0.20 M KBr solution.

c) in 0.20 M $Pb(NO_3)_2$ solution.

7. Which of the following substances would be more soluble in an **acid solution** than in pure water.

a) CuI

b) $PbCl_2$

c) Bi_2S_3

d) $CaCO_3$

e) $Mg_3(PO_4)_2$

8. Write the **formation constant expressions** for the following complex ions.

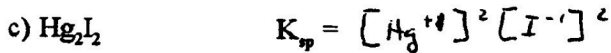
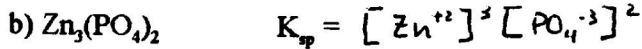
a) $Zn(OH)_4^{2-}$

b) $Co(NH_3)_6^{+3}$

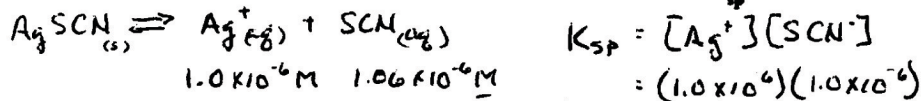
c) HgI_4^{2-}

9. Calculate the **concentrations of Cd^{+2} , $Cd(CN)_4^{2-}$ and CN^{-1}** at equilibrium when 0.50 grams of $Cd(NO_3)_2$ dissolves in 500 mL of 0.50 M NaCN. (K_f for $Cd(CN)_4^{2-}$ is 7.1×10^{16})

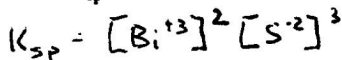
1. Write the solubility product expression for the following compounds.



2. The molar solubility of AgSCN is 1.0×10^{-6} . Calculate its K_{sp} .



3. The K_{sp} for bismuth sulfide, Bi_2S_3 is 1.6×10^{-72} . Calculate its solubility in g/L.



If $x = \text{moles/L of soluble Bi}_2\text{S}_3$, THEN

$$1.6 \times 10^{-72} = (2x)^2 (3x)^3 = 108x^5 \rightarrow x = \sqrt[5]{\frac{1.6 \times 10^{-72}}{108}}$$

$$x = 1.915 \times 10^{-15} \text{ M Bi}_2\text{S}_3$$

$$\text{Bi}_2\text{S}_3_{(s)} \rightleftharpoons 2 \text{Bi}^{+3}_{(aq)} + 3 \text{S}^{-2}_{(aq)}$$

$$x \times 14.33 \text{ g/mol} = 8.82 \times 10^{-13} \text{ g/L}$$

4. A volume of 75.0 mL of 0.060 M NaF is mixed with 25.0 mL of 0.15 M $\text{Sr}(\text{NO}_3)_2$. Calculate the concentrations in the final solution of NO_3^- , Na^+ , Sr^{+2} and F^- . (K_{sp} for SrF_2 is 2.0×10^{-10})

$$(75 \text{ mL})(0.060 \text{ M NaF}) = 4.5 \text{ mmol NaF}$$

$$\equiv 4.5 \text{ mmol Na}^+, 4.5 \text{ mmol F}^-$$

$$(25 \text{ mL})(0.15 \text{ M Sr}(\text{NO}_3)_2) = 3.75 \text{ mmol Sr}(\text{NO}_3)_2$$

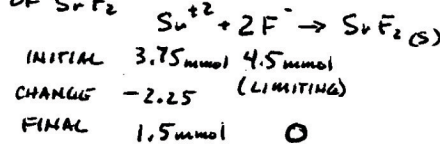
$$\equiv 3.75 \text{ mmol Sr}^{+2}, 7.5 \text{ mmol NO}_3^-$$

SINCE Na^+ AND NO_3^- ARE SPECTATORS, THEIR CONC. WON'T CHANGE... SO

$$[\text{Na}^+]_{\text{FINAL}} = \frac{4.5 \text{ mmol}}{100 \text{ mL}} = 0.045 \text{ M Na}^+$$

$$[\text{NO}_3^-]_{\text{FINAL}} = \frac{7.5 \text{ mmol}}{100 \text{ mL}} = 0.075 \text{ M NO}_3^-$$

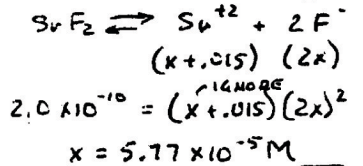
FIRST, ASSUME COMPLETE PPTN OF SrF_2



ALL THE F^- PPTS TAKING ONLY 1/2 AS MUCH Sr^{+2} WITH IT LEAVING

$$\frac{1.5 \text{ mmol}}{100 \text{ mL}} = 0.015 \text{ M Sr}^{+2} \text{ STILL IN SOLN}$$

NOW, CALCULATE HOW MUCH SrF_2 WOULD REDISSOLVE IN THE PRESENCE OF 0.015 M Sr^{+2}



BUT $[\text{F}^-] = 2x = 1.15 \times 10^{-4}$
THE $[\text{Sr}^{+2}] \approx 0.015 \text{ M}$

5. Solid NaI is slowly added to a solution that is 0.010 M in Cu^{+1} and 0.010 M in Ag^{+1} . (the K_{sp} 's for CuI and AgI are 5.1×10^{-12} and 8.3×10^{-17} , respectively)

a) Which compound will begin to precipitate first? AgI SINCE ITS K_{sp} IS SMALLER.

b) Calculate $[\text{Ag}^+]$ when CuI just begins to precipitate. FIRST CALCULATE $[\text{I}^-]$ AT THE POINT WHERE CuI PPT.

$$5.1 \times 10^{-12} = [\text{Cu}^{+1}][\text{I}^-]$$

$$= (0.010)(x)$$

$$\text{so } x = 5.1 \times 10^{-10} = [\text{I}^-]$$

NOW, HOW MUCH Ag^+ IS ALLOWED IN SOLUTION WHEN $[\text{I}^-] = 5.1 \times 10^{-10}$

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

$$= (x)(5.1 \times 10^{-10})$$

$$x = 1.63 \times 10^{-7} = [\text{Ag}^+]$$

c) What percent of Ag^+ remains in solution at this point?

$$\% \text{ Ag REMAINING} = \frac{1.63 \times 10^{-7} \text{ M}}{0.010 \text{ M INITIALLY}} \times 100 = 1.63 \times 10^{-3} \%$$

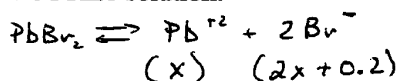
6. The K_{sp} of $PbBr_2$ is 8.9×10^{-6} . Calculate its molar solubility in: $PbBr_2 \rightleftharpoons Pb^{+2} + 2Br^{-}$

a) pure water. $8.9 \times 10^{-6} = (x)(2x)^2 = 4x^3$

$$x = \sqrt[3]{\frac{8.9 \times 10^{-6}}{4}} = \boxed{1.31 \times 10^{-2} M}$$

SINCE $x = [Pb^{+2}] = \text{sol. of } PbBr_2$.

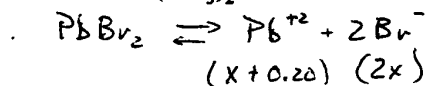
b) in 0.20 M KBr solution.



$$8.9 \times 10^{-6} = (x)(2x + 0.2)^2 \approx (x)(0.20)^2$$

$$\text{so } x = \frac{8.9 \times 10^{-6}}{(0.20)^2} = \boxed{2.25 \times 10^{-4} M}$$

c) in 0.20 M $Pb(NO_3)_2$ solution.



$$8.9 \times 10^{-6} = (x + 0.20)(2x)^2 \approx 0.80x^2$$

$$x = \sqrt{\frac{8.9 \times 10^{-6}}{0.80}} = \boxed{3.16 \times 10^{-3} M}$$

7. Which of the following substances would be more soluble in an acid solution than in pure water.

- | | | | | |
|------------------------------|------------------------------|----------------------------|----------------------------|----------------------------|
| NO | NO | YES | YES | YES |
| a) CuI | b) $PbCl_2$ | c) Bi_2S_3 | d) $CaCO_3$ | e) $Mg_3(PO_4)_2$ |
| ↑
CONS. OF
STRONG ACID | ↑
CONS. OF
STRONG ACID | ↑
CONS. OF
WEAK ACID | ↑
CONS. OF
WEAK ACID | ↑
CONS. OF
WEAK ACID |

8. Write the formation constant expressions for the following complex ions.

a) $Zn(OH)_4^{2-}$ $K_f = \frac{[Zn(OH)_4^{2-}]}{[Zn^{+2}][OH^-]^4}$

b) $Co(NH_3)_6^{+3}$ $K_f = \frac{[Co(NH_3)_6^{+3}]}{[Co^{+3}][NH_3]^6}$

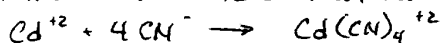
c) HgI_4^{2-} $K_f = \frac{[HgI_4^{2-}]}{[Hg^{+2}][I^-]^4}$

9. Calculate the concentrations of Cd^{+2} , $Cd(CN)_4^{2-}$ and CN^{-} at equilibrium when 0.50 grams of $Cd(NO_3)_2$ dissolves in 500 mL of 0.50 M NaCN. (K_f for $Cd(CN)_4^{2-}$ is 7.1×10^{16})

$$0.50 \text{ g } Cd(NO_3)_2 \left(\frac{1 \text{ mol}}{236.4 \text{ g}} \right) = 2.115 \times 10^{-3} \text{ mol } Cd(NO_3)_2 \approx 2.115 \times 10^{-3} \text{ mol } Cd^{+2}$$

$$(0.500 \text{ L})(0.5 \text{ M NaCN}) = 0.25 \text{ mol NaCN} \approx 0.25 \text{ mol } CN^{-}$$

FIRST ASSUME COMPLETE COMPLEX FORMATION



INIT.	2.115×10^{-3}	0.25	
(LIMIT)		$-4(2.115 \times 10^{-3})$	$+2.115 \times 10^{-3}$
FINAL	0	0.24154 mol	0.00423 M
		REMAINING	CREATED
		$\div 0.500 \text{ L}$	$\div 0.500 \text{ L}$
		0.483 M	0.00423 M

NOW LOOK AT IT AS A DISSOCIATION.

$$K_d = \frac{1}{7.1 \times 10^{16}} = 1.41 \times 10^{-17} = \frac{[Cd^{+2}][CN^{-}]^4}{[Cd(CN)_4^{2-}]}$$

$$[CN^{-}] \approx 0.483 \text{ M}$$

$$[Cd(CN)_4^{2-}] \approx 0.00423 \text{ M}$$

$$x = 1.10 \times 10^{-18} \text{ M} = [Cd^{+2}]$$