Chapter 16 Number 4 (16.10 – 16.11) (Unit 3) 12 March 2018

1. Write the equilibrium expression along with the appropriate arrows for each of the following sparingly soluble salts and then write the K_{sp} expression for the equilibrium.

1a. AgCN

$AgCN(s) \rightleftharpoons Ag^+ + CN^-$ $K_{sp} = [Ag^+][CN^-]$

1b. BaF_2

$BaF_2(s) \rightleftharpoons Ba^{2+} + 2F^-$ $K_{sp} = [Ba^{2+}][F^-]^2$

1c. $AuBr_3$

$AuBr_3(s) \rightleftharpoons Au^{3+} + 3Br^-$ $K_{sp} = [Au^{3+}][Br^-]^3$

1d $Cu_3(PO_4)_2$

$Cu_3(PO_4)_2(s) \rightleftharpoons 3Cu^{2+} + 2PO_4^{3-}$ $K_{sp} = [Cu^{2+}]^3[PO_4^{3-}]^2$

2. What is the molar solubility of barium sulfate in pure water? Given $K_{sp} = 1.1 \times 10^{-10}$

M $BaSO_4(s) \rightleftharpoons Ba^{2+} + SO_4^{2-}$

I lots 0 0

C $-x$ x x

E lots x x

$K_{sp} = [Ba^{2+}][SO_4^{2-}] = x^2 = 1.1 \times 10^{-10}$ → $x = 1.05 \times 10^{-5}$

3. Which member of each pair has a larger molar solubility? (K_{sp} values in parentheses)

3a. $ZnCO_3$ (1.2×10^{-10}) or AgBr (5.4×10^{-13})

These are both 1:1 salts so we can compare K_{sp} values.

$ZnCO_3$ is more soluble

3b. CuCl (1.7×10^{-7}) or AgCl (1.8×10^{-10})

These are also 1:1 salts so direct comparison of K_{sp} is OK

CuCl is more soluble

3c. PbI_2 (8.5×10^{-9}) or $BaSO_4$ (1.1×10^{-10})

1:2 salt and 1:1 salt; we need to solve for molar solubility and then compare.

PbI_2 $x = 1.3 \times 10^{-3}$ M $BaSO_4$: $x = 1.05 \times 10^{-5}$

4. When 250 mg SrF_2 is added to 1 L water, the salt dissolves to a very small extent. At equilibrium, the concentration of F^- is 2.1×10^{-3} M. (a) What is the molar solubility and (b) what is K_{sp}?

M $SrF_2 \rightleftharpoons Sr^{2+} + 2F^-$

I "lots" 0 0

C $-x$ x $2x$ molar solubility = x

E x $2x$

$2x = 2.1 \times 10^{-3}$ M → $x = 1.05 \times 10^{-3}$ M

5. Saturated calcium hydroxide contains 1.78 g/L. (a) What is the molar solubility and (b) what is K_{sp}? (c) What is the pH? $K_{sp} = 4.6 \times 10^{-9}$

$\text{Solubility} = \frac{1.78\ g/L}{74.1\ g/mol} = 0.0240$ mol/L

$x = 0.0240$ mol/L

$K_{sp} = 4x^3 = 5.5 \times 10^{-5}$

$[OH^-] = 2x = 4.8 \times 10^{-2}$ M

pOH = 1.32 pH = 12.68

6. What is the molar solubility and concentration of each ion in a saturated solution of HgS? $K_{sp} = 1 \times 10^{-54}$.

M $HgS \rightleftharpoons Hg^{2+} + S^{2-}$ $K_{sp} = [Hg^{2+}][S^{2-}]$

I 0 0

C x x $= x^2$

E x x

$x = [Hg^{2+}] = [S^{2-}] = 1.0 \times 10^{-27}$

7. Calcium hydroxide has a $K_{sp} = 4.7 \times 10^{-6}$.

7a. What is the $[OH^-]$ and pH of a saturated solution of calcium hydroxide?

M $Ca(OH)_2 \rightleftharpoons Ca^{2+} + 2OH^-$

I 0 0

C x $2x$ $[OH^-] = 2x = 2.1 \times 10^{-2}$

E x $2x$

$4.7 \times 10^{-6} = 4x^3$ $x = 1.06 \times 10^{-2}$ M pH = 12.32

7b. What is the molar solubility? What is the solubility in units of mg/L?

$x = 1.06 \times 10^{-2}$ mol/L

$= \frac{1.06 \times 10^{-2}\ mol}{L} \left| \frac{74.1\ g}{mol} \right| \frac{1000\ mg}{g}$

$= 785$ mg/L

8. Calculate the K_{sp} for silver sulfite if the solubility of Ag_2SO_3 in pure water is 4.6×10^{-3} g/L. MM = 295.8

A. 3.8×10^{-15} B. 1.5×10^{-14}

C. 2.4×10^{-10} D. 4.8×10^{-10}

Now try these problems from the book:
Section 16.10 – 16.11. Problems 20 – 25, 98 – 106, even.

Chapter 16 Number 5 (16.12 – 16.14) (Unit 3) 14 March 2018

1. What is the molar solubility of AgSCN and $[Ag^+]$ in a 1.0 L solution containing 0.010 M NaSCN? K_{sp} = 1.03×10^{-10}?

$NaSCN \rightarrow Na^+ + SCN^-$

	$AgSCN(s) \rightleftharpoons$	$Ag^+ +$	SCN^-	$K_{sp} = [Ag^+][SCN^-]$
I	lots	0	0,010	$(x)(0,010) = 1,03 \times 10^{-10}$
C	-x	+x	+x	
E	lots	x	0,010+x	

x = very small

x

2. What is the molar solubility of $PbCrO_4$ and $[Pb^{2+}]$ in a 1.0 L solution containing 0.010 M K_2CrO_4? $K_{sp} = 2.8 \times 10^{-13}$?

$2K^+ \quad CrO_4^{2-}$

	$PbCrO_4 \rightleftharpoons$	$Pb^{2+} +$	CrO_4^{2-}	$K_{sp} =$
I		0	0,010	$[Pb^{2+}][CrO_4^{2-}]$
C		+x	+x	$= (x)(0,010)$
E		x	0,010+x	

$x = 2,8 \times 10^{-11}$

molar solubility = $x = 2,8 \times 10^{-11}$ M

3. What is the maximum $[Co^{2+}]$ in a buffered solution with a pH = 11.00? K_{sp} $(Co(OH)_2)$ = 5.9×10^{-15}

pH = 11 → pOH = 3,00 $[OH^-] = 1 \times 10^{-3}$

	$Co(OH)_2 \rightleftharpoons$	$Co^{2+} +$	$2OH^-$	$K_{sp} = [Co^{2+}][OH^-]^2$
I	lots	0	$1,0 \times 10^{-3}$	$[Co^{2+}] = 5,9 \times 10^{-15}$
C	-x	+x	+2x	$(1,0 \times 10^{-3})^2$
E	lots	x	$1,0 \times 10^{-3}$	

x is very small $Co^{2+} = 5,8 \times 10^{-9}$ M

4. Will a precipitate form if 0.0010 mol solid sodium carbonate is stirred into a 250 mL solution of 0.050 M calcium nitrate? K_{sp} for $CaCO_3$ = 5.0×10^{-9}

	$CaCO_3(s) \rightleftharpoons$	$Ca^{2+} +$	CO_3^{2-}	
I		0,050	,0040	$Q_{sp} = ,050 \times ,0040$

$[CO_3^{2-}] = \frac{0,0010 \text{ mol}}{0,25 \text{ L}}$

$Q_{sp} = 2,0 \times 10^{-4}$

$Q_{sp} > K_{sp}$

∴ ppt forms

5. Which of the following activities will produce a precipitate? Write either "No ppt" or write the formula of the precipitate predicted.

5a. Adding solid 0.10 mmol NaOH to 1.00 L of 0.045 M $Ca(OH)_2$. K_{sp} = 4.7×10^{-6}.

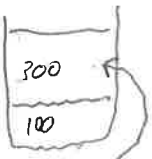
Let's see if it's sat'd.

	$Ca(OH)_2 \rightleftharpoons$	$Ca^{2+} +$	$2OH^-$	
I		,045	,090	$Q_{sp} = ,045 \times ,090^2 = 3,6 \times 10^{-4}$

It already at equilib. So adding OH^- will shift it left (LeChatelier's)

Skip this question!

5b. Mixing 100 mL 0.0010 M $Pb(NO_3)_2$ with 300 mL 0.00050 M KI. $K_{sp}(PbI_2)$ = 8.5×10^{-9}.



	$PbI_2(s) \rightleftharpoons$	$Pb^{2+} +$	$2I^-$	$K_{sp} =$
I		$2,5 \times 10^{-4}$	$3,75 \times 10^{-4}$	$Q_{sp} = 3,5 \times 10^{-11}$
C				
E				

$M_c V_c = M_d V_d$ for Pb^{2+}; $M_d = 2,5 \times 10^{-4}$

I^-; $M_d = 3,75 \times 10^{-4}$

No ppt!

5c. Adding equal volumes of 1 M NaCl and 1 M $AgNO_3$. Consult the table of K_{sp} values in your textbook, page A-15.

	$AgCl(s) \rightleftharpoons$	$Ag^+ +$	Cl^-	
I		0,50	0,50	$Q_{sp} = 0,25$
C				$Q_{sp} > K_{sp}$
E				∴ ppt

$K_{sp} = 1,8 \times 10^{-10}$

5d. Adding equal volumes of 1 M NaOH and 1 M $CuCl_2$.

	$Cu(OH)_2(s) \rightleftharpoons$	$Cu^{2+} +$	$2OH^-$	
I		0,50	0,50	$Q_{sp} = 0,50 \times 0,50^2 = 0,125$
C				$Q_{sp} > K_{sp}$ ∴ ppt
E				

6. Which insoluble compound in each pair should be more soluble if nitric acid is added to the solution?

(a) PbI_2 or $PbCO_3$

(b) $Cu(OH)_2$ or $CuCl_2$

(c) BaS or $BaSO_4$ X Both S^{2-} and SO_4^{2-} are wb.

7. Which insoluble compound in each pair should be more soluble if nitric acid is added to the solution?

(c) $Ba(OH)_2$ or $BaSO_4$ X Both

(b) $Fe_2(CO_3)_2$ or Hg_2Cl_2

(a) PbI_2 or CaS

8. What is the molar solubility of $Mg(OH)_2$ in a basic solution with a pH of 12.00? K_{sp} for $Mg(OH)_2$ is 5.6×10^{-12}.

A. 5.6×10^{-10} M

B. 5.6×10^{-8} M

C. 2.4×10^{-6} M

D. 1.1×10^{-4} M

$1,06 \times 10^{-2}$

	$Mg(OH)_2 \rightleftharpoons$	$Mg^{2+} +$	$2OH^-$
I	lots	0	,010
C	-x	+x	+2x
E	lots	x	0,010

$K_{sp} = 5,6 \times 10^{-12} = (x)(,010)^2$

$x = 5,6 \times 10^{-8}$

Now try these problems from the book:

Section 16.12 – 16.14. Problems 26, 27, 28, 33, 34, 35, 110, 112, 114a, b. Note: In 16.12, we will skip the discussion about formation constants, starting on 693, mid-page and through the end of the section.