Solubility Product Packet

PRACTICE #1

$AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq)$ $K_{sp} = [Ag^+][Cl^-] = 1.8 \times 10^{-10}$

$PbF_2(s) \rightleftharpoons Pb^{2+}(aq) + 2F^-(aq)$ $K_{sp} = [Pb^{2+}][F^-]^2 = 7.1 \times 10^{-7}$

$Ca_3(PO_4)_2 \rightleftharpoons 3Ca^{2+}(aq) + 2PO_4^{3-}(aq)$ $K_{sp} = [Ca^{2+}]^3[PO_4^{3-}]^2 = 1 \times 10^{-33}$

PRACTICE #2

AgCl: $K_{sp} = [Ag^+][Cl^-] = (x)(x) = 1.8 \times 10^{-10}$ $x = [Ag^+]$ and $[Cl^-] = 1.3 \times 10^{-5}$ M

solubility AgCl = 1.3×10^{-5} mol/liter = 1.9×10^{-3} g/L

PbF_2 $K_{sp} = [Pb^{2+}][F^-]^2 = (x)(2x)^2 = 4x^3 = 7.1 \times 10^{-7}$ $x = 5.6 \times 10^{-3}$

$[Pb^{2+}] = 5.6 \times 10^{-3}$ M $[F^-] = 1.12 \times 10^{-2}$ M

solubility PbF_2 = 5.61×10^{-3} mol/L $\Rightarrow$ 1.37 g/L

$Ca_3(PO_4)_2$ $K_{sp} = [Ca^{2+}]^3[PO_4^{2-}]^2 = (3x)^3(2x)^2 = 108x^5 = 1 \times 10^{-33}$ $x = 9.8 \times 10^{-8}$ moles/liter

$[Ca^{2+}] = 2.9 \times 10^{-7}$ M $[PO_4^{3-}] = 1.96 \times 10^{-7}$ M

solubility $Ca_3(PO_4)_2 = 3 \times 10^{-5}$ g/L

(FM = 310.3)

PRACTICE #3

(a) [redacted]

$Li_2CO_3 \rightleftharpoons 2Li^+ + CO_3^{2-}$

$\sim$ | 0 | 0

-0.0742 | $+2(0.0742)$ | $+0.0742$

$5.48\ g/L \Rightarrow 0.0742\ mol/L$

$[Li^+] = 0.148\ M$

$[CO_3^{2-}] = 0.0742\ M$

$K_{sp} = [Li^+]^2[CO_3^{2-}] = (0.148)^2(0.0742) = 0.00162$

(b) $PbBr_2 \rightleftharpoons Pb^{2+} + 2Br^-$

	$PbBr_2$	Pb^{2+}	$2Br^-$
I	$\sim$	0	0
C	-0.0214	$+0.0214$	$+2(0.0214)$
E		$0.0214\ M$ (given)	$0.0428\ M$

$K_{sp} = [Pb^{2+}][Br^-]^2 = (0.0214)(0.0428)^2 = 3.9 \times 10^{-5}$

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

	$Ca(OH)_2$	Ca^{2+}	$2OH^-$
I	$\sim$	0	0
C	-0.01	$+0.01$	$+0.02$
E		0.01	$0.02\ M$

use pH to find $[OH^-] = 0.02\ M$

$K_{sp} = [Ca^{2+}][OH^-]^2 = (0.01)(0.02)^2 = 4 \times 10^{-6}$

PRACTICE #4

#22 (a) $Mg(OH)_2 \rightleftharpoons Mg^{2+} + 2OH^-$

	$Mg(OH)_2$	Mg^{2+}	$2OH^-$
I	—	0	0
C	$-x$	$+x$	$+2x$
E		x	$2x$

$K_{sp} = [Mg^{2+}][OH^-]^2 = 6 \times 10^{-12} = (x)(2x)^2$

$x = 1.1 \times 10^{-4}$ mole/liter

or $0.0064\ g/L$

(b)

		$Mg(OH)_2$	Mg^{2+}	$2OH^-$
I		$\sim$		$0.082\ M$ (from $Ba(OH)_2$)
C		$-x$	$+x$	$+2x$
E		$\sim$	x	$0.082 + 2x$

ignore $2x$

$K_{sp} = [Mg^{2+}][OH^-]^2$

$6 \times 10^{-12} = (x)(0.082)^2$

$x = 9 \times 10^{-10}$ mol/L or

$5 \times 10^{-8}\ g/L$

PRACTICE #4 cont'd

given from $MgCl_2$

22(c) $Mg(OH)_2 \rightleftharpoons Mg^{2+} + 2OH^-$

I	~	0.0050	0
Δ	~	+x	+2x
E	~	0.0050+x	2x

$K_{sp} = [Mg^{2+}][OH^-]^2 = 6 \times 10^{-12}$

$(0.0050)(2x)^2 = 6 \times 10^{-12}$

$x = 1.73 \times 10^{-5}$ mol/liter

or 1×10^{-3} g/L

PRACTICE #5

Summary (c) What is the potential ppt? $Pb(OH)_2$.

Use K_{sp} for $Pb(OH)_2$

+ dissolving equation for $Pb(OH)_2 \rightleftharpoons Pb^{2+} + 2OH^-$

$K_{sp} = [Pb^{2+}][OH^-]^2 = 4.2 \times 10^{-15}$

$M_1V_1 = M_2V_2$ (combined volume)

$(0.01500L)(0.0100M) = M_2(0.490L)$ $M_2 = [OH^-]$ in mixture $= 3.06 \times 10^{-4}$ M

$(0.475L)(0.0075M) = M_2(0.490)$ $M_2 = [Pb^{2+}]$ in mixture $= 0.0073$ M

$Q = [Pb^{2+}][OH^-]^2 = (0.0073)(3.06 \times 10^{-4})^2 = 6.8 \times 10^{-10}$

$Q > K$, so REVERSE reaction is favored.

Yes, PPT forms!

PRACTICE #5 cont'd

Summary (g)

$Pb(OH)_2 \rightleftharpoons Pb^{2+} + 2OH^-$ $\quad K_{sp} = [Pb^{2+}][OH^-]^2 = 4.2 \times 10^{-15}$

$Fe(OH)_2 \rightleftharpoons Fe^{2+} + 2OH^-$ $\quad K_{sp} = [Fe^{2+}][OH^-]^2 = 5 \times 10^{-17}$

In solution, $[Pb^{2+}] = \frac{0.0200 \text{ mol}}{0.425 \text{ L}} = 0.047 M$

$[Fe^{2+}] = \frac{0.0200 \text{ mol}}{0.425 \text{ L}} = 0.047 M$

Ignore given amount of OH^- → it will NOT be added all at once, but instead will be slowly added.

Plug in & solve for OH^- in each K_{sp} expression:

$Pb(OH)_2$ $\quad 4.2 \times 10^{-15} = (0.047)[OH^-]^2$ $\quad [OH^-] = 3 \times 10^{-7} M$

$Fe(OH)_2$ $\quad 5 \times 10^{-17} = (0.047)[OH^-]^2$ $\quad [OH^-] = 3.3 \times 10^{-8} M$ ← this will be exceeded FIRST

So $Fe(OH)_2$ will precipitate first

p440 #32

$PbSO_4 \rightleftharpoons Pb^{2+} + SO_4^{2-}$ $\quad K_{sp} = [Pb^{2+}][SO_4^{2-}] = 1.8 \times 10^{-8}$

$Pb(OH)_2 \rightleftharpoons Pb^{2+} + 2OH^-$ $\quad K_{sp} = [Pb^{2+}][OH^-]^2 = 2.8 \times 10^{-16}$

Solve for Pb^{2+} in each:

$PbSO_4$: $\quad 1.8 \times 10^{-8} = [Pb^{2+}][0.020 M]$ $\quad [Pb^{2+}] = 9 \times 10^{-7} M$

$Pb(OH)_2$: $\quad 2.8 \times 10^{-16} = [Pb^{2+}][0.020 M]^2$ $\quad [Pb^{2+}] = 7 \times 10^{-13} M$ ↑ exceeded first

$Pb(OH)_2$ forms first

(b) OMIT