Ksp Problems – Chemistry

Name: _____

1) The value of Ksp of AgCl is 1.8×10^{-10}. What would be the molar concentration of Ag^+ and Cl^- in pure water placed in contact with solid AgCl(s)?

(a) 1.8×10^{-10} M
(b) 1.3×10^{-5} M
(c) 3.24×10^{-20} M

$Ksp = [Ag^+][Cl^-]$

$1.8 \times 10^{-10} = [x][x]$

x = **0.000013416 M or 1.3416×10^{-5} M**

2) The molar solubility of $PbCl_2$ in 0.10 M NaCl is 1.7×10^{-3} moles in a liter (that is 1.7×10^{-3} moles of $PbCl_2$ will dissolve in 1 liter of the solution). What is the Ksp of $PbCl_2$?

(a) Ksp = 1.8×10^{-5}
(b) Ksp = 1.9×10^{-8}
(c) Ksp = 1.7×10^{-4}

$PbI_2 \leftrightarrow Pb^+ + 2\,Cl^-$

$Ksp = [Pb^+][Cl^-]^2$

$Ksp = [1.7 \times 10^{-3}][3.4 \times 10^{-3}]^2$

Ksp = **1.965×10^{-8}**

3) What are the molar concentrations of ions in solution when solid PbI_2 is in contact with pure water? (Ksp for $PbI_2 = 7.9 \times 10^{-9}$)

(a) $[Pb^{+2}] = 1.3 \times 10^{-3}$ M & $[I^-] = 2.6 \times 10^{-3}$ M
(b) $[Pb^{+2}] = 1.6 \times 10^{-3}$ M & $[I^-] = 3.2 \times 10^{-3}$ M
(c) $[Pb^{+2}] = [I^-] = 2.0 \times 10^{-3}$ M

$PbI_2 \leftrightarrow Pb^+ + 2\,I^-$

$Ksp = [Pb^+][I^-]^2$

$7.9 \times 10^{-9} = [x][2x]^2$

$3.95 \times 10^{-9} = x^3$

x = **1.581×10^{-3} M Pb^+** **3.162×10^{-3} M I^-**

4) What is the molar concentration of $[Ag^+]$ in AgCl solution in 0.10 M NaCl ? (Ksp = 1.8×10^{-10}) Remember that in this case the molar solubility of AgCl is equal to the $[Ag^+]$ as only the Ag^+ reflects the amount of AgCl that dissolved.

(a) Ag+ = 1.3×10^{-5} M
(b) Ag+ = 0.10 M
(c) Ag+ = [AgCl] = 1.8×10^{-9} M

$Ksp = [Ag^+][Cl^-]$

$1.8 \times 10^{-10} = [x][x]$

x = **0.000013416 M or 1.3416×10^{-5} M**

5) Will $CaSO_4$ precipitate if 50 mL of 0.0010 M $CaCl_2$ is added to 50 mL of 0.010 M Na_2SO_4? (Ksp for $CaSO_4$ = 2.4×10^{-5})

(a) no precipitation will occur
(b) it is at equilibrium
(c) precipitation will occur

Problem 6

How many grams (g) of $CaSO_4$ is formed when 20 mL of 0.010 M Na_2SO_4 is added to 100 mL of 0.001 M $CaCl_2$?

(a) 0.0001g
(b) 0.01g

Write equibrium expressions for the solubility of CaF_2 and $Ca_3(PO_4)_2$.

$CaF_{2(s)} \rightleftarrows Ca^{+2} + 2F^{-1}$ **$Ksp = [Ca^{+2}][F^{-1}]^2$**

$Ca_3(PO_4)_{2(s)} \rightleftarrows 3Ca^{+2} + 2PO_4^{-3}$ **$Ksp = [Ca^{+2}]^3 [PO_4^{-3}]^2$**

Sample Problem #2

If 0.0067g $CaCO_3$ soluble in 1.0L of water, calculate Ksp

molar solubility = (0.0067g/L)(1 mol/100g) = $6.7x10^{-5}$ M

$CaCO_{3(s)} \rightleftarrows Ca^{+2} + CO_3^{-2}$

$6.7x10^{-5}$M $6.7x10^{-5}$M $6.7x10^{-5}$M

$Ksp = [Ca^{+2}][CO_3^{-2}] = [6.71x10^{-5}][6.7x10^{-5}] = 4.5$**$x10^{-9}$**

Sample Problem #3

If 0.017g CaF_2 soluble in 1.0L of water, calculate Ksp

molar solubility = (0.017g/L(1 mol/78g) = $2.15x10^{-4}$ M

$CaF_{2(s)} \rightleftarrows Ca^{+2} + 2F^{-1}$

$2.153x10^{-4}$M $2.153x10^{-4}$M $4.30x10^{-4}$M

$Ksp = [Ca^{+2}][F^{-1}]^2 = [2.15x10^{-4}][4.3x10^{-4}]^2 = 4.0$**$x10^{-11}$**

(a) Ag+ = 1.3 x 10^{-5} M
(b) Ag+ = 0.10 M
(c) Ag+ = [AgCl] = 1.8 x 10^{-9} M

Sample Problem #4

For AgCl, Ksp = $1.8x10^{-10}$ Calculate grams AgCl soluble per liter

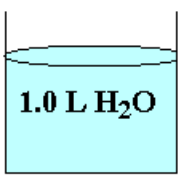
$AgCl_{(s)} \rightleftarrows Ag^{+1} + Cl^{-1}$

x x x

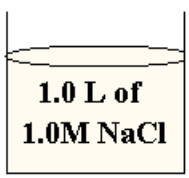
$Ksp = [Ag^{+1}][Cl^{-1}] = 1.8x10^{-10} = x^2$

x = $1.34x10^{-5}$ M (1.34x10^{-5} mol/L)(143g/mol) = **0.0018 g/L**

Common-Ion Effect



or



Where is AgCl more soluble?

0.0018g AgCl soluble per liter water (already did this calculation)

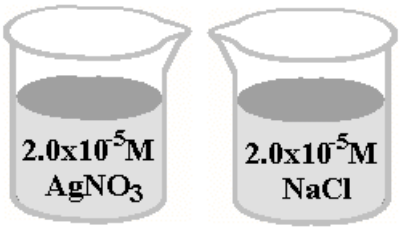
For the 1.0M NaCl solution, $[Cl^{-1}]$ = 1.0 M

$AgCl_{(s)} \rightleftarrows Ag^{+1} + Cl^{-1}$

x x x+1 (approximation: x+1~1)

$K_{sp} = [Ag^{+1}][Cl^{-1}] = [x][1] = 1.8x10^{-10}$ $x = 1.8x10^{-10}$ mol/L or **$2.6x10^{-8}$ g/L**

Precipitation of Ionic Compounds



Will precipitate form if solutions mixed in 1:1 ratio?

K_{sp} for AgCl = $1.8x10^{-10}$
After mixing, $[Ag^{+1}] = [Cl^{-1}] = 1.0x10^{-5}$M
Now determine the ion product (IP)
$IP = [Ag^{+1}][Cl^{-1}] = [1.0x10^{-5}][1.0x10^{-5}] = 1.0x10^{-10}$
Compare IP to K_{sp}:
If IP > K_{sp} precipitate forms
If IP < K_{sp} no precipitate forms
If IP = K_{sp} no precipitate forms but solution is saturated
For this problem, IP < Ksp and no precipitate forms!

Sample Problem #5
Will mixture precipitate if equal volumes of $3.0x10^{-3}$M Ba^{+2} & $2.0x10^{-3}$M CO_3^{-2} mixed?
K_{sp} for $BaCO_3$ is $5.0x10^{-9}$
After mixing, $[Ba^{+2}] = 1.5x10^{-3}$M $[CO_3^{-2}] = 1.0x10^{-3}$M
$IP = [Ba^{+2}][CO_3^{-2}] = [1.5x10^{-3}][1.0x10^{-3}] = 1.5x10^{-6}$
Since IP > Ksp, precipitate forms!
Will mixture precipitate if 20.0mL $3.0x10^{-4}$M Ba^{+2} & 30.0mL 2.0 $x10^{-4}$M CO_3^{-2} mixed?
After mixing, $M_1V_1 = M_2V_2$ $(3.0x10^{-4})(20mL) = M_2(50mL)$ $[Ba^{+2}] = 1.2x10^{-4}$M
$M_1V_1 = M_2V_2$ $(2.0x10^{-4})(30mL) = M_2(50mL)$ $[CO_3^{-2}] = 1.2x10^{-4}$M
$IP = [Ba^{+2}][CO_3^{-2}] = [1.2x10^{-4}][1.2x10^{-4}] = 1.4x10^{-8}$
Since IP > Ksp, precipitate forms!

Sample Problem #6
Is 0.10M $Mg(NO_3)_2$ soluble at pH of 12?
$[Mg^{+2}] = 0.10M$ $[OH^{-1}] = 0.01M$
$Mg(OH)_{2(s)} \rightleftarrows Mg^{+2} + 2OH^{-1}$ $K_{sp} = [Mg^{+2}][OH^{-1}]^2 = 7.1x10^{-12}$
$IP = [Mg^{+2}][OH^{-1}]^2 = [0.10][0.01]^2 = 1.0x10^{-5}$
Since IP > Ksp, precipitate forms!

Sample Problem #7
Is 0.10M $Mg(NO_3)_2$ soluble at pH of 8
$[Mg^{+2}] = 0.10M$ $[OH^{-1}] = 1.0x10^{-6}$M
$Mg(OH)_{2(s)} \rightleftarrows Mg^{+2} + 2OH^{-1}$ $K_{sp} = [Mg^{+2}][OH^{-1}]^2 = 7.1x10^{-12}$
$IP = [Mg^{+2}][OH^{-1}]^2 = [0.10][1.0x10^{-6}]^2 = 1.0x10^{-13}$
Since IP < Ksp, no precipitate forms!

Sample Problem #8

Determine optimum conditions for separating 0.10 Mg^{+2} & 0.10M Ca^{+2}
The ions can be separated by adjusting pH since

$Ca(OH)_2$ Ksp = $6.5x10^{-6}$ more soluble

$Mg(OH)_2$ Ksp = $7.1x10^{-12}$ less soluble

Adjust pH to make saturated solution of $Ca(OH)_2$ but do <u>not</u> precipitate $Ca(OH)_2$
To make saturated solution of $Ca(OH)_2$:

$Ksp = [Ca^{+2}][OH^{-1}]^2 = [0.10][OH^{-1}]^2 = 6.5x10^{-6}$

$[OH^{-1}]^2 = 6.5x10^{-5}$

$[OH^{-1}] = 8.1x10^{-3}$ pOH = 2.09 pH =11.91

Adjust pH at 11.91 Ca^{+2} does not precipitate but Mg^{+2} will ppt

Sample Problem #9

Determine optimum conditions to separate 0.10M Ni^{+2} & 0.10M Sr^{+2} by precipitating with Na_2CO_3

$NiCO_3$ Ksp = $1.3x10^{-7}$ more soluble

$SrCO_3$ Ksp = $9.3x10^{-10}$ less soluble

Add CO_3^{-2} to make saturated solution of $NiCO_3$ but do <u>not</u> precipitate $NiCO_3$
To make saturated solution of $NiCO_3$:

$Ksp = [Ni^{+2}][CO_3^{-2}] = [0.10][CO_3^{-2}] = 1.3x10^{-7}$

$[CO_3^{-2}] = 1.3x10^{-6}$ M

Adjust Na_2CO_3 concentration at $1.3x10^{-6}$M

Ni^{+2} does not precipitate but Sr^{+2} will ppt