SCROLL TO BOTTOM FOR ANSWERS

Ksp=Equilibrium Constant for Solubility Products

The K_{sp} is specifically used for an equilibrium between an undissolved solid and its ions in solution.

How to interpret K_{sp}

$$MX_{(s)} \rightleftharpoons M^{+}_{(aq)} + X^{-}_{(aq)}$$

$$K_{sp} =$$

Low K_{sp}	
High K_{sp}	

Example 1 Solid silver chromate is added to pure water at 25 ^{o}C. Some of the solid remains undissolved $Ag2CrO_{4(s)}$ at the bottom of the flask. The mixture is stirred for several days to ensure that equilibrium is achieved between the undissolved and the solution. Analysis of the equilibrated solution shows that its silver ion concentration is 1.3×10^{-4} moles/L.
Assuming that Ag_2CrO_4 dissociates completely in water and that there are no other important equilibria involving the Ag+ or CrO_4^{-2} ions in the solution, calculate Ksp for this compound.

Example 2 The Ksp for CaF_2 is 3.9×10^{-11} at 25 ^{o}C. Assuming that CaF_2 dissociates completely upon dissolving and that there are no other important equilibria affecting its solubility, calculate the solubility of CaF_2 in grams per liter.

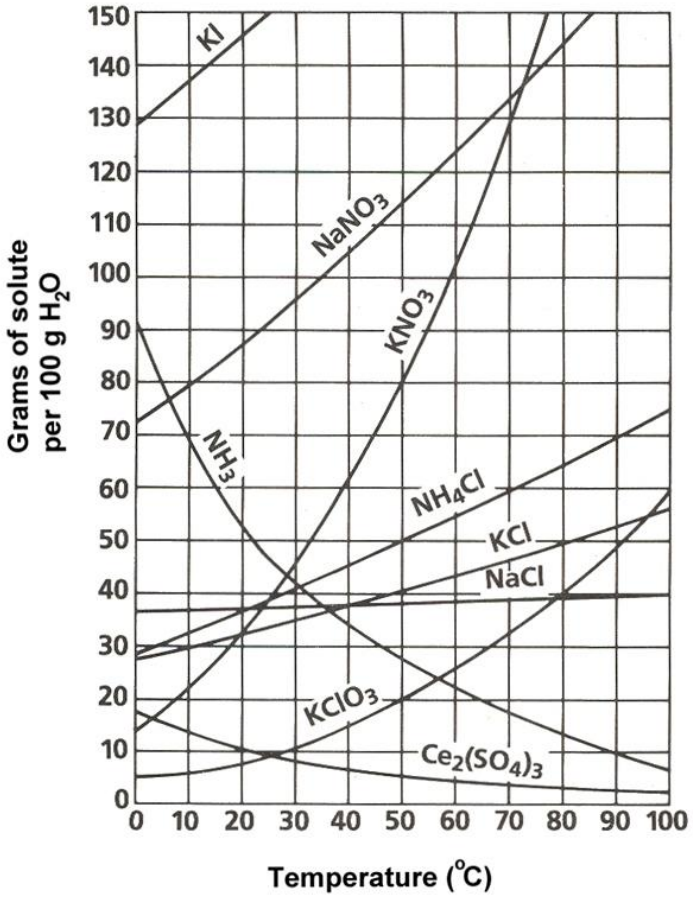
1.1×10^{-12}

$1.6 * 10^{-2}$ g CaF_2/L soln

Example 3 $LaF_{2(s)}$ + heat $\rightleftharpoons$ $La^{+2}_{(aq)}$ + 2 $F^{-}_{(aq)}$

In the above equilibrium, list two ways by which the solubility of LaF_2 could be reduced.

Example 4 **For which substance would Ksp increase with a lower temperature? Explain your reasoning.**



Homework for Ksp

1. Calculate the solubility in grams per liter of silver sulfide (Ag_2S)in order to decide whether it is accurately labeled when described as an insoluble salt. (Ag_2S: $K_{sp} = 6.3 \times 10^{-50}$)

2. Determine which salt — $CaCO_3$ or Ag_2CO_3 — is more soluble in water in units of moles per liter?

$CaCO_3$: $K_{sp} = 2.8 \times 10^{-9}$

Ag_2CO_3: $K_{sp} = 8.1 \times 10^{-12}$

3. In a saturated solution of MgF_2 at 18ºC, the concentration of Mg^{2+} is $1.21´10^{-3}$ moles/L. The equilibrium is represented by $MgF_2(s) \rightleftharpoons Mg^{2+}(aq) + 2\ F^-(aq)$

a) Write the expression for the solubility-product constant, K_{sp}, and calculate its value at 18ºC.

b) How could you raise the solubility of magnesium fluoride?

c) How could you lower it?

4. Determine the Ksp of $Ca(OH)_2$ if 0.0105 moles dissolves in 1 kg of water.

5. Use the graph in your notes and list two substances for which Ksp will increase with increasing temperature.

Homework for Ksp

1. Calculate the solubility in grams per liter of silver sulfide (Ag_2S)in order to decide whether it is accurately labeled when described as an insoluble salt. (Ag_2S: K_{sp} = 6.3 x 10^{-50})

	$Ag_2S_{(s)}$	**$2\ Ag^+_{(aq)}$**	**$S^{-2}_{(aq)}$**
I moles/L	**We don't care**	**0**	**0**
C moles/L	**x = solubility in moles/L**	**2x**	**x**
E moles/L	**We don't care - x**	**2x**	**x**

K_{sp} = [**Ag^+]^2[S^{-2}]**
6.3 x 10^{-50} = $(2x)^2(x)$
6.3 x 10^{-50} = $4x^3$
x = (6.3 x 10^{-50} / 4)$^{1/3}$ = 2.5 X 10^{-16} moles/L
solubility= 2.5 X 10^{-16} moles/L (2*108+32)= **6.2 X 10^{-15} g of $Ag_2S_{(s)}$ / L**
That's not much so it is correctly labeled as insoluble.

2. Determine which salt — $CaCO_3$ or Ag_2CO_3 — is more soluble in water in units of moles per liter?

$CaCO_3$: K_{sp} = 2.8 x 10^{-9}

Ag_2CO_3: K_{sp} = 8.1 x 10^{-12}

Use a chart like in #1	**Use a chart like in #1**
$CaCO_3$	Ag_2CO_3
Ksp = 2.8 X10^{-9} = [**Ca^{+2}][CO_3^{-2}]** 2.8 X10^{-9} = x(x) 2.8 X10^{-9} = x^2 x = 5.3 X10^{-5} moles/L	Ksp = 8.1 X10^{-12} = [**Ag^+]^2[CO_3^{-2}]** 8.1 X10^{-12} = $(2x)^2(x)$ 8.1 X10^{-12} = = $4x^3$ **x = (**8.1 X10^{-12} / 4)$^{1/3}$ = 1.3X10^{-4}moles/L So Ag_2CO_3 is more soluble even though it's Ksp is smaller

3. In a saturated solution of MgF_2 at 18ºC, the concentration of Mg^{2+} is 1.21X 10^{-3} moles/L. The equilibrium is represented by $MgF_2(s) \rightleftharpoons Mg^{2+}(aq) + 2\ F^-(aq)$

a) Write the expression for the solubility-product constant, K_{sp}, and calculate its value at 18ºC.

$K_{sp} =$ **$[\ Mg^{+2}\ ][F^-\ ]^2$**

	$MgF_2(s)$	$Mg^{2+}(aq)$	$2\ F^-(aq)$
I moles/L	**We don't care**	**0**	**0**
C moles/L	1.21X 10^{-3}	1.21X 10^{-3}	2* 1.21X 10^{-3}
E moles/L	**We don't care -** 1.21X 10^{-3}	1.21X 10^{-3}	**2.42 X 10^{-3}**

$K_{sp} =$ $[1.21X\ 10^{-3}]$**$[\ 2.42\ X\ 10^{-3}]^2$**

$= 7.1\ X\ 10^{-9}$

b) How could you raise the solubility of magnesium fluoride?

Remove fluoride or magnesium ion by precipitating it with the appropriate ion.

c) How could you lower it?

Add fluoride or magnesium ion from another source.

4. Determine the Ksp of $Ca(OH)_2$ if 0.0105 moles dissolves in 1 kg of water.

	$Ca(OH)_2\ (s)$	$Ca^{2+}(aq)$	$2\ OH^-(aq)$
I moles/L	**We don't care**	**0**	**0**
C moles/L	0.0105 moles/L 1kg = 1L for water	0.0105	2* 0.0105
E moles/L	**We don't care -** 0.0105	0.0105	**0.021**

$K_{sp} =$ $[0.0105]$**$[\ 0.021]^2 = 4.6\ X\ 10^{-6}$**

5. Use the graph in your notes and list two substances for which Ksp will increase with increasing temperature.

Choose any two that are increasing functions.

6. 2.0×10^{-5}

7. 3.2 X 10-11 moles/L