Chemistry 12

Solubility Equilibrium II

Name:
Date:
Block:

1. **Forming a Precipitate**
2. **Solubility Product Constant *(One Source of Ions)***

Forming a Precipitate

Example:

A solution may contain the ions **Ca^{2+}, Sr^{2+} and Zn^{2+}**. How would you precipitate the ions out of solution individually? Describe your answer using a flow chart.

- All are cations - therefore an addition of an _____________ will precipitate out these cations.
- There are also ____________________ in the solution to help balance out the charge.

- What can precipitate out Ca^{2+}?
- What can precipitate out Sr^{2+}?
- What can precipitate out Zn^{2+}?
- **What needs to be added first?**

As a flow chart:

Ca^{2+}, Sr^{2+}, Zn^{2+}

Practice:

1. For each of the following solutions, describe a process to individually remove each ion. Be sure to list the compounds that you add in order, and the method of removing the precipitate.

   a. Ag^{+} Ba^{2+} and Be^{2+}

   b. Br^{-}, $SO_4{}^{2-}$ and S^{2-}

   c. OH^{-}, $PO_4{}^{3-}$ and S^{2-}

   d. Cr^{3+}, Ca^{2+} and Mg^{2+}

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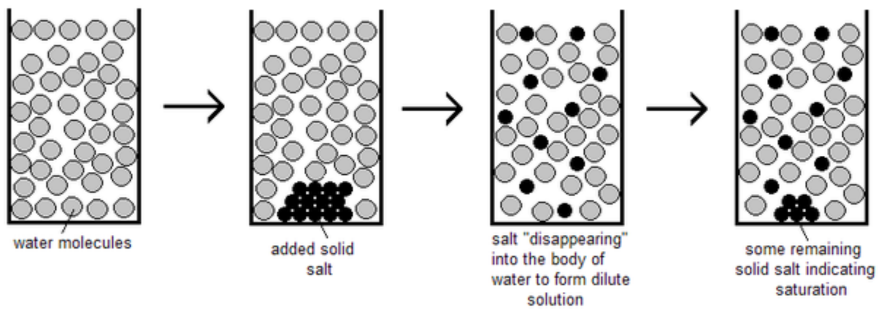
Solubility Product Constant K_{sp} *(One Source of Ions)*

In a **saturated** solution, **equilibrium** is established between the dissolving and recrystallization of a salt.

$$AB_{(s)} \leftrightharpoons A^{+}_{(aq)} + B^{-}_{(aq)}$$

$K_{eq} = K_{sp} =$

The solubility product constant, ________, is the ______________ of the _________ _____________________________ in a ______________________ solution raised to the power of the coefficients in the equilibrium.



Why aren't we using ICE TABLES?

Let's use an example with some mole ratios.

	$CD_{2\,(s)}$	$\leftrightharpoons$	$C^{2+}_{(aq)}$	+	$D^{-}_{(aq)}$
Initial *(Where the stress is introduced)*					
Change *(How the system responds to the stress)*					
Equilibrium *(New equil'm concentrations)*					

Lab Simulation: Salts & Solubility

Ionization Equation Extra Practice:

- Represents the salt breaking apart into **ions**
  - $NaCl \rightarrow$ ___ Na^+ + ___ Cl^-
- If the salt were $CaCl_2$
  - $CaCl_2 \rightarrow$ ___ Ca^{2+} + ___ Cl^-
- Mole ratios represent the relative amounts of ions in solution

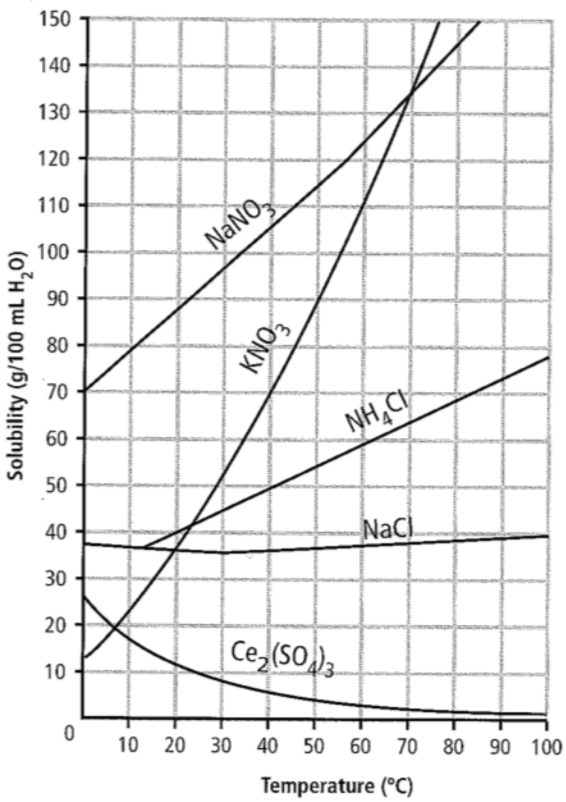
$NaCl_{(aq)}$	$\rightarrow$	$Na^+_{(aq)}$	+	$Cl^-_{(aq)}$
1.0M				
$CaCl_{2\,(aq)}$	$\rightarrow$	$Ca^{2+}_{(aq)}$	+	$2\ Cl^-_{(aq)}$
1.0M				

Practice:

1. 0.25M KOH
2. 0.75M $SrCl_2$
3. 0.20M NH_4NO_3
4. 0.45M Ag_2CrO_4
5. 0.60M $Pb(IO_3)_2$
6. 0.011M $Mg(OH)_2$
7. 0.45M $BaCO_3$
8. 0.50M $(NH_4)_2SO_3$

Solubility Curves

Consider the graph below:



a) At 10°C, which salt has the highest solubility?

b) At 10°C, which salt has the lowest solubility?

c) At 90°C, which salt has the highest solubility?

d) At 90°C, which salt has the lowest solubility?

e) If you put 40 g of NH_4Cl in 100 mL of water at 90°C, will you be able to form a saturated solution?

f) Approximately how many more grams of NH_4Cl could you add until it is saturated?

g) If you put 60 g of KNO_3 into 100 mL of water at 20°C and gradually heat the solution, what will you observe?

h) If you dissolve 100 g of both $NaNO_3$ and KNO_3 in 100 mL of water at 90°C and then cool the mixture to 10°C, which salt will form crystals first?

i) $Ce_2(SO_4)_3$ is an unusual substance as it does not follow the usual trend. What is unusual about $Ce_2(SO_4)_3$?

The molar solubility of a substance is the molar concentration of a solute in a saturated solution.

MOLE RATIO WILL BE VERY IMPORTANT IN THIS UNIT!!

We need to write out the IONIZATION/DISSOCIATION equation to figure out the ratio.

Solubility = "s"

$BaCO_{3\,(s)} \leftrightharpoons$ ___ $Ba^{2+}_{(aq)}$ + ___ $CO_3^{2-}{}_{(aq)}$ *Ratio of ions:* K_{sp} = *Solubility =*	$Fe(OH)_{2\,(s)} \leftrightharpoons$ ___ $Fe^{2+}_{(aq)}$ + ___ $OH^{-}_{(aq)}$ *Ratio of ions:* K_{sp} = *Solubility =*
$Fe(OH)_{3\,(s)} \leftrightharpoons$ ___ $Fe^{3+}_{(aq)}$ + ___ $OH^{-}_{(aq)}$ *Ratio of ions:* K_{sp} = *Solubility =*	$Sr_3(PO_4)_{2\,(s)} \leftrightharpoons$ ___ $Sr^{2+}_{(aq)}$ + ___ $PO_4^{3-}{}_{(aq)}$ *Ratio of ions:* $K_{sp} = 1.0 \times 10^{-31}$ *Solubility =*

Solubility (M) → K_{sp}

(1) The molar solubility of $CaSO_4$ is 8.4×10^{-3} M at a particular temperature. Calculate its K_{sp}.

- What is the equation representing the equilibrium?

- Write the K_{sp} expression and substitute the concentration of ions into the K_{sp} expression:

(2) The solubility of lead (II) chloride is 4.4 g/L. Calculate its K_{sp}.

(3) A student prepares a saturated solution by dissolving 5.5×10^{-5} mol of $Al(OH)_3$ in 500. mL of solution. Calculate the K_{sp} of $Al(OH)_3$.

(4) A student evaporated 150. mL of a saturated solution of magnesium phosphate. If 0.16g of solute remains, calculate the K_{sp}.

(5) Calculate the K_{sp} of silver oxalate if the solubility is 0.033 g/L.

(6) A compound has a solubility of 7.1×10^{-5} M at 25^0C. According to its K_{sp}, the compound is:

A. CuS B. AgBr C. $CaCO_3$ D. $CaSO_4$

K_{sp} → Solubility (M)

(1) Calculate the molar solubility of iron (II) hydroxide from its K_{sp}.

(2) Calculate the molar solubility of iron (III) hydroxide from its K_{sp}.

(3) Which of the following substances has the lowest solubility?

A. BaS B. CuS C. FeS D. ZnS

(4) How many moles of dissolved solute are present in 100.0mL of a saturated $SrCO_3$ solution?

A. 5.6×10^{-11} mol B. 2.4×10^{-6} mol C. 2.4×10^{-5} mol D. 2.4×10^{-4} mol

<u>Worksheet 3.2</u>

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