

## Identify and Solve $K_{sp}$ Problems Associated with Ionic Compounds

An ionic compound consists of a metal and a nonmetal, or a metal and a polyatomic ion.

A metal is either found in Group I, or Group II of the Periodic Table and will have a positive charge of +1 or +2. Metals outside of the group can have multiple valences (transition elements) and their charges are identified by the Roman numerals. The only exceptions are Aluminum (Al) = +3; Zinc (Zn) = +2; Silver (Ag) = +1. With a salt, the net charge of the molecule will be equal to zero (0). The negative charge can be determined once you realize that Group VII ions (Br, I, Cl, F) will be -1 and in the polyatomics associated with:

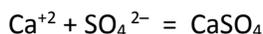
	$SO_4 = -2$	$PO_4 = -3$	$OH = -1$
<b>Calcium Sulfate</b>	$CaSO_4$	$Ca^{+2} SO_4^{2-}$	
<b>Lead (II) Chloride</b>	$PbCl_2$	$Pb^{+2} + 2Cl^-$	
<b>Iron (III) Hydroxide</b>	$Fe(OH)_3$	$Fe^{+3} + 3OH^-$	

To determine the chemical formula of the above compounds, we need to determine the charges of the individual elements.

Examples:

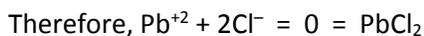
### 1. Calcium Sulfate

Calcium is in Group II and will have a positive (+2) charge, while sulfate (based on memorization of values of polyatomics), will equal (-2). Since the sum total of charges must equal, we have the following:



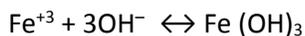
### 2. Lead (II) Chloride

Roman numeral (II) means lead has a (+2) charge – ( $Pb^{+2}$ ). Chloride is found in the Group VII of the Periodic Table and its charge is equal to (-1).



### 3. Iron (III) Hydroxide

Iron has a (+3) charge – ( $Fe^{+3}$ ). Based on polyatomic table values, the charge for OH is (-1). For the compound to be neutral, we need 3 (OH)'s, which would give a value of -3.



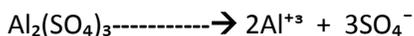
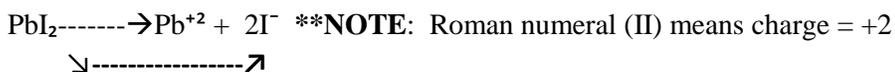
## Solving $K_{sp}$ Problems

### Steps to follow:

- 1.) Dissociate salt into individual ions
- 2.) Write up ICE Table
- 3.) Solve for appropriate value

Examples:

1. Calculate the molar solubility of Lead (II) Iodide from its  $K_{sp}$  ( $9.8 \times 10^{-9}$ )  
 \*The first step requires us to write the chemical formula of this compound. (See how to identify ionic compounds) and then break into a positive and negative ion:



Remember, these salts will always dissociate into 2 separate ions, a positive and a negative ion.

$\text{PbI}_2$  ( $K_{sp}$ ) =  $9.8 \times 10^{-9}$  (from table in book)

2. Next, set up an ICE Table, remembering that solids have NO impact on the  $K_{sp}$  ICE Table

$\text{PbI}_2$ (s) $\longrightarrow$	$\text{Pb}^{+2}$	$+2\text{I}^-$
<b>I</b>	0	0
<b>C</b>	x	$2x$
<b>E</b>	x	$2x$

$$K_{sp} = \frac{[\text{products}]}{[\text{reactants}]} = \frac{[x][2x]^2}{[\text{PbI}_2](s) = 1} = [x] \cdot [4x^2]$$

$$9.8 \times 10^{-9} = [x][4x^2]$$

$$9.8 \times 10^{-9} = 4x^3$$

$$2.45 \times 10^{-9} = x^3$$

$$1.35 \times 10^{-9} = x$$

**MOLAR SOLUBILITY** =  $x = 1.35 \times 10^{-9}$  moles/Liter = concentration of Pb in  $\text{PbI}_2$ )

If the question asks for molar solubility of Iodide ion, the answer will be  $2x$ , or  $2.7 \times 10^{-9}$  moles/Liter