

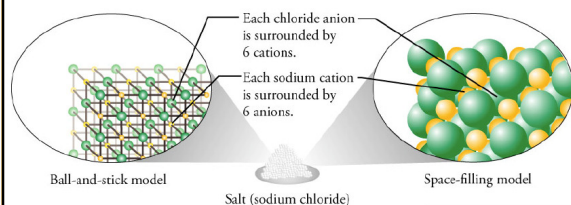
## Ionic Bonds

### Ionic Compounds Naming Ionic Formulas

## Properties of Ionic Compounds (salts)

- Crystal (salt) formation
- High melting and boiling temperature
- Brittle and hard
- Low conductivity as solids, high conductivity as dissolved ions (liquid)
- Form between metals and non-metals

## NaCl Structure



Note that there is no one molecule, but rather a crystal structure formed by the many ions!

## Ionic Compounds

- Attraction between + ions and - ions
- Electrons go from metals to nonmetals
- Ion charges follow rule of octet

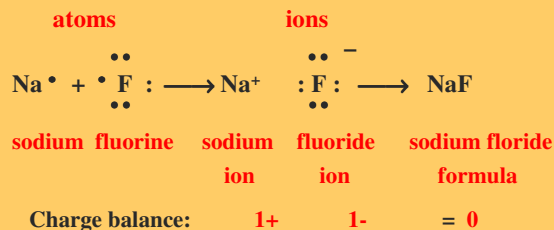
*electron transfer is always*

metal  $\longrightarrow$  nonmetal

total electrons **lost** = total electrons **gained**

## Formulas of Ionic Compounds

Formulas of ionic compounds are determined from the charges on the ions



## Writing a Formula

Write the formula for the ionic compound that will form between Ba<sup>2+</sup> and Cl<sup>-</sup>.

**Solution:**

1. Balance charge with + and - ions
2. Write the positive ion of metal first, and the negative ion **Ba<sup>2+</sup> Cl<sup>-</sup>**
3. Write the number of ions needed as subscripts **BaCl<sub>2</sub>**

## Learning Check

Write the correct formula for the compounds containing the following ions:

A.  $\text{Na}^+$ ,  $\text{S}^{2-}$

1)  $\text{NaS}$       2)  $\text{Na}_2\text{S}$       3)  $\text{NaS}_2$

B.  $\text{Al}^{3+}$ ,  $\text{Cl}^-$

1)  $\text{AlCl}_3$       2)  $\text{AlCl}$       3)  $\text{Al}_3\text{Cl}$

C.  $\text{Mg}^{2+}$ ,  $\text{N}^{3-}$

1)  $\text{MgN}$       2)  $\text{Mg}_2\text{N}_3$       3)  $\text{Mg}_3\text{N}_2$

## Polyatomic Ions

- There are also polyatomic ions

List of Polyatomic Ions to Memorize:

$\text{NH}_4^+$ ammonium	$\text{OH}^-$ hydroxide
$\text{NO}_2^-$ nitrite	$\text{H}_3\text{O}^+$ hydronium
$\text{NO}_3^-$ nitrate	$\text{PO}_4^{3-}$ phosphate
$\text{SO}_3^{2-}$ sulfite	$\text{CO}_3^{2-}$ carbonate
$\text{SO}_4^{2-}$ sulfate	$\text{CN}^-$ cyanide
$\text{ClO}^-$ hypochlorite	$\text{CrO}_4^{2-}$ chromate
$\text{ClO}_2^-$ chlorite	$\text{Cr}_2\text{O}_7^{2-}$ dichromate
$\text{ClO}_3^-$ chlorate	$\text{C}_2\text{H}_3\text{O}_2^-$ acetate
$\text{ClO}_4^-$ perchlorate	$\text{O}_2^{2-}$ peroxide
$\text{MnO}_4^-$ permanganate	

## Polyatomic Ions

- Are written in parenthesis if the empirical formula contains a subscript
- What is the formula for  $\text{PO}_4^{3-}$  and  $\text{Fe}$ ?  
 $\text{Fe}_3(\text{PO}_4)_2$
- What is the formula for  $\text{Mg}$  and  $\text{NO}_3^-$ ?  
 $\text{Mg}(\text{NO}_3)_2$

	$\text{Mg}^{2+}$	$\text{Fe}^{2+}$	$\text{Al}^{3+}$	$\text{K}^+$	$\text{Ca}^{2+}$	$\text{Na}^+$	$\text{NH}_4^+$	$\text{Fe}^{3+}$
$\text{Cl}^-$	$\text{MgCl}_2$	$\text{FeCl}_2$	$\text{AlCl}_3$	$\text{KCl}$	$\text{CaCl}_2$	$\text{NaCl}$	$\text{NH}_4\text{Cl}$	$\text{FeCl}_3$
$\text{OH}^-$	$\text{MgOH}_2$	$\text{Fe}(\text{OH})_2$	$\text{Al}(\text{OH})_3$	$\text{KOH}$	$\text{Ca}(\text{OH})_2$	$\text{NaOH}$	$\text{NH}_4\text{OH}$	$\text{Fe}(\text{OH})_3$
$\text{O}^{2-}$	$\text{MgO}$	$\text{FeO}$	$\text{Al}_2\text{O}_3$	$\text{K}_2\text{O}$	$\text{CaO}$	$\text{Na}_2\text{O}$	$(\text{NH}_4)_2\text{O}$	$\text{Fe}_2\text{O}_3$
$\text{P}^{3-}$	$\text{Mg}_3\text{P}_2$	$\text{Fe}_3\text{P}_2$	$\text{AlP}$	$\text{K}_3\text{P}$	$\text{Ca}_3\text{P}_2$	$\text{Na}_3\text{P}_2$	$(\text{NH}_4)_3\text{P}$	$\text{FeP}$
$\text{S}^{2-}$	$\text{MgS}$	$\text{FeS}$	$\text{Al}_2\text{S}_3$	$\text{K}_2\text{S}$	$\text{CaS}$	$\text{Na}_2\text{S}$	$(\text{NH}_4)_2\text{S}$	$\text{Fe}_2\text{S}_3$
$\text{PO}_4^{3-}$	$\text{Mg}_3(\text{PO}_4)_2$	$\text{Fe}_3(\text{PO}_4)_2$	$\text{AlPO}_4$	$\text{K}_3\text{PO}_4$	$\text{Ca}_3(\text{PO}_4)_2$	$\text{Na}_3\text{PO}_4$	$(\text{NH}_4)_3\text{PO}_4$	$\text{FePO}_4$
$\text{NO}_3^-$	$\text{Mg}(\text{NO}_3)_2$	$\text{Fe}(\text{NO}_3)_2$	$\text{Al}(\text{NO}_3)_3$	$\text{KNO}_3$	$\text{Ca}(\text{NO}_3)_2$	$\text{NaNO}_3$	$\text{NH}_4\text{NO}_3$	$\text{Fe}(\text{NO}_3)_3$
$\text{SO}_4^{2-}$	$\text{MgSO}_4$	$\text{FeSO}_4$	$\text{Al}_2(\text{SO}_4)_3$	$\text{K}_2\text{SO}_4$	$\text{CaSO}_4$	$\text{Na}_2\text{SO}_4$	$(\text{NH}_4)_2\text{SO}_4$	$\text{Fe}_2(\text{SO}_4)_3$

## Naming Binary Ionic Compounds

- Contain 2 different elements
- Name the metal first, then the nonmetal with the ending *-ide*.
- Use name of a metal with a fixed charge  
these are: **Groups 1A, 2A, 3A** and  $\text{Ag}^+$ ,  $\text{Zn}^{2+}$ , and  $\text{Cd}^{2+}$

Examples:

$\text{NaCl}$	sodium chloride
$\text{ZnI}_2$	zinc iodide
$\text{Al}_2\text{O}_3$	aluminum oxide

## Learning Check

Complete the names of the following binary compounds:

$\text{Na}_3\text{N}$	sodium	_____
$\text{KBr}$	potassium	_____
$\text{Al}_2\text{O}_3$	aluminum	_____
$\text{MgS}$		_____

### Solution

Complete the names of the following binary compounds:

Na <sub>3</sub> N	sodium <b>nitride</b>
KBr	potassium <b>bromide</b>
Al <sub>2</sub> O <sub>3</sub>	aluminum <b>oxide</b>
MgS	magnesium <b>sulfide</b>

### Transition Metals

Many form 2 or more positive ions

<u>1+</u>	<u>2+</u>	<u>1+ or 2+</u>	<u>2+ or 3+</u>
Ag <sup>+</sup>	Cd <sup>2+</sup>	Cu <sup>+</sup> , Cu <sup>2+</sup>	Fe <sup>2+</sup> , Fe <sup>3+</sup>
silver ion	cadmium ion	copper(I) ion copper (II) ion	iron(II) ion iron(III) ion
	Zn <sup>2+</sup>		
	zinc ion		

### Learning Check

- A. The formula for the ionic compound of Na<sup>+</sup> and O<sup>2-</sup> is  
1) NaO      2) Na<sub>2</sub>O      3) NaO<sub>2</sub>
- B. The formula of a compound of aluminum and chlorine is  
1) Al<sub>3</sub>Cl      2) AlCl<sub>2</sub>      3) AlCl<sub>3</sub>
- C. The formula of Fe<sup>3+</sup> and O<sup>2-</sup> is  
1) Fe<sub>3</sub>O<sub>2</sub>      2) FeO<sub>3</sub>      3) Fe<sub>2</sub>O<sub>3</sub>

### Solution

- A. The formula for the ionic compound of Na<sup>+</sup> and O<sup>2-</sup> is  
2) Na<sub>2</sub>O
- B. The formula of a compound of aluminum and chlorine is  
3) AlCl<sub>3</sub>
- C. The formula of Fe<sup>3+</sup> and O<sup>2-</sup> is  
3) Fe<sub>2</sub>O<sub>3</sub>

### Names of Variable Ions

Use a roman number after the name of a metal that forms two or more ions

**Transition metals and the metals in groups 4A and 5A**

FeCl <sub>3</sub>	(Fe <sup>3+</sup> )	iron (III) chloride
CuCl	(Cu <sup>+</sup> )	copper (I) chloride
SnF <sub>4</sub>	(Sn <sup>4+</sup> )	tin (IV) fluoride
PbCl <sub>2</sub>	(Pb <sup>2+</sup> )	lead (II) chloride
Fe <sub>2</sub> S <sub>3</sub>	(Fe <sup>3+</sup> )	iron (III) sulfide

### Learning Check

Complete the names of the following binary compounds with variable metal ions:

FeBr <sub>2</sub>	iron (____) bromide
Cu <sub>2</sub> O	copper (____) oxide
SnCl <sub>4</sub>	____(____) _____
Fe <sub>2</sub> O <sub>3</sub>	_____
CuS	_____

### Solution

Complete the names of the following binary compounds with variable metal ions:

$\text{FeBr}_2$  iron (II) bromide

$\text{Cu}_2\text{O}$  copper (I) oxide

$\text{SnCl}_4$  tin (IV) chloride

$\text{Fe}_2\text{O}_3$  iron (III) oxide

$\text{CuS}$  copper (II) sulfide

### Learning Check

Name the following compounds:

A.  $\text{CaO}$   
1) calcium oxide      2) calcium(I) oxide  
3) calcium (II) oxide

B.  $\text{SnCl}_4$   
1) tin tetrachloride      2) tin(II) chloride  
3) tin(IV) chloride

C.  $\text{Co}_2\text{O}_3$   
1) cobalt oxide      2) cobalt (III) oxide  
3) cobalt trioxide

### Solution

Name the following compounds:

A.  $\text{CaO}$       1) calcium oxide

B.  $\text{SnCl}_4$       3) tin(IV) chloride

C.  $\text{Co}_2\text{O}_3$       2) cobalt (III) oxide