

# Types of Compounds

## Molecular

nonmetal  $\bar{c}$  nonmetal

nonmetal atoms

covalent bonds

electrons shared

molecules

$H_2O$ ,  $CO_2$ ,  $H_2C_2H_3O_2$

## Ionic

metal  $\bar{c}$  nonmetal

Ions

Ionic bonds

electrons not shared

formula unit

$MgCl_2$ ,  $NaCl$ ,  $Na_2CO_3$

## Basic Definitions from 6 grade

compound: two or more atoms bonded together by chemical bonds.

Molecule: collection of atoms (2 or more) bonded together by covalent bonds.

Note: Ionic compounds do not have molecules they have formula units.

Ions = charged particles

Ion: Is an element or collection of elements bonded by chemical bonds that have an imbalance of electrons (-) compared to protons(+).

For example

If an atom with eleven protons (+11, Na) has ten electrons (-10), then the difference,  $+11 - 10 = +1$  means that this particular atom has a net charge of +1.

If an atom with nine protons (+9, F) has ten electrons, then the difference,  $+9 - 10 = -1$  means that this particular atom has a net charge of -1.

Ions can be elemental (single type of atom) or molecular (collection nonmetals bonded by covalent bonds).

Examples:  $K^+$ ,  $Mg^{+2}$  or  $CO_3^{-2}$ ,  $Cr_2O_7^{-2}$   
elemental molecular

rxn = reaction

## A. Elemental Ions

An atom with a different number of electrons than protons. Remember that the number of protons is fixed but electrons can be exchanged during chemical rxns.

Remember two fundamentals:

{ Metals = give up electrons  
Nonmetals = take electrons

→ when a metal reacts with a nonmetal, electrons are transferred from the metal to the nonmetal, and oppositely charged ions are formed.

Salt: a neutral compound (net charge is zero) that contains a metal and nonmetal that are ionized (charged). The opposite charges cancel each other - net charge is zero.

## Salt (continued)

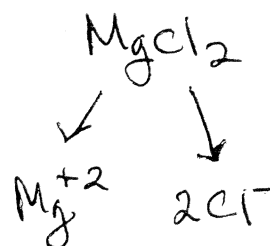
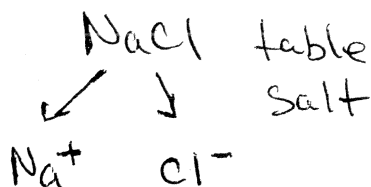
$e^-$  = electron

cation = (+) positive ion; lost  $e^-$

anion = (-) negative ion; gained  $e^-$

Salt = contains a cation and an anion.

Examples :



First we will learn the Main Group Ions  
Then we will see how they form.

Metals

Nonmetals (add-ide)

1A

2A

5A

6A

7A

$H^+$

$Be^{+2}$

$Li^+$

$Mg^{+2}$

$Na^+$

$Ca^{+2}$

$K^+$

$Sr^{+2}$

$Rb^+$

$Ba^{+2}$

$Cs^+$

$N^{-3}$

$P^{-3}$

phosphide

nitride

$O^{-2}$

oxide

$S^{-2}$

sulfide

oxide

$F^-$  fluoride

$Cl^-$  chloride

$Br^-$  bromide

$I^-$  iodide

Names :

use elemental  
name followed by the  
word ion.

Assume group 1A or 2A has  
reacted with 5A, 6A or 7A.

Must commit to memory

$e^-$  = electron

where does the charge come from?

Metals give up  $e^-$ , so they typically have a

(+) charge because the atom has more protons than electrons.

1A

For  $H^+ \quad +1p - 0e^- = +1$

$Li^+ \quad +3p - 2e^- = +1$

$Na^+ \quad +11p - 10e^- = +1$

$K^+ \quad +19p - 18e^- = +1$

$Rb^+ \quad +37p - 36e^- = +1$

$Cs^+ \quad +55p - 54e^- = +1$

} gives up  $1e^-$

2A

$Be^{+2} \quad +4p - 2e^- = +2$

$Mg^{+2} \quad +12p - 10e^- = +2$

$Ca^{+2} \quad +20p - 18e^- = +2$

$Sr^{+2} \quad +38p - 36e^- = +2$

$Ba^{+2} \quad +56p - 54e^- = +2$

} gives up  $2e^-$

Anions have a negative charge because they have more  $e^-$  than protons (+).

5A

$$N^{-3} \quad +7p - 10e^- = -3$$

$$P^{-3} \quad +15p - 18e^- = -3$$

} gained  $3e^-$

6A

$$O^{-2} \quad +8p - 10e^- = -2$$

$$S^{-2} \quad +16p - 18e^- = -2$$

} gained  $2e^-$

7A

$$F^- \quad +9p - 10e^- = -1$$

$$Cl^- \quad +17p - 18e^- = -1$$

$$Br^- \quad +35 - 36e^- = -1$$

$$I^- \quad +53 - 54e^- = -1$$

} gained  $1e^-$

composed of:

molecular  
molecules

ionic  
ions

atomic  
atoms

metallic  
atoms

Network  
covalent  
atoms

lattice sites;  
in crystal

molecules

ions

atoms

atoms

atoms

Bonding:

intermolecular  
forces (IMF)

ionic  
bonds

IMF

"metallic"  
"sea electrons"

covalent

Bp:

low

high

low

high

high

mp:

low

high

low

high

high

Examples:

$H_2O$  mp =  $0^\circ C$

$NH_3$  mp =  $-77^\circ C$

$CS_2$  mp =  $-110$

$NaCl$  mp =  $801^\circ C$

$Ne, Kr,$   
 $Cl_2$   
↓

$Cl_2$  mp =  $-151^\circ C$

$Fe$  mp =  $1100^\circ C$

↑ mp =  $3900^\circ C$   
 $C(s)$   
diamond

$SiO_2$

conductivity:

not

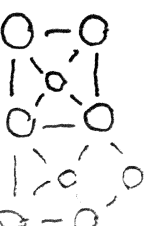
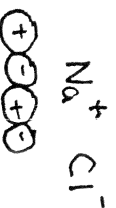
only when  
melted or  
molten

not

Solid and  
liquid is  
conductive.

not

Bonding:  
Example



# Types of compounds

Nomenclature = naming

## Terms

Binary: two different parts

Binary ionic compounds: A compound that contains two different types of ions. An ionic compound will have a metal cation and either an elemental anion or a polyanion.

## Type I Binary Compounds

Group 1A, 2A cations paired with 5A, 6A, 7A or polyanion. The elemental name of the metal is used followed by the name of the elemental anion using the -ide suffix or using the name of the polyanion.

$\text{LiCl}$  = lithium chloride

↑

Salt = cation + anion

## Type I

### Naming Binary Ionics:

NaCl sodium chloride

MgCl<sub>2</sub> magnesium chloride

Al<sub>2</sub>O<sub>3</sub> Aluminum oxide

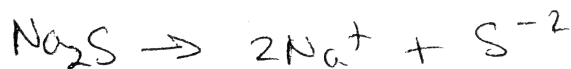
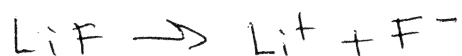
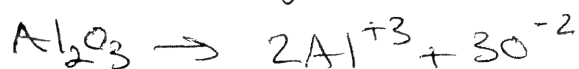
LiF lithium fluoride

Na<sub>2</sub>S sodium sulfide

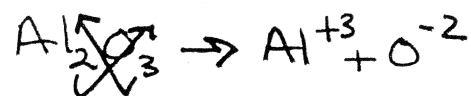
CaF<sub>2</sub> calcium fluoride

### Ionization Equations

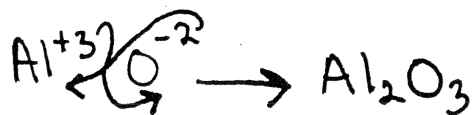
Splitting Binary compounds apart:



note: you can reverse  
drop charge:



Forming compounds: Drop charge method



## Other types of ionic compounds

### 1. Group 1A or 2A with polyanions

1A    2A

H<sup>+</sup>    Be<sup>+2</sup>

Li<sup>+</sup>    Mg<sup>+2</sup>

Na<sup>+</sup>    Ca<sup>+2</sup>

K<sup>+</sup>    Sr<sup>+2</sup>

Rb<sup>+</sup>    Ba<sup>+2</sup>

Cs<sup>+</sup>

Polyanions (molecular ions)

SO<sub>4</sub><sup>-2</sup> sulfate

OH<sup>-</sup> hydroxide

CO<sub>3</sub><sup>-2</sup> carbonate

CrO<sub>4</sub><sup>-2</sup> chromate

PO<sub>4</sub><sup>-3</sup> phosphate

NO<sub>3</sub><sup>-</sup> nitrate

MnO<sub>4</sub><sup>-</sup> permanganate

} see previous  
packet for  
full list  
of 24 molec-  
-ular ions.

### Naming Polyanion Compounds

Li<sub>2</sub>SO<sub>4</sub>    lithium sulfate

Na<sub>2</sub>CO<sub>3</sub>    sodium carbonate

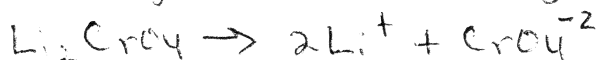
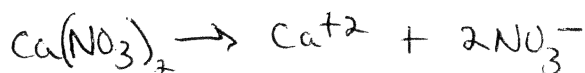
MgCrO<sub>4</sub>    magnesium chromate

Rb<sub>3</sub>PO<sub>4</sub>    rubidium phosphate

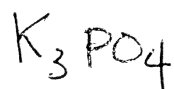
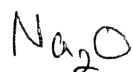
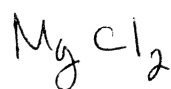
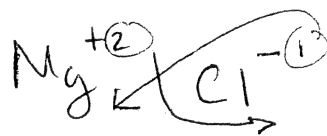
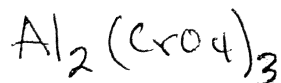
KMnO<sub>4</sub>    potassium permanganate

these are salts.  
The cation + anion  
is equal to zero.  
Overall charge on  
compound is zero.

### Splitting apart



Drop charge method to make compounds:



Net charge on compound is zero.

## Type II Binary Compounds

Transition metals (cations) combine with

5A, 6A, 7A or poly anions to make

compounds. The naming is different

because transition elements can have

more than one charge. For example,

Cu can be  $\text{Cu}^+$  and  $\text{Cu}^{+2}$ , Fe can be

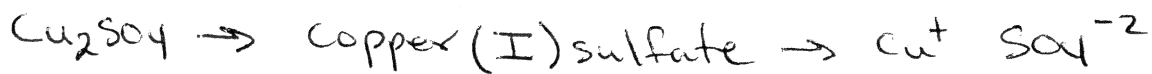
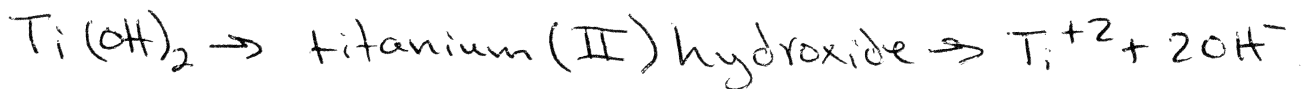
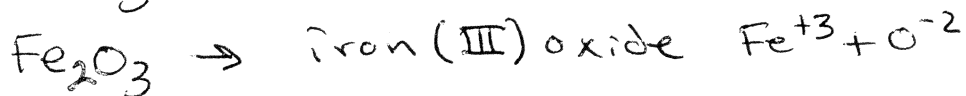
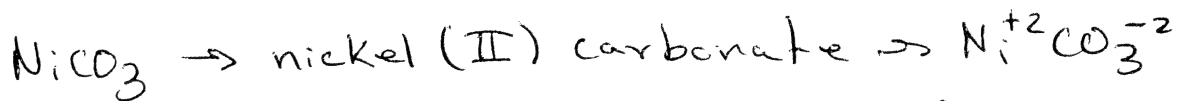
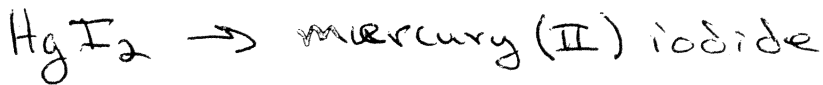
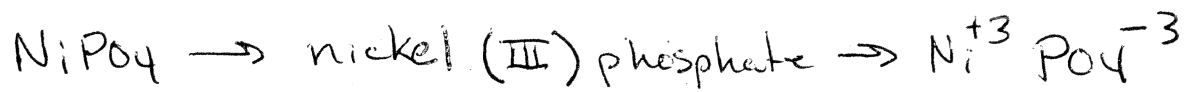
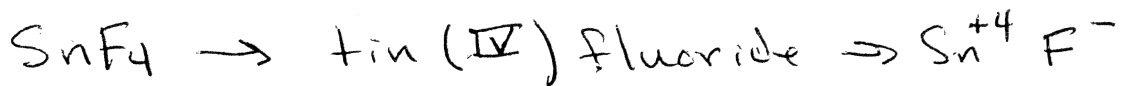
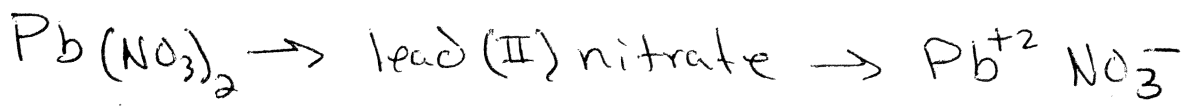
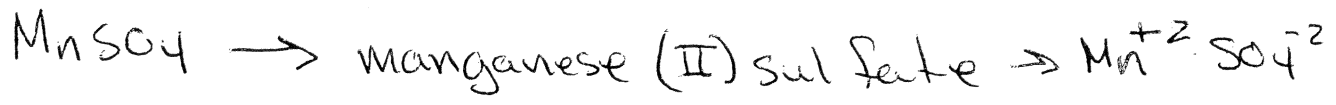
$\text{Fe}^{+2}$  and  $\text{Fe}^{+3}$ .

roman III for  $\text{Fe}^{+3}$

$\text{FePO}_4$  is iron (III) phosphate

$\text{Fe}_3(\text{PO}_4)_2$  is iron (II) phosphate

## Examples Transition elements & various anions



## molecular ions

### poly cation

$\text{NH}_4^+$  ammonium

### poly anions

$\text{NO}_3^-$  nitrate

$\text{SO}_4^{2-}$  sulfate

$\text{NO}_2^-$  nitrite

$\text{SO}_3^{2-}$  sulfite

$\text{PO}_4^{3-}$  phosphate

$\text{HSO}_4^-$  bisulfate  
hydrogen sulfate

$\text{PO}_3^{3-}$  phosphite

$\text{CO}_3^{2-}$  carbonate

$\text{HCO}_3^-$  bicarbonate  
hydrogen carbonate

$\text{OH}^-$  hydroxide

$\text{CN}^-$  cyanide

$\text{H}_2\text{PO}_4^-$  dihydrogen phosphate

$\text{C}_2\text{H}_3\text{O}_2^-$  acetate

$\text{ClO}^-$  hypochlorite

$\text{ClO}_2^-$  chlorite

$\text{ClO}_3^-$  chlorate

$\text{ClO}_4^-$  perchlorate

# KNOW YOUR IONS

|           |                  |           |                  |           |                  |          |                 |
|-----------|------------------|-----------|------------------|-----------|------------------|----------|-----------------|
| Hydrogen  | H <sup>+</sup>   | Magnesium | Mg <sup>+2</sup> | Zinc      | Zn <sup>+2</sup> | Sulfide  | S <sup>-2</sup> |
| Lithium   | Li <sup>+</sup>  | Calcium   | Ca <sup>+2</sup> | Aluminum  | Al <sup>+3</sup> | Fluoride | F <sup>-</sup>  |
| Sodium    | Na <sup>+</sup>  | Strontium | Sr <sup>+2</sup> | Nitride   | N <sup>-3</sup>  | Chloride | Cl <sup>-</sup> |
| Potassium | K <sup>+</sup>   | Barium    | Ba <sup>+2</sup> | Phosphide | P <sup>-3</sup>  | Bromide  | Br <sup>-</sup> |
| Beryllium | Be <sup>+2</sup> | Silver    | Ag <sup>+</sup>  | Oxide     | O <sup>-2</sup>  | Iodide   | I <sup>-</sup>  |

## SOME METALS THAT FORM TWO IONS

|             |           |                  |              |             |                               |
|-------------|-----------|------------------|--------------|-------------|-------------------------------|
| Copper (I)  | [Cuprous] | Cu <sup>+</sup>  | Mercury (I)  | [Mercurous] | Hg <sub>2</sub> <sup>+2</sup> |
| Copper (II) | [Cupric]  | Cu <sup>+2</sup> | Mercury (II) | [Mercuric]  | Hg <sup>+2</sup>              |
| Iron (II)   | [Ferrous] | Fe <sup>+2</sup> | Tin (II)     | [Stannous]  | Sn <sup>+2</sup>              |
| Iron (III)  | [Ferric]  | Fe <sup>+3</sup> | Tin (IV)     | [Stannic]   | Sn <sup>+4</sup>              |

## OTHER CATIONS

Ammonium NH<sub>4</sub><sup>+</sup>

## OTHER ANIONS

Acetate C<sub>2</sub>H<sub>3</sub>O<sub>2</sub><sup>-</sup>  
 Chromate CrO<sub>4</sub><sup>-2</sup>  
 Dichromate Cr<sub>2</sub>O<sub>7</sub><sup>-2</sup>

Cyanide CN<sup>-</sup>  
 Hydroxide OH<sup>-</sup>  
 Oxalate C<sub>2</sub>O<sub>4</sub><sup>-2</sup>  
 Peroxide O<sub>2</sub><sup>-2</sup>

|                                          |                                           |                                        |                                      |
|------------------------------------------|-------------------------------------------|----------------------------------------|--------------------------------------|
| Perbromate BrO <sub>4</sub> <sup>-</sup> | Perchlorate ClO <sub>4</sub> <sup>-</sup> | Periodate IO <sub>4</sub> <sup>-</sup> |                                      |
| Bromate BrO <sub>3</sub> <sup>-</sup>    | Chlorate ClO <sub>3</sub> <sup>-</sup>    | Iodate IO <sub>3</sub> <sup>-</sup>    | Nitrate NO <sub>3</sub> <sup>-</sup> |
| Bromite BrO <sub>2</sub> <sup>-</sup>    | Chlorite ClO <sub>2</sub> <sup>-</sup>    | Iodite IO <sub>2</sub> <sup>-</sup>    | Nitrite NO <sub>2</sub> <sup>-</sup> |
| Hypobromite BrO <sup>-</sup>             | Hypochlorite ClO <sup>-</sup>             | Hypoiodite IO <sup>-</sup>             |                                      |

|                                         |                                       |                                         |                                            |
|-----------------------------------------|---------------------------------------|-----------------------------------------|--------------------------------------------|
| Carbonate CO <sub>3</sub> <sup>-2</sup> | Sulfate SO <sub>4</sub> <sup>-2</sup> | Phosphate PO <sub>4</sub> <sup>-3</sup> | Permanganate MnO <sub>4</sub> <sup>-</sup> |
|                                         | Sulfite SO <sub>3</sub> <sup>-2</sup> | Phosphite PO <sub>3</sub> <sup>-3</sup> |                                            |

## BI-ANIONS

|                                           |                                         |
|-------------------------------------------|-----------------------------------------|
| Bicarbonate HCO <sub>3</sub> <sup>-</sup> | Bisulfite HSO <sub>3</sub> <sup>-</sup> |
| Bisulfate HSO <sub>4</sub> <sup>-</sup>   | Bisulfide HS <sup>-</sup>               |

## THIO-ANIONS

|                                                         |
|---------------------------------------------------------|
| Thiocyanate SCN <sup>-</sup>                            |
| Thiosulfate S <sub>2</sub> O <sub>3</sub> <sup>-2</sup> |

# Memorize

## (A) Acids

HCl hydrochloric acid  
HBr hydrobromic acid  
HI hydroiodic acid  
H<sub>2</sub>SO<sub>4</sub> sulfuric acid  
HNO<sub>3</sub> nitric acid  
HClO<sub>4</sub> perchloric acid

## (B) Bases

NaOH sodium hydroxide  
KOH potassium hydroxide  
Ca(OH)<sub>2</sub> calcium hydroxide  
Sr(OH)<sub>2</sub> strontium hydroxide  
Ba(OH)<sub>2</sub> barium hydroxide

## (C) Diatomic Molecules

|                           |                            |
|---------------------------|----------------------------|
| N <sub>2</sub> = nitrogen | Cl <sub>2</sub> = chlorine |
| O <sub>2</sub> = oxygen   | F <sub>2</sub> = fluorine  |
| H <sub>2</sub> = hydrogen | Br <sub>2</sub> = bromine  |
|                           | I <sub>2</sub> = iodine    |