

# Naming Compounds Handout

## IONIC COMPOUNDS versus MOLECULAR COMPOUNDS

- ionic compound:** consist of **cations** (positive ions) and **anions** (negative ions) held together by electrostatic attraction
- usually **metal + nonmetal(s)**
  - made of monatomic ions, polyatomic ions, and/or both
    - **monatomic ions:** consist of a single atom
    - **polyatomic ions:** consist of more than one atom
- molecular compound:** consist of **nonmetal atoms** bonded together by shared electrons (covalent bonding)
- **acid:** a molecular compound that releases hydrogen ions ( $H^+$ ) when dissolved in water

## NAMING MONATOMIC CATIONS:

Metal atoms lose valence electrons to form positively charged ions, called **cations**.

An ion formed from an individual atom is a **monatomic** (or monoatomic) **cation**.

- I. Groups IA to IIIA elements silver (Ag), zinc (Zn) and cadmium (Cd) form only one type of ion each:
- Group IA elements form +1 ions:  $Li^+$ ,  $Na^+$ ,  $K^+$ ,  $Rb^+$ ,  $Cs^+$
  - Group IIA elements form +2 ions:  $Be^{+2}$ ,  $Mg^{+2}$ ,  $Ca^{+2}$ ,  $Sr^{+2}$ ,  $Ba^{+2}$
  - Group IIIA elements form +3 ions:  $Al^{+3}$
  - silver ion =  $Ag^+$ ; zinc ion =  $Zn^{+2}$ ; cadmium ion =  $Cd^{+2}$

When a Group IA–IIIA element, silver, zinc, or cadmium forms an ion, it is named:

**element name + ion**

e.g.  $Na^+$  = sodium ion

$Sr^{+2}$  = strontium ion

$Zn^{+2}$  = zinc ion

II. The **Stock system** is used to name transition metals and other metals that form more than one ion:

- iron (Fe) forms two ions:  $\text{Fe}^{+2}$  and  $\text{Fe}^{+3}$
- lead (Pb) forms two ions:  $\text{Pb}^{+2}$  and  $\text{Pb}^{+4}$

When a a metal can form more than one ion, each ion is named:

**element name (charge in Roman numerals) + ion**

e.g.  $\text{Fe}^{+2}$  = iron (II) ion

$\text{Pb}^{+2}$  = lead (II) ion

$\text{Cu}^{+}$  = copper (I) ion

$\text{Fe}^{+3}$  = iron (III) ion

$\text{Pb}^{+4}$  = lead (IV) ion

$\text{Cu}^{+2}$  = copper (II) ion

Name each of the following monatomic cations:

$\text{Li}^{+}$  = \_\_\_\_\_

$\text{Cd}^{+2}$  = \_\_\_\_\_

$\text{Ag}^{+}$  = \_\_\_\_\_

$\text{Cu}^{+2}$  = \_\_\_\_\_

$\text{Al}^{+3}$  = \_\_\_\_\_

$\text{Mg}^{+2}$  = \_\_\_\_\_

$\text{Mn}^{+2}$  = \_\_\_\_\_

$\text{Sn}^{+4}$  = \_\_\_\_\_

$\text{H}^{+}$  = \_\_\_\_\_

$\text{Co}^{+3}$  = \_\_\_\_\_

$\text{Fe}^{+3}$  = \_\_\_\_\_

$\text{Na}^{+}$  = \_\_\_\_\_

$\text{K}^{+}$  = \_\_\_\_\_

$\text{Ti}^{+4}$  = \_\_\_\_\_

$\text{Ca}^{+2}$  = \_\_\_\_\_

$\text{Ni}^{+2}$  = \_\_\_\_\_

## NAMING MONATOMIC ANIONS:

Nonmetal atoms gain valence electrons to form **negatively charged ions** called **anions**.

When a nonmetal forms an ion, it is named:

**element stem name + “ide” + ion**

e.g.      O = **oxygen** atom       $\Rightarrow$        $O^{-2}$  = **oxide** ion  
            N = **nitrogen** atom       $\Rightarrow$        $N^{-3}$  = **nitride** ion

Name each of the following monatomic anions:

$F^{-}$  = \_\_\_\_\_       $Cl^{-}$  = \_\_\_\_\_

$Br^{-}$  = \_\_\_\_\_       $S^{-2}$  = \_\_\_\_\_

$I^{-}$  = \_\_\_\_\_       $P^{-3}$  = \_\_\_\_\_

## NAMING POLYATOMIC IONS:

Ions made up of more than one atom are **polyatomic ions**:

- only one polyatomic cation:  $NH_4^{+}$  = **ammonium ion**
- many polyatomic anions: see table below

$NH_4^{+}$  = ammonium ion

### Polyatomic ions

$OH^{-}$  = hydroxide ion

$NO_2^{-}$  = nitrite ion

$C_2H_3O_2^{-}$  = acetate ion

$CN^{-}$  = cyanide ion

$NO_3^{-}$  = nitrate ion

$PO_4^{-3}$  = phosphate ion

$CrO_4^{-2}$  = chromate ion

$SO_4^{-2}$  = sulfate ion

$MnO_4^{-}$  = permanganate ion

$Cr_2O_7^{-2}$  = dichromate ion

$SO_3^{-2}$  = sulfite ion

$CO_3^{-2}$  = carbonate ion

$HCO_3^{-}$  = hydrogen carbonate ion or bicarbonate ion

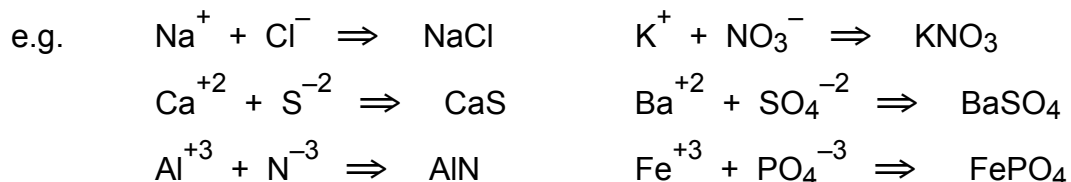
Name each of the following polyatomic ions:



## WRITING CHEMICAL FORMULAS GIVEN INDIVIDUAL IONS

Compounds must be neutral  $\Rightarrow$  total +ve charge = total -ve charge

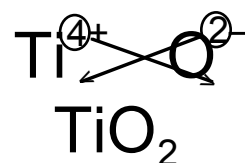
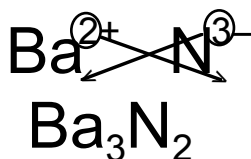
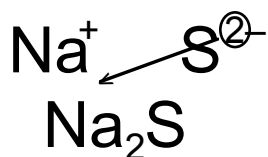
1. If the two ions have exactly opposite charges (+1 and -1, +2 and -2, +3 and -3)  
fi **formula of the compound contains one of each ion**



Combine each pair of ions to get the formula of the compound they form:

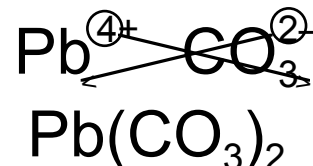
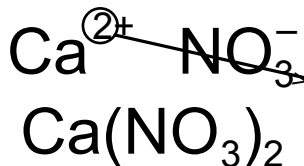
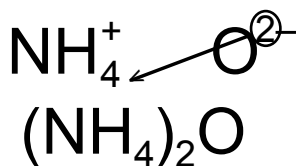


- 2a. If two monatomic ions have different charges  
 ⇒ **use crossover rule to get formula of the compound**
- superscript for cation becomes subscript for anion
  - superscript for anion becomes subscript for cation
  - **simplify subscripts** to get lowest ratio of atoms
- (Note: **Only the numbers cross down**, not the signs!)



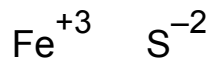
Ti<sub>2</sub>O<sub>4</sub> is simplified!

- b. If two ions have different charges and at least polyatomic ion is involved  
 ⇒ **use crossover rule to get formula of the compound**
- if more than one of polyatomic ion in formula, use parentheses
  - **simplify subscripts** to get lowest ratio of atoms
- (Note: Again **only the numbers cross down**, not the signs!)



Pb<sub>2</sub>(CO<sub>3</sub>)<sub>4</sub> is simplified!

Combine each pair of ions to get the formula of the compound they form:





## GIVEN THE CHEMICAL FORMULA, NAME THE COMPOUND

1. If the metal is in Groups IA–IIIA, silver, cadmium, or zinc, then just name the metal cation and the anion:

e.g. **NaCl**  $\Rightarrow$  Na = **sodium** and Cl = **chloride**  $\Rightarrow$  **sodium chloride**

**BaI<sub>2</sub>**  $\Rightarrow$  Ba = **barium** and I = **iodide**  $\Rightarrow$  **barium iodide**

**Al(OH)<sub>3</sub>**  $\Rightarrow$  Al = **aluminum** and OH = **hydroxide**  $\Rightarrow$  **aluminum hydroxide**

**ZnSO<sub>4</sub>**  $\Rightarrow$  Zn = **zinc** and SO<sub>4</sub> = **sulfate**  $\Rightarrow$  **zinc sulfate**

2. If the metal can form more than one ion,
  - a. Use reverse crossover to get the individual ions
    - Make the **subscript of cation** the **negative charge of anion**
    - Make the **subscript of anion** the **positive charge of cation**
  - b. Check to make sure the charges on the ions are correct
  - c. Name the cation and the anion, then remove “ion” from both

e.g. **NiBr<sub>2</sub>**  $\Rightarrow$  **Ni<sup>+2</sup>** = **nickel (II)** ion    **Br<sup>-</sup>** = **bromide** ion  
Is bromide’s charge really –1? YES!

then  $\Rightarrow$  **NiBr<sub>2</sub>** = **nickel (II) bromide**

- d. If a polyatomic ion is involved, remember that more than one polyatomic is shown in parentheses—i.e. **DO NOT bring up the subscript of atoms in a polyatomic ion to be the charge of the metal!**

**CuSO<sub>4</sub>**  $\Rightarrow$  There is only ONE Cu and ONE SO<sub>4</sub>, so get the charge for the Cu based on the SO<sub>4</sub>. The formula is **SO<sub>4</sub><sup>-2</sup>**, and there is only ONE **SO<sub>4</sub><sup>-2</sup>**, so **Cu**’s charge here must be **+2** for the compound to have an overall charge of zero.

$\Rightarrow$  **Cu<sup>+2</sup>** = **copper (II)** ion    **SO<sub>4</sub><sup>-2</sup>** = **sulfate** ion

then  $\Rightarrow$  **CuSO<sub>4</sub>** = **copper (II) sulfate**

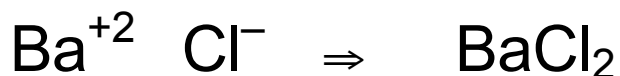
Give the name for each compound given its chemical formula:

Formula	Individual Ions	Name of Compound
MgCl <sub>2</sub>	Mg <sup>+2</sup> Cl <sup>-</sup>	magnesium chloride
LiOH		
ZnCO <sub>3</sub>		
K <sub>2</sub> S		
FePO <sub>4</sub>		
SnO <sub>2</sub>		
CuBr <sub>2</sub>		
Ag <sub>3</sub> N		
Mn(CN) <sub>2</sub>		
AgC <sub>2</sub> H <sub>3</sub> O <sub>2</sub>		

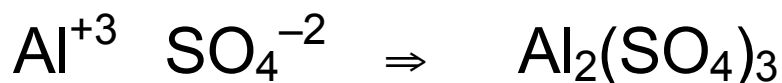
### WRITING CHEMICAL FORMULAS GIVEN THE COMPOUND NAME

Get the individual ions from the name, then combine them using the crossover rule:

e.g. barium chloride  $\Rightarrow$  barium = Ba<sup>+2</sup> chloride = Cl<sup>-</sup>



aluminum sulfate  $\Rightarrow$  aluminum = Al<sup>+3</sup> sulfate = SO<sub>4</sub><sup>-2</sup>





Give the name for each compound given its chemical formula:

Name of Compound	individual ions	Formula
lithium cyanide	$\text{Li}^+ \text{CN}^-$	$\text{LiCN}$
iron (III) sulfate		
calcium iodide		
tin (IV) dichromate		
cadmium nitrite		
copper (II) acetate		
zinc carbonate		
lead (II) phosphide		
potassium sulfite		
cobalt (II) nitride		
nickel (II) permanganate		

## NAMING MOLECULAR COMPOUNDS

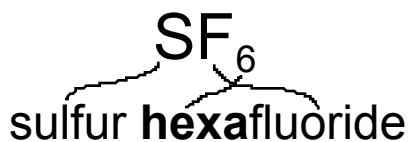
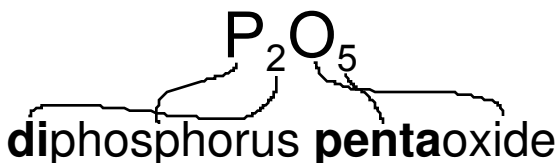
Indicate number of atoms of each element with **Greek prefix** before element name:

# of atoms	Greek Prefix	# of atoms	Greek Prefix
1	mono (usually omitted)	6	hexa
2	di	7	hepta
3	tri	8	octa
4	tetra	9	nona
5	penta	10	deca

For the **first element**: **Greek prefix + element name**

For the **second element**: **Greek prefix + element name stem + “-ide”**

Note: **Mono is generally omitted**, except in common names like  
**CO = carbon monoxide**



Name the following molecular compounds:

$SO_3$  = \_\_\_\_\_  $SiBr_4$  = \_\_\_\_\_

$XeF_6$  = \_\_\_\_\_  $ClF_3$  = \_\_\_\_\_

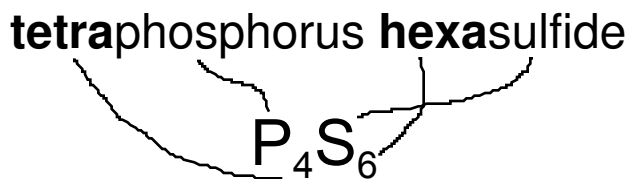
$N_2O_4$  = \_\_\_\_\_  $Cl_2O_7$  = \_\_\_\_\_

$PCl_5$  = \_\_\_\_\_  $P_4O_{10}$  = \_\_\_\_\_

## DETERMINING FORMULAS OF MOLECULAR COMPOUNDS

Use Greek prefix(es) to determine number of atoms of each element in formula.

Get **elements** and **number of atoms** of each from name:



Give the formulas for each of the following molecular compounds:

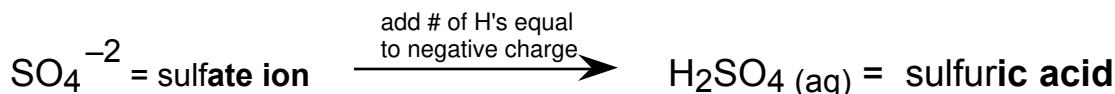
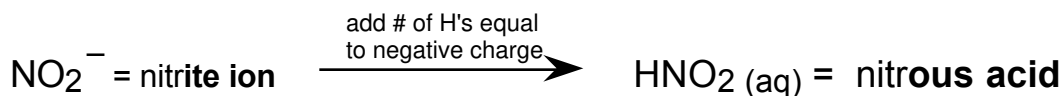
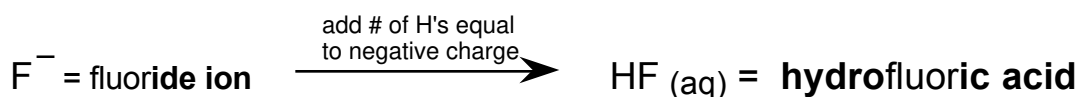
nitrogen trichloride      dibromine heptaoxide      dinitrogen pentasulfide

## DETERMINING FORMULAS AND NAMES OF ACIDS FROM IONS

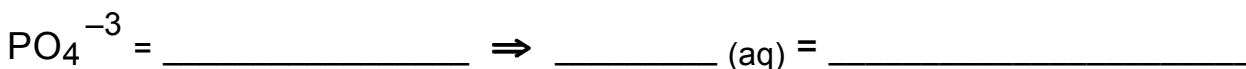
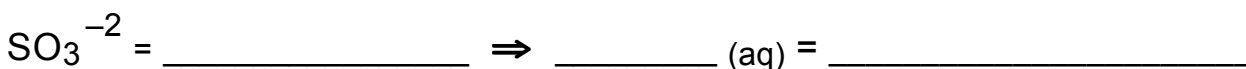
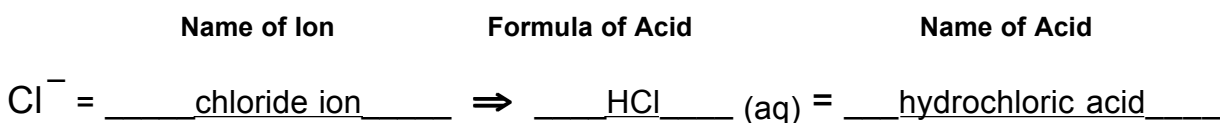
Given an ion,

we can get formula of acid by: adding **H atoms** equal to negative charge on ion

we can name for acid: depending on suffix of ion name



Name each of the following ions, and determine the formula and name of the corresponding acid that forms from the ion.



Name each of the following acids:

HBr (aq)= \_\_\_\_\_ H<sub>2</sub>CrO<sub>4</sub> (aq)= \_\_\_\_\_

H<sub>2</sub>SO<sub>4</sub> (aq)= \_\_\_\_\_ HC<sub>2</sub>H<sub>3</sub>O<sub>2</sub> (aq)= \_\_\_\_\_

Give the formula for each of the following acids: [Don't forget to indicate (aq)!]

hydrofluoric acid = \_\_\_\_\_ nitrous acid = \_\_\_\_\_

phosphoric acid = \_\_\_\_\_ chromic acid = \_\_\_\_\_

hydroiodic acid = \_\_\_\_\_ carbonic acid = \_\_\_\_\_

sulfurous acid = \_\_\_\_\_ nitric acid = \_\_\_\_\_

### PUTTING IT ALL TOGETHER:

Name each of the following compounds:

BaCl<sub>2</sub> \_\_\_\_\_ NiBr<sub>2</sub> \_\_\_\_\_

HNO<sub>3</sub>(aq) \_\_\_\_\_ SO<sub>2</sub> \_\_\_\_\_

AgF \_\_\_\_\_ PbSe<sub>2</sub> \_\_\_\_\_

NiSO<sub>3</sub> \_\_\_\_\_ PF<sub>5</sub> \_\_\_\_\_

K<sub>2</sub>SO<sub>4</sub> \_\_\_\_\_ Cr(C<sub>2</sub>H<sub>3</sub>O<sub>2</sub>)<sub>3</sub> \_\_\_\_\_

FeP \_\_\_\_\_ Al<sub>2</sub>(CO<sub>3</sub>)<sub>3</sub> \_\_\_\_\_

CuMnO<sub>4</sub> \_\_\_\_\_ Cd(OH)<sub>2</sub> \_\_\_\_\_