Naming Simple Compounds
Ionic Compounds

Ionic compounds

• consist of positive and negative ions.

• have attractions called ionic bonds between positively and negatively charged ions.

• have high melting and boiling points.

• are solid at room temperature.
Salt is An Ionic Compound

Sodium chloride or “table salt” is an example of an ionic compound.
Naming Ionic Compounds with Two Elements

To name a compound that contains two elements,

- identify the **cation** and **anion**.
- name the cation first followed by the name of the anion.
An ionic formula

- consists of positively and negatively charged ions.
- is neutral.
- has charge balance.

**total positive charge = total negative charge**

The symbol of the metal is written first followed by the symbol of the nonmetal.
Charge Balance In MgCl₂

In MgCl₂,

- a Mg atom loses two valence electrons.
- two Cl atoms each gain one electron.
- subscripts indicate the number of ions needed to give charge balance.

\[ \text{Mg}^{2+} + 2\text{Cl}^- \rightarrow \text{MgCl}_2\]
Charge Balance in $\text{Na}_2\text{S}$

In $\text{Na}_2\text{S}$.

- two Na atoms lose one valence electron each.
- one S atom gains two electrons.
- subscripts show the number of ions needed to give charge balance.

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Guide to Writing Formulas from the Name

STEP 1
Identify the cation and anion.

STEP 2
Balance the charges.

STEP 3
Write the formula, cation first, using subscripts from charge balance.
Writing Ionic Formulas from Charges

Charge balance is used to write the formula for sodium nitride, a compound containing Na\(^+\) and N\(^{3-}\).

\[
\begin{align*}
3 \left\{ \begin{array}{c}
Na^+ \\
Na^+ \\
Na^+
\end{array} \right. \\
Na^+ + N^{3-} & = Na_3N \\
3(+1) + 1(3-) & = 0
\end{align*}
\]
The balance of charges in Aluminum Oxide

The Crossover Method

$\text{Al}^{3+} \text{O}^{2-}$ Write each atom with its predicted charge from the periodic table. The cation is first by convention.

$\text{Al}_2^{3+} \text{O}_3^{2-}$ Take the superscript on each atom and write the number as the subscript on the other atom.

$\text{Al}_2\text{O}_3$ Remove the charges and simplify if necessary. (If both subscripts are the same number, then the correct formula has one of each species. For example, $\text{Ca}_2\text{O}_2$ simplifies to $\text{CaO}$.)

Two +3 charges (total +6) are balanced by three −2 charges (−6).
Formula from Ionic Charges

Write the ionic formula of the compound with Ba\(^{2+}\) and Cl\(^{-}\).

- Write the symbols of the ions.  
  \(\text{Ba}^{2+} \quad \text{Cl}^{-}\)

- Balance the charges.  
  \(\text{Ba}^{2+} \quad \text{Cl}^{-} \quad \text{two Cl}^{-} \text{ needed}\)  
  \(\text{Cl}^{-} \quad \text{Cl}^{-}\)

- Write the ionic formula using a \textit{subscript 2} for two chloride ions that give charge balance.  
  \(\text{BaCl}_2\)
Learning Check

Select the correct formula for each of the following ionic compounds.

A. Na\(^+\) and S\(^{2-}\)
   1) NaS
   2) Na\(_2\)S
   3) NaS\(_2\)

B. Al\(^{3+}\) and Cl\(^-\)
   1) AlCl\(_3\)
   2) AlCl
   3) Al\(_3\)Cl

C. Mg\(^{2+}\) and N\(^{3-}\)
   1) MgN
   2) Mg\(_2\)N\(_3\)
   3) Mg\(_3\)N\(_2\)
Solution

A. Na\(^+\) and S\(^{2-}\)
   2) Na\(_2\)S
   check: \(2\text{Na}^+ + \text{S}^{2-} = 2(1+) + 1(2-) = 0\)

B. Al\(^{3+}\) and Cl\(^-\)
   1) AlCl\(_3\)
   check: \(\text{Al}^{3+} + \text{Cl}^- = (3+) + 3(1-) = 0\)

C. Mg\(^{2+}\) and N\(^{3-}\)
   3) Mg\(_3\)N\(_2\)
   check: \(2\text{Mg}^{2+} + 2\text{N}^{3-} = 2(3+) + 2(3-) = 0\)
Useful relationships from the periodic table

<table>
<thead>
<tr>
<th>IA</th>
<th>IIA</th>
<th>IIIA</th>
<th>IVA</th>
<th>VA</th>
<th>VIA</th>
<th>VIIA</th>
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<tr>
<td>Hydride</td>
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<tr>
<td>H^-</td>
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<td>Lithium</td>
<td>Beryllium</td>
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<tr>
<td>Li^+</td>
<td>Be^{2+}</td>
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<td></td>
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</tr>
<tr>
<td>Sodium</td>
<td>Magnesium</td>
<td>Aluminum</td>
<td></td>
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</tr>
<tr>
<td>Na^+</td>
<td>Mg^{2+}</td>
<td>Al^{3+}</td>
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<tr>
<td>Potassium</td>
<td>Calcium</td>
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<td>K^+</td>
<td>Ca^{2+}</td>
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<td>Rubidium</td>
<td>Strontium</td>
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<td>Rb^+</td>
<td>Sr^{2+}</td>
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<td></td>
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<tr>
<td>Cesium</td>
<td>Barium</td>
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<td></td>
</tr>
<tr>
<td>Cs^+</td>
<td>Ba^{2+}</td>
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</tr>
<tr>
<td>Carbide</td>
<td>Nitride</td>
<td>Oxide</td>
<td>Fluoride</td>
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<tr>
<td>C^{4-}</td>
<td>N^{3-}</td>
<td>O^{2-}</td>
<td>F^-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphide</td>
<td>Sulfide</td>
<td>Chloride</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P^{3-}</td>
<td>S^{2-}</td>
<td>Cl^-</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Selenide</td>
<td>Bromide</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Se^{2-}</td>
<td>Br^-</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Telluride</td>
<td>Iodide</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Te^{2-}</td>
<td>I^-</td>
<td></td>
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</table>
# Names of Some Common Ions

<table>
<thead>
<tr>
<th>Group Number</th>
<th>Formula of Ion</th>
<th>Name of Ion</th>
<th>Group Number</th>
<th>Formula of Ion</th>
<th>Name ofIon</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A (1)</td>
<td>Li⁺</td>
<td>Lithium</td>
<td>5A (15)</td>
<td>N³⁻</td>
<td>Nitride</td>
</tr>
<tr>
<td></td>
<td>Na⁺</td>
<td>Sodium</td>
<td>6A (16)</td>
<td>P³⁻</td>
<td>Phosphide</td>
</tr>
<tr>
<td></td>
<td>K⁺</td>
<td>Potassium</td>
<td></td>
<td>O²⁻</td>
<td>Oxide</td>
</tr>
<tr>
<td>2A (2)</td>
<td>Mg²⁺</td>
<td>Magnesium</td>
<td>7A (17)</td>
<td>S²⁻</td>
<td>Sulfide</td>
</tr>
<tr>
<td></td>
<td>Ca²⁺</td>
<td>Calcium</td>
<td></td>
<td>F⁻</td>
<td>Fluoride</td>
</tr>
<tr>
<td></td>
<td>Ba²⁺</td>
<td>Barium</td>
<td></td>
<td>Cl⁻</td>
<td>Chloride</td>
</tr>
<tr>
<td>3A (3)</td>
<td>Al³⁺</td>
<td>Aluminum</td>
<td></td>
<td>Br⁻</td>
<td>Bromide</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>I⁻</td>
<td>Iodide</td>
</tr>
</tbody>
</table>
# Examples of Ionic Compounds with Two Elements

<table>
<thead>
<tr>
<th>Formula</th>
<th>Ions</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>NaCl</td>
<td>Na(^+) Cl(^-)</td>
<td>sodium chloride</td>
</tr>
<tr>
<td>K(_2)S</td>
<td>K(^+) S(^{2-})</td>
<td>potassium sulfide</td>
</tr>
<tr>
<td>MgO</td>
<td>Mg(^{2+}) O(^{2-})</td>
<td>magnesium oxide</td>
</tr>
<tr>
<td>Ca(_2)I</td>
<td>Ca(^{2+}) I(^-)</td>
<td>calcium iodide</td>
</tr>
<tr>
<td>Al(_2)O(_3)</td>
<td>Al(^{3+}) O(^{2-})</td>
<td>aluminum oxide</td>
</tr>
</tbody>
</table>
# Learning Check

Write the formulas and names for compounds of the following ions:

<table>
<thead>
<tr>
<th></th>
<th>Br(^-)</th>
<th>S(^{2-})</th>
<th>N(^{3-})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na(^+)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Al(^{3+})</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Br&lt;sup&gt;-&lt;/sup&gt;</td>
<td>S&lt;sup&gt;2-&lt;/sup&gt;</td>
<td>N&lt;sup&gt;3-&lt;/sup&gt;</td>
</tr>
<tr>
<td>-------</td>
<td>----------------</td>
<td>----------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Na&lt;sup&gt;+&lt;/sup&gt;</td>
<td>NaBr sodium bromide</td>
<td>Na&lt;sub&gt;2&lt;/sub&gt;S sodium sulfide</td>
<td>Na&lt;sub&gt;3&lt;/sub&gt;N sodium nitride</td>
</tr>
<tr>
<td>Al&lt;sup&gt;3+&lt;/sup&gt;</td>
<td>AlBr&lt;sub&gt;3&lt;/sub&gt; aluminum bromide</td>
<td>Al&lt;sub&gt;2&lt;/sub&gt;S&lt;sub&gt;3&lt;/sub&gt; aluminum sulfide</td>
<td>AlN aluminum nitride</td>
</tr>
</tbody>
</table>
Most transition metals and Group 4(14) metals form 2 or more positive ions.

Zn$^{2+}$, Ag$^+$, and Cd$^{2+}$ form only one ion.
Metals that form more than One Cation

The name of metals with two or more positive ions (cations) use a **Roman numeral** to identify ionic charge.

<table>
<thead>
<tr>
<th>Element</th>
<th>Possible Ions</th>
<th>Name of Ion</th>
<th>Element</th>
<th>Possible Ions</th>
<th>Name of Ion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chromium</td>
<td>^Cr^{4+}</td>
<td>chromium(IV)</td>
<td>Lead</td>
<td>Pb^{2+}</td>
<td>lead(II)</td>
</tr>
<tr>
<td></td>
<td>Cr^{3+}</td>
<td>chromium(III)</td>
<td></td>
<td>Pb^{4+}</td>
<td>lead(IV)</td>
</tr>
<tr>
<td>Copper</td>
<td>Cu^{+}</td>
<td>copper(I)</td>
<td>Tin</td>
<td>Sn^{2+}</td>
<td>tin(II)</td>
</tr>
<tr>
<td></td>
<td>Cu^{2+}</td>
<td>copper(II)</td>
<td></td>
<td>Sn^{4+}</td>
<td>tin(IV)</td>
</tr>
<tr>
<td>Gold</td>
<td>Au^{+}</td>
<td>gold(I)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Au^{3+}</td>
<td>gold(III)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>Fe^{2+}</td>
<td>iron(II)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fe^{3+}</td>
<td>iron(III)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Naming Ionic Compounds with Variable Charge Metals

STEP 1
Determine the charge of the cation from the anion.

STEP 2
Name the cation by its element name and a Roman numeral in parentheses for the charge.

STEP 3
Name the anion by changing the last part of its element name to ide.

STEP 4
Write the name of the cation first and the name of the anion second.
Transition metals with two different ions use a **Roman numeral** after the name of the metal to indicate ionic charge.

<table>
<thead>
<tr>
<th>Formula</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>FeCl$_2$</td>
<td>iron(II) chloride</td>
</tr>
<tr>
<td>FeCl$_3$</td>
<td>iron(III) chloride</td>
</tr>
<tr>
<td>Cu$_2$S</td>
<td>copper(I) sulfide</td>
</tr>
<tr>
<td>CuCl$_2$</td>
<td>copper(II) chloride</td>
</tr>
<tr>
<td>SnCl$_2$</td>
<td>tin(II) chloride</td>
</tr>
<tr>
<td>PbBr$_4$</td>
<td>lead(IV) bromide</td>
</tr>
</tbody>
</table>
Naming FeCl₂

To name FeCl₂
1. Determine the charge of the cation using the charge of the anion (Cl⁻).
   Fe ion + 2 Cl⁻ = Fe ion + 2- = 0
   Fe ion = 2+
2. Name the cation by the element name and add a Roman numeral in parenthesis to show its charge.
   Fe²⁺ = iron(II)
3. Write the anion with an ide ending.
   FeCl₂ = iron(II) chloride
Naming $\text{Cr}_2\text{O}_3$

To name $\text{Cr}_2\text{O}_3$

1. Determine the charge of cation from the anion ($\text{O}^{2-}$).

\[
\begin{align*}
2 \text{ Cr ions} & + 3 \text{ O}^{2-} = 0 \\
2 \text{ Cr ions} & + 3 (2-) = 0 \\
2 \text{ Cr ions} & - 6 = 0 \\
2 \text{ Cr ions} & = +6 \\
\text{Cr ion} & = 3+ = \text{Cr}^{3+}
\end{align*}
\]

2. Name the cation by the element name and add a Roman numeral in parenthesis to show its charge.

$\text{Cr}^{3+} = \text{chromium(III)}$

3. Write the anion with an *ide* ending.

$\text{chromium(III) oxide} = \text{Cr}_2\text{O}_3$
Learning Check

Select the correct name for each.

A. \( \text{Fe}_2\text{S}_3 \)
   1) iron sulfide
   2) iron(II) sulfide
   3) iron(III) sulfide

B. \( \text{CuO} \)
   1) copper oxide
   2) copper(I) oxide
   3) copper(II) oxide
Solution

Select the correct name for each.

A. $\text{Fe}_2\text{S}_3$
   3) iron (III) sulfide $\text{Fe}^{3+}$ $\text{S}^{2-}$

B. $\text{CuO}$
   3) copper (II) oxide $\text{Cu}^{2+}$ $\text{O}^{2-}$
A **polyatomic ion**
- is a group of atoms.
- has an overall ionic charge.

Some examples of polyatomic ions are

<table>
<thead>
<tr>
<th>Ion</th>
<th>Name</th>
<th>Ion</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>NH$_4^+$</td>
<td>ammonium</td>
<td>OH$^-$</td>
<td>hydroxide</td>
</tr>
<tr>
<td>NO$_3^-$</td>
<td>nitrate</td>
<td>NO$_2^-$</td>
<td>nitrite</td>
</tr>
<tr>
<td>CO$_3^{2-}$</td>
<td>carbonate</td>
<td>PO$_4^{3-}$</td>
<td>phosphate</td>
</tr>
<tr>
<td>HCO$_3^-$</td>
<td>hydrogen carbonate (bicarbonate)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Some Compounds with Polyatomic Ions

Window cleaner
$\text{NH}_4\text{OH}$

Plaster molding
$\text{CaSO}_4$

Fertilizer
$\text{NaNO}_3$

$\text{NH}_4^+$
Ammonium ion

$\text{OH}^-$
Hydroxide ion

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

$\text{SO}_4^{2-}$
Sulfate ion

$\text{Na}^+$

$\text{NO}_3^-$
Nitrate ion
<table>
<thead>
<tr>
<th>Ion</th>
<th>Name</th>
<th>Ion</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{Hg}_2^{2+}$</td>
<td>Mercury(I)</td>
<td>$\text{NCS}^-$</td>
<td>Thiocyanate</td>
</tr>
<tr>
<td>$\text{NH}_4^+$</td>
<td>Ammonium</td>
<td>$\text{CO}_3^{2-}$</td>
<td>Carbonate</td>
</tr>
<tr>
<td>$\text{NO}_2^-$</td>
<td>Nitrite</td>
<td>$\text{HCO}_3^-$</td>
<td>Hydrogen carbonate</td>
</tr>
<tr>
<td>$\text{NO}_3^-$</td>
<td>Nitrate</td>
<td></td>
<td>(bicarbonate is a widely used common name)</td>
</tr>
<tr>
<td>$\text{SO}_3^{2-}$</td>
<td>Sulfite</td>
<td>$\text{ClO}^-$</td>
<td>Hypochlorite</td>
</tr>
<tr>
<td>$\text{SO}_4^{2-}$</td>
<td>Sulfate</td>
<td>$\text{ClO}_2^-$</td>
<td>Chlorite</td>
</tr>
<tr>
<td></td>
<td>Hydrogen sulfate</td>
<td>$\text{ClO}_3^-$</td>
<td>Chlorate</td>
</tr>
<tr>
<td></td>
<td>(bisulfate is a widely used common name)</td>
<td>$\text{ClO}_4^-$</td>
<td>Perchlorate</td>
</tr>
<tr>
<td>$\text{OH}^-$</td>
<td>Hydroxide</td>
<td>$\text{C}_2\text{H}_3\text{O}_2^-$</td>
<td>Acetate</td>
</tr>
<tr>
<td>$\text{CN}^-$</td>
<td>Cyanide</td>
<td>$\text{MnO}_4^-$</td>
<td>Permanganate</td>
</tr>
<tr>
<td>$\text{PO}_4^{3-}$</td>
<td>Phosphate</td>
<td>$\text{Cr}_2\text{O}_7^{2-}$</td>
<td>Dichromate</td>
</tr>
<tr>
<td>$\text{HPO}_4^{2-}$</td>
<td>Hydrogen phosphate</td>
<td>$\text{CrO}_4^{2-}$</td>
<td>Chromate</td>
</tr>
<tr>
<td>$\text{H}_2\text{PO}_4^-$</td>
<td>Dihydrogen phosphate</td>
<td>$\text{O}_2^{2-}$</td>
<td>Peroxide</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\text{C}_2\text{O}_4^{2-}$</td>
<td>Oxalate</td>
</tr>
</tbody>
</table>
The names of common polyatomic anions

- end in *ate*.
  \[ \text{NO}_3^- \quad \text{nitr}a\text{te} \quad \text{PO}_4^{3-} \quad \text{phosph}a\text{te} \]
- with *one oxygen less* end in *ite*.
  \[ \text{NO}_2^- \quad \text{nitr}i\text{te} \quad \text{PO}_3^{3-} \quad \text{phosph}i\text{te} \]
- with hydrogen attached use the prefix *hydrogen* (or *bi*).
  \[ \text{HCO}_3^- \quad \text{hydrogen} \quad \text{carbonate} \quad \text{(bi}c\text{arbon}ate) \]
  \[ \text{HSO}_3^- \quad \text{hydrogen} \quad \text{sulfite} \quad \text{(bi}s\text{ulf}ite) \]
# Names and Formulas of Common Polyatomic Ions

<table>
<thead>
<tr>
<th>Nonmetal</th>
<th>Formula of Ion(^a)</th>
<th>Name of Ion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen</td>
<td>OH(^-)</td>
<td>Hydroxide</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>NH(_4^+)</td>
<td>Ammonium</td>
</tr>
<tr>
<td></td>
<td>NO(_3^-)</td>
<td>Nitrate</td>
</tr>
<tr>
<td></td>
<td>NO(_2^-)</td>
<td>Nitrite</td>
</tr>
<tr>
<td>Chlorine</td>
<td>ClO(_4^-)</td>
<td>Perchlorate</td>
</tr>
<tr>
<td></td>
<td>ClO(_3^-)</td>
<td>Chlorate</td>
</tr>
<tr>
<td></td>
<td>ClO(_2^-)</td>
<td>Chlorite</td>
</tr>
<tr>
<td></td>
<td>ClO(^-)</td>
<td>Hypochlorite</td>
</tr>
<tr>
<td>Carbon</td>
<td>CO(_3^{2-})</td>
<td>Carbonate</td>
</tr>
<tr>
<td></td>
<td>HCO(_3^-)</td>
<td>Hydrogen carbonate (or bicarbonate)</td>
</tr>
<tr>
<td></td>
<td>CN(^-)</td>
<td>Cyanide</td>
</tr>
<tr>
<td></td>
<td>C(_6)H(_5)O(_3)(CH(_2)COO(^-))</td>
<td>Acetate</td>
</tr>
</tbody>
</table>

\(^a\) Oxyanions
## Names and Formulas of Common Polyatomic Ions

<table>
<thead>
<tr>
<th>Nonmetal</th>
<th>Formula of Ion(^a)</th>
<th>Name of Ion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfur</td>
<td>(\text{SO}_4^{2-})</td>
<td>Sulfate</td>
</tr>
<tr>
<td></td>
<td>(\text{HSO}_4^-)</td>
<td>Hydrogen sulfate (or bisulfate)</td>
</tr>
<tr>
<td></td>
<td>(\text{SO}_3^{2-})</td>
<td>Sulfite</td>
</tr>
<tr>
<td></td>
<td>(\text{HSO}_3^-)</td>
<td>Hydrogen sulfite (or bisulfite)</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>(\text{PO}_4^{3-})</td>
<td>Phosphate</td>
</tr>
<tr>
<td></td>
<td>(\text{HPO}_4^{2-})</td>
<td>Hydrogen phosphate</td>
</tr>
<tr>
<td></td>
<td>(\text{H}_2\text{PO}_4^-)</td>
<td>Dihydrogen phosphate</td>
</tr>
<tr>
<td></td>
<td>(\text{PO}_3^{3-})</td>
<td>Phosphite</td>
</tr>
<tr>
<td>Chromium</td>
<td>(\text{CrO}_4^{2-})</td>
<td>Chromate</td>
</tr>
<tr>
<td></td>
<td>(\text{Cr}_2\text{O}_7^{2-})</td>
<td>Dichromate</td>
</tr>
<tr>
<td>Manganese</td>
<td>(\text{MnO}_4^-)</td>
<td>Permanganate</td>
</tr>
</tbody>
</table>

\(^a\) As ionic compounds.
Naming Compounds with Polyatomic Ions

• The positive ion is named first followed by the name of the polyatomic ion.

\[
\begin{align*}
\text{NaNO}_3 & \quad \text{sodium nitrate} \\
\text{K}_2\text{SO}_4 & \quad \text{potassium sulfate} \\
\text{Fe(}\text{HCO}_3\text{)}_3 & \quad \text{iron(III) bicarbonate} \\
\quad & \quad \text{or iron(III) hydrogen carbonate} \\
\text{(NH}_4\text{)}_3\text{PO}_3 & \quad \text{ammonium phosphite}
\end{align*}
\]
Formation of Ionic Compounds
## Some Compounds with Polyatomic Ions

<table>
<thead>
<tr>
<th>Formula</th>
<th>Name</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>BaSO₄</td>
<td>Barium sulfate</td>
<td>X-ray contrast medium</td>
</tr>
<tr>
<td>CaCO₃</td>
<td>Calcium carbonate</td>
<td>Antacid, calcium supplement</td>
</tr>
<tr>
<td>Ca₃(PO₄)₂</td>
<td>Calcium phosphate</td>
<td>Calcium replenisher</td>
</tr>
<tr>
<td>CaSO₃</td>
<td>Calcium sulfite</td>
<td>Preservative in cider and fruit juices</td>
</tr>
<tr>
<td>CaSO₄</td>
<td>Calcium sulfate</td>
<td>Plaster casts</td>
</tr>
<tr>
<td>AgNO₃</td>
<td>Silver nitrate</td>
<td>Topical anti-infective</td>
</tr>
<tr>
<td>NaHCO₃</td>
<td>Sodium bicarbonate</td>
<td>Antacid</td>
</tr>
<tr>
<td>Zn₃(PO₄)₂</td>
<td>Zinc phosphate</td>
<td>Dental cements</td>
</tr>
<tr>
<td>FePO₄</td>
<td>Iron(III) phosphate</td>
<td>Food and bread enrichment</td>
</tr>
<tr>
<td>K₂CO₃</td>
<td>Potassium carbonate</td>
<td>Alkalizer, diuretic</td>
</tr>
<tr>
<td>Al₂(SO₄)₃</td>
<td>Aluminum sulfate</td>
<td>Antiperspirant, anti-infective</td>
</tr>
<tr>
<td>AlPO₄</td>
<td>Aluminum phosphate</td>
<td></td>
</tr>
</tbody>
</table>
Learning Check

Match each formula with the correct name.

A. MgS  1) magnesium sulfite
    MgSO₃  2) magnesium sulfate
    MgSO₄  3) magnesium sulfide

B. Ca(ClO₃)₂  1) calcium chlorate
    CaCl₂  2) calcium chlorite
    Ca(ClO₂)₂  3) calcium chloride
Solution

Match each formula with the correct name:

A. \( \text{MgS} \) 3) magnesium sulfide
   \( \text{MgSO}_3 \) 1) magnesium sulfite
   \( \text{MgSO}_4 \) 2) magnesium sulfate

B. \( \text{Ca(ClO}_3\text{)}_2 \) 1) calcium chlorate
   \( \text{CaCl}_2 \) 3) calcium chloride
   \( \text{Ca(ClO}_2\text{)}_2 \) 2) calcium chlorite
Learning Check

Name each of the following compounds:

A. Mg(NO₃)₂
B. Cu(ClO₃)₂
C. PbO₂
D. Fe₂(SO₄)₃
E. Ba₃(PO₃)₂
Solution

Name each of the following compounds:

A. Mg(NO₃)₂ magnesium nitrate  
B. Cu(ClO₃)₂ copper(II) chlorate  
C. PbO₂ lead(IV) oxide  
D. Fe₂(SO₄)₃ iron(III) sulfate  
E. Ba₃(PO₃)₂ barium phosphite
Writing Formulas with Polyatomic Ions

The formula of an ionic compound

- containing a polyatomic ion must have a charge balance that equals zero (0).

\[ \text{Na}^+ \text{ and } \text{NO}_3^- \rightarrow \text{NaNO}_3 \]

- with two or more polyatomic ions has the polyatomic ions in parentheses.

\[ \text{Mg}^{2+} \text{ and } 2\text{NO}_3^- \rightarrow \text{Mg(NO}_3)_2 \]

subscript 2 for charge balance
### Learning Check

Select the correct formula for each.

**A. aluminum nitrate**

1) $\text{AlNO}_3$  
2) $\text{Al(NO)}_3$  
3) $\text{Al(NO}_3)_3$

**B. copper(II) nitrate**

1) $\text{CuNO}_3$  
2) $\text{Cu(NO}_3)_2$  
3) $\text{Cu}_2(\text{NO}_3)$

**C. iron(III) hydroxide**

1) $\text{FeOH}$  
2) $\text{Fe}_3\text{OH}$  
3) $\text{Fe(OH)}_3$

**D. tin(IV) hydroxide**

1) $\text{Sn(OH)}_4$  
2) $\text{Sn(OH)}_2$  
3) $\text{Sn}_4(\text{OH})$
Solution

Select the correct formula for each.

A. aluminum nitrate
   3) Al(NO₃)₃
B. copper(II) nitrate
   2) Cu(NO₃)₂
C. iron(III) hydroxide
   3) Fe(OH)₃
D. tin(IV) hydroxide
   1) Sn(OH)₄
Learning Check

Write the correct formula for each.

A. potassium bromate
B. calcium carbonate
C. sodium phosphate
D. iron(III) oxide
E. iron(II) nitrite
Solution

Write the correct formula for each.

A. potassium bromate \( \text{KBrO}_3 \)
B. calcium carbonate \( \text{CaCO}_3 \)
C. sodium phosphate \( \text{Na}_3\text{PO}_4 \)
D. iron(III) oxide \( \text{Fe}_2\text{O}_3 \)
E. iron(II) nitrite \( \text{Fe(NO}_2\text{)}_2 \)
# Rules for Naming Ionic Compounds

<table>
<thead>
<tr>
<th>Type</th>
<th>Formula Feature</th>
<th>Naming Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ionic compound (two elements)</td>
<td>Symbol of metal followed by symbol of nonmetal; subscripts used for charge balance.</td>
<td>Use element name for metal; Roman numeral required if more than one positive ion is possible. For nonmetal use element name with <em>ide</em> ending.</td>
</tr>
<tr>
<td></td>
<td>Examples: Na₂O, Fe₂S₃</td>
<td>Examples: Sodium oxide, Iron(III) sulfide</td>
</tr>
<tr>
<td>Ionic compound (more than two elements)</td>
<td>Usually symbol of metal followed by a polyatomic ion composed of nonmetals; parentheses may enclose polyatomic ion for charge balance.</td>
<td>Use element name for metal, with Roman numeral if needed, followed by name of polyatomic ion.</td>
</tr>
<tr>
<td></td>
<td>Examples: Mg(NO₃)₂, CuSO₄, (NH₄)₂CO₃</td>
<td>Examples: Magnesium nitrate, Copper(II) sulfate, Ammonium carbonate</td>
</tr>
</tbody>
</table>
Flowchart for Naming Ionic Compounds

Flowchart for Naming Ionic Compounds

Metal (or NH₄⁺) | Nonmetal
---|---

Q: Does the metal form one positive ion or more?

One | More
---|---

Group 1A (1)–3A (13), Zn, Ag, or Cd | Metal in B Groups 3B–12B, Groups 4A (14) or 5A (15)

Q: Is the nonmetal ion formed from a single atom or a polyatomic ion with oxygen?

Single ion | Polyatomic ion
---|---

Monatomic ion such as Cl⁻, S²⁻ | Polyatomic ion such as CO₃²⁻ or SO₄²⁻

Use the name of the element or use "ammonium" for the NH₄⁺ ion. | Use the name of the element and a Roman numeral in parentheses for the positive charge of the ion.

Use the root of the name of the element adding ide ending. | Use the name of the polyatomic with an ate or icate ending.
Covalent Bonding
QUESTION

Hypochlorous acid is related to the anion found in common household bleach. Which of the following is that common anion?

1. \( \text{ClO}_4^- \)
2. \( \text{ClO}_3^- \)
3. \( \text{ClO}_2^- \)
4. \( \text{ClO}^- \)
QUESTION

Which of the following provides the correct name for \( \text{Ca(H}_2\text{PO}_4\text{)}_2 \)?

1. Calcium dihydrogen phosphate
2. Calcium (II) hydrogen phosphate
3. Calcium di-dihydrogen phosphate
4. Calcium (II) dihydrogen phosphate
Binary Covalent Compounds (Type III)

Covalent bonds form

• when atoms *share electrons* to complete octets.

• between two nonmetal atoms.

• between nonmetal atoms from Groups 4A(14), 5A(15), 6A(16), and 7A(17).
Naming Covalent Compounds

To name covalent compounds

• **STEP 1:** Name the first nonmetal as an element.

• **STEP 2:** Name the second nonmetal with an *ide* ending.

• **STEP 3:** Use *prefixes* to indicate the number of atoms (subscript) of each element.
Naming Covalent Compounds

What is the name of SO₃?

1. The first nonmetal is S sulfur.
2. The second nonmetal is O named oxide.
3. The subscript 3 of O is shown as the prefix tri.

\[ \text{SO}_3 \rightarrow \text{sulfur trioxide} \]

The subscript 1 (for S) or mono is understood.
Naming Covalent Compounds

Name \( \text{P}_4\text{S}_3 \).

1. The first nonmetal \( \text{P} \) is phosphorus.
2. The second nonmetal \( \text{S} \) is sulfide.
3. The subscript 4 of \( \text{P} \) is shown as \textit{tetra}.
   
   The subscript 3 of \( \text{S} \) is shown as \textit{tri}.

\[
\text{P}_4\text{S}_3 \rightarrow \text{tetraphosphorus tri sulfide}
\]
### Formulas and Names of Some Covalent Compounds

<table>
<thead>
<tr>
<th>Formula</th>
<th>Name</th>
<th>Commercial Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS₂</td>
<td>carbon disulfide</td>
<td>Manufacture of rayon</td>
</tr>
<tr>
<td>CO₂</td>
<td>carbon dioxide</td>
<td>Carbonation of beverages, fire extinguishers propellant in aerosols, dry ice</td>
</tr>
<tr>
<td>SiO₂</td>
<td>silicon dioxide</td>
<td>Manufacture of glass, computer parts</td>
</tr>
<tr>
<td>NCl₃</td>
<td>nitrogen trichloride</td>
<td>Bleaching of flour in some countries (prohibited in U.S.)</td>
</tr>
<tr>
<td>ClO₂</td>
<td>chlorine dioxide</td>
<td>Breweries; bleaching textiles</td>
</tr>
<tr>
<td>SO₃</td>
<td>sulfur trioxide</td>
<td>Manufacture of explosives</td>
</tr>
<tr>
<td>SF₆</td>
<td>sulfur hexafluoride</td>
<td>Electrical circuits (insulation)</td>
</tr>
<tr>
<td>ClO₂</td>
<td>chlorine dioxide</td>
<td>Bleaching pulp (for making paper), flour, leather</td>
</tr>
<tr>
<td>ClF₃</td>
<td>chlorine trifluoride</td>
<td>Rocket propellant</td>
</tr>
</tbody>
</table>

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Learning Check

Select the correct name for each compound.

A. \( \text{SiCl}_4 \)
   1) silicon chloride
   2) tetrasilicon chloride
   3) silicon tetrachloride

B. \( \text{P}_2\text{O}_5 \)
   1) phosphorus oxide
   2) phosphorus pentoxide
   3) diphosphorus pentoxide

C. \( \text{Cl}_2\text{O}_7 \)
   1) dichlorine heptoxide
   2) dichlorine oxide
   3) chlorine heptoxide
Solution

Select the correct name for each compound.

A. SiCl₄  3) silicon tetrachloride
B. P₂O₅  3) diphosphorus pentoxide
C. Cl₂O₇  1) dichlorine heptoxide
Write the name of each covalent compound.

CO _____________________
CO$_2$ _____________________
PCl$_3$ _____________________
CCl$_4$ _____________________
N$_2$O _____________________
Write the name of each covalent compound.

CO   carbon monoxide
CO₂  carbon dioxide
PCl₃  phosphorus trichloride
CCl₄  carbon tetrachloride
N₂O  dinitrogen monoxide
Guide to Writing Formulas

The prefixes in the name are used to write the formula.

**STEP 1:** Write the symbols in the order of the elements in the name.

**STEP 2:** Write any prefixes as subscripts.

*Example:* Write the formula for carbon disulfide.

**STEP 1:** Elements are C and S

**STEP 2:** No prefix for carbon means 1 C

Prefix di = 2

Formula: $\text{CS}_2$
Learning Check

Write the correct formula for each of the following.

A. phosphorus pentachloride

B. dinitrogen trioxide

C. sulfur hexafluoride
Solution

Write the correct formula for each of the following.

A. phosphorus pentachloride
   \[ \text{1 P penta} = 5 \text{ Cl} \quad \text{PCI}_5 \]

B. dinitrogen trioxide
   \[ \text{di} = 2 \text{ N tri} = 3 \text{ O} \quad \text{N}_2\text{O}_3 \]

C. sulfur hexafluoride
   \[ \text{1 S hexa} = 6 \text{ F} \quad \text{SF}_6 \]
Learning Check

Identify each compound as ionic or covalent and give its correct name.

A. $\text{SO}_3$
B. $\text{BaCl}_2$
C. $(\text{NH}_4)_3\text{PO}_4$
D. $\text{Cu}_2\text{CO}_3$
E. $\text{N}_2\text{O}_4$
<table>
<thead>
<tr>
<th>Formula</th>
<th>Name&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCl&lt;sub&gt;3&lt;/sub&gt;</td>
<td>Boron trichloride</td>
</tr>
<tr>
<td>CCl&lt;sub&gt;4&lt;/sub&gt;</td>
<td>Carbon tetrachloride</td>
</tr>
<tr>
<td>CO</td>
<td>Carbon monoxide</td>
</tr>
<tr>
<td>CO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>Carbon dioxide</td>
</tr>
<tr>
<td>NO</td>
<td>Nitrogen monoxide</td>
</tr>
<tr>
<td>NO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>Nitrogen dioxide</td>
</tr>
<tr>
<td>N&lt;sub&gt;2&lt;/sub&gt;O</td>
<td>Dinitrogen monoxide</td>
</tr>
<tr>
<td>N&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;3&lt;/sub&gt;</td>
<td>Dinitrogen trioxide</td>
</tr>
<tr>
<td>N&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;4&lt;/sub&gt;</td>
<td>Dinitrogen tetroxide</td>
</tr>
<tr>
<td>N&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt;</td>
<td>Dinitrogen pentoxide</td>
</tr>
<tr>
<td>PCl&lt;sub&gt;3&lt;/sub&gt;</td>
<td>Phosphorus trichloride</td>
</tr>
<tr>
<td>PCl&lt;sub&gt;5&lt;/sub&gt;</td>
<td>Phosphorus pentachloride</td>
</tr>
<tr>
<td>SF&lt;sub&gt;6&lt;/sub&gt;</td>
<td>Sulfur hexafluoride</td>
</tr>
</tbody>
</table>

<sup>a</sup>When the prefix ends in a or o and the element name begins with a or o, the final vowel of the prefix is dropped for ease of pronunciation. For example, carbon monoxide, not carbon mono-oxide, and dinitrogen tetroxide, not dinitrogen tetra-oxide. However, PI<sub>3</sub> is phosphorus triiodide, not phosphorus tri-iodide.
Binary Acids

Acids produce $\text{H}^+$ when dissolved in water. They are compounds that ionize in water.

If the anion does not contain oxygen:

- HCl hydrogen chloride hydrochloric acid
- HF hydrogen fluoride hydrofluoric acid

If the anion contain oxygen

Anion ends in-ate, the suffix –ic is added to the root name. Anion ends in –ite, the suffix –ous.
### TABLE 3.4 Nomenclature of Some Oxoacids and Their Salts

<table>
<thead>
<tr>
<th>Oxidation Name of Salt</th>
<th>Formula</th>
<th>State of Acid(^a)</th>
<th>Name of Acid(^b)</th>
<th>of Salt(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium hypochlorite</td>
<td>Cl: +1</td>
<td>HClO</td>
<td>Hypochlorous acid</td>
<td>NaClO</td>
</tr>
<tr>
<td>Sodium chlorite</td>
<td>Cl: +3</td>
<td>HClO(_2)</td>
<td>Chlorous acid</td>
<td>NaClO(_2)</td>
</tr>
<tr>
<td>Sodium chlorate</td>
<td>Cl: +5</td>
<td>HClO(_3)</td>
<td>Chloric acid</td>
<td>NaClO(_3)</td>
</tr>
<tr>
<td>Sodium perchlorate</td>
<td>Cl: +7</td>
<td>HClO(_4)</td>
<td>Perchloric acid</td>
<td>NaClO(_4)</td>
</tr>
<tr>
<td>Sodium nitrite</td>
<td>N: +3</td>
<td>HNO(_2)</td>
<td>Nitrous acid</td>
<td>NaNO(_2)</td>
</tr>
<tr>
<td>Sodium nitrate</td>
<td>N: +5</td>
<td>HNO(_3)</td>
<td>Nitric acid</td>
<td>NaNO(_3)</td>
</tr>
<tr>
<td>Sodium sulfite</td>
<td>S: +4</td>
<td>H(_2)SO(_3)</td>
<td>Sulfurous acid</td>
<td>Na(_2)SO(_3)</td>
</tr>
<tr>
<td>Sodium sulfate</td>
<td>S: +6</td>
<td>H(_2)SO(_4)</td>
<td>Sulfuric acid</td>
<td>Na(_2)SO(_4)</td>
</tr>
</tbody>
</table>

\(^a\)In all these acids, H atoms are bonded to O atoms, not the central nonmetal atom. Often, formulas are written to reflect this fact, for instance, HOCl instead of HClO.