Chemical Names & Formulas

Water

Ammonia

Methane
## Why “Systematic Names” ?

<table>
<thead>
<tr>
<th># atomic particles</th>
<th>3 (p, n, e)</th>
</tr>
</thead>
<tbody>
<tr>
<td># elements</td>
<td>110+</td>
</tr>
<tr>
<td># elements in earth’s crust (99%)</td>
<td>8</td>
</tr>
<tr>
<td># elements in all living things</td>
<td>25</td>
</tr>
<tr>
<td># compounds</td>
<td>&gt;14,000,000</td>
</tr>
</tbody>
</table>
**Why “Systematic Names” ?**

<table>
<thead>
<tr>
<th>Compound</th>
<th>Chemical Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>$\text{H}_2\text{O}$</td>
</tr>
<tr>
<td>Lime</td>
<td>$\text{CaO}$</td>
</tr>
<tr>
<td>Lye</td>
<td>$\text{NaOH}$</td>
</tr>
<tr>
<td>Potash</td>
<td>$\text{K}_2\text{CO}_3$</td>
</tr>
<tr>
<td>Table Salt</td>
<td>$\text{NaCl}$</td>
</tr>
<tr>
<td>Laughing Gas</td>
<td>$\text{N}_2\text{O}$</td>
</tr>
<tr>
<td>Baking Soda</td>
<td>$\text{NaHCO}_3$</td>
</tr>
</tbody>
</table>
Atoms and Ions

Atom:
- neutral
- no net charge
- (# $p^+$ = # $e^-$)

e.g. Na $\rightarrow$ 11 $p^+$ and 11 $e^-$
    Cl $\rightarrow$ 17 $p^+$ and 17 $e^-$
Atoms and Ions

Ion:
- atom (or group of atoms)
- has + or – charge
- has more or less e⁻
- only the # of e⁻ changes

e.g. Na⁺ → 11 p⁺ and 10 e⁻
Cl⁻ → 17 p⁺ and 18 e⁻
Atoms and Ions

\[ \text{Na vs. Na}^+ \]

\[ \text{Cl vs. Cl}^- \]

\[ \text{Very different} \]

Demo: Fe vs. Fe\(^{+3}\)
Ions

Positive charge: “cation”

Na\(^+\)  Ca\(^{2+}\)  Al\(^{3+}\)

These atoms lost electrons

Negative charge: “anion”

Cl\(^-\)  O\(^{2-}\)  SO\(_4^{2-}\)

These atoms gained electrons
Compounds

➔ Substances composed of 2 or more different atoms

HCl   NaCl   CO₂
Chemical Formulas

→ Shows the kinds and numbers of each type of atom in a chemical compound.

Water = H₂O

two atoms of H  one atom of O
Compounds

Molecular
• Atoms bonded as a unit
  • nonmetals
  e.g. H₂O

Ionic
• Ions held together by + and - charges
  • metal + nonmetal
  e.g. NaCl

Charges NOT shown
Molecular & Ionic Compounds
1. Molecular Formulas

Molecules are represented by molecular formulas: discrete units of bonded nonmetals.

e.g. \( \text{H}_2\text{O} \) & \( \text{CO}_2 \)

"covalent" bond

"structural" formula for water
Naming Molecular Compounds
(bonded nonmetal atoms)

prefix-1\textsuperscript{st} atom-prefix-2\textsuperscript{nd} atom-ide

number

\( \text{N}_2\text{O}_5 = \text{dinitrogen pentoxide} \)
<table>
<thead>
<tr>
<th>Number</th>
<th>Prefix</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mono</td>
</tr>
<tr>
<td>2</td>
<td>Di</td>
</tr>
<tr>
<td>3</td>
<td>Tri</td>
</tr>
<tr>
<td>4</td>
<td>Tetra</td>
</tr>
<tr>
<td>5</td>
<td>Penta</td>
</tr>
<tr>
<td>6</td>
<td>Hexa</td>
</tr>
<tr>
<td>7</td>
<td>Hepta</td>
</tr>
<tr>
<td>8</td>
<td>Octa</td>
</tr>
<tr>
<td>9</td>
<td>Nona</td>
</tr>
<tr>
<td>10</td>
<td>Deca</td>
</tr>
</tbody>
</table>

*Note: don’t use ‘mono’ for the first atom.*
Try It

CO$_2$  N$_2$O

PCl$_3$  SF$_6$

SO$_3$  N$_2$O$_4$

H$_2$O  Dangerous chemical
Ionic Formulas

Ionic compound is represented by a formula unit, the lowest ratio of atoms in the compound.

NaCl
“ionic” bond
Na\(^+\) and Cl\(^-\)
Naming Ionic Compounds

(positive metal ion + negative nonmetal ion)

➔ First must learn ion names and charges!
Monatomic Ions (single atom ions)

Metals → form cations (+)
Mg loses two e\(^-\) to form Mg\(^{+2}\)

Nonmetals → form anions (-)
The name ends in “ide”
Cl gains one e\(^-\) to form Cl\(^-\)

Charge from Periodic Table
# Common Monatomic Ions

<table>
<thead>
<tr>
<th></th>
<th>+1</th>
<th>+2</th>
<th>+3</th>
<th></th>
<th>-3</th>
<th>-2</th>
<th>-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Li⁺</td>
<td>Be²⁺</td>
<td>Al³⁺</td>
<td></td>
<td>N³⁻</td>
<td>O²⁻</td>
<td>F⁻</td>
</tr>
<tr>
<td>2</td>
<td>Na⁺</td>
<td>Mg²⁺</td>
<td></td>
<td></td>
<td>P³⁻</td>
<td>S²⁻</td>
<td>Cl⁻</td>
</tr>
<tr>
<td>3</td>
<td>K⁺</td>
<td>Ca²⁺</td>
<td></td>
<td></td>
<td>As³⁻</td>
<td>Se²⁻</td>
<td>Br⁻</td>
</tr>
<tr>
<td>4</td>
<td>Rb⁺</td>
<td>Ba²⁺</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>I⁻</td>
</tr>
</tbody>
</table>

*end in --ide*
Monatomic Ions: Try It!!!

When the following elements become ions, state:

- ion name
- charge
- number of e\(^{-}\) lost or gained

Ca  P  K
S  Br  Al
Monatomic Ions:

Some metals can form two different types of ions.

Iron: \( \text{Fe}^{+2} \) and \( \text{Fe}^{+3} \)

Copper: \( \text{Cu}^{+1} \) and \( \text{Cu}^{+2} \)

• See Periodic Table for charges.
Multiple Charges: Names

- **Stock System:**
  “atom (charge)”

  - $\text{Fe}^{2+}$ is Iron(II) ion
  - $\text{Fe}^{3+}$ is Iron(III) ion
Multiple Charges: Names

• Classical System:
  Latin name ending in
  “ous” for lower charge
  “ic” for the higher charge
  
  $\text{Fe}^{2+}$ is Ferrous ion
  $\text{Fe}^{3+}$ is Ferric ion
## Others

<table>
<thead>
<tr>
<th>Ion</th>
<th>Stock</th>
<th>Classic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu⁺</td>
<td>Copper(I)</td>
<td>Cuprous</td>
</tr>
<tr>
<td>Cu²⁺</td>
<td>Copper(II)</td>
<td>Cupric</td>
</tr>
<tr>
<td>Pb²⁺</td>
<td>Lead(II)</td>
<td>Plumbous</td>
</tr>
<tr>
<td>Pb⁴⁺</td>
<td>Lead(IV)</td>
<td>Plumbic</td>
</tr>
<tr>
<td>Sn²⁺</td>
<td>Tin(II)</td>
<td>Stannous</td>
</tr>
<tr>
<td>Sn⁴⁺</td>
<td>Tin(IV)</td>
<td>Stannic</td>
</tr>
</tbody>
</table>
Polyatomic Ions

Some atoms group together as a unit to form an ion.

$\text{NO}_3^-$
Polyatomic Ion: Charged group of atoms acting as a unit

<table>
<thead>
<tr>
<th>Polyatomic Ion</th>
<th>Charges</th>
<th>Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>nitrate ion</td>
<td>$\text{NO}_3^-$</td>
<td><img src="image" alt="Nitrate ion" /></td>
</tr>
<tr>
<td>phosphate ion</td>
<td>$\text{PO}_4^{3-}$</td>
<td><img src="image" alt="Phosphate ion" /></td>
</tr>
<tr>
<td>sulfate ion</td>
<td>$\text{SO}_4^{2-}$</td>
<td><img src="image" alt="Sulfate ion" /></td>
</tr>
<tr>
<td>ammonium ion</td>
<td>$\text{NH}_4^+$</td>
<td><img src="image" alt="Ammonium ion" /></td>
</tr>
</tbody>
</table>
Regents Table ‘E’
Note “ite” & “ate” pairs

<table>
<thead>
<tr>
<th>--ite</th>
<th>--ate</th>
</tr>
</thead>
<tbody>
<tr>
<td>sulfite: $\text{SO}_3^{2-}$</td>
<td>sulfate: $\text{SO}_4^{2-}$</td>
</tr>
<tr>
<td>nitrite: $\text{NO}_2^-$</td>
<td>nitrate: $\text{NO}_3^-$</td>
</tr>
<tr>
<td>chlorite: $\text{ClO}_2^-$</td>
<td>chlorate: $\text{ClO}_3^-$</td>
</tr>
</tbody>
</table>

Be able to recognize them !!!
Ionic Formulas

Name: cation then anion name

• Potassium chloride
  \[
  \text{K}^+ \quad \text{Cl}^- \\
  \text{KCl}
  \]

Charges must “balance”
But don’t write charges!
Ionic Formulas

• Calcium bromide
  \[ \text{Ca}^{2+} \quad \text{Br}^- \]
  \[ \text{CaBr}_2 \text{ (balance charge)} \]

• Copper(I) sulfate
  \[ \text{Cu}^+ \quad \text{SO}_4^{2-} \]
  \[ \text{Cu}_2\text{SO}_4 \]
Shortcut $\Rightarrow$ “Criss Cross”

Copper(I) sulfate

$\text{Cu}^+ \quad \text{SO}_4^{2-}$

$\text{Cu}_2(\text{SO}_4)_1 = \text{Cu}_2\text{SO}_4$

Need to recognize polyatomic ions
Shortcut → “Criss Cross”

Calcium sulfide

\[ \text{Ca}^{2+} + \text{S}^{2-} \]

\[ \text{Ca}_2\text{S}_2 = \text{CaS} \quad (\text{reduce}) \]
Shortcut $\rightarrow$ “Criss Cross”

Iron(III) Carbonate

$\text{Fe}^{3+} \quad \text{CO}_3^{2-}$

$\text{Fe}_2(\text{CO}_3)_3$

(brackets needed for polyatomic ion with subscript)
Name or Give the Formula of That Compound!!!

✓ Silver chloride
✓ CuBr₂
✓ Ammonium bromide
✓ Mg₃(PO₄)₂
✓ Calcium chromate
Try Some More!!

✓ N₂O₅
✓ PCl₃
✓ AlCl₃
✓ Sodium hydrogen sulfate
✓ SnO₂
General Properties

Molecular Compounds

Weak “intermolecular forces”
(molecular attractions)
Low melting & boiling points

Ionic Compounds

Strong ionic attractions
High melting & boiling points
Naming Acids

- Acids are a special class of compounds with $\text{H}^+$ as the cation.

Example:

$\text{H}^+$ with $\text{Cl}^-$

$\text{HCl}(aq)$

where $(aq) = \text{dissolved in water}$
Naming Acids

Acids are named according to the anion.

1. If the anion ends in –ide, the acid is hydro-——-ic acid.

Cl\(^-\) is chloride

HCl\((aq)\) is hydrochloric acid
Naming Acids

2. If the anion ends in –ite, the acid is -----ous acid.

SO$_3^{2-}$ is sulfite
H$_2$SO$_3$(aq) is sulfurous acid
Naming Acids

3. If the anion ends in –ate, the acid is –ic acid.

$NO_3^-$ is nitrate
$HNO_3(aq)$ is nitric acid
Naming Acids: Try It

Name

✓ HCN(aq)
✓ HClO₄(aq)
✓ HClO(aq)
✓ HCl(aq)
Naming Acids: Try It

Write the formula for:

✓ carbonic acid
✓ nitrous acid

Regents Table K
Summary: Names & Formulas

- Atoms vs. ions
  \[
  \text{Na} \quad \rightarrow \quad \text{Na}^+ 
  \]

- Compounds:
  - molecular (nonmetals)
  - ionic (metal + nonmetal)

\[
\text{cation}(+) \quad \text{anion}(-) 
\]
Summary: Names & Formulas

- Molecular compound: -prefix-atom-prefix-atom-ide

\[ \text{N}_2\text{O}_5 = \text{dinitrogen pentoxide} \]
Summary:

Ionic compounds
- know names & charges
  • monatomic ions (Periodic Table)
  • transition metals
    - stock system: iron(II)
  • polyatomic ions: NO$_3^-$
  • compound name: cation$+$anion
Study Guide
Warm-up

How many $p^+$ and $e^-$ in Ca and Ca$^{+2}$?
Is Ca$^{+2}$ and anion or cation?

What are the two general types of compounds?
How do you recognize each?
Warm-up

Name $\text{NO}_2$ and $\text{N}_2\text{F}_4$
Warm-up

Give the symbol and the name of the ion that each element forms:

Mg   Al   P   Br

How do you know \( \text{NH}_4\text{NO}_3 \) is ionic even though it has only nonmetal atoms?
Warm-up

1. Fill in the table:

<table>
<thead>
<tr>
<th>Molecular</th>
<th>Ionic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Types of atoms</td>
<td></td>
</tr>
<tr>
<td>Name of formula</td>
<td></td>
</tr>
<tr>
<td>Name of bond</td>
<td></td>
</tr>
</tbody>
</table>

2. Name $\text{N}_2\text{O}$ and $\text{Al}_2(\text{SO}_4)_3$. 
Name or give formula:

- gold(I) sulfate: \( S_2\text{Cl}_5 \)
- barium phosphide: \( \text{Fe}_3(\text{PO}_4)_2 \)
- calcium hydrogen carbonate
Warm-up

Write the formula unit for sodium sulfate.

Why can’t this formula be reduced?
Name or give formula:

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Name or Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>NH₄⁺</td>
<td>magnesium nitride</td>
</tr>
<tr>
<td>S⁻²</td>
<td>calcium sulfate</td>
</tr>
<tr>
<td>SO₃⁻²</td>
<td>aluminum hydrogen sulfate</td>
</tr>
<tr>
<td>NaCN</td>
<td>barium phosphate</td>
</tr>
<tr>
<td>SnO</td>
<td>FeC₂O₄</td>
</tr>
<tr>
<td>PBr₃</td>
<td>N₂O</td>
</tr>
<tr>
<td>SO₃</td>
<td>Au₂SO₄</td>
</tr>
<tr>
<td>OH⁻</td>
<td></td>
</tr>
</tbody>
</table>
Warm-up

Name or write formula:

• $\text{H}_2\text{SO}_3$
• Hydroiodic acid
• $\text{N}_2\text{S}_4$
• $\text{FeSO}_3$
Warm-up

Name or write formula:
• lead(IV) carbonate
• barium nitride
• CO
• SnS₂
• sulfurous acid