Unit 2: Part 2 - Nomenclature (aka naming molecules)

Objective - to be able to name and categorize chemical molecules.
Monatomic Ions

- Monatomic **cations** are identified simply by the element’s name.
  - $K^+$ is called the potassium cation
  - $Mg^{2+}$ is called the magnesium cation
- For monatomic **anions**, the ending of the element’s name is dropped, and the ending -ide is added to the root name.
  - $F^-$ is called the fluoride anion
  - $N^{3-}$ is called the nitride anion
### Common Monatomic Ions

<table>
<thead>
<tr>
<th>Main-group elements</th>
<th>1+</th>
<th>2+</th>
<th>3+</th>
</tr>
</thead>
<tbody>
<tr>
<td>lithium</td>
<td>Li⁺</td>
<td>beryllium</td>
<td>Be²⁺</td>
</tr>
<tr>
<td>sodium</td>
<td>Na⁺</td>
<td>magnesium</td>
<td>Mg²⁺</td>
</tr>
<tr>
<td>potassium</td>
<td>K⁺</td>
<td>calcium</td>
<td>Ca²⁺</td>
</tr>
<tr>
<td>rubidium</td>
<td>Rb⁺</td>
<td>strontium</td>
<td>Sr²⁺</td>
</tr>
<tr>
<td>cesium</td>
<td>Cs⁺</td>
<td>barium</td>
<td>Ba²⁺</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1–</th>
<th>2–</th>
<th>3–</th>
</tr>
</thead>
<tbody>
<tr>
<td>fluoride</td>
<td>F⁻</td>
<td>oxide</td>
</tr>
<tr>
<td>chloride</td>
<td>Cl⁻</td>
<td>sulfide</td>
</tr>
<tr>
<td>bromide</td>
<td>Br⁻</td>
<td></td>
</tr>
<tr>
<td>iodide</td>
<td>I⁻</td>
<td></td>
</tr>
</tbody>
</table>
Significance of a Chemical Formula

• The chemical formula shows how many atoms are in a compound.

• example: octane — $\text{C}_8\text{H}_{18}$

  The subscript after the C tells you there are 8 carbon atoms in the molecule.

  The subscript after the H tells you there are 18 hydrogen atoms in the molecule.
• The formula for an **ionic compound** represents one unit—the simplest ratio of the cations and anions.

• **example:** aluminum sulfate

\[ \text{Al}_2(\text{SO}_4)_3 \]

Parentheses surround the polyatomic ion to identify it as a unit.

Subscript tells you the number of atoms.

There is no subscript for sulfur - that means 1.
Binary Ionic Compounds

- Compounds composed of two elements are known as **binary compounds**.
- The positive charges and negative charges must balance.
  - example: magnesium bromide
    - Ions combined: \( \text{Mg}^{2+}, \text{Br}^-, \text{Br}^- \)
    - Chemical formula: \( \text{MgBr}_2 \)
"Crossing over" method

- **example:** aluminum oxide

1) Write the symbols for the ions.
   \[ \text{Al}^{3+} \quad \text{O}^{2-} \]

2) Write the formula and then cross the numbers down.
   \[ \text{Al}_2 \text{O}_3 \]

3) The correct formula is \( \text{Al}_2\text{O}_3 \)
Naming Binary Ionic Compounds

- **Nomenclature** or naming system.
- The name of the cation is given first, followed by the name of the anion, which ends in *-ide*:
  - example: $\text{Al}_2\text{O}_3$ — aluminum oxide
- For most simple ionic compounds, it is assumed that you know the charges.
Write the formulas for the binary ionic compounds formed between the following elements:

a. zinc (Zn$^{2+}$) and iodine
b. zinc (Zn$^{2+}$) and sulfur
The Stock System of Nomenclature

• Some elements such as iron make different cations.
• Roman numerals indicate an ion’s charge.
  • examples: $\text{Fe}^{2+}$ iron(II)
  $\text{Fe}^{3+}$ iron(III)
Sample Problem B

Write the formula and give the name for the compound formed by the ions \( \text{Cr}^{3+} \) and \( \text{F}^- \).
Polyatomic Ions

• **Oxyanions**—polyatomic ions that contain oxygen.

• There are multiple different types of oxyanions.

  • **example:** nitrogen can form $\text{NO}_3^-$ or $\text{NO}_2^-$.  

    • The ion with more oxygen atoms ends in *-ate*. The ion with less oxygen atoms ends in *-ite*.
    
    • This unique ending are kept when naming.

\[
\text{NO}_3^- \quad \text{NO}_2^- \\ 
\text{nitrate} \quad \text{nitrite}
\]
Family of oxyions

Boron
\[ \text{BO}_3^{\text{--3}} \]
borate

Nitrogen
\[ \text{NO}_3^- \quad \text{nitrato} \]
\[ \text{NO}_2^- \quad \text{nitrite} \]

Sulfur
\[ \text{SO}_4^{2-} \quad \text{sulfato} \]
\[ \text{SO}_3^{2-} \quad \text{sulfate} \]

Carbon
\[ \text{CO}_3^{\text{--2}} \]
carbonate

Phosphorus
\[ \text{PO}_4^{\text{--3}} \quad \text{phosphate} \]
\[ \text{PO}_3^{\text{--3}} \quad \text{phosphite} \]

Selenium
\[ \text{SeO}_4^{2-} \quad \text{selenato} \]
\[ \text{SeO}_3^{2-} \quad \text{selenite} \]

Arsenic
\[ \text{AsO}_4^{\text{--3}} \quad \text{arsenato} \]
\[ \text{AsO}_3^{\text{--3}} \quad \text{arsenite} \]

Tellurium
\[ \text{TeO}_4^{2-} \quad \text{tellurato} \]
\[ \text{TeO}_3^{2-} \quad \text{tellurite} \]

Chlorine
\[ \text{ClO}_4^- \quad \text{perclorato} \]
\[ \text{ClO}_3^- \quad \text{clorato} \]
\[ \text{ClO}_2^- \quad \text{clorito} \]
\[ \text{ClO}^- \quad \text{hipoclorito} \]

Bromine
\[ \text{BrO}_4^- \quad \text{perbromato} \]
\[ \text{BrO}_3^- \quad \text{bromato} \]
\[ \text{BrO}_2^- \quad \text{bromito} \]
\[ \text{BrO}^- \quad \text{hipobromito} \]

Iodine
\[ \text{IO}_4^- \quad \text{periodato} \]
\[ \text{IO}_3^- \quad \text{iodato} \]
\[ \text{IO}_2^- \quad \text{iodito} \]
\[ \text{IO}^- \quad \text{hipoi odio} \]
Chlorine

$\text{ClO}_4^-$ - perchlorate
$\text{ClO}_3^-$ - chlorate
$\text{ClO}_2^-$ - chlorite
$\text{ClO}^-$ - hypochlorite
Sample Problem C

Write the name and formula for tin(IV) and sulfate.
Naming Binary Molecular Compounds

• Molecular compounds (nonmetals) use prefixes.
  • examples: CCl$_4$ — carbon tetrachloride ($tetra$- = 4)
    CO — carbon monoxide ($mon$- = 1)
    CO$_2$ — carbon dioxide ($di$- = 2)
Sample Problem D

a. Give the name for \( \text{As}_2\text{O}_5 \).
b. Write the formula for oxygen difluoride.
Acids and Salts

• In the laboratory, the term *acid* usually refers to a solution in water of an acid compound rather than the acid itself.

  • *example:* hydrochloric acid refers to a water solution of the molecular compound hydrogen chloride, HCl

  • *examples:*
    - sulfuric acid  \( \text{H}_2\text{SO}_4 \)
    - nitric acid  \( \text{HNO}_3 \)
    - phosphoric acid  \( \text{H}_3\text{PO}_4 \)
    - sulfate  \( \text{SO}_4^{2-} \)
    - nitrate  \( \text{NO}_3^- \)
    - phosphate  \( \text{PO}_4^{3-} \)
Acids and Salts, continued

• An ionic compound composed of a cation and the anion from an acid is referred to as a salt.

• examples:
  • Table salt, NaCl, contains the anion from hydrochloric acid, HCl.
  • Calcium sulfate, CaSO$_4$, is a salt containing the anion from sulfuric acid, H$_2$SO$_4$.
  • The bicarbonate ion, HCO$_3^-$, comes from carbonic acid, H$_2$CO$_3$. 
Khan Exercises Due

1. Isotope composition: Counting protons, electrons, and neutrons (practice)
2. Significant figures (exercise)
3. Scientific Notation (exercise)
4. Electron Configuration (exercise)
5. Naming ionic compounds (practice)
6. Find the formula for ionic compounds (practice)