CHEMICAL FORMULAS: THE ACRONYMS OF CHEMISTRY

- Composed of element symbols, subscripts and sometimes parentheses
- Subscripts tell the number of atoms of that element in 1 molecule of compound, so you know the exact number of atoms of each element in a compound.
- Compounds are electrically neutral so formulas must contain equal numbers of + and - charges
FORMULAS AND NAMES

You need to be able to write:

- The formula when given a name
- The name when given a formula

- CaO is calcium oxide
  - How did I know that?
- The formula for sodium nitrate is NaNO$_3$
  - That one is even less obvious
- How about ammonium carbonate?
  - Yikes!
- Or how do I name NaHCO$_3$?

START WITH THE EXCEPTIONS

Memorize these common names and formulas:

H$_2$O = Water, steam, ice.
NH$_3$ = Ammonia.
CH$_4$ = Methane.
NaCl = Table salt.
C$_{12}$H$_{22}$O$_{11}$ = Table sugar.
CHEMICAL BONDS

To name compounds or write formulas we have to know how the atoms are connected together:

– Ionic bonds: electron transfer  ex: Na⁺ Cl⁻
  Very strong bonds; high melting and boiling points, usually have a metal cation
– Covalent (molecular) bonds: electron sharing
  Form between nonmetals; vary in strength from very strong bonds to weaker bonds

We name ionic compounds, molecular compounds and acids differently.

POLYATOMIC IONS: ATOM WANNABES

• Certain groups of atoms act as a unit (as if they were one atom) in chemical reactions.
  – These groups of atoms contain more than one kind of atom, so they are called polyatomic. Their atoms are held together by covalent bonds
  – They have a charge (usually having gained a few electrons) so they are called polyatomic ions
  – They have their own names! (which you must learn)
  – We find them in ionic compounds and oxoacids

• In formulas, polyatomic ions are set off in parentheses (if there are more than one of them)
  – More on this later.......
**POLYATOMIC IONS - LEARN THESE**

<table>
<thead>
<tr>
<th><strong>Ions with -1 charge</strong></th>
<th></th>
<th><strong>Ions with -3 charge</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>perchlorate</td>
<td>ClO$_4^{-1}$</td>
<td>phosphate</td>
</tr>
<tr>
<td>chlorate</td>
<td>ClO$_3^{-1}$</td>
<td>phosphite</td>
</tr>
<tr>
<td>chlorite</td>
<td>ClO$_2^{-1}$</td>
<td></td>
</tr>
<tr>
<td>hypochlorite</td>
<td>ClO$^{-1}$</td>
<td></td>
</tr>
<tr>
<td>perbromate</td>
<td>BrO$_4^{-1}$</td>
<td></td>
</tr>
<tr>
<td>bromate</td>
<td>BrO$_3^{-1}$</td>
<td></td>
</tr>
<tr>
<td>bromite</td>
<td>BrO$_2^{-1}$</td>
<td></td>
</tr>
<tr>
<td>hypobromite</td>
<td>BrO$^{-1}$</td>
<td></td>
</tr>
<tr>
<td>periodate</td>
<td>IO$_4^{-1}$</td>
<td></td>
</tr>
<tr>
<td>iodate</td>
<td>IO$_3^{-1}$</td>
<td></td>
</tr>
<tr>
<td>iodite</td>
<td>IO$_2^{-1}$</td>
<td></td>
</tr>
<tr>
<td>hypoiodite</td>
<td>IO$^{-1}$</td>
<td></td>
</tr>
<tr>
<td>nitrate</td>
<td>NO$_3^{-1}$</td>
<td></td>
</tr>
<tr>
<td>nitrite</td>
<td>NO$_2^{-1}$</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Ions with a -2 Charge</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>hydroxide</td>
</tr>
<tr>
<td>cyanide</td>
</tr>
<tr>
<td>thiocyanate</td>
</tr>
<tr>
<td>acetate</td>
</tr>
<tr>
<td>permanganate</td>
</tr>
<tr>
<td>bicarbonate</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Ions with +1 charge</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>amonium ion</td>
</tr>
<tr>
<td>hydronium ion</td>
</tr>
</tbody>
</table>

The most productive method of committing these ions to memory is first memorize the ones that have the “ate” ending. This is the most common ending.

Classifying Substances for Naming and Writing Formulas
IONIC COMPOUNDS

• Ionic compounds are made of ions, usually a metal + nonmetal or metal + polyatomic ion.
• No individual molecule units, instead have a 3-D array of cations and anions made of formula units.

• Ionic compounds always contain cations and anions.
• The sum of the + charges of the cations must equal the sum of the − charges of the anions.

NAMING IONIC COMPOUNDS

1. Identify the cation (metal) and anion (non metal or polyatomic ion).
2. Name by simply naming the ions.
   – The cation comes first. If the cation is:
     • Type I metal (can find charge on chart) = Metal name.
     • Type II metal (can’t predict charge) = Metal name (charge).
     • Polyatomic ion = Name of polyatomic ion.
   – The anion is named second. If the anion is a:
     • Nonmetal = Stem/base of nonmetal name + -ide.
       – For example oxygen becomes oxide; sulfur becomes sulfide
     • Polyatomic ion = Name of polyatomic ion.
We know whether an atom forms a cation or anion by its position on the chart:

- Metals form cations having the same charge as their group number for Group A metals (Type I metals, also Ag⁺, Cd²⁺, Ni²⁺, Zn²⁺)
- Transition metals also form cations, but their charges are not predictable (aka Type II metals)
- Nonmetals form anions (- charge)
  - Formed by elements on right side of chart (nonmetals).
  - Their charges are Group Number - 8

**METAL CATIONS: TYPE I OR TYPE II?**

- **Type I metals**
  - Metals whose ions only have one possible charge.
    - Group 1A, 2A, 3A (Al³⁺, Ga³⁺, In³⁺)
  - Determine charge by position on periodic table.
    - 1A = +, 2A = 2+, 3A = 3+.  

  4 transition metals need to be memorized:
  - Ag⁺, Cd²⁺, Ni²⁺, Zn²⁺

- **Type II** *(Note: Being a Type II metal does not mean the charge is 2+)*
  - If not Type I, then it's Type II
  - Metals whose ions have >1 possible charge (transition metals)
  - Determine the metal cation charge by looking at the charge on the anion in the compound.
NONMETAL ANIONS: SPECIAL NAMING

- Determine the charge from position on the periodic table.
- To name anion, change ending on the element name to –ide.

<table>
<thead>
<tr>
<th>Group 4A</th>
<th>Group 5A</th>
<th>Group 6A</th>
<th>Group 7A</th>
</tr>
</thead>
<tbody>
<tr>
<td>-4</td>
<td>-3</td>
<td>-2</td>
<td>-1</td>
</tr>
<tr>
<td>C = Carbide</td>
<td>N = Nitride</td>
<td>O = Oxide</td>
<td>F = Fluoride</td>
</tr>
<tr>
<td>Si = Silicide</td>
<td>P = Phosphide</td>
<td>S = Sulfide</td>
<td>Cl = Chloride</td>
</tr>
</tbody>
</table>

MOLECULAR COMPOUNDS

- Two or more nonmetals.
- Smallest unit is a molecule.
- They form electron-sharing or covalent bonds
**Binary Molecular Compounds**

1. Name first element in formula first.
   - Use the full name of the element.

2. Name the second element in the formula with an –ide, as if it were an anion.

3. Use a prefix in front of each name to indicate the number of atoms (Only molecular compounds get prefixes).
   - Never use the prefix *mono-* on the first element.

**Prefixes for Molecular Compounds**

- **1** = *mono-*
  - Not used on first nonmetal.
- **2** = *di-*
- **3** = *tri-*
- **4** = *tetra-*
- **5** = *penta-*
- **6** = *hexa-*
- **7** = *hepta-*
- **8** = *octa-*
- Drop last “a” if name begins with vowel:
  
  \[ \text{CO} = \text{carbon monoxide}, \text{not carbon mono oxide} \]
**ORDER OF ELEMENTS IN A FORMULA**

Nonmetals are written this order: *(Where are they?)*

<table>
<thead>
<tr>
<th>Order of Listing Nonmetals in Chemical Formulas</th>
<th>C</th>
<th>P</th>
<th>N</th>
<th>H</th>
<th>S</th>
<th>I</th>
<th>Br</th>
<th>Cl</th>
<th>O</th>
<th>F</th>
</tr>
</thead>
</table>

• How would you write these formulas?
  
  – *A compound is made of two atoms of bromine and one atom of calcium.*
  
  – *Another compound is made of one atom of carbon, one atom of magnesium and three atoms of oxygen.*
  
  – *This compound has one atom of nitrogen, three atoms of oxygen and one atom of sodium.*

**ACIDS**

• Formulas always start with “H” because all acids contain H⁺¹ cation(s) and an anion.
  
  – Donate H⁺ in aqueous solution.
  
  – Binary acids have H⁺¹ cation(s) and one kind of nonmetal anion.
  
  – Oxyacids have one or more H⁺¹ cations and a polyatomic anion.
NAMING ACIDS

Binary Acids: *Names always start with ‘hydro’*

- **Hydro**- prefix + stem of the name of the nonmetal + -ic suffix.
- Write a **hydro**- prefix.
- Follow with the nonmetal name.
- Change ending on nonmetal name to *-ic*.
- Write the word *acid* at the end of the name.
- Examples: \( \text{HCl} = \text{hydrochloric acid}; \text{HF} = \text{hydrofluoric acid} \)

Oxyacids: *hydrogen + polyatomic ion*

- Names start with the stem of polyatomic ion name
- If polyatomic ion ends in *-ate* = Name of polyatomic ion with *-ic*
- If polyatomic ion ends in *-ite* = Name of polyatomic ion with *-ous*
- Write the word *acid* at the end of the name
- Examples: \( \text{H}_2\text{SO}_4 = \text{sulfuric acid}; \text{HClO}_2 = \text{chlorous Acid} \)

BEWARE THE “IDES” OF NAMING

- “ide” at the end of a name means there is a non-metal element, not a polyatomic ion *(exceptions: hydroxide ion, cyanide ion)*.
- Memorize these common names and formulas:
  - \( \text{H}_2\text{O} = \text{Water, steam, ice} \quad \text{NH}_3 = \text{Ammonia} \)
  - \( \text{CH}_4 = \text{Methane} \quad \text{NaCl} = \text{Table salt} \)
  - \( \text{C}_{12}\text{H}_{22}\text{O}_{11} = \text{Table sugar} \)
- Elements are named as their element name
- If the formula starts with H, it’s an acid
- If name ends in “acid”, the formula better start with H
- And for acids: *ate* → “icK” and “ite” → “ous”
FORMULA-TO-NAME FLOWCHART

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