Chemical Formulas and Equations
Introduction

- **Empirical formula**
  - The simplest whole number ratio
  - Ionic compounds
  - Example: NaCl

- **Molecular Formula**
  - The actual numbers of atoms
  - Covalent compounds

- **Structural Formula**
  - Relative arrangements of atoms
<table>
<thead>
<tr>
<th>Name</th>
<th>Molecular formula</th>
<th>Sketch</th>
<th>Structural formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>H₂O</td>
<td><img src="image" alt="Water Sketch" /></td>
<td>O=H</td>
</tr>
<tr>
<td>Ammonia</td>
<td>NH₃</td>
<td><img src="image" alt="Ammonia Sketch" /></td>
<td>N≡H</td>
</tr>
<tr>
<td>Hydrogen peroxide</td>
<td>H₂O₂</td>
<td><img src="image" alt="Hydrogen Peroxide" /></td>
<td>O=O</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>CO₂</td>
<td><img src="image" alt="Carbon Dioxide Sketch" /></td>
<td>O=C=O</td>
</tr>
</tbody>
</table>

Glucose : Simple sugar  
Molecular formula : C₆H₁₂O₆  
Empirical Formula : CH₂O
**Formula Weights**

- The formula wt. → sum of all of the at. wt
- Eg: $\text{H}_2\text{O}$

<table>
<thead>
<tr>
<th>Atoms</th>
<th>Atomic Weight</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 H</td>
<td>2*(1 u)</td>
<td>2 u</td>
</tr>
<tr>
<td>1 O</td>
<td>1*(16 u)</td>
<td>16 u</td>
</tr>
</tbody>
</table>

» Formula Wt for Water = 18 u

**Molecular Weight**

- Formula weight of a molecule
Percent Composition of Compounds

\[ \% \text{Element} = \left( \frac{(\text{At. Wt}) \times (\# \text{ atoms})}{\text{Formula Wt}} \right) \times 100\% \]
Copper (II) Sulfate : CuSO$_4$

- 1 atom of Cu $\rightarrow$ $1 \times 63.5 \text{ u} = 63.5 \text{ u}$
- 1 atom of S $\rightarrow$ $1 \times 32.1 \text{ u} = 32.1 \text{ u}$
- 4 atoms of O $\rightarrow$ $4 \times 16 \text{ u} = 64 \text{ u}$

• Formula Weight $\left( \frac{63.5 \text{ u}}{159.6} \right) \times 100\% = 39.8\%$

$%Cu = \left( \frac{63.5u}{159.6} \right) \times 100\% = 39.8\%$

• Mass percent of O

$%O = \left( \frac{16u}{159.6} \right) \times 100\% = 40.1\%$
Chemical Equations
Introduction
– Bonds are formed or broken
– Change in matter
– New materials with new properties
– Energy changes.
– Chemical Eqn
Balancing equations

– Chemical equations
  • conversion of reactants to products
  • + indicates combination
  • Example
    – \( C + O_2 \rightarrow CO_2 \)

Reactant

Products

Balanced Equation
– Law of conservation of mass
  • Atoms are neither created nor destroyed
  • Can be combined differently or converted into energy.
– Balancing a chemical reaction
  • add coefficients in front of the compounds
  • Do not change the subscripts.
- The **subscripts** → how many atoms of a particular element

- The **coefficient** → number of molecules of the compound.

<table>
<thead>
<tr>
<th>( CO_2 )</th>
<th>means</th>
<th>One molecule of carbon dioxide consisting of one atom of carbon attached to two atoms of oxygen</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 ( CO_2 )</td>
<td>means</td>
<td>Three molecules of carbon dioxide, each consisting of one atom of carbon attached to two atoms of oxygen</td>
</tr>
</tbody>
</table>
– Four basic steps.
  • correct formula
  • Inventory the # of each kind of atom on both sides
  • Place coefficients in front of formulas
  • Take another inventory to determine if:
    – The # of atoms on both sides of the equation are now balanced.
    – The coefficients are lowest possible whole number ratios.
Conventions

- gas (g)
- Liquid (l)
- Aqueous solution (aq)
- Escaping gas (↑)
- Solid formation (↓)
- Change of temperature (Δ)
Examples

\[ C_3H_8 + O_2 \rightarrow CO_2 + H_2O \]

- Inventory -1
- Reactants \( \text{Products} \)
  - 3 C \( \text{1 C} \)
  - 8 H \( \text{2 H} \)
  - 2 O \( \text{3 O} \)

- Choose Coeff \( \rightarrow 3 \) in front of CO\(_2\)

\[ C_3H_8 + O_2 \rightarrow 3CO_2 + H_2O \]
Contd..

\[ C_3H_8 + O_2 \rightarrow 3CO_2 + H_2O \]

Inventory -2

<table>
<thead>
<tr>
<th>Reactants</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 C</td>
<td>3 C</td>
</tr>
<tr>
<td>8 H</td>
<td>2 H</td>
</tr>
<tr>
<td>2 O</td>
<td>7 O</td>
</tr>
</tbody>
</table>

Choose Coeff → 4 → in front of H₂O

\[ C_3H_8 + O_2 \rightarrow 3CO_2 + 4H_2O \]
Contd..

\[ C_3H_8 + O_2 \rightarrow 3CO_2 + 4H_2O \]

Inventory -2

<table>
<thead>
<tr>
<th>Reactants</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 C</td>
<td>3 C</td>
</tr>
<tr>
<td>8 H</td>
<td>8 H</td>
</tr>
<tr>
<td>2 O</td>
<td>10 O</td>
</tr>
</tbody>
</table>

Choose Coeff → 5 → in front of \( O_2 \)

\[ C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O \]
Contd..

\[ C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O \]

Inventory -2

<table>
<thead>
<tr>
<th>Reactants</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 C</td>
<td>3 C</td>
</tr>
<tr>
<td>8 H</td>
<td>8 H</td>
</tr>
<tr>
<td>10 O</td>
<td>10 O</td>
</tr>
</tbody>
</table>

**BALANCED**