Conservation of Mass

- One of the basic principles of chemistry is that matter can not be created or destroyed during a chemical process.
- During a chemical reaction, how atoms are connected to one another is changed.

Types of Chemical Reactions

- **Combustion**
  \[ C_2H_6 + O_2 \rightarrow CO_2 + H_2O \]
- **Synthesis (Combination)**
  \[ A + B \rightarrow C \]
- **Decomposition**
  \[ A \rightarrow B + C \]
- **Single Replacement**
  \[ A + BC \rightarrow B + AC \]
- **Double replacement (metathesis)**
  \[ AB + CD \rightarrow AD + CB \]
Balancing Reactions

- A chemical reaction must be balanced using the lowest whole number stoichiometric coefficients (multiplication factors) to ensure that the number of atoms (or moles) of each element are the same on both the reactant and product sides of the reaction.

Balancing - Combustion Reactions

1. Balance the carbon atoms.
   - Place a stoichiometric coefficient in front of the CO\(_2\) so that there are the same number of carbon atoms (n) as in the organic compound (C\(_n\)H\(_m\)), which is the fuel.

2. Balance the hydrogen atoms.
   - Place a stoichiometric coefficient in front of the H\(_2\)O so that there are the same number of hydrogen atoms (m) as there are in the organic fuel.

3. Balance the oxygen atoms.
   - Count the total number of oxygens on the product side (CO\(_2\) and H\(_2\)O).
   - If the number of oxygens on the product side is even and the number of oxygens on the reactant side is also even (or odd and odd), place the appropriate coefficient in front of the O\(_2\) to achieve mass balance.
   - If the number of oxygens on the products side is odd and the number on the reactant side is even, double all of the coefficients (except for the O\(_2\)) to achieve an even number of oxygens on both sides. Then place a coefficient in front of the O\(_2\) to achieve mass balance.

Balancing - Combustion Reactions Examples

\[
\_ \text{CH}_4 + \_ \text{O}_2 \rightarrow \_ \text{CO}_2 + \_ \text{H}_2\text{O}
\]

1. \text{CH}_4 + \_ \text{O}_2 \rightarrow \text{CO}_2 + \_ \text{H}_2\text{O}

2. \text{CH}_4 + \_ \text{O}_2 \rightarrow \text{CO}_2 + 2 \text{H}_2\text{O}

3. \text{CH}_4 + \_ \text{O}_2 \rightarrow \text{CO}_2 + 2 \text{H}_2\text{O}

Both sides have an even number of oxygen atoms (2 and 4), so add the coefficient in front of the O\(_2\) to achieve the balanced reaction:

\[
\text{CH}_4 + 2 \text{O}_2 \rightarrow \text{CO}_2 + 2 \text{H}_2\text{O}
\]
Balancing - Combustion Reactions

Examples

\[ \_ \text{C}_2\text{H}_6 + \_ \text{O}_2 \rightarrow \_ \text{CO}_2 + \_ \text{H}_2\text{O} \]

1. \[ \text{C}_2\text{H}_4 + \_ \text{O}_2 \rightarrow 2 \text{CO}_2 + \_ \text{H}_2\text{O} \]
2. \[ \text{C}_2\text{H}_4 + \_ \text{O}_2 \rightarrow 2 \text{CO}_2 + 3 \text{H}_2\text{O} \]
3. \[ \text{C}_2\text{H}_4 + \_ \text{O}_2 \rightarrow 2 \text{CO}_2 + \_ \text{H}_2\text{O} \]

There is an even number of oxygens on the reactants side (2) and an odd number on the products side (4 + 3), so double the coefficients.

\[ 2 \text{C}_2\text{H}_4 + \_ \text{O}_2 \rightarrow 4 \text{CO}_2 + 6 \text{H}_2\text{O} \]

Now add the coefficient in front of the \( \text{O}_2 \) to achieve the balanced reaction.

\[ 2 \text{C}_2\text{H}_4 + 7 \text{O}_2 \rightarrow 4 \text{CO}_2 + 6 \text{H}_2\text{O} \]

Balancing - Combustion Reactions

Examples

\[ \_ \text{C}_2\text{H}_5\text{OH} + \_ \text{O}_2 \rightarrow \_ \text{CO}_2 + \_ \text{H}_2\text{O} \]

1. \[ \text{C}_2\text{H}_5\text{OH} + \_ \text{O}_2 \rightarrow 2 \text{CO}_2 + \_ \text{H}_2\text{O} \]
2. \[ \text{C}_2\text{H}_5\text{OH} + \_ \text{O}_2 \rightarrow 2 \text{CO}_2 + 3 \text{H}_2\text{O} \]
3. \[ \text{C}_2\text{H}_5\text{OH} + \_ \text{O}_2 \rightarrow 2 \text{CO}_2 + 3 \text{H}_2\text{O} \]

There is an even number of oxygens on the reactants side (3) and an odd number on the products side (4 + 3), so double the coefficients.

\[ \text{C}_2\text{H}_5\text{OH} + 3 \text{O}_2 \rightarrow 2 \text{CO}_2 + 3 \text{H}_2\text{O} \]

Balancing - Combustion Reactions

Examples

\[ \_ \text{C}_2\text{H}_2 \rightarrow \_ \text{CO}_2 + \_ \text{H}_2\text{O} \]

\[ \_ \text{CH}_3\text{CO}_2\text{CH}_3 + \_ \text{O}_2 \rightarrow \_ \text{CO}_2 + \_ \text{H}_2\text{O} \]
Balancing - Synthesis and Decomposition Reactions

- The methods used for balancing synthesis and decomposition reactions are similar to those used to balance combustion reactions.
- Balance one element at a time, being sure to go back and check any previously balanced elements if necessary.

Balancing - Synthesis and Decomposition Reactions Examples

\[ \text{HgO} \rightarrow \text{Hg} + \text{O}_2 \]

\[ \text{H}_2 + \text{Cl}_2 \rightarrow \text{HCl} \]

\[ \text{N}_2 + \text{O}_2 \rightarrow \text{N}_2\text{O}_5 \]