Physical Science

Chapter 17
Chemical Reactions

Changes in Matter

- **Physical Change** - A change that alters the form of a substance but not the chemical makeup of the substance, a change of state
  - Words like: crush, smash, tear, evaporate, slice, breakdown, dissolve, absorb, swell, burst

- **Chemical Change** - One or more substances combine or decompose to form a chemically different substance
  - Words like: react, burns, forms, decomposed, rusting, sour, rotting, digesting, cooked, molecular change
Matter & Its Changes

- **Physical Changes** – Alters form or appearance but doesn’t change it into another substance i.e. Water evaporates into water vapor, a rock is broken into pieces.
- It’s like printing a word in a different font, it’s the same word just looks different!
  
  \[\text{stampedes} \rightarrow \text{stampedes}\]

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Matter & Its Changes

- **Chemical change**- changes the material into a new substance i.e. hydrogen and oxygen combine to form water.
  - Chemical reactions take place when chemical bonds are either formed or broken.
  - Strong chemical bonds resist change: glass
  - Weak chemical bonds breakdown easily: wood
- A chemical change is like scrambling letters to form new words
  
  \[\text{stampedes} \rightarrow \text{made + steps}\]

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Observing Chemical Reactions

- Chemical reactions produce new substances that can usually be detected by observing the evidence:
  - Color change
  - Precipitation
  - Temperature change
  - Property change
  - Gas produced

Chemical Reactions

- Chemical reactions occur when chemical bonds are formed or broken
  - Strong chemical bonds resist change: glass
  - Weak chemical bonds breakdown easily: wood

[Diagram of chemical bonds and reactions]
Writing Chemical Reactions

- Elements are represented by a one or two letter symbol
  - a. When symbol is a single letter: always capitalize: Hydrogen=H
  - b. When symbol is two letters, capitalize first letter & lower case second letter: Sodium = Na

![Chemical Elements]

Writing Chemical Reactions

- Chemical formulas show the ratio of elements found in molecules and compounds
  - a. Subscript numbers designate how many atoms of each element are present: H₂O₂; 2 Hydrogen atoms and 2 Oxygen atoms are present in this molecule
  - b. When no subscript number is shown: it is understood that there is only one atom present: H₂O = 2 Hydrogen atoms and only one Oxygen atom are present in this molecule

![Chemical Formulas]
Structure of an Chemical Equation:

- Conservation of Mass - Matter cannot be created nor destroyed so there must be the same number of atoms on each side of the equation.
- Beginning materials are reactants.
- Ending materials are products.
- Example of Chemical reaction:
  Reactant + Reactant → Product + Product

\[ 2H_2 + O_2 \rightarrow 2H_2O \]

Structure of an Equation:

**Coefficient**: a whole number in front of an element or molecule in a chemical reaction; tells how many of each compound or element is present.

\[ 6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2 \]

\[ 2H_2 + O_2 \rightarrow 2H_2O \]
Counting Atoms in an Equation

- If no subscript present it is assumed to be 1 atom
- If elements in brackets or parenthesis, treat same as in math.
- Coefficients multiple the entire molecule atoms
- You must add all reactant molecules together & compare w/ all molecules in the products

<table>
<thead>
<tr>
<th>CaCl₂</th>
<th>Ca₃(PO₄)₂</th>
<th>2Ca₃(PO₄)₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca=1</td>
<td>Ca=3</td>
<td>Ca=6</td>
</tr>
<tr>
<td>Cl=2</td>
<td>P=2</td>
<td>P=4</td>
</tr>
<tr>
<td></td>
<td>O=8</td>
<td>O=16</td>
</tr>
</tbody>
</table>

\[2H₂ + O₂ \rightarrow 2H₂O\]

4H, 2O = 4H, 2O

It's best to list the # of atoms under the molecules as we are doing in these examples

Balancing Equations

- Remember matter cannot be created or destroyed
- Therefore the # of reactant atoms must equal the # of product atoms

\[2H₂ + O₂ \rightarrow 2H₂O\]

4 Reactant Hydrogens = 4 Product Hydrogens
2 Reactant Oxygen = 2 Product Oxygen
This reaction is balanced!
Balance this…

\[ CH_4 + O_2 \rightarrow CO_2 + H_2O \]

**Step 1:** Count the atoms on both sides of the equation & compare

\[ CH_4 + O_2 \rightarrow CO_2 + H_2O \]

\[
\begin{align*}
C &= 1 & C &= 1 \\
H &= 4 & H &= 2 \\
O &= 2 & O &= 3
\end{align*}
\]

**Step 2:** apply a coefficient to a molecule to balance an “easy” atom (in this case, we can add a 2 coefficient to the product water to balance the H’s)

**Step 3:** Recount

\[ CH_4 + O_2 \rightarrow CO_2 + 2H_2O \]

\[
\begin{align*}
C &= 1 & C &= 1 \\
H &= 4 & H &= 4 \\
O &= 2 & O &= 4
\end{align*}
\]

**Step 4:** apply a coefficient to a molecule to balance the next off balanced atom (in this case, the oxygens are not yet balanced. We can add a coefficient of 2 in front of the reactant oxygen to correct this)

**Step 5:** Recount

**Step 6:** Continue doing this until all atoms are balanced

\[ CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O \]

\[
\begin{align*}
C &= 1 & C &= 1 \\
H &= 4 & H &= 4 \\
O &= 4 & O &= 4
\end{align*}
\]

BALANCED!!
Classifying Chemical Reactions

- **Synthesis**: When two or more substances combine to form a more complex substance
  \[ 2H_2 + O_2 \rightarrow 2H_2O \]

- **Decomposition**: When a complex substance is broken into two or more simpler substances:
  \[ 2H_2O \rightarrow 2H_2 + O_2 \]

- **Replacement**: When one element replaces another or when two elements in different compounds change places:
  \[ 2CuO + C \rightarrow 2Cu + CO_2 \]

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**Synthesis Reactions**

**Combination or Synthesis**

\[ A + B \rightarrow AB \]

\[ 2H_2 + O_2 \rightarrow 2H_2O \]
Decomposition Reactions

Decomposition

AB ---> A + B

2HgO ---> 2Hg + O₂

Replacement Reactions

- 2 types:
  - Single Replacement
  - Double Replacement

<table>
<thead>
<tr>
<th>Single Replacement</th>
<th>Double Replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>A + BC ---&gt; B + AC</td>
<td>AB + CD ---&gt; CB + AD</td>
</tr>
<tr>
<td>Zn + 2HCl ---&gt; H₂ + ZnCl₂</td>
<td>2HCl + ZnS ---&gt; ZnCl₂ + H₂S</td>
</tr>
</tbody>
</table>
Controlling Chemical Reactions

- Every chemical reaction involves a change in energy.
- Some reactions release energy in the form of heat (exothermic)
- Some reactions absorb energy & the container holding the reaction gets colder to the touch (endothermic)

Getting Reactions Started

- The activation energy is the energy needed by a system to initiate the reaction. It is the minimum energy needed for a specific chemical reaction to occur. Once achieved, the reaction continues until reactants are extinguished.
Enough is enough....
Stop already!!

OK