Chapter 7: Chemical Reactions

Physical Science
C. Goodman, Doral Academy Charter High School, 2012-2013
Based on a presentation by Holt, Rinehart and Winston
Section 7.1 – Essential questions

1. What is a chemical reaction?
2. Why do substances react?
3. What is the role of energy in chemical reactions?
Section 7.1 - Vocabulary

- reactant
- product
- chemical energy
- exothermic reaction
- endothermic reaction
What is a chemical reaction?

- Chemical change, forming new substances.
  - **Reactant**: a substance or molecule that participates in a chemical reaction
  - **Product**: a substance that forms in a chemical reaction
Chemical reactions rearrange atoms

- Do not create the atoms of the products or destroy the atoms of the reactants
Possible signs of a chemical reaction

1. Gas formation
2. Solid formation
3. Change in temperature (gets hot or cold)
4. Color change
Energy and chemical reactions

Chemical reactions always involve changes in energy.
Breaking bonds

1. Energy must be added to break bonds.

   - Many forms of energy can be used to break bonds:
     - Heat
     - Electricity
     - Light
Making bonds

2. Forming bonds releases energy.
Energy in chemical bonds

- **chemical energy**: the energy released when a chemical compound reacts to produce new compounds
Example

Reactants   Products

Isooctane  Oxygen  →  Carbon dioxide  Water  Energy
\( \text{C}_8\text{H}_{18} \)  \( \text{O}_2 \)  \( \text{CO}_2 \)  \( \text{H}_2\text{O} \)  energy
Exothermic reactions

- **exothermic reaction**: a chemical reaction in which energy is released as **heat**
- energy released (to make bonds in products) > energy absorbed (to break the bonds in reactants)
Endothermic reactions

- endothermic reaction: a chemical reaction that requires energy input

- Endothermic reactions absorb energy

  - energy for breaking bonds of reactants > energy of forming bonds of products
And to view the difference graphically...
Minilab: Exothermic and Endothermic Reactions

Safety precautions

A. CaCl₂ is poisonous. Do not ingest!
B. The product of the first reaction is acidic. Avoid contact with skin and eyes.
C. Use safety goggles and gloves.
D. Wash hands thoroughly with soap and water after completing the lab.

Purpose

A. To observe exothermic and endothermic reactions

Hypothesis (none)
Minilab: Exothermic and Endothermic Reactions

Data analysis questions (4 points)

A. Describe each reaction. Explain what changes were signs of a chemical reaction.

B. Which reaction was endothermic, and which was exothermic? How could you tell?

Conclusion

A. Paragraph 1: purpose, materials, procedures (2 points)

B. Paragraph 2: data. Describe the reactions, and explain which reaction is exothermic and which is endothermic, and why. (4 points)
Minilab: Exothermic and Endothermic Reactions

Data table (4 points)

<table>
<thead>
<tr>
<th>Reactants</th>
<th>Products (observations of reaction)</th>
<th>Reaction type (endothermic, exothermic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water + NaHCO$_3$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ CaCl$_2$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Section 7.2 – Essential questions

1. What is a chemical equation?
2. Why must chemical reactions be “balanced?”
3. How can you write a balanced chemical equation?
Section 7.2 - Vocabulary

- Chemical equation
- Balanced chemical equation
- Mole ratio
- Subscript
- Coefficient
- Reactant
- Product
Chemical Equations

- **chemical equation**: a representation of a chemical reaction that uses symbols to show the relationship between the reactants and the products
  - Rearranging elements in reactants to create new combinations of elements (new compounds) in the products of the reaction
  - $\text{Na} + \text{Cl}_2 \rightarrow \text{NaCl}$
  - $\text{Na} + \text{Cl}_2 \rightarrow 2\text{NaCl}$
The simplest way to describe a chemical reaction...

**Word equation**

methane and oxygen yield carbon dioxide and water

**Molecular model**

![Molecular model](image)

**Chemical equation**

$$\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$$
Balanced chemical equations: what?

- When the number of atoms/moles of each element of the products matches the number of atoms/moles of each element of the reactants, the chemical equation is said to be balanced.

- *Let's look at one...*
Reading a chemical equation

- Where are the reactants and products?
Balanced chemical equations: why?

- Balanced chemical equations reflect the Law of Conservation of Mass (between reactants and products).
Balanced chemical equations: how?

- A chemical equation is balanced by adding coefficients in front of one or more of the formulas.
Math Skills

Balancing Chemical Equations
Write the equation that describes the burning of magnesium in air to form magnesium oxide.

1. Identify the reactants and products.
   Magnesium and oxygen gas are the reactants that form the product, magnesium oxide.

2. Write a word equation for the reaction.
   magnesium + oxygen → magnesium oxide
Math Skills, *continued*

3. Write the equation using formulas for the elements and compounds in the word equation. Oxygen in air is \( \text{O}_2 \), not \( \text{O} \).

\[
\text{Mg} + \text{O}_2 \rightarrow \text{MgO}
\]

4. Balance the equation one element at a time.

<table>
<thead>
<tr>
<th>Reactants</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{Mg} + \text{O}_2 )</td>
<td>( \text{MgO} )</td>
</tr>
</tbody>
</table>

count atoms: \( \text{Mg} = 1, \text{O} = 2 \) \( \text{Mg} = 1, \text{O} = 1 \)
### Math Skills, continued

<table>
<thead>
<tr>
<th>Reactants</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>balance oxygen:</td>
<td></td>
</tr>
<tr>
<td>$Mg + O_2 \rightarrow 2MgO$</td>
<td>$Mg = 2, O = 2$</td>
</tr>
<tr>
<td>$Mg = 1, O = 2$</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>balance magnesium:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$2Mg + O_2 \rightarrow 2MgO$</td>
<td>$Mg = 2, O = 2$</td>
</tr>
<tr>
<td>$Mg = 2, O = 2$</td>
<td></td>
</tr>
</tbody>
</table>
Huhhh?

- Let’s go over that step by step...
Law of What???

- Check it out...
- `..\..\..\..\Physical Science Resource Disk\Powerpoints\FILES\CH07\75038.html`
Practice Time!!!

- p. 229 #1-5
- Grading scale
  - 1 pt each, 3 pts for #3-5, 16 pts total
  - A: 15-16
  - B: 13-14
  - C: 11-12
  - D: 9-10
  - F: <9
Section 7.3 – Essential questions

1. How is classifying chemical reactions useful?
2. What are the five types of chemical reactions?
Section 7.3 - Vocabulary

- synthesis reaction
- decomposition reaction
- combustion reaction
- single-displacement reaction
- double-displacement reaction
Classifying Reactions

〉 How does learning about reaction types help in understanding chemical reactions?

〉 You can use patterns to identify kinds of chemical reactions and to predict the products of the chemical reactions.
Visual Concept: Synthesis Reaction

- **Synthesis Reactions**
  - Chemical reaction: $2\text{Ca} + \text{O}_2 \rightarrow 2\text{CaO}$
Synthesis reactions combine substances.

**synthesis reaction**: a reaction in which two or more substances combine to form a new compound

- The general form of a synthesis reaction is:
  \[ A + B \rightarrow AB \]

- Example: \[ 2Na + Cl_2 \rightarrow 2NaCl \]
Visual Concept: Decomposition Reaction

\[(\text{NH}_4)_2\text{Cr}_2\text{O}_7 \rightarrow \text{N}_2 + 4\text{H}_2\text{O} + \text{Cr}_2\text{O}_3\]
Decomposition reactions break substances apart.

**decomposition reaction**: a reaction in which a single compound breaks down to form two or more simpler substances

- Decomposition reactions have the general form:
  $$AB \rightarrow A + B$$

- Example: $$2H_2O \rightarrow 2H_2 + O_2$$
Visual Concept: Combustion Reaction
Classifying Reactions, continued

- **Combustion reaction**: the oxidation reaction (uses oxygen) of a substance, in which heat is released
- Activation energy needed
- Exothermic reaction
- When combust hydrocarbons, creates H₂O
  - If lots of O₂ => CO₂ + H₂O
  - If less O₂ => CO + H₂O
  - If little O₂ => C (carbon, or soot) + H₂O
  - If no O₂ => no combustion
Single Displacement

\[ 3\text{CuCl}_2 + 2\text{Al} \rightarrow 2\text{AlCl}_3 + 3\text{Cu} \]
Classifying Reactions, continued

- **single-displacement reaction**: a reaction in which one element takes the place of another element in a compound.
- In general, a more reactive element will take the place of a less reactive one.
- All alkali metals and some other metals undergo similar single-displacement reactions with water.
- Single-displacement reactions have the general form:
  \[ AX + B \rightarrow BX + A \]
- Example: \[ 3CuCl_2 + 2Al \rightarrow 2AlCl_3 + 3Cu \]
Double-Displacement Reaction

\[ \text{AX} + \text{BY} \rightarrow \text{AY} + \text{BX} \]

\[ \text{Pb(NO}_3\text{)}_2 + \text{K}_2\text{CrO}_4 \rightarrow \text{PbCrO}_4 + 2\text{KNO}_3 \]
Classifying Reactions, continued

- In double-displacement reactions, ions appear to be exchanged between compounds.
  
  - **double-displacement reaction**: a reaction in which a gas, a solid precipitate, or a molecular compound forms from the apparent exchange of atoms or ions between two compounds.

  - Double-displacement reactions have the general form:
    \[ AX + BY \rightarrow AY + BX \]

  - Example: \[ \text{Pb(NO}_3\text{)}_2 + \text{K}_2\text{CrO}_4 \rightarrow \text{PbCrO}_4 + 2\text{KNO}_3 \]
Section 7.4 – Essential questions

1. What is reaction rate?
2. What factors will change reaction rate?
3. What is the role of catalysts in chemical reactions?
Section 7.4 - Vocabulary

- reaction rate
- catalyst
Reaction rate:
How fast a reaction takes place. For any reaction to occur, the particles of the reactants must collide with one another.
Factors Affecting Reaction Rates

What kinds of things speed up a reaction?

a. Anything that increases speed of particles will increase contact between them.

b. Anything that increases contact between particles will increase the rate of a reaction.
What are those factors?
Factors Affecting Reaction Rates, continued

- Higher temperatures.
- Large surface area
- Higher concentrations of reactants
- Higher pressure.
Factors Affecting Reaction Rates, *concentration*

**Effect from Concentration**
- Red ball colliding with a blue for chemical reaction to take place.
- Increasing the number of red balls per unit volume (concentration).
- Probability of effective collision between red and blue balls is higher.
Factors Affecting Reaction Rates, *surface area*

Hydrogen ions can hit the outer layer of atoms...

...but not these in the centre of the lump.

With the same number of atoms now split into lots of smaller bits, there are hardly any magnesium atoms inaccessible to the hydrogen ions.

Molecules on upper layer have a lower chance of combining.
Factors Affecting Reaction Rate
Catalysts

- **catalyst**: is a substance that changes the rate of a chemical reaction without being consumed or changed significantly.
Catalysts

Catalysts are often used in industry to make reactions go faster, and with less energy required.
Enzymes

- Enzymes are biological catalysts.
- **Enzyme**: a type of protein that speeds up metabolic reactions in plants and animals without being permanently changed or destroyed.