Physical Science Chapter 21

Chemical Reactions

Link to Fireworks Video with Music

A Nova fireworks video
Have you ever been camping?

Think about a campfire and toasting marshmallows. What are the chemical reactions that take place?

Wood burns, marshmallows toast. How do these things change if you don’t change anything?
21:1 Chemical Changes

Describing Chemical Reactions:
A chemical reaction is a change of one or more substances into a new substance.
The substances that react or change are the reactants.
The new substances produced are the products.
21:1 Chemical Changes

The mass of the products always equals the mass of the reactants.

reactants $\rightarrow$ products
What you should already know:
The law of conservation of mass states that:

in a chemical reaction matter is neither created or destroyed.
21:1 Chemical Changes

Why is this important for me to know?

How do we use this information in our daily lives? Gives some examples.

Chemical reactions

• Cook our food
• Warm our homes
• Provide energy to our bodies

In the future, chemical reactions will be responsible for all of these plus prevent and cure diseases, make life easier and more enjoyable and provide things we cannot imagine now.
21:1 Chemical Changes

Lavoisier – French chemist proved conservation of mass. Lavoisier experimented with mercury (II) oxide and heat, and yeast production of CO$_2$. He found that mass of the products equaled mass of the reactants.

Lab Yeast Produces Chemical Reactions
21:1 Chemical Changes

Writing Equations: chemical equations use chemical formulas and symbols to describe a chemical reaction and the products it produces. Chemical formulas express the relationship between elements in the compound and molecules they make up.
Coefficients are numbers which represent the number of units of each substance in a reaction. Knowing coefficients of chemical reactions allows chemists to use the correct amounts of reactants to predict the amounts of products.
Subscripts are numbers which represent the number of atoms in a molecule of a particular element. Symbols are used to show state of reactants: (s) solid, (aq) aqueous, (g) gas, (l) liquid.
21:1 Chemical Changes

Diatomict gases are gases that are never represented in formulas by single atoms. They include hydrogen, nitrogen, oxygen, fluorine, chlorine, bromine, iodine.

Metals react with the atmosphere in different ways.
Rust is oxygen reacting with iron forming iron oxide. Aluminum reacts with oxygen to form aluminum oxide. Copper reacts to form copper oxide.
A chemical reaction has happened if there is evidence of:

- A change in color
- A gas is produced
- Change in temperature
- Change in odor
- Change in state
- Gives off a precipitate
- Light is produced

Fireworks
Yeast is a microscopic, one-celled organism belonging to the group of organisms called fungi. There are many kinds of yeasts, some of them of great importance to humans. Yeast is necessary to make leavened bread, beer, and cheese. It is rich in B vitamins; a form of yeast called brewer's yeast is used as a diet supplement. Yeasts are found in the soil, in water, on the surface of plants, and on the skin of humans and other animals. Like other fungi, yeasts obtain food from the organic matter around them; they secrete enzymes that break down the organic matter into nutrients they can absorb. As yeast live and grow, they respire as other living things. They consume sugars and give off carbon dioxide gas into their environment.
Balances have been used for a very long time to compare the weights of different objects. Usually, an unknown weight is put in one pan and known weights are put in the other until the two pans are even. Chemical equations are balanced in a similar way.
Chemical Equations

Checking for balance—law of conservation of mass requirement

A balanced chemical reaction – both sides of equation have same number of atoms of each element.
21:2 Chemical Equations

Choosing coefficients — becomes easier with practice; trial and error at first.
Writing balanced chemical equations—a four-step process
1. Describe the reaction in __________ words.
2. Write the __________ equation using formulas and symbols
3. Check for __________ balance
4. Add __________ coefficients where needed
How to Balance Equations

\[2 \text{Li} + 2 \text{H}_2\text{O} \rightarrow 2 \text{LiOH} + \text{H}_2\]

- List all the elements on each side.
- Count the elements on each side.
- Balance.
Balance this equation in your notes:

\[
\text{NaN}_3 \rightarrow \text{Na} + \text{N}_2
\]

(work & check)

\[
2\text{NaN}_3 \rightarrow 2\text{Na} + 3\text{N}_2
\]
Why is it necessary to balance equations for chemical reactions?

Conservation of mass requires that the number of atoms of an element on the left side equals the number of atoms on the right side. Balanced equations accurately depict chemical changes.
Write a balanced chemical equation for this reaction:
Iron metal plus oxygen produces iron(II) oxide.

\[2Fe \quad + \quad O_2 \quad \rightarrow \quad 2FeO\]
21:2 Chemical Equations

The Objective: apply the law of conservation of mass to write balanced chemical equations.

Write a balanced chemical equation for this reaction:

Sodium metal plus water produces sodium hydroxide plus hydrogen gas.

\[ 2 \text{Na} + 2 \text{H}_2\text{O} \rightarrow 2 \text{NaOH} + \text{H}_2 \]
Explain why oxygen gas must always be written as $O_2$ in a chemical equation.

Oxygen gas exists as a diatomic molecule, therefore is written as $O_2$. 
21:2 Chemical Equations

- Balancing Equations Activity
- More Practice Problems
Balance these equations:

1. \( \text{N}_2 + 3 \text{H}_2 \rightarrow 2 \text{NH}_3 \)
2. \( 2 \text{KClO}_3 \rightarrow 2 \text{KCl} + 3 \text{O}_2 \)
3. \( 2 \text{NaCl} + \text{F}_2 \rightarrow 2 \text{NaF} + \text{Cl}_2 \)
4. \( 2 \text{H}_2 + \text{O}_2 \rightarrow 2 \text{H}_2\text{O} \)
5. \( \text{Pb(OH)}_2 + 2 \text{HCl} \rightarrow 2 \text{H}_2\text{O} + \text{PbCl}_2 \)

The Objective: apply the law of conservation of mass to write balanced chemical equations.
Nitrogen is the most abundant gas in the atmosphere. However, in the atmosphere, nitrogen is held in molecules by very strong triple bonds. In order to be used by living things, these triple bonds need to be broken. Lightning can supply energy that frees nitrogen atoms to form new compounds.
A reaction has happened if there is evidence of:
- A change in color
- A gas is produced
- Change in temperature
- Change in odor
- Change in state
- Gives off a precipitate
- Light is produced
Chemical reactions are the “machinery” that drive our universe. For example just in one adult human body there are billions maybe even trillions of chemical reactions that occur every second.
We can categorize these chemical reactions based on what happens to the reactants and the products that result.

Most chemical reactions will fall into one of five categories:

- Synthesis Reactions
- Decomposition Reactions
- Single Displacement Reactions
- Double Displacement Reactions
- Combustion Reactions
21:3 Classifying Chemical Reactions

Synthesis reaction—two or more substances form a new substance;

\[ A + B \rightarrow C \]

The Objective: apply the law of conservation of mass to write balanced chemical equations.
21:3 Classifying Chemical Reactions

Decomposition reaction— one substance breaks down into two or more substances; \( AB \rightarrow A + B \)

The Objective: apply the law of conservation of mass to write balanced chemical equations.
Single-displacement reaction – one element replaces another one in a compound; $A + BC \rightarrow AC + B$
21:3 Classifying Chemical Reactions

Before a basketball game, the coach assembles the players and chooses five to form the starting team. Which one of the four reactions does this resemble?

Synthesis

One of the starting players on the basketball team fouls out of the game. The coach substitutes a player from the bench into the game. Which one of the four reaction types does this resemble?

Single displacement

Math Skills Activity pg 644

The Objective: apply the law of conservation of mass to write balanced chemical equations.
Double-displacement reaction results if a precipitate, water, or a gas forms when two ionic compounds in solution are combined;

\[ AB + CD \rightarrow AD + CB \]

The Objective: apply the law of conservation of mass to write balanced chemical equations.
Quick Review
Types of Chemical Reactions

- Synthesis Reaction
- Decomposition Reaction
- Single-Displacement Reaction
- Double-Displacement Reaction
Classify this reaction as synthesis, decomposition, single-displacement or double-displacement:

1. \( \text{CaO(s)} + \text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2 \text{(aq)} \)  
   
   synthesis

2. \( \text{Fe(s)} + \text{CuSO}_4 \text{(aq)} \rightarrow \text{FeSO}_4 \text{(aq)} + \text{Cu(s)} \)  
   
   single-displacement

3. \( \text{NH}_4\text{NO}_3 \text{(s)} \rightarrow \text{N}_2\text{O} \text{(g)} + 2\text{H}_2\text{O} \text{(g)} \)  
   
   decomposition

4. \( \text{FeCl}_3 + 3\text{NaOH} \rightarrow \text{Fe(OH)}_3 + 3\text{NaCl} \)  
   
   Double-Displacement
21:3 Classifying Chemical Reactions

A reaction has happened if there is evidence of:

- A change in color
- A gas is produced
- Change in temperature
- Change in odor
- Change in state
- Gives off a precipitate
- Light is produced
Quiz

Use a blank piece of notebook paper to answer these questions.

1. Balance this equation.
   \[ \underline{\text{Hg}} + \underline{\text{O}_2} \rightarrow \underline{\text{HgO}} \]

2. Which of the four classifications of reactions are these equations:
   a. \[ 2\text{Na} + \text{Cl}_2 \rightarrow 2\text{NaCl} \]
   b. \[ \text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O} \]
   c. \[ 2\text{H}_2\text{O} \rightarrow 2\text{H}_2 + \text{O}_2 \]
3. Name 3 signs that a chemical reaction has occurred..

4. The Law of Conservation of Mass says that

_______________________________________

_______________________________________

5. The _______ are substances that combine to form new compounds in a chemical reaction.

6. The new substances formed in a chemical reaction are called the ______________.

The End
Vocabulary Discussion / Check
This animal is a comb jellyfish. Most comb jellies are capable of giving off light. What type of reaction allows the comb jelly to give off light? Why is it important that the jelly generates light without heat?
Chemical reactions involve energy exchange.

1. Breaking chemical bonds requires energy.

2. Forming chemical bonds releases energy.
When its usefulness is over, a building is demolished by dynamite. Dynamite charges must be placed carefully so the building collapses inward, where it cannot harm people or property.
Exergonic reactions — energy required to break bonds is less than the energy released from new bonds; energy given off is usually light.

Exothermic reactions — energy given off in the form of heat.

The Objective: To investigate and better understand physical and chemical changes and reactions.
More Energy In.

Endergonic reactions — more energy is required to break bonds than to form new ones; need energy for the reaction to occur.

If energy needed is heat, the reaction is endothermic.
A catalyst speeds up a chemical reaction without itself being permanently changed.

An inhibitor prevents or slows a chemical reaction or interferes with a catalyst’s action.

The Objective: To investigate and better understand physical and chemical changes and reactions.
What is the definition of a calorie?

Calorie is the heat needed to raise 1 g of H₂O by 1°C.

What is the difference in a food calorie and a chemical calorie?

1 food calorie = 1,000 cal.

The joule is another label for energy used in chemistry. 4.184 J = 1 cal.
Glow sticks contain three different chemicals—an ester and a dye in the outer section and hydrogen peroxide in a center glass tube. Bending the stick breaks the tube and mixes the three components. This is an example of chemiluminescence.

The Objective: To investigate and better understand physical and chemical changes and reactions.
Test over Chapter 21 soon. and homework is due.