

Lesson 5: Chemical Energy

☐ Getting Started

Today you will learn about chemical bonds — attractive forces between atoms that keep them together in groups. They are not physically attached, but a force holds or bonds them together. Because of these bonds between atoms, these substances have potential energy in the form of chemical energy. When a chemical reaction occurs, one or more of the chemicals becomes a new and different substance. During a chemical reaction, the bonds between atoms are broken or created.

Stuff You Need

- *Let's Explore Energy* by Moving Beyond the Page
- baking soda
- citric acid (kit)
- clear glass cup
- colored pencils or markers
- glass jar (kit)
- graduated cylinder (kit)
- large marshmallows
- measuring spoons
- periodic table of elements (kit)
- plastic spoon
- scissors
- small bowl
- small, colored marshmallows
- steel wool (kit)
- thermometer (kit)
- uncooked spaghetti noodles
- vinegar

Ideas to Think About

- How are matter and energy related?
- How do substances interact and change into new substances?
- What is the difference between a molecule and a compound?

Things to Know

- An **atom** is the smallest component of an element and is made up of protons, neutrons, and electrons.
- An **element** is a substance made up of one type of atom.
- A **molecule** is formed when two or more atoms are bonded chemically. The atoms can be the same element or they can be different. These atoms can be the same element (like O₂ or H₂) or different elements (like H₂O or CO₂).

- A **compound** is a molecule made up of two or more elements. All compounds are molecules, but not all molecules are compounds. Example: O_2 (oxygen gas) is a molecule, but it is not a compound because it contains only one element. H_2O (water) is both a molecule and a compound because it contains two different elements (hydrogen and oxygen).
- Scientists have another name for the first law of thermodynamics: the *law of conservation of mass-energy*.
- An **exothermic reaction** is a chemical reaction that releases energy in the form of heat and/or light.
- In an **endothermic reaction**, energy is taken in and is transformed into chemical bond energy.

☐ Reading and Questions

Read about chemical energy on pages 15-20 of the *Let's Explore Energy* booklet and then answer these questions.

1. What makes an atom of one element different than an atom of another element?

2. In a chemical reaction, what are reactants? What are products?

3. Explain the role of energy in a chemical reaction.

Activities☐ **Activity 1: Modeling Molecules**

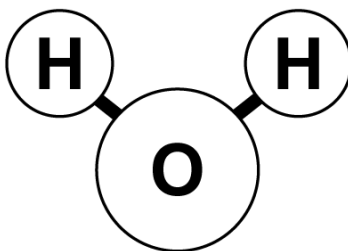
Each element on the periodic table of elements has its own symbol. The symbol for hydrogen is H. Find hydrogen on your periodic table. Try a few more to get familiar with the periodic table:

- What element has the symbol of Ti?
- What is the symbol for helium?
- What is the element Sn?

Remember that a molecule is two or more atoms bonded together. These atoms can be the same element, or they can be different elements. When we want to describe what a molecule is made of, we use the symbols of each atom and put them together into a chemical formula. Here is an example of a formula you are very familiar with:



This, of course, is the chemical formula for water. Chemical formulas tell you the names of the elements in the molecules and how many atoms of each element there are. The formula for water indicates that there are two hydrogen atoms and one oxygen atom in a molecule of water. As you saw in today's reading, this is what a water molecule looks like:



As you can see above, a molecule is formed when two or more atoms bond together. The atoms in a molecule can be the same element or different elements:

- O_2 (oxygen gas) and H_2 (hydrogen gas) are molecules, but they are NOT compounds because they contain only one type of element.
- H_2O (water) and CO_2 (carbon dioxide) are both molecules AND compounds because they contain atoms from at least two different elements.

All compounds are molecules, **but** not all molecules are compounds.

On the "Modeling Molecules" activity page you will find a list of some common molecules. Using your periodic table of elements as a reference, identify the elements that are joined together to form each molecule, and then create a model of the molecule using marshmallows and spaghetti. Use small marshmallows to represent hydrogen, and use large marshmallows to represent the other atoms. Hydrogen atoms are smaller than other atoms. You may also want to use the small marshmallows to represent oxygen in the copper sulfate molecule.

On your first try you will probably not structure the atoms just right. That is okay. Give it your best guess, and then you can correct the marshmallow structures with your parent after you have given it one try.

☐ Activity 2: Matter and Energy

In the last lesson you learned about the laws of thermodynamics. Remember that the first law of thermodynamics says that neither energy nor matter can be created or destroyed, but they can change. Matter can change from one state — from being a solid, liquid, or a gas — to another state. Melting ice is an example of matter (water) changing from a solid to a liquid. Elements can be combined to form new substances, as you modeled in Activity 1. Energy can change from chemical to electric to kinetic, or from light to heat. You have already conducted experiments in the last few lessons to observe how energy can be changed from one form to another.

Scientists have another name for the first law of thermodynamics: the *law of conservation of mass-energy*. It tells us four important facts about matter and energy:

1. Matter can't be created or destroyed.
2. Energy can't be created or destroyed.
3. Sometimes energy can be changed into matter.
4. Sometimes matter can be changed into energy.

This law says that the total amount of mass (matter) and energy in the entire universe remains the same, even if matter and energy change forms or change into each other.

Demonstrate these ideas by following the directions on the "Matter and Energy" activity page. When you have found words for each category, explain to a parent

how your words demonstrate the law of conservation of mass-energy.

☐ **Activity 3: Exothermic and Endothermic Reactions**

Chemical reactions cause atoms to rearrange into different combinations of matter, just as you demonstrated in Activity 2. It takes energy to begin a reaction because the bonds between atoms must be broken first. Energy is released when bonds are formed.

Review the difference between an exothermic and an endothermic reaction in your *Let's Explore Energy* booklet. Then conduct the two experiments on the "Exothermic and Endothermic Reactions" activity page.

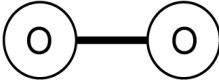
Materials Note: Save the glass jar to use in Lesson 2 of "The Living Seas" unit.

Wrapping Up

Review the definitions of an atom, a molecule, and a compound. Try to explain to your parent what occurs during a chemical reaction. Think about the difference between an exothermic reaction and an endothermic reaction.

Modeling Molecules

Directions: Using your copy of the periodic table of elements as a reference, identify the elements and number of atoms of each element found in the given molecules. Create a model of the molecule using marshmallows and uncooked spaghetti. Then draw your model. A water molecule has been done for you.

Molecule	Elements Present	Number of Atoms	Molecule or Compound?	Diagram
O_2 oxygen gas	oxygen (O)	2	molecule compound both	
H_2 hydrogen gas			molecule compound both	
H_2O water			molecule compound both	
CO_2 carbon dioxide			molecule compound both	
$NaCl$ salt			molecule compound both	

MATTER AND ENERGY

Directions: Color the word "MATTER" one color. Color the word "ENERGY" another color. Cut out all the letters. Use the letters to make words that illustrate the following ideas. Write your words in the table.



FACTS ABOUT MATTER AND ENERGY:

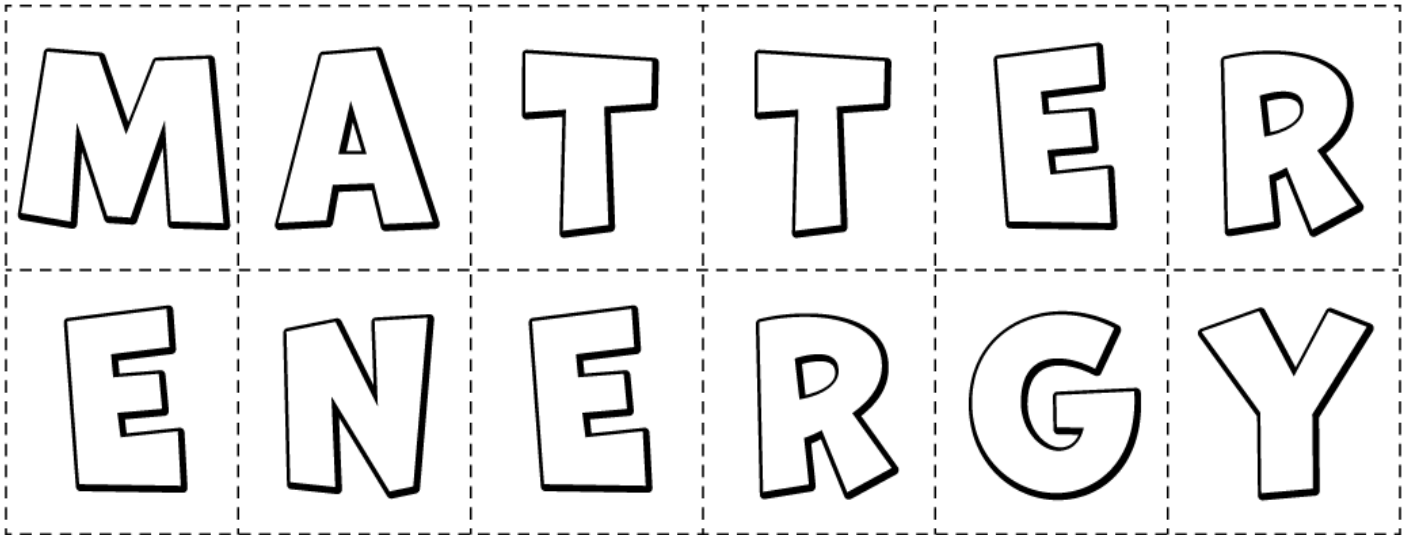
Fact #1: Matter can't be created or destroyed.

Fact #2: Energy can't be created or destroyed.

Fact #3: Sometimes matter can be changed into energy.

Fact #4: Sometimes energy can be changed into matter.

#1: Change matter into different forms by making 3 words that use only letters from "matter".	#2: Change energy into different forms by making 2 words that use only letters from "energy".	#3: Make 2 words that use at least one letter from "energy" but mostly use letters from "matter".	#4: Make 2 words that use at least one letter from "matter" but mostly use letters from "energy".



Exothermic Reaction

Materials:

- steel wool
- vinegar
- glass jar with lid
- thermometer
- small bowl

Procedure:

1. Put the thermometer in the jar, close the lid, and wait 5 minutes.
2. Remove the thermometer and record the temperature.
3. Put some vinegar into a small bowl. Soak the steel wool in the vinegar for 1 minute.
4. Squeeze the excess vinegar out of the steel wool.
5. Wrap the wool around the thermometer, place the wool/thermometer in the jar, and close the lid.
6. After 5 minutes, remove the thermometer and record the temperature.

Questions:

What was the difference between the initial temperature of the air in the jar and the temperature after the steel wool soaked in vinegar was added to the jar?

Did the reaction produce heat? yes / no

How do you know? _____

Endothermic Reaction

Materials:

- plastic spoon
- glass cup
- citric acid
- measuring spoons
- thermometer
- baking soda
- graduated cylinder

Procedure:

Note: You may want to do this experiment over a sink to avoid a mess.

1. Pour 1 tablespoon of citric acid into the glass cup.
2. Use your graduated cylinder to measure 25 ml of water. Pour the water into the glass cup and stir with a plastic spoon.
3. Put the thermometer in the cup and record the temperature of the citric acid solution.
4. Remove the thermometer and stir in a heaping teaspoon of baking soda (sodium bicarbonate).
5. Re-insert the thermometer and record the temperature every 30 seconds for 3 minutes.

Questions:

What happened to the temperature when the baking soda was stirred in the citric acid?

Was energy taken in? yes / no

How do you know? _____

An endothermic reaction can be observed when a decrease in temperature occurs as a reaction takes place. Once the reaction is over, the temperature will return to room temperature.



Lesson 5: Chemical Energy

Getting Started

? Ideas to Think About

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⦿ Skills

- Recognize that all matter is made of small particles called atoms, too small to see with the naked eye. (S)
- Distinguish between atom, element, molecule, and compound. (S)
- Understand that endothermic reactions absorb energy and exothermic reactions give off energy. (S)

Introducing the Lesson

Explain to your child that today he will observe chemical reactions. This will help him to understand how energy causes change. Ask him what he knows about elements, atoms, molecules, and compounds. Can he think of a substance that is made of more than one element?

Reading and Questions

1. What makes an atom of one element different than an atom of another element?

They have a different number of protons in their nucleus.

2. In a chemical reaction, what are reactants? What are products?

Reactants are the substances that are being combined and are reacting with each other. Products are the substances that result from the reaction. (In an exothermic reaction, energy is also considered a product.)

3. Explain the role of energy in a chemical reaction.

Energy is used at the beginning of a reaction to break apart the bonds between atoms. Then, as products are formed, energy is given off when atoms recombine and form new bonds.

Activities

Activity 1: Modeling Molecules

First, your child should have used the periodic table to find out the following:

- What element has the symbol of Ti? (titanium)
- What is the symbol for helium? (He)
- What is the element Sn? (tin)

Your child will use marshmallows and spaghetti to model some common molecules. Check your child's molecules to see that they reflect the correct atoms and number of atoms. The structure will likely be different for some of the molecules. This is okay. After he has worked through the molecules once on his own, you can go back with him and model the elements as they actually exist. (The answer key shows each atom labeled for your reference. Your child's models do not need to be labeled unless he wants to do so.)

Molecule	Elements Present	Number of Atoms	Molecule or Compound?	Diagram
O ₂ oxygen gas	oxygen (O)	2	molecule compound both	
H ₂ hydrogen gas	hydrogen (H)	2	molecule compound both	
H ₂ O water	hydrogen (H)	2	molecule compound both	
	oxygen (O)	1		
CO ₂ carbon dioxide	carbon (C)	1	molecule compound both	
	oxygen (O)	2		
NaCl salt	sodium (Na)	1	molecule compound both	
	chlorine (Cl)	1		

Activity 2: Matter and Energy

For this activity, your child will demonstrate his understanding of the law of conservation of mass-energy.

Answers will vary. Words for #3 and #4 will overlap, especially shorter words where half of the letters may come from each word. This is fine. The point of the activity is to reinforce the ideas that matter changes form, energy changes form, matter can change into energy, and energy can change into matter. Ask your child how the words he chose demonstrate those principles.

Some of the words your child may find include the following:

1. rat, mat, team, tar, tram, mare, mart, meat, mate, rate, ream, are, tamer
2. grey, green, eye, yen, rye
3. enter, tree, many, germ, target, mean, name, yam, team
4. grate, rage, range, ranger, year, eager, yearn, game, gamer, meager

Activity 3: Exothermic and Endothermic Reactions

Ask your child to explain what he observed during his endothermic and exothermic reactions.

Wrapping Up

Questions to Discuss

- What is a chemical reaction? (When two substances, or reactants, are mixed, the chemical bonds between atoms are broken or rearranged, and new products are formed.)
- What is the difference between an endothermic reaction and an exothermic reaction? (An endothermic reaction takes in heat energy and turns it into bond energy. An exothermic reaction changes bond energy to heat and/or light.)
- How are matter and energy similar? (You cannot create or destroy matter or energy, but you can change matter and energy into different forms.)

Things to Review

Review the difference between an atom, a molecule, and a compound.