**Lesson 7 - Chemical Reactions**

**Storyline Summary:**

At this point, students have seen that molecules of carbon dioxide gas can intermingle and become dissolved among the water molecules in a sample of water. They also know that the amount of carbon dioxide in the atmosphere has increased dramatically over the last 100 years or so. The question now is where does all this extra carbon dioxide come from, and how does it make the water acidic.

In this lesson, students will answer the first question about where the carbon dioxide comes from. They will do this by learning about a combustion reaction of the candle flame they saw in the first lesson. Students know that the burning candle produces carbon dioxide and this lesson on chemical reactions will show them how the chemical reaction produces this gas.

Through a series of demonstrations and activities, students learn that in chemical reactions, the atoms of the reactants unbond, rearrange, and rebond to form the products. Students also see that the same type and number of atoms in the reactants end up in the products and that no new atoms are created or destroyed. Students also learn that increasing the amount of reactants results in more products, but that increasing the amount of only one reactant will not increase the amount of products indefinitely.

Students also observe the clues that a chemical reaction has occurred: production of a gas, production of a precipitate, and a change in temperature. Another clue of chemical change - a change in color - will be explored in the next lesson with a pH indicator. Students will relate their observations to the ocean acidification model.

**Note:** This lesson includes four parts. Depending on the length of time you spend on each component, this lesson will probably take at least four or five class periods.

**What students do:**

**Part 1** - Students investigate the chemical reaction of a burning candle to establish the meaning and behavior of “reactants” and “products” in a chemical reaction.

**Part 2** – Students explore the chemical reaction between vinegar and baking soda to see that a chemical reaction can produce a gas and that the amount of reactants affects the amount of products.

**Part 3** – Students explore a chemical reaction between a baking soda solution and a calcium chloride solution to understand the production of a precipitate.

**Part 4** – Students conduct an endothermic and an exothermic chemical reaction to see that chemical reactions can result in a change in temperature.

**What students learn:**

* Chemical reactions create one or more new substances with new properties.
* In a chemical reaction, the atoms of the reactants unbond, rearrange, and rebond to form the products.
* Increasing the amount of reactants increases the amount of products.
* A clue that a chemical reaction has taken place is production of gas, forming a precipitate, or a change in temperature.

**Materials & Preparation**

**Part 1 – What is a Chemical Reaction?**

***Materials for the Demonstration***

* Tea light candle or other small stable candle
* Matches
* Glass jar, large enough to be placed over the candle

***Materials for Each Student***

* Atom cut-outs from the activity sheet
* Sheet of colored paper or construction paper
* Colored pencils
* Scissors
* Glue or tape

**Part 2 – Production of a Gas**

**Materials for the First Demonstration**

* + Vinegar
  + Graduated cylinder (50 mL)
  + Baking soda
  + Clear plastic cup

**Materials for the Second Demonstration**

* + Vinegar
  + Baking soda
  + Detergent solution
  + Dropper
  + Graduated cylinder (50 mL)
  + Measuring spoon (½ teaspoon)
  + Plastic waste container
  + Small cup

**Materials for Each Group**

* + Vinegar in a cup
  + Baking soda in a cup
  + Detergent solution in a cup
  + Dropper
  + Graduated cylinder (50 mL)
  + Measuring spoons (⅛, ¼, and ½ teaspoon)
  + Plastic waste container

**Part 3 – Forming a Precipitate**

***Materials for the Demonstration***

* Sodium carbonate
* Epsom salt (magnesium sulfate)
* 2 clear plastic cups
* Test tube
* Water

***Materials for Each Group***

* Baking soda
* Calcium chloride
* Water
* Graduated cylinder
* Measuring spoon (½ teaspoon) or balance
* 2 clear plastic cups
* Masking tape
* Pen

**Part 4 – Energy Changes in Chemical Reactions**

***Materials for the Each Group***

* Vinegar
* Baking soda
* Calcium chloride
* Water
* Thermometer
* 4 small cups
* Disposable self-heating hand warmer
* Self-inflating balloon

***Additional Materials if You Choose to do the Extra Extend***

* Magnesium sulfate
* Sodium carbonate
* Citric acid
* Universal indicator

# Part 1 – What is a Chemical Reaction?

# (From Middle School Chemistry – Chapter 6, Lesson 1)

# ENGAGE

## Review what happens during a *physical change* and introduce the idea of *chemical change*.

Tell students that in previous lessons they have studied different aspects of physical change. They have seen the dissolving of solids, liquids, and gases in water which are all physical changes. During dissolving, no new substances have been formed. The ions or molecules can still come back together to form the original substance.

Let students know that in the following lessons they will explore what happens during a *chemical* change. In a chemical change, one or more new substances are formed.

Remind students that they saw the burning candle with an indicator in the first lesson of the unit.

Ask students:

* **What was the gas produced by the burning candle that made the indicator change color?**

Students should remember that it was carbon dioxide gas. Let students know that the question now is: What happens during the burning of the candle to produce the carbon dioxide gas? Where did the carbon dioxide gas come from? Let students know that they will investigate that question.

***Materials for the Demonstration***

* Tea light candle or other small stable candle
* Matches

***Materials for Each Student***

* Atom cut-outs from the activity sheet
* Sheet of colored paper or construction paper
* Colored pencils
* Scissors
* Glue or tape

1. **As a demonstration, light a candle and ask students what they think is happening to produce carbon dioxide gas.**

## Procedure

1. Carefully light a tea light candle or other small candle.
2. Keep the candle burning as you ask students the questions below. You will put the candle out in the second part of the demonstration.

## Expected Results

The wick will catch on fire and the flame will be sustained by the chemical reaction.

The following question is not easy, and students are not expected to know the answer at this point. However, thinking about a candle burning in terms of a chemical reaction is a good place to start developing what it means when substances react chemically.

Ask students:

## What do you think are the reactants in this chemical reaction?

Wax and oxygen from the air are the reactants.

Students often say that the string or wick is burning. It is true that the string of the wick does burn but it’s the wax on the string and not so much the string itself that burns and keeps the candle flame burning. Explain that the molecules that make up the wax combine with oxygen from the air to make the products carbon dioxide and water vapor.

Explain that in most chemical reactions, two or more substances, called *reactants,* interact to create different substances called *products*. Tell students that burning a candle is an example of a chemical reaction. Point out to students that this is one of the major characteristics of a chemical reaction:

**In a chemical reaction, atoms in the reactants combine in new and different ways to form the molecules of the products.**

Students may be surprised that water can be produced from combustion. Since we use water to extinguish a fire, it may seem strange that water is actually produced by combustion. You may want to let students know that when they metabolize or “burn” food in their bodies, they also produce carbon dioxide and water.

# EXPLAIN

## Introduce the chemical equation for the combustion of methane and explain that atoms rearrange to become different molecules.

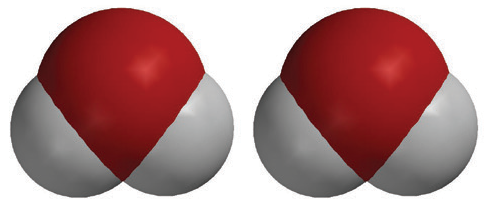
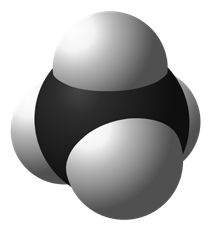
Explain to students that wax is made of long molecules called *paraffin* and that paraffin is made up of only carbon atoms and hydrogen atoms bonded together. Molecules made of only carbon and hydrogen are called *hydrocarbons*. Tell students that you will use the simplest hydrocarbon (methane) as a model to show how the wax, or any other hydrocarbon, burns.

**Project the image *Methane and Oxygen React*.**

[www.acs.org/middleschoolchemistry/simulations/chapter6/lesson1.html](http://www.acs.org/middleschoolchemistry/simulations/chapter6/lesson1.html)

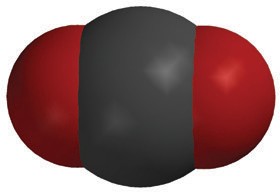
**CH4**

methane



**2O2**

oxygen



**CO2**

carbon dioxide

**2H2O**

water

+



+



Show students that there is methane and oxygen on the left side of the chemical equation and carbon dioxide and water on the right side. Explain that the molecules on the left side are the *reactants* and the ones on the right side are the *products*. When the candle was burning, the paraffin reacted with oxygen in the air to produce carbon dioxide and water, similar to the chemical reaction between methane and oxygen.

Explain to students that the chemical formula for methane is CH4. This means that methane is made up of one carbon atom and four hydrogen atoms.

Show students that the other reactant is two molecules of oxygen gas. Point out that each molecule of oxygen gas is made up of two oxygen atoms bonded together. It can be confusing for students that oxygen the atom, and oxygen the molecule, are both called *oxygen*. Let students know that when we talk about the oxygen in the air, it is always the molecule of oxygen, which is two oxygen atoms bonded together, or O2.

Ask students:

## Where do the atoms come from that make the carbon dioxide and the water on the right side of the equation?

The atoms in the products come from the atoms in the reactants. In a chemical reaction, bonds between atoms in the reactants are broken and the atoms rearrange and form new bonds to make the products.

***Note****: Leave this equation projected throughout the activity in the Explore section of this lesson. Students will need to refer to it as they model the chemical reaction.*

## Give Each Student an Activity Sheet for Part 1.

Students will record their observations and answer questions about the activity on the activity sheet. The *Explain It with Atoms and Molecules* and *Take It Further* sections of the activity sheet will either be completed as a class, in groups, or individually, depending on your instructions. Look at the teacher version of the activity sheet to find the questions and answers.

# EXPLORE

# 4. Have students make a model to show that in a chemical reaction the atoms of the reactants rearrange to form the products.

A group of black letters in a circle

Description automatically generated**Question to Investigate**

Where do the atoms in the products of a chemical reaction come from?

## Materials for Each Student

* Atom model cut-outs (carbon, oxygen, and hydrogen)
* Sheet of colored paper or construction paper
* Colored pencils
* Scissors
* Glue or tape

## Procedure

### **Prepare the Atoms**

1. **A hand touching a yellow and red and white chart

   Description automatically generated with medium confidence**Color the carbon atoms black, the oxygen atoms red, and leave the hydrogen atoms white.
2. Use scissors to carefully cut out the atoms.

### **Build the Reactants**

1. On a sheet of paper, place the atoms together to make the molecules of the reactants on the left side of the chemical equation for the combustion of methane.
2. Write the chemical formula under each molecule of the reactants. Also draw a “+” sign between the reactants.

After you are sure that students have made and written the formula for the reactant molecules, tell students that they will rearrange the atoms in the reactants to form the products.

### **Build the Products**

1. Draw an arrow after the second oxygen molecule to show that a chemical reaction is taking place.
2. Rearrange the atoms in the reactants to make the molecules in the products on the right side of the arrow.
3. Write the chemical formula under each molecule of the products. Also draw a “+” sign between the products.

Tell students that in a chemical reaction, the atoms in the reactants come apart, rearrange, and make new bonds to form the products.

### **Represent the Chemical Equation**

1. Have students use their remaining atoms to make the reactants again to represent the chemical reaction as a complete chemical equation.
2. Glue or tape the atoms to the paper to make a more permanent chemical equation of the combustion of methane.

# EXPLAIN

## Help students count the number of atoms on each side of the equation.

**Project the animation *Combustion of Methane*.**

[www.acs.org/middleschoolchemistry/simulations/chapter6/lesson1.html](http://www.acs.org/middleschoolchemistry/simulations/chapter6/lesson1.html)

Show students that the atoms in methane and oxygen need to come apart like in their models. Also point out that the atoms arrange themselves differently and rebond to form new products. This is also like their model. Be sure that students realize that the atoms in the products only come from the reactants. There are no other atoms available. No new atoms are created, and no atoms are destroyed.

***Note:*** *Explain to students that chemical reactions are more complicated than the simplified model shown in the animation. The animation shows that bonds between atoms in the reactants are broken, and that atoms rearrange and form new bonds to make the products.*

*In reality, the reactants need to collide and interact with each other in order for their bonds to break and rearrange. Also, the animation shows all of the atoms in the reactants coming apart and rearranging to form the products. But in many chemical reactions, only some bonds are broken, and groups of atoms stay together as the reactants form the products.*

Read more about the combustion of methane in *Teacher Background.*

Guide students as you answer the following question together:

## How many carbon, hydrogen, and oxygen atoms are in the reactants compared to the number of carbon, hydrogen, and oxygen atoms in the products?

Show students how to use the big number (coefficient) in front of the molecule and the little number after an atom of the molecule (subscript) to count the atoms on both sides of the equation. Explain to students that the subscript tells how many of a certain type of atom are in a molecule. The coefficient tells how many of a particular type of molecule there are. So if there is a coefficient in front of the molecule and a subscript after an atom, you need to multiply the coefficient times the subscript to get the number of atoms.

For example, in the products of the chemical reaction there are 2H2O. The coefficient means that there are two molecules of water. The subscript means that each water molecule has two hydrogen atoms. Since each water molecule has two hydrogen atoms and there are two water molecules, there must be 2 x 2 = 4 hydrogen atoms.

|  |  |  |
| --- | --- | --- |
| **Atoms** | **Reactant side** | **Product side** |
| Carbon | 1 | 1 |
| Hydrogen | 4 | 4 |
| Oxygen | 4 | 4 |

***Note****: The coefficients indicate the ratios of the numbers of molecules in a chemical reaction. It is not the actual number as in two molecules of oxygen and one molecule of methane since there are usually billions of trillions of molecules reacting. The coefficient shows that there are twice as many oxygen molecules as methane molecules reacting. It would be correct to say that in this reaction there are two oxygen molecules for every methane molecule.*

## Explain that mass is conserved in a chemical reaction.

Ask students:

## Are atoms created or destroyed in a chemical reaction?

No.

## How do you know?

There are the same number of each type of atom on both the reactant side and the product side of the chemical equation we explored.

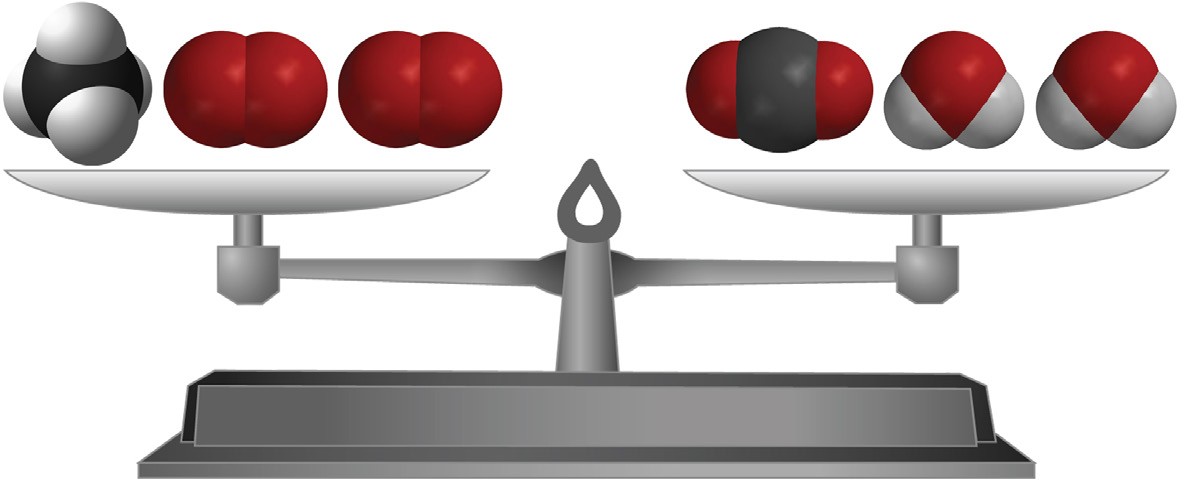
## In a physical change, like changing state from a solid to a liquid, the substance itself doesn’t really change. How is a chemical change different from a physical change?

In a chemical change, the molecules in the reactants interact to form new substances. In a physical change, like a state change or dissolving, no new substance is formed.

Explain that another way to say that no atoms are created or destroyed in a chemical reaction is to say, “Mass is conserved.”

**Project the image *Balanced Equation*.** [www.acs.org/middleschoolchemistry/simulations/chapter6/lesson1.html](http://www.acs.org/middleschoolchemistry/simulations/chapter6/lesson1.html)

Explain that the balance shows the mass of methane and oxygen on one side exactly equals the mass of carbon dioxide and water on the other. When an equation of a chemical reaction is written, it is “balanced” and shows that the atoms in the reactants end up in the products and that no new atoms are created, and no atoms are destroyed.



+

**CH4**

oxygen

methane

**2O2**

**CO2**

carbon dioxide

**2H2O**



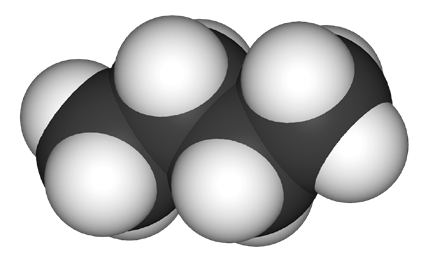
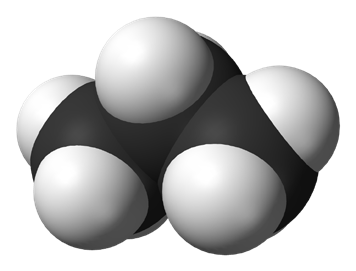
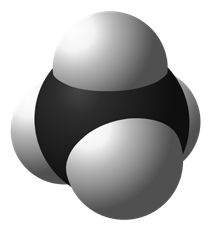
+

water

**EXTEND**

## Introduce two other combustion reactions and have students check to see whether or not they are balanced.

Tell students that, in addition to the wax and methane, some other common hydrocarbons are propane (the fuel in outdoor gas grills), and butane (the fuel in disposable lighters). Have students count the number of carbon, hydrogen, and oxygen atoms in the reactants and products of each equation to see if the equation is balanced. They should record the number of each type of atom in the chart on their activity sheet.



**CH4**

methane

**C3H8**

propane

**C4H10**

butane

## Lighting an outdoor gas grill—Combustion of propane

C3H8 + 5O2 → 3CO2 + 4H20

## Using a disposable lighter—Combustion of butane

2C4H10 + 13O2 → 8CO2 + 10H2O

After students have counted each type of atom, review their answers to make sure they know how to interpret subscripts and coefficients.

**9. Have a class discussion about how burning the wax in the candle relates to the problem of ocean acidification.**

Ask students:

* **How does the chemical reaction of the burning candle and the example of the combustion of methane relate to the problem of ocean acidification?**

Students can refer back to the reading in Lesson 1 to realize that the burning of the wax candle and the combustion of methane are examples of burning fossil fuels. The wax and methane are hydrocarbons. The burning of hydrocarbons in transportation, manufacturing, electricity generation, heating buildings, and other uses produces enormous amounts of carbon dioxide gas.

**Part 2 - Production of a Gas**

(From Middle School Chemistry – Chapter 6, Lesson 2)

# ENGAGE

Students have seen that the combustion reaction of a burning candle produces the gases carbon dioxide and water vapor. Let students know that you will demonstrate another familiar reaction that also produces a gas but in a different way.

**1. As a demonstration, combine vinegar and baking soda to show students the chemical reaction described in the equation.**

**Materials for the Demonstration**

* + Vinegar
  + Graduated cylinder (50 mL)
  + Baking soda
  + Clear plastic cup

## A person pouring baking soda into a cup Description automatically generatedProcedure

* 1. Use a graduated cylinder to measure 10 mL of vinegar.
  2. Place about ½ teaspoon of baking soda in a clear plastic cup.
  3. While students watch, pour the vinegar into the baking soda.

## Expected Results

Bubbles will form and rise in the cup.

Ask students:

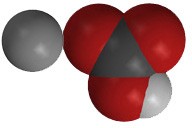
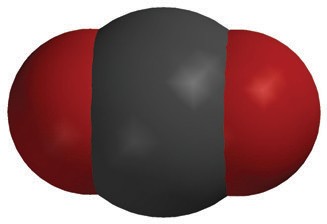
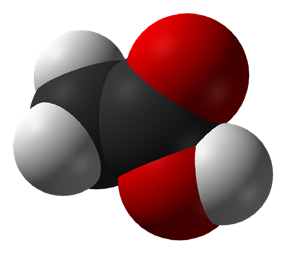
## A liquid and a solid were combined and you saw bubbling, which is made from gas. Do you think a chemical reaction occurred? Why? A chemical reaction occurred because a different substance was produced when the reactants combined.

## 2. Have students look at the chemical equation for the vinegar and baking soda reaction as you discuss the reactants.

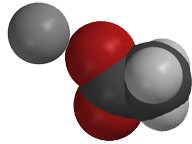
Remind students that in the last lesson, they learned that in a chemical reaction, certain atoms in the reactant molecules unbond from one another and then rearrange and rebond in different ways to form the products. Students saw that the same type and number of atoms were in the reactants as were in the products. Let students know that although the reaction in this lesson looks more complicated, these same principles still apply.

**Project the image Reactants.** [www.acs.org/middleschoolchemistry/simulations/chapter6/lesson2.html](http://www.acs.org/middleschoolchemistry/simulations/chapter6/lesson2.html)

Show students the chemical equation for the reaction between vinegar and baking soda.



+



+

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**C2H4O2**

acetic acid

**NaHCO3**

sodium bicarbonate

**NaC2H3O2**

sodium acetate

**H2O**

water

**CO2**

carbon dioxide

Ask students about vinegar:

## Acetic acid mixed with water is vinegar. Usually, vinegar is a solution of about 5% acetic acid and 95% water. When a reactant is in solution, the water is usually not listed as a reactant. Which atoms make up a molecule of acetic acid (vinegar)?

Carbon, hydrogen, and oxygen (C, H, and O).

## What do the little numbers below and to the right of each letter mean?

These are the number of that particular atom in the acetic acid molecule. There are two carbon atoms, four hydrogen atoms, and two oxygen atoms in an acetic acid molecule.

## Do you think every acetic acid molecule has this formula?

Yes. The chemical formula for a substance is unique to that substance and defines what it is.

Ask students about baking soda:

* **Sodium bicarbonate is baking soda. What atoms is sodium bicarbonate made of?**

Sodium, hydrogen, carbon, and oxygen (Na, H, C, and O).

## How many of each type of atom are there in the compound sodium bicarbonate?

There are one sodium atom, one hydrogen atom, one carbon atom, and three oxygen atoms in every unit of sodium bicarbonate.

**Project the image *Products*.**

[www.acs.org/middleschoolchemistry/simulations/chapter6/lesson2.html](http://www.acs.org/middleschoolchemistry/simulations/chapter6/lesson2.html)

A screenshot of a computer

Description automatically generatedPoint out the products in the chemical reaction.

Ask students:

## Look at the chemical equation. What is the gas produced in the chemical reaction between vinegar and baking soda?

Carbon dioxide

## What else is produced in this chemical reaction?

When vinegar and baking soda react, atoms rearrange to form sodium acetate (the salty and sour flavor in salt-and-vinegar-flavored potato chips), water, and carbon dioxide.

Continue to project the chemical equation as you and students count the number of atoms on both the reactant side and product side of the equation.

## 3. Review the concept that mass is conserved in a chemical reaction.

Help students count the atoms in the reactants and in the products of the vinegar-baking soda reaction. Make sure students see that every type of atom on the left side of the equation is also on the right. Also be sure that they see that there is an equal number of each type on both sides of the equation.

Guide students as you answer the following questions together:

## Is every type of atom on the left side of the equation also on the right side of the equation? Yes. Why?

Atoms from the reactants rearrange to form the products. Atoms are not created or destroyed in a chemical reaction.

* **How many of each type of atom is on the reactant side of the equation?**

3 carbon atoms, 5 hydrogen atoms, 5 oxygen atoms, and 1 sodium atom.

## How many of each type of atom is on the product side of the equation?

3 carbon atoms, 5 hydrogen atoms, 5 oxygen atoms, and 1 sodium atom.

**Project the image *Mass is Conserved*.** [www.acs.org/middleschoolchemistry/simulations/chapter6/lesson2.html](http://www.acs.org/middleschoolchemistry/simulations/chapter6/lesson2.html)

A grey scale with red and grey spheres

Description automatically generated

Point out that the type and number of atoms in the reactants and in the products are exactly the same. This is an important concept in chemistry: In a chemical reaction, all the atoms in the reactants end up in the products. When an equation of a chemical reaction is written, it is “balanced” to show this. A balanced chemical equation shows that no atoms are destroyed and no new atoms are created in the chemical reaction. Explain to students that another way of saying that no atoms are created or destroyed in a chemical reaction is that *mass is conserved*.

# EXPLORE

## 4. As a demonstration, combine vinegar, detergent, and baking soda in a graduated cylinder so that foam rises and spills over the top.

**Teacher Preparation for the Demonstration and for Each Group**

* + Make a detergent solution by adding 1 teaspoon of liquid dish detergent to 2 tablespoons of water. Divide this detergent solution equally into one small cup for each group.
  + Place about 1 tablespoon of vinegar in a small cup for each group.
  + Place about 2 teaspoons of baking soda in a small cup for each group.

## Materials for the Demonstration

* + Vinegar
  + Baking soda
  + Detergent solution
  + Dropper
  + Graduated cylinder (50 mL)
  + Measuring spoon (½ teaspoon)
  + Plastic waste container
  + Small cup

## Procedure

1. Use a graduated cylinder to measure 10 mL of vinegar.
2. Pour the vinegar in a small cup and add 1 drop of detergent. Swirl gently to mix.
3. A person holding a glass and measuring the liquid

   Description automatically generatedAdd ½ teaspoon of baking soda to the empty graduated cylinder.
4. Place the graduated cylinder in a plastic waste container.
5. Pour the vinegar and detergent from the

cup into the graduated cylinder. Have students observe the level of foam in the graduated cylinder.

1. Rinse the graduated cylinder over the waste container.

## Expected Results

White foam will rise in the graduated cylinder and overflow.

## 5. Discuss how to change the amount of foam produced so that it rises to the top of the cylinder without overflowing.

Ask students:

* **What could you change to create a foam that rises as close as possible to the top of the cylinder without overflowing?**

Students might mention variables such as:

* + - The amount of vinegar, detergent, or baking soda.
    - The order in which the substances are added to the graduated cylinder.

Explain that the amount of detergent should not be varied in this activity because it is used as an indicator to help measure the amount of gas produced in the reaction. Also, the baking soda should be added to the cylinder first. The vinegar is poured in afterwards to cause better mixing of reactants.

Remind students that 10 mL of vinegar and ½ teaspoon of baking soda caused the foam to overflow. Students should consider these amounts as they plan how much of each reactant they will use as they start their trials.

Ask students:

## Can you add the baking soda first and then the vinegar on one trial and then switch it for the other trials? No. Why not?

Every test should be conducted the same way. For example, in the demonstration baking soda was placed in the graduated cylinder before the vinegar and detergent were added. This method mixes the baking soda and vinegar well. All new trials should be conducted this same way.

## Should you rinse the graduated cylinder each time? Yes. Why?

Any products or leftover reactants that remain in the graduated cylinder may affect the next reaction. It is best to rinse the cylinder after each trial.

## How will you remember the amounts you used in each trial?

## Students should realize the necessity of making and recording accurate measurements in the chart provided.

## Give each Student an Activity Sheet for Part 2.

Students will record their observations and answer questions about the activity on the activity sheet. The *Explain It with Atoms & Molecules* and *Take It Further* sections of the activity sheet will either be completed as a class, in groups, or individually, depending on your instructions. Look at the teacher version of the activity sheet to find the questions and answers.

## 6.Have each group experiment with different amounts of vinegar and baking soda to get the foam to rise to the top of the graduated cylinder without overflowing.

Tell students that they should try to get the foam to stop as close as possible to the top of the cylinder without overflowing. You may choose to limit students to a maximum of three tries or let them experiment further if time and supplies allow.

## Question to Investigate

How can you make just the right amount of foam that rises to the top of the graduated cylinder without overflowing?

## Materials for Each Group

* + Vinegar in a cup
  + Baking soda in a cup
  + Detergent solution in a cup
  + Dropper
  + Graduated cylinder (50 mL)
  + Measuring spoons (⅛, ¼, and ½ teaspoon)
  + Plastic waste container

## Procedure

1. Decide on how much vinegar and baking soda you will use and write these amounts in the chart on the activity sheet.
2. Use a graduated cylinder to measure the amount of vinegar your group agreed on.
3. Pour the vinegar in a small cup and add 1 drop of detergent. Swirl gently to mix.
4. Cartoon of girls wearing goggles and holding glasses and measuring thermometer

   Description automatically generatedAdd the amount of baking soda your group agreed on to the empty graduated cylinder.
5. Place the graduated cylinder in a plastic waste container.
6. Pour the vinegar and detergent from the cup into the graduated cylinder. Observe the level of foam in the graduated cylinder.
7. Rinse the graduated cylinder over the waste container.

## Expected Results

Using ⅛ teaspoon of baking soda, 5 mL of vinegar, and 1 drop of detergent will probably cause the foam to rise to the top of the cylinder without overflowing. Results may vary.

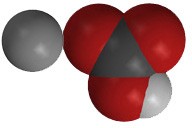
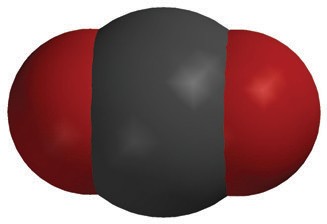
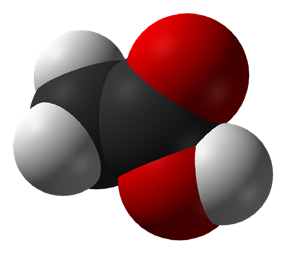
Have groups share their findings about the amounts of baking soda and vinegar that came closest to reaching the top of the cylinder. Did each group use similar amounts of baking soda and vinegar?

# EXPLAIN

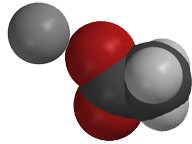
## Discuss why adjusting the amount of reactants affects the amount of products.

**Project the image *Controlling Amount of Products Formed*.** [www.acs.org/middleschoolchemistry/simulations/chapter6/lesson2.html](http://www.acs.org/middleschoolchemistry/simulations/chapter6/lesson2.html)

Show students the chemical equation for the reaction between vinegar and baking soda.



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**C2H4O2**

acetic acid

**NaHCO3**

sodium bicarbonate

**NaC2H3O2**

sodium acetate

**H2O**

water

**CO2**

carbon dioxide

Ask students:

## Why, on the molecular level, does changing the amount of baking soda or vinegar affect the amount of carbon dioxide gas produced?

Products are made from the reactants, so adding more reactants will produce more of the products.

The important point for students to realize is that atoms from *both* reactants are necessary to produce the products. Using less baking soda, for instance, produces less carbon dioxide gas because there are fewer atoms from the baking soda to produce the carbon dioxide. In general, using more of one or more reactants will result in more of one or more products. Using less of one or more reactants will result in less of one or more products. Let students know that this principle has limits.

***Note****: It is not necessary for students at the middle school level to know which particular atom in the reactants ended up in which product. It might seem strange, but sometimes a product can be made up of atoms from only one reactant. In the vinegar and baking soda reaction, the atoms in the CO2 only come from the sodium bicarbonate.*

Ask students:

## What would you do if you wanted to make more carbon dioxide?

Add more vinegar and more baking soda.

## Could you just keep adding more and more baking soda to the same amount of vinegar to get more carbon dioxide?

No. This might work for a while, as long as there is extra vinegar, but eventually there would be no atoms left of vinegar to react with the extra baking soda, so no more carbon dioxide would be produced.

**Part 3 - Forming a Precipitate**

(From Middle School Chemistry – Chapter 6, Lesson 3)

***Key Concepts***

* The ions or molecules in two solutions can react to form a solid.
* A solid formed from two solutions is called a *precipitate*.

***Summary***

Students will combine two clear colorless solutions (baking soda solution and calcium chloride solution) and see the formation of a solid and a gas. Students will analyze the chemical equation for the reaction and see that all atoms in the reactants end up in the products. They will make the connection between the chemical equation and the real substances and see that the solid and gas produced in the actual reaction are also in the products of the equation.

***Objective***

Students will be able to explain that for a chemical reaction to take place, the reactants interact, bonds between certain atoms in the reactants are broken, the atoms rearrange, and new bonds between the atoms are formed to make the products. Students will also be able to explain that this definition applies to the production of a solid called a *precipitate*.

***Evaluation***

The activity sheet will serve as the “Evaluate” component of each 5-E lesson plan. The activity sheets are formative assessments of student progress and understanding. A more formal summative assessment is included at the end of each chapter.

***Safety***

Be sure you and the students wear properly fitting goggles. If you do the demonstration with copper II sulfate solution, ammonia, and hydrogen peroxide at the end of the lesson, pour the resulting solution and precipitate in a cup or beaker and allow it to evaporate. Put the small amount of solid in a paper towel and dispose in the trash or use a disposal method required by local regulations. Sodium carbonate may irritate skin. Wash hands after the activity. Magnesium sulfate dust can irritate respiratory tract.

Follow all safety precautions regarding use, storage, and disposal of copper II sulfate and sodium carbonate.

***Materials for the Demonstration***

* Sodium carbonate
* Epsom salt (magnesium sulfate)
* 2 clear plastic cups
* Test tube
* Water

***Materials for Each Group***

* Baking soda
* Calcium chloride
* Water
* Graduated cylinder
* Measuring spoon (½ teaspoon) or balance
* 2 clear plastic cups
* Masking tape
* Pen

# ENGAGE

## Do a demonstration by combining two clear colorless solutions that produce a white solid and introduce the term *precipitate*.

**Materials for the Demonstration**

* + Magnesium sulfate (Epsom salt)
  + Sodium carbonate
  + Water
  + 2 clear plastic cups
  + 1 tablespoon
  + 1 teaspoon

## Teacher Preparation

* + Pour 100 mL of water in one clear plastic cup and add 10 g (about 1 tablespoon) of magnesium sulfate. Stir until the solution is clear.
  + Pour 50 mL of water in another clear plastic cup and add 5 g (about 1 teaspoon) of sodium carbonate. Stir until the solution is clear.

## A person pouring liquid into a glass Description automatically generatedProcedure

1. Hold up the two clear colorless solutions and slowly pour the smaller amount into the larger.

## Expected Results

Particles of a white solid will form.

Ask students:

## Would you consider adding a sodium carbonate solution to a magnesium sulfate solution a chemical reaction?

Yes.

## Why or why not?

Combining the two clear colorless liquids is a chemical change because a different solid substance is formed.

Tell students that a precipitate is an insoluble solid that forms when two solutions are combined and react chemically. Insoluble means that the solid will not dissolve.

## Give Each Student an Activity Sheet for Part 3.

Students will record their observations and answer questions about the activity on the activity sheet. The *Explain It with Atoms & Molecules* and *Take It Further* sections of the activity sheet will either be completed as a class, in groups, or individually, depending on your instructions. Look at the teacher version of the activity sheet to find the questions and answers.

# EXPLORE

## 2. Have students combine two liquids to observe another precipitate.

**Question to Investigate**

How do you know when a precipitate is formed in a chemical reaction?

## Materials for Each Group

* + Baking soda
  + Calcium chloride
  + Water
  + Graduated cylinder
  + Measuring spoon (½ teaspoon) or balance
  + 2 clear plastic cups
  + Masking tape
  + Pen

***Note****: If you would like students to practice using a balance to weigh grams, have them weigh two grams each of baking soda and calcium chloride.*

## A person pouring water into a glass Description automatically generatedProcedure

1. Use masking tape and a pen to label 2 plastic cups

*baking soda solution* and *calcium chloride solution*.

1. Use a graduated cylinder to add 20 mL of water to each cup.
2. Add 2 g (about ½ teaspoon) of calcium chloride to the water in its labeled cup. Swirl until as much of the calcium chloride dissolves as possible.
3. Add 2 g (about ½ teaspoon) of baking soda to the water in its labeled cup. Swirl until as much of the baking soda dissolves as possible. There may be some undissolved baking soda remaining in the bottom of the cup.
4. Carefully pour the baking soda solution into the calcium chloride solution. Try not to pour in any undissolved baking soda. Observe.

## Expected Results

Bubbling and a white precipitate appear.

## Discuss student observations.

Ask students:

## What did you observe when you mixed the baking soda solution and the calcium chloride solution?

The solutions bubbled and little white particles of solid formed.

## Did you observe a precipitate?

Yes. The white particles appeared after the two solutions were combined.

## Do you think this was a chemical reaction? Yes. Why?

The two substances that were combined were liquids and the substances that were produced were a solid and a gas. These products seem to be different from the reactants.

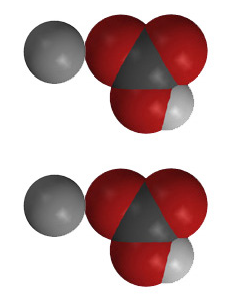
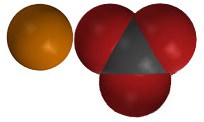
# EXPLAIN

## Discuss the products produced in this chemical reaction.

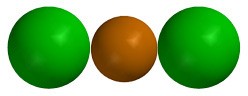
Remind students that in the chemical reactions they have seen so far, certain atoms in the reactant molecules unbond from one another and then rearrange and rebond in different ways to form the products. They saw that the same type and number of atoms were in the reactants as were in the products.

**Project the image *Calcium Chloride and Sodium Bicarbonate*.**

[www.acs.org/middleschoolchemistry/simulations/chapter6/lesson3.html](http://www.acs.org/middleschoolchemistry/simulations/chapter6/lesson3.html)



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**CaCl2**

calcium chloride

**2NaHCO3**

sodium bicarbonate

**CaCO3**

calcium carbonate

**2NaCl**

sodium chloride

**H2O**

water

**CO2**

carbon dioxide

Ask students:

## What products of the reaction do you recognize?

Students should recognize sodium chloride (NaCl), water (H2O), and carbon dioxide (CO2).

## Look at the product side of the chemical equation. What gas is produced in the chemical reaction?

Carbon dioxide gas.

## What do you think is the precipitate?

The salt and water are clear and colorless as a solution, so the precipitate must be CaCO3, which is calcium carbonate. Tell students that calcium carbonate is ordinary chalk.

## How many of each type of atom is on the reactant side of the equation?

1 calcium atom, 2 chlorine atoms, 2 sodium atoms, 2 hydrogen atoms, 2 carbon atoms, and 6 oxygen atoms.

* **How many of each type of atom is on the product side of the chemical equation?**

1 calcium atom, 2 chlorine atoms, 2 sodium atoms, 2 hydrogen atoms, 2 carbon atoms, and 6 oxygen atoms.

## Is this a balanced chemical equation? If so, how do you know?

## Yes. The same type and number of atoms are in the reactants and products.

Make sure students see that every type of atom on the left side of the equation is also on the right. Also be sure that they see that there is an equal number of each type on both sides of the equation.

# EXPLORE

1. **Separate the products to show that the precipitate is a solid.**

**Ask students:**

* + **How do you think we could separate the precipitate from the other products?**

Put everything in a filter and let the liquid run through.

**Question to Investigate**

Can you separate the calcium carbonate from the rest of the products?

## Materials for Each Group

* Coffee filter or paper towel
* Tall clear plastic cup

## A cartoon of a child pouring milk into a glass Description automatically generatedProcedure

1. Use a large enough coffee filter (or paper towel) so that you can push it about ⅓ of the way into the cup and still have enough left to hold it around the outside of the cup.
2. While holding the coffee filter in place, pour the products into the center of the coffee filter.
3. Allow the liquid to drip through the filter. This may take 5 – 10 minutes.
4. Set the precipitate aside and allow the water to evaporate.

## Expected results

A white solid will remain in the coffee filter. After the water evaporates, the calcium carbonate will be a white powder.

***Note****: If you’d like to separate the salt from the water that flowed through the filter, pour the liquid into a clean empty cup and allow the water to evaporate for a few days. As the water evaporates, students will begin to see cube-shaped salt crystals forming in the solution. Eventually, only salt crystals will remain in the cup.*

Ask students:

## What is the solid white substance on the paper?

Calcium carbonate (chalk).

* **Is filtering out the calcium carbonate and allowing the water to evaporate a chemical change or a physical change? Why?**

Physical change. These substances were already present in the water, so no new chemicals are made.

## What evidence was there that a chemical reaction occurred when you combined baking soda solution and calcium chloride solution?

A gas and a white solid were formed.

1. **Confirm that a chemical reaction took place.**

Ask students:

* **How could we compare the precipitate to the reactants to be sure that the precipitate is actually different from both of them?**

Do a solubility test on all three substances.

## Question to Investigate

Is the solubility of the precipitate different than the solubility of baking soda and calcium chloride?

## Ask students:

* **In setting up a solubility test, should we use the same amount of each substance?**

Yes

## Should we use the same amount of water?

Yes

## Materials for Each Group

* Dry precipitate on paper towel
* Balance
* 3 small plastic cups
* Graduated cylinder
* ¼ teaspoon
* Popsicle stick (optional)
* Calcium chloride
* Baking soda
* Water

## A hand holding a measuring spoon Description automatically generatedProcedure

1. Label 3 cups sodium bicarbonate, calcium chloride, and precipitate.
2. Use a spoon or popsicle stick to scrape the precipitate into a pile.
3. Scoop up the precipitate into a ¼ teaspoon until it is as full as possible. Place the ¼ teaspoon of precipitate into its labeled cup.
4. A hand pouring liquid into a measuring cup

   Description automatically generatedPlace ¼ teaspoon of sodium bicarbonate and calcium chloride into their labeled cups.
5. Add 25 mL of water to each cup and gently swirl until the solids dissolve as much as possible. Look to see the amount of solid that remains undissolved in each cup.

## Expected results

The sodium bicarbonate and calcium chloride dissolve but the precipitate does not.

Since the precipitate does not dissolve like either of the reactants, it must be a different substance than the reactants. Therefore, a chemical reaction must have occurred.

Point out to students that the substance Calcium Carbonate will play an important role in the story of ocean acidification that students will soon learn about.

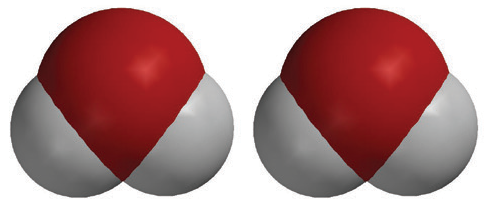
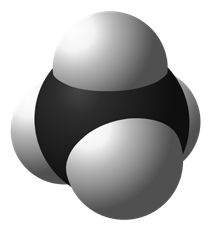
# EXTEND

## In-Class or At-Home Project.

Have students use objects such as gum drops, beads, M&Ms, Legos, or other small objects to represent the atoms in two of the three reactions they have explored so far. Students can tape or glue the objects to poster board and write down the chemical formula for the reactants and products.

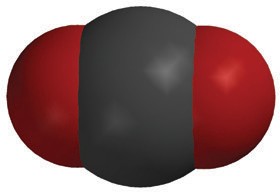
**CH4**

methane



**2O2**

oxygen



**CO2**

carbon dioxide

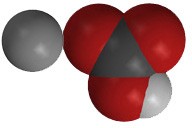
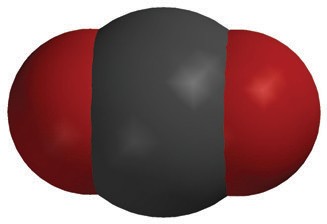
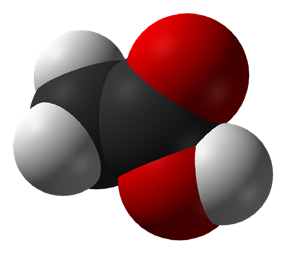
**2H2O**

water

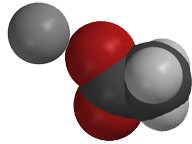
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**C2H4O2**

acetic acid

**NaHCO3**

sodium bicarbonate

**NaC2H3O2**

sodium acetate

**H2O**

water

**CO2**

carbon dioxide

**Part 4 - Energy Changes in Chemical Reactions**

***Key Concepts***

* If two substances react and the temperature of the mixture decreases, the reaction is endothermic.
* If two substances react and the temperature of the mixture increases, the reaction is exothermic.
* A chemical reaction involves the breaking of bonds in the reactants and the forming of bonds in the products.
* It takes energy to break bonds.
* Energy is released when bonds are formed.
* If a reaction is endothermic, it takes more energy to break the bonds of the reactants than is released when the bonds of the products are formed.
* If a reaction is exothermic, more energy is released when the bonds of the products are formed than it takes to break the bonds of the reactants.

***Summary***

Students will conduct two chemical reactions. In the first, the temperature will go down (endothermic) and in the second, the temperature will go up (exothermic). Students will see an animation to review a concept that was introduced in Chapter 5 - that it takes energy to break bonds and that energy is released when new bonds are formed. Students will use this idea to explain why a reaction is either endothermic or exothermic.

***Objective***

Students will be able to define an endothermic and exothermic reaction. Students will be able to use the concept of energy in bond breaking and bond making to explain why one reaction can be endothermic and another reaction can be exothermic.

***Evaluation***

The activity sheet will serve as the “Evaluate” component of each 5-E lesson plan. The activity sheets are formative assessments of student progress and understanding. A more formal summative assessment is included at the end of each chapter.

***Safety***

Be sure you and the students wear properly fitting goggles.

***Materials for the Each Group***

* Vinegar
* Baking soda
* Calcium chloride
* Water
* Thermometer
* 4 small cups
* Disposable self-heating hand warmer
* Self-inflating balloon

***Additional Materials if You Choose to do the Extra Extend***

* Magnesium sulfate
* Sodium carbonate
* Citric acid
* Universal indicator

# ENGAGE

## 1. Show three videos of chemical reactions with very dramatic temperature changes.

Tell students that you will show them three chemical reactions where the temperature increases dramatically.

**Project the video *Thermite Reaction*.**

[www.acs.org/middleschoolchemistry/simulations/chapter6/lesson7.html](http://www.acs.org/middleschoolchemistry/simulations/chapter6/lesson7.html)

After adding one or more catalysts, iron oxide (rust) and aluminum react to produce elemental iron and aluminum oxide. So much heat is produced in this reaction that the iron becomes a liquid. The heat is so intense that the molten iron can be used to weld railroad tracks together.

**Project the video *Nitrogen Triiodide Reaction*.**

[www.acs.org/middleschoolchemistry/simulations/chapter6/lesson7.html](http://www.acs.org/middleschoolchemistry/simulations/chapter6/lesson7.html)

This is a decomposition reaction where nitrogen triiodide decomposes into nitrogen gas and purple iodine vapor. Nitrogen triiodide crystals are so unstable that just a light touch will cause them to rapidly decompose generating a great deal of heat.

**Project the video *White Phosphorus Reaction*.**

[www.acs.org/middleschoolchemistry/simulations/chapter6/lesson7.html](http://www.acs.org/middleschoolchemistry/simulations/chapter6/lesson7.html)

White phosphorus is dissolved in a solvent and spread on a piece of paper. When the solvent evaporates, the phosphorus reacts with oxygen in the air in a combustion reaction.

Ask students to make a prediction:

## Do you think substances can react and cause the temperature of the mixture to decrease?

Tell students that this lesson is going to explore temperature changes in chemical reactions.

## Give Each Student an Activity Sheet for Part 4.

Students will record their observations and answer questions about the activity on the activity sheet. The *Explain It with Atoms & Molecules* and *Take It Further* sections of the activity sheet will either be completed as a class, in groups, or individually, depending on your instructions. Look at the teacher version of the activity sheet to find the questions and answers.

# EXPLORE

## 2. Have students measure the change in temperature of the reaction between baking soda and vinegar.

**Question to Investigate**

Does the temperature increase, decrease, or stay the same in the reaction between baking soda and vinegar?

## Materials

* + Vinegar in a cup
  + Baking soda in a cup
  + Thermometer

***Materials Note****: The amount of the solutions must be enough to cover the bulb of the thermometer. If they aren’t, use a smaller cup or clip the end of a plastic-backed thermometer so that the backing is flush with the bottom of the bulb.*

## Teacher Preparation

* + Place about 10 mL of vinegar in a small plastic cup for each group.
  + Place about ½ teaspoon of baking soda in a small cup for each group.

## Procedure

1. A hand pouring a liquid into a measuring cup

   Description automatically generatedPlace a thermometer in the vinegar. Read the thermometer and record the temperature on the activity sheet.
2. While the thermometer is in the cup, add all the baking soda from your cup.
3. Watch the thermometer to observe any change in temperature. Record the temperature after it has stopped changing.

## Expected Results

If you begin with room-temperature vinegar, the temperature will decrease by about 7 °C. The amount of temperature decrease will vary. Carbon dioxide gas is also produced.

## Discuss student observations.

Ask students:

## Did the temperature increase, decrease, or stay the same when you combined baking soda and vinegar?

The temperature decreased.

## What is the lowest temperature reached during your group’s reaction?

There will likely be some variation.

Tell students that when the temperature of a chemical reaction decreases, the reaction is called an *endothermic* reaction. The first part of the word, *endo,* means in or into and *thermic* has to do with heat or energy. So, an endothermic reaction means that more energy goes into making the reaction happen than is released by the reaction. This leaves the reaction mixture at a lower temperature.

## 4. Have students measure the change in temperature of the reaction between baking soda solution and calcium chloride.

**Question to Investigate**

Does the temperature increase, decrease, or stay the same in the reaction between baking soda solution and calcium chloride?

## Materials

* + Baking soda solution in a cup
  + Calcium chloride in a cup
  + Thermometer

## Teacher Preparation

* + Make a baking soda solution by dissolving about 2 tablespoons of baking soda in 1 cup of water. Stir until no more baking soda will dissolve.
  + Place about 10 mL of baking soda solution in a small plastic cup for each group.
  + Place about ½ teaspoon of calcium chloride in a small cup for each group.

## Procedure

1. Place a thermometer in the baking soda solution. Read the thermometer and record the temperature on the activity sheet.
2. While the thermometer is in the cup, add all the calcium chloride from the cup.
3. Watch the thermometer to observe any change in temperature. Record the temperature when it stops changing.

## Expected Results

The temperature of the solution should increase by about 15–20 °C. The temperature increase will vary. Carbon dioxide gas is produced, and a white cloudy precipitate, calcium carbonate, is formed.

## Discuss student observations.

Ask students:

Read more about exothermic and endothermic chemical reactions in *Teacher Background.*

## Did the temperature increase, decrease, or stay the same when you combined baking soda solution and calcium chloride?

The temperature increased.

## What is the highest temperature reached during your group’s reaction?

There will likely be some variation.

Tell students that when the temperature of a chemical reaction increases, the reaction is called an *exothermic* reaction. The first part of the word, *exo,* means out or out of, and *thermic* has to do with heat or energy. So, an exothermic reaction means that more energy goes out or is released by the reaction than goes into it. This leaves the reaction mixture at a higher temperature.

# EXPLAIN

## Explain how differences in the energy required to break bonds and make bonds cause temperature changes during chemical reactions.

Tell students that an example of a very exothermic reaction is the combustion or burning of fuel like the gas in a kitchen stove. Even if students have seen the animation of the combustion of methane from Chapter 6, Lesson 1, remind them that methane (CH4) reacts with oxygen (O2) from the air to produce carbon dioxide gas (CO2) and water vapor (H2O) and a lot of energy.

**Project the animation *Methane Combustion Energy*.**

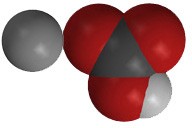
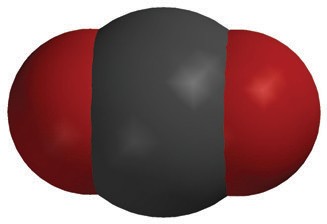
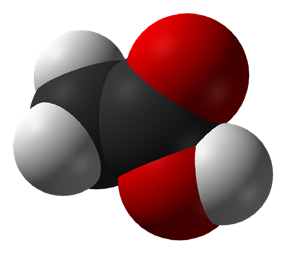
[www.acs.org/middleschoolchemistry/simulations/chapter6/lesson7.html](http://www.acs.org/middleschoolchemistry/simulations/chapter6/lesson7.html)

Click on the methane and the oxygen to show that it takes energy to break the bonds of the reactants. This is shown by “energy arrows” going *into* the molecules of the reactants. Then click on the carbon dioxide and the water to show that energy is released when the atoms bond to make the products. This is shown by the energy arrows coming *out* of the molecules in the products.

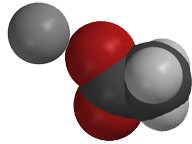
Show students that more energy was released when the bonds in the products were formed than was used to break the bonds of the reactants. This is shown by larger energy arrows coming out of the products and smaller energy arrows going into the reactants. Since more energy was released than was used, this reaction gets warmer and is exothermic.

**Project the image *Baking Soda and Vinegar Reaction*.**

[www.acs.org/middleschoolchemistry/simulations/chapter6/lesson7.html](http://www.acs.org/middleschoolchemistry/simulations/chapter6/lesson7.html)



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**C2H4O2**

acetic acid

**NaHCO3**

sodium bicarbonate

**NaC2H3O2**

sodium acetate

**H2O**

water

**CO2**

carbon dioxide

Ask students:

## Is this an endothermic or exothermic reaction?

Endothermic.

## What do you know about the amount of energy required to break the bonds of the reactants compared to the amount of energy released when the products are formed?

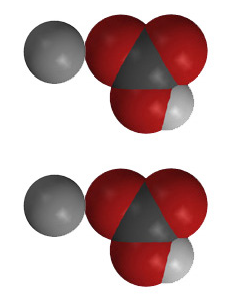
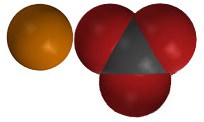
It took more energy to break the bonds of the reactants than was released when the bonds in the products were formed.

* **If we were using energy arrows, where would the bigger and smaller arrows go?**

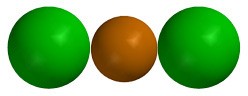
A bigger arrow going in would be on the reactant side and a smaller arrow coming out would be on the product side.

**Project the image *Baking Soda and Calcium Chloride Reaction*.**

[www.acs.org/middleschoolchemistry/simulations/chapter6/lesson7.html](http://www.acs.org/middleschoolchemistry/simulations/chapter6/lesson7.html)



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**CaCl2**

calcium chloride

**2NaHCO3**

sodium bicarbonate

**CaCO3**

calcium carbonate

**2NaCl**

sodium chloride

**H2O**

water

**CO2**

carbon dioxide

Ask students:

## Is this an endothermic or exothermic reaction?

Exothermic

## What do you know about the amount of energy required to break the bonds of the reactants compared to the amount of energy released when bonds in the products are formed?

More energy was released when bonds in the products were formed than was required to break the bonds in the reactants.

* **If we were using energy arrows, where would the bigger and smaller arrow go?**

A smaller arrow going in would be on the reactant side and a bigger arrow coming out would be on the product side.

**Project the animation *Endothermic Reaction*.** [www.acs.org/middleschoolchemistry/simulations/chapter6/lesson7.html](http://www.acs.org/middleschoolchemistry/simulations/chapter6/lesson7.html)

Remind students that a chemical reaction involves the breaking of bonds in the reactants and the making of bonds in the products. Also remind them that it takes energy to break bonds and that energy is released when bonds are formed.

In an endothermic reaction, it takes more energy to break the bonds of the reactants than is released when the bonds in the products are formed. In an endothermic reaction, the temperature goes down.

**Project the animation *Exothermic Reaction*.** [www.acs.org/middleschoolchemistry/simulations/chapter6/lesson7.html](http://www.acs.org/middleschoolchemistry/simulations/chapter6/lesson7.html)

Explain that in an exothermic reaction it takes less energy to break the bonds of the reactants than is released when the bonds in the products are formed. In an exothermic reaction, the temperature goes up.

# EXTEND

1. **Have a class discussion about the chemical equation that forms carbonic acid.**

Students now have a basic knowledge of the breaking and making of bonds in a chemical reaction. They also know that the main source of carbon dioxide that gets in the ocean is a product of the chemical reaction of burning fossil fuels.

To help tie their new knowledge of chemical reactions to the issue of ocean acidification, show students the chemical equation for the formation of carbonic acid from the first lesson.

Ask students:

* **Is this a balanced equation and how do you know?**

A red and black molecule

Description automatically generated

The equation is balanced since all the atoms in the reactants on the left end up in the products on the right. Remind students that the two arrows means that this is a certain type of reaction in which the reactants form the products, but some of the products also break apart into the reactants again.

Remind students that in previous lessons they have looked the process of dissolving and whether temperature affects dissolving. Let students know that since they now understand the basics of chemical reactions, they can explore whether temperature affects the rate of a chemical reaction. Since ocean temperatures are rising, this may have an effect on the process of ocean acidification.