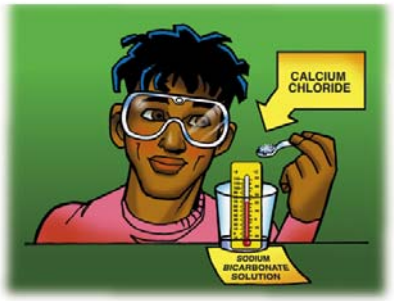
Lesson 4
Temperature change

TEACHER GUIDE

Lesson summary



Students meet scientist Jason Williams, an industrial chemist who designs the materials and processes for making solar cells. He explains that during the summers, Antarctic days are very long, sometimes lasting a couple of weeks or more. That makes solar energy an abundant natural resource near the South Pole. Solar cells convert energy from the sun into electrical energy. Converting energy from one form to another is an important process. In the activity, students will conduct two chemical reactions that convert chemical energy into thermal energy.

Key concepts

- A change in temperature is a clue that a chemical reaction may have occurred.
- When the temperature increases during a chemical reaction, it is called an *exothermic reaction*.
- When the temperature decreases during a chemical reaction, it is called an *endothermic reaction*.
- It takes energy to break chemical bonds in the reactants.
- Energy is released when chemical bonds form in the products.

Safety

Be sure you and the students wear properly fitting goggles. Read and follow all safety warnings on the labels of the sodium bicarbonate, citric acid, calcium chloride, and universal indicator containers. Also follow the warnings on the packaging of the foot warmer. Have students wash their hands after the activity.

Proper disposal

At the end of the lesson, have students pour their used solutions in a waste container. The resulting solution from the final demo should be placed in this container, too. Then dispose of all of this liquid waste down the drain or according to local regulations. The left-over sodium bicarbonate, citric acid, and calcium chloride powders can be disposed of with the classroom trash. The used foot warmer may be disposed of with the classroom trash. Wipe up spills with paper towels and dispose of them with the classroom trash.

Introduction

1. Introduce students to a scientist and his work.
Distribute the student activity sheets for Lesson 4. In this lesson, students meet industrial chemist Jason Williams. He develops the materials that make up solar cells.
He explains that there is an abundant supply of sunshine during the Antarctic summers. Because scientists work on the continent in the summer, there is also a higher demand for electricity. Solar panels convert energy from the sun into electrical energy. Students will conduct two chemical reactions that explore the conversion of chemical energy into thermal energy.

Teacher demonstration

2. Do a demonstration to introduce students to the idea that the temperature can increase dramatically in some chemical reactions.
Show students a hand warmer. Tell them these products work because of a chemical reaction that begins as soon as the package is opened. One of the hand warmer's main ingredients is very fine iron powder. Moisture and oxygen from the air react with the iron and release heat as part of a chemical reaction. This reaction is basically the same as rusting, but it happens much faster.

You will need

- 1 hand warmer

Preparation instructions

- Open the packaging for the hand warmer about fifteen minutes before you meet the students. If using scissors to open the package, be sure that you do not accidentally cut the hand warmer.

Procedure

1. Pass the hand warmer around so that students can feel that it is warm.

Expected results

The hand warmer will begin to warm up slowly but will remain warm for a few hours.

Tell students that there is always a change in temperature during chemical reactions. Sometimes they are dramatic, like with the hand warmer. Other times, the change is so slight that you might not notice it.

Ask students to predict

- **Do you think it is possible for the temperature of a chemical reaction to go down?**
  Students may not be sure at this point, but the temperature can increase or decrease during a chemical reaction.

Explain that if the temperature goes up, the reaction is called an *exothermic* reaction. More heat energy *exits*. If the temperature goes down, the reaction is called an *endothermic* reaction. More heat energy goes *in* to make the chemical reaction happen.

Ask students

- **Is the chemical reaction between the iron filings and the oxygen and water in the air an endothermic or exothermic reaction?**
  Exothermic.

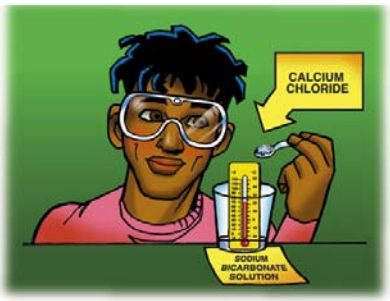
Student activity

3. Have students use a thermometer to observe the temperature changes in two different chemical reactions.
Review with students how to read a thermometer. Let students know that they will measure both the starting temperature and either the highest or lowest temperature reached using the Celsius scale.

Activity summary

Information on how to conduct this activity is included on the student activity sheet. Students will monitor temperature changes during two different chemical reactions. The temperature decreases during one chemical reaction and increases in the other.

Preparation instructions



- Use the pre-made stickers to label one set of portion cups *citric acid*, *calcium chloride,* and *sodium bicarbonate* for each group. If you conducted lessons 1 and 3, reuse these labeled cups.
- Place 1 teaspoon of citric acid, calcium chloride, and sodium bicarbonate in their labeled cups.
- Use scissors to clip the bottom of the plastic backing off each thermometer so that the bottom of the plastic lines up with the bottom of the red bulb. This way, the amount of liquid used in the activity will cover the bulb of the thermometer completely.

Expected results

- *Chemical reaction between citric acid solution and sodium bicarbonate*
  There will be bubbling, and the temperature will decrease.
- *Chemical reaction between sodium bicarbonate solution and calcium chloride*
  There will be bubbling, and the temperature will increase.

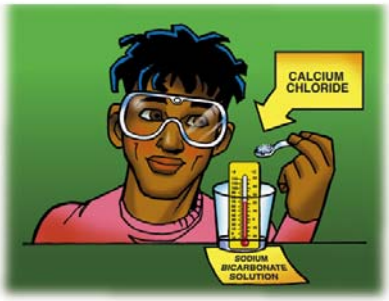
Have groups share their starting and final temperature for each reaction. Also have them classify each as either an *endothermic* or *exothermic* reaction. The temperature decreases in endothermic reactions and increases in exothermic reactions.

Student activity

4. Have students conduct the chemistry challenge by adjusting reactants to get the temperature between 40° and 50° C.

Ask students

- **What do you think will happen if you used more calcium chloride in the exothermic reaction?**
  Increasing the amount of the calcium chloride will cause the temperature to increase more.



Activity summary
Students should refer to their activity sheet for guidance on how to conduct this activity. They will conduct the exothermic reaction again but this time with the goal of getting the highest temperature somewhere between 40° and 50° C. They will record the amount of calcium chloride used and the highest temperature reached. You may wish to limit either the time or the number of trials students conduct.

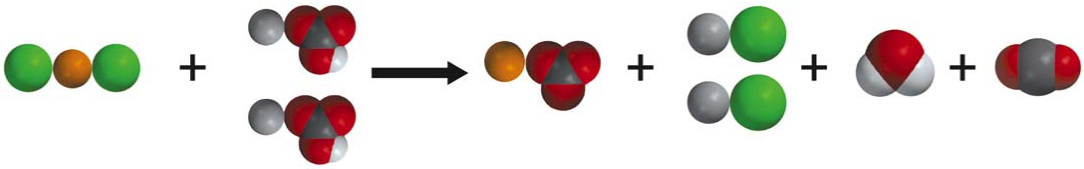
Expected results
Adding more calcium chloride will cause a greater increase in temperature.

Class discussion

5. Discuss the "big chemistry idea" to help students understand what makes a chemical reaction either endothermic or exothermic.
The big chemistry idea on the student activity sheet revisits the idea that in a chemical reaction atoms or groups of atoms in the reactants rearrange and re-bond to form the products. It also describes endothermic and exothermic reactions in terms of the energy used and released as bonds between atoms break and form.

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.

- A chemical reaction is endothermic when it takes more energy to break the bonds in the reactants than is released when the new bonds form to make the products.
- A chemical reaction is exothermic when more energy is released when the new bonds form to make the products than is used to break the bonds in the reactants.



$CaCl_2$	$2NaHCO_3$	$CaCO_3$	$2NaCl$	H_2O	CO_2
calcium chloride	sodium bicarbonate	calcium carbonate	sodium chloride	water	carbon dioxide

Ask students

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

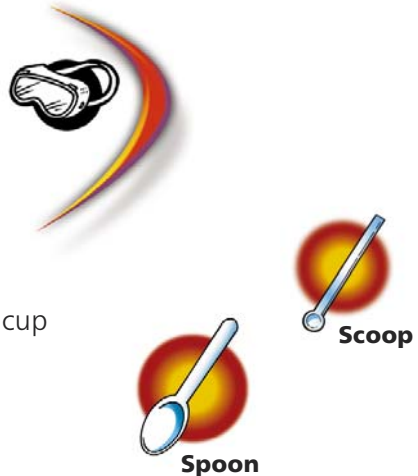
Teacher demonstration

6. Pour solutions from cup to cup and have students identify the clues of chemical change.

In this demonstration, you will pour the entire contents of one cup into another that contains a small amount of citric acid, then sodium carbonate, then calcium chloride, and then citric acid again. As you pour the contents of one cup into the next, have students identify each of the clues of chemical change. Bring closure to all of the hands-on explorations students have conducted in this kit with this colorful demonstration.

You will need

- Goggles
- Universal indicator
- Citric acid
- Sodium carbonate
- Calcium chloride
- Water
- Thermometer
- Small metric measuring cup
- Small scoop
- Small spoon
- 5 clear plastic cups



Preparation instructions

Line up 5 clear plastic cups. Place the following in each of 5 cups:

- First cup—30 mL water and 30 drops of universal indicator
- Second cup—1 scoop of citric acid
- Third cup—1 spoon of sodium carbonate
- Fourth cup—1 spoon of calcium chloride
- Fifth cup—1 spoon of citric acid

Procedure

1. Place the thermometer into the green indicator solution and make a note of the temperature.
2. Move the thermometer to the second cup and pour all of the green indicator solution into the cup. Swirl and make a note of the temperature.
3. Move the thermometer to the third cup and pour all of this solution into the next cup. Swirl and make a note of the temperature.
4. Move the thermometer to the fourth cup and pour all of this solution into the next cup. Swirl and make a note of the temperature.
5. Move the thermometer to the fifth cup and pour the entire contents of the cup into the next cup. Swirl and make a note of the temperature.

Expected results

- Cup 1—Solution is green.
- Cup 2—Solution turns pink.
- Cup 3—Solution turns purple.
- Cup 4—Solution turns a chalky blue and the temperature increases.
- Cup 5—Solution bubbles, turns orange, and becomes clear.

Ask students

- **Which clues of chemical change did you observe?**

  A color change, production of a gas, a slight change in temperature,

Application

Have students read the real-world application on the student activity sheet. Explain that exothermic chemical reactions are used by military troops in remote locations so that they can have hot meals when they are in the field.

Meals-Ready-to-Eat, or MREs, use a chemical reaction to warm up a pouch of food in about 10 minutes.