3.1 Understand the Question

Think About Thermal Energy and Chemical Energy

You are already familiar with several types of energy. Some energy tranformations are easy to spot. For example, a child at the top of a playground slide has gravitational potential energy. The child has fun transforming this energy into kinetic energy. However, some types of energy are harder to see. The indicators are less visible. The factors may also be difficult to measure. As you explore thermal and chemical energy, pay attention to how their indicators and factors differ from those of other types of energy you have explored.

Get Started

Earlier in this Unit, you observed a pop-up toaster as it made a slice of toast. At that time, you made a list of all the kinds of energy you saw. Your list probably included transformations involving thermal energy and chemical energy, even if you did not yet have the names for them. You will return to that list now and review your observations of the operation of a toaster.

Thermal clothing helps keep thermal energy in so a person stays warm.

Look at your notes from the toaster demonstration and answer the following questions. Some will be easy to answer, and some might be difficult. If you do not know the answer to any of these questions now, you will by the end of this *Learning Set.*

- Thermal energy is experienced as *heat.* What happens in the toaster as a result of thermal energy? How do you know the toaster transforms thermal energy? What do you think might be an indicator of thermal energy?
- How can you tell how much thermal energy is present? What factors do you think would control how much thermal energy an object has?
- Chemical energy is energy that is related to *chemical changes.* What role do you think chemical energy plays in the toaster?

- Do you think thermal energy is a type of potential energy or a type of kinetic energy?
- Do you think chemical energy is a type of potential energy or a type of kinetic energy?

Communicate

Share Your Ideas

Share your answers to the questions with the class. Discuss what roles thermal energy and chemical energy play in the toaster. Discuss whether each is kinetic or potential energy. Note any disagreements you have. Later, you will have a chance to put questions on the *Project Board* that you need to answer to settle your disagreements.

Explore

Skiers often use hand warmers when they are outside in cold weather. Hand warmers are small plastic pouches with a liquid in them. When you activate a hand warmer by snapping it, it gets warm without the use of batteries. You will be making some observations of a hand warmer. Observe the changes that happen, and look for indicators of thermal energy and chemical energy.

Materials

- **hand warmer**

Procedure

1. You will receive a hand warmer. Pass the hand warmer around your group. Handle it carefully so it is not activated before everybody in your group gets to examine it.
2. Make a drawing of the hand warmer, and record what you see and feel.
3. After everyone has examined it, activate the hand warmer by snapping it. Pay attention to the hand warmer from the time it is snapped. Record any changes you see, feel, or hear occurring inside the hand warmer.
4. Pass the hand warmer around again, and record other observations using your senses of sight and touch.

Analyze Your Results

After you have recorded all of your observations, discuss the following questions with members of your group.

1. What changes did you observe in the hand warmer after it was activated?
2. What do you think caused the change in temperature? Think about the events that occurred immediately after it was activated to help you justify your answer.
3. What types of energy can you identify in the hand warmer? What are the indicators of each type? Can you think of any factors that might affect the amount of energy?
4. Compare and contrast the operation of a hand warmer to the operation of a pop-up toaster. How are they alike? How are they different?
5. Can you think of other ways to generate these types of energy?

Communicate Your Results

Share Your Ideas

As a class, share your observations and ideas about the changes you observed in the hand warmer. Discuss the types of energy present in the hand warmer. Also, discuss their indicators, the factors that might affect how much energy is available, and other ways to generate thermal and chemical energy. Note any disagreements you have. Later, you will have a chance to put questions on the *Project Board* that will help you settle those disagreements.

heat: thermal energy that is transferred from one place to another.

exothermic: giving off heat because of a chemical change.

How Do Hand Warmers Work?

In the type of hand warmer you explored, a pouch contains water, a chemical called sodium acetate, and a small piece of metal. When the metal is bent, tiny pieces of the metal chip off. The metal chips are a perfect place for sodium acetate crystals to form. Before you know it, all of the sodium acetate has formed crystals. During this process, **heat** is given off. The heat is thermal energy that is transferred from inside the pouch to your hand. This is why you felt the *temperature* of the hand warmer rise. A process that gives off heat is called an **exothermic** process. The pouch also becomes harder as the liquid transforms into solid crystals.

In the exploration, you noticed the indicator for thermal energy, which is an increase in temperature. Hand warmers like the one you observed can be used again and again. To reuse the pouch after it cools off, you place it in boiling water for a few minutes. Heat from the hot water is transferred to the water in the pouch. In a short while, the crystals come apart. A process such as this, which requires an input of heat, is called an **endothermic** process. After the pouch cools off, it is ready to be used again.

You may think that the crystals of sodium acetate melted, but, in fact, they dissolved. When a crystal dissolves, tiny particles break off the crystal and mix completely with water. Eventually, all of the solid dissolves, and you see only a liquid inside the pouch. You may have seen this process if you have stirred sugar into tea. At first, you can see the crystals swirl around as you mix the tea, but after a while, they disappear because they have dissolved.The process of the sodium acetate crystals in the hand warmer coming out of the water and going back in when heated is a physical change.

There is another type of hand warmer that is not reusable. This type uses iron powder with water, salt, and air. The salt speeds up the exothermic reaction of the iron with oxygen in air so that a lot of heat is given off. This is a **chemical change** and produces a new, reddish-orange chemical, iron oxide. Iron oxide, or rust, cannot be easily transformed back into iron. Some of the indicators of a chemical change can be seen in this reaction, such as a change in color and heat being given off. Another indicator of a chemical change is the formation of a new substance in the form of a gas or a solid.

When a chemical change occurs, at least one new substance is made, and an energy transformation generally occurs. If the change is exothermic, chemical energy is transformed into thermal energy. If the change is endothermic, thermal energy is transformed into chemical energy.

endothermic: requires heat for a chemical change.

chemical change: a change that produces one or more new substances.

A burning candle gives off heat. Do you think this is an endothermic process or an exothermic process?

Reflect

1. Look again at the energy-transformation cartoon you analyzed previously to find examples of thermal energy and chemical energy. For each example, what happens as a result of transformations involving thermal or chemical energy?
2. What other examples can you think of in which thermal energy or chemical energy is transformed to power something or make something happen?
3. What do you think are indicators that thermal energy or chemical energy is involved in energy transformation?
4. How do you think heat and chemical energy are related? How do you think heat and thermal energy are related?
5. What might be factors that determine how much thermal energy or chemical energy an object has?

Update the *Project Board*

The question for this *Learning Set* is, *What are thermal energy and chemical energy?* You are just beginning to build your understanding of thermal energy and chemical energy. Add what you think you know about thermal and chemical energy to the *What do we think we know?* column of the *Project Board.* Your class probably has some disagreements about these energy types. You may have identified some things you do not yet understand about thermal and chemical energy. For example, you might not agree about whether each is kinetic energy or potential energy. In the *What do we need to investigate?* column, record questions that, when answered, will help you resolve these disagreements and address the *Big Challenge.*

What's the Point?

When the hand warmer is activated, the liquid sodium acetate inside it turns solid. As it crystallizes, heat is given off, and the hand warmer becomes warmer and harder. Change in temperature is an indicator of thermal energy. Thermal energy is transferred from the hand warmer to the hands of the person holding it. In another type of hand warmer you read about, a chemical change takes place. Iron powder is changed into rust. Changes in temperature and color are indicators of chemical change. So is the formation of a new substance.