CONCEPT 3

Energy can be transferred or transformed.

law of conservation of energy law stating that energy is neither created nor destroyed, but is transformed from one form of energy to another or transferred from one object to another

Scientists have conducted thousands of experiments to investigate the properties of energy. The results of these experiments are consistent. The total amount of energy present before energy is transferred or transformed is always exactly equal to the total amount of energy present afterwards. In other words, energy is neither created nor destroyed. Instead, it is transformed from one form of energy to another, or transferred from one object to another. This concept is called the **law of conservation of energy** (Figure 3.4).

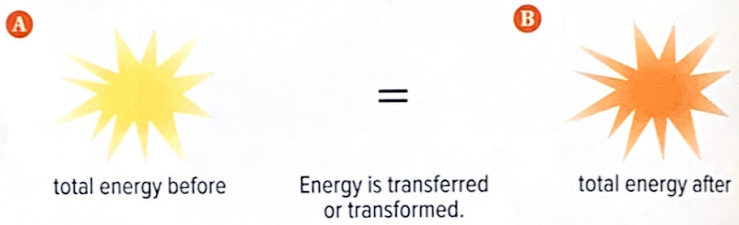

Figure 3.4 According to the law of conservation of energy, energy present before energy transfer or transformation A is equal to energy present afterward B. The form of energy may change (the shapes differ in colour), but the amount of energy remains equal (the size of the shape is the same).

The transfer and transformation of energy often enables useful tasks to be carried out. For example, observe the system in Figure 3.5. Chemical potential energy is transformed into electrical potential energy in the battery. When a light bulb is placed in a closed circuit, electrical potential energy is transformed into electrical kinetic energy, and current flows. As the current flows through the light bulb, the energy is transformed into radiant energy—visible light, with some infrared and ultraviolet radiation—and thermal energy. Because the light energy lets you see, a useful task is carried out.

Energy Transformation, Energy Transfer, and Systems

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No energy transformation is 100 percent efficient. Each time that energy changes form, some of it becomes unusable. For example, the system in Figure 3.5 is designed to transform chemical potential energy into light energy. The thermal energy is an unusable byproduct of this energy transformation. In fact, all energy transformations result in some amount of unusable energy. This idea, and how it is linked to the law of conservation of energy, is shown in Figure 3.6.

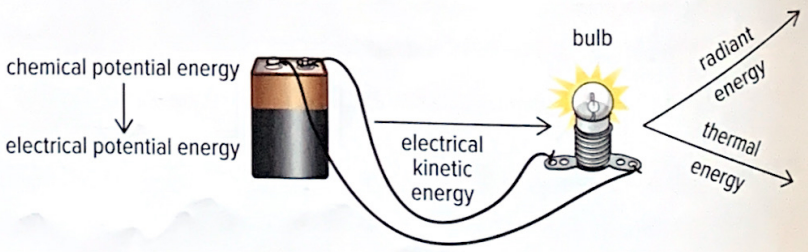

Figure 3.5 Energy is both transformed and transferred in this image, but it is never destroyed. The result is that a useful task is carried out.

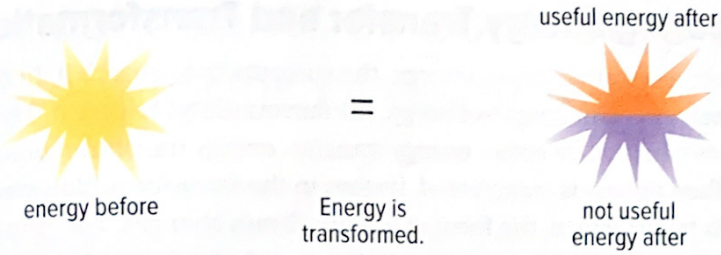

Figure 3.6 When energy is transformed, some of that energy becomes energy that is not useful to carry out a task. However, total energy is still conserved.

Types of Systems

Sometimes, non-useful energy is described as "lost." However, whether this energy actually leaves the system depends on which type of system it is—open, closed, or isolated. Each type of system is described in terms of the transformation of energy and the transfer of both energy and matter.

- An open system can exchange both energy and matter with its surroundings.
- A closed system can exchange energy, but not matter, with its surroundings.
- An isolated system cannot exchange energy or matter with its surroundings.

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Figure 3.7 illustrates the three types of systems.

Open System

An uncovered pot of potatoes boiling on the stove is an open system. Thermal energy is transferred from the stove burner to the pot and its contents, as well as to the surrounding cooler air. As the water boils, thermal energy is also transformed into the mechanical kinetic energy of rising steam. As the steam leaves the pot, the system loses both matter and energy to the surroundings.

Closed System

A pressure cooker with potatoes boiling represents a closed system, because the tightly sealed lid prevents loss of matter and energy to the surroundings in steam. Thermal energy can be transferred into the system from contact between the pot and the stove. It also can be transferred out of the system where the pot contacts the surrounding cooler air and through transformation into radiant energy.

Isolated System

The pot of potatoes inside an insulated container represents an isolated system. In theory, the insulation prevents the exchange of any energy or matter between the system and its surroundings. In reality, energy exchange is significantly reduced, but not eliminated entirely. This is because it is hard to completely isolate a system.

Figure 3.7 An open system, a closed system, and an isolated system are shown. **Applying: Why is it impossible to cook potatoes in an isolated system in real life?**

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Comparing Energy Transfer and Transformation

Whenever a system releases energy, the surroundings absorb it. In the same way, when a system absorbs energy, the surroundings release it. These processes can involve either energy transfer, energy transformation, or both. When energy is *transferred*, it stays in the same form. However, when energy is *transformed*, the form of energy always changes. For example, when one pool ball strikes another in **Figure 3.8**, mechanical kinetic energy is transferred from one ball to the other, but it is also transformed into sound and thermal energy, which are absorbed by the surroundings. We cannot feel the resulting small change in the thermal energy of the surroundings. But, we do hear the vibrating air molecules as sound when it reaches our ears.

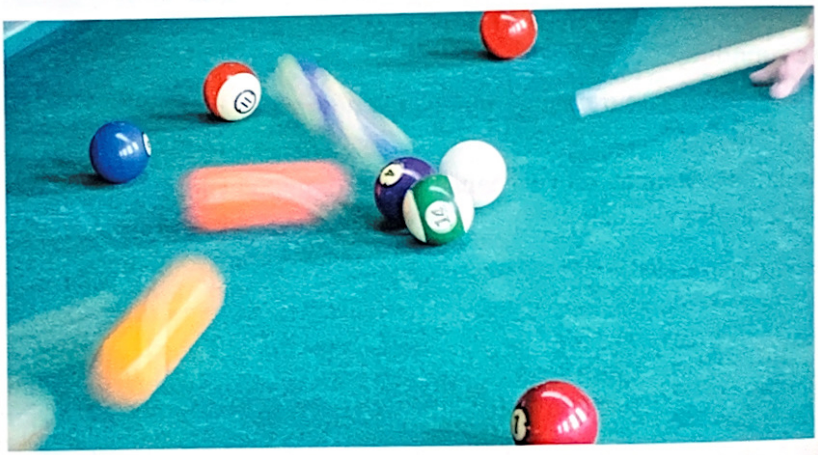

Figure 3.8 In pool, mechanical kinetic energy is transferred from one ball to another, but it is also transformed into sound and thermal energy.

Activity

Modelling Energy Transfer and Transformation

1. Build a catapult with the materials provided by your teacher.
2. Experiment with the design of your catapult to determine changes that affect its performance.
3. Record all the ways that energy is transformed and transferred as your catapult operates.
4. Using your observations, try to determine what variables affected energy transformation in the catapult. To answer this question, consider how changes to your design affected a certain function. For instance, if you used an elastic band in your design, did the length or thickness of the band affect the distance the catapult was able to throw an object? What type of energy might have been affected by this variable?

Before you leave this page . . .

1. Describe the law of conservation of energy.
2. How do energy transfer and transformation differ? How are they similar?
3. Use an example from your everyday life to show how you could change an open system to **a)** a closed system and **b)** an isolated system.