

## Energy is not transferred as heat in an adiabatic process

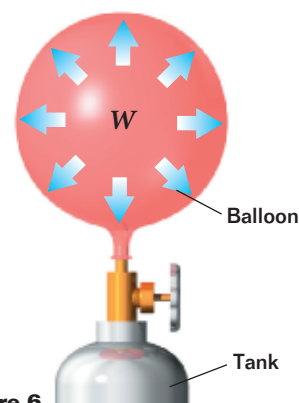
When a tank of compressed gas is opened to fill a toy balloon, the process of inflation occurs rapidly. The internal energy of the gas does not remain constant. Instead, as the pressure of the gas in the tank decreases, so do the gas's internal energy and temperature.

If the balloon and the tank are thermally insulated, no energy can be transferred from the expanding gas as heat. A process in which changes occur but no energy is transferred to or from a system as heat is called an **adiabatic process**. The decrease in internal energy must therefore be equal to the energy transferred from the gas as work. This work is done by the confined gas as it pushes the wall of the balloon outward, overcoming the pressure exerted by the air outside the balloon. As a result, the balloon inflates, as shown in **Figure 6**. Note that unlike an isothermal process, which must happen slowly, an adiabatic process must happen rapidly.

As mentioned earlier, the three processes described here rarely occur ideally, but many situations can be approximated by one of the three processes. This allows you to make predictions. For example, both refrigerators and internal-combustion engines require that gases be compressed or expanded rapidly. By making the approximation that these processes are adiabatic, one can make quite good predictions about how these machines will operate.

## adiabatic process

*a thermodynamic process during which no energy is transferred to or from the system as heat*



**Figure 6** As the gas inside the tank and balloon rapidly expands, its internal energy decreases. This energy leaves the system by means of work done against the outside air.

## SECTION REVIEW

1. In which of the situations listed below is energy being transferred as heat to the system in order for the system to do work?
  - a. Two sticks are rubbed together to start a fire.
  - b. A firecracker explodes.
  - c. A red-hot iron bar is set aside to cool.
2. A mixture of gasoline vapor and air is placed in an engine cylinder. The piston has an area of  $7.4 \times 10^{-3} \text{ m}^2$  and is displaced inward by  $7.2 \times 10^{-2} \text{ m}$ . If  $9.5 \times 10^5 \text{ Pa}$  of pressure is placed on the piston, how much work is done during this process? Is work being done *on* or *by* the gas mixture?
3. A weather balloon slowly expands as energy is transferred as heat from the outside air. If the average net pressure is  $1.5 \times 10^3 \text{ Pa}$  and the balloon's volume increases by  $5.4 \times 10^{-5} \text{ m}^3$ , how much work is done by the expanding gas?
4. **Critical Thinking** Identify the following processes as isothermal, isovolumetric, or adiabatic:
  - a. a tire being rapidly inflated
  - b. a tire expanding gradually at a constant temperature
  - c. a steel tank of gas being heated