An example of a system would be the flask, balloon, water, and steam that were heated over the burner. As the burner transferred energy as heat to the system, the system's internal energy increased. When the expanding steam did work on the air outside the balloon by pushing it back (as the balloon expanded), the system's internal energy decreased. Some of the energy transferred to the system as heat was transferred out of the system as work done on the air.

A system is rarely completely isolated from its surroundings. In the example above, a heat interaction occurs between the burner and the system, and work is done by the system on the surroundings (the balloon moves the outside air outward). Energy is also transferred as heat to the air surrounding the flask because of the temperature difference between the flask and the surrounding air. In such cases, we must account for all of the interactions between the system and its **environment** that could affect the system's internal energy.

environment

the combination of conditions and influences outside a system that affect the behavior of the system

Work done on or by a gas is pressure multiplied by volume change

In thermodynamic systems, work is defined in terms of pressure and volume change. Pressure is a measure of how much force is applied over a given area ($P = F/A$). Change in volume is equal to area multiplied by displacement ($\Delta V = Ad$). These expressions can be substituted into the definition of work introduced in the chapter "Work and Energy" to derive a new definition for the work done on or by a gas, as follows:

$$W = Fd$$

$$W = Fd\left(\frac{A}{A}\right) = \left(\frac{F}{A}\right)(Ad) = P\Delta V$$

WORK DONE BY A GAS

$$W = P\Delta V$$

work = pressure × volume change

This chapter will use only this new definition of work. Note that this definition assumes that P is constant.

If the gas expands, as shown in **Figure 2,** ΔV is positive, and the work done by the gas on the piston is positive. If the gas is compressed, ΔV is negative, and the work done by the gas on the piston is negative. (In other words, the piston does work on the gas.) When the gas volume remains constant, there is no displacement and no work is done on or by the system.

Although the pressure can change during a process, work is done only if the volume changes. A situation in which pressure increases and volume remains constant is comparable to one in which a force does not displace a mass even as the force is increased. Work is not done in either situation.

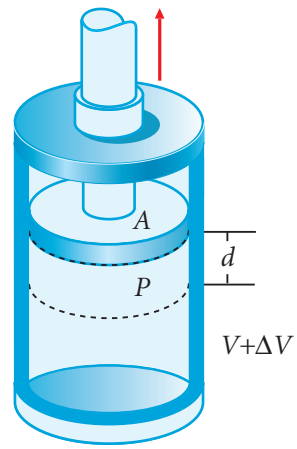

Figure 2
Work done on or by the gas is the product of the volume change (area A multiplied by the displacement d) and the pressure of the gas.