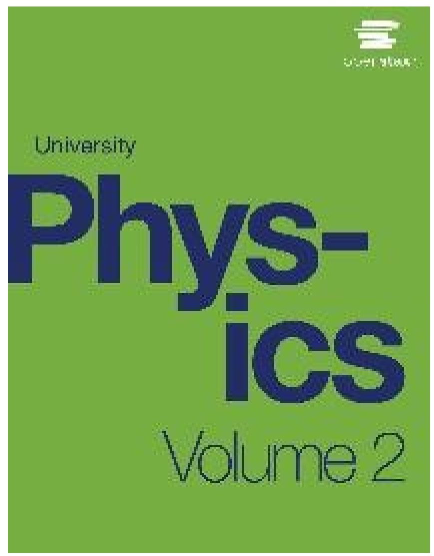
UNIVERSITY PHYSICS

Chapter 3 THE FIRST LAW OF THERMODYNAMICS

PowerPoint Image Slideshow



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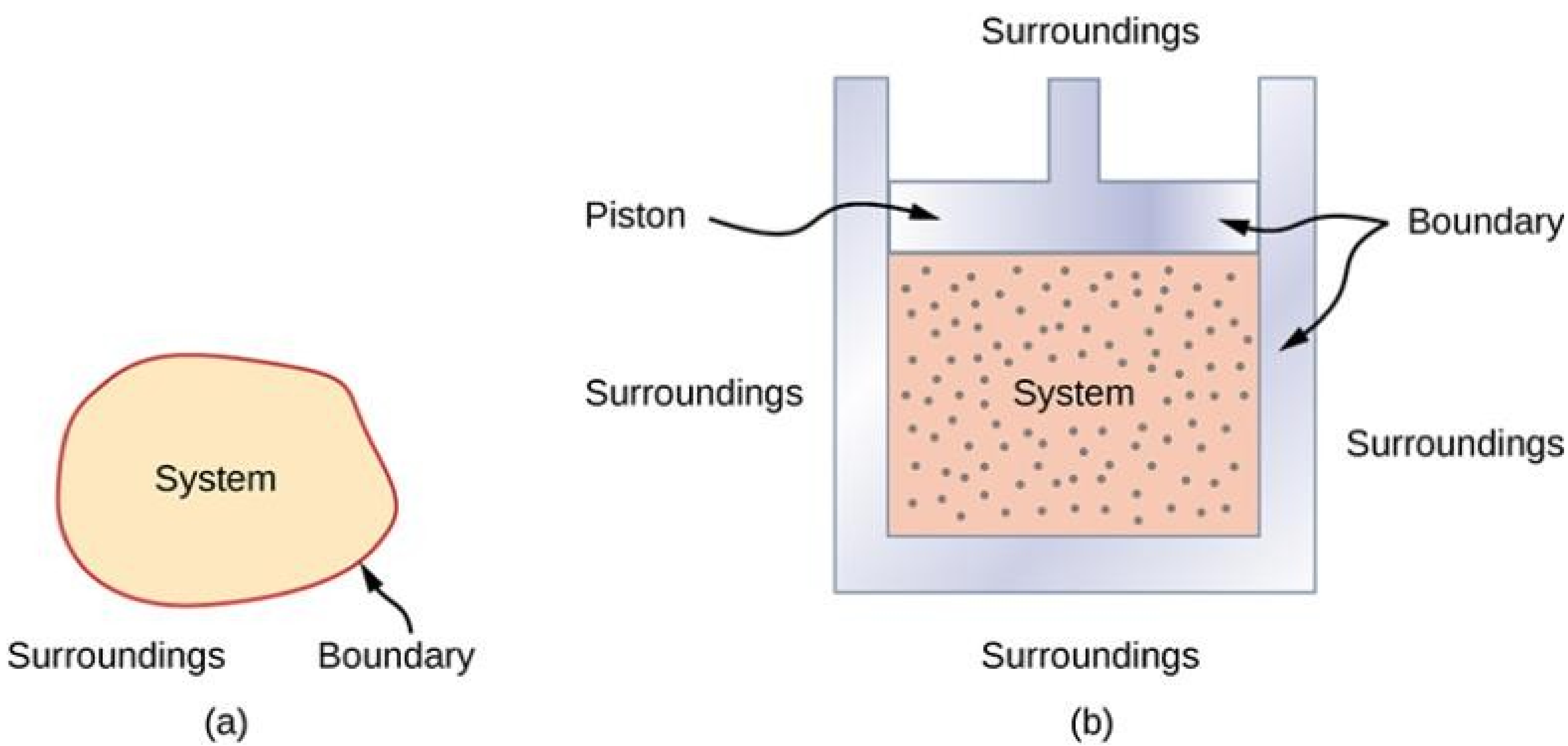
Introduction

FIGURE 3.2

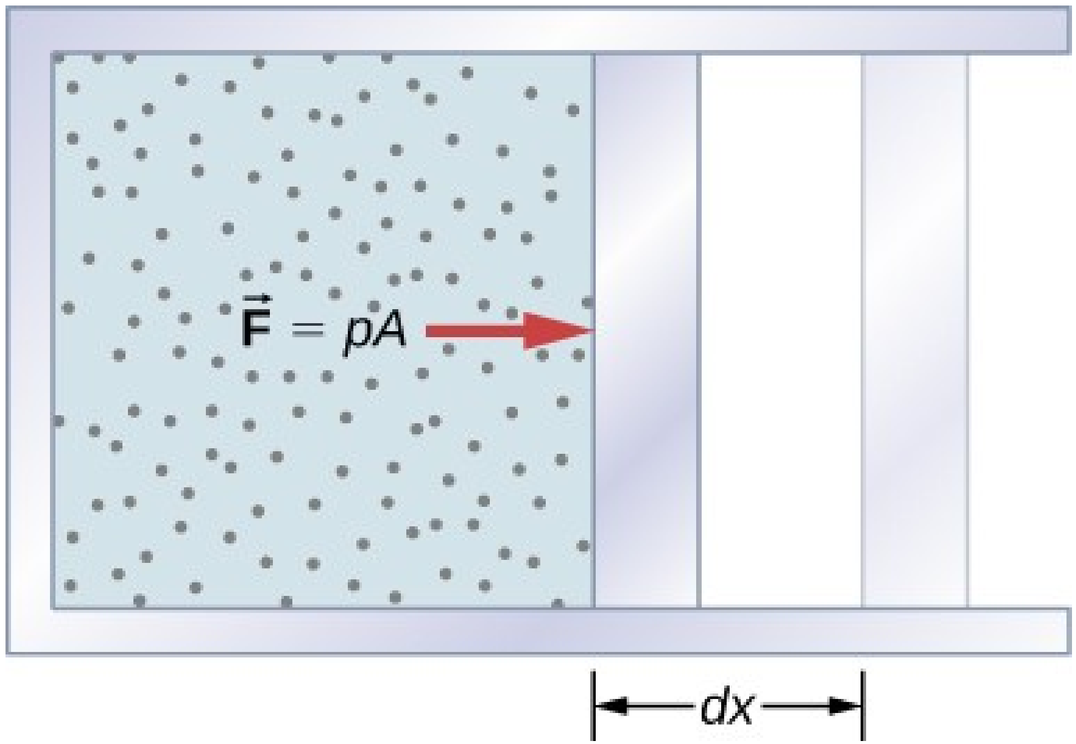


a) A system, which can include any relevant process or value, is self-contained in an area. The surroundings may also have relevant information; however, the surroundings are important to study only if the situation is an open system.

b) The burning gasoline in the cylinder of a car engine is an example of a thermodynamic system.

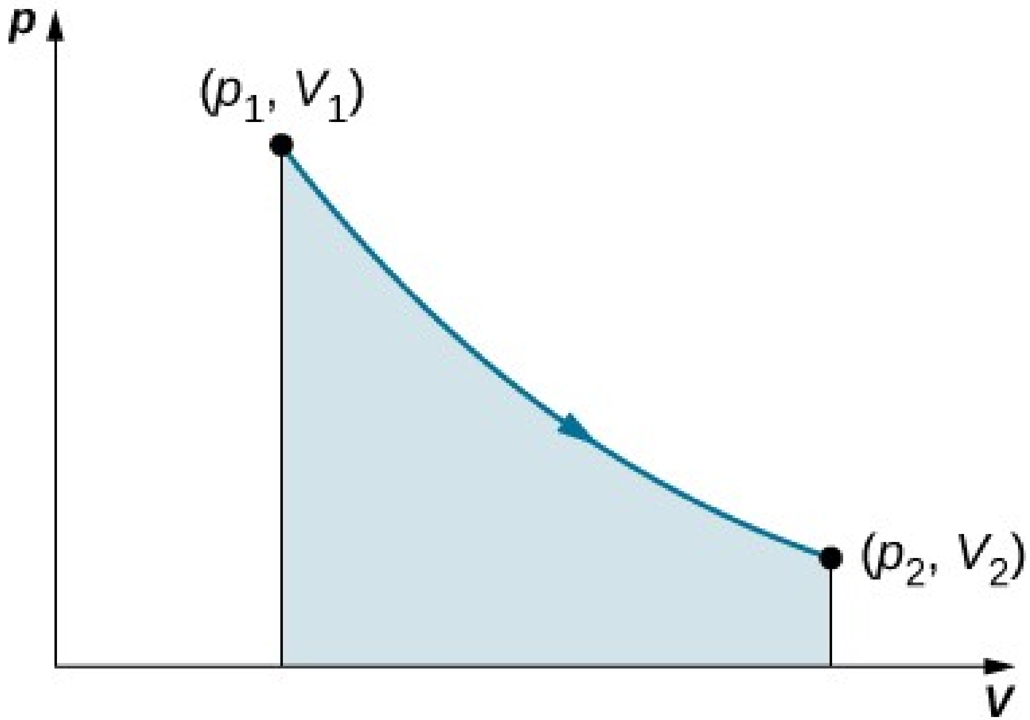
Work and PV diagrams

FIGURE 3.4



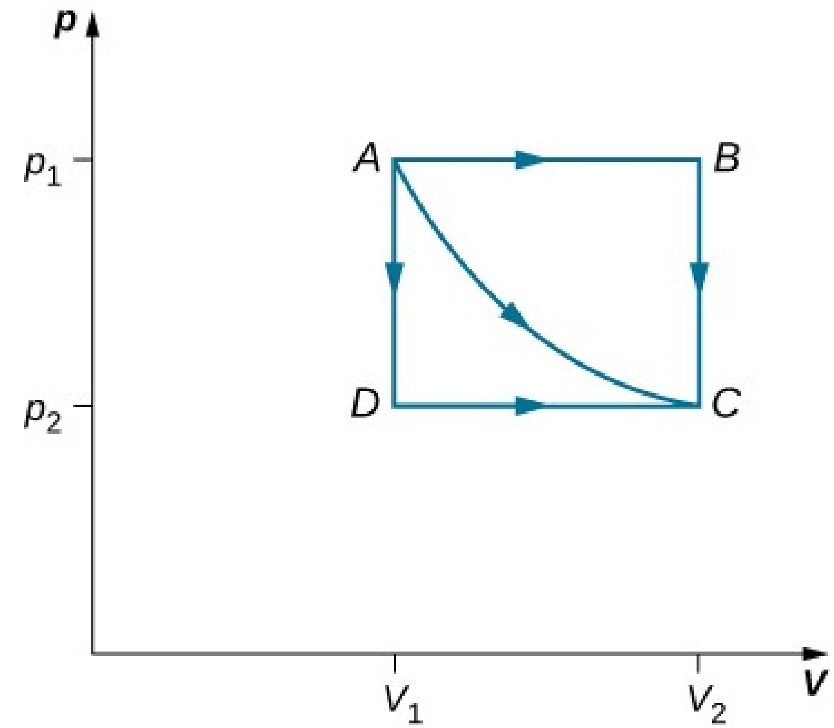
The work done by a confined gas in moving a piston a distance dx is given by $dW = Fdx = pdV$.

FIGURE 3.5



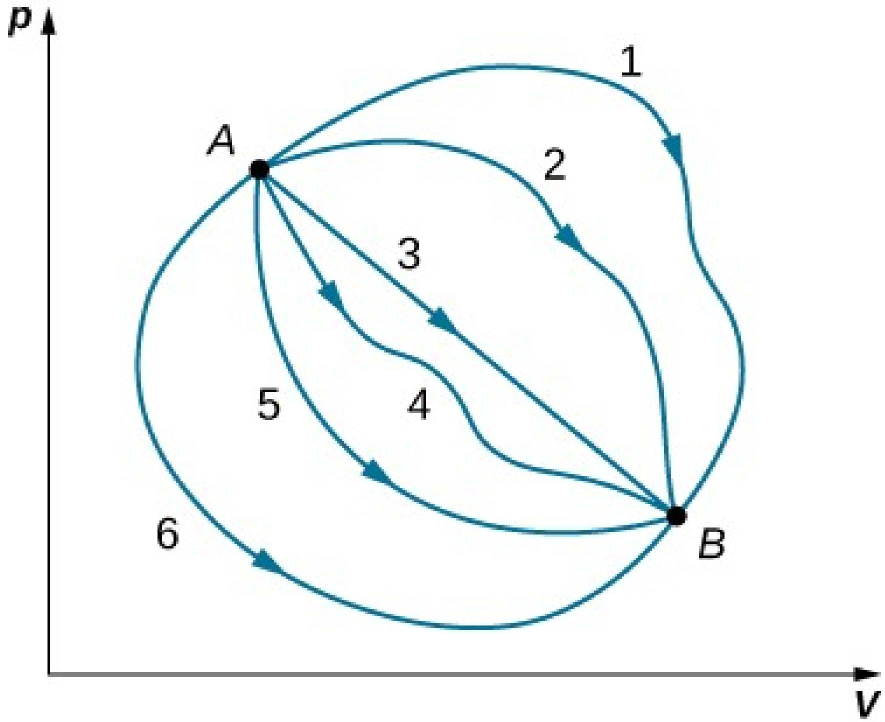
When a gas expands slowly from V_1 to V_2, the work done by the system is represented by the shaded area under the pV curve.

FIGURE 3.6



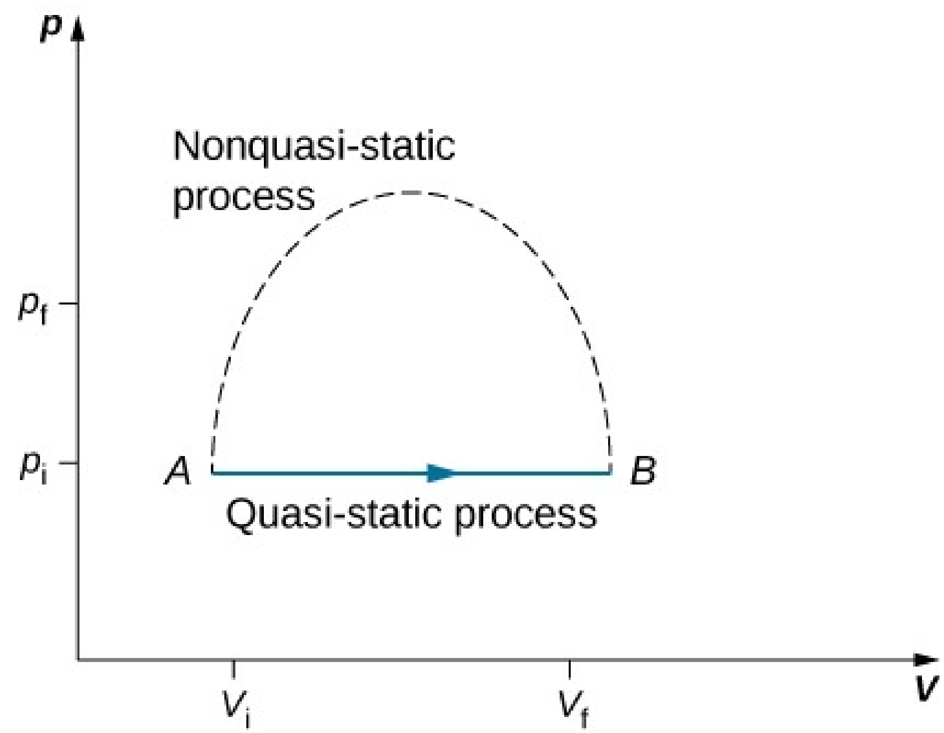
The paths *ABC*, *AC*, and *ADC* represent three different quasi-static transitions between the equilibrium states *A* and *C*.

FIGURE 3.7



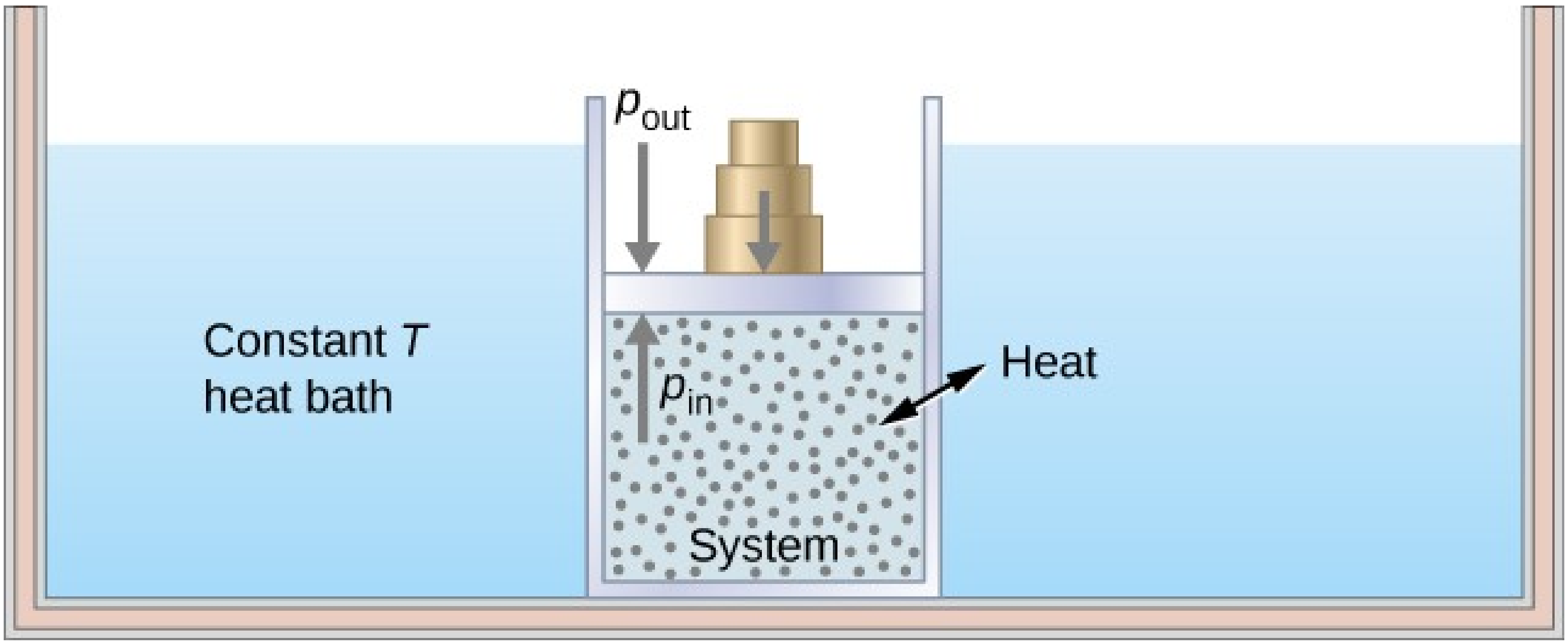
Different thermodynamic paths taken by a system in going from state *A* to state *B*. For all transitions, the change in the internal energy of the system $\Delta E_{int} = Q - W$ is the same.

FIGURE 3.8



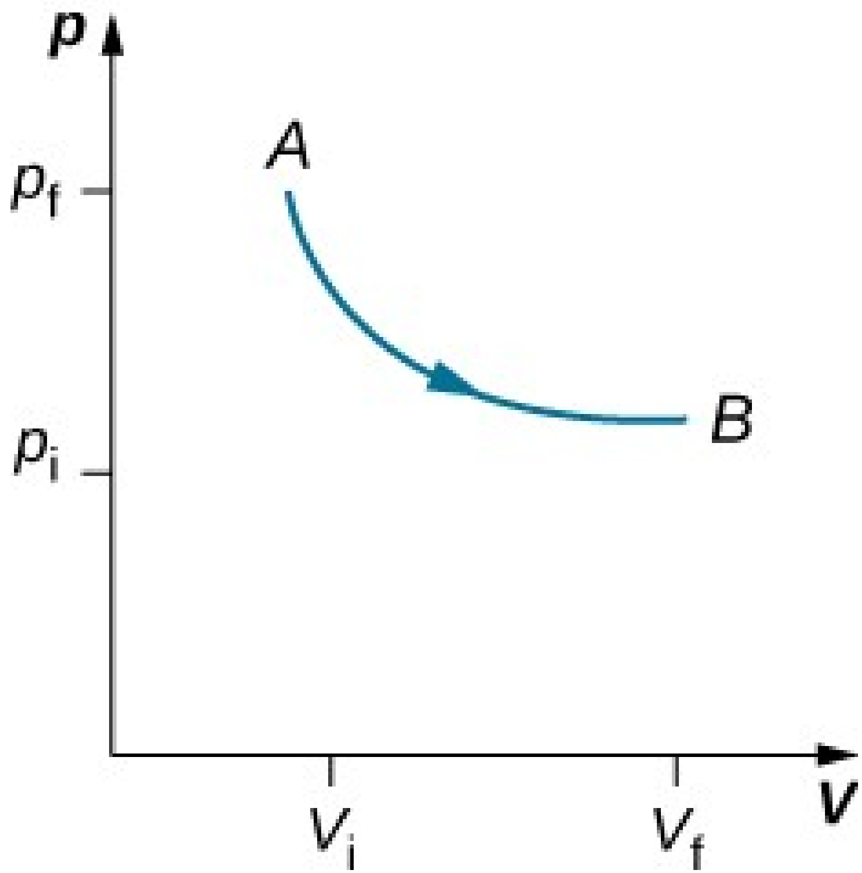
Quasi-static and non-quasi-static processes between states *A* and *B* of a gas. In a quasi-static process, the path of the process between *A* and *B* can be drawn in a state diagram since all the states that the system goes through are known. In a non-quasi-static process, the states between *A* and *B* are not known, and hence no path can be drawn. It may follow the dashed line as shown in the figure or take a very different path.

FIGURE 3.9



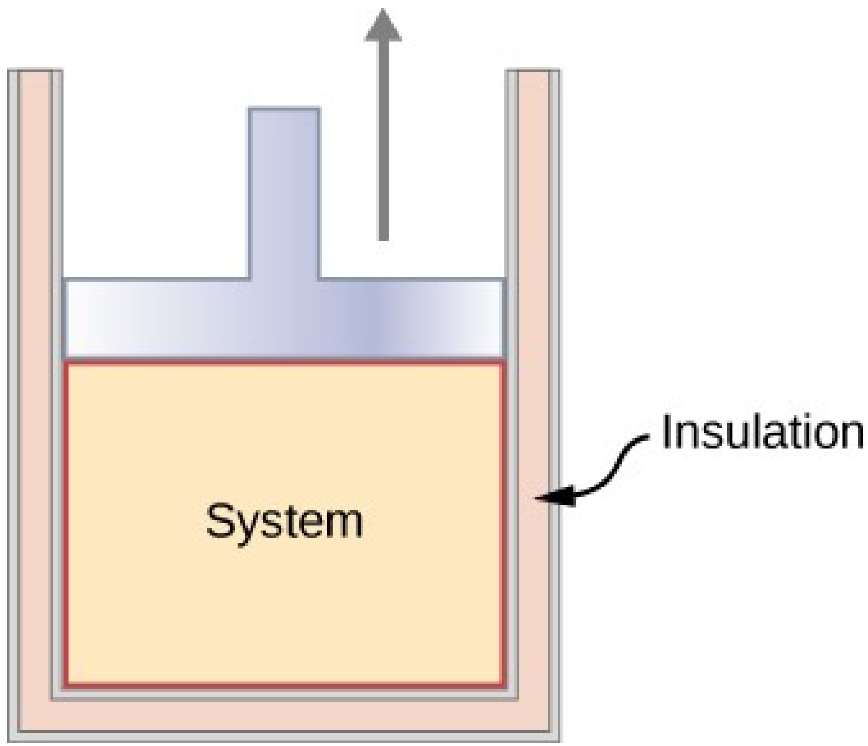
Expanding a system at a constant temperature. Removing weights on the piston leads to an imbalance of forces on the piston, which causes the piston to move up. As the piston moves up, the temperature is lowered momentarily, which causes heat to flow from the heat bath to the system. The energy to move the piston eventually comes from the heat bath.

FIGURE 3.10



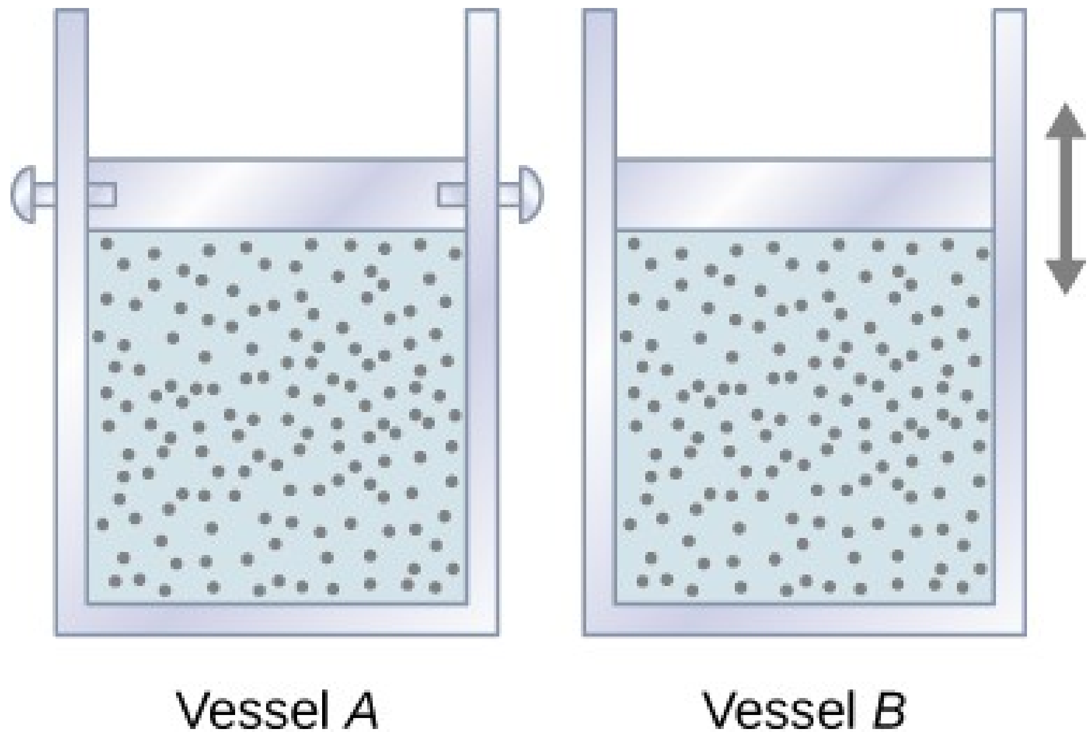
An isothermal expansion from a state labeled *A* to another state labeled *B* on a *pV* diagram. The curve represents the relation between pressure and volume in an ideal gas at constant temperature.

FIGURE 3.11



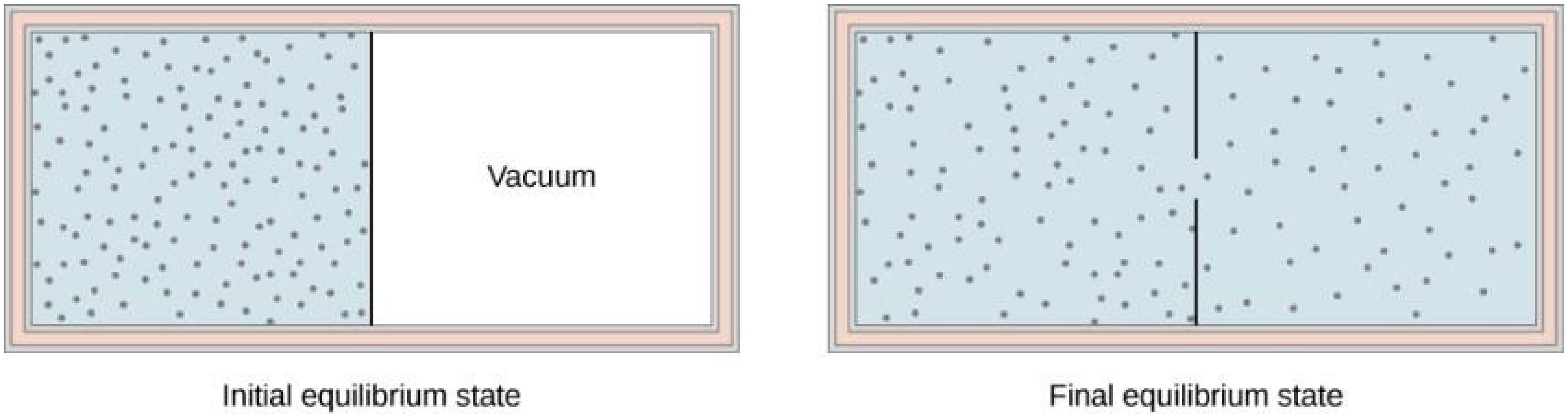
An insulated piston with a hot, compressed gas is released. The piston moves up, the volume expands, and the pressure and temperature decrease. The internal energy goes into work. If the expansion occurs within a time frame in which negligible heat can enter the system, then the process is called adiabatic. Ideally, during an adiabatic process no heat enters or exits the system.

FIGURE 3.12



Two vessels are identical except that the piston at the top of *A* is fixed, whereas that atop *B* is free to move against a constant external pressure *p*.

FIGURE 3.13



The gas in the left chamber expands freely into the right chamber when the membrane is punctured.

FIGURE 3.14

When sand is removed from the piston one grain at a time, the gas expands adiabatically and quasi-statically in the insulated vessel.

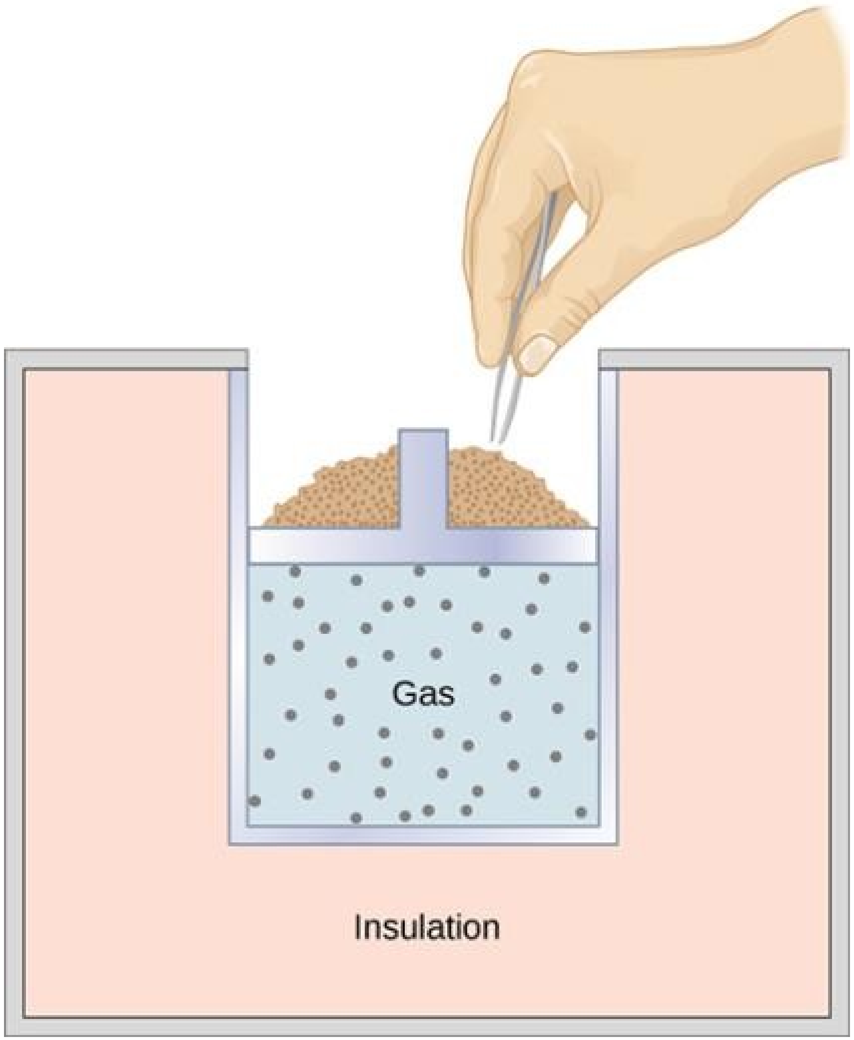
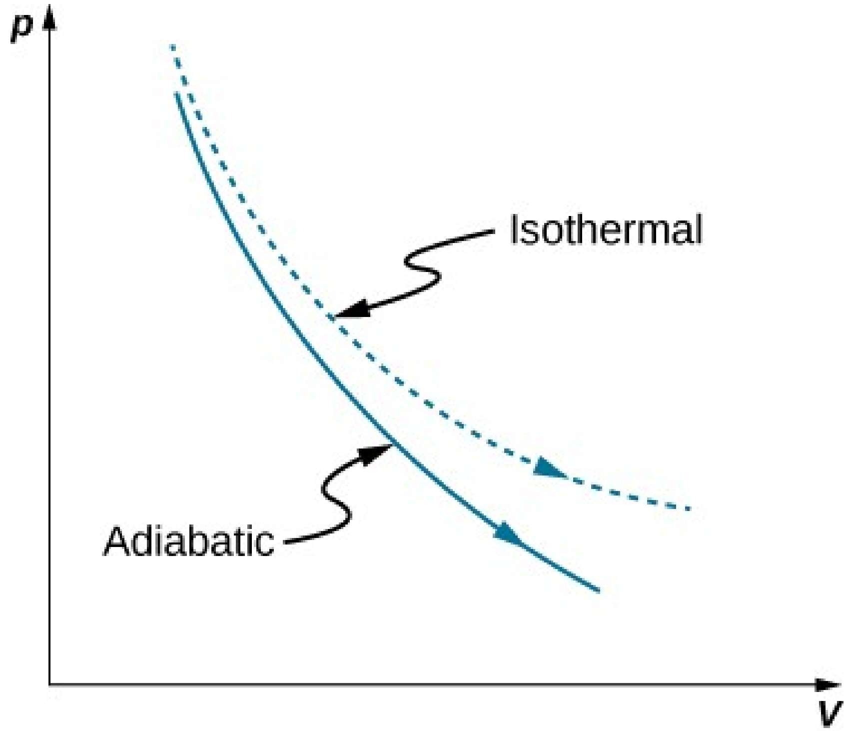


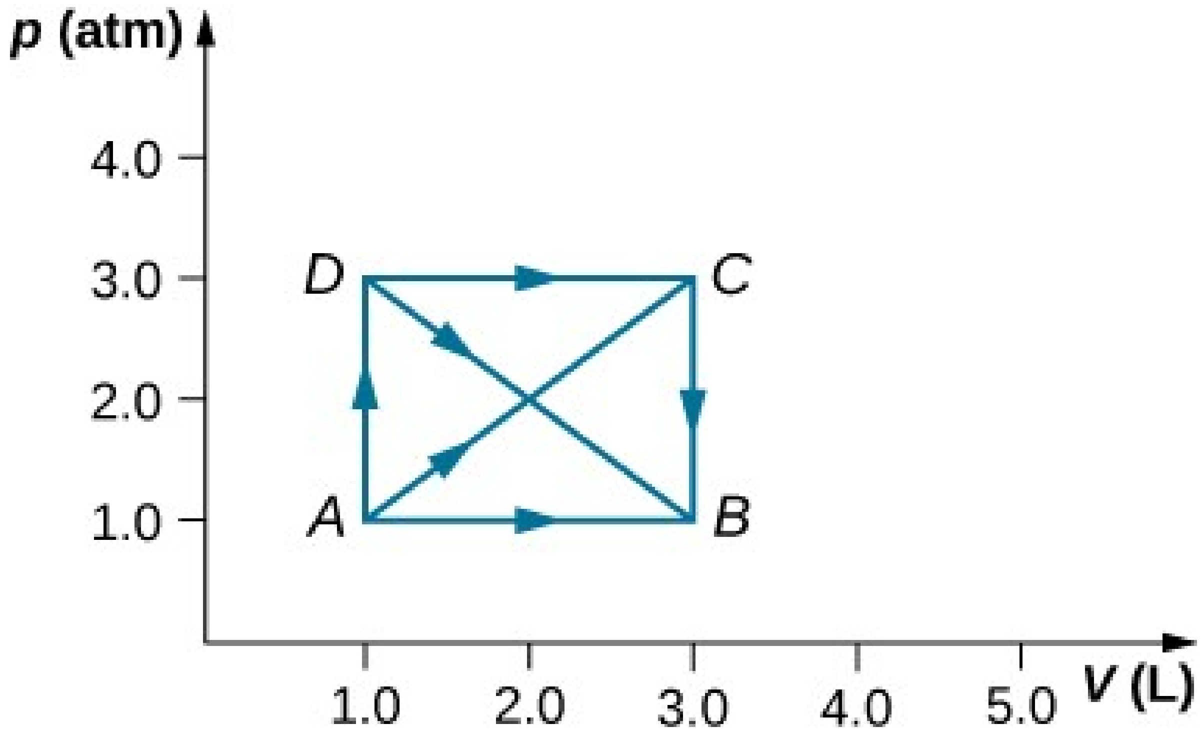
FIGURE 3.15



Quasi-static adiabatic and isothermal expansions of an ideal gas.

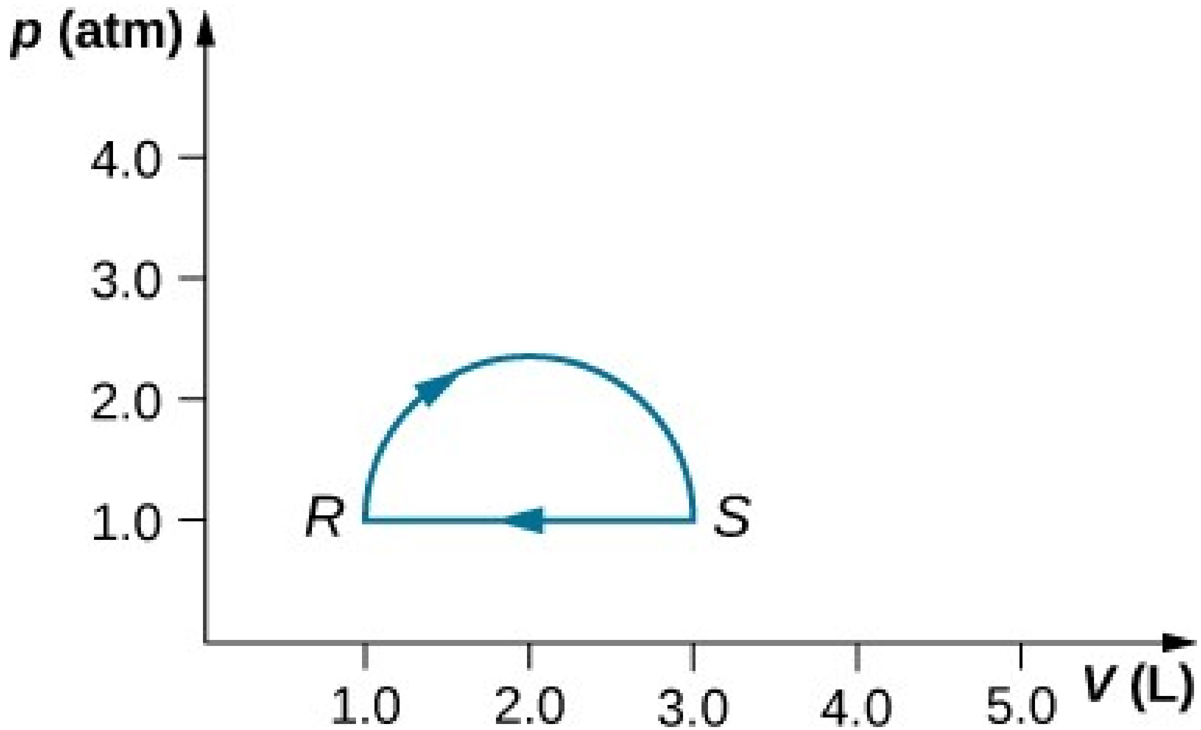
Examples

EXERCISE 28



As shown below, calculate the work done by the gas in the quasi-static processes represented by the paths (a) AB; (b) ADB; (c) ACB; and (d) ADCB

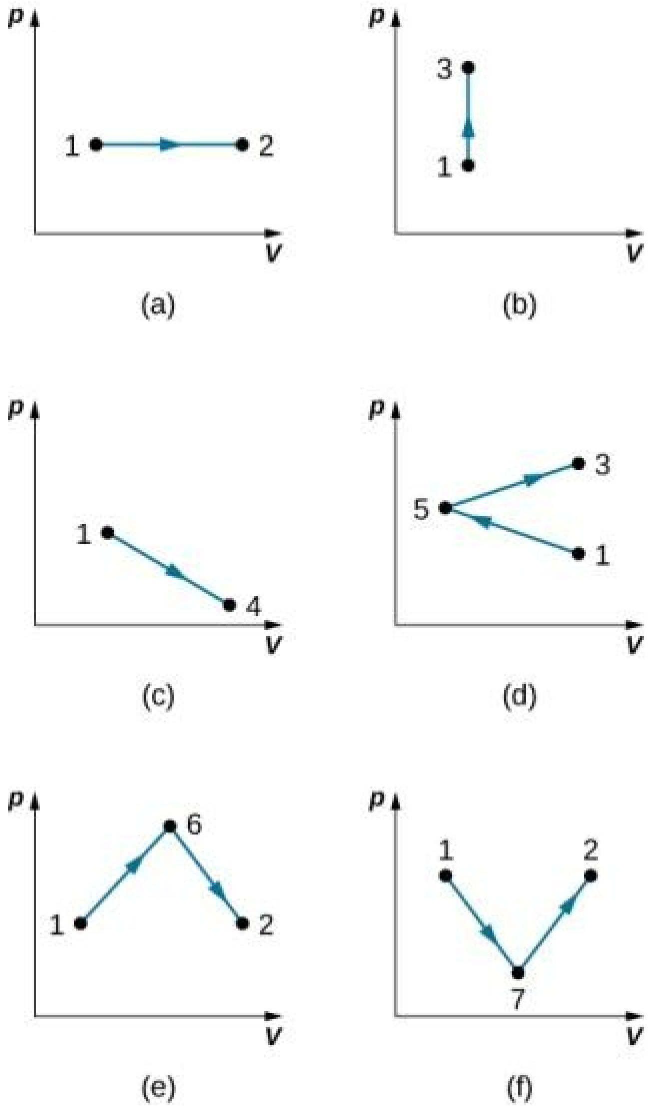
EXERCISE 29



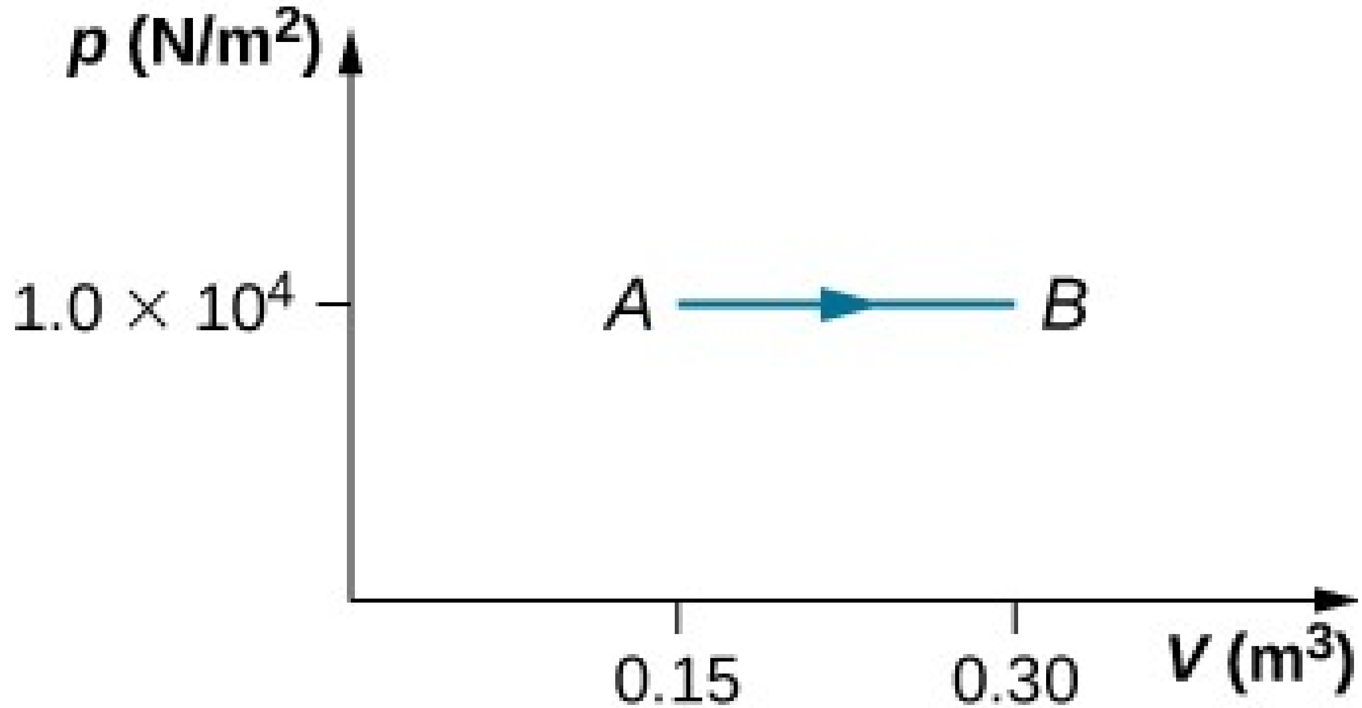
(a) Calculate the work done on the gas along the closed path shown below. The curved section between R and S is semicircular. (b) If the process is carried out in the opposite direction, what is the work done on the gas?

EXERCISE 37

Find the work done in the quasi-static processes shown below. The states are given as (p, V) values for the points in the pV plane: 1 (3 atm, 4 L), 2 (3 atm, 6 L), 3 (5 atm, 4 L), 4 (2 atm, 6 L), 5 (4 atm, 2 L), 6 (5 atm, 5 L), and 7 (2 atm, 5 L).

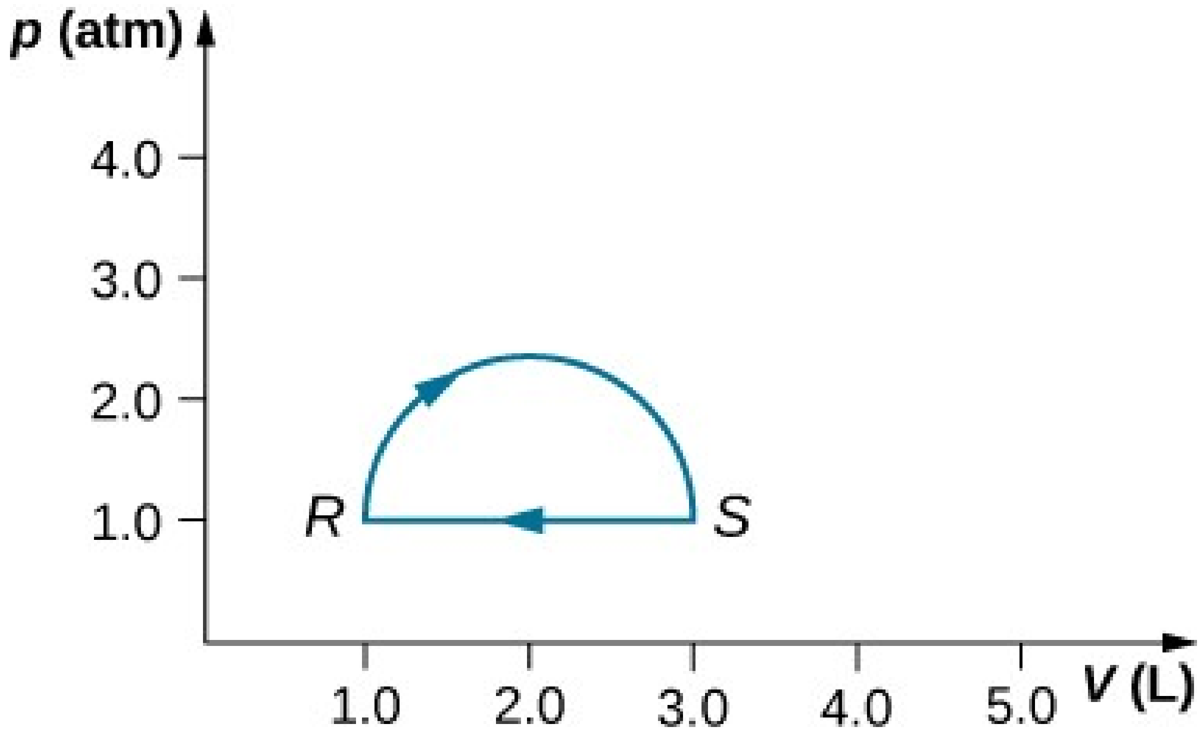


EXERCISE 42



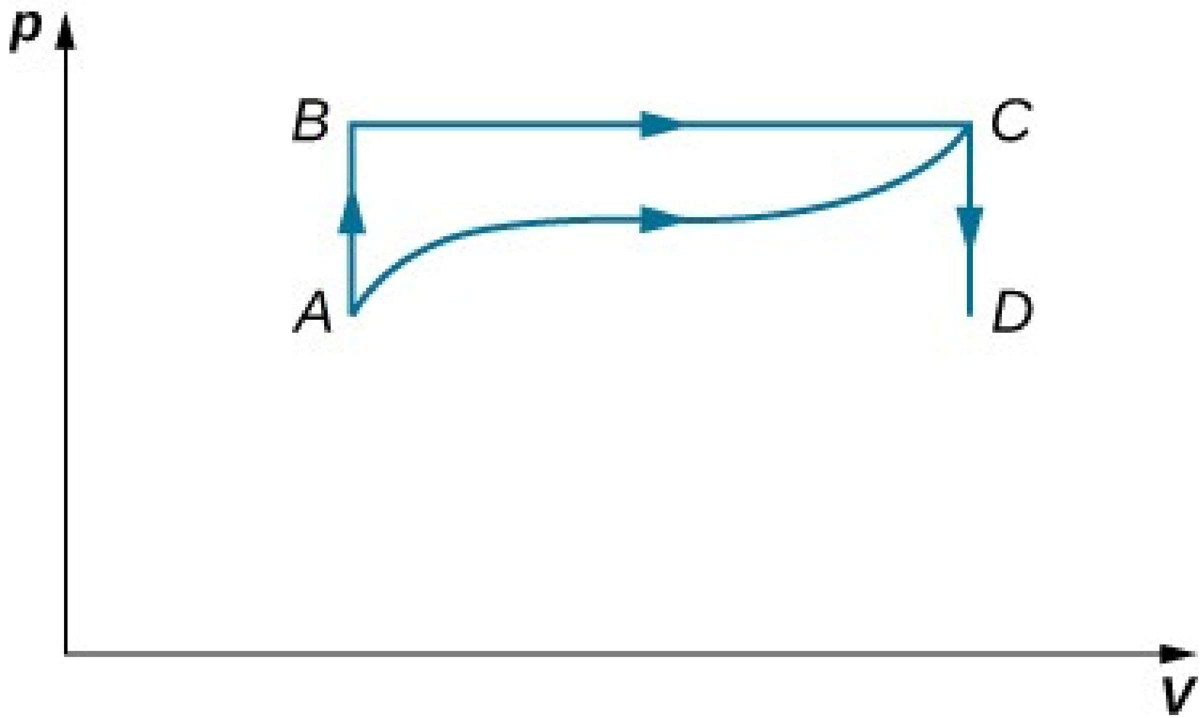
During the isobaric expansion from A to B represented below, 3,100 J of heat are added to the gas. What is the change in its internal energy?

EXERCISE 43



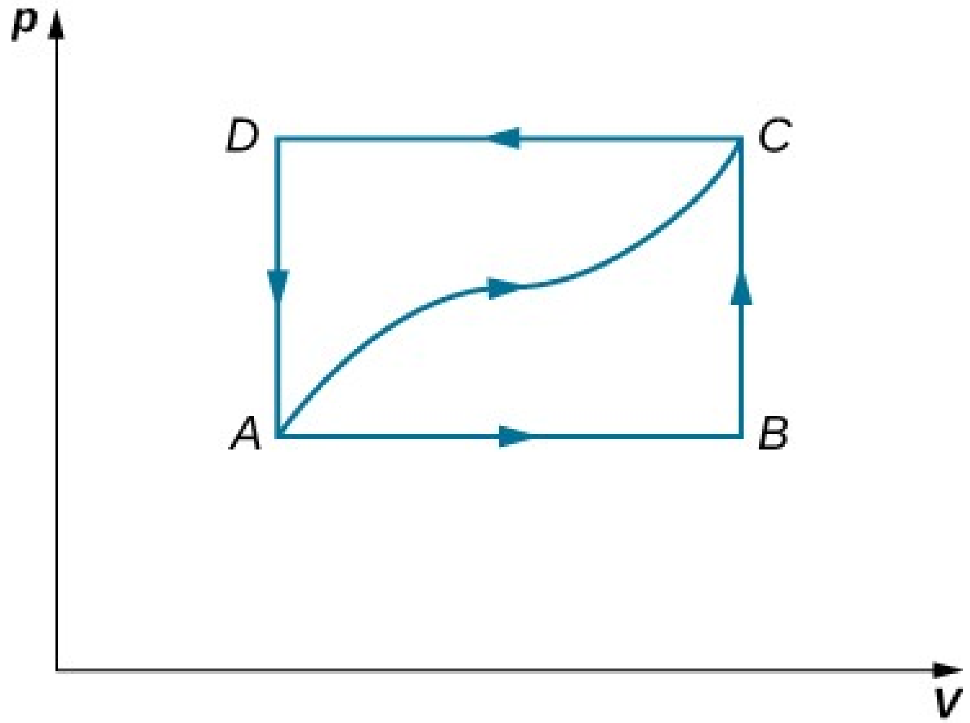
(a) What is the change in internal energy for the process represented by the closed path shown below? (b) How much heat is exchanged? (c) If the path is traversed in the opposite direction, how much heat is exchanged?

EXERCISE 44



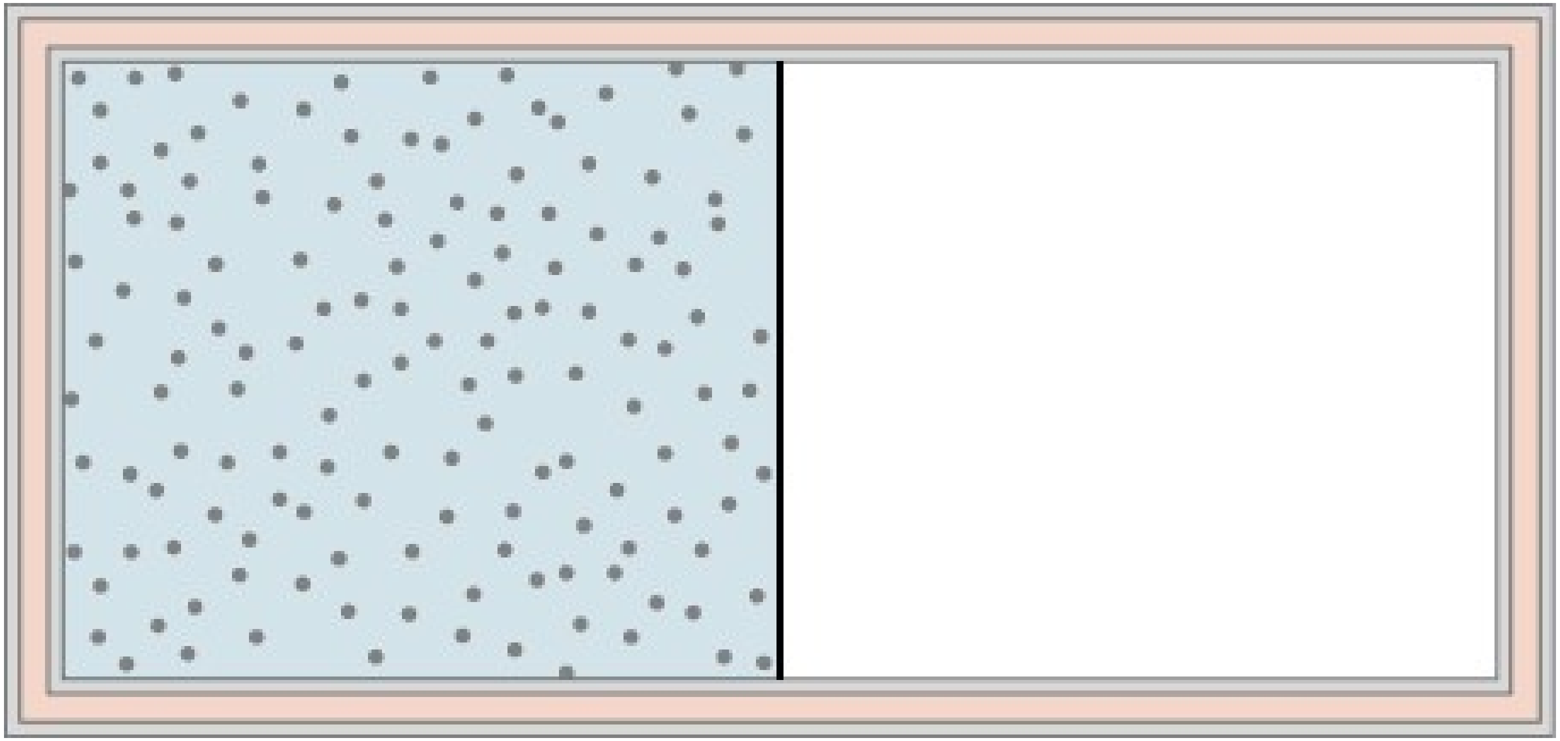
When a gas expands along path AC shown below, it does 400 J of work and absorbs either 200 or 400 J of heat. (a) Suppose you are told that along path ABC, the gas absorbs either 200 or 400 J of heat. Which of these values is correct? (b) Give the correct answer from part (a), how much work is done by the gas along ABC? (c) Along CD, the internal energy of the gas decreases by 50 J. How much heat is exchanged by the gas along this path?

EXERCISE 45



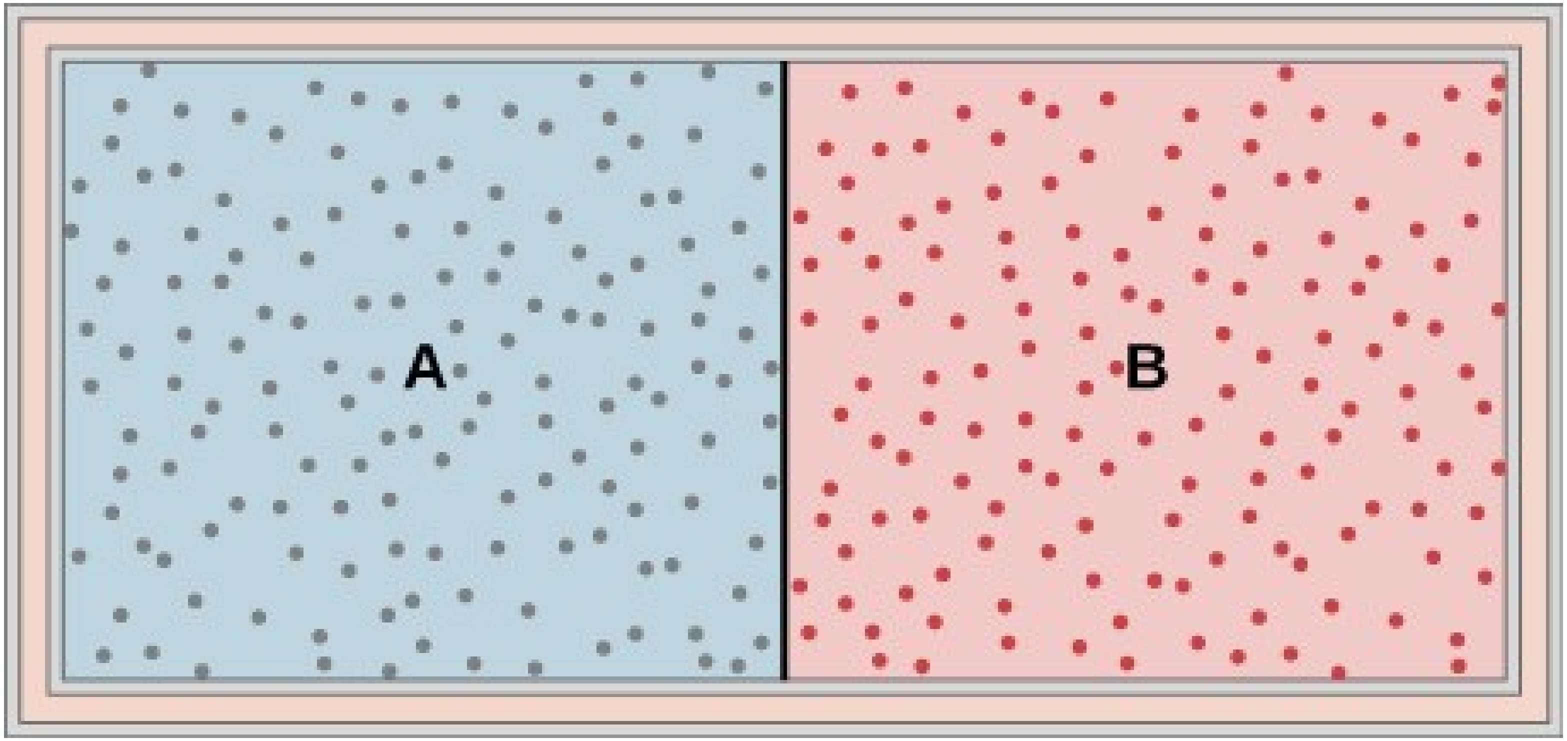
When a gas expands along *AB* (see below), it does 20 J of work and absorbs 30 J of heat. When the gas expands along *AC*, it does 40 J of work and absorbs 70 J of heat. (a) How much heat does the gas exchange along *BC*? (b) When the gas makes the transition from *C* to *A* along *CDA*, 60 J of work are done on it from *C* to *D*. How much heat does it exchange along *CDA*?

EXERCISE 46



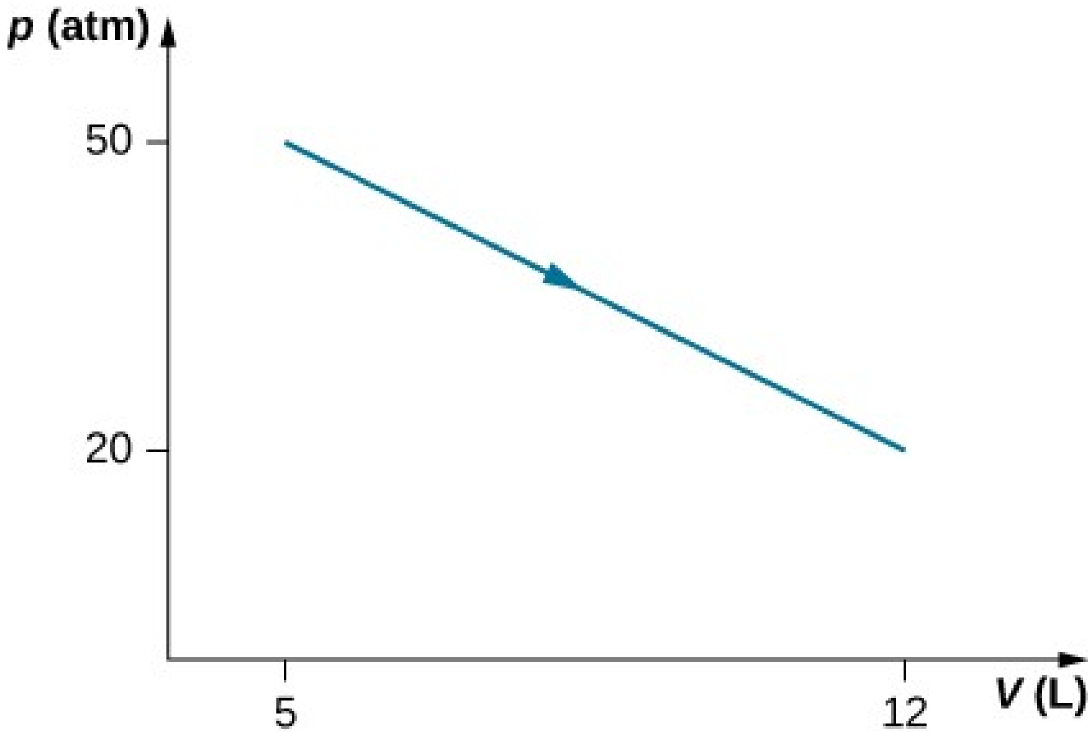
A dilute gas is stored in the left chamber of a container whose walls are perfectly insulating (see below), and the right chamber is evacuated. When the partition is removed, the gas expands and fills the entire container. Calculate the work done by the gas. Does the internal energy of the gas change in this process?

EXERCISE 47



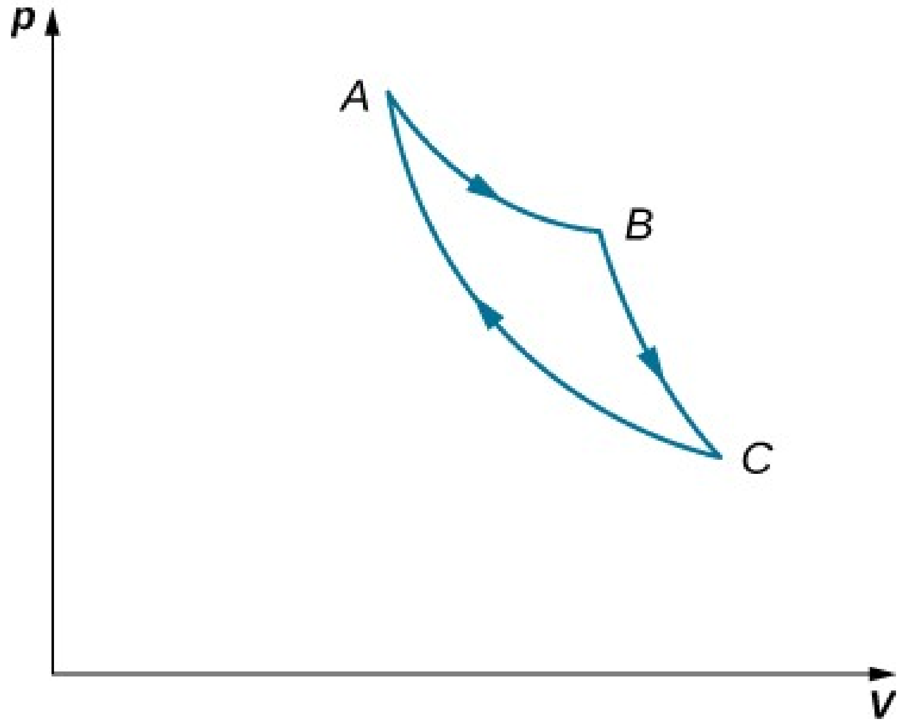
Ideal gases A and B are stored in the left and right chambers of an insulated container, as shown below. The partition is removed and the gases mix. Is any work done in this process? If the temperatures of A and B are initially equal, what happens to their common temperature after they are mixed?

EXERCISE 49



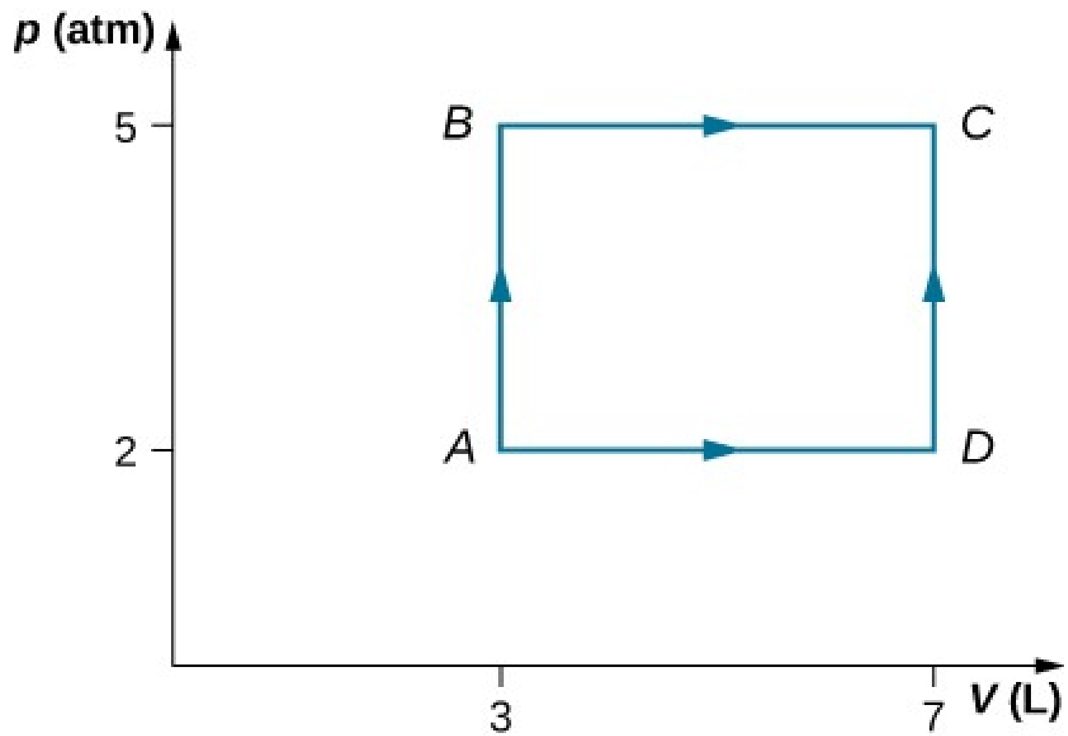
Consider the process for steam in a cylinder shown below. Suppose the change in the internal energy in this process is 30 kJ. Find the heat entering the system.

EXERCISE 57



An ideal gas expands isothermally along AB and does 700 J of work (see below). (a) How much heat does the gas exchange along AB? (b) The gas then expands adiabatically along BC and does 400 J of work. When the gas returns to A along CA, it exhausts 100 J of heat to its surroundings. How much work is done on the gas along this path?

EXERCISE 58



Consider the processes shown below for a monatomic gas. (a) Find the work done in each of the processes AB, BC, AD, and DC. (b) Find the internal energy change in processes AB and BC. (c) Find the internal energy difference between states C and A. (d) Find the total heat added in the ADC process. (e) From the information given, can you find the heat added in process AD? Why or why not?