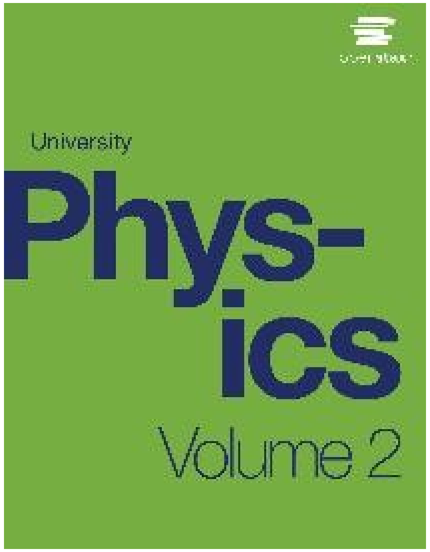
UNIVERSITY PHYSICS

Chapter 4 THE SECOND LAW OF THERMODYNAMICS

PowerPoint Image Slideshow



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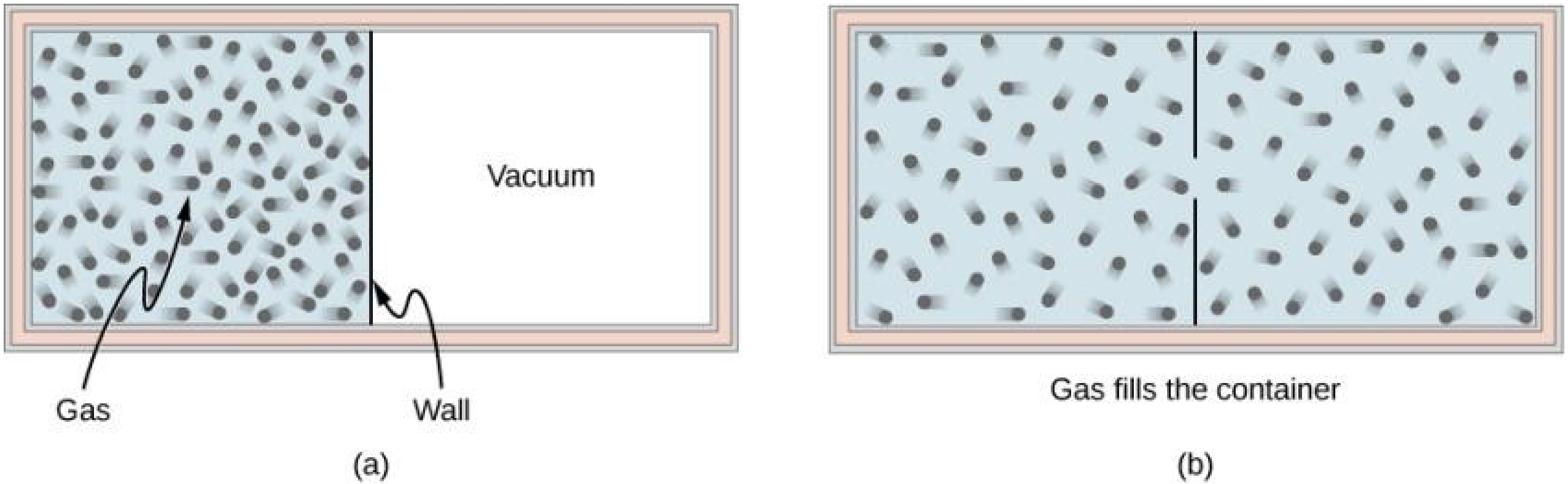
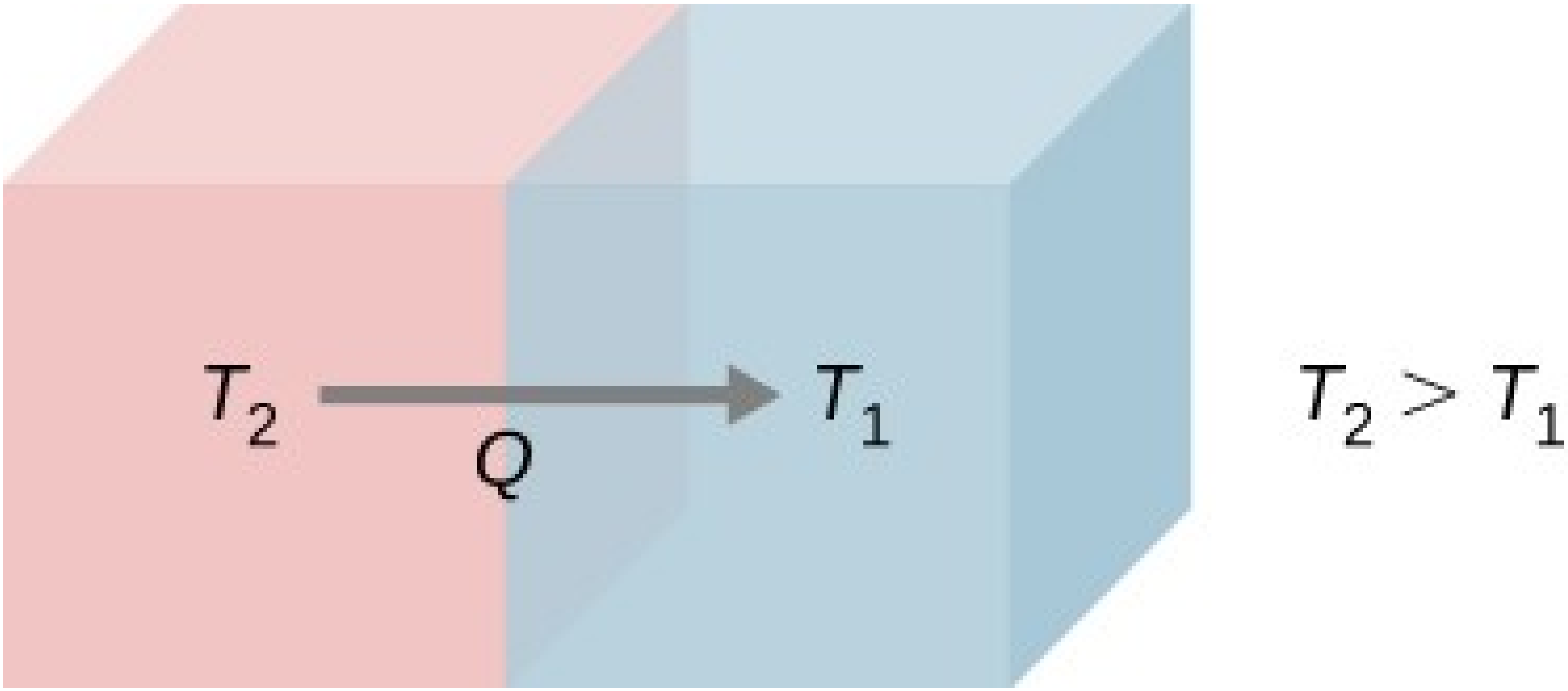
Second law: entropy tends to increase

FIGURE 4.2



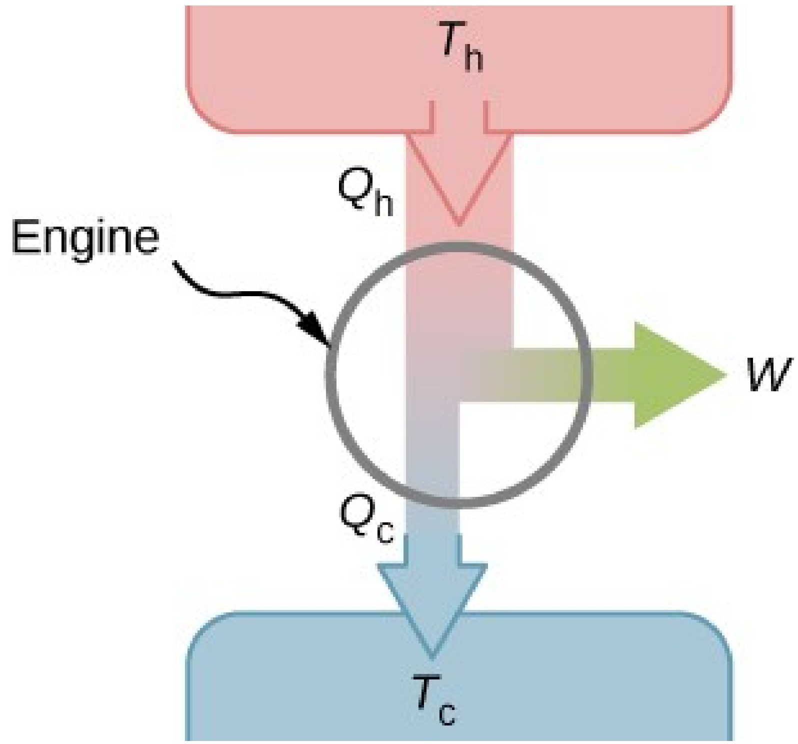
A gas expanding from half of a container to the entire container (a) before and (b) after the wall in the middle is removed.

FIGURE 4.3



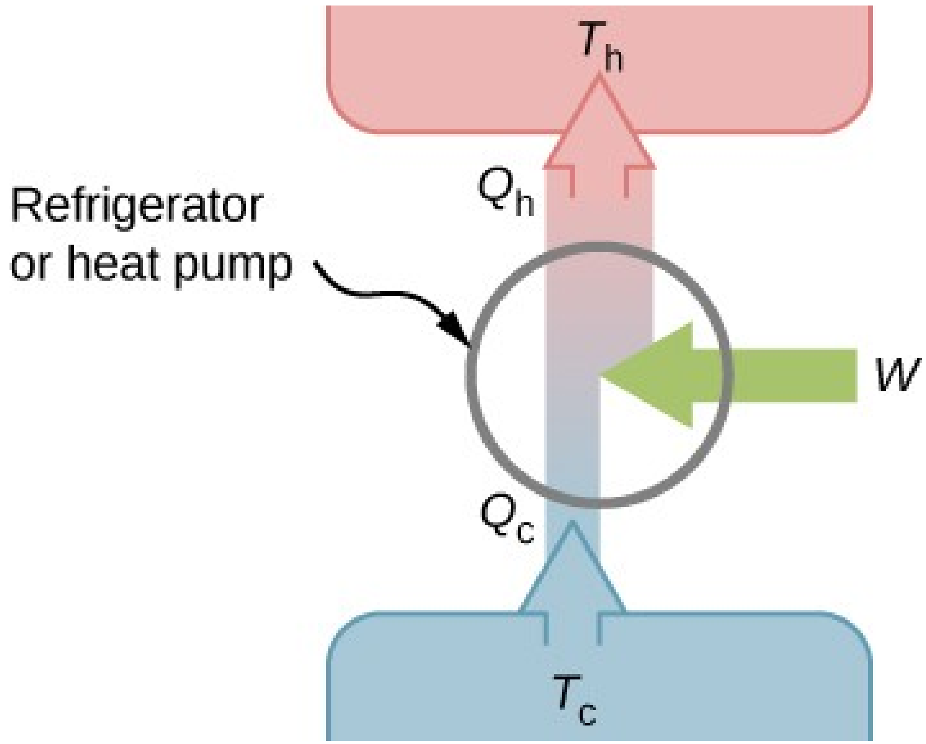
Spontaneous heat flow from an object at higher temperature T_2 to another at lower temperature T_1.

FIGURE 4.4



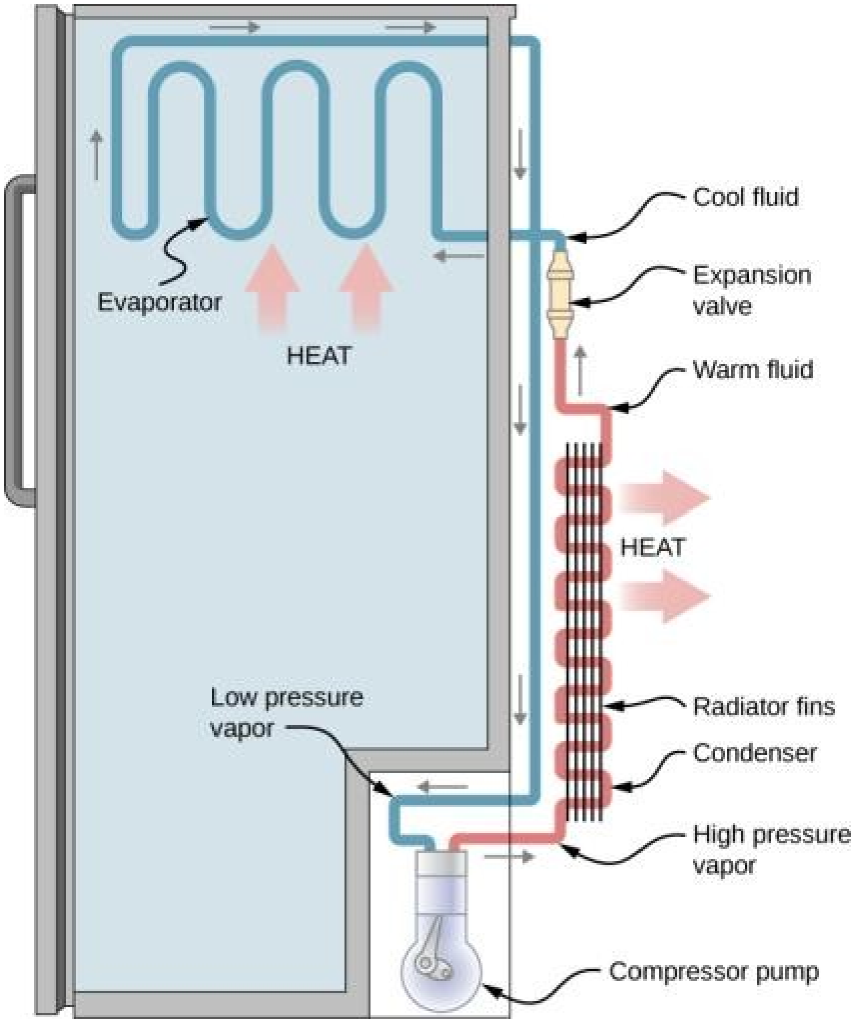
A schematic representation of a heat engine. Energy flows from the hot reservoir to the cold reservoir while doing work.

FIGURE 4.6



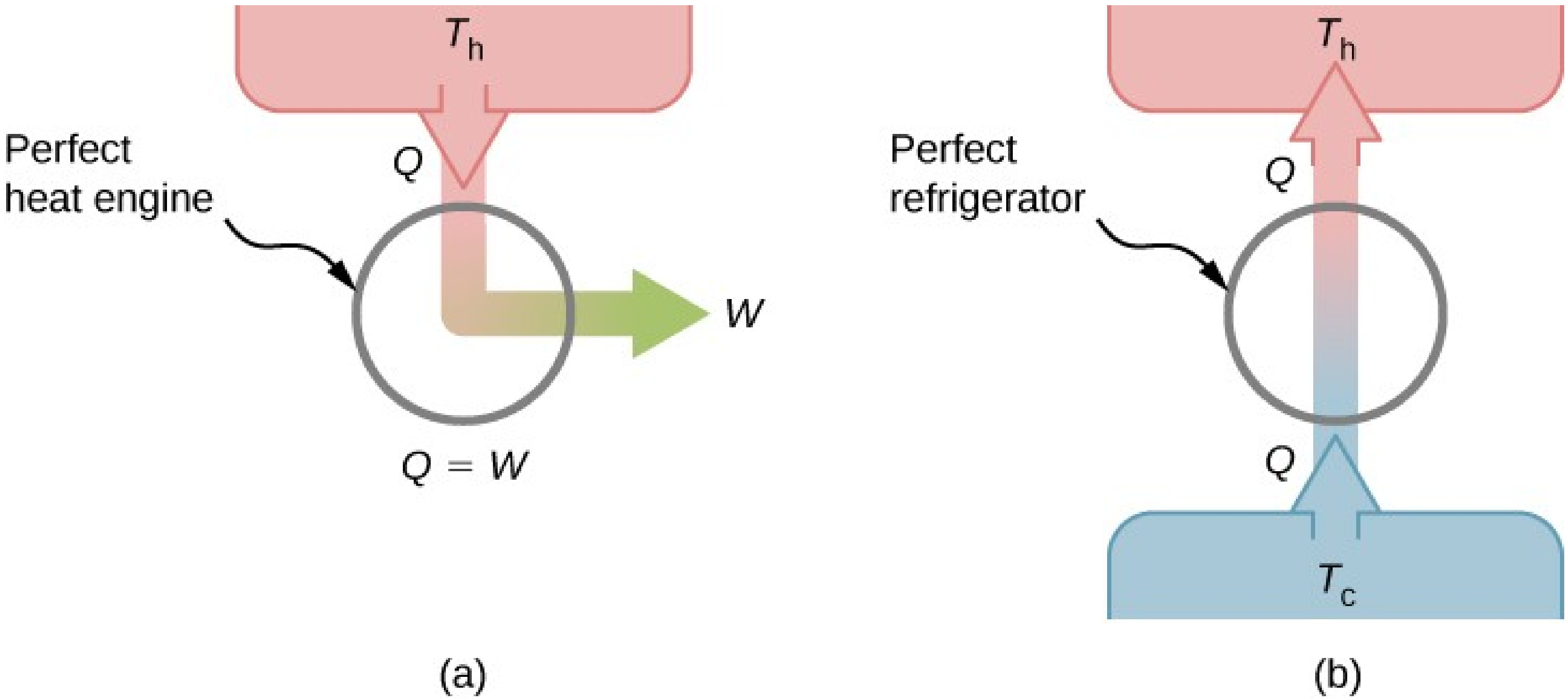
A schematic representation of a refrigerator (or a heat pump). The arrow next to work (*W*) indicates work being put into the system.

FIGURE 4.7



A schematic diagram of a household refrigerator. A coolant with a boiling temperature below the freezing point of water is sent through the cycle (clockwise in this diagram). The coolant extracts heat from the refrigerator at the evaporator, causing coolant to vaporize. It is then compressed and sent through the condenser, where it exhausts heat to the outside.

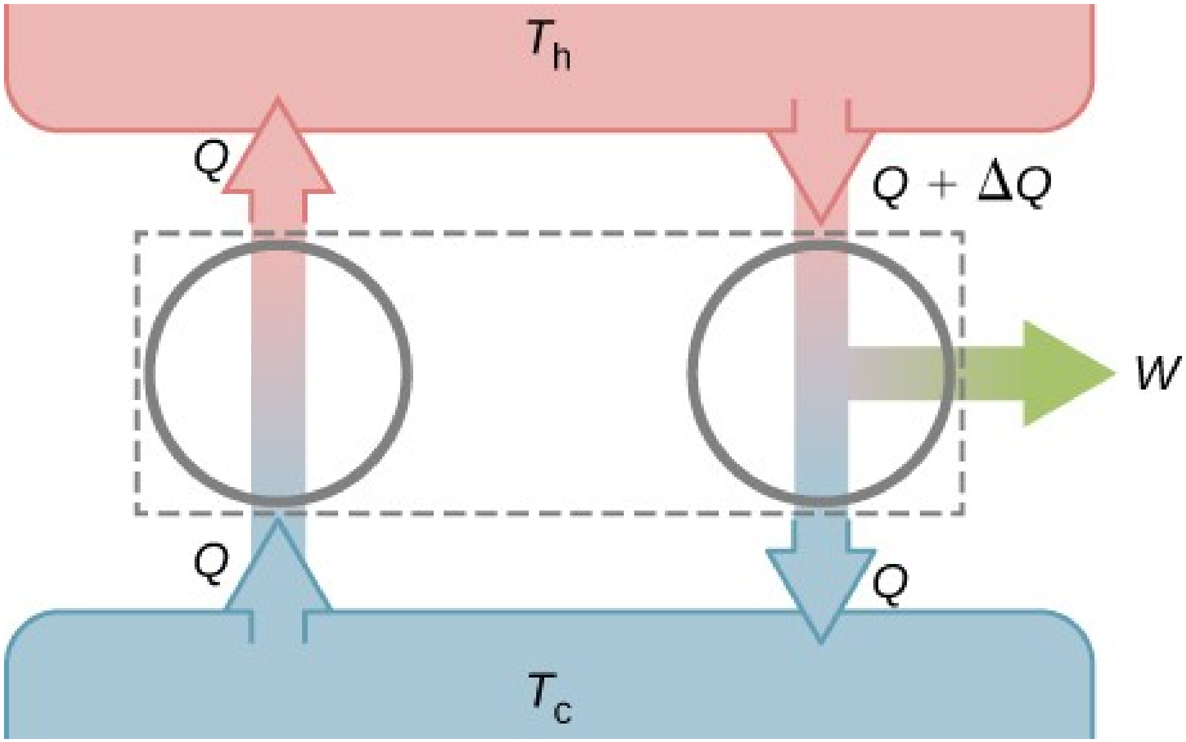
FIGURE 4.8



a) A “perfect heat engine” converts all input heat into work.

b) A “perfect refrigerator” transports heat from a cold reservoir to a hot reservoir without work input. Neither of these devices is achievable in reality.

FIGURE 4.9



Combining a perfect refrigerator and a real heat engine yields a perfect heat engine because $W = \Delta Q$.

FIGURE 4.16

The closed loop passing through states *A* and *B* represents a reversible cycle.

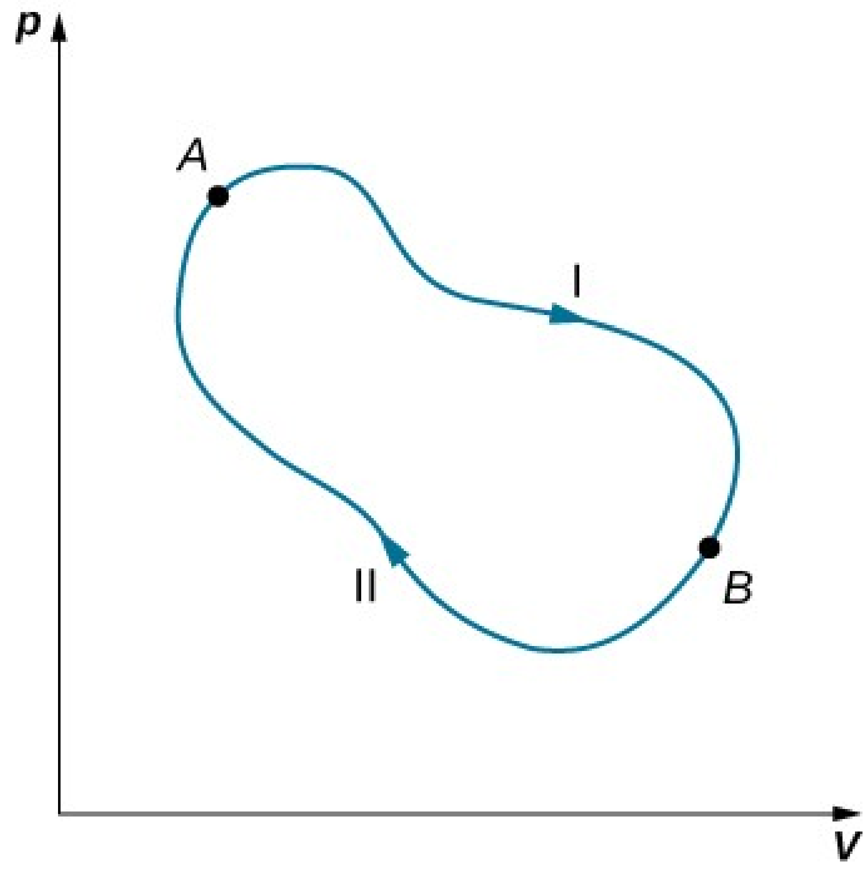
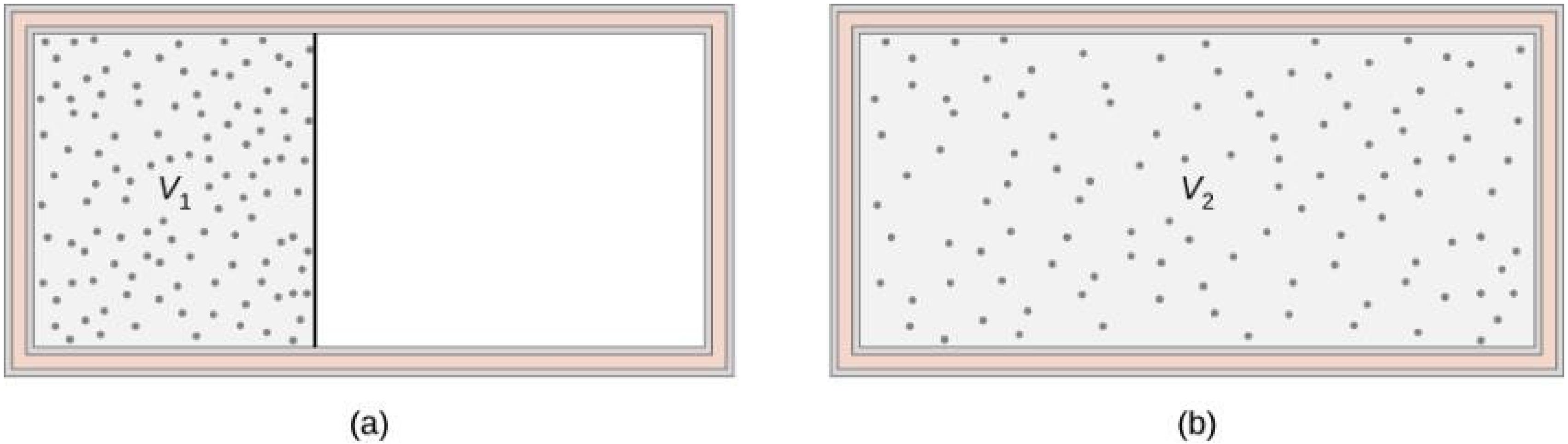


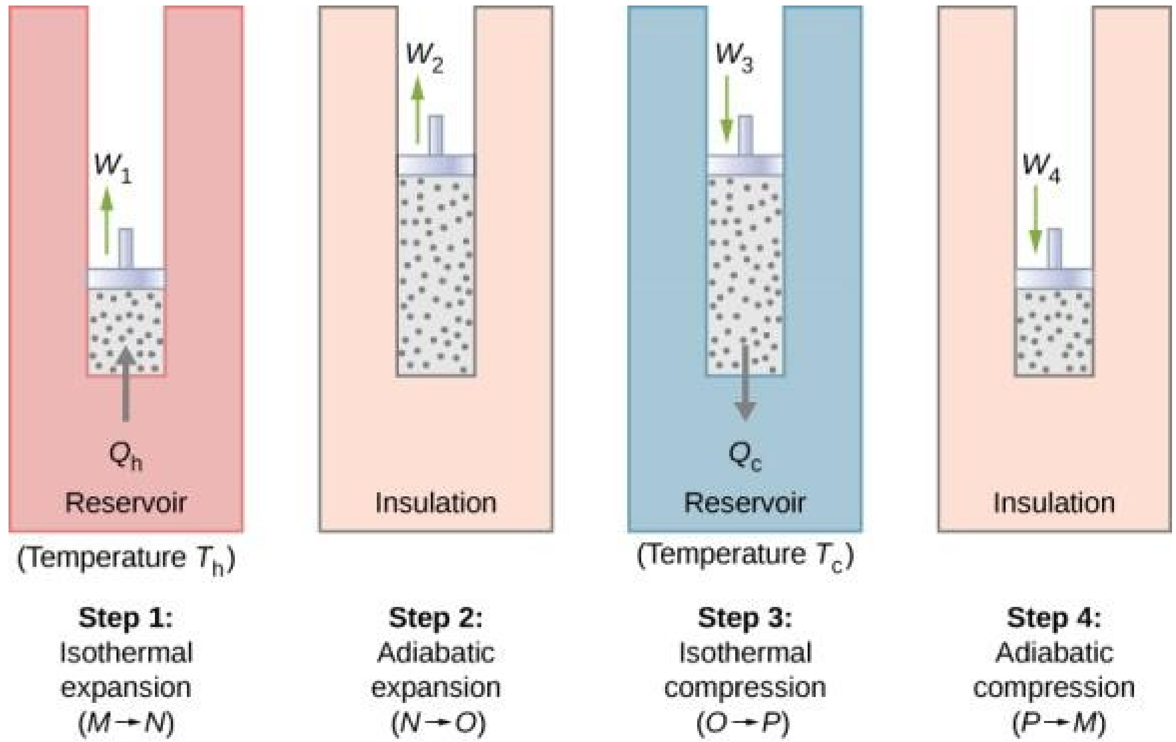
FIGURE 4.18



The adiabatic free expansion of an ideal gas from volume V_1 to volume V_2.

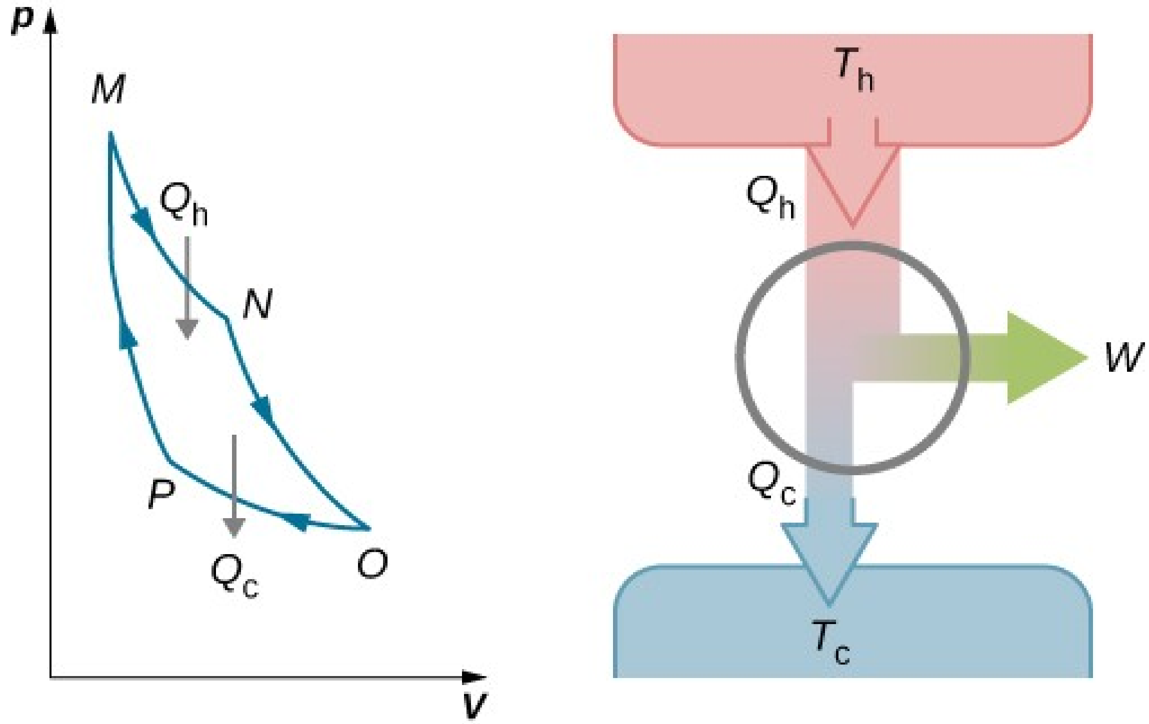
Carnot Cycle

FIGURE 4.11



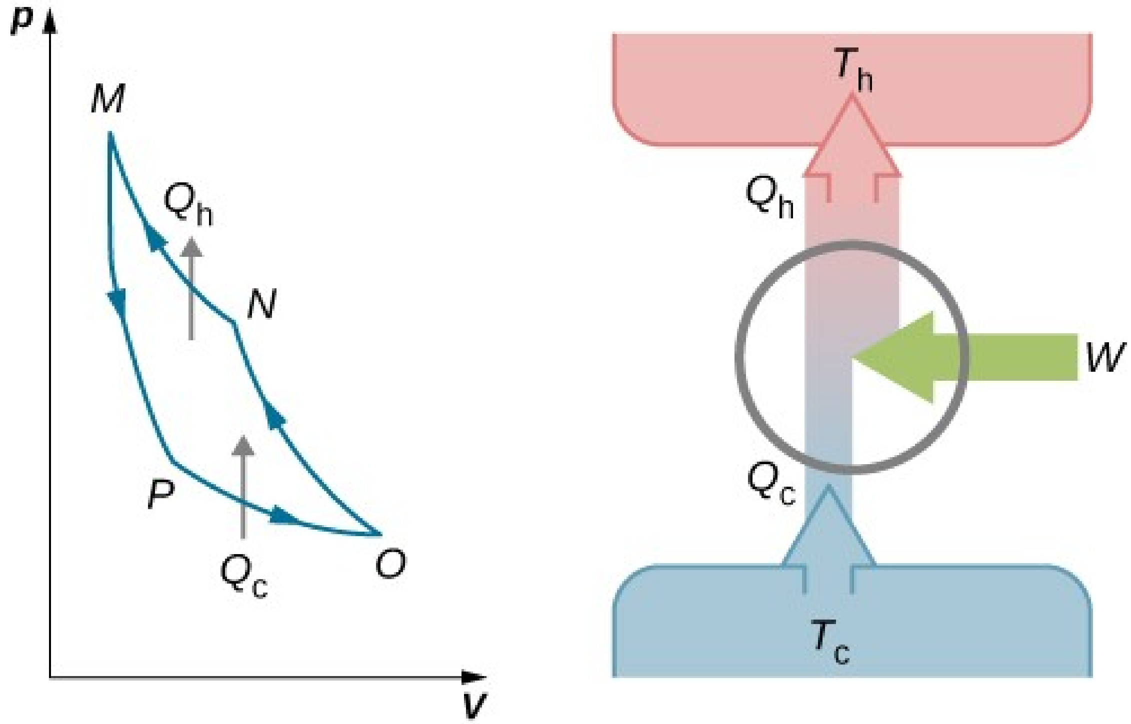
The four processes of the Carnot cycle. The working substance is assumed to be an ideal gas whose thermodynamic path *MNOP* is represented in **Figure 4.12**.

FIGURE 4.12



The total work done by the gas in the Carnot cycle is shown and given by the area enclosed by the loop *MNOPM*.

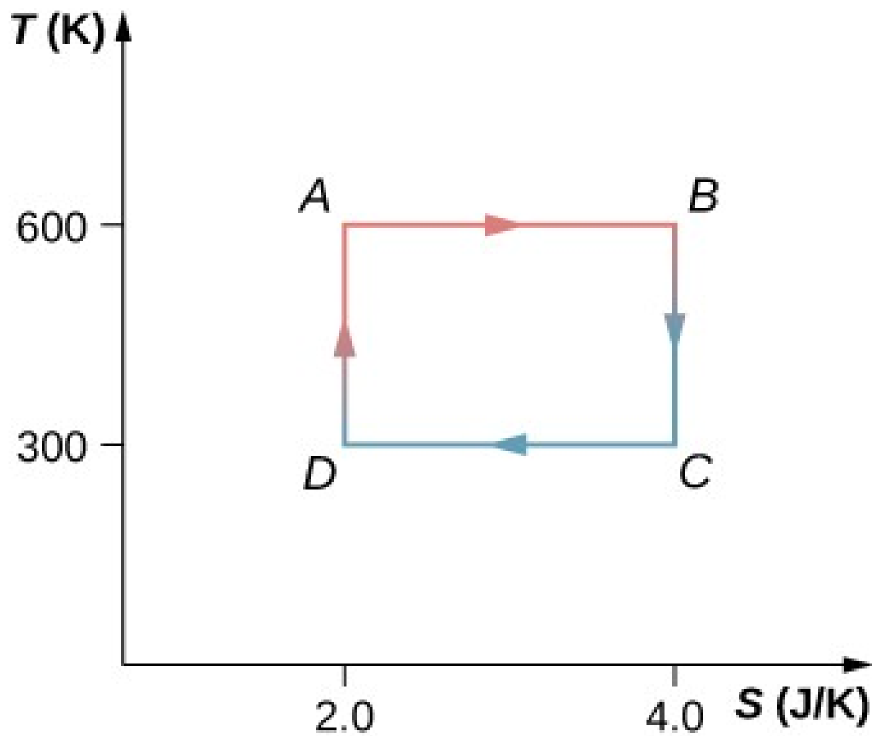
FIGURE 4.13



The work done on the gas in one cycle of the Carnot refrigerator is shown and given by the area enclosed by the loop *MPONM*.

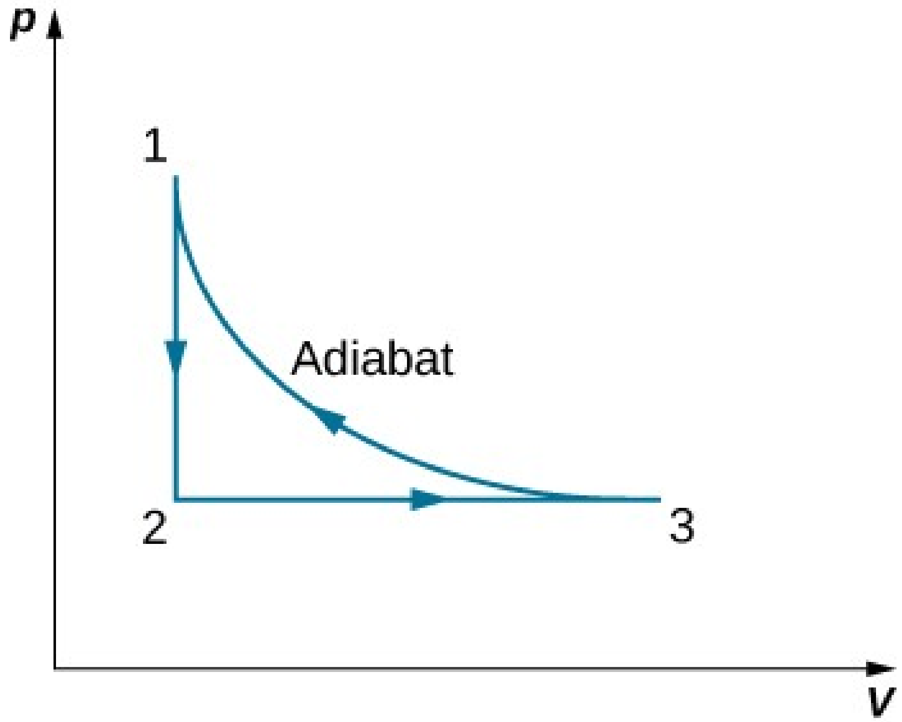
Examples

EXERCISE 61



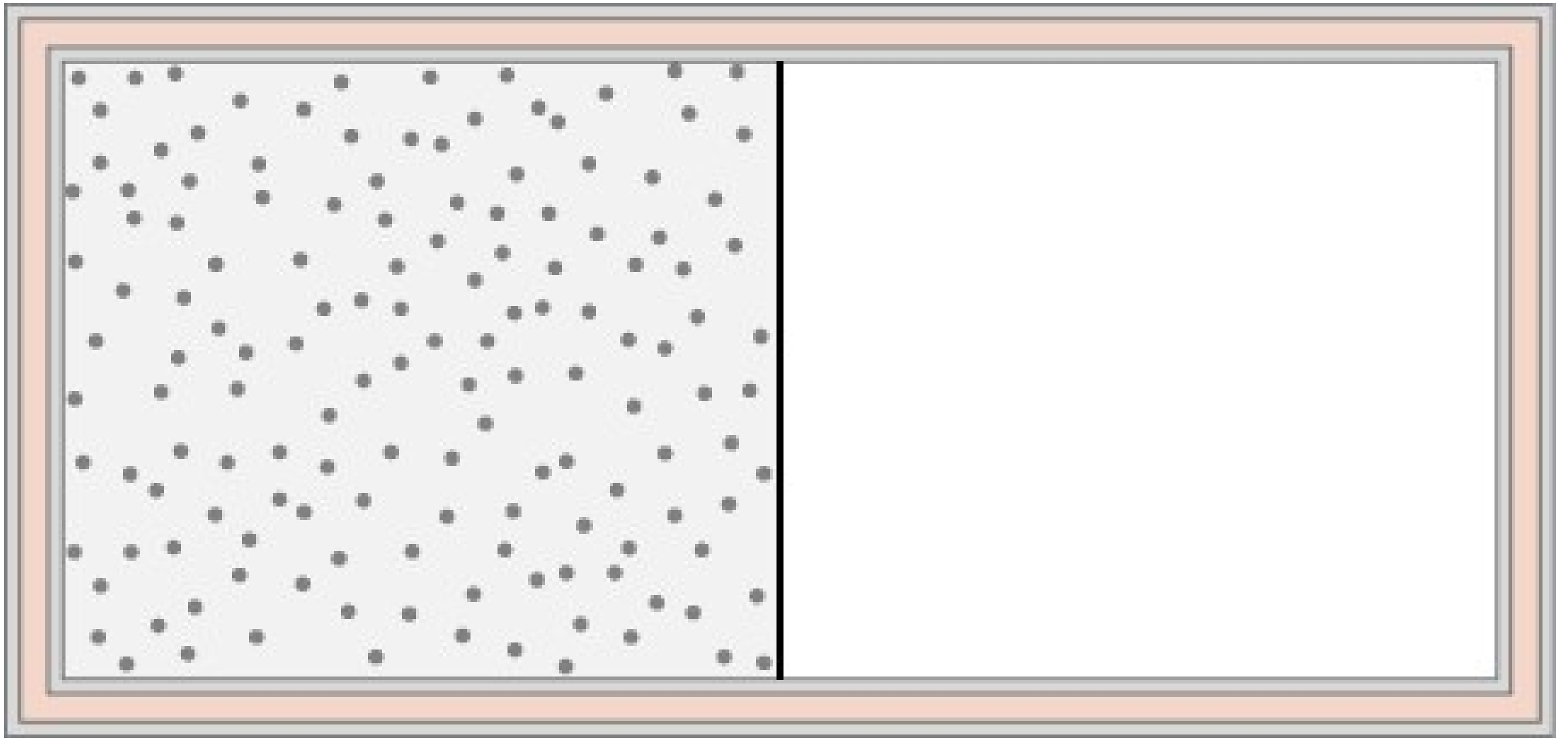
The Carnot cycle is represented by the temperature-entropy diagram shown below. (a) How much heat is absorbed per cycle at the high-temperature reservoir? (b) How much heat is exhausted per cycle at the low-temperature reservoir? (c) How much work is done per cycle by the engine? (d) What is the efficiency of the engine?

EXERCISE 63



A monoatomic ideal gas (n moles) goes through a cyclic process shown below. Find the change in entropy of the gas in each step and the total entropy change over the entire cycle.

EXERCISE 74



An ideal gas at temperature T is stored in the left half of an insulating container of volume V using a partition of negligible volume (see below). What is the entropy change per mole of the gas in each of the following cases? (a) The partition is suddenly removed and the gas quickly fills the entire container. (b) A tiny hole is punctured in the partition and after a long period, the gas reaches an equilibrium state such that there is no net flow through the hole. (c) The partition is moved very slowly and adiabatically all the way to the right wall so that the gas finally fills the entire container.