4.9: Chapter 4 Problems

An underlined problem number or problem-part letter indicates that the numerical answer appears in Appendix I.

4.1 Explain why an electric refrigerator, which transfers energy by means of heat from the cold food storage compartment to the warmer air in the room, is not an impossible "Clausius device."

4.2 A system consisting of a fixed amount of an ideal gas is maintained in thermal equilibrium with a heat reservoir at temperature T. The system is subjected to the following isothermal cycle:

1. The gas, initially in an equilibrium state with volume V_0, is allowed to expand into a vacuum and reach a new equilibrium state of volume V'.

2. The gas is reversibly compressed from V' to V_0.

For this cycle, find expressions or values for w, $\oint \mathrm{d}q/T$, and $\oint \mathrm{d}S$.

4.3 In an irreversible isothermal process of a closed system:

(a) Is it possible for ΔS to be negative?

(b) Is it possible for ΔS to be less than q/T ?

4.4 Suppose you have two blocks of copper, each of heat capacity $C_V = 200.0 \mathrm{JK}^{-1}$. Initially one block has a uniform temperature of $300.00\ \mathrm{K}$ and the other $310.00\ \mathrm{K}$. Calculate the entropy change that occurs when you place the two blocks in thermal contact with one another and surround them with perfect thermal insulation. Is the sign of ΔS consistent with the second law? (Assume the process occurs at constant volume.)

4.5 Refer to the apparatus shown in Figs. 3.23 on page 101 and 3.26 on page 103 and described in Probs. 3.3 and 3.8. For both systems, evaluate ΔS for the process that results from opening the stopcock. Also evaluate $\int \mathrm{d}q/T_{\mathrm{ext}}$ for both processes (for the apparatus in Fig. 3.26, assume the vessels have adiabatic walls). Are your results consistent with the mathematical statement of the second law?

Figure 4.13

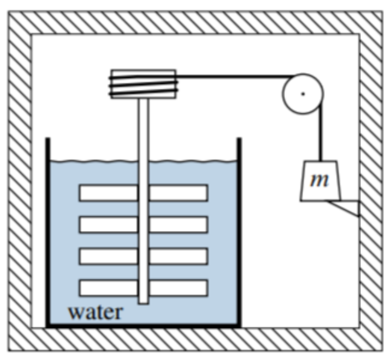

Figure 4.13

4.6 Figure 4.13 shows the walls of a rigid thermally-insulated box (cross hatching). The system is the contents of this box. In the box is a paddle wheel immersed in a container of water, connected by a cord and pulley to a weight of mass m. The weight rests on a stop located a distance h above the bottom of the box. Assume the heat capacity of the system, C_V, is independent of temperature. Initially the system is in an equilibrium state at temperature T_1.

When the stop is removed, the weight irreversibly sinks to the bottom of the box, causing the paddle wheel to rotate in the water. Eventually the system reaches a final equilibrium state with thermal equilibrium. Describe a reversible process with the same entropy change as this irreversible process, and derive a formula for ΔS in terms of m, h, C_V, and T_1.