Exercise 6. The following facts are known about five separate processes that occur to a closed system. Specify, as best you can, the entropy change that occurs to the *system*. Answer increases, decreases, or can't tell. Process (a) Q = 2 J; (b) Q = -2 J; (c) Q = -2 J and W = 3 J; (d) Q = -2 J and W^i_{irr} = 1 J; (e) Q = -2 J and W^i_{irr} = 3 J.

Exercise 7. A closed system undergoes a process with an entropy change of -2 J/K. What conclusions can be drawn about (a) the entropy change of the surroundings? (b) the direction of heat flow?

Exercise 8. A system is made to undergo, in turn, two processes between the same initial and final equilibrium states. One of the two processes is reversible, the other irreversible. Which process will result in a greater entropy change of: (a) the system? (b) the universe? What is the entropy change of the universe for the reversible process?

The production that occurs within a system can be explicitly determined by carefully examining the terms of eqn. IIIB-21. We define them as the thermal and mechanical entropy change, respectively.

$$dS = \frac{đQ + đW^i_{irr}}{T_{eq}} = dS_{th} + dS_m \qquad \text{(IIIB-21)}$$

where

$$dS_{th} \equiv \frac{đQ}{T_{eq}} \qquad dS_m \equiv \frac{đW^i_{irr}}{T_{eq}} \qquad \text{(IIIB-24a,b)}$$

We have explicitly identified the temperature as its equilibrium value, T_{eq}. This specificity is necessary since we will deal with systems that are not in thermal equilibrium, i.e., those with nonuniform temperature. The equilibrium temperature corresponding to a nonequilibrium state is the temperature that would be achieved were the system isolated and allowed to relax to equilibrium.

Note to the Student. In the following sections we identify the sources of entropy production. We reinforce these principles with numerical illustrations requiring separate consideration of the magnitude of force and temperature differentials within the system. Use of these calculation procedures is not an objective of the unit. (Calculation of the net effect of thermal and mechanical irreversibility are objectives of Units IVA and IVC.) Study these problems insofar as they help you to recognize the sources of mechanical and thermal irreversibility.

A. Mechanical Entropy Production

Since irreversible work is positive semidefinite, $đW^i_{irr} \geq 0$, the mechanical entropy term is pure production.

$$dS_m = \frac{đW^i_{irr}}{T_{eq}} \geq 0 \qquad \text{(IIIB-24b)}$$

Mechanical irreversibility can originate in any intrinsic work mode. As specific illustrations, we cite the three mechanical irreversibilities considered in Section III of Unit IB.