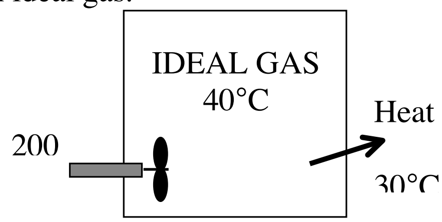
Homework #12 Solutions
ME/CH EN 2300

1. **7-17C** Increases.

2. 7-23 A rigid tank contains an ideal gas that is being stirred by a paddle wheel. The temperature of the gas remains constant as a result of heat transfer out. The entropy change of the gas is to be determined.

Assumptions The gas in the tank is given to be an ideal gas.

Analysis The temperature and the specific volume of the gas remain constant during this process. Therefore, the initial and the final states of the gas are the same. Then $s_2 = s_1$ since entropy is a property. Therefore,

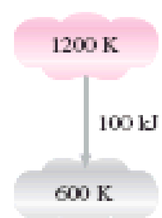


$$\Delta S_{sys} = \mathbf{0}$$

3. 7-25 Heat is transferred directly from an energy-source reservoir to an energy-sink. The entropy change of the two reservoirs is to be calculated and it is to be determined if the increase of entropy principle is satisfied.

Assumptions The reservoirs operate steadily.

Analysis The entropy change of the source and sink is given by



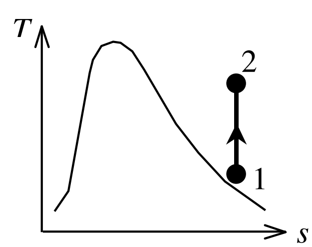
$$\Delta S = \frac{Q_H}{T_H} + \frac{Q_L}{T_L} = \frac{-100\text{ kJ}}{1200\text{ K}} + \frac{100\text{ kJ}}{600\text{ K}} = \mathbf{0.0833\ kJ/K}$$

Since the entropy of everything involved in this process has increased, this transfer of heat is **possible**.

4. **7-37** Water is compressed in a compressor during which the entropy remains constant. The final temperature and enthalpy are to be determined.

Analysis The initial state is superheated vapor and the entropy is

$$\left.\begin{array}{l} T_1 = 160°\text{C} \\ P_1 = 35\text{ kPa} \end{array}\right\} \begin{array}{l} h_1 = 2800.7\text{ kJ/kg} \\ s_1 = 8.1531\text{ kJ/kg}\cdot\text{K} \end{array} \quad \text{(from EES)}$$



Note that the properties can also be determined from Table A-6 by interpolation but the values will not be as accurate as those by EES. The final state is superheated vapor and the properties are (Table A-6)

$$\left.\begin{array}{l} P_2 = 300\text{ kPa} \\ s_2 = s_1 = 8.1531\text{ kJ/kg}\cdot\text{K} \end{array}\right\} \begin{array}{l} T_2 = \mathbf{440.5°C} \\ h_2 = \mathbf{3361.0\ kJ/kg} \end{array}$$

5. **7-67** A hot copper block is dropped into water in an insulated tank. The final equilibrium temperature of the tank and the total entropy change are to be determined.

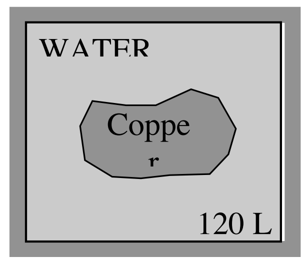
Assumptions **1** Both the water and the copper block are incompressible substances with constant specific heats at room temperature. **2** The system is stationary and thus the kinetic and potential energies are negligible. **3** The tank is well-insulated and thus there is no heat transfer.

Properties The density and specific heat of water at 25°C are ρ = 997 kg/m^3 and c_p = 4.18 kJ/kg.°C. The specific heat of copper at 27°C is c_p = 0.386 kJ/kg.°C (Table A-3).

Analysis We take the entire contents of the tank, water + copper block, as the *system*. This is a *closed system* since no mass crosses the system boundary during the process. The energy balance for this system can be expressed as

$$\underbrace{E_{in} - E_{out}}_{\substack{\text{Net energy transfer}\\ \text{by heat, work, and mass}}} = \underbrace{\Delta E_{system}}_{\substack{\text{Change in internal, kinetic,}\\ \text{potential, etc. energies}}}$$

$$0 = \Delta U$$



or,

$$\Delta U_{Cu} + \Delta U_{water} = 0$$

$$[mc(T_2 - T_1)]_{Cu} + [mc(T_2 - T_1)]_{water} = 0$$

where

$$m_{water} = \rho V = (997\ \text{kg/m}^3)(0.120\ \text{m}^3) = 119.6\ \text{kg}$$

Using specific heat values for copper and liquid water at room temperature and substituting,

$$(50\ \text{kg})(0.386\ \text{kJ/kg}\cdot°\text{C})(T_2 - 80)°\text{C} + (119.6\ \text{kg})(4.18\ \text{kJ/kg}\cdot°\text{C})(T_2 - 25)°\text{C} = 0$$

$$T_2 = \mathbf{27.0°C}$$

The entropy generated during this process is determined from

$$\Delta S_{copper} = mc_{avg}\ln\left(\frac{T_2}{T_1}\right) = (50\ \text{kg})(0.386\ \text{kJ/kg}\cdot\text{K})\ln\left(\frac{300.0\ \text{K}}{353\ \text{K}}\right) = -3.140\ \text{kJ/K}$$

$$\Delta S_{water} = mc_{avg}\ln\left(\frac{T_2}{T_1}\right) = (119.6\ \text{kg})(4.18\ \text{kJ/kg}\cdot\text{K})\ln\left(\frac{300.0\ \text{K}}{298\ \text{K}}\right) = 3.344\ \text{kJ/K}$$

Thus,

$$\Delta S_{total} = \Delta S_{copper} + \Delta S_{water} = -3.140 + 3.344 = \mathbf{0.204\ kJ/K}$$