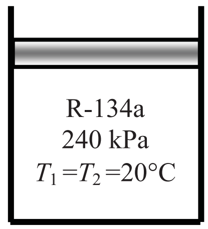
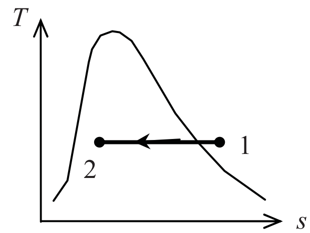
8-52 R-134a undergoes an isothermal process in a closed system. The work and heat transfer are to be determined.

Assumptions **1** The system is stationary and thus the kinetic and potential energy changes are zero. **2** There are no work interactions involved other than the boundary work. **3** The thermal energy stored in the cylinder itself is negligible. **4** The compression or expansion process is quasi-equilibrium.

Analysis The energy balance for this system can be expressed as





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

$$W_{in}-Q_{out}=\Delta U=m(u_2-u_1)$$

The initial state properties are

$$\left.\begin{aligned}P_1&=240\text{ kPa}\\T_1&=20°\text{C}\end{aligned}\right\}\begin{aligned}u_1&=246.74\text{ kJ/kg}\\s_1&=1.0134\text{ kJ/kg}\cdot\text{K}\end{aligned}\quad\text{(Table A-13)}$$

For this isothermal process, the final state properties are (Table A-11)

$$\left.\begin{aligned}T_2&=T_1=20°\text{C}\\x_2&=0.20\end{aligned}\right\}\begin{aligned}u_2&=u_f+x_2u_{fg}=78.86+(0.20)(162.16)=111.29\text{ kJ/kg}\\s_2&=s_f+x_2s_{fg}=0.30063+(0.20)(0.62172)=0.42497\text{ kJ/kg}\cdot\text{K}\end{aligned}$$

The heat transfer is determined from

$$q_{in}=T_0(s_2-s_1)=(293\text{ K})(0.42497-1.0134)\text{ kJ/kg}\cdot\text{K}=-172.4\text{ kJ/kg}$$

The negative sign shows that the heat is actually transferred from the system. That is,

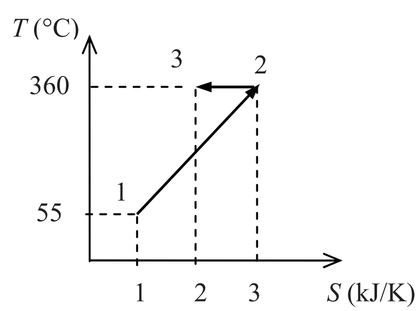
$$q_{out}=\mathbf{172.4\ kJ/kg}$$

The work required is determined from the energy balance to be

$$w_{in}=q_{out}+(u_2-u_1)=172.4\text{ kJ/kg}+(111.29-246.74)\text{ kJ/kg}=\mathbf{36.95\ kJ/kg}$$

8-53 The total heat transfer for the process 1-3 shown in the figure is to be determined.

Analysis For a reversible process, the area under the process line in *T*-*s* diagram is equal to the heat transfer during that process. Then,



$$\begin{aligned}Q_{1\text{-}3}&=Q_{1\text{-}2}+Q_{2\text{-}3}\\&=\int_1^2 TdS+\int_2^3 TdS\\&=\frac{T_1+T_2}{2}(S_2-S_1)+T_2(S_3-S_2)\\&=\frac{(360+273)+(55+273)\text{ K}}{2}(3-1)\text{kJ/K}+(360+273\text{ K})(2-3)\text{kJ/K}\\&=\mathbf{328\ kJ}\end{aligned}$$