5-72 Air in a closed system undergoes an isothermal process. The initial volume, the work done, and the heat transfer are to be determined.

Assumptions **1** Air is an ideal gas since it is at a high temperature and low pressure relative to its critical point values of 132.5 K and 3.77 MPa. **2** The kinetic and potential energy changes are negligible, $\Delta ke \cong \Delta pe \cong 0$. **3** Constant specific heats can be used for air.

Properties The gas constant of air is $R = 0.287$ kJ/kg·K (Table A-1).

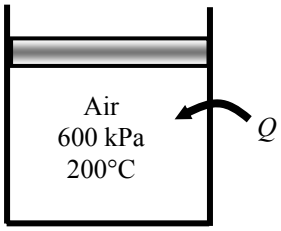
Analysis We take the air as the system. This is a *closed system* since no mass crosses the boundaries of the system. The energy balance for this system can be expressed as

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

$$Q_{\text{in}} - W_{b,\text{out}} = \Delta U = mc_{\nu}(T_2 - T_1)$$

$$Q_{\text{in}} - W_{b,\text{out}} = 0 \quad (\text{since } T_1 = T_2)$$

$$Q_{\text{in}} = W_{b,\text{out}}$$



The initial volume is

$$V_1 = \frac{mRT_1}{P_1} = \frac{(2\text{ kg})(0.287\text{ kPa}\cdot\text{m}^3/\text{kg}\cdot\text{K})(473\text{ K})}{600\text{ kPa}} = \mathbf{0.4525\ m^3}$$

Using the boundary work relation for the isothermal process of an ideal gas gives

$$W_{b,\text{out}} = m\int_1^2 P\,d\nu = mRT\int_1^2 \frac{d\nu}{\nu} = mRT\ln\frac{\nu_2}{\nu_1} = mRT\ln\frac{P_1}{P_2}$$

$$= (2\text{ kg})(0.287\text{ kPa}\cdot\text{m}^3/\text{kg}\cdot\text{K})(473\text{ K})\ln\frac{600\text{ kPa}}{80\text{ kPa}} = \mathbf{547.1\,kJ}$$

From energy balance equation,

$$Q_{\text{in}} = W_{b,\text{out}} = \mathbf{547.1\,kJ}$$

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