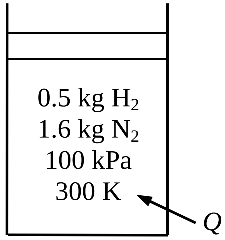
13-68 A piston-cylinder device contains a gas mixture at a given state. Heat is transferred to the mixture. The amount of heat transfer and the entropy change of the mixture are to be determined.

Assumptions **1** Under specified conditions both H_2 and N_2 can be treated as ideal gases, and the mixture as an ideal gas mixture. **2** Kinetic and potential energy changes are negligible.

Properties The constant pressure specific heats of H_2 and N_2 at 450 K are 14.501 kJ/kg.K and 1.049 kJ/kg.K, respectively. (Table A-2b).

Analysis (*a*) Noting that $P_2 = P_1$ and $\mathbf{V}_2 = 2\mathbf{V}_1$,



$$\frac{P_2\mathbf{V}_2}{T_2} = \frac{P_1\mathbf{V}_1}{T_1} \longrightarrow T_2 = \frac{2\mathbf{V}_1}{\mathbf{V}_1}T_1 = 2T_1 = (2)(300\text{ K}) = 600\text{ K}$$

From the closed system energy balance relation,

$$E_{\text{in}} - E_{\text{out}} = \Delta E_{\text{system}}$$

$$Q_{\text{in}} - W_{b,\text{out}} = \Delta U \quad \rightarrow \quad Q_{\text{in}} = \Delta H$$

since W_b and ΔU combine into ΔH for quasi-equilibrium constant pressure processes.

$$\begin{aligned} Q_{\text{in}} &= \Delta H = \Delta H_{H_2} + \Delta H_{N_2} = \left[mc_{p,\text{avg}}(T_2 - T_1)\right]_{H_2} + \left[mc_{p,\text{avg}}(T_2 - T_1)\right]_{N_2} \\ &= (0.5\text{ kg})(14.501\text{ kJ/kg}\cdot\text{K})(600-300)\text{K} + (1.6\text{ kg})(1.049\text{ kJ/kg}\cdot\text{K})(600-300)\text{K} \\ &= \mathbf{2679\,kJ} \end{aligned}$$

(*b*) Noting that the total mixture pressure, and thus the partial pressure of each gas, remains constant, the entropy change of the mixture during this process is

$$\begin{aligned} \Delta S_{H_2} &= \left[m(s_2 - s_1)\right]_{H_2} = m_{H_2}\left(c_p \ln\frac{T_2}{T_1} - \cancelto{0}{R\ln\frac{P_2}{P_1}}\right)_{H_2} = m_{H_2}\left(c_p \ln\frac{T_2}{T_1}\right)_{H_2} \\ &= (0.5\text{ kg})(14.501\text{ kJ/kg}\cdot\text{K})\ln\frac{600\text{ K}}{300\text{ K}} \\ &= 5.026\text{ kJ/K} \end{aligned}$$

$$\begin{aligned} \Delta S_{N_2} &= \left[m(s_2 - s_1)\right]_{N_2} = m_{N_2}\left(c_p \ln\frac{T_2}{T_1} - \cancelto{0}{R\ln\frac{P_2}{P_1}}\right)_{N_2} = m_{N_2}\left(c_p \ln\frac{T_2}{T_1}\right)_{N_2} \\ &= (1.6\text{ kg})(1.049\text{ kJ/kg}\cdot\text{K})\ln\frac{600\text{ K}}{300\text{ K}} \\ &= 1.163\text{ kJ/K} \end{aligned}$$

$$\Delta S_{\text{total}} = \Delta S_{H_2} + \Delta S_{N_2} = 5.026\text{ kJ/K} + 1.163\text{ kJ/K} = \mathbf{6.19\,kJ/K}$$