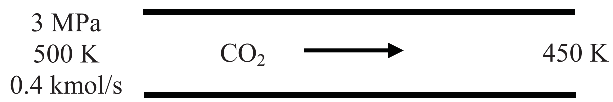
4-110 Carbon dioxide flows through a pipe at a given state. The volume and mass flow rates and the density of CO_2 at the given state and the volume flow rate at the exit of the pipe are to be determined.

Analysis (*a*) The volume and mass flow rates may be determined from ideal gas relation as



$$\dot{V}_1 = \frac{\dot{N} R_u T_1}{P} = \frac{(0.4\text{ kmol/s})(8.314\text{ kPa.m}^3\text{/kmol.K})(500\text{ K})}{3000\text{ kPa}} = \mathbf{0.5543\ m^3/s}$$

$$\dot{m}_1 = \frac{P_1 \dot{V}_1}{R T_1} = \frac{(3000\text{ kPa})(0.5543\text{ m}^3/s)}{(0.1889\text{ kPa.m}^3\text{/kg.K})(500\text{ K})} = \mathbf{17.60\ kg/s}$$

The density is

$$\rho_1 = \frac{\dot{m}_1}{\dot{V}_1} = \frac{(17.60\text{ kg/s})}{(0.5543\text{ m}^3\text{/s})} = \mathbf{31.76\ kg/m^3}$$

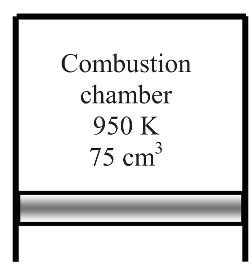
(b) The volume flow rate at the exit is

$$\dot{V}_2 = \frac{\dot{N} R_u T_2}{P} = \frac{(0.4\text{ kmol/s})(8.314\text{ kPa.m}^3\text{/kmol.K})(450\text{ K})}{3000\text{ kPa}} = \mathbf{0.4988\ m^3/s}$$

4-111 The cylinder conditions before the heat addition process is specified. The temperature after the heat addition process is to be determined.

Assumptions **1** The contents of cylinder is approximated by the air properties. **2** Air is an ideal gas.

Analysis The ratio of the initial to the final mass is



$$\frac{m_1}{m_2} = \frac{\text{AF}}{\text{AF}+1} = \frac{22}{22+1} = \frac{22}{23}$$

The final temperature may be determined from ideal gas relation

$$T_2 = \frac{m_1}{m_2}\frac{V_2}{V_1}T_1 = \left(\frac{22}{23}\right)\left(\frac{150\text{ cm}^3}{75\text{ cm}^3}\right)(950\text{ K}) = \mathbf{1817\ K}$$