Problem 2-64  A 0.5 m$^3$ rigid tank containing hydrogen at 20°C and 600 kPa is connected by a valve to another 0.5 m$^3$ rigid tank that holds hydrogen at 30°C and 150 kPa. The valve is then opened, and the system is allowed to reach thermal equilibrium with the surroundings which are 15°C. Determine the final pressure in the tank system.

\[ V = V_A + V_B = 0.5 + 0.5 = 1.0 \text{ m}^3 \]

\[ m_A = \left( \frac{P V}{R T_1} \right)_A = \frac{(600 \text{ kPa})(0.5 \text{ m}^3)}{(4.124 \text{ kPa} \cdot \text{m}^3/\text{kg} \cdot \text{K})(293 \text{ K})} = 0.248 \text{ kg} \]

\[ m_B = \left( \frac{P V}{R T_1} \right)_B = \frac{(150 \text{ kPa})(0.5 \text{ m}^3)}{(4.124 \text{ kPa} \cdot \text{m}^3/\text{kg} \cdot \text{K})(303 \text{ K})} = 0.060 \text{ kg} \]

\[ m = m_A + m_B = 0.248 + 0.060 = 0.308 \text{ kg} \]

\[ P = \frac{m R T_2}{V} = \frac{(0.308 \text{ kg})(4.124 \text{ kPa} \cdot \text{m}^3/\text{kg} \cdot \text{K})(288 \text{ K})}{1.0 \text{ m}^3} = 365.8 \text{ kPa} \]
Problem 2-65 A 20 m³ tank contains nitrogen at 25°C and 800 kPa. Some Nitrogen is then allowed to escape until the pressure in the tank drops to 600 kPa. If the temperature at this point is 20°C, determine the amount of nitrogen that has escaped.

Treating N₂ as an ideal gas, the initial and the final masses in the tank are determined to be

\[ m_1 = \frac{P_1V}{RT_1} = \frac{(800 \text{ kPa})(20 \text{ m}^3)}{(0.2968 \text{ kPa} \cdot \text{m}^3 / \text{kg} \cdot \text{K})(298 \text{ K})} = 180.9 \text{ kg} \]

\[ m_2 = \frac{P_2V}{RT_2} = \frac{(600 \text{ kPa})(20 \text{ m}^3)}{(0.2968 \text{ kPa} \cdot \text{m}^3 / \text{kg} \cdot \text{K})(293 \text{ K})} = 138.0 \text{ kg} \]

Thus the amount of N₂ that escaped is

\[ \Delta m = m_1 - m_2 = 180.9 - 138.0 = 42.9 \text{ kg} \]
Problem 2-68 A fan is to be installed to ventilate a 10 x 15 m smoking lounge that is 2.4 m high. Fresh air is supplied to the room at a rate of 30 L/sec per person. For 25 smokers in the room, determine a) the flow rate for the fan, and b) number of times the air in the room is changed per hour.

(a) The volume of the smoking lounge is

\[ V = (\text{length})(\text{width})(\text{height}) = (10 \, \text{m})(15 \, \text{m})(2.4 \, \text{m}) = 360 \, \text{m}^3 \]

Noting that there are 25 smokers, the fresh air requirement of the lounge is

\[ \dot{V}_{\text{fresh}} = (30 \, \text{L/s.smoker})(25 \, \text{smokers}) = 750 \, \text{L/s} = 0.750 \, \text{m}^3 / \text{s} \]

Therefore, the flow rate of the fan to be installed must be at least 750 L/s.

(b) The number of air changes per hour (ACH) is determined from

\[ ACH = \frac{\text{Air flow rate per hour}}{\text{volume of the room}} = \frac{(0.750 \, \text{m}^3 / \text{s})}{360 \, \text{m}^3} \left( \frac{3600 \, \text{s}}{1 \, \text{h}} \right) = 7.5 \, \text{h}^{-1} \]