Problem 1.11

Rooms A and B are the same size, and are connected by an open door. Room A, however, is warmer (perhaps because its windows face the sun). Which room contains the greater mass of air? Explain carefully.

Solution

Assume the air in these rooms obeys the ideal gas law.

$$PV = nRT$$

Each room has its own pressure, volume, temperature, and number of moles of air.

$$\begin{cases} P_A V_A = n_A R T_A \\ P_B V_B = n_B R T_B \end{cases} \tag{1}$$

Since rooms A and B are the same size, they have the same volume.

$$V_A = V_B$$

Since rooms A and B are connected by an open door, they have the same pressure.

$$P_A = P_B$$

As a result, equation (1) becomes

$$\begin{cases} P_B V_B = n_A R T_A \\ P_B V_B = n_B R T_B \end{cases}.$$

By the transitive property,

$$n_A R T_A = n_B R T_B.$$

Solve for n_A, the number of moles in room A.

$$n_A = \left(\frac{T_B}{T_A}\right) n_B$$

Because room A is warmer than room B, $T_A > T_B$, which makes the quantity in parentheses less than 1. This means

$$n_A < n_B.$$

There are more moles of air in room B, meaning room B contains the greater mass of air.