Problem 1.10

Estimate the number of air molecules in an average-sized room.

Solution

Assume the air is at room temperature (25°C, or 298.15 K) and atmospheric pressure (1 atm, or 101 325 Pa) so that the ideal gas law applies.

$$PV = nRT$$

Solve for n, the number of moles. Let the room be a box with dimensions of $\sqrt[3]{100}$ m $\times$ $\sqrt[3]{100}$ m $\times$ $\sqrt[3]{100}$ m so that $V = 100$ m^3.

$$n = \frac{PV}{RT} = \frac{(101\,325 \text{ Pa})(100 \text{ m}^3)}{\left(8.314 \frac{\text{J}}{\text{mol}\cdot\text{K}}\right)(298.15 \text{ K})} \approx 4000 \text{ mol}$$

Multiply the number of moles by Avogadro's constant to get the number of molecules in the air.

$$\begin{aligned} N &= n \times N_A \\ &\approx (4000 \text{ mol}) \times \left(6.02 \times 10^{23} \frac{\text{air molecules}}{\text{mol}}\right) \\ &\approx 10^{27} \text{ air molecules} \end{aligned}$$