2.7: The Ideal Gas Constant and Boltzmann's Constant

Having developed the ideal gas equation and analyzed experimental results for a variety of gases, we will have found the value of R. It is useful to have R expressed using a number of different energy units. Frequently useful values are

$$\begin{aligned} R &= 8.314 \text{ Pa m}^3 \text{ K}^{-1} \text{ mol}^{-1} \\ &= 8.314 \text{ J K}^{-1} \text{ mol}^{-1} \\ &= 0.08314 \text{ L bar K}^{-1} \text{ mol}^{-1} \\ &= 1.987 \text{ cal K}^{-1} \text{ mol}^{-1} \\ &= 0.08205 \text{ L atm K}^{-1} \text{ mol}^{-1} \end{aligned}$$

We also need the gas constant expressed per molecule rather than per mole. Since there is Avogadro's number of molecules per mole, we can divide any of the values above by $\overline{N}$ to get R on a per-molecule basis. Traditionally, however, this constant is given a different name; it is ***Boltzmann's constant***, usually given the symbol k.

$$k = R/\overline{N} = 1.381 \times 10^{-23} \text{ J K}^{-1} \text{ molecule}^{-1}$$

This means that we can also write the ideal gas equation as $PV = nRT = n\overline{N}kT$. Because the number of molecules in the sample, N, is $N = n\overline{N}$, we have

$$PV = NkT.$$