CHAPTER OVERVIEW

6: Quantal Ideal Gases

In the previous chapter, we found that at high temperatures, an ideal gas of diatomic molecules with spring interactions has a heat capacity of $\frac{7}{2}k_B$ per molecule: $\frac{3}{2}k_B$ from the translational degrees of freedom, k_B from the rotational degrees of freedom, and k_B from the spring degrees of freedom. If the temperature is decreased, the spring degrees of freedom become governed by quantum mechanics rather than classical mechanics, the equipartition theorem no longer holds, and eventually these degrees of freedom "freeze out" and contribute nothing to the heat capacity: the total heat capacity per molecule becomes $\frac{5}{2}k_B$. If the temperature is decreased still further, the story is repeated for the rotational degrees of freedom and eventually they freeze out. What happens if the temperature is decreased yet again? Do the translational degrees of freedom then freeze out as well? The answer is "sort of", but the crossover from the classical to the quantal regime is complicated in this case by the quantal requirement of interchange symmetry. This requirement gives rise to a much richer and more interesting crossover behavior than is provided by simple freeze out.