CHAPTER OVERVIEW

7: Classical Statistical Mechanics

Dynamics of particles is given by Newton's laws or, if we include quantum effects, the quantum mechanics of point-particles. Thus, if we have a large number of particles such as molecules or atoms which constitute a macroscopic system, then, in principle, the dynamics is determined. Classically, we just have to work out solutions to Newton's laws. But for systems with large numbers of particles, such as the Avogadro number which may be necessary in some cases, this is a wholly impractical task. We do not have general solutions for the three-body problem in mechanics, let alone for 10^{23} particles. What we can attempt to do is a statistical approach, where one focuses on certain averages of interest, which can be calculated with some simplifying assumptions. This is the province of Statistical Mechanics.

If we have N particles, in principle, we can calculate the future of the system if we are given the initial data, namely, the initial positions and velocities or momenta. Thus we need $6N$ input numbers. Already, as a practical matter, this is impossible, since $N \sim 10^{23}$ and we do not, in fact, cannot measure the initial positions and momenta for all the molecules in a gas at any time. So generally we can make the assumption that a probabilistic treatment is possible. The number of molecules is so large that we can take the initial data to be a set of random numbers, distributed according to some probability distribution. This is the basic working hypothesis of statistical mechanics. To get some feeling for how large numbers lead to simplification, we start with the binomial distribution.
