Section 0
Aims and Objectives of the Course

0.1 Thermodynamics and Statistical Mechanics

0.1.1 The nature of these disciplines

Thermodynamics provides a description of the macroscopic properties of matter and their inter-relationships. The laws of thermodynamics impose inviolable constraints on the behaviour of systems. Thus, for instance, we might find a relation between the thermal capacity of a gas measured at constant pressure and at constant volume. Thermodynamics provides relationships between thermodynamic variables.

Statistical Mechanics explains the macroscopic properties of matter in terms of its microscopic details. Thus it enables us to calculate thermodynamic variables of a system in terms of a microscopic model of that system. It helps us understand the significance of the thermodynamic variables — particularly those such as temperature and entropy which have no microscopic / mechanical explanation. Statistical mechanics will also explain the laws of thermodynamics from microscopic first principles.

Statistical mechanics has a predictive power. We construct a microscopic model. Using the tools of statistical mechanics we can calculate something which is measurable, thereby offering the possibility of an experimental test of our model. The tools of statistical mechanics are general, but the microscopic models are system-specific. In this course we will introduce the tools and see them in action on various model systems.

Thermodynamics, on the other hand, is completely general. It must apply to all systems and therein lies its power. Its results do not depend on the microscopic model of the system. If we find that somehow or other we have managed to violate the laws of thermodynamics then we have a problem!

Thermodynamics also makes life easier. Thermodynamics tells us about simple relationships between different properties of a system. So if used in conjunction with statistical mechanics we don't have to calculate *all* properties starting from the microscopic model.

0.1.2 Historical Perspective

Thermodynamics and statistical mechanics evolved as separate disciplines. Thermodynamics is quite old, having started with people such as Robert Boyle (1627-1691), Benjamin Thompson, Count Rumford (1753-1814) and Sadi Carnot (1796-1832).

Statistical mechanics really got underway with the work of Josiah Willard Gibbs (1839-1903) and Ludwig Boltzmann (1844-1906).