3.1: Prelude to Thermodynamics

Albert Einstein, a noted physicist, said of thermodynamics (Einstein, 1979)

> *"A law is more impressive the greater the simplicity of its premises, the more different are the kinds of things it relates, and the more extended its range of applicability. (..) It is the only physical theory of universal content, which I am convinced, that within the framework of applicability of its basic concepts will never be overthrown."*

Thermodynamics is the study of how energy flows into and out of systems and how it flows through the universe. People have been studying thermodynamics for a very long time and have developed the field a great deal, including the incorporation of high-level mathematics into the process. Many of the relationships may look cumbersome or complicated, but they are always describing the same basic thing: the flow of energy through the universe.

Energy, of course, can be used to do many useful things, such as allow us to drive our cars, use electronic devices, heat our homes, and cook our food. Chemistry is important as well since many of the processes in which we generate energy depend on chemical reactions (such as the combustion of hydrocarbons to generate heat or electron transfer reactions to generate electron flow.) The previous chapter investigated gases which are convenient systems to use to frame many discussions of thermodynamics since they can be modeled using specific equations of state such as the ideal gas law or the van der Waals law. These relationships depend on an important class of variables known as **state variables**.

State variables are those variables which depend only upon the current conditions affecting a system. Pressure, temperature and molar volume are examples of state variables. A number of variables required to describe the flow of energy in a system do depend on the pathway a system follows to come into its current state.

To illustrate the difference, consider climbing a mountain. You may choose to walk straight up the side of the mountain, or you may choose to circle the mountain several times in order to get to the top. These two pathways will differ in terms of how far you actually walk (a path-dependent variable) to attain the same change in altitude (an example of a state variable.)