5: Thermodynamic Processes

We shall be considering what happens when we perform certain *processes* on various *systems*. The processes will usually entail either doing work on a system or adding heat to it, or perhaps we shall allow the system to do work on its surroundings, or the system may lose heat to its surroundings.

Often the system we have in mind will be a gas enclosed by a movable piston inside a cylinder, but it need not be that. The system may be a solid or a liquid, in which there is little change in volume. Or the system may have several phases, such as gas, liquid and solid. There may be several components to the system – for example, a mixture of chemicals. Or the system may be a magnetic material, and we do work on it by putting it in a magnetic field and magnetizing it. Some fundamental thermodynamical laws apply to *any* thermodynamical system and are of great generality. Other laws may apply only to certain specific types of system, and we must always be on our guard to recognize which are general laws applicable to any system, and which are special equations applicable only to particular systems.

We shall, in our imagination, carry out processes under various ideal conditions. Thus, we may imagine a process to be *isothermal* (carried out at constant temperature) or *isobaric* (constant pressure) or *isochoric* (constant volume). We may imagine a process in which no heat is added to or is lost from the system. Such a process is adiabatic.

A process may be *quasistatic* or *nonquasistatic*. Let us imagine that we have a box of gas, and we suddenly heat one wall of the box by pushing that wall up against a source of heat. Not all of the gas will immediately become hotter. At first, the gas near to the heated wall will start to warm up, while the gas at the far end of the box will scarcely be aware of what has happened. Eventually, heat will permeate throughout the box, but this may take some time, and the system is not at all in static equilibrium while these changes are taking place. Likewise, if we have a gas held inside a cylinder by means of a movable piston, and we suddenly move the piston inwards. This will not result in an immediate change to a higher pressure throughout the gas. At the very most the information about the new position of the piston can travel through the gas only at the speed of sound. Considerable local turbulence is likely to be caused, and it will be some time before the gas settles down to its new uniform pressure throughout. Both of these processes are *nonquasistatic*.

For a process to be *quasistatic*, the pressure and temperature of the system must differ from those of its surroundings by only an infinitesimal amount at all times during the process; the process must take place slowly, so that the system passes through an infinite succession of quasi-equilibrium states. The prefix "quasi" is often translated as "almost"; a more precise meaning is "as it were" or "as if it were". The reader will conclude that there cannot ever literally be any process that is truly static. This is also true of other processes, such as isothermal and adiabatic processes. Such processes are limiting theoretical processes. A real process may be intermediate between the ideal extremes, although it may also be quite close to one of the ideal extremes.