

The Nature of Irreversibility excerpt pp 28 and 29

entropy

Entropy S is an extensive parameter of a system that helps to assess the flow of energy through a thermodynamic process. It quantifies the amount of a system's thermal energy that is unavailable for conversion into mechanical work. Entropy can be defined at both the macroscopic and submicroscopic levels, but rather obscurely in each.

It was originally defined at the macroscopic level for what were called thermodynamically reversible processes, i. e., those for which, after each cycle, the system is returned to virtually the same state as we have seen. Thus, by reversing the equation for an incremental heat change, we obtain:

$$dS = dQ / T$$

where the temperature T is divided into the increment of heat energy dQ that is transferred into and out of a system on each cycle in performing mechanical work. As is usual with macroscopic thermodynamics, this definition ignores whatever the associated facts might be concerning the lower levels of reality involving the atoms and molecules of which the system is comprised.

In thermodynamics, entropy has been found to be very generally useful and it has several other reformulations. Entropy was discovered via mathematics, which merely states that it was derived by analogy to the role of volume in the determination of mechanical work. It is understood more as a logical consequence of relations between physical parameters that were discovered by experiment than as having itself resulted from some particular experiment. It is a quantity that behaves as a function of the overall state of a system.

At a lower level of description in statistical mechanics, the additional concepts of 'order' and 'disorder' of lower-level constituents of a system were introduced into the concept of entropy as additional concomitants as we will discuss in more detail further on. Recently thermodynamic processes are often described in terms of the state of order of a system, such that entropy has become an expression of the degree of randomness. In more modern submicroscopic interpretations entropy is defined as the amount of additional information needed to specify the exact physical state of a system, given the system's higher level thermodynamic description in terms of the usual pressure, volume, temperature, and density. As a consequence, the second law of thermodynamics is now more typically seen by physicists as dependent on this particular definition of entropy.

In this scheme entropy is more descriptively expressed in the following terms:

$$S \equiv k + \log n$$

Where k is Boltzmann's constant as previously defined, and n is defined as the number of submicroscopic particle states in the system consistent with a single given state of the system at the macroscopic level. There is, of course, a huge number of alternative possible positions and velocities of the individual particles in the phase space of the system. All of these possible alternatives give rise to the very same volume, pressure, density, and temperature (macroscopic state) of that system but with an effectual difference with regards entropy.

We will expend considerable discussion on this topic presently.