23.2: Second Law of Thermodynamics

What use is entropy? In our example we found that the number of states for the situation in which all of the internal energy of a brick is restricted to half of the brick is much less than the number of states available when no restrictions are put upon the distribution of the same amount of internal energy through the entire brick. Thus, the entropy, which is just proportional to the logarithm of the number of available states, is less in the restricted case than it is in the unrestricted case.

This turns out to be generally true. *Any* measurable restriction we place on the distribution of internal energy in the brick turns out to result in a *much* smaller number of available quantum mechanical states and hence a smaller value for the entropy. Once such a restriction is lifted, all possible states become available, and according to the postulates of statistical mechanics the brick eventually evolves to the point where it is roaming randomly through these states. The probability of the brick revisiting the original restricted set of states is so small as to be completely ignorable once it forgets its initial state, because these states form only a miniscule fraction of the states available to the brick. Thus, with a very high degree of certainty, one can say that the entropy of the brick increases when the restriction is lifted.

Strictly speaking, our definition of entropy is only valid after the brick has reached equilibrium, i. e., when the initial state has been forgotten. The entropy during the equilibration period according to our definition is technically undefined.

Our inferences about a brick can be extended to any isolated system, i. e., any system that doesn't exchange mass or energy with the outside world: *The entropy of any isolated system consisting of a large number of atoms will not spontaneously decrease with time.* This principle is called the *second law of thermodynamics*.