9.10: A Slightly Philosophical Digression on Energy and Entropy

The content of the first law of thermodynamics is that there is a state function, which we call energy, which has the property that $\Delta E_{universe} = 0$ for any process that can occur. The content of the second law is that there is a state function, which we call entropy, which has the property that $\Delta S_{universe} > 0$ for any spontaneous process.

These two state functions exhaust the range of independent possibilities: Suppose that we aspire to find a new and independent state function, call it B, which further characterizes the possibilities open to the universe. What other condition could B impose on the universe—or *vice versa*? The only available candidate might appear to be $\Delta B_{universe} < 0$. However, this does not represent an independent condition, since its role is already filled by the quantity $-\Delta S_{universe}$.

Of course, we can imagine a state function, B, which is not simply a function of S, but for which

$\Delta B_{universe} > 0$, $\Delta B_{universe} = 0$, or $\Delta B_{universe} < 0$, according as the process is spontaneous, reversible, or impossible, respectively. For any given change, ΔB would not be the same as ΔS; however, ΔB and ΔS would make exactly the same predictions. If $\Delta B_{universe}$ were more easily evaluated than $\Delta S_{universe}$, we would prefer to use B rather than S. Nevertheless, if there were such a function B, its role in our description of nature would duplicate the role played by S.