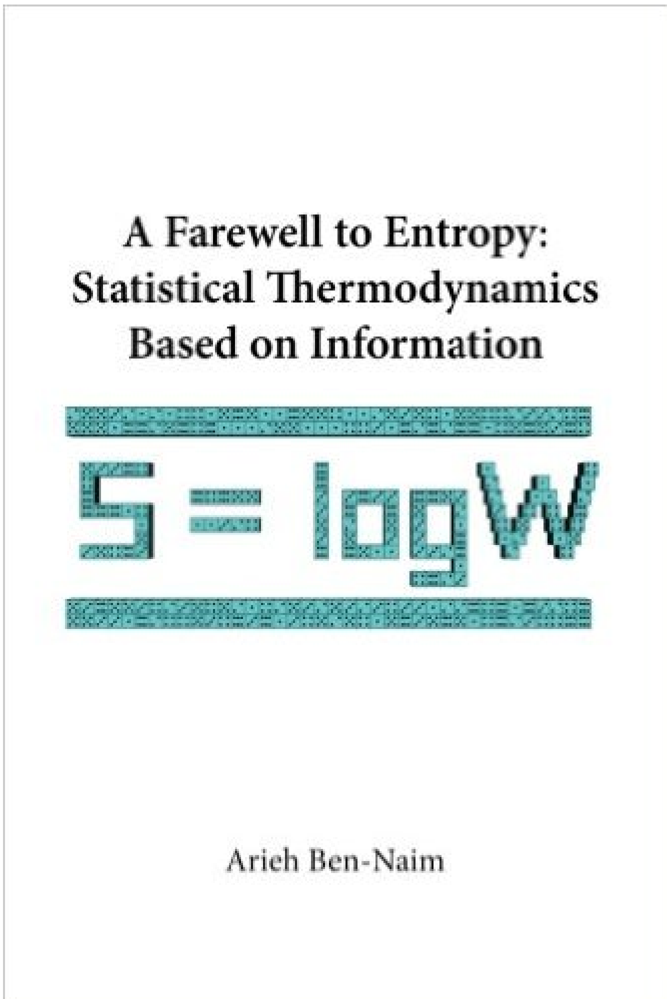
A Farewell To Entropy



Synopsis

The principal message of this book is that thermodynamics and statistical mechanics will benefit from replacing the unfortunate, misleading and mysterious term “entropy” with a more familiar, meaningful and appropriate term such as information, missing information or uncertainty. This replacement would facilitate the interpretation of the “driving force” of many processes in terms of informational changes and dispel the mystery that has always enshrouded entropy. It has been 140 years since Clausius coined the term “entropy” almost 50 years since Shannon developed the mathematical theory of “information” - subsequently renamed “entropy”. In this book, the author advocates replacing “entropy” by “information”, a term that has become widely used in many branches of science. The author also takes a new and bold approach to thermodynamics and statistical mechanics. Information is used not only as a tool for predicting distributions but as the fundamental cornerstone concept of thermodynamics, held until now by the term “entropy”. The topics covered include the fundamentals of probability and information theory; the general concept of information as well as the particular concept of information as applied in thermodynamics; the re-derivation of the Sackur-Tetrode equation for the entropy of an ideal gas from purely informational arguments; the fundamental formalism of statistical mechanics; and many examples of simple processes the “driving force” for which is analyzed in terms of information.

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Customer Reviews

Finally a book that brings information theory and thermodynamics together in a comprehensive way! Ben-Naim paves the way for a future generation of innovation in statistical thermodynamics using the tools of information theory.The traditional understanding of entropy associates it with disorder. While this view is useful in many contexts, it fails to explain some properties of entropy. Ben-Naim leads us into identifying entropy with uncertainty, or the "missing information" of the system. Information possessed by whom? In this case, we are not talking about perception or communication. Wherever the number of states of a thermodynamic system resides, there resides the entropy.Ben-Naim explains the so-called Gibbs-paradox in a most satisfying way (Appendix O). A related phenomenon occurs when we mix two chemical species and leave the volume and temperature unchanged. We originally have Na moles of gas A and Nb moles of gas B, each in its respective container of volume V. If we now mix both substances into a single container also of volume V, the entropy remains unchanged. If we insist in understanding entropy as disorder, the mixed container looks more disordered; but the entropy stayed constant. This is not a paradox. In this process, the volume available for substance A and substance B to explore never changed, so the counting of states is unaltered. The missing locational information about gas A and gas B is constant for this process. This treatment applies to ideal mixtures, where the particles don't interact among themselves.For processes where the particles do interact, we will observe additional correlations which reduce the missing information, a.k.a. entropy. The physical coupling of intermolecular forces translates into statistical correlations.

In the Preface, the author states that there are many good books on statistical thermodynamics, and that this is not a textbook on this subject. However, though few other books exist that make use of the concept of "information" in statistical thermodynamics, this seems to be the first one that bases the full construction of the theory upon the information. For this reason, the approach by Arieh Ben-Naim is really modern and deserves a careful reading.Personally, I don't think that this book can not be used as a textbook. Indeed, it is quite self consistent and builds step by step the core of the theory in such a way that any student is able to follow all arguments. Actually, it is true that it does not contain everything, but what is the textbook that really contains everything? May be, the only unpleasant thing for a student is the non negligible amount of time spent commenting the differences with other well known references, in particular the explanations of the probable reasons why Gibbs did not reach the very same results. But comments like these would be a valuable resource for teachers, on the other hand.If I had to choose one thing in this book, I would recommend to enjoy the derivation of the Sackur-Tetrode equation (chapter 4): it is really beautiful and does not have the "shadows" that classical derivations suffer. For the very first time, I should say, I think I have understood it, thanks to this book.However, the most important point of the whole book, the real starting point of the full construction, is the following.

In the Introduction, Ben-Naim greets us with a teaser: those of us who think that the (ideal) entropy of mixing is positive, have a problem. We should take our medication and read this book till we come to our senses and realize that the entropy of mixing is zero. But first things, first.Ben-Naim uses Shannon's entropy (information) to re-interpret statistical thermodynamics. This has been done before, most notably by Jaynes, who is quoted throughout the book. Ben-Naim, however, goes further to argue that all other interpretations of entropy are wrong. The very term, "entropy,'' he argues, is part of the problem: it means nothing and should be abandoned. Even "enfometry'' or "average surpisal" would be more meaningful terms. From here on the book goes back and forth between being a technical presentation of information theory, or a repetitive litany of arguments on semantics. So, what about the entropy of mixing? The argument is laid out in section 6.7. It is long and somewhat rambling ("we already feel in our bones that some information has been lost forever in the process...'' p279) but it goes something like this:Consider the classical mixing experiment, a box divided into two parts, each filled with a different ideal gas. Remove the partition and let the system equilibrate. Ben-Naim argues that the corresponding increase of entropy arises, not from mixing, but from the expansion of the gases (each gas has more volume to roam). Mixing is entirely incidental, he argues, as relevant to this process as the shape of the container into which the gases expand. If we compress the mixed gases isothermally to half the volume of the mixture, its entropy would become the same as that of the pure gases before mixing. Ergo, the entropy of mixing is zero!

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