ENTROPY: REFLECTIONS OF A CLASSICAL THERMODYNAMICIST

B.G. KYLE

Emeritus Professor of Chemical Engineering
Kansas State University
Manhattan

ENTROPY

For thermodynamics we feel a sense of awe
And marvel at the power of those early minds
Who showed that mundane matters lead to natural law
And boldly stated that the universe unwinds.
The second law is never denied its due
In science, belles-lettres, and philosophy.
It pales the onward-and-upward view,
For no one is consoled by entropy.
While nothing temporal eludes its iron rule
And most would take decay's decree as true,
The sage's bane can be the builder's tool
As entropy shows the best that we can do.
This useful concept prompts a primal groan,
A dread we've only named but always known.

PREFACE

This work, *ENTROPY: REFLECTIONS OF A CLASSICAL THERMODYNAMICIST*, is a multi-chaptered essay on entropy and its paradoxes. Taken in its entirety the work presents the various views of entropy and the resulting paradoxes, and in the final chapter attempts conceptual closure. Because each of the intermediate chapters (Chaps. 3—8) deals with a single topic and is somewhat independent, selective reading should be possible. However, if the reader is unfamiliar with quantum statistical mechanics, it is recommended that chapter 2 be read before proceeding to later chapters.

The perspective is philosophical, but not excessively so. The philosophical slant is my own and no effort has been made to present a balanced view. In this I am following the advice of George Santayana who put the following words into the mouth of one of the characters of his novel *The Last Puritan*

"The trouble with you philosophers is that you misunderstand your vocation. You ought to be poets, but you insist on laying down the law for the universe … and are vexed with one another because your inspirations are not identical."

My own "inspiration" has developed from many years of teaching thermodynamics to chemical engineering students and is classically and practically oriented. I have outlined my perspective in section 1.4. While it is impossible to discuss entropy without using mathematics, I have attempted to use a heuristic rather than a rigorous tone and place those derivations that are not absolutely essential in an appendix at the end of each chapter.

The work begins with a brief overview of thermodynamics which emphasizes its strangeness, describes its method, and exposes the confusion resulting from the various types of entropy found in the literature. This is followed by chapter 2 where the microscopic perspective is described. This involves only the bare minimum of quantum statistical mechanics necessary to convey the central ideas and to present entropy from the statistical point of view. Chapter 3 covers the third law and absolute entropies and

shows that zero entropy at zero absolute temperature can not be interpreted in terms of spatial order. Chapter 4 deals with information theory and chapter 5 examines Maxwell's demon. In these two chapters the argument for entropy as a measure of information is explored and rejected. Chapter 6 presents a simplified version of Boltzmann's H-theorem together with the paradoxes it inspired. The Gibbs mixing paradox with a suggested resolution is presented in chapter 7. Chapter 8 contains various metaphoric applications of entropy in areas outside of physical science.

The final chapter is my attempt to resolve of the entropy enigma. My view is that entropy should be considered a useful function and not an intrinsic property of matter and therefore difficulties arise when we try to explain it microscopically or in terms of information. I realize that this view is unconventional and will perhaps be unpopular with some readers, but I believe that I have made a reasonably strong case for it.

Except for a few minor changes or additions, the material in chapters 3, 5, and 8 has been published previously as a series of papers in *Chemical Engineering Education*.

B.G. Kyle
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