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# THE CONCEPTS OF CLASSICAL THERMODYNAMICS

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# PREFACE

There exist today many excellent treatises on classical thermodynamics such as those of Guggenheim, Landsberg, Pippard, and Wilson, to mention but a few. It is not my purpose to supplant them, even were I competent to do so. On the contrary, this small volume is intended merely to present the basic ideas of classical thermodynamics on a purely phenomenological level, against a general background of physical theory. This is done in a way which should give the reader a feeling of easy familiarity with the laws to be introduced and the concepts to be defined. It is just this feeling which the student so often lacks after a first study of the subject. In a sense, therefore, my aim is very circumscribed. There will be no attempt at completeness or generality, and all manner of simplifying assumptions will be introduced from time to time. This procedure is, I think, likely to enhance the reader's chances of getting a basic understanding of the subject, and any required generalizations can be undertaken at a later stage.

My general approach tries to couple simplicity with reasonable sophistication. It should be clearly understood from the outset that, superficial appearances to the contrary, this is *not* an axiomatic treatment of the subject. Undeniably useful though an axiomatic treatment of a physical theory may be, it too easily gives the appearance of a logical exercise, and were this to be the case here the whole purpose of this work would be vitiated. Moreover, to carry through a valid axiomatic development is likely to require at times assumptions so restrictive as to put its relevance to *physical* theory in doubt. This point of principle seems to be sometimes overlooked. At any rate, frankly pragmatic though the character of the present approach may be on occasion, it is constantly governed by the main aims of simplicity and clarity, however much I may in fact have failed to achieve these.

Though this volume is reasonably self-contained, it might well be read alongside one of the standard treatises already referred to. I adhere strictly to the phenomenological point of view, not least in order to counter the widely held opinion that one can gain an understanding of the concept of entropy, for instance, only on a statistical basis. In the first place, it might be reflected that the theoretical foundations of statistical thermodynamics are difficult to a degree which makes it doubtful whether the belief in question can be sustained. Be that as it may, it involves an obvious logical difficulty: a statement of the kind 'the results of statistical thermodynamics must not lead to contradictions with the laws of phenomenological thermodynamics' becomes meaningless if the latter can be 'understood' only on the basis of the former: to grant that it is meaningful is to grant that the conceptual frameworks of both theories are *separately* well defined.

After some general remarks concerning physical theories as such, the subject is developed in a manner which does not place undue verbal emphasis on terms characteristic of the realm of engineering. Moreover, the introduction of ideal gases into the basic parts of the theory is avoided, for there is a didactic weakness inherent in an early appeal to the properties of a class of substances whose existence in nature is later denied by one of the principal laws of thermodynamics. The four main laws are stated in their traditional order even though, from a pedagogic viewpoint, there are advantages in stating the second before the first. With regard to the former, Carathéodory's formulation has been adopted, since this allows one to achieve a clearer separation between the mathematical and the physical content of the theory, even if, contrary to a widely held view, its supposed greater logical economy appears to be somewhat illusory. The concept of entropy is introduced in various alternative ways, with a certain emphasis on the idea of an ordering of states. Some redundancy is of little account: I have not aimed at the greatest possible brevity. Indeed, as a result of closely scrutinizing points which are often scarcely examined at all, this exposition may appear somewhat old-fashioned in its discursiveness. It may not be out of place to emphasize that it is intended to be of an elementary character, though here and there it may reveal itself as being a little more sophisticated than most elementary treatments of the subject; an occasional reference to an unfamiliar branch of physics may simply be left unread.

The systematic development of the general theory has been kept unencumbered by discussions of specific applications. These have been relegated to the last two chapters, where they are presented

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in an orderly fashion on the basis of a classification which assigns to any particular application a certain character. It will be appreciated that the material of these chapters is mainly intended to serve a methodological purpose. Bearing in mind at the same time that this work will mostly be used as collateral reading, the absence of numerical examples should occasion no surprise.

My warmest thanks go to Professor Arthur Hambly and to Dr Daniel Greenberg for reading the whole manuscript, and to Mr Malcolm Urquhart for reading the first three chapters. Their advice has been of great value to me. The responsibility for any errors and omissions which remain is of course entirely mine. To Mrs Myrene Hickey I wish to express my appreciation of the excellence and patience she displayed in typing the manuscript.

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*Canberra* H.A.B.
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