Preface

This book is an introduction to statistical physics aimed at undergraduate students in physics and engineering. It may also serve as a reference for graduate students and researchers. The fact that thermodynamics and statistical physics have a very wide domain of relevance and validity, as well as a very long tradition, often leads to abstract and axiomatic presentations even for beginners. We have chosen the opposite direction, namely to discuss the key ideas and methods through concrete representative systems, and to treat general ideas as casual by-products. This choice is expressed already in the structure of the book, consisting of five parts: (I) *The Kinetic Theory of Gases*; (II) *Statistical Physics with Paramagnets*; (III) *Statistical Physics and Thermodynamics*, which deals with the Einstein solid and monoatomic ideal gases; (IV) *From Ideal Gas to Photon Gas*, which covers also equilibrium of chemical reactions and the Debye model; (V) *Of Fermions and Bosons.*

This approach runs the pedagogical risk that a casual reader may form the impression that he is facing a limited set of special cases. We confront this pitfall technically, by introducing explicit remarks about the generality of results at appropriate places; methodologically, by accumulating enough applications for every major idea to make its validity and generality stand out; and philosophically, observing that physics moves forward most of its ideas by analogies to cleverly chosen simple systems for which profound intuitions have been formed.

Originally this text was the backbone of a course in statistical physics at the Open University of Israel, which is a university for education at a distance. As such, it is vital to provide the student with a text that not only presents the material clearly, but also stimulates him or her to a higher state of active participation, to replace frontal study. This is achieved by inserting a large number of tasks (exercises) into the body of the text. They are aimed at maintaining contact with the experience of the student, either by numerical examples or by rederiving a result in a new way. They are also intended to reduce the amount of inattentive reading, by systematic insertions of break-points. Exercises of a second type serve as corollary applications of newly introduced methods and techniques. A third type fills the gaps left (intentionally) in the process of many derivations. In some places we have preferred not to break the flow of reasoning, introducing first the result and only then the corresponding exercise which calls for the reader to complete the details. Thus, a little patience is required at least at the outset.

In order to raise further the level of active involvement, each part is followed by several "self-assessment" exercises which are generally more extensive and of higher level than the ones in the text. They require frequently an ability to integrate ideas and methods from several parts of the course. The last — and very important — component is the detailed solutions to all exercises of all types, at the end of each part, which should contribute significantly to a successful study.

After the first Hebrew edition was used for about ten years, a second edition was published and is still in use by the Open University. It is this revised and extended version that we now make available to a wider audience. This volume is mainly a translation of the second Hebrew edition, but includes further revisions, additions and updates and should be considered a third edition of the text.

The material of this text corresponds to a semester's course, preferably in a second year. It assumes a prior acquaintance with calculus, basic mechanics, electricity and magnetism and modern physics, as well as some familiarity with thermodynamic concepts. Usually, a statistical physics course is taken after thermodynamics. However, we felt that the text would be more self-contained if a brief compendium of thermodynamic concepts and methods was introduced for coherence with the rest of the text. This led to Chap. 0 of Part II.

A final word concerning notation and units. We have adopted the convention of bold letters for vectors and italics for their absolute value or other scalars. Thus we write, for example, $|\mathbf{v}| = v$. As for units we follow the increasing tendency towards the SI (International System), based on the metric system. However, this convention is used in moderation and we allow, from time to time, other commonly used units, like electron volt (eV) as an energy scale for atomic systems or atmosphere for pressure. The deviations from the SI are particularly pronounced in dealing with magnetic systems. In that case we have chosen to avoid the confusion caused by attributing different units to the magnetic quantities $\mathbf{B}$, $\mathbf{H}$ and $\mathbf{M}$, and have adhered to the cgs system.

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