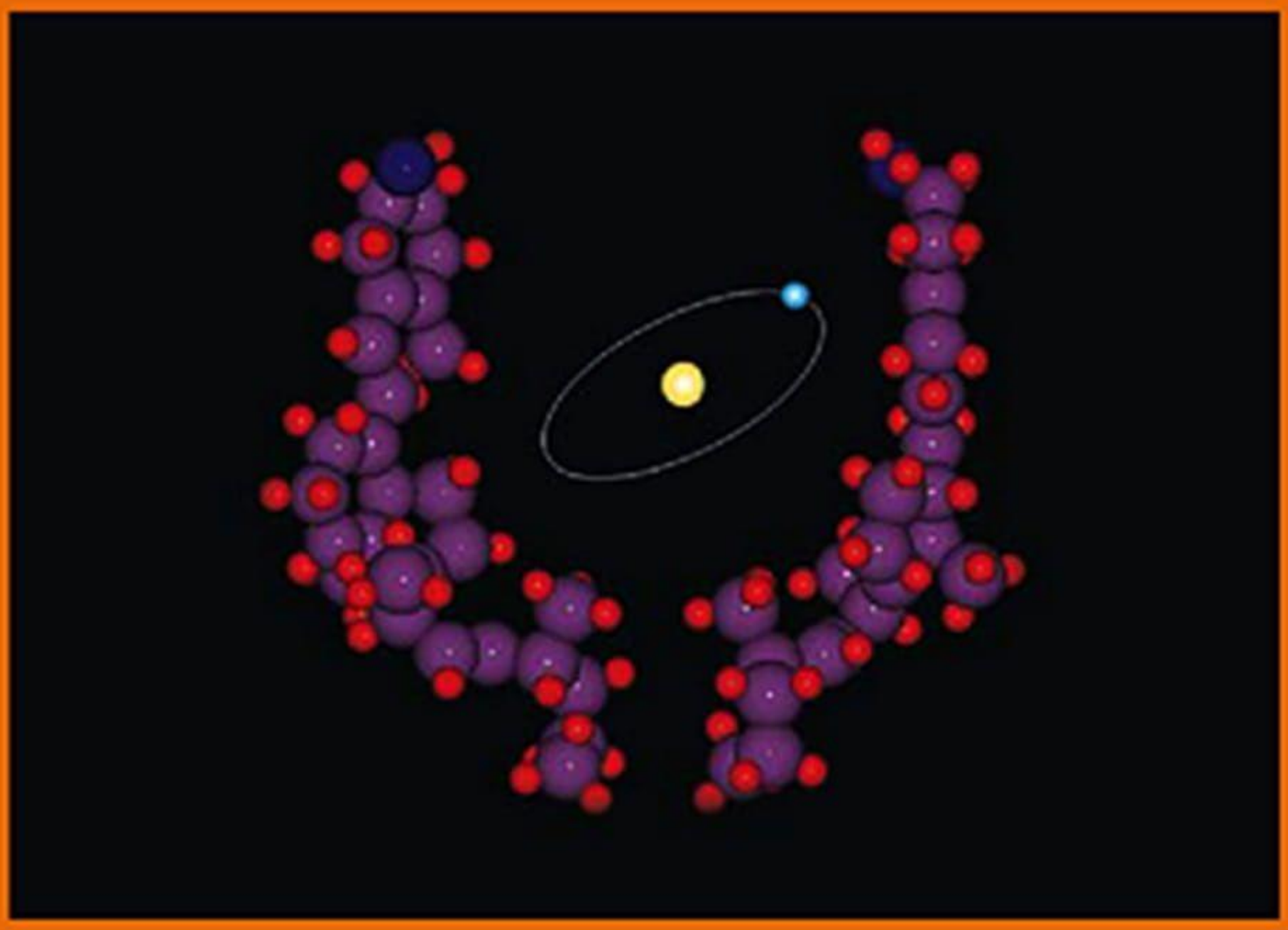
Physics for Chemists

Ruslan P. Ozerov and Anatoli A. Vorobyev



Colour for textiles

A user's handbook

Wilfred Ingamells PhD MSc CText FTI CCol FSDC

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1993

Society of Dyers and Colourists

Physics for Chemists

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Preface

For many years the Society of Dyers and Colourists has been aware of the need for a book covering the basic science and technology of textile coloration for the benefit of readers without a detailed scientific background. In the mid-1980s the late Dr Frank Jones of the University of Leeds started to write such a book, but sadly he died before he could complete this worthwhile task. The torch was then passed to me, with the brief to prepare a work for those who probably lack science qualifications at A-level but who nevertheless need to become familiar to some extent with the work of the professional colourist. The target readership included people working in nontechnical capacities in industry, and students of home economics, textile design and management. The aim is to introduce such readers to the relevant technological background and the basic principles of coloration, and show how colour is assessed objectively in modern industry.

I am grateful to several people for their assistance, including Paul Dinsdale (the Society's editor), Jean Macqueen, for her expert editorial work on the manuscript and index, and Carol Davies, for painstaking typesetting and layout. I also acknowledge the Textile Institute, Manchester, for permission to reproduce Figures 4.12, 4.13, 6.7, 6.9, 6.10 and 6.12, and Miss B Lomas of the Textile Technology Department, UMIST, Manchester, for permission to reproduce Figures 4.1 and 4.2, and for kindly providing suitable copies.

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All miracles of nature, no matter how extraordinary they are, have always found their explanation in the laws of physics

Jules Verne
Journey to the Center of the Earth

Preface

In this new century, the development of science, technology, industry, etc., will require new materials and devices, which will in many respects differ from those of the past. Even now, there are many such examples. Certainly, the main foundation of these achievements is science, primarily physics, which enables the solid building of chemical, biological and atomic technologies, etc.

In general, this book is a textbook on physics, but takes the above circumstances into account. It is aimed at students and scientists in the field of technology (chemical, biological and other branches of sciences), who will be working in the times ahead. The book differs substantially from standard physics textbooks in its choice of subjects, the manner of its presentation, selection of examples and illustrations as well as problems to be solved by the reader. The book contains problems important for chemists such as the language of potential curves and the essence of the theory of molecular collisions, and a large part is devoted to molecular physics with classical Boltzmann and Maxwell statistics, transport phenomena, etc. In a special part, the dielectric and magnetic properties of molecules are considered from the point of view of their structure. Optics is also covered in order to give the reader some idea of how its laws can be used for molecular structure analysis. Quantum mechanics is presented in an adapted form, aimed at a description of atomic and molecular spectroscopy. A special chapter describes tunneling both as a general phenomenon and as a mechanism of chemical reactions. Special attention is paid, also in an adapted form, to inter-atomic fine and superfine interactions, which are the basis of many modern and productive physical methods in the field of atomic and molecular structural investigations. Solid-state theory is presented on the basis of quantum statistics in order to form a bridge to their properties. A new technological field—nano-scale technology—is touched on here. In our opinion, no other textbook covers the sophisticated modern subjects mentioned above in such an acceptable form.

Physics always operates with certain models—simplified representations of real systems. The ideal gas model is one such example. Despite its variety of real gas properties, this simple model assists in understanding the behavior of more complex systems using more complex factors permitted within the model, and it provides numerical results. For example, the introduction of additional interactions leads to van der Waals's gas and allows further inclusion of virial factors, which in turn make the model more universally applicable to all gases. When using the model, the level of required accuracy has to be defined and on that basis, an appropriate model can be selected.

The authors have aimed to make the subject matter easy to master; therefore many theoretical approaches in the text have been presented in an adapted manner, while the more strict proofs are given separately throughout each chapter in the *Examples*, in the *Problems/Tasks* at the end of each chapter, and particularly in the *Appendices*. A set of important constants is given in *Appendix A*1 to facilitate the solution of the problems. Units of measurement of physical values are also listed there.

The text is further enhanced by the illustrative material, including selected drawings, graphs and tables, which are an inseparable part of the book and greatly simplify understanding of the text. The book will be particularly useful for students, not only in the narrow area of their future profession but also in allowing them a broader glimpse of the surrounding world. In our opinion, this is necessary to encourage in the young people of the twenty-first century a firm perception of the world as an objective reality. The book pays a good deal of attention to the laws they need to learn in order to acquire new knowledge and to use if to expand human possibilities both in industrial and spiritual spheres of activity.

The book's nine chapters provide a description of the main laws of mechanics, statistical physics, thermodynamics, physics of dielectrics and magnetics, wave optics, quantum mechanics and physics of electronic shell of atoms, solid-state physics, physics of electromagnetic waves and physical methods of investigation. It contains a large amount of comprehensive information, useful for everybody in all stages of tutorial, practical and scientific activity.

For successfully understanding the book, the reader should have a knowledge of the mathematical laws of, and some experience regarding, operation with vectors, differentiation and integration of elementary functions and others. Mathematics is the language of physics: the faults in mathematics must be considered as the faults in physics.

The book is the fruit of our long experience at the Mendeleev University of Chemical Technology (MUChT) in Moscow. The results we have achieved have had a great influence on the content of the book and the problems chosen. One of us (RO) participated in publishing a textbook on physics under the auspices of the "State Program of Education and Science Integration" ("Physics in Chemical Technology" in collaboration with Professor E.F. Makarov from the Institute of Chemical Physics of Russian Academy of Sciences). Although it appeared in a very limited edition, which meant that the book wasn't available for purchase, it has nevertheless greatly influenced the publication of this new work. One of the authors (RO) has spent a relatively long time at The University of Western Australia (UWA) in Perth, and this too has had a significant influence on the content and style of the book.

R.P. Ozerov
A.A. Vorobjev

Acknowledgments

It happens that both co-authors of this book, learning together in the same institute (Moscow Institute of Physical Engineering) and working thereafter for a very long period of time in the same department of the Moscow University of Chemical Technology have now been separated by long distance, corresponding only by telephone and e-mail. Therefore this part of the acknowledgment is expressed mostly by one of us, namely RPO.

Firstly I would like to give my thanks the late Professor Edvard N. (Ted) Maslen, my colleague on the commission on Electron Density of the International Union of Crystallography; he strongly supported an acceptance of my previous student Dr. Victor A. Streltsov to a postdoctoral position at the Crystallography Centre of the University of Western Australia, which has resulted in an profitable collaboration with the D.I. Mendeleev Institute of Chemical Technology in Moscow.

Ted and Professor Sid Hall made provision for a very favorable and productive investigation into X-ray crystallography. I greatly appreciate the initiative that Professor Sid Hall showed when he undertook on the position to assist me, especially considering the unusual circumstances.

Dr. Alexandre N. Sobolev jointed the project a little latter; though the skill he has acquired in UWA made him a high-class specialist in X-ray crystallography. His skill and determination are extremely valued and his endless commitment enabled me to complete this book.

I have never met a more kind and generous specialist like Professor Alan White. He was always forthcoming with valuable advice and support.

I would also like to acknowledge Professor Brian N. Figgis who helped me immensely with my previous book "*Electron density and chemical bonding in crystals*."

Dr. Lindsay Byrne—a rare find as an NMR guru—is a devoted man with much enthusiasm and was always willing to help.

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AV and me would like to express our gratitude to Professor Vitalii I. Khromov for his help and valuable advice.

I would dearly like to thank the head of the School of Biomedical, Biomolecular and Chemical Sciences, The University of Western Australia, Professor Geoff Stewart and Mrs Leigh Swan for the pleasant and prosperous working environment they provided. Without this comfort and assistance I would not have been able to finish this project.

I express my gratitude to my friend Mrs Suzanne Collins—the extra class specialist in English teaching—for her valuable help and advice.

I am greatly obliged to all member of my family who helped me at all stages of my work.

Professor Ruslan P. Ozerov
Professor Anatoli Vorobyev

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Recommendations to the Solution of the Physical Problems

Readers are recommended to begin solving the problems by writing down the given data in the normal way. On the left-hand side, all the data should be written in a column as accurately as possible. At this point, it is useful to translate all the given date to the SI system of units in order to avoid confusion at the end. In the majority of cases, it is also very useful to make a competent analysis of the task, choose a reference system, and make the drawing indicating all the details correctly; with the proper indication of all details; it can be said that a reliable drawing is 50% of the solution.

The solution should be carried out, as a rule, in a general form, i.e., without intermediate numerical calculations down to the final answer; this means that the symbol for the physical value sought should remain on the left-hand side of the answer, while the symbols for the physical values of the given conditions and the necessary physical constants should be on the right-hand side. The values of physical constants are listed in *Appendix* 1.

It is also useful to accompany the decision with a brief explanation, both physical and mathematical, to state the physical ideas behind the solution. Moreover, the mathematical treatment should also be explained: if the definite integral is treated, the limits should be explained. In square root calculations it is desirable to explain whether both roots should proceed or one root should be rejected and why? The final answer in a general form should be marked by any way. We especially want to emphasize that a general solution is of greater significance and value: it means that not just the particular problem has been solved, but a real task. The results can then always be used to solve similar problems without starting the treatment again from the very beginning.

The analysis of the dimension of the result is one of the important stages of the solution; it permits one to be confident of the result. It is necessary to carry out calculations keeping the desired accuracy in mind; more often three significant figures will be sufficient. The numerical answer should be written down as a number increased to the proper power of 10 or using multiple prefixes, e.g., $A = 2.56 \times 10^7$ J and/or 25.6 MJ.

It is important that one should be certain that a reasonable result has been achieved, i.e., the speed of a body does not exceed the speed of light, or its size does not exceed the size of the universe, etc.

We wish our readers all success!

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