



NUCLEAR AND RADIOCHEMISTRY

3rd Edition

Gerhart Friedlander
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For Nicholas Smith
with best wishes,
Ernest Ruskamp

**Nuclear and
Radiochemistry**

Property of Nicholas Smith

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Third Edition

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Preface

Over 30 years have passed since the forerunner of this text appeared under the title *Introduction to Radiochemistry*. Casual comparison will reveal little resemblance between the slender 1949 volume and the present work. Yet through the several editions our purpose has remained the same: to provide a textbook for advanced undergraduate and beginning graduate students who have some chemical but little or no nuclear physics background and to make available a ready reference source for practitioners of nuclear chemistry, radiochemistry, and related fields.

In adopting the present title of the book in 1955 we gave explicit recognition to a dichotomy in the field and in the audience addressed, a dichotomy that has probably become even more pronounced since then. The book is written as an introductory text for two broad groups: nuclear chemists, that is, scientists with chemical background and chemical orientation whose prime interest is the study of nuclear properties and nuclear reactions; and radiochemists, that is, chemists concerned with the chemical manipulation of radioactive sources and with the application of radioactivity and other nuclear phenomena to chemical problems (whether in basic chemistry or in biology, medicine, earth and space sciences, etc.). Despite the apparently growing division between these two audiences, individuals have always moved fairly freely from one field to the other, and we continue to feel that nuclear chemistry and radiochemistry interact strongly with each other and indeed are so interdependent that their discussion together is almost necessary in an introductory text.

In choosing and arranging the subject matter we have been guided by the firm conviction that a good grounding in the fundamentals of radioactivity and other nuclear phenomena is equally essential for both of the broad groups we are trying to address. At the same time we are fully aware that for those who wish to do active research in nuclear chemistry this book can serve only as an introduction; they will certainly want to go on to more advanced nuclear physics books. We have assumed that students using this book have had basic courses in chemistry and physics. While we do not expect that the reader has a rigorous quantum-mechanics background, some acquaintance with the language of quantum mechanics is needed. This is often covered in a modern physics course dealing with the basics of atomic structure or even in many first-year "general" chemistry and physics courses.

In keeping with the general purposes outlined, the material in this third edition has been somewhat rearranged. After the essentially unchanged, largely historical chapter 1 we have put all the basic material on nuclear properties, radioactivity, and nuclear reactions in chapters 2–5, and we hope that these chapters will form the backbone of practically any course in which this book is used at all. The relative emphasis on different parts of this material may, of course, differ widely, and we have put some sections in small print to indicate that they might be considered too advanced and detailed for some courses. The choice among the remaining 10 chapters will depend very much on the predilections of the instructor, the length and purpose of the course, and the preparation of the students. One can pick and choose among the chapters, and in most instances the order is not crucial, although it seems advisable, for example, to precede any discussion of Radiation Detection and Instruments (chapter 7) with coverage of Interactions of Radiation with Matter (chapter 6). In a course oriented toward nuclear studies, chapter 10 (Nuclear Models) would probably be taken up right after chapters 3 and 4, whereas a chemically oriented course might at that point jump to chapters 11 (Radiochemical Applications) and 12 (Nuclear Processes as Chemical Probes).

In the 17 years since the preparation of the preceding edition the field covered has greatly changed and expanded. Well over half of the text in this edition is newly written. The temptation to expand the book considerably was great, but in order to keep the size and price within reasonable bounds we have also excised much old material that no longer seemed as essential or appropriate as it did 15 or 20 years ago. As a result the text has grown only modestly. No attempt has been made to convert to consistent use of SI units in this edition; however, they are introduced occasionally in the body of the text and definitions of the relevant SI units are given in appendix A.

The preparation of this new edition has been in progress for a long time. It was interrupted by the untimely death of one of the authors. Julian Malcolm Miller died suddenly in December 1976 after participating actively in the planning and writing of the revision. We have greatly missed his knowledgeable, stimulating, perceptive participation in the latter stages of our work on the manuscript, but we have attempted to complete the task in the spirit with which he approached it. Although our other coauthor, Joseph W. Kennedy, has been dead for over 20 years, his contributions to concept and content are also still in evidence.

We have, as in previous editions, given a set of exercises and a list of references at the end of each chapter. To quote from the original 1949 preface, the exercises “are intended as an integral part of the course, and only with them does the text contain the variety of specific examples which we consider necessary for an effective presentation.” Some old exercises have been retained, some new ones added. The references are listed by initial of first author and a serial number, and most of them are referred to

in the text. Some selected, specific research papers, including some of historical interest, are cited, but a particular effort has been made to give references to comprehensive review articles and books that provide thorough coverage of a subject area and can serve as a guide to the literature. General references to works that cover broad areas, such as the subject matter of a whole chapter, are marked with an asterisk.

We are very much indebted to C. M. Lederer and V. S. Shirley for preparing the Table of Nuclides in appendix D from their much more extensive *Table of Isotopes*, 7th edition (Wiley, New York, 1978). Throughout the text we have relied on their book as the primary source of half-life and radiation energy data.

We have had the benefit of helpful advice from many colleagues. The suggestions concerning general subject matter to be covered were not always mutually compatible, since they ranged from pleas for much more rigorous nuclear physics to appeals for much greater emphasis on applications. This divergence of opinion reflects, we believe, the breadth of the field and the wide spectrum of courses for which our book has been found useful in the past. We can only hope that this new edition will again find such widespread use and, for the reasons outlined earlier, we have again chosen a middle ground between the two extreme positions mentioned.

We are grateful to those colleagues who were kind enough to read parts of the manuscript; they include J. H. Barker, J. P. Blewett, J. B. Cumming, W. Faubel, P. P. Gaspar, G. E. Gordon, V. P. Guinn, P. Gütlich, L. A. Haskin, M. Kaplan, P. J. Karol, P. Peuser, L. P. Remsberg, D. G. Sarantites, A. M. Schmitt, A. C. Wahl, M. J. Welch, J. Weneser, and M. A. Yates; each of them offered useful comments and called our attention to errors and inaccuracies. Our very special thanks go to H. N. Erten and G. Herrmann, both of whom read almost the entire manuscript with great care and made innumerable helpful suggestions. Whatever errors and misstatements remain in the book are, of course, our responsibility. We earnestly request any reader who finds a mistake, no matter how trivial, to communicate it to us, so that it can be eradicated in later printings.

Both of us had the benefit of sabbatical leaves from our home institutions during the major writing effort. One of us (G. F.) was the recipient of a Senior Scientist Award from the Alexander von Humboldt Foundation that enabled him to spend the year 1978–1979 at the Institut für Kernchemie at the University of Mainz; he is deeply grateful both to the Humboldt Foundation and to the host institute and its Director, Professor Günter Herrmann, for providing an ideal atmosphere for this writing effort. Special thanks go to Mr. W. Kelp for the meticulous care with which he prepared many of the illustrations.

The younger author (E. S. M.), who was five years old when the first version of the text appeared, spent his sabbatical year at the California Institute of Technology in the Division of Chemistry and Chemical

Engineering as a guest of Professor Sheldon K. Friedlander. He is very grateful for the hospitality and stimulating environment that he enjoyed during that year with "the other Friedlander." He would also like to thank Professors John H. Seinfeld and Harry B. Gray for making his stay in the Division so pleasant. William Wilson and the USEPA deserve special thanks for providing financial support that made this sabbatical leave possible. We would like to acknowledge the help of several people who typed portions of the manuscript: Elaine E. Granger at Cal Tech; and Betty Henley, Mary Baetz, and Karen Klein at Washington University.

We are grateful to Brookhaven National Laboratory and Washington University for making it possible for us to undertake the time-consuming task of preparing this new edition.

Blue Point, New York
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May 1981

GERHART FRIEDLANDER
EDWARD S. MACIAS

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