Chemistry:
A Contemporary Approach

G. Tyler Miller, Jr.

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Chemistry:
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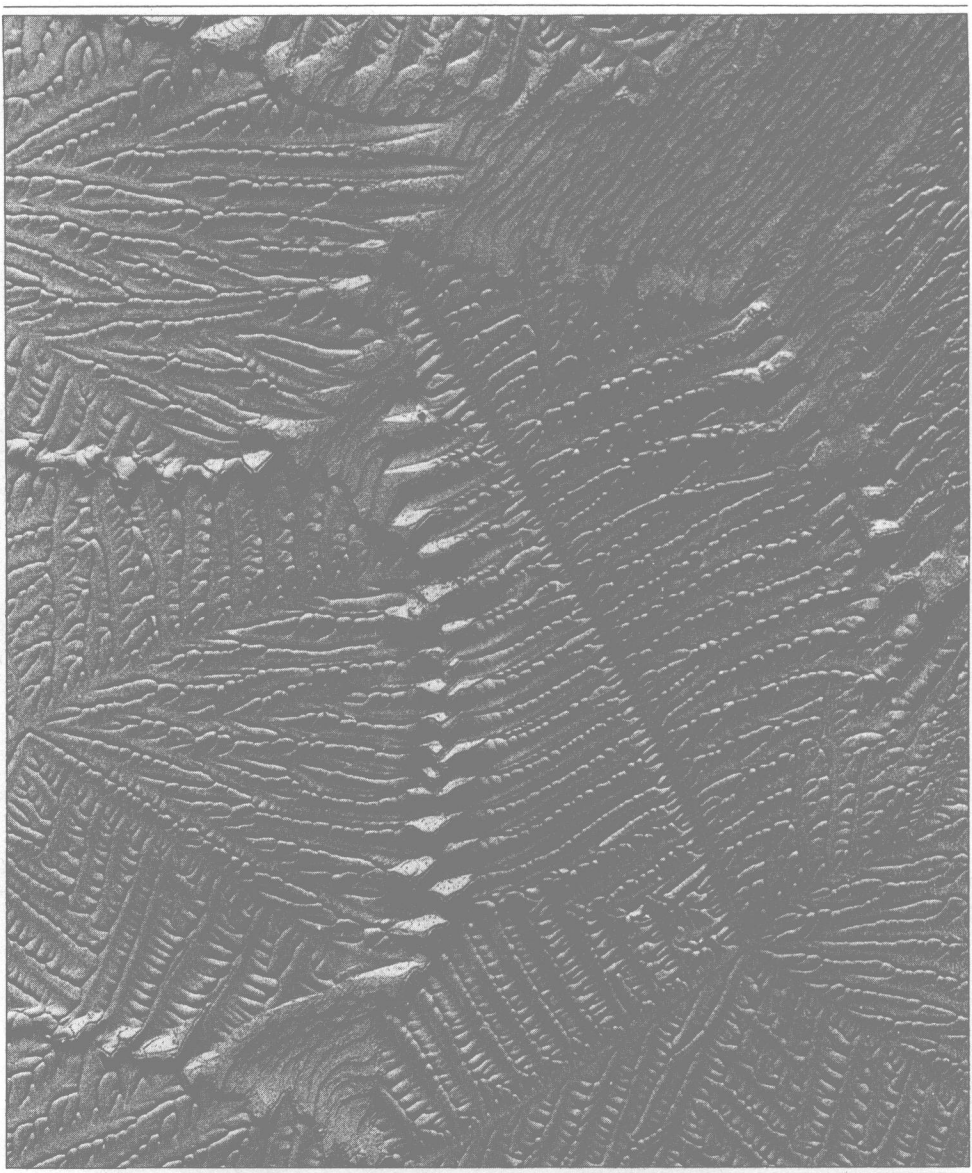
Chemistry ought to be not for chemists alone.

Miguel de Unamuno



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Preface

For over seventeen years I've taught introductory chemistry to science and nonscience students in full year, semester, and quarter courses. Like you, I've been searching for the ideal chemistry text. After surveying a large number of chemistry teachers I discovered that most of us face the same major difficulties. We need a text (1) that can be used in a flexible manner to suit our own preferences and interests, and (2) that integrates principles and applications throughout in an interesting manner.

A number of topics are common to most introductory chemistry courses, but we like to emphasize our pet topics and vary the sequence in which topics are covered. There are three basic solutions to this problem: (1) use an encyclopedic text and pick out the desired topics and sequence of topics, (2) use a short text and supplement it with handouts or paperbacks, or (3) write your own textbook.

A serious problem with the encyclopedic approach (at least in the textbooks I have seen and used) is that there is no system for determining which topics can be omitted without loss of continuity. In addition, varying the order of topics can be disastrous for the student if there is no convenient scheme for knowing the earlier conceptual or factual sections upon which a given topic is based. Students frequently find skipping around in encyclopedic texts a bewildering rat maze. As instructors, we could partially solve this problem by reading almost every word of a text before we plan and teach a course. But like ideal gases this is an unnatural state.

Supplementing a short text with handouts also creates problems. Frequently, the beginning student has difficulty correlating multiple sources that are written in different styles and are not smoothly and clearly integrated into the basic text. This, plus the added expense, is why more and more chemistry teachers are switching away from the once popular paperback or handouts approach. Furthermore, many instructors do not have the time to write the numerous supplements the handout approach requires.

Obviously, the fact that you are reading this preface indicates that I've chosen the third approach to dealing with the flexibility dilemma. Most textbooks list flexibility of use as a major feature, but few live up to this claim. Each has some flexible elements, but these elements have not been integrated into a total and simple system. I'm not claiming that this text completely solves the flexibility dilemma, but it does represent a serious attempt to develop a new and integrated system for meeting these needs, especially for nonscience majors.

Trying to achieve a balance between principles and applications provides us with another quandary. In our survey, many of you complained about texts that overemphasized applications at the expense of principles, while others complained of too much emphasis on principles. In addition, most of you indicated that sections on principles are dull (at least to the student). Keeping these requisites in mind, I have tried to present a balanced, flexible, and interesting approach to the principles–applications quandary. The remainder of this preface describes the major features of the teaching and learning system used in this book.

Flexibility: Coverage of Topics and Level of Difficulty The key to varying topics and level of difficulty in this text is a relatively simple system for using sections (and pages) marked with an asterisk(*). Throughout the text, asterisks are used to indicate *material that may be omitted without loss of continuity.* Any section marked with an asterisk may be used as basic material for your course, or it may be omitted. In either case, it will not be needed for your students to understand material in later sections that are not marked with an asterisk.

Three types of material are marked with an asterisk: (1) certain sections *within each chapter,* (2) supplements and guest essays *at the end of each chapter,* which provide either more advanced material or additional applications, and (3) eight quantitative supplements *at the end of the basic text.* To make it easy for you and your students to locate these sections and supplements, asterisks are shown in the table of contents, with the subheadings in each chapter, and at the top of each appropriate page.

Why include asterisked material within chapters, at the end of chapters, and at the end of the text? Why not place all of these sections at the end of the appropriate chapters and call them supplements? The answer to this question involves an explanation of the extensive reviewing process used to develop this book. Hundreds of chemistry teachers, including 41 reviewers who provided detailed comments, helped us decide whether material should be basic or optional. If most reviewers wanted a topic to be optional or omitted but a few felt strongly that it should be left in, the topic became an end-of-chapter or end-of-book supplement. On the other hand, if most felt the topic was important but a few wanted it omitted, it was left within the chapter and marked with an asterisk. Because of the unusually large number of reviewers and the diversity of institutions at which they teach, their opinions should be representative of the majority of chemistry teachers.

With this asterisk system you should be able to delete or add topics at will. You won't have to read the entire book before planning your course to know which topics are used in later chapters. Also, you won't have to bother with a number of extra handouts or require your students to invest in supplementary books. As a further aid, throughout the text there are references to earlier sections upon which later material is based. Thus, if necessary, students can quickly review relevant earlier material.

Flexibility: Organization Some instructors want to emphasize health applications of chemistry; others want an environmental, consumer, or resource emphasis; and others want a balanced approach. Within each of these approaches the sequence in which applications are taught varies widely. The design of this text allows all of these emphases and sequences. The major plan of the text is:

Part I: Introduction (1 chapter)

Part II: Some Chemical Principles (6 chapters)

Part III: Environmental Chemistry (4 chapters)

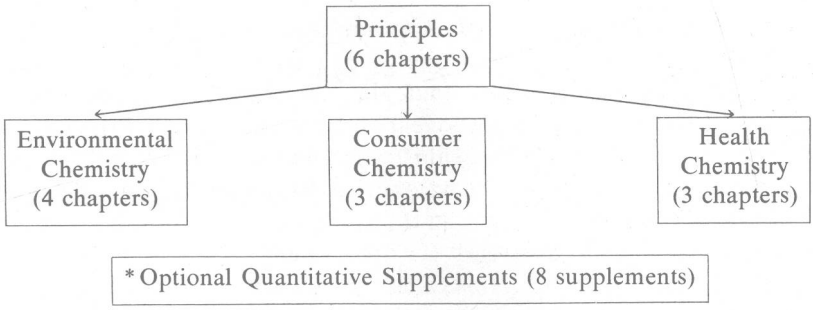
Part IV: Consumer Chemistry (3 chapters)

Part V: Chemistry and Health (3 chapters)

* Concluding Unscientific Postscript: Confronting the Next 30 Years

* Optional Quantitative Supplements (8 supplements)

After the principles section (6 chapters) has been covered (either in depth or briefly by omitting the desired asterisked material), you may teach the applied sections in *any order* that suits your needs.



The three applied sections are not dependent on one another. Like magnetic blocks on a board, they can be placed in any order.

Flexibility: Course Length and Emphasis

For Semester or Longer Courses: Cover all or most material in the basic text as desired. For a quantitative course, use the desired number of optional quantitative supplements found at the end of the basic text. (For full-year or more extensive semester courses, see G. Tyler Miller, Jr., *Chemistry: Principles and Applications* [Wadsworth, 1976].)

For Semester or Briefer Courses: Cover the desired mix of full chapters or parts of chapters by omitting specific major parts, chapters, end-of-chapter and end-of-book supplements, or asterisked sections within chapters. A number of quarter or semester courses with different emphases are possible. Among the many possibilities are:

Balanced Approach: Omit some asterisked sections within chapters, all or most end-of-chapter supplements, and end-of-book supplements.

Environment Emphasis: Cover Chapters 1 through 11 and perhaps the postscript.

Consumer Emphasis: Cover Chapters 1 through 7 and 12 through 14.

Life-Health Emphasis: Cover Chapters 1 through 7 and 15 through 17.

In each case, you can vary the level and extent of coverage by using or omitting the asterisked sections within and at the end of chapters.

Flexibility: Nonquantitative or Quantitative Courses The basic text is written on a qualitative basis with no calculations. However, eight optional supplements that emphasize quantitative calculations and give a more detailed treatment of nomenclature are provided at the end of the basic text. These supplements are cross-referenced where appropriate throughout the basic text and can be used flexibly for a variety of courses. Detailed solutions are provided for half of the practice questions and problems in each supplement. Thus, in quantitative courses, students do not have

the inconvenience and expense of using a separate paperback for quantitative calculations.

Integrated Use of Principles and Applications Principles such as structure, bonding, periodicity, reactions, and energy are covered early in the book in a nonquantitative manner. Numerous analogies, short applications, and simple diagrams are used to help make principles clear and more interesting. Principles are then applied in later sections of the book to illustrate important aspects of the chemistry of health, consumer materials, and the environment. By having some applications in the principles section and some principles in the applications sections, the text integrates and reinforces key ideas in chemistry for the student.

You can use the flexibility of this system to provide the desired balance between principles and applications. If you emphasize principles you can cover most or all of the material in the six principles chapters. Then omit one or more of the major parts on applications or the numerous asterisked sections within these parts. With a course emphasizing applications, the principles chapters can be covered in an abbreviated manner by omitting most or all of the asterisked material.

Despite many claims, no book that I know of fully integrates principles and applications. But I have devoted considerable effort to approaching this difficult and elusive goal.

Learning-Oriented System Many students find chemistry a difficult subject. In talking with them, I learned that some of their troubles stem not from chemistry but from the lack of such well-known learning devices as chapter summaries, glossaries, simple illustrations, and an adequate number of review questions.

Students are particularly confused by the complexity of layout and design in most introductory texts. The variety of elements in a chemistry text—formulas, tables, diagrams, equations, calculations, definitions—are often put together in an unnecessarily complex manner, so that the student's attention is drawn in too many directions. Different typefaces and type sizes, overuse of color, and scattered layouts add to the student's confusion.

Many beginning students want structural formulas written out in detail (at least in the beginning of the book). They do not know that —CH_2— means that two hydrogens are bonded to the carbon atom. In addition, they are bewildered by complex chemical structures. As chemists, we automatically disregard most of the structure and immediately focus on key functional groups. To help beginning students learn this important technique, we have shaded key functional groups in a molecule.

This text has been designed around two simple principles: (1) keep the layout simple and (2) provide the student with an integrated system of learning devices. Most books have one or more learning-oriented features, but few have a total system of these devices. The key elements of the learning-oriented system used in this book are:

A summary list of accomplishments at the end of each chapter, which can be used as a chapter review or as a pre-chapter set of objectives. (Students frequently complain that pre-chapter objectives mean little to them because they are usually full of technical terms.)

Detailed structural formulas rather than the condensed form that often confuses beginning students.

Shading of functional groups to direct attention to key parts of complex molecules.

A list of terms for review at the end of each chapter. Terms in asterisked sections are marked with an asterisk.

A comprehensive glossary at the end of the book.

Many functional illustrations that simplify complex interrelationships.

A large number of questions at the end of each chapter. Each question has a reference back to the section to which it is related. Questions based on asterisked sections are marked with an asterisk.

Detailed solutions to half of the problems in the end-of-book quantitative supplements.

References for further reading at the end of each chapter.

Simplicity and clarity of design. This book contains a more diverse array of features than most chemistry textbooks, yet the designer has kept the layout uncluttered and amazingly simple.

Guest Essays Eleven prominent scientists have written short essays that are used throughout the book. (See the list of contributors at the end of this preface.) This unique feature is used to illustrate the diverse ways in which scientists think and act.

Extensive Manuscript Review Hundreds of teachers responded to an initial questionnaire concerning their needs in introductory chemistry courses. The detailed outline for this book was then reviewed by over one hundred teachers from a diverse array of institutions.

Forty-one manuscript reviewers greatly aided me in developing this book. Fifteen reviewers from universities, colleges, and community colleges read the original and revised manuscripts and were extremely helpful in improving the basic text and supplement format. They also helped insure that the text is accurate and up-to-date and provided many interesting ideas for the development of topics. Twenty-six other reviewers read different applied portions of the manuscript at various stages to help insure their quality and accuracy. (See the complete list of reviewers at the end of this preface.)

I have tried to provide you with a text that is interesting, flexible, oriented toward student learning, and devoted to presenting a balance between major chemical concepts and their applications. I hope that you and your students will provide me with feedback that will enable me to improve its usefulness in future editions.

Acknowledgments I wish to thank all of the chemists who took time to respond to our questionnaire and review the outline of this book. I am particularly indebted to the detailed manuscript reviewers who took the time to point out errors and suggest many important improvements. The deficiencies remaining are mine, not theirs.

It is with great pleasure that I extend special thanks to the prominent scholars who provided guest essays for this book.

My sincere thanks also go to Mrs. Ruth Y. Wetmore for her skill and patience in typing and for the improvements she suggested. It is a rare author who has the services of an expert typist, who is also an editor and author in her own right. I also wish to thank my son Greg for helping me assemble the index.

One of the pleasures in writing this book has been the opportunity to work with members of Wadsworth Publishing Company. I am particularly indebted to Mary Arbogast for her careful editing and numerous improvements in the manuscript, to Darwen Hennings, Vally Hennings, John Waller, and Judy Scheidig for their exciting and innovative artwork, to Ann Wilkinson, the designer who incorporated the many elements of this book into a beautifully simple design, and to Lori Thoreson, the editorial assistant who magically and efficiently kept everything organized. But above all, I wish to thank Jack Carey, Chemistry Editor at Wadsworth. In addition to designing a superb reviewing system, he provided many helpful ideas for the overall format of this book in brainstorming sessions lasting into the wee hours of the morning. He is one of those rare and creative editors who knows how to inspire and help an author struggling to give birth to a manuscript.

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Guest Essayists

John G. Backus (University of Southern California), *Enemies Are Useful!*

Lester R. Brown (Overseas Development Council), *Expanding Food Production in a Finite Ecosystem*

Melvin Calvin (University of California, Berkeley), *One Thing Leads to Another*

Arie J. Haagen-Smit (California Institute of Technology; Chairman of the National Air Quality Criteria Academy, Committee for the Environmental Protection Agency), *From Terpenes and Essential Oils to Smog*

Samuel Hale, Jr. (Deputy Assistant Administrator for Solid Waste Management—Environmental Protection Agency), *The Current Status of Resource Recovery*

David R. Inglis (University of Massachusetts), *The Energy Frontier*

Vincent J. Schaefer (Director of Atmospheric Science Research Center, SUNY at Albany), *Fine Particles in the Atmosphere*

Glenn T. Seaborg (University of California, Berkeley), *The Role of Energy in Our Future Growth and Change*

James D. Watson (Harvard University), *The Double Helix*

Kenneth E. F. Watt (University of California, Davis), *Pollution Control: An Input Approach or an Output Approach?*

Alvin M. Weinberg (Oak Ridge National Laboratory, Tennessee), *A Faustian Bargain We Should Accept*

The 41 Reviewers Who Helped Perfect the Textbook

Teachers who helped develop the basic text–supplement format. They also provided many interesting ideas for useful approaches to topics.

David L. Adams, North Shore Community College

Ronald M. Backus, American River College

Robert C. Brasted, University of Minnesota at Minneapolis

Fred Breitbeil, DePaul University

Danette Dobyns, California State College at Dominguez Hills

Gordon Evans, Tufts University

Robert D. Gaines, Central Washington State College

Patrick M. Garvey, Des Moines Area Community College

M. Lynne Hardin, University of Texas at Arlington

E. Lyndol Harris, McMurray College

James Heinrich, Southwestern College

Vincent Hoagland, California State College at Sonoma

Ray L. Johnson, Hillsdale College

Paul E. Robbins, Armstrong State College

Ross W. Westover, Cañada College

Specialists who reviewed portions of the text at various stages in its development to insure the quality and accuracy of the applied material.

Virgil R. Baker, Arizona State University

Ian G. Barbour, Carleton College

Georg Borgstrom, Michigan State University

Arthur C. Borror, University of New Hampshire

Richard A. Cellarius, The Evergreen State College

Preston Cloud, University of California, Santa Barbara

Richard A. Cooley, University of California, Santa Cruz

W. T. Edmonson, University of Washington

Paul Feeny, Cornell University

Ted L. Hanes, California State University at Fullerton

C. S. Holling, University of British Columbia

David R. Inglis, University of Massachusetts

Edward J. Kormondy, The Evergreen State College

William W. Murdoch, University of California, Santa Barbara

John E. Oliver, Indiana State University

Harry Perry, Legislative Reference Service, Library of Congress

Grace L. Powell, University of Akron

Henry A. Schroeder, Dartmouth Medical School

Howard M. Smolkin, United States Environmental Protection Agency

John E. Stanley, University of Virginia

Tinco E. A. van Hylckama, Texas Tech University

Donald E. Van Meter, Ball State University

Kenneth E. F. Watt, University of California, Davis

Charles G. Wilber, Colorado State University

Samuel J. Williamson, New York University

George M. Woodwell, Brookhaven National Laboratory

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Detailed Table of Contents

*Throughout the book, an asterisk denotes a topic that may be omitted without loss of continuity.