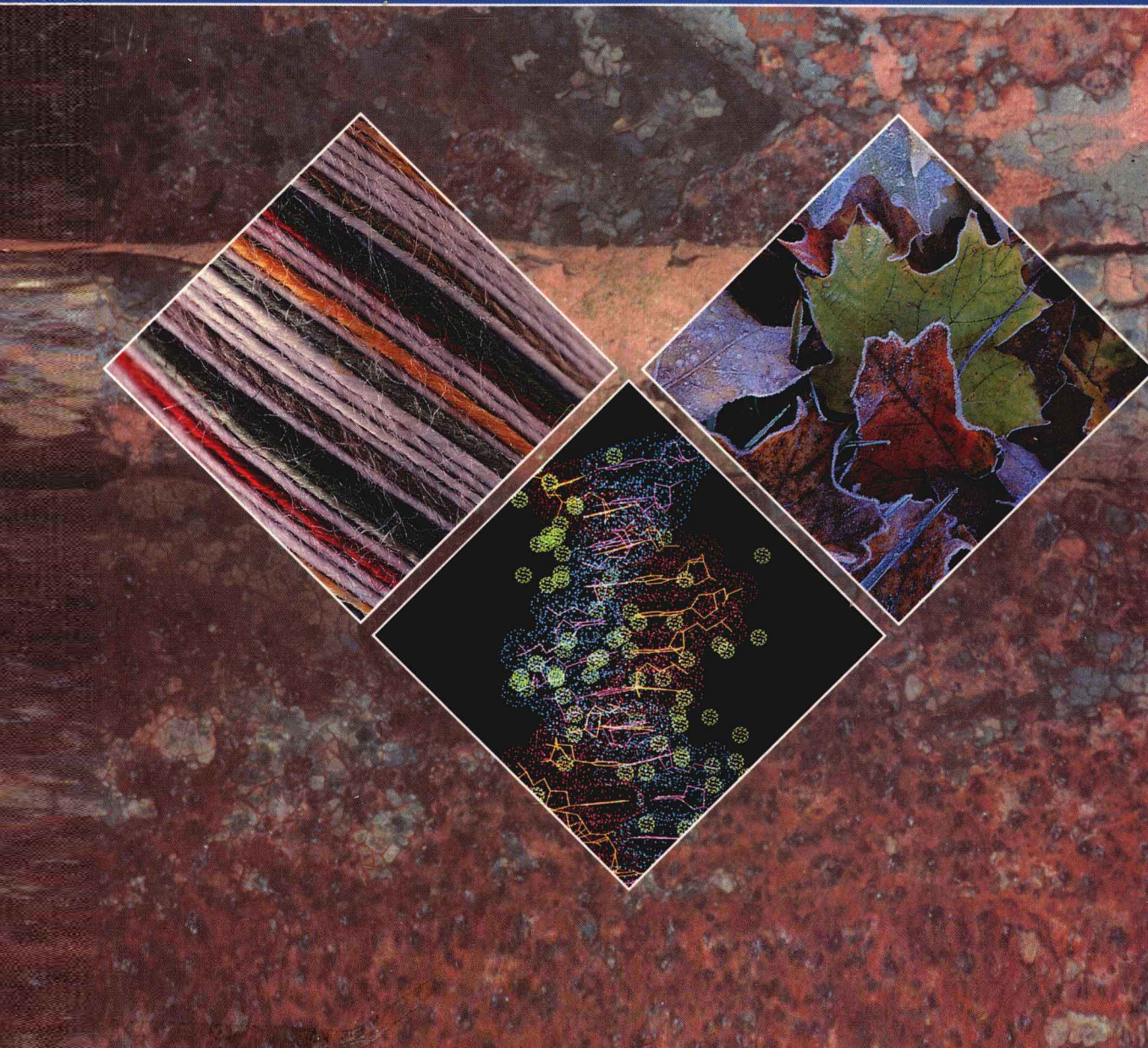
CHEMISTRY

A CONTEMPORARY APPROACH/THIRD EDITION

G. TYLER MILLER, JR. DAVID G. LYGRE



Chemistry

A Contemporary Approach

Third Edition

G. TYLER MILLER, JR.

DAVID G. LYGRE
Central Washington University

With contributions by
Wesley D. Smith
Ricks College,
Coauthor of Second Edition

Wadsworth Publishing Company
Belmont, California
A Division of Wadsworth, Inc.

Chemistry Editor: Jack Carey
Editorial Assistant: Kathy Shea
Production Editor: Gary Mcdonald
Managing Designer: Andrew H. Ogus
Print Buyer: Karen Hunt
Art Editor: Donna Kalal
Permissions Editor: Robert M. Kauser
Copy Editor: Betty Duncan-Todd
Photo Researcher: Sarah Bendersky
New Illustrations: Victor Royer, Amy Hennig
Compositor: Syntax International
Cover: Andrew H. Ogus
Cover photo credits and Part Opening photo credits are found following the index.

Printed in the United States of America 19

3 4 5 6 7 8 9 10—95 94 93 92

Library of Congress Cataloging-in-Publication Data

Miller, G. Tyler (George Tyler), 1931–
Chemistry, a contemporary approach / G. Tyler Miller, Jr David Lygre, with contributions by Wesley D. Smith.—3rd ed.
p. cm.
Includes bibliographical references and index.
ISBN 0-534-14280-X
1. Chemistry. I. Lygre, David G. II. Smith, Wesley D., 1930–
III. Title.
QD31.2.M48 1991
540—dc20 90-39904
CIP

Chemistry: A Contemporary Approach

Preface

To the Student

WHY STUDY CHEMISTRY? Chemistry is fun and interesting and is involved in almost everything you do. When you decide what to buy, use, or eat, you are making chemical decisions. Throughout your life you will encounter controversial issues such as acid rain, nuclear power, use of pesticides, and genetic engineering. A knowledge of chemistry can help you make wiser decisions in these and other matters that affect you, your loved ones, and society as a whole.

HOW THIS BOOK IS ORGANIZED Look at the brief table of contents on p. v. Notice that this book is divided into five major parts.

Part I is a brief introduction to science and chemistry. Part II presents some basic principles of chemistry that are used throughout the rest of the book.

Parts III, IV, and V discuss applied areas of chemistry. Part III examines the air, water, soil, energy, and mineral resources on which we depend. You will learn how we use these resources and how abusing them can pollute the environment that keeps us and other animals and plants alive and healthy.

Part IV is devoted to the chemistry of everyday consumer products such as plastics, soap, detergents, toothpastes, deodorants, and skin and hair products. You will also learn about the chemistry of fertilizers, pesticides, and chemicals in the foods you eat.

Part V discusses drugs used in medicine and those that alter behavior and moods. You will also learn about toxic chemicals and how chemistry can be used to genetically change organisms, replace body parts, and improve athletic performance. To get a better picture of what you will be learning, take a few minutes to look at the detailed table of contents on pp. viii–xiv.

THIS BOOK IS FLEXIBLE Chemistry teachers differ in what they consider to be most useful and important in a chemistry course. Courses also differ in length, so many teachers have to decide which parts of this book to use.

We have designed this book to give your teacher great flexibility in making such choices. Once Parts I and II have been studied, the other three parts can be covered in any order; don't be concerned if your instructor skips around.

Chemistry teachers also differ over whether you should be introduced to chemical arithmetic in a course of this type. Some will concentrate only on chemical principles that involve only arithmetic. Others will use the brief sections in Chapters 1 and 5 and the two appendices at the end of this book to introduce you to chemical arithmetic. In these sections and appendices, the only math you will be using is simple addition, multiplication, and division.

Most chapters contain one or more "Chemistry Spotlights" highlighted in boxes. Some give interesting applications of chemistry; others describe how certain chemical discoveries were made. Some show that scientists are people who do not fit the stereotyped images you often see on TV and in the movies. We hope you enjoy reading these spotlights as much as we did writing them.

LEARNING OBJECTIVES AND CHAPTER SUMMARIES We have put a number of aids in this book to help you learn about chemistry. One way to help people learn is to give them an overview of what they will learn, present the necessary details, and then summarize what has been presented. This is our approach.

Each chapter begins with a few general questions, or learning objectives, written in easy-to-understand language (for example, see the questions on p. 24). They give you an idea of what you will be learning in each chapter. After you finish a chapter, you should try to answer these questions to review what you have learned.

At the end of each chapter, you will find a brief summary of the major ideas discussed in that chapter. Reading it will reinforce what you have learned and help you answer the questions posed in the general objectives. Don't read only the summary and skip reading the chapter. The summary is not complete, and it is written on the assumption that you have read the chapter.

CHEMICAL VOCABULARY Chemistry, like all subjects, introduces you to new terms with specialized meanings. We have used three ways to help you identify these key terms. When each term is introduced and defined, it is printed in **boldfaced type**. For review we have put a list of the key terms in each chapter at the end of each chapter. This list also shows the page

number where each term is defined. Key terms are also included in the index.

You need to learn this chemical vocabulary and some of the shorthand symbols chemists use to represent chemical elements, compounds, and reactions. Think of chemical elements as the letters of chemistry, chemical compounds as its words or combinations of letters, and chemical reactions as its phrases or sentences.

One good way to memorize this information is to use flash cards. When you see a chemical term or formula that your instructor expects you to know, take a small card or piece of paper. Write the term or formula on one side and its meaning or chemical name on the other side. Take a few of these cards with you each day. Look at each term or formula and see if you can give its correct definition or name. Put the ones you get wrong in a separate place and keep studying them until you know them.

PRACTICE EXERCISES AND END-OF-CHAPTER REVIEW QUESTIONS In many chapters, you will find practice exercises to test what you have just studied. We suggest that you cover the answer given below each question. Next read the question and give your answer. Then uncover the answer and see if you got it right. If you can't answer the question, restudy the material or get help from your instructor.

At the end of each chapter, you will find other questions to test your knowledge. Answers to the odd-numbered questions are given in the back of the book. We suggest that you try to answer the question and then look up the answer to see if you got it right.

There are also several discussion questions that test your ability to think about and apply the chemical knowledge you have learned in each chapter. Because many of these questions involve opinions, value judgments, and different possible answers, we have not provided answers for them.

SIMPLIFYING COMPLEX MOLECULES If you look through this book, you will see some complex chemical formulas. In most cases, our purpose in giving these formulas is to show you key similarities and differences between important chemicals. Usually, the part of the structure that is similar (or different) is shown in **boldfaced color**. We also use boldfaced color to identify certain key parts of molecules known as *functional groups.* These groups of one or more atoms in a complex molecule are the key to that molecule's chemical behavior. So when you look at the formula of a molecule, focus on the key groups that are in color.

VISUAL AIDS We have developed a variety of diagrams to illustrate complex chemical ideas in a simple manner. We have also used many photos to give you a better picture of how chemistry occurs in the real world.

FURTHER READINGS You may want to read other books and articles to get more information about some of the topics in this book. A list of suggested readings for each chapter is given in the back of this book beginning on p. 650.

IF YOU NEED MORE HELP If you don't understand something, ask questions in class. You can also seek out your instructor and any available teaching assistants after class. Studying with other students also helps.

Don't wait until the last day or night before a test to get help. Most of the things you learn in one section or chapter are needed to understand what follows.

There is also a study guide that can help you learn the material in this book. You should be able to buy or order one from your bookstore. For each chapter section, this guide gives detailed learning objectives and key terms. It has many short-answer questions with answers that allow you to test your knowledge. A glossary covering the entire book is also provided.

HELP US IMPROVE THIS BOOK We need your help in improving this book in future editions. Writing and publishing a book is an incredibly complex process. This means that any book will have some typographical errors and other minor problems. If you find what you believe is an error, write it down and send it to us.

We would also appreciate hearing about what you like and dislike about this book. This information helps us make the book better. Some of the things you will read in this edition were suggested by students like you.

Send any errors you find and any suggestions for improvement to Jack Carey, Wadsworth Publishing Company, 10 Davis Drive, Belmont, CA 94002. He will send them on to us.

AND NOW Relax and enjoy yourself as you learn more about the exciting world of chemistry.

To the Instructor

OUR GOALS We believe that chemistry can be presented in an accurate and meaningful way to students who have little or no prior interest or background in chemistry. We also want to help students discover that chemistry is fun, interesting, and important in their lives.

Recent studies have shown that the scientific literacy of the average citizen has declined. Yet such knowledge is more important than ever.

We wrote this book to provide students who don't intend to become scientists with a basic knowledge of chemistry and its applications. We believe that this information can help them participate more effectively in societal issues. It can also help them make more effective decisions about environmental and resource problems, their health, and the numerous products they buy.

READABILITY Students often complain that their textbooks are difficult and boring to read. We have tried to overcome this problem by writing this book in a clear, interesting, and informal style.

We try to relate the chemical information in this book to the student's own life. We keep sentences and paragraphs short. We do not use long words when short ones can express an idea just as well.

Most chapters contain one or more "Chemistry Spotlights" highlighted in boxes. Some give further interesting applications of chemistry. Others describe how certain chemical discoveries were made. Some show that scientists are people who do not fit the stereotyped images we often see on TV and in the movies.

FLEXIBILITY Teachers using this book have courses that last for different lengths of time. They also may disagree on the topics to be covered and their sequence.

With these problems in mind, we have designed this book to be flexible enough to meet your particular needs. This book is organized into five major parts. These parts are shown in the brief table of contents on p. v and described briefly in the preface to the student.

This organizational pattern gives you considerable flexibility. After you have covered all or most of the principles in Part II, you can cover the rest of the book in almost any order. We have included in Part II only those principles of chemistry that we apply and reinforce in other parts of the book.

One key to this flexibility is including a simple introduction to biochemistry (Chapter 9) in Part II. This material is useful for Chapter 15 and beyond and is especially useful for Chapters 18 to 22. Other books for this type of course either do not give enough of this biochemical information or scatter it throughout the book. This makes it hard to vary the order of certain chapters.

Some of you prefer to make no use of mathematics in this type of course. Others want to include some of the simple arithmetic used in making conversions between units of measurement and stoichiometric calculations.

We have allowed for both possibilities. Conversions between metric units are mentioned briefly in Section 1.4. This can be expanded by using any or all parts of the two appendices on exponential numbers, units, and

unit conversions. The only part of the main text that includes stoichiometry is Section 5.5. Instructors not wishing to use any chemical arithmetic can omit these two sections and the two appendixes.

EMPHASIS ON LEARNING AIDS To help students learn more effectively, we have included a comprehensive system of learning aids. These include the following:

- *General Objectives* Each chapter begins with several simply worded questions (see p. 24). They give the student an overview of the chapter and can be used as review questions after the chapter is completed.
- *Chapter Summaries* (See page 54.)
- *Key Terms* When any new term is defined, the term is shown in **boldfaced type**. A list of these terms is given at the end of each chapter (see p. 55). Each term is followed by the page number where the term was defined. Key terms are also included in the index. We have not provided a glossary because we believe that it is better for students to review terms in the context where they are defined. A glossary is available in the optional *Student Study Guide.*
- *Practice Exercises and End-of-Chapter Questions* Practice exercises with answers are given within some chapters to allow students to test their knowledge before proceeding to new material (see p. 32). More questions are given at the end of each chapter (see p. 56), with answers to odd-numbered questions given in the back of the book. Each chapter also has several discussion questions designed to have students think about and apply what they have learned (see p. 57).
- *Simplified Chemical Structures* The structures of complex molecules have been simplified by showing key parts in **boldfaced color** (see pp. 230 and 231).
- *Visual Aids* Many diagrams and photographs are used to illustrate complex chemical ideas in a simple manner and to show how chemistry occurs in the real world (see pp. 186, 187, and 188).
- *Further Readings* A list of books and articles provides further information about the material in each chapter for students and instructors. These readings are listed by chapter at the end of the book (p. 650).

EXTENSIVE MANUSCRIPT REVIEW This edition and the two earlier ones were reviewed by 61 chemistry teachers. Their names are given in the list that follows this preface. This extensive reviewing system has provided us with

many helpful suggestions and minimizes errors. It also helps make each edition accurate and up-to-date.

MAJOR CHANGES IN THIS EDITION We have devoted considerable effort to making this book even more readable. Sentences and paragraphs have been shortened. The wording has been simplified. We have also used a more personal writing style to help make the book more interesting.

The entire book has been updated and new material has been added. For example, we have added new material on enzymes, AIDS, indoor air pollution, drugs to improve athletic performance, and various consumer products. We have also deleted unnecessary material to keep the book from getting longer. The order of Chapters 14 and 15 has been reversed from the previous edition to improve clarity. Some topics within chapters have also been rearranged to improve flow and clarity.

Chapter summaries have been added. More practice exercises have been added to some chapters. We have substantially increased the number of questions at the end of each chapter.

SUPPLEMENTARY MATERIALS A student study guide and an instructor's manual accompany this textbook. For each chapter section, the *Student Study Guide* gives detailed learning objectives and key terms. There are also many short-answer questions with answers that allow your students to test their knowledge of each chapter section. The study guide also contains a glossary for the entire book.

The *Instructor's Manual* has hundreds of test questions and answers to end-of-chapter questions not answered in the text. Master sheets for making *overhead transparencies* of many key diagrams are available from the publisher.

FEEDBACK We need your help in improving this book in future editions. Writing and publishing a textbook is an extremely complex process. Any textbook is almost certain to have some typographical errors and other minor problems. Our extensive reviewing system helps minimize errors, but some will probably slip through. If you find any errors, please write them down and send them to us. Most errors can be corrected in subsequent printings of this edition, rather than our waiting for a new edition.

We would also appreciate you telling us how to improve this book. We all have the same goal of trying to find the best way to teach students about chemistry. Helping us helps you and your students. We also hope you will encourage your students to evaluate this book and send us their suggestions for improvement.

Send any errors you find and your suggestions for improvement to Jack Carey, Wadsworth Publishing Company, 10 Davis Drive, Belmont, CA 94002. He will send them on to us.

ACKNOWLEDGMENTS We want to thank the chemistry teachers who took time from their busy schedules to make detailed reviews of each edition of this book and those who corrected errors and sent in many helpful suggestions. Any remaining deficiencies and errors are ours, not theirs.

We are especially indebted to Wesley D. Smith, Ricks College, who served as a coauthor for the second edition of this book. His work on Chapters 15 ("Laundry Products") and 16 ("Personal Products") and on the study guide for the second edition is especially appreciated. For this edition, we give special thanks to Robert D. Gaines, Central Washington University, for revising the *Student Study Guide* and the *Instructor's Manual.*

Others have also made important contributions. They include production editor Gary Mcdonald, copy editor Betty Duncan-Todd, managing designer Andrew H. Ogus, art editor Donna Kalal, and artists Victor Royer and Amy Hennig. We also thank Sue Belmessieri, editorial assistant, for coordinating reviews and somehow juggling several hundred tasks at the same time with competence and good humor. Above all, we wish to thank Jack Carey, chemistry editor at Wadsworth, for help, encouragement, and an extremely useful reviewing system.

Manuscript Reviewers

David L. Adams, North Shore Community College
Ronald M. Backus, American River College
Virgil R. Baker, Arizona State University
Ian G. Barbour, Carleton College
Eunice Bonar, University of Texas at Arlington
Georg Borgstrom, Michigan State University
Arthur C. Borror, University of New Hampshire
Robert C. Brasted, University of Minnesota at Minneapolis
Fred Breitbeil, DePaul University
Richard A. Cellarius, Evergreen State College
Preston Cloud, University of California, Santa Barbara
Richard A. Cooley, University of California, Santa Cruz
Danette Dobyns, California State College at Dominguez Hills
W. T. Edmonson, University of Washington
Gordon Evans, Tufts University
Frank Fazio, Indiana University of Pennsylvania
Paul Feeny, Cornell University

Robert D. Gaines, Central Washington University
Patrick M. Garvey, Des Moines Area Community College
Ted L. Hanes, California State University at Fullerton
Richard Hanson, University of Arkansas
M. Lynne Hardin, University of Texas at Arlington
Keith Harper, North Texas State College
E. Lyndol Harris, McMurray College
James Heinrich, Southwestern College
Vincent Hoagland, California State College at Sonoma
C. S. Holling, University of British Columbia
David R. Inglis, University of Massachusetts
Floyd L. James, Miami University
Ray L. Johnson, Hillsdale College
Stanley N. Johnson, Orange Coast College
Lee Kalbus, California State College, San Bernardino
Donald King, Western Washington University
C. R. Kistner, University of Wisconsin
Edward J. Kormondy, 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
William F. Pfeiffer, Utica College
Albert Plaush, Saginaw Valley State College
Grace L. Powell, University of Akron
John T. Riley, Western Kentucky University
Paul E. Robbins, Armstrong State College
Henry A. Schroeder, Dartmouth Medical School
Howard M. Smolkin, United States Environmental Protection Agency
John E. Stanley, University of Virginia
Max Taylor, Bradley University
Tinco E. A. van Hylckama, Texas Tech University
Donald E. Van Meter, Ball State University
Pothen Varughese, Indiana University of Pennsylvania
Kenneth E. F. Watt, University of California, Davis
Douglas West, Illinois State University
Ross W. Westover, Cañada College
Charles G. Wilber, Colorado State University
D. H. Williams, Hope College
Samuel J. Williamson, New York University
Archie S. Wilson, University of Minnesota
Byron J. Wilson, Brigham Young University
George M. Woodwell, Brookhaven National Laboratory
Noel S. Zaugg, Ricks College
Arden Zipp, State University of New York, Cortland

Contents In Brief

Contents