

Chemistry

& Chemical Reactivity

	Hydrogen 1 H 1.00794	Helium 2 He 4.00260
Nitrogen 7 N 14.0067	Oxygen 8 O 15.9994	Fluorine 9 F 18.9984
Phosphorus 15 P 30.9738	Sulfur 16 S 32.06	Chlorine 17 Cl 35.453
Arsenic 33 As 74.9216	Selenium 34 Se 78.96	Bromine 35 Br 79.904
Antimony 51 Sb 121.75	Tellurium 52 Te 127.6	Xenon 54 Xe 131.29
Bismuth 83 Bi 208.9804	Po 84 Po (209)	Astatine 85 At (210)

Kotz &
Treichel

THIRD EDITION

Chemistry & Chemical Reactivity

Third Edition



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Saunders Golden Sunburst Series

SAUNDERS COLLEGE PUBLISHING

Harcourt Brace College Publishers

Fort Worth Philadelphia San Diego New York Orlando Austin
San Antonio Toronto Montreal London Sydney Tokyo

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Permissions Department, Harcourt Brace & Company, 6277 Sea Harbor Drive, Orlando, Florida
32887-6777.

Text Typeface: New Baskerville
Compositor: York Graphic Services
Publisher: John Vondeling
Developmental Editor: Elizabeth C. Rosato
Managing Editor and Project Editor: Carol Field
Copy Editor: Linda Davoli
Manager of Art & Design: Carol Bleistine
Art Directors: Anne Muldrow and Carol Bleistine
Text Design: Rebecca Lloyd Lemna
Cover Design: Lawrence R. Didona
Text Artwork: George Kelvin and JAK Studios
Layout Artist: Claudia Durrell
Photo Editor: Kathrine Kotz
Director of EDP: Tim Frelick
Production Manager: Charlene Squibb
Marketing Managers: Marjorie Waldron and Angus McDonald

Cover: Beaker boiling over by Jook Leung, © FPG International

Printed in the United States of America

CHEMISTRY & CHEMICAL REACTIVITY

ISBN 0-03-001291-0

Library of Congress Catalog Card Number: 95-069433

678 032 9876543

Preface

This is the third edition of *CHEMISTRY & CHEMICAL REACTIVITY*. Although some years have passed since the book was first conceived, the principal theme has remained the same: to provide a broad overview of the principles of chemistry and the reactivity of chemical elements and compounds. We also have hoped to convey that chemistry, a field with a lively history, is also dynamic, with important new developments on the horizon. In addition, we want to provide some insight into the chemical aspects of the world around us. For example, what materials are important to our economy, how does chemistry contribute to health care, and what role do chemists play in protecting the environment? By tackling the principles leading to answers to these questions, you can come to a better general understanding of nature and to an appreciation for some of the consumer products coming from the chemical industry. Indeed, one of the objectives of this book is to provide the tools and background information for you to function as an informed citizen in a technologically complex world. Learning something of the chemical world is as important as understanding some basic mathematics and biology and having an appreciation for fine music and literature.

We are also very excited by the fact that this is the first chemistry textbook to be offered on a CD-ROM (compact disc-read-only-memory). Computers have the capability to organize and convey information, and our CD-ROM is the first attempt to make this resource available to students. Not only is the actual textbook—with all the photos and figures—available on the CD-ROM, but the material in each chapter is presented in an interactive manner. In addition, there are mathematical and molecular modeling tools and an illustrated database of compounds and their properties. The disc is meant to be an individual learning tool. Therefore, it is available for purchase with the textbook or as a stand-alone product. The contents of the disc are outlined in more detail below.

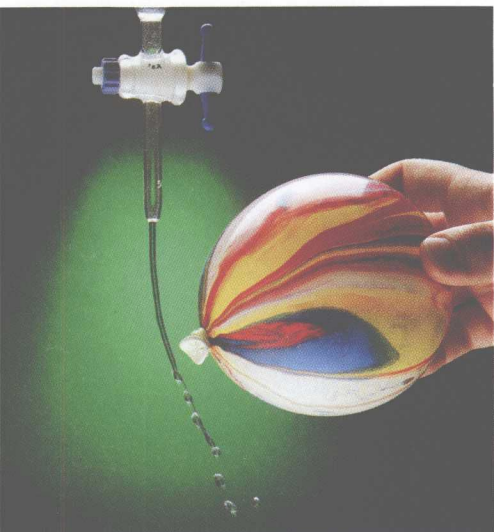
The authors of this book became chemists because, simply put, it is exciting to discover new compounds and find new ways to apply chemical principles. We hope to have conveyed our enjoyment of chemistry in this book as well as our awe at what is known about chemistry and, just as important, what is not known!

AUDIENCE FOR THE BOOK AND CD-ROM

CHEMISTRY & CHEMICAL REACTIVITY is a textbook for introductory courses in chemistry for students interested in further study in science, whether that science is biology, chemistry, engineering, geology, physics, or related subjects. Our assumption is that students beginning this course have had some preparation in algebra and in general science. Although undeniably helpful, a previous exposure to chemistry is neither assumed nor required.

PHILOSOPHY AND APPROACH OF THE BOOK

When the first edition of this book was planned, we had two major, but not independent, goals. This edition shares these same goals. The first was to con-



struct a book that students would enjoy reading and that would offer, at a reasonable level of rigor, chemistry and chemical principles in a format and organization typical of college and university courses today. Second, we wanted to convey the utility and importance of chemistry by introducing the properties of the elements, their compounds, and their reactions as early as possible and by focusing the discussion as much as possible on these subjects.

A glance at the introductory chemistry texts currently available shows that there is a generally common order of treatment of chemical principles used by educators. With a few minor changes, we followed that order. That is not to say that the chapters cannot be used in some other order. For example, although the behavior of gases is often studied early in a chemistry course, the chapter on this topic (Chapter 12) has been placed with chapters on liquids, solids, and solutions because it logically fits with these other topics. It can easily be read and understood, however, after covering only the first four or five chapters of the book.

The discussion of organic chemistry (Chapter 11) is typically left to one of the final chapters in chemistry textbooks. We believe, however, that the importance of organic compounds in biochemistry and in the chemical industry means that we should present that material earlier in the sequence of chapters. Therefore, we placed it in the middle of the book, following the chapters on structure and bonding. We chose this position because the principles of structure and bonding are particularly well illustrated by organic compounds. In any event, this chapter may be covered at almost any point in the book.

In addition, one of the authors of this text sometimes teaches the material on equilibria involving insoluble solids (Chapter 19) before acid-base equilibria (Chapters 17 and 18), and introduces kinetics (Chapter 15) and thermodynamics (Chapter 20) as a unit, after all of the material on equilibria. Although chapters are loosely organized into groups with common themes, *every attempt has been made to make the chapters as independent as possible.*

The order of topics in the text was also devised to introduce as early as possible the background required for the laboratory experiments usually done in General Chemistry. For this reason, chapters on common reaction types (especially acid-base and oxidation-reduction reactions, Chapter 4) and stoichiometry (Chapter 5) begin the book. In addition, because an understanding of energy is so important in the study of chemistry, thermochemistry is introduced in Chapter 6.

The American Chemical Society has been urging educators to put “chemistry” back into introductory chemistry courses, and we agree wholeheartedly. Therefore, we describe the elements, their compounds, and their reactions as early and as often as possible in three ways. First, there are numerous color photographs of reactions occurring, of the elements and common compounds, and of common laboratory operations and industrial processes. Second, we bring material on the properties of elements and compounds as early as possible into the Exercises and Study Questions and introduce new principles using realistic chemical situations. Third, we include sections called *Current Issues in Chemistry* that discuss such topics as the effects of chlorine-containing compounds in the environment (Chapter 2), buckyball chemistry (Chapter 3), the chemistry of black smokers (Chapter 4), the disposal of industrial wastes (Chapter 5), the use of hydrogen as a fuel (Chapter 6), the chemistry of NO (Chapter 9), surviving at sea (Chapter 14), and the destruction of the earth’s ozone layer (Chapter 15).

PHILOSOPHY AND APPROACH OF THE CD-ROM

The CD-ROM was co-authored by William Vining and produced by Archipelago Productions. It is designed to take advantage of what computers do best: allow the user to *interact* with information. Therefore, our goal was to produce “an interactive movie about the book.” The material in each chapter is presented in a series of “screens,” each presenting an idea or concept and allowing the user to interact with the information in some manner—by seeing video of a reaction in progress, by changing a variable in a chemical experiment and watching what happens to the system, or by listening to important tips and ideas about ways to understand a concept or solve a problem. In addition, you will see practicing chemists describe how the topic of the chapter applies to their work.

To make the CD-ROM even more useful, the text of the actual book is also present, with all the photos and figures. Therefore, you will be able to study the material using the interactive presentation, and you can find the most pertinent section of the book with the click of a mouse. If you need information on a compound or need to plot a graph or view a molecule, the other tools on the disc are readily available. A workbook to accompany the CD-ROM will help you use the interactive presentation of the book.

The combination of an interactive presentation of chemistry, coupled with the text of the actual book and other tools for doing chemistry, means that the CD-ROM provides all the resources needed to learn chemistry. Depending on your needs, and the availability of computer facilities, you may purchase only the book, only the CD-ROM with its workbook, or both the book and the CD-ROM.

THE AUTHORS

John Kotz has been the principal author of the first two editions of this book, working with Keith Purcell. With this edition we welcome a new author to our team, Professor Paul Treichel of the University of Wisconsin–Madison. Paul has over 30 years of experience teaching General Chemistry to majors and nonmajors. His background in inorganic chemistry has contributed to writing this text, particularly with respect to the chemistry of the elements and to aspects of molecular structure.

John C. Kotz received his Ph.D. from *Cornell University* in 1964 and currently teaches chemistry at the *SUNY College at Oneonta*, where he was promoted to University Distinguished Teaching Professor in 1986. In 1979, he was a Fulbright Lecturer and Research Scholar in Lisbon, Portugal. He has received the National Catalyst Award in Chemical Education from the Chemical Manufacturers Association. Kotz is an editor of *Chem Matters* magazine and is on the board of editors of the *Journal of Chemical Education: Software*. He is also the co-author of two inorganic chemistry textbooks and another Saunders introductory general chemistry text, *The Chemical World: Concepts and Applications*.

Paul Treichel, Jr., received a B.S. from the *University of Wisconsin–Madison* in 1958 and a Ph.D. from *Harvard University* in 1962. After a year of postdoctoral study at *Queen Mary College* in London, he

assumed a faculty position at the *University of Wisconsin–Madison*, where he has taught general and inorganic chemistry for 32 years and served as Department Chair from 1986 to 1995. Treichel's research in organometallic chemistry, aided by 75 graduate and undergraduate students, has resulted in the publication of more than 160 articles in scientific journals.

ORGANIZATION OF THE BOOK

CHEMISTRY & CHEMICAL REACTIVITY is organized in two ways. First, there are chapters on the *Principles of Reactivity*, and others on *Bonding and Molecular Structure* that are especially important in carrying the themes of the book.

The chapters on *Principles of Reactivity* introduce you to the factors involved in chemical reactions that lead to the successful production of products. Thus, under this topic you will study common types of reactions, the energy involved in reactions, and the factors that affect the speed of a reaction.

The principles of *Bonding and Molecular Structure* are particularly important. If you page through the book, you will notice the abundance of molecular models, some drawn by George Kelvin, our principal artist for this edition, and others drawn with a computer. As described in several places in the book (An Introduction—The Nature of Chemistry; Chapter 3: *Buckyballs, AIDS, and Chemistry*; and Chapter 9: *Computer Molecular Modeling*) an understanding of molecular structures is one cornerstone of modern chemistry. Using the latest laboratory techniques for uncovering molecular structures and computer programs that generate revealing portraits of structures, chemists have enormous insight into the ways molecules react.

Second, the book is also divided roughly into five sections, each with a grouping of chapters with a common theme.

Part 1: The Basic Tools of Chemistry

Certain ideas and methods form the fabric of chemistry, and these basic tools are introduced in Part 1. Chapter 1 defines some important terms and is a review of units and mathematical methods. Chapters 2 and 3 introduce atoms and molecules, and Chapter 2 introduces the periodic table, one of the most important resources available to chemists. In Chapters 4 and 5 we begin to discuss some principles of chemical reactivity and to introduce the numerical methods used by chemists to extract quantitative information from chemical reactions. Chapter 6 is the first introduction to the energy involved in chemical processes.

Part 2: The Structure of Atoms and Molecules

One major goal of this section is to outline (in Chapters 7 and 8) the current theories of the arrangement of electrons in atoms and some of the historical developments that led to these ideas. With this background information, we can understand better why atoms and their ions have different chemical and physical properties. This discussion is tied closely to the periodic table so that these properties can be recalled and predictions made. In Chapter 9 we discuss how the electrons of atoms in a molecule may lead to chemical bonding and the properties of these bonds. In addition, we show how to derive the three-dimen-

sional structure of simple molecules. Finally, Chapter 10 considers two of the major theories of chemical bonding in more detail.

This part of the book is completed with a discussion of organic chemistry in Chapter 11. Organic chemistry is such an enormous area of chemistry that we cannot hope to cover it in detail in this book. We chose to focus on the structures of compounds and on compounds of particular importance, such as synthetic polymers.

Part 3: States of Matter

The behavior of the three states of matter—gases, liquids, and solids—is described in that order in Chapters 12 and 13. The discussion of liquids and solids is tied to gases through the description of intermolecular forces, with particular attention given to liquid and solid water. Chapter 13 also considers the solid state, an area of chemistry currently undergoing a renaissance. In Chapter 14 we talk about the properties of solutions, intimate mixtures of gases, liquids, and solids.

Part 4: The Principles of Reactivity

This section is wholly concerned with the *Principles of Reactivity*. Chapter 15 examines the important question of the rates of chemical processes and the factors controlling these rates. With this in mind, we move to Chapters 16 through 19, to consider chemical reactions at equilibrium. After an introduction to equilibrium in Chapter 16, we highlight the reactions involving acids and bases in water (Chapters 17 and 18) and reactions leading to insoluble salts (Chapter 19). To tie together the discussion of chemical equilibria, we again explore thermodynamics in Chapter 20. As a final topic in this section, we describe in Chapter 21 a major class of chemical reactions—those involving the transfer of electrons—and the use of these reactions in electrochemical cells.

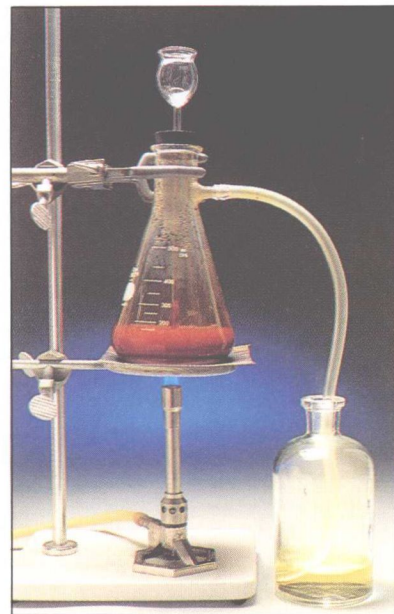
Part 5: The Chemistry of the Elements and Their Compounds

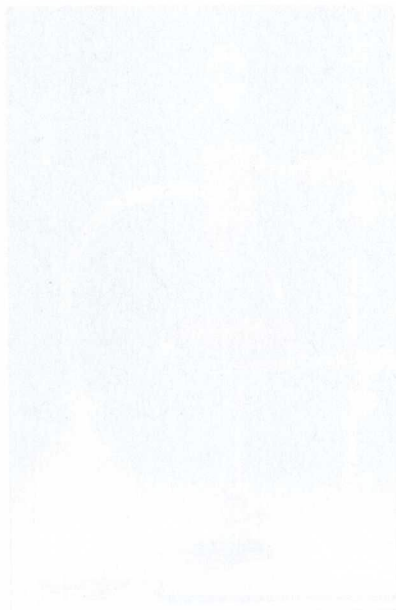
Although the chemistry of the various elements is described throughout the book, Part 5 considers this topic in a more systematic way. Chapter 22 presents the chemistry of the representative elements, and Chapter 23 is a discussion of the transition elements and their compounds. Finally, Chapter 24 is a brief discussion of nuclear chemistry.

ORGANIZATION OF THE CD-ROM

The organizational metaphor for the CD-ROM is that of a chemistry building. There is the “lecture room” where you will find the interactive version of the book. This is linked to the “library” in which you will find the full version of the book in computer-readable form, as well as a database of information on several hundred compounds. Finally, there is a “laboratory” with various tools that chemists use: graphing and mathematical tools and a program for viewing molecular structures.

To make the CD-ROM as useful as possible, we have also prepared a “workbook” with exercises and problems to be done as you work through a chapter. The workbook also contains the Appendices to the book.

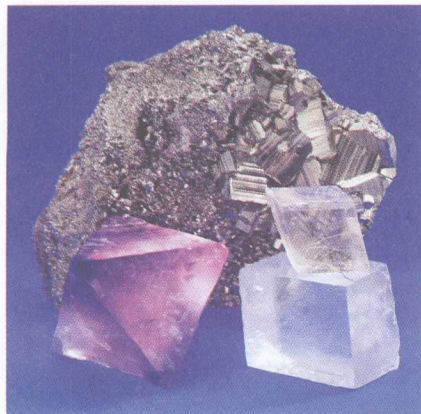




NEW TO THIS EDITION

There are several new and exciting features to the third edition of *CHEMISTRY & CHEMICAL REACTIVITY*. For example

- The Saunders Interactive General Chemistry CD-ROM accompanies the text and provides students with the entire text of the book on the disc, extensive interactive capabilities, mathematical and molecular modeling tools, and an illustrated database of compounds. (See separate discussions on the CD-ROM in this Preface.)
- A more cohesive organization of chemical reactions and stoichiometry (Chapters 4 and 5, respectively) gives students the necessary background required for laboratory experimentation.
- An early discussion of organic chemistry (Chapter 11) stresses the importance of organic compounds in biochemistry and the chemical industry. Immediately following the chapters on structure and bonding, Chapter 11 applies the principles of those chapters. For those who wish to cover this material elsewhere in their course, this is a completely transportable chapter.
- A greater emphasis on conceptual problem solving is provided with “Problem-Solving Tips and Ideas,” which target common errors and difficulties; revised examples integrated throughout the text; flow diagrams to immerse students in essential critical-thinking activities; and a dedicated section of conceptual problems at the end of each chapter.
- A refined art program features color-coded molecular models using both computer and artwork by George Kelvin, pedagogical use of color in periodic tables, and more than 600 full-color photos, many of which are completely new.
- High-interest “Portrait of a Scientist,” “Current Issues in Chemistry,” and “Interviews with Chemists” sections emphasize diversity and direct attention to the contributions of women and minorities in the field of chemistry.
- A new Introductory chapter presents the dynamic, current, applicable nature of chemistry, giving students insight into numerous areas of study.



FEATURES AND LEARNING AIDS IN THE BOOK

Problem Solving

Worked Examples and Solved Exercises

Several hundred worked-out examples serve as models for solving end-of-chapter problems. We developed the detailed solutions using the technique of dimensional analysis and highlighted the answers. Exercises follow all examples, with solutions given in Appendix L.

Problem-Solving Flow Diagrams

Scattered throughout the book and in the examples are problem-solving flow diagrams. Use these diagrams to help organize the information contained in the problems.

Problem-Solving Tips and Ideas

Based on our years of teaching chemistry, we have found that students make certain errors in solving problems and have very specific difficulties. These “Tips and Ideas” pass on our experience to you.

End-of-Chapter Study Questions

The end-of-chapter questions, some of which are illustrated with photographs or art, include review questions, questions classified by type, and general questions. *The classified problems are in matched pairs.* The first member of each pair is numbered with a bold-faced number and the answer is given in Appendix M.

Conceptual Questions

These questions ask you to think through the solution to a question or problem. Mathematics generally is not involved.

Summary Questions

Summary questions link the concepts discussed in the current chapter with those in previous chapters.

Essays on History and Current Issues

Portrait of a Scientist

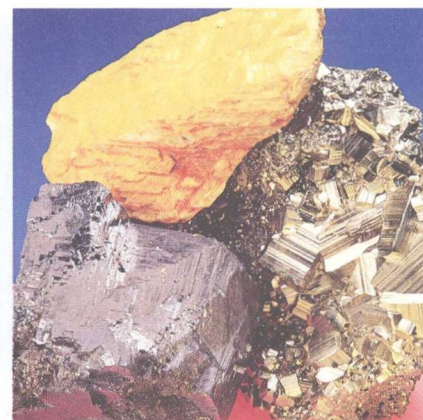
These essays are about the lives of important scientists and provide some insight into the historical background of chemistry.

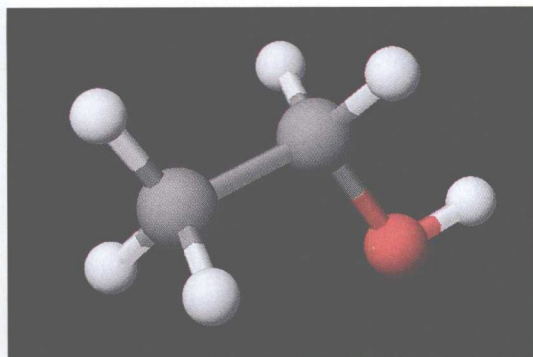
Current Issues in Chemistry

Scattered about the book are a number of essays that describe the applications of chemistry in the world today, from the current controversy over banning chlorine to the uses of buckyballs in medicine.

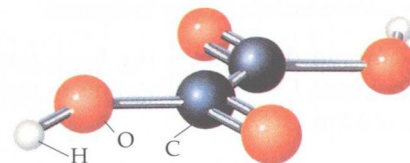
Interviews with Chemists

Interviews with three eminent chemists from different fields of chemistry appear in the book. These prominent teachers and researchers talk about how they became involved in science, about their research and their work in teaching or industry, and their views of the frontier areas of science, the importance of science in our society, and environmental concerns.

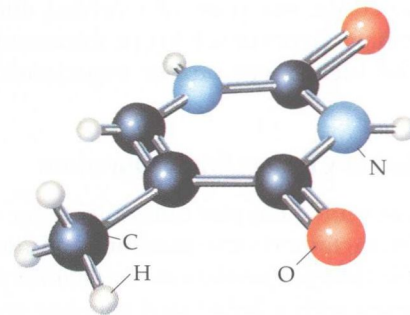




A computer-generated model of ethanol, $\text{CH}_3\text{CH}_2\text{OH}$. The C atoms are gray, the H atoms are white, and the O atom is red.



(a)



(b)

© George V. Kelvin

Two molecular formulas. (a) Oxalic acid, a compound found in many plants. (b) Thymine, one of the bases in DNA.

Illustrations

Full-Color Photography

Over 600 full-color photos, chosen specifically for this book, illustrate common elements, compounds, and minerals, as well as reactions and other processes in progress.

Use of Color in Art

Our pedagogical use of color makes the diagrams as attractive and meaningful as possible. For example,

- In the periodic tables in the text metals are shown in blue, metalloids in green, and nonmetals in yellow.
- A common color scheme is used in the illustration of molecular models.

Other Features

- Each chapter ends with Chapter Highlights, a summary of the important concepts, equations, and key terms.
- Boxes entitled “A Closer Look” delve deeper into topics related to the subject being discussed. They provide a more detailed discussion of a subject or a look into chemical research.

- Appendices at the back of the book include a review of mathematical methods, a table of conversion factors, important constants, and a glossary of terms in the combined index/glossary. Inside the back cover are short tables of useful constants and a listing of all of the data tables in the book.
- A Chemical Puzzler opens each chapter by asking thought-provoking questions. After reading a chapter, the students should be able to solve the Chemical Puzzler. We also provide brief answers to the puzzlers in Appendix L.

SUPPORTING MATERIALS

Written Materials for Student and Instructor

Pocket Guide by John DeKorte, Glendale Community College, contains useful summaries of each text section, as well as helpful problem-solving reminders and tips.

Study Guide by Harry Pence, SUNY–Oneonta, accompanies the text and has been designed around key objectives of the book. Each chapter includes a list of the main concepts, important terms, questions testing mastery of each objective, a test evaluating overall mastery of the chapter, and a set of comprehensive questions.

Student Solutions Manual by Alton Banks, North Carolina State University, contains detailed solutions to designated, end-of-chapter Study Questions.

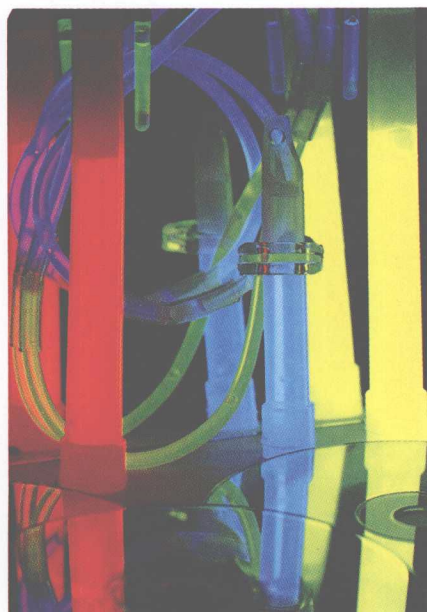
The Use of Estimates in Solving Chemistry Problems by Michael Green and Denise Garland, both of The City College of the City University, New York, is designed to help students gain a feel for chemistry by first solving problems approximately and getting past the memorization of formulas.

Test Bank by Karen Eichstadt, Ohio University, contains over 1100 multiple choice questions and numerous fill-in printed questions for each chapter.

Instructor's Resource Manual by Jack Kotz, Susan Young of Roanoke College, Lynn Hunsberger of the University of Louisville, and Linda Zarzana of American River College, suggests alternative organizations for the course, classroom demonstrations, and worked-out solutions to questions not designated by a bold-faced number in the text.

Overhead Transparency Acetates provide a set of 150 full-color transparencies with large labels for viewing even in a large lecture hall. In addition, these transparencies as well as those from other Saunders College Publishing chemistry textbooks are available on the *Chemistry of Life* videodisc, available now, and the *Chemistry in Perspective* videodisc, due to publish January 1996. The transparencies and videodiscs are available at no charge to adopters of this book.

Chemical Principles in the Laboratory, 6th edition, by Emil Slowinski and Wayne Wolsey, both of Macalester College, and William Masterton, University of Connecticut, provides detailed directions and advance study assignments. This manual contains 42 experiments that have been selected with regard to cost and safety and that have been thoroughly class-tested.



Instructor's Manual to accompany **Chemical Principles in the Laboratory**, 6th edition, provides lists of equipment and chemicals needed for each experiment.

Multimedia Materials

Saunders Interactive General Chemistry CD-ROM is a revolutionary interactive tool. This multimedia presentation serves as a companion to the text, or it can be used as an alternative to the text, because *CHEMISTRY & CHEMICAL REACTIVITY*, 3e, appears in its entirety on the CD-ROM. Divided into chapters, the CD-ROM presents ideas and concepts with which the user can interact in several different ways, for example, by watching a reaction in progress, changing a variable in an experiment and observing the results, and listening to tips and suggestions for understanding concepts or solving problems. Students navigate through the CD-ROM using original animation and graphics, interactive tools, pop-up definitions, over 100 video clips of chemical experiments, which are enhanced by sound effects and narration, and over 100 molecular models and animations.

Cambridge Scientific ChemDraw and Chem3D are available shrink-wrapped with the text for a nominal fee. These software packages enable students to draw molecular structures using ChemDraw. Users draw with ChemDraw and then can transfer their structure into Chem3D, which allows them to create, manipulate, and view three-dimensional color models for a clearer image of a molecule's shape and reaction sites. Cambridge Scientific provides an accompanying User's Guide and Quick Reference Card, written exclusively for Saunders College Publishing.

f(g) Scholar-Spreadsheet/Graphing Calculator/Graphing Software f(g) Scholar is a powerful scientific/engineering spreadsheet software program with over 300 built-in math functions, developed by Future Graph, Inc. It uniquely integrates graphing calculator, spreadsheet, and graphing applications into one, and allows for quick and easy movement between the applications. Students will find many uses for f(g) Scholar across their science, math, and engineering courses, including working through their laboratories from start to finished reports. Other features include a programming language for defining math functions, curve fitting, three-dimensional graphing, and equation displaying. When bookstores order f(g) Scholar through Saunders College Publishing, they can pass on our exclusive low price to the student.

CalTech Chemistry Animation Project (CAP) is a set of six video units of unmatched quality and clarity that cover the chemical topics of Atomic Orbitals, Valence Shell Electron Pair Repulsion Theory, Crystals and Unit Cells, Molecular Orbitals in Diatomic Molecules, Periodic Trends, and Hybridization and Resonance.

The Chemistry of Life Videodisc contains over 100 molecular model animations, chemical reaction videos, and approximately 2500 still images from a variety of Saunders College Publishing chemistry textbooks.

The Chemistry in Perspective Videodisc contains over 110 minutes of motion footage, including molecular model animations, chemical reaction videos, animated principles of chemistry, and videos demonstrating chemical principles at work in every day life, as well as 2000 still images from Saunders College Publishing 1996 chemistry titles.

LectureActive™ Software for Macintosh and IBM formats accompanies The Chemistry of Life Videodisc and contains references to all video clips and still images. Instructors can create custom lectures quickly and easily. Lectures can be read directly from the computer screen or printed with barcodes that contain videodisc instructions.

Barcode Manual for The Chemistry of Life Videodisc contains complete descriptions, barcode labels, and reference numbers for every video clip and still image. The Manual also provides practical advice about The Chemistry of Life Videodisc and set-up instructions for first-time users.

ExaMaster+™ Computerized Test Bank is the software version of the printed Test Bank. Instructors can create thousands of questions in a multiple-choice format. A command reformats the multiple-choice question into a short-answer question. Adding or modifying existing problems, as well as incorporating graphics, can be done. ExaMaster has gradebook capabilities for recording and graphing students' grades.

KC?Discoverer Software (JCE:Software), developed by a team of chemists, is an extensive database allowing users to explore 48 different properties of the chemical elements, such as atomic radii, density, ionization energy, color, reactivity with air, water, and acids and bases. The HELP menu provides a reference for the source of data for each of the properties and the database. KC?Discoverer Software has the capability to correlate with the Periodic Table Videodisc. Chosen as the "official" database for this book, references appear in the Annotated Instructor's Edition of this text, and all the data tables in this book reflect information from KC?Discoverer. This program is available to qualified adopters or it may be purchased directly from JCE: Software, Department of Chemistry, University of Madison, Wisconsin, 1101 University Avenue, Madison, WI 53706.

Periodic Table Videodisc: Reactions of the Elements (JCE: Software), by Alton Banks, North Carolina State University, features still and live footage of the elements, their uses, and their reactions with air, water, acids, and bases. Users operate the videodisc from a videodisc player with a hand-controlled keypad, a barcode reader, or an interface to a computer running KC?Discoverer Software. It is particularly useful as a way to demonstrate chemical reactions in a large lecture room. Available to qualified adopters.

Shakhashiri Demonstration Videotapes feature well-known instructor Bassam Shakhashiri, University of Wisconsin, performing 50 three- to five-minute chemical demonstrations. An accompanying Instructor's Manual describes each demonstration and includes discussion questions.

World of Chemistry Videotapes, taken from the popular PBS television series and hosted by Nobel laureate Roald Hoffmann, are two 40-minute videos highlighting topics such as the mole, bonding, and acid-base chemistry and their applications. Order through the Annenberg Foundation at 1-800-LEARNER.

Acknowledgments

Preparing the third edition of *CHEMISTRY & CHEMICAL REACTIVITY* took more than eighteen months of continuous effort. However, as in our work on the first two editions, we have had the support and encouragement of family and of some wonderful friends, colleagues, and students.

We begin by expressing our great appreciation to Mel Joesten, John Moore, and Jim Wood, co-authors with JCK on *The Chemical World*. This book set the tone for a new style of introductory chemistry books, and some of the ideas and materials developed during its writing have been used in this edition of *CHEMISTRY & CHEMICAL REACTIVITY*. In particular, we acknowledge John's contribution to the material on thermodynamics and kinetics and Mel's contribution to the section on polymer chemistry.

SAUNDERS COLLEGE PUBLISHING

The editorial staff of Saunders College Publishing has once again been extraordinarily helpful. The project has benefited from their good humor, friendship, and dedication. Much of the credit goes to our Publisher, John Vondeling. We have worked with John for many years and have become fast friends. His support and confidence are greatly appreciated—and he wears better ties than in the past. He has promised a long fishing trip when we retire.

The Developmental Editor for this edition was Beth Rosato. In addition to being a very pleasant colleague, she is a good chemist, is well organized, and has insight into the proper balance in a book. She has been a trusted friend and confidant, and we have appreciated her great efforts to make this a successful book.

Carol Field has once again served as both our Managing Editor and Project Editor. In addition, she has served as the Developmental Editor for CD-ROM. We have now worked with Carol for over eight years, and she has become part of our family. Her close attention to detail has helped make past editions of this book successful.

No book can be successful without proper marketing. Margie Waldron, Director of Marketing, and her staff have again been very helpful. Angus McDonald, Product Manager, joined the marketing team at Saunders specifically to market chemistry texts. We are always happy to work with Margie and Angus, and would even be willing to be part of a magic act again.

Our team at Saunders College Publishing is completed with Anne Muldrow, Carol Bleistine, Charlene Squibb, and Tim Frelick, who kept the art program and production of the book organized. Jay Freedman again did a wonderful job of creating the index/glossary.

PHOTOGRAPHY AND ART

Most of the color photographs for this edition have again been beautifully done by Charles D. Winters of Oneonta. He produced hundreds of photos for the

book and the CD-ROM, as well as the videos for the CD-ROM, often under great deadline pressure. We have worked with Charlie for some years and have become close friends. Charlie is still willing to eat the fried egg sandwiches one of us makes for him for lunch, and we listen to his old jokes—and always forget them.

Many of the illustrations in the book are by George Kelvin. George is simply the best scientific illustrator working today. He took our sketches and rendered them accurately and with an eye to a perspective most useful to students. We have thoroughly enjoyed working with him.

CD-ROM

William Vining of Hartwick College is largely responsible for authoring the CD-ROM version of the book. One of the authors (JCK) is proud that Bill is one of his former students and has become a close colleague. When we needed someone to translate the book into an interactive CD-ROM, Bill was our first choice. He is energetic, creative, pleasant to work with, and he has done a magnificent job.

The CD-ROM was produced by Archipelago Productions of Lake Tahoe, San Francisco, San Diego, and points in between. The vision was provided by Gary Lopez, an oceanographer who became interested in producing environmental films and educational software. It is Gary who has guided us through the very difficult, expensive, and complex task of creating the CD-ROM version of the text. He is a good friend.

Creating multimedia software cannot be done by a single person. We have had a large team of very talented people working on this project. Pat Harman designed the CD-ROM and played a principal role in translating our ideas into images on the computer screen. He has been a wonderful and creative colleague and we thank him for his patience. Bill Gudmundson created the computer art and animation sequences, and Brian Rowlett designed the software tools. Bruce Hoffman wrote the script for the spoken material and edited the written text. Nicole Taylor managed the project and kept track of the hundreds of photos and hours of video that we needed. Brian Griffith, Charles Hamper, Mark Keller, and Birgit Maddox completed the team of graphic artists on the project. We simply cannot thank them enough. They worked very hard against severe deadlines with good humor, and their creativity never waned. We all hope we have time to relax together someday.

Some of the original planning for the CD-ROM took place in an informal meeting at the University of Wisconsin–Madison. We wish to thank John and Betty Moore for hosting that gathering and for their comments, and Kathy Christoph, Jon Holmes, and Paul Schatz for their valuable insights.

CAChe SCIENTIFIC

Several years ago CAChe Scientific, Inc., made a grant of a Molecular Modeling Worksystem to JCK. This software has been used heavily by students in general and inorganic chemistry courses. It was also used to prepare molecular models for this book, the CD-ROM, and the new laserdisc from Saunders College Publishing. The people at CAChe—especially George Fabel, George Purvis, Evelyn Brosnan, and Rick DeHoff—have been extremely helpful, and we wish to acknowledge their support with gratitude.



OTHERS

Publishing a book and a CD-ROM is a complicated process. A large team of people is needed to carry out the task. Two members of that team not yet mentioned—but who have been the keys to its success—are Susan Young and Katie Kotz.

Susan Young is a postdoctoral associate of one of the authors (JCK). She has had a wide range of responsibilities on the book and CD-ROM. All of the computer-generated images were her creation, and she worked closely with Charlie Winters on the photography and video program. She checked galley proofs, worked out answers to problems, and prepared the Annotated Instructor's Edition. In addition, she taught General and Inorganic Chemistry and helped students at SUNY-Oneonta, and she did it all with energy and good humor. We shall miss her greatly when she moves on to a faculty position at Roanoke College.

Katie Kotz kept the work in Oneonta—photography, video production, text preparation, and photo research—organized. Her organizational skills and her expertise in maintaining a large database of information have been invaluable. In addition, she has been the wonderful wife of one of the authors for 34 years.

John C. Kotz
Paul Treichel, Jr.
July 1995