

# WORLD OF CHEMISTRY

..... SECOND EDITION

**JOESTEN  
& WOOD**



# World of Chemistry

SECONDEDITION

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(C.D. Winters)

## Preface

### Approach and Scope

The second edition of *World of Chemistry* continues in the tradition of the first edition in providing a text for nonscience majors that presents chemistry in its broad cultural, social, and economic context. Since the text covers topics that concern students' everyday lives, updating the chapters to include the most recent information on subjects such as energy, new advances in materials, and environmental issues has been an important part of the revision. The comments of reviewers who have used the first edition have been a valuable resource. Mary E. Castellion, who joined the writing team as contributing editor, played a significant role in planning, writing, and editing the second edition. The end result has culminated in a major revision that both preserves and expands the fundamental approach of the first edition—to teach chemical principles within the framework of real-world applications.

To the beginning student there may be a mystery in chemistry, but to leave the workings of the chemist as a mystery suggests that the liberally educated person must be dependent upon the chemist for those chemical decisions that affect society as a whole. *World of Chemistry* is based on the belief that the liberal arts student can see and appreciate the chain of events leading from chemical fact to chemical theory and the ingenious manipulation of materials based on the chemical theories. Thoughtful students will then see that the intellectual struggles in chemistry are closely akin to their own personal intellectual pursuits and will feel that each educated individual should and can have a say in how the applications of chemical knowledge are to affect the human experience.

The topics covered in this book have been selected based on what we and others who have used the first edition have observed to be student interests:

1. Feeling the satisfaction of understanding the cause of natural phenomena.
2. Understanding the scientific bases for making the important personal choices demanded for the use of chemicals and chemical products.
3. Participating on a rational basis in the societal choices that will affect the quality of human life.

4. Helping to preserve and restore the quality of the environment along with a sensible approach to the recycling of natural resources.
5. Developing an insight into the perplexing problem of chemical dependency.
6. Sensing the balance involved in population control, the chemical control of disease, and the ability of the world to produce food.
7. Choosing personal habits in exercise programs and in nutritional selections that are compatible with healthful living.
8. Going places in vehicles that reflect the best uses of the materials used in transportation.
9. Using present energy reserves at a sensible rate, as new energy sources are developed for the long term.

All of these paramount interests, as well as many of lesser note, are featured in *World of Chemistry*, Second Edition.

## Organization

*World of Chemistry* utilizes the common sense approach that is too often lost as the chemical community presents itself to the educated public at large. As in the total human experience, there is in chemical studies a fundamental relationship between cause and effect—structure causes function, chemical periodicity, and consequent material properties. We have selected carefully that thread of chemical history that shows chemistry to be the human endeavor it is. With the aid of ongoing communication with college students, as well as the critical reviews from our peers, we feel this text effectively tells the essential chemical story. The philosophical setting for the text is presented in Chapter 1, whetting the appetite of the students to reach a level of understanding that may have previously been thought to belong only to the scientific elite. Chapters 2 through 15, while laying the groundwork for an intellectual consideration of the effect of chemistry on society, are replete with interesting applications to which the liberal arts students readily relate. The remainder of the text addresses problems that generate intense interest from the general public. These issues include synthetic materials that dramatically alter the human environment; the nutritional basis of healthy living; medicines and drugs; pollution and the conservation of natural resources; consumer chemistry; and the agricultural production of food for a hungry world population.

The book is organized to allow its use for either a one- or two-semester course. The approach followed throughout the book is to link chemical principles within the framework of real-world applications. As a result, selection of several earlier chapters for a one-semester course will still provide the student with a sense of the relevancy of the chemical principles taught in later chapters.

After setting the philosophical tone for the book in **Chapter 1**, basic concepts about atoms, compounds, the periodic table, and nuclear changes are presented in **Chapters 2 through 5**. Chemical bonding, states of matter, chemical reactions, acids and bases, and oxidation and reduction are covered in **Chapters 6 through 10**.



The sources of our natural raw materials, and the energy, and consumer products we derive from them, are the focus of **Chapters 11 through 14**. Inorganic chemicals from the air, land, and sea are discussed in Chapter 11. Organic chemistry and its relevance to energy sources and materials is described in Chapters 12 and 14, with Chapter 13 including a discussion of nuclear energy and other alternate energy sources.

The chemical principles of biochemistry are discussed in **Chapter 15**, and the remaining chapters in the book are topic-centered. **Chapters 16 through 19** address biochemistry-based topics. Consumer chemistry, with an emphasis on personal-care products, is covered in Chapter 16. Health-related topics are then covered in a logical order: nutrition, toxic substances, and medicinal chemistry. Next, in **Chapters 20 and 21**, we look at our environment: water quality and abundance, and air quality. Finally, the text closes with a topic of major importance to us all—feeding the world (**Chapter 22**).

## Major Changes in This Revision

Chapter 1 now includes a connection to chemistry-related stories in newspapers and can lead students to discussions of science in the news throughout the course. Chapter 2 introduces the macro-micro aspect of the chemical view of matter, and systematically defines essential terms needed in following chapters. A new chapter, Chapter 7, States of Matter and Solutions, has been added in response to reviewer and user comments about the need for more emphasis on these topics. The properties of water have been moved from the chemical reactions chapter to Chapter 7.

Updated topics include recycling (Chapter 11), energy sources (Chapter 13), consumer products (Chapter 16), global warming and ozone layer depletion (Chapter 21), medicines (Chapter 19), nutrition (Chapter 17), environmental issues (Chapters 18, 20, 21), and feeding the world population (Chapter 22). The number of chapters remains the same as in the first edition, but the order has been changed. Nuclear Reactions (Chapter 5) now comes immediately after the Periodic Table (Chapter 4) rather than after Chemical Reactivity (Chapter 8). The treatment of organic chemistry has been rearranged to relate the chemical principles more directly to the applications: Chapter 12 discusses Energy and Hydrocarbons, and Chapter 14, Organic Chemicals and Polymers, emphasizes industrial and consumer uses of organic chemicals. In keeping with the theme of stressing the application of chemical principles to the students' everyday lives, the chapter on consumer chemistry has been moved from the end of the book to Chapter 16. The topical natures of Chapters 16 through 22 allow for their use individually or in a different sequence. During the complete revision of every chapter, we have, in addition to updating, selectively diminished coverage of some topics.

## New to the Second Edition

A major focus during the revision has been to incorporate into each chapter guides to what is important and tools that will assist students in learning.

**Chapter opening questions** highlight the most important aspects of the chapter topic.

**Essential terms** are defined upon their first use. They are boldfaced and definitions are given in the new Glossary/Index.

**Worked examples** within chapters demonstrate how to utilize the simple concepts in this course that require problem solving. Each Example is accompanied by one or more Exercises that are answered in Appendix F, thereby helping students to check their understanding. The Examples and Exercises, together with the Self Tests featured in the first edition, help students gain confidence about smaller segments of material before they try to answer questions and problems at the end of the chapters.

**Optional mathematical problem solving sections** appear at the ends of certain chapters (unit conversions in Chapter 2, gas law arithmetic in Chapter 7, simple stoichiometry in Chapter 8, pH in Chapter 9, and nutritional calories in Chapter 17). This feature is provided in response to what we have learned from users of the first edition. There is a wide variation in the amount of mathematical problem solving that different instructors choose to incorporate in this course. By placing these sections at the ends of chapters, they are easily skipped by those who wish to do so.

**End of chapter questions and problems** are all new and have greatly increased in number. They are divided into two groups, to again meet the varying needs of instructors who do or do not include mathematical problem solving: **Questions for Review and Thought** include some questions that review chapter material and others that require thought about the meaning and application of chemical concepts. **Problems** are usually mathematical and appear only in appropriate chapters.

The scope of our emphasis on the relationship of chemistry to everyday life has been broadened with three new types of boxed features:

**Frontiers in the World of Chemistry** describe new developments related to chapter topics; developments that frequently attract attention in the media.

**Science and Society** essays focus on science-related societal issues of the type that often raise difficult questions and do not have clearcut answers.

**Discovery Experiments** are activities that students can carry out on their own. Some are experiments using materials readily available at home or on campus, and others lead the students to examine consumer products, their personal environments, or their lifestyles.

In addition, new **Personal Side** boxes highlight the achievements of recent contributors to the science of chemistry, and **World of Chemistry** boxes feature interviews from *The World of Chemistry Video Series*.

For today's students, visual impact is approaching equal importance with the written word. With the assistance of the team of creative professionals assembled by Saunders College Publishing, the second edition of *World of Chemistry* has a greatly enhanced art and photo program.

**Macro-micro visualizations** throughout the book, drawn by our outstanding scientific illustrator, George Kelvin, are designed to help students with what is always difficult for them—relating what they can see to the chemist's micro view of materials.

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## New to the Second Edition

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**Chapter opening questions** highlight the most important aspects of the chapter topic.



**Photos**, chosen for their visual appeal, also relate people and everyday circumstances to the chemistry under discussion, in addition to illustrating chemical concepts and the properties of materials.

**Connections to the World of Chemistry videotapes** have been expanded by introducing marginal quotations from interviews with scientists, new still photos (identified by the program so that the tie-in can be discussed), and some new *World of Chemistry* boxes.

Through the services of the **Harcourt Brace Custom Publishing Group**, portions of *World of Chemistry*, 2e, can be packaged according to individual needs. Instructors who wish to augment *World of Chemistry*, 2e, with their own material or to make selected chapters available in courses with a different focus than that of the textbook as a whole should contact their local Saunders College Publishing sales representative.

## Accompanying Materials to *World of Chemistry*, Second Edition

### Printed Materials for Instructor and Student

*Student Study Guide with Selected Solutions*, by Walt Volland of Bellevue Community College, Washington, provides section-by-section list of main topics, listing of objectives, key terms, detailed solutions to all the end-of-chapter odd-numbered Questions for Review and Thought as well as selected Problems, suggested readings on related topics, and “Bridging the Gap”—a set of intriguing activities designed to connect chapter topics to everyday life.

*Instructor’s Resource Manual with The World of Chemistry Video Series Correlation Material* includes three sections:

1. *Notes to the Instructor* includes detailed solutions to the end-of-chapter Problems that do not appear in the text and Student Study Guide with Selected Solutions.
2. *Printed Test Bank* of multiple-choice questions and problems.
3. *Correlation Guide I*, by Cheryl Dembe of Diablo Valley College, California, provides a detailed synopsis of each of the 26 videos from *The World of Chemistry Video Series* with a special section referencing corresponding textbook material.

*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.

*Overhead Transparencies* set includes 100 full-color acetates with labels enlarged for easy viewing.

*Laboratory Manual to accompany World of Chemistry*, 2e by John Blackburn, John Craig, Paul Langford, and Melvin Joesten includes 45 experiments

that include pre- and post-lab questions, safety considerations, as well as a new, introductory discussion of risk versus benefit.

*Instructor's Manual to accompany the Lab Manual* provides listing of equipment and reagents needed for each experiment, as well as suggested demonstrations and safety considerations for pre-lab instruction.

## Multimedia Materials

*The World of Chemistry Video Package.* *The World of Chemistry*, Second Edition, is presented as either a stand-alone course in chemistry for nonscience majors or as an integral part of a comprehensive telecourse package including a series of 26 thirty-minute video programs, with an accompanying telecourse study guide, telecourse faculty manual, and a telecourse laboratory manual. Sponsored by the Annenberg/CPB Project and corporate sponsors, *The World of Chemistry* video series was developed by the late Dr. Isidore Adler of the University of Maryland and Dr. Nava Ben-Zvi of Hebrew University of Jerusalem. The video programs feature Nobel laureate and Priestley medalist Roald Hoffmann and provide a comprehensive survey of the field of chemistry and its impact on modern society. The series was jointly produced by the University of Maryland and The Educational Film Center. For information on ordering the videocassettes, call 1-800-LEARNER.

*The World of Chemistry: Selected Demonstrations and Animations I and II* are two videodiscs produced by JCE:SOFTWARE. For information on these videodiscs contact JCE:SOFTWARE, John W. Moore and Jon L. Holmes, Department of Chemistry, University of Wisconsin-Madison, 1101 Madison Avenue, Madison, WI 53706.

*The Saunders Interactive General Chemistry CD-ROM* (Designed exclusively for Saunders College Publishing by Archipelago Productions and authored by Jack Kotz of SUNY-Oneonta and Bill Vining of Hartwick College).

Based on our best-selling general chemistry text *Chemistry & Chemical Reactivity*, 3e, and including the text in its entirety, the CD-ROM serves as a useful multimedia companion to *World of Chemistry*, 2e, by providing imaginative and innovative approaches to learning chemistry.

With the CD-ROM, students navigate through original animation and graphics, interactive tools, and pop-up definitions, as well as over 100 video clips and chemical experiments enhanced by sound effects and narration. A student workbook accompanies the CD-ROM, and important technical information and suggestions for accessing some of the CD-ROM's unique teaching features are available to professors.

*CalTech Chemistry Animation Project (CAP)* is a set of five video units covering the following chemical topics with unmatched quality and clarity: Atomic Orbitals, Valence Shell Electron Pair Repulsion Theory, Crystals and Unit Cells, Molecular Orbitals in Diatomic Molecules, and Periodic Trends.

With an emphasis on general chemistry, the *Chemistry in Perspective Videodisc* includes over 110 minutes of motion footage, including molecular model animations, chemical reaction videos, animated principles of chemistry, and excerpts from *The World of Chemistry* video series that correlate with the *The*

*World of Chemistry* boxed essays found in the textbook, as well as 2000 still images from Saunders College Publishing 1996 chemistry textbooks.

With the emphasis on organic and biological chemistry, 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.

*LectureActive™ Software* and *Barcode Manuals* for our videodiscs enable instructors to customize their lectures with our chemistry videodiscs. Available for both IBM and Macintosh.

## Reviewers

We are deeply grateful to all the reviewers who have contributed to the improvement of the manuscript and teaching aids for the second edition. We would especially like to thank Walt Volland, Bellevue Community College, Washington, who provided a thorough review of the edited manuscript, contributed chapter questions, and provided solutions to the chapter questions and problems. We also appreciate the thoughtful comments of all our other reviewers:

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Reviewers of the first edition included:

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 J. Leland Hollenberg *University of Redlands*



Keith Kennedy *St. Cloud State University*  
Robert E. Miller *Keene State College*  
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Many of the drawings in this book were done by George Kelvin, an outstanding science illustrator. His drawings not only illustrate the principles of chemistry, but also are truly works of art. We also acknowledge Sue Howard, Photo Editor, for her efforts in locating so many beautiful photographs to illustrate the applications of chemical principles and Charles Winters for his creative and excellent photographs.

We initiated the use of *Chemistry You Can Do* experiments that students can do on their own in *The Chemical World: Concepts and Applications* by J. C. Kotz, M. D. Joesten, J. L. Wood, and J. W. Moore, 1994, Saunders College Publishing. We wish to thank John Moore, University of Wisconsin—Madison, for contributing many of the *Chemistry You Can Do* experiments and class testing each of them prior to their publication. Since the *Chemistry You Can Do* experiments have been well received by both students and faculty, we decided to add experiments for students to the Second Edition of *World of Chemistry*. Many of these experiments, called *Discovery Experiments*, previously appeared as *Chemistry You Can Do* experiments and were adapted from activities published by the Institute for Chemical Education as *Fun with Chemistry, Volumes I and II*. These were originally collected for ICE by Mickey and Jerry Sarquis of Miami University, Ohio.

Given the broad scope of topics in our book, we sometimes must rely on the assistance of experts. For this edition we would like to thank Dr. Keith Brown, Director of Hair Color Research, Clairol, Inc., who reviewed sections on hair chemistry. Also, we wish to acknowledge the support we received from the efforts of the authors of two textbooks that we view as outstanding: Lori A. Smolin and Mary B. Grosvenor, *Nutrition: Science and Applications*, Saunders College Publishing, 1994; and Peter H. Raven, Linda R. Berg, and George B. Johnson, *Environment*, Saunders College Publishing, 1993.

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Although much help has come our way, the responsibility for the contents of the text rests entirely on us.

As in all of our previous works, we dedicate this effort to our families and gratefully acknowledge their support and understanding during the preparation of this manuscript.

MDJ

JLW

*Nashville, Tennessee*

NOVEMBER 1995



(C.D. Winters)

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(Tom Hollyman/Photo Researchers)

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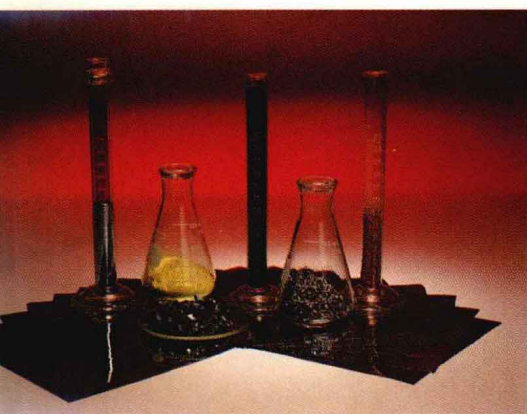
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