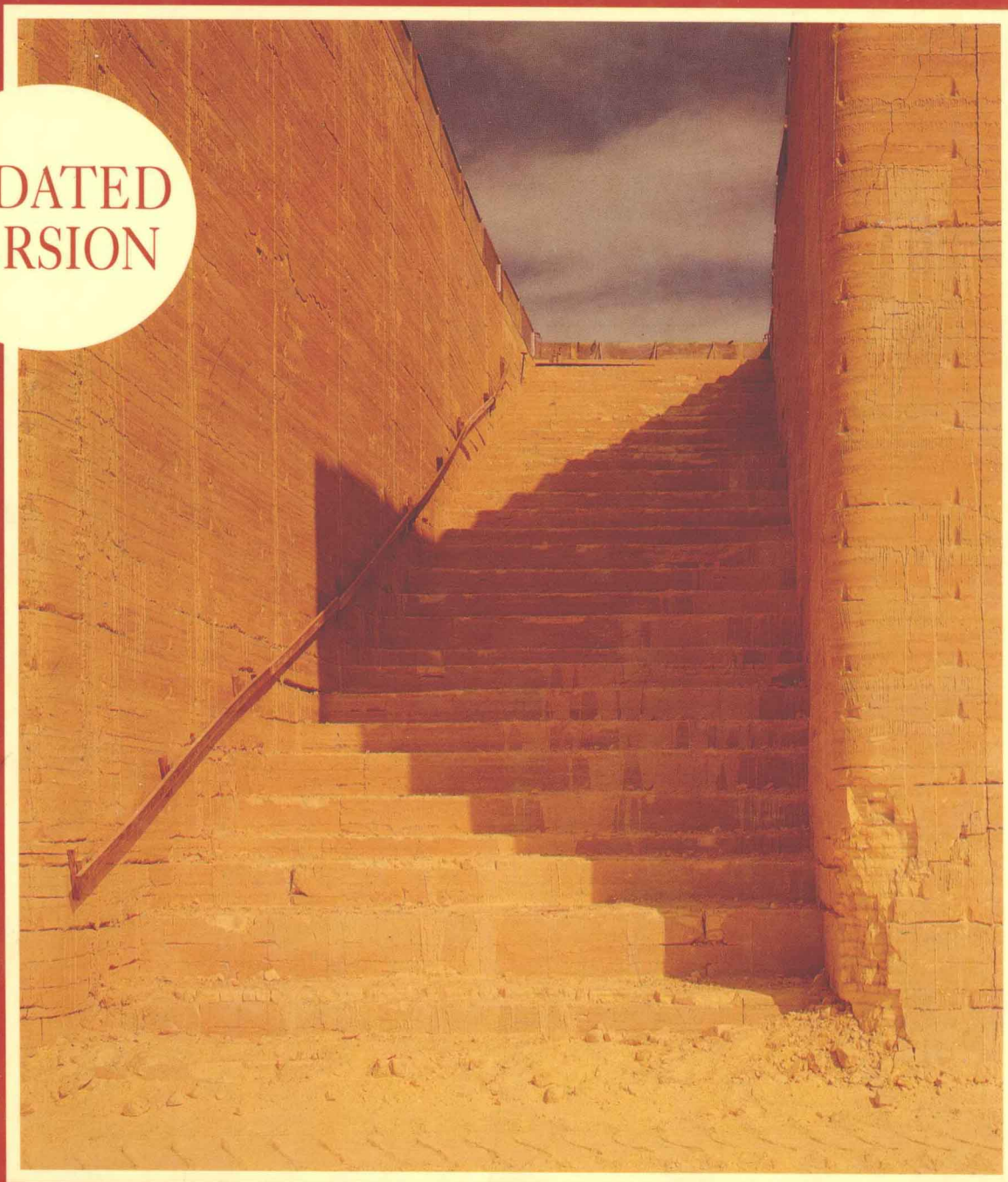


# GENERAL CHEMISTRY

SECOND EDITION

UPDATED  
VERSION



P. W. ATKINS



J. A. BERAN

# **GENERAL CHEMISTRY**

**SECOND EDITION, UPDATED VERSION**

**P. W. ATKINS**

*Oxford University*

**J. A. BERAN**

*Texas A&I University*

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(Top) At high temperatures, a mixture of powdered iron and sulfur will react to produce a number of iron sulfides. As the reaction proceeds, there is a vigorous evolution of energy as heat. (Ken Karp)

(Middle) The head of a “strike-anywhere” match is composed of potassium chlorate,  $\text{KClO}_3$ , which acts as an oxidizing agent, and tetraphosphorus trisulfide,  $\text{P}_4\text{S}_3$ , which acts as a reducing agent. It also contains a binder and ground glass (to enhance the frictional heating when the match is struck). (Chip Clark)

(Bottom) When cooled very slowly, rhombic sulfur forms large crystals. Here the crystals are shown embedded in cooled magma, the molten rock that lies beneath the crust of the Earth, that has risen to the surface and solidified. (Chip Clark © 1989)

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# ***GENERAL CHEMISTRY***

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*Most elemental sulfur is obtained as a by-product of the petroleum industry. This huge mound of sulfur was produced by the reaction of hydrogen sulfide and sulfur dioxide. The golden staircase rising through the mound symbolizes the progress that you will make in chemistry as you work through this text.*

▲ ▲ ▲ ▲



## ABOUT THE AUTHORS



A leading chemist, science writer, and educator, **P. W. Atkins** lectures in physical chemistry at the Oxford University and is a fellow of Lincoln College, Oxford. Among his many publications are *Physical Chemistry, Fourth Edition*, the leading textbook in that field, *Quanta* (Oxford University Press), *Inorganic Chemistry* (with D.F. Shriver and C.H. Langford), the leading textbook in its field, and three volumes for the Scientific American Library (*Molecules*, *The Second Law*, and *Atoms, Electrons, and Change*).

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Dr. Beran is the author of the bestselling *Laboratory Manual for General Chemistry*, and *Laboratory Manual for Fundamentals of Chemistry*.



# **PREFACE**

The guiding principle in revising *GENERAL CHEMISTRY* remains our desire to develop in students a scientific attitude—what we have come to think of as “a sense of the reasonable.” The result, within the chapters, the examples, and the exercises, is a consistent and thoughtful focus on learning chemistry by reasoning one’s way to an answer. We aim to show students how to develop problem-solving skills by asking the right questions rather than merely applying the right formulas.

We believe that our collaboration has produced a text that combines thoughtful, tested pedagogy with a sense of the integrity of the scientific enterprise, and does so in a visually pleasing and highly readable way.

## ***CHANGES IN THE SECOND EDITION***

Of the many changes in this second edition of *GENERAL CHEMISTRY*, perhaps the most significant is our coauthorship. We have worked closely together during the preparation of this edition, continually drawing upon each other’s skills and experience, and we believe instructors and students alike will benefit from our collaboration.

Our approach was not merely to graft on new material. Rather, we dismantled the book and, on the basis of three years of firsthand classroom use and feedback from many users of the first edition, decided what succeeded. Then we brought in new

approaches that we knew from experience worked in the classroom, and rewrote and reassembled the parts—continually integrating feedback from our many readers—into a text that we believe is highly teachable and responsive to both instructors and students. With the help of a corps of reviewers, many of whom used the first edition, we have reconsidered literally every word, as well as the overall structure of the book. The result is a newly invigorated text that clearly communicates chemistry to students.

Recognizing that many students have had little or no exposure to the scientific method, we have made sure that the early chapters proceed gradually. Throughout the revision process we carefully evaluated and agreed on what is teachable when and how a topic is best introduced, with the result that the more advanced material now appears later in the book than it did in the first edition.

We emphasize throughout that frequently a uniform mode of thought can be deployed to solve a wide variety of problems. For instance, we have adopted in this edition a consistent way of setting up equilibrium calculations and a more consistent (and more natural) way of dealing with conversion factors.

We also have paid considerable attention to the uniformity of level. Chapter 3, which introduces the different classes of chemical reactions, is now pitched at a more introductory level than it was in the first edition. Chapters 8 and 9, on molecular structure, have been entirely reorganized so that

one chapter (8) takes the reader from octet completion through to molecular shapes in terms of VSEPR theory; then Chapter 9 develops the details of electron distributions, treating valence bond theory in much greater detail than in the first edition and concluding with a section on molecular orbitals.

A similar major reorganization of material has taken place in Chapters 14 and 15 on acids and bases. We have grouped all the elementary material in Chapter 14 and have moved the more advanced material into Chapter 15. This arrangement allows instructors to select more easily the depth at which they prefer to cover acids, bases, and equilibrium. In particular, throughout these chapters we have adopted a uniform style of setting up and solving equilibrium problems, which the student should find easy to apply in a consistent way.

Other important changes within the text include a reorganized discussion of the role of electron pairs by way of Lewis acids and bases in Chapter 8, which allows instructors to go on to the theory of bonding in the context of real chemical reactions. Thermochemistry and enthalpy change are now the exclusive focus of Chapter 6; the first and second laws of thermodynamics are discussed together in the redrafted Chapter 16. Recent developments in a variety of subjects are incorporated throughout the text and the problems, including the latest on superconductivity, ozone depletion, smog control, DNA research, and new species such as the buckminsterfullerene.

## NEW SUPPORT FOR STUDENTS

In addition to smoothing the level of exposition, particularly in the important early chapters, we have added human interest with two innovations in this edition. The first is the series of **Guest Boxes**, contributions from leaders in a variety of important fields that place their work in the context of the given chapter and indicate some of the unsolved problems working chemists and researchers face. We intentionally avoided biographical or philosophical essays, for we want to show students how the ideas they are meeting in the book are developed and applied in the real world. The second innovation is the **Cases** that conclude each chapter. These develop an interesting theme of applied or descriptive chemistry with a brief set of questions, often drawing upon previous chapters' skills, to

test the student's ability to go beyond the basics. As the last item in each chapter, the Cases, which are often illustrated, function as a magnet of interest.

All the material at the end of each chapter has been reconsidered for this edition. For instance, the exercises, many of which are new, are now divided into two groups. **Classified exercises** cover the material systematically; they are paired, with the answers to the first (i.e., odd-numbered) of each pair given at the end of the text. Classified exercises are followed by the unpaired **Unclassified exercises**, which span the chapter without reference to the topic headings.

All defined terms are now in bold face type, and the fundamental ones are set off from the text. As in the first edition, the **Glossary** at the end of the book gives not only definitions but also examples of the use of many important terms. We have also included a number of in-text **Boxes** that describe interesting and motivating material that would otherwise interrupt the text. The expanded appendices include a review of basic mathematical skills and tables of data for help in problem solving.

## ENDURING STRENGTHS OF THE TEXT

In making the many changes described here we were also mindful of the strengths that won praise for the first edition, and we planned carefully to retain them. The clarity of exposition, the striking artwork, and the sensitivity to students' needs continue to be hallmarks of the text.

Users of the first edition uniformly praised its readable style. We believe the chapters are even more readable now. Many readers praised the illustrations for being informative as well as attractive: we have retained and even expanded upon them. Many line drawings have been redone for even greater clarity, and many new photographs have been added. The first edition was also admired for the strategy sections within the worked examples, and we have retained them. These sections set the scene, suggest to students how to organize their thoughts for solving the problem, and indicate how to estimate the order of magnitude of the answer. In the second edition, the worked examples are more closely concentrated in the principle chapters than before, better to reinforce important skills.

The extensive work we have done in this revision



has built upon the strengths of the first edition. Our ideas have been shaped by our own experience and by feedback from previous users, students, and reviewers. Underlying our efforts has been our commitment to providing students with a text that will convey not only the content of chemistry but the excitement of the subject as well.

## ***SUPPLEMENTS TO THE TEXT***

We are fortunate to have been joined in this revision by a group of experienced and dedicated teachers who have worked hard and imaginatively to produce an excellent set of supplementary materials. These supplements are:

- **Study Guide** by David Becker, Oakland Community College and Oakland University. Identifies key words and concepts, important chemical and mathematical equations, and common pitfalls in problem-solving. Includes a generous selection of self-test questions and special sections that highlight descriptive chemistry the students should remember.
- **Student's Solutions Manual** by Joseph Topping, Towson State University, and Charles Trapp, University of Louisville. Contains detailed solutions for the exercises and case questions not answered in the text.
- **Instructor's Manual** by Joseph Topping and Charles Trapp. Contains detailed solutions to all exercises and case questions in the text, with chapter outlines, objectives, review questions and solutions, and teaching hints.
- **Test Bank** by Robert Balahura, University of Guelph. Available in hard copy, IBM, and Macintosh formats. Provides approximately 1000 test items in multiple choice format.
- **Overhead Transparencies**. Includes over 200 sharply rendered figures and tables from the text, most in full color.
- **Videotaped Lecture Demonstrations** by Ted Baldwin, Industrial Words and Images (Dewey Carpenter, Louisiana State University, consultant). A four-hour set of vivid presentations of chemical phenomena. The convenient way to demonstrate a wide variety of experiments that are elaborate, potentially hazardous, or expensive to create.
- **Videodisc of Lecture Demonstrations and Chemical Illustrations** by Ted Baldwin, Industrial Words and Images, and Windsor Digital. A two-sided laserdisc containing highlights of the 56 demonstrations in our videotape series and many new demonstrations, plus approximately 1000 figures and photographs.
- **Laboratory Separates** by Julian L. Roberts, Jr., J. Leland Hollenberg, and James M. Postma. A complete package of individual laboratory experiments that allows flexibility in designing a laboratory sequence.
- **Annotated Instructor's Version**, thoroughly annotated by P. W. Atkins, J. A. Beran, and D. Becker. Provides marginal references to additional demonstrations, relevant articles in the literature, teaching suggestions, tie-ins to both the Overhead Transparency package and the Videotaped Lecture Demonstrations, thought-provoking questions and applications, and insights into chemical principles.

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We welcome comments and suggestions from students and instructors alike; please write to us in care of Scientific American Books.

P. W. A.  
 J. A. B.

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