

P R I N C I P L E S O F

Modern Chemistry

third edition



OXTOBY &
NACHTRIEB



PRINCIPLES OF MODERN CHEMISTRY

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THIRD EDITION



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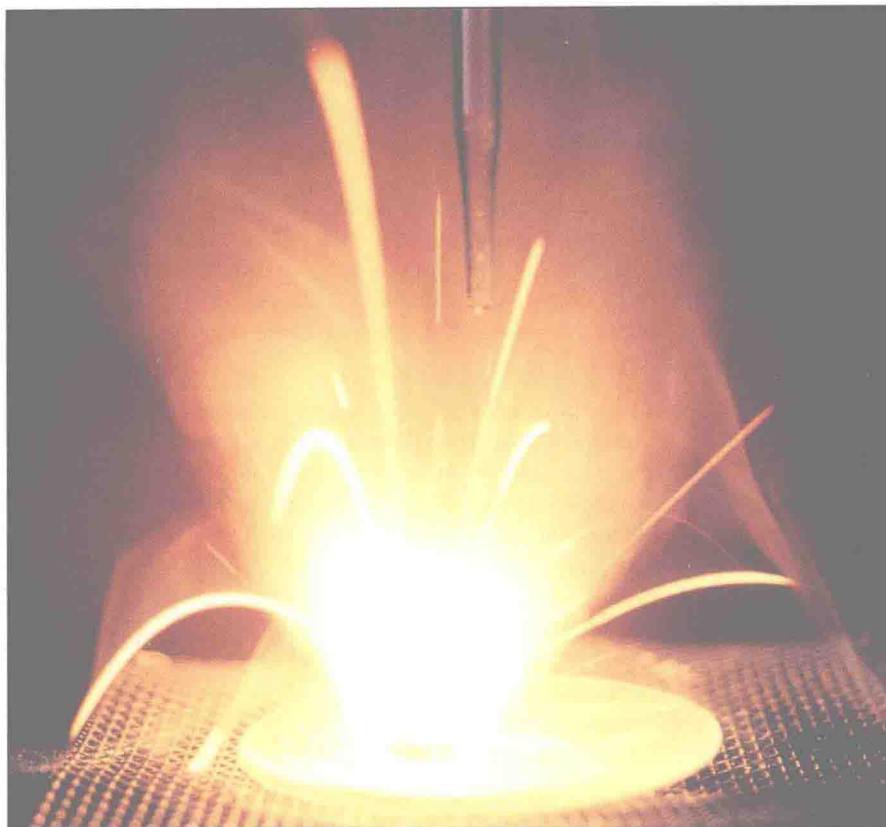
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The reaction of sodium with water.

P R E F A C E

The organization of the third edition of *Principles of Modern Chemistry* is fundamentally the same as that of the first two editions, although a number of changes and additions have been made to improve the text. Chemistry, as an experimental science, is introduced to students in terms of macroscopic concepts and principles that have their origins in the laboratory before the more abstract, theoretical, interpretative aspects of the subject are presented. Of course, the long-range goal is to persuade students that both theory and experiment are indispensable to the progress of science and to help them appreciate that each of these approaches informs and guides the other.

CHANGES IN THIS EDITION

Several changes in organization have been made in this edition, and several chapters have been extensively rewritten:

- A brief introduction to the constituents of the atoms (electrons, protons, neutrons) and their masses and charges has been moved to Chapter 1, so that the subsequent discussion of Lewis structures and the periodic table in Chapter 2

has a more solid foundation. This material also connects closely to the general theme of Chapter 1: the analysis of what makes up matter.

Intermolecular forces are introduced earlier in this edition, first in the context of nonideal gases (Chapter 3) and then in connection with liquids and solids (Chapter 4). This allows a more modern, molecular-level approach to a number of topics in general chemistry.

Chapters 13 through 15 have been extensively revised in response to comments from reviewers. Chapter 13 now includes many-electron as well as single-electron atoms, and Chapter 14 is a comprehensive treatment of chemical bonding. Chapter 15 contains an expanded treatment of modern spectroscopy and two important areas of application: photosynthesis and atmospheric photochemistry.

End-of-chapter problems have been revised, with a new category introduced: Cumulative Problems. These problems relate the new material in the chapter closely to that in earlier chapters, and help to show interconnections between different aspects of chemistry. Chapters 18 through 23 do not include such problems, because most of the problems in these chapters are cumulative in their very nature, incorporating applications of chemical principles to the study of chemical processes.

Many small changes have been made to clarify the presentations and to make the figures more useful. Up-to-date topics such as the fullerenes have been introduced.

TEACHING OPTIONS

As in the previous editions, an instructor may choose to alter the order in which the chapters are presented for a chemistry course; the text is structured to permit this kind of flexibility. For example, some instructors may wish to cover the material on atomic structure and chemical bonding earlier in their courses. In this case, they can move directly to Chapters 13 through 15 after Chapter 7, or even after Chapter 2. Certain topics may be omitted without loss of continuity. For example, a principles-oriented course might cover the first 17 chapters thoroughly and then select only one or two of the last chapters for close attention. A course with a more descriptive orientation might omit the sections entitled “A Deeper Look,” which are more advanced mathematically than the main part of the book, and cover the last six chapters more systematically. Further suggestions for ways of using this book in courses with different plans of organization are given in the Instructor’s Manual.

FEATURES

Mathematical Level

This book presupposes a solid high school background in algebra and coordinate geometry. We introduce the concepts of slope and area in the physical and chemical contexts in which they arise, and we use differential and integral notation only where necessary. The book is designed to be fully self-contained in its use of mathematical methods. In this context, Appendix C should prove particularly useful to the student and the instructor.

Key equations in the text are indicated by boldface numbers on the right, and practice should be gained in using them for chemical calculations. Other equations, such as intermediate steps in mathematical derivations, are less central to the overall line of reasoning in the book.

Worked Examples

This textbook includes worked examples, which help to show the methods of reasoning applied in solving chemical problems. The examples are inserted immediately after the corresponding principles have been presented, and references are made to related problems at the end of the chapter. Careful attention is given in the examples to the proper use of units, significant figures, and scientific notation.

A Deeper Look

Sections titled “A Deeper Look” provide students with the physical origins of observed chemical behavior. They are sometimes more advanced mathematically than the main parts of the book. Their use allows the instructor considerable flexibility in the level of course material taught.

Key Terms

Key terms appear in **boldface** where they are first introduced. In addition, definitions for most key terms are included in the Index/Glossary for ready reference.

Concepts and Skills

Each chapter concludes with a list of concepts and skills for review by the student. Included in this list are references back to the section in which the topic was covered, and forward to problems that help to test mastery of the particular skill involved. This feature is helpful for self-testing and review of material.

Practice Exercises

At the end of each of Chapters 1 through 17 there is a practice exercise that is built around a problem of chemical interest and draws on material from the entire chapter for its solution. Working through these exercises provides a useful review of material from the chapter, helps students to put principles into practice, and prepares them to solve the problems that follow.

Problems

Problems are grouped into three categories. Answers to odd-numbered “Paired Problems” are collected in Appendix G and enable the student to check the answer to the first problem in a pair before undertaking the second problem, which is parallel to it. The “Additional Problems,” which are unpaired, provide further applications of the principles developed in the chapter. The “Cumulative Problems” integrate material from the chapter with topics presented earlier in the book. The more challenging problems are indicated with an asterisk.

Appendices

Appendices A, B, and C are important pedagogically. Appendix A discusses experimental error and scientific notation, while Appendix B introduces the SI system of units used throughout the book and describes the methods used for converting units. Appendix C provides a review of mathematics for general chemistry. Appendices D, E, and F are compilations of thermodynamic, electrochemical, and physical data, respectively. Students gain experience in using them through many of the problems in the book.

Index/Glossary

The index/glossary at the back of the book gives a brief definition of key terms and a reference to the pages on which that term appears.

SUPPLEMENTS

Study and Problem-Solving Guide The best way to master physical and chemical concepts is to solve problems; even students with outstanding mathematical skills can encounter difficulties with chemistry problems. Trouble usually arises in passing from the words of the problem through formal statements of concepts to manipulating mathematical equations. The *Study and Problem-Solving Guide* by Wade A. Freeman of the University of Illinois at Chicago helps students meet such difficulties head-on. It summarizes definitions, concepts, and equations, gives some additional insights into the material presented in the text, provides problem-solving hints, and, as a practical illustration, presents detailed solutions to all the odd-numbered problems in this book. Each student is strongly encouraged to purchase a copy of this book.

CalTech Chemistry Animation Project (CAP) This consists of a set of six video units that cover, with unmatched quality and clarity, 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.

Instructor's Manual The Instructor's Manual contains solutions to even-numbered problems as well as suggestions for ways to use this book in courses with different plans of organization.

Overhead Transparencies A set of at least 110 full-color figures and tables from the text is available.

ACKNOWLEDGMENTS

In preparing this third edition, I have benefited greatly from the comments of students who used the first two editions over the past several years. I would also like to acknowledge the many helpful suggestions of colleagues in Chicago and at other colleges and universities who have taught from this book.

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Several new photos by C. D. Winters appear in this edition. Fay Yates assisted with printing, copying, and mailing. I am particularly grateful to my wife and children for their encouragement in the revision of this book.

Sadly, my friend and colleague Norman Nachtrieb died in September, 1991, and thus was not able to take part in the preparation of this edition. I have greatly missed his sound advice, and his deep knowledge of and love for chemistry. I trust that he would have been proud of this new edition of our book.

David W. Antony

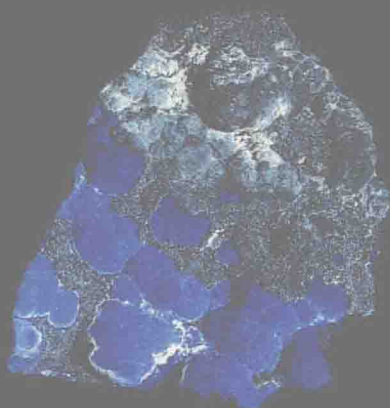
The University of Chicago

June 1995

The search for truth is in one way hard and in another easy, for it is evident that no one can master it fully or miss it completely. But each adds a little to our knowledge of nature, and from all the facts assembled there arises a certain grandeur.

(Greek inscription, taken from Aristotle, on the facade of the National Academy of Sciences building in Washington, D.C.)

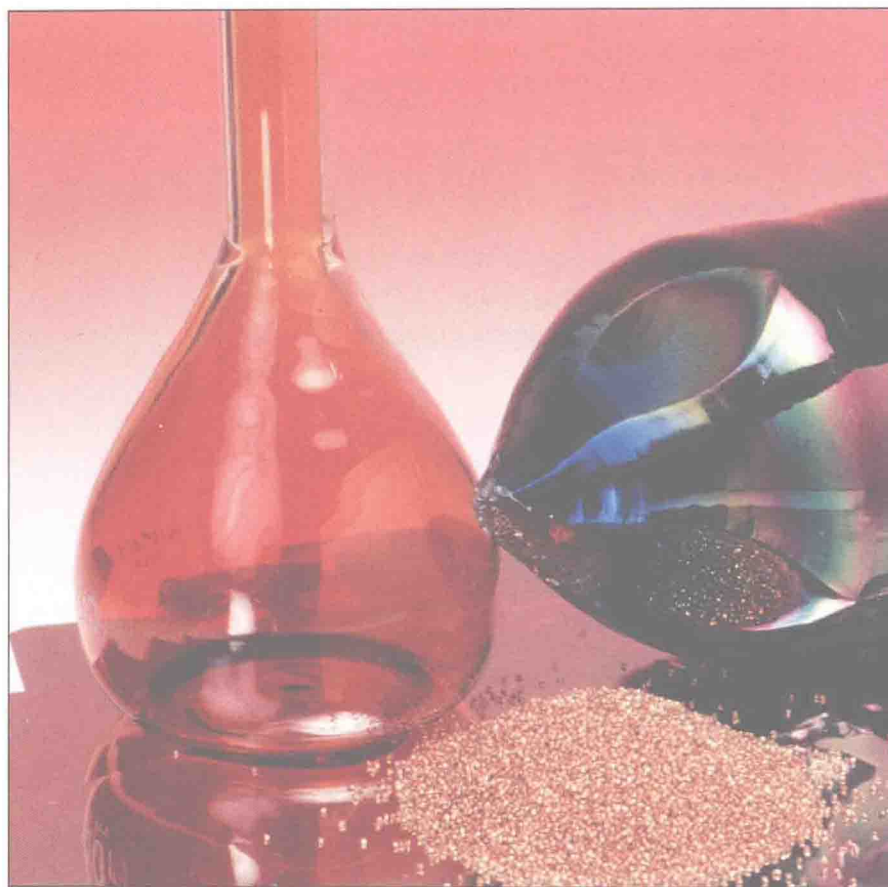
Azurite.



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Samples of bromine and silicon (top) and of copper (below) on a reflecting sheet of aluminum.

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