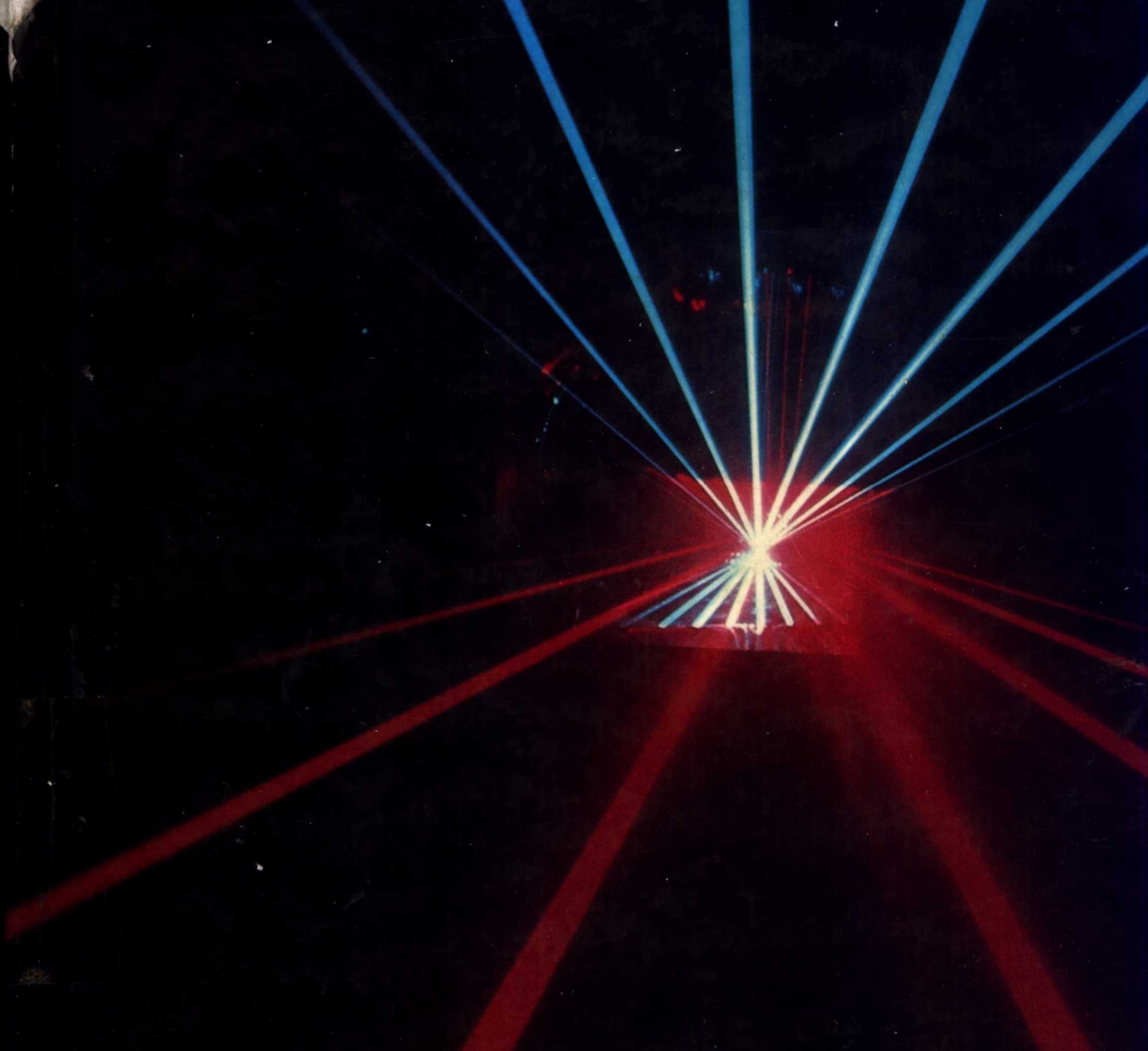
Modern University Chemistry

Norbert T. Porile



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Norbert T. Porile
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Physical Constants

Avogadro's number	$N_A = 6.022045 \times 10^{23}\ \mathrm{mol^{-1}}$
Bohr radius	$a_0 = 0.5291771\ \text{Å} = 5.291771 \times 10^{-11}\ \mathrm{m}$
Boltzmann constant	$k = 1.38066 \times 10^{-23}\ \mathrm{J\ K^{-1}}$
Coulomb's law constant	$\alpha = 1.1126501 \times 10^{-10}\ \mathrm{C^2\ N^{-1}\ m^{-2}}$
Electron charge	$e = 1.602189 \times 10^{-19}\ \mathrm{C}$
Electron mass	$m_e = 9.10953 \times 10^{-31}\ \mathrm{kg}$
Faraday's constant	$F = 96{,}485\ \mathrm{C\ mol^{-1}}$
Gas constant	$R = 8.3144\ \mathrm{J\ mol^{-1}\ K^{-1}}$
	$= 0.082057\ \mathrm{L\ atm\ mol^{-1}\ K^{-1}}$
Gravitational acceleration	$g = 9.80665\ \mathrm{m\ s^{-2}}$
Ideal gas molar volume at STP	$\bar{V}_{id} = 22.4138\ \mathrm{L\ mol^{-1}}$
Neutron mass	$m_n = 1.674954 \times 10^{-27}\ \mathrm{kg}$
Planck's constant	$h = 6.62618 \times 10^{-34}\ \mathrm{J\ s}$
Proton mass	$m_p = 1.672648 \times 10^{-27}\ \mathrm{kg}$
Rydberg constant	$\mathcal{R} = 1.09737318 \times 10^{7}\ \mathrm{m^{-1}}$
Speed of light (in vacuum)	$c = 2.9979246 \times 10^{8}\ \mathrm{m\ s^{-1}}$

Conversion Factors

1 electron volt (eV) = 1.602189×10^{-19} J
1 calorie = 4.184 J
1 u = 1.660566×10^{-27} kg = 931.502 MeV
1 L atm = 101.325 J

Preface

Modern University Chemistry is intended for a first-year course for students who have had introductory high school courses in the physical sciences and enough mathematics to be taking calculus concurrently. I envision this textbook as being useful in courses taken by science and engineering students as well as for students in other areas who desire a strong background in chemistry.

The distinguishing feature of this book is its emphasis on chemistry as a quantitative experimental science. My approach is to present the experimental facts, the quantitative models based on these facts, and the more general theories that serve to unify the subject. In a textbook that stresses the quantitative aspects of a subject, it is easy, but undesirable, to reach beyond its confines and introduce relationships whose validity cannot be demonstrated. I have avoided this practice by either deriving all quantitative relationships or at least discussing their origin. The level of the mathematics used is dictated by the nature of each topic. Calculus, for example, is used in the chapters on thermodynamics because this makes it possible to derive all the important quantitative relationships.

There is no single generally accepted organizational scheme for a general chemistry text. Some instructors prefer to cover macroscopic phenomena before turning to the underlying microscopic behavior, while others prefer the opposite approach; some instructors prefer to integrate descriptive chemistry as fully as possible, while others prefer to treat it separately. In certain cases, the need to permit students to move between different general chemistry courses determines the sequence of topics; in others, the coordination between laboratory and lecture topics is of importance. I have written this textbook in a way that lends itself to diverse topical sequences and have, in fact, used the material in various sequences in my own course.

The basic scheme I follow is to develop macroscopic and microscopic chemistry in parallel. Thus, the first three chapters are introductory and examine the structure of matter, stoichiometry, and properties of gases. Chapter 4 describes the molecular basis of gas behavior and leads to a detailed consideration of atomic structure and chemical periodicity in the next two chapters. Chapters 7 through 9 deal with various aspects of chemical equilibrium; in the following four chapters, thermodynamics and its applications to phase equilibria, solutions, and electrochemistry are considered. After a discussion of chemical kinetics in Chapter 14, I return to microscopic chemistry: Chapters 15 through 18 describe chemical bonding, molecular structure, and intermolecular interactions. The separation of the chapters on bonding from those on atomic structure makes it necessary for the student, when studying chemical bonding, to review the introduction to quantum mechanics presented in the chapters on atomic structure. I believe that a second exposure to these abstract concepts is highly beneficial. The textbook continues with an examination of the representative elements, the solid state, and transition metals (Chapters 19 through 21), and concludes with organic and biochemistry and nuclear chemistry (Chapters 22 and 23). The five appendices present units and conversion factors, a review of the mathematics used, and numerical data tables. Chapter 1 includes an appendix on significant figures in numerical problems.

The book is readily adaptable to diverse sequences of topics. Instructors who wish to cover macroscopic chemistry before microscopic chemistry can defer Chapters 5 and 6 until after Chapter 14. On the other hand, those who wish to present microscopic chemistry first can cover Chapters 15 through 17 after Chapter 6. Descriptive chemistry is incorporated throughout the chapters. However, the acid–base chemistry and redox chemistry of the representative elements are treated separately in Chapter 19. This material can be integrated more fully by covering the sections on acid–base chemistry immediately after Chapter 8, which describes acid–base equilibria, and by covering the sections on redox chemistry after Chapter 13 (electrochemistry).

The design and organization of this textbook enhances the student's study and retention of the subject. Numbered sections and lettered subsections signal individual topics. Important terms are printed in boldface when first introduced and defined. Every chapter includes examples illustrating the application of the pertinent chemical principles. Students should be encouraged to work these examples, since mastering the art of problem-solving is an important aspect of chemistry. Each chapter concludes with many problems of varying difficulty. Wherever appropriate, problems that require the use of calculus are included, marked by an asterisk (*). Answers to most numerical problems are given at the back of the book. A complete solutions manual is available to instructors.

I have generally used SI units throughout this book. I have not been overly rigid about this, however, and have used several non-SI units because of their convenience or their wide use in the scientific literature. These include the standard atmosphere and the torr (mm Hg) as units of pressure, the angstrom as a unit of length in atoms and molecules, and the electron volt as a unit of energy of single particles. I have taken a conservative approach to the current controversy over the periodic table group numbers and have used the conventional American designations. However, both the old and the new IUPAC conventions are mentioned briefly. I have generally avoided the IUPAC provisional names and symbols for newly discovered elements; instead, I refer to these elements by their atomic numbers.

This textbook developed from my involvement during the past decade with the Honors General Chemistry course at Purdue University. My understanding of the subject has been clarified and sharpened as a result of my interaction with the outstanding students in this course. It is my pleasure to acknowledge their contributions. Special thanks are due to the class of 1985–86, which used a draft version of this book and made numerous suggestions for its improvement.

In writing this book, I have profited from numerous discussions with my colleagues at Purdue University. I particularly thank George Bodner, Robert Grimley, John Grutzner, Jurgen Honig, David McMillin, and William Robinson. I am very appreciative of the detailed comments on the manuscript by the following reviewers: Ruth H. Aranow (Johns Hopkins University), Mario E. Baur (University of California at Los Angeles), J. Aaron Bertrand (Georgia Institute of Technology), Luther K. Brice Jr. (Virginia Polytechnic Institute), Alan Campion (University of Texas), Leigh B. Clark (University of California, San Diego), Richard F. Fenske (University of Wisconsin), Robert E. Frost (State University of New York at Albany), Patrick L. Jones (The Ohio State University), Darl H. McDaniel (Univeristy of Cincinnati), Clyde Metz (College of Charleston), Peter B. Moore (Yale University), Norman H. Nachtrieb (University of Chicago), Richard P. Schmitt (Texas A & M University), Peter E. Siska (University of Pittsburgh), Richard M. Stratt (Brown University), Bradford Wayland (University of Pennsylvania), D. T. Zajicek (University of Massachusetts), J. J. Zuckerman (University of Oklahoma), and Steven S. Zumdahl (University of Illinois). Clyde Metz also independently worked out all the examples and end-of-chapter problems.

I am grateful to all the people at Academic Press and Harcourt Brace Jovanovich who worked on this book, particularly to my acquisitions editors, Jeff Holtmeier and Don Schumacher, who supported and encouraged me throughout. I am grateful to Mary Castellion, who did an excellent job as developmental editor. I also wish to thank Gail Shively for ably and cheerfully typing the manuscript in its several drafts.

Part of this book was written while I was the recipient of a Senior U.S. Scientist Award from the Alexander Von Humboldt Foundation at Philipps University, Marburg, Federal Republic of Germany. I wish to thank the Humboldt Foundation for its support and the staff of the Kernchemie, Marburg, for their hospitality.

Finally, I am grateful to my family for their constant support and encouragement during the years I devoted to this book. My wife Miriam helped me with numerous questions of English usage as well as with the proofreading. My son Jim read portions of the text, providing me with numerous helpful suggestions from his perspective as an undergraduate chemistry major.

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Chapter Titles

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