Gordon Barrow *General Chemistry*

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Wadsworth Publishing Company, Inc. Belmont, California

ISBN-0-534-00048-7
L. C. Cat. Card No. 76-161062
Printed in the United States of America

1 2 3 4 5 6 7 8 9 10——76 75 74 73 72

Airbrushing: Mark Schroeder
Graphs: Carleton Brown

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Preface

For too long, introductory college chemistry courses have been overly influenced by the narrowing forces of our professional view of our subject. That the study of chemistry stems from attention to the world around us, not a world apart, is the principal tenet on which this book is based.

I have convinced myself—and I hope that you will be convinced—that the material essential to more advanced chemistry and other scientific disciplines can be presented on the basis of a "worldly" view of chemistry. Thus, without greatly modifying the material expected in a freshman chemistry text, I have tried to suggest that chemistry stems from, and provides entries into, almost all aspects of the physical world. You will notice, however, that while these entries are recognized and are used as avenues into chemistry, extended excursions into the various environmental and ecological aspects that are of current concern are not made. The text is a chemistry text and these worldly avenues provide a springboard into the subject.

Chemistry itself is the organization of experimental results into laws, the development of a molecular model, and finally the coupling of these components so that our physical world can be further explored or mastered. The essence of both the organization and the molecular model will, I hope, show clearly through the obscuring and alienating details of both the macroscopic and molecular worlds. For example, topics such as wave mechanics and thermodynamics can be thoroughly grasped only with years of advanced study. But by focusing on their essential, qualitative features, a sound working knowledge of such topics can be obtained, even in a freshman chemistry course. Thus, particular attention has been paid to the wave nature of particles and the consequences for atomic and molecular structure, and this is done with few of the trappings of wave mechanics. The simplest extension of these ideas to the bonding and structure of covalent molecules is emphasized. Inorganic crystal structures are developed on the basis of close-packed structures without including extraneous material on crystal systems and lattice types. The development of thermodynamics focuses on energy and entropy changes and tries to avoid the complicating q's and w's or an early introduction of free energy. The molecular basis of entropy is developed so that the student can make qualitative predictions of relative entropies and entropy changes. The kinetics of chemical reactions, and their relation to reaction mechanisms, are introduced in the context of chemical studies rather than as a formal and isolated discipline.

This overall approach—focusing on experimental studies of the physical world that lead naturally to the facts and theories of chemistry—interweaves the theoretical and descriptive aspects of chemistry. Moreover, this descriptive material is modern and is related to many subjects with which we ordinarily deal. Hence, chemistry becomes a less isolated and apparently artificial discipline.

What goals might a teacher or student set for the introductory college chemistry course for which this text is intended? Many facts and figures will be taught, and some will be learned, but these, although valuable in later courses, are adjuncts to the principal objectives. Here are two objectives that I think are worthy additions to those that stem from prerequisite demands.

First, the studies that this text assist should be of value for, and an inducement to, further professional or recreational activities in one or more of the many aspects of the physical world that can be approached through chemistry. One such area is chemistry itself and the further development of our knowledge of the molecular world. But there are many other aspects of our physical world that can be approached from a base of introductory chemical studies. The six major parts of this book, which range from air and the atmosphere to biological materials and processes, suggest some of the areas in which extensions are appropriate.

Second, these studies of chemistry should lead to a firm grasp of the nature and basis of man's greatest scientific achievement—the discovery, or invention, of the world of molecules and the interpretation of the properties and reactions of materials by means of this molecular model. Many other aspects of science will remain complex and inscrutable without further study, but mastery of the essence of one area of science will change your attitude toward all areas. Thus, once you are at home with the central idea of chemistry, you will never again find science a remote and forbidding, or even threatening, subject.

Acknowledgments

It is possible to publicly thank only a few of the many who have helped me form the ideas on which this book is based or who have assisted in the development of the book itself.

First, I would like to acknowledge the wonderful hospitality of the entire chemistry faculty and staff of Dartmouth College during the year of 1969–70, when much of the manuscript was assembled and partially class-tested.

Very helpful and much-appreciated reviewing of all or part of the manuscript was performed by Eric Allen of the Atmospheric Research Center, Charles E. Braun of Dartmouth College, Forrest C. Hentz, Jr., of North Carolina State University, Malcolm E. Kenney of Case-Western Reserve University, I. M. Klotz of Northwestern University, Frank L. Lambert of Occidental College, Rollie E. Meyers of the University of California at Berkeley, James E. Shields of Eli Lilly and Company, and Marion C. Woods of California State College at Hayward.

Especially helpful were the instructors who reviewed the completed manuscript and met with me in conference to discuss each chapter: Milton E. Fuller of California State College at Hayward, Jack Healey of Chabot College, Gerald Thomas of San Francisco State College, and Gordon Williams of Monterey Peninsula College.

I am deeply indebted to all these reviewers for their many contributions, their pointing out of the errors of my ways, and the better treatments and examples that I have incorporated throughout the text.

For their excellent service in readying the manuscript for production, I would like to thank Mary Arbogast for the editorial work and Mark Schroeder for the artwork. I am grateful, also, to the Hopkins Marine Station of Stanford University and the Naval Postgraduate School, both in Monterey, for the use of their library facilities.

Notes on the mechanics of the text

In studies of a subject as intricate as chemistry, it is often difficult to recognize the overall direction and interrelation of the topics. In response to this problem, flow diagrams and summaries are placed at the beginning of each chapter. Both these guides will merit casual attention before the chapter is studied. Only after this study will all of their features be appreciated. In the flow diagrams, both experimental and conceptual inputs are indicated in color. The major connections that lead, as a result of the developments of the chapter, from these inputs to important new results or relationships are shown. Thoughtful attention to these interrelations will provide an appreciation of the overall scheme of the chapter, and this will make study of the components of the chapter more satisfying. Flow diagrams can show the development of the chapter in many different ways and in various amounts of detail, and even greater value will accrue at this stage if you develop your own flow sheet and use the given one only as an example. The overall basis, development, and purpose of each chapter can be firmly grasped when a flow diagram is constructed.

"Concepts to master and facts to know" and *"Operations to be able to perform"* are check lists at the end of each chapter. With these you can judge your progress in mastering the information and operations introduced in the chapter. Again, you are encouraged to add to the existing lists so that they will be in accord with the emphasis and direction of your course; you should develop your own check lists, perhaps on the basis of those provided, so that you have explicit lists of objectives appropriate to the emphasis and direction of your course.

Both worked out *Examples* and *Exercises* appear in the body of each chapter. These are intended to illustrate and reinforce the discussion of the text material. *Problems* at the end of the chapter can play the same role and also serve as tests, or self-tests, of your ability to use the material of the chapter.

Finally, *marginal notes* contain material that is supplementary to the main text. These notes tell of extensions, limitations, variations, and so forth, and can be looked on as optional enrichment material.

Notes to the instructor

Mathematics background In many parts of the text, numerical values are attached to quantities and there is a continuous effort to make you appreciate some of these numerical values. Furthermore, some arithmetic operations are necessary to relate these quantities. Only seldom are more difficult mathematical operations called for. Most noteworthy of these are exponents and logarithms that enter first as aids to the manipulation and display of numerical quantities. To a much lesser extent, and then optionally, the treatment of the slope of a curve in terms of the derivative of a function is recognized. All these operations are reviewed in the appendixes in detail adequate for the use to which they are put here.

Stoichiometry You will notice that there is no early, concentrated treatment of stoichiometry. The intent is to introduce gradually the components of such calculations—the ideas of atoms, molecules, chemical formulas, moles, and balanced equations. Then, with a familiarity with such quantities, calculations of amounts of reactants and products can be carried out with little difficulty. For those instructors who prefer to deal with stoichiometry as a formal unit, a treatment that facilitates this approach is given in an appendix.

Placement of atomic and molecular structure Some instructors may prefer to begin the college course immediately with a study of the structures of atoms and molecules and with the ideas drawn from the wave nature of particles, atomic orbitals, electron configurations, and so forth. Although the text is written to put this material in relation to the notion of molecules and their constituent atoms, to the basic experimental studies of spectra, and to the chemical properties and periodic organization of the elements, such an alternate approach can be used. To do so one would assume, as can reasonably be done, that the students have a general familiarity with the idea of atoms and molecules. Then the course can begin with Chapter 6, "The Electronic Basis of the Periodic Table of the Elements." This would probably be followed by Chapter 7, "Molecules and Molecular Structure."

The two most likely avenues to pursue after this beginning would be to continue with Chapter 8, "Crystal Structures," or to return to the first chapters of the text and study how the properties of gases are interpreted in terms of the molecular model.

Thus, some variation in the order of the topics in the first eight chapters can easily be made without losing sight of the idea that chemical studies stem from our detailed investigation of the physical world.

Kinetics The rates of reactions and the information that can be gained from their study are included in sections 19.3 and 22.6, along with the chemical systems on which these studies are based. Alternatively, these *kinetic* topics can be dealt with together. This is done in outline form in Appendix G to facilitate the more formal introduction to the subject that might be preferred by some instructors.

Thermodynamics The principal treatment of thermodynamics—heat and work from chemical reactions, entropy, equilibria, and so forth—begins in Chapter 13.

Some preparation for this material *precedes* these treatments. Thus in the second, third, and fourth chapters, the kinetic energies of molecules, dissociation and ionization energies, the energies of quanta and of solar radiation are all dealt with. Energies for molar amounts of materials are introduced in Chapter 9 in relation to the easily appreciated processes of vaporization and condensation, and melting and freezing.

The principal thermodynamic chapters are also *followed* by uses of the thermodynamic material that is developed. Energies are considered in connection with the conversion of inorganic and organic materials. The biological processes that store and release energy constitute an important part of the final chapter, Chapter 22. The intent is to lead into the thermodynamic material and, following its presentation, to make natural use of the material so that the consideration of the energy and entropy, or the free energy, of chemical reactions seems to be a proper facet of the study of chemical processes.

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