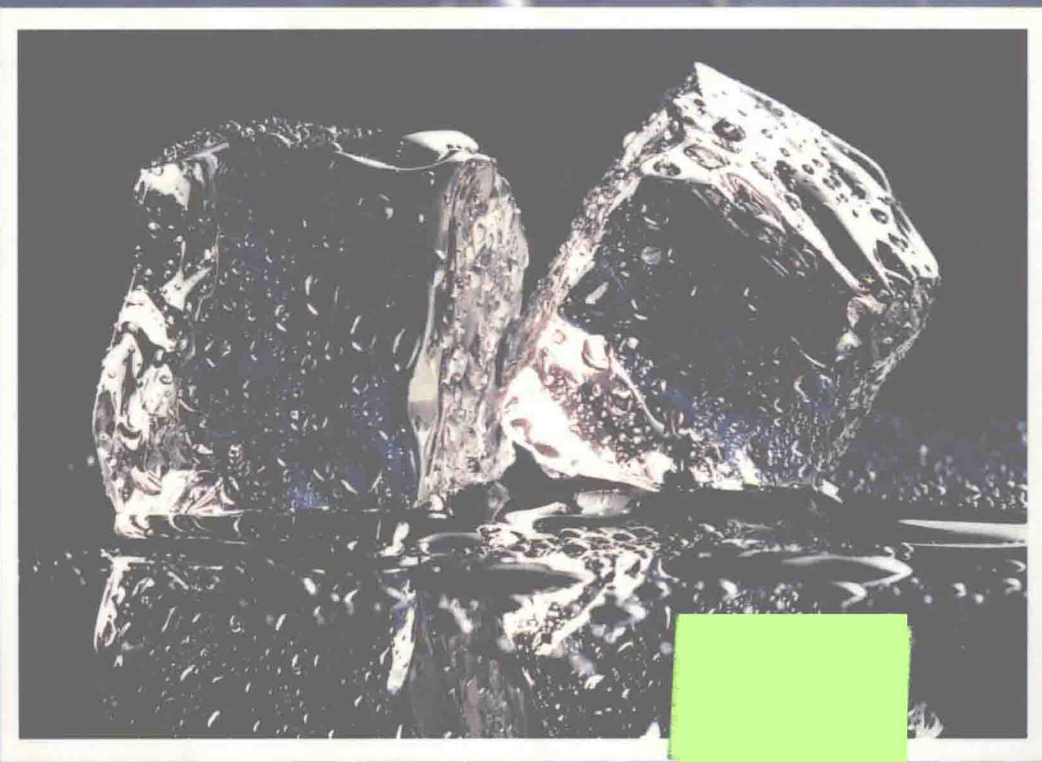


FUNDAMENTALS OF

CHEMISTRY



SECOND EDITION

David E. Goldberg

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David E. Goldberg

Brooklyn College



Boston, Massachusetts Burr Ridge, Illinois Dubuque, Iowa
Madison, Wisconsin New York, New York San Francisco, California St. Louis, Missouri

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*To my students,
who have taught me
a great deal*

Preface

Chemistry is a dynamic, rapidly changing field that comprises an extraordinarily interesting subject to study and a challenging one to teach. Today, as perhaps never before, the world is looking to the field of chemistry to provide answers to some of the most challenging problems that confront each of us as citizens of the global community. We live in a world in which we are confronted with products, problems, and changes that our parents and grandparents never dreamed of. And we are learning that what happens on the other side of the world can have a profound impact on us and our lives. Problems such as global climate change, loss of stratospheric ozone, and human-created ecological disasters such as the 1991 oil well fires in Kuwait have become subjects of daily discussion in newspapers and on television. Each discipline of science, but especially chemistry, will contribute to solving these problems, as well as others not yet encountered. In addition, the field of chemistry will continue to yield new processes and materials that will open up whole new vistas of opportunities and benefits.

As citizens of the global community, we need a solid foundation in scientific principles—including chemical principles—to help us better understand the world around us, as well as to contribute positively to that world. It is my hope that students using this book will develop a foundation of chemical principles with which they can begin to understand the processes that make up the world and underlie life and will use that foundation to succeed and prosper, not only in any subsequent chemistry courses but in life as well.

Audience and Philosophy

This book is intended primarily to serve beginning chemistry students, who typically have had no instruction, or limited instruction, in chemistry. These students often need help not only with mathematical manipulations, but also with reading and writing scientific material with precision. When the author was a child, he was told orally that Benedict Arnold was a traitor and at a different time that Lewis and Clark were traders. These two descriptive words sounded alike to me, but I knew from the context that Lewis and Clark were not held in the same disdain. If the two words had been presented together, there would have been no problem in understanding the difference. In this text, I have tried to put concepts and terms that might be confused by students together in the same problem so that the differences can be understood from the beginning.

The factor label method (dimensional analysis) is used help the student translate word problems into easily solved algebraic expressions. In many places, a problem is stated in parts to lead the student stepwise through a solution; later the

same problem appears as a whole, worded as it might appear on an examination. There is a series of figures that build on preceding ones to reveal the fundamental unity of the concept of the mole. Many problems are worded so as to show the student that very different questions may sound similar and that the same question may be presented in very different words; these will encourage the student to try to understand concepts and not to memorize solutions. When different terms that look or sound alike are presented and explained together, the student can more easily learn both (see Problems 5.1, 5.2, 5.3, 5.5, 5.6, 5.14 and 5.16, for example).

Frequent use of analogies to daily life helps students understand that chemistry problems are not significantly different from everyday problems, even though they may seem more difficult because of their unfamiliarity. For example, calculations involving dozens of pairs of socks and moles of diatomic molecules may be carried out by the same methods (Problems 7.6 and 7.7). Oxidizing and reducing agents can be compared conceptually to dish towels and wet dishes (Examples 14.5 and 14.6). Specific heat calculations are like those involving room rates at a hotel (Example 16.13). The similarity of a catalyst to a marriage broker is presented in Problem 8.15.

Modern nomenclature is used throughout the text (the Stock system for inorganic compounds and IUPAC nomenclature for organic compounds), but common names for the simplest organic compounds are included and the older system for naming cations is mentioned. Classical group numbering is used in the periodic table since this numbering is an aid to learning many elementary concepts (the number of electrons in an atom's outermost shell, for example).

The second edition of this text has been changed to reflect requests by colleagues in several areas, but its major philosophy and teaching techniques have not been altered. The principal aim to teach the student as (s)he comes to the class has been maintained.

The second edition includes several major topics not covered in the first edition. Notable among these are Atomic and Ionic Sizes, Ionization Potential and Electron Affinity, Electronegativity and Bond Polarity, Molecular Shape, and Polar and Nonpolar Molecules, (all in Chapter 13) and Enthalpies of Chemical Reactions (Section 14.4). The added material gives instructors even more flexibility in the topics they choose to cover in their courses. (Practically no one covers the whole book.)

This edition has also been made more flexible by making optional Chapter 4, Detailed Electronic Configurations, and the parts of later chapters dependent on this chapter. The later material dependent on Chapter 4 has been highlighted with green background, so that instructors can easily tell their students which parts to omit if they so choose.

The number of end-of-chapter exercises has been increased about 50%, with selected problems highlighted in red that have solutions included in the text as Appendix 5.

Pedagogical Devices

The text includes a variety of pedagogical devices. These were chosen and designed to answer the question "If I were a student, what would help me organize and understand the material covered in this book?"

1. *Key Terms and Symbols.* Each chapter begins with a listing of the key terms and the symbols or abbreviations that are used in the chapter. Sectional references are provided. Students have the opportunity to use these lists to

review their understanding of the important terms and symbols before examinations.

2. *Chapter Outline.* There is also an outline at the beginning of each chapter. The outline allows students to tell at a glance how the chapter is organized and what major topics are included.
3. *Learning Objective.* At the start of each section, a learning objective is presented to alert students to the key concepts covered in the section. These objectives are another valuable study tool for students when they are reviewing chapter material for examinations.
4. *Boldfaced Key Terms.* Key terms appear in **boldface** when they are introduced within the text and are immediately defined in context. These terms are also listed, with sectional references, at the start of the chapter. All key terms are defined in the glossary.
5. *Items of Interest.* Throughout the text, boxes titled “Item of Interest” relate the subject matter to the real world.
6. *Marginal Comments.* Marginal comments are designed to alert the student to a key point, a helpful hint, or a safety caution.
7. *Tables.* Numerous strategically placed tables list and summarize important information, making it readily accessible for efficient study.
8. *Enrichment Boxes.* Throughout the text, boxes titled “Enrichment” highlight special topics that take the text material to a more extended level. Students will find them to be a lively and interesting feature as they investigate the processes of chemistry.
9. *Examples and Practice Problems.* The book has a wealth of Examples that show the student the step-by-step solution to the problem presented, which is directly related to the preceding textual information. The Practice Problems that follow most Examples give students the opportunity to solve a similar problem immediately. Solutions to Practice Problems are presented at the end of the book to provide immediate feedback.
10. *Photographs.* A wide array of visually appealing and informative photographs is used to help students understand chemical and physical phenomena and pique their interest.
11. *Illustrations.* Because a picture is worth a thousand words, each chapter is amply illustrated with accurate, colorful diagrams that clarify difficult concepts and enhance learning.
12. *Flow Diagrams.* To help students understand the steps in problem solving, flow diagrams have been included at key locations throughout the text. These diagrams allow students to visualize the process of solving a problem.
13. *Summary.* At the end of the chapter, there is a summary of the major concepts covered. Each section is reviewed in paragraph form. The summary, along with the chapter outline and section objectives, provides a complete overview of the chapter material.
14. *Items for Special Attention.* Appearing at the end of every chapter, this unique section highlights and emphasizes key concepts that often confuse students. This section anticipates students’ questions and problem areas and helps them avoid many pitfalls.
15. *Self-Tutorial Problems.* This end-of-chapter section presents problems in simple form designed as teaching devices. Many are from everyday life, and they

emphasize the importance of identifying the information needed to answer questions, thus encouraging the advancement of students' analytical skills.

16. *Problems.* The problems in this end-of-chapter set are grouped under headings that match the chapter's section titles. This organization allows students to practice the problem-solving skills and methods associated with each important concept presented in the text.
17. *General Problems.* The final set of problems in each chapter is more difficult than the others and is not classified by topic. Many of these problems require knowledge of two or more concepts. Similar in scope to the type of questions students will be confronted with on tests, these problems provide students with an excellent means by which to judge their knowledge of the chapter's contents.
18. *Appendixes.* The book contains a complete set of appendixes, which include the solutions to the in-text Practice Problems (Appendix 4) and selected end-of-chapter problems (Appendix 5). A short review of scientific algebra and a unique presentation detailing the use of the electronic calculator (Appendix 1) will help students overcome any mathematical deficiencies. Lists of symbols, abbreviations, prefixes and suffixes, and mathematical equations (Appendixes 2 and 3) make the book more user-friendly.
19. *Glossary.* A complete glossary of all important terms is found at the end of the text.

Supplemental Materials

An extensive supplemental package has been designed to support this book. It includes the following elements:

1. *Instructor's Manual.* The instructor's manual contains the printed test item file, a list of transparencies, and suggestions on how to organize the course.
2. *Student Study Guide.* The student study guide offers students a variety of exercises, self-tests, and hints to promote their comprehension of the basics as well as the more difficult concepts.
3. *Transparencies.* A set of 50 color transparencies is available to help the instructor coordinate the lecture with key illustrations from the text.
4. *Customized Transparency Service.* If adopters are interested in acetates of text figures not included in the standard transparency set, those acetates will be custom-made upon request. Contact your local Wm. C. Brown Publishers sales representative for more information.
5. *TestPak.* This computerized classroom management system/service includes a database of test questions, reproducible student self-quizzes, and a grade-recording program. Disks are available for IBM and Apple computers, and no programming experience is required. If a computer is not available, instructors can choose questions from the Test Item File in the instructor's manual and phone or FAX Wm. C. Brown Publishers to request a printed exam, which will be returned within 48 hours.
6. *Laboratory Manual.* Written by Kathy Tyner of Southwestern College, *Lab Exercises in Preparatory Chemistry* features 62 class-tested experiments. The manual can be easily customized to suit instructors' individual needs. The instructor can delete experiments, add his or her own experiments, or change the arrangement to create a custom manual to fit specific class needs.

7. *Laboratory Resource Guide*. This helpful prep guide contains the hints that the author has learned over the years to ensure success in the laboratory.
8. *ChemSkill Builder, Personalized Problem-Sets for General Chemistry*. Developed by James D. Spain and Harold J. Peters of Electronic Homework Systems, Inc., *ChemSkill Builder* software challenges your students knowledge of introductory chemistry with an array of individualized problems. Organized to accompany any introductory chemistry text, this student-oriented software generates questions for students in a randomized fashion with a constant mix of variables. No two students will receive the same electronic homework problems—ensuring an accurate test of students' knowledge. This unique software program records grades on the quizzes. These grades can easily be transferred to an instructor's record keeping file.
9. *Videotapes*. Narrated by Ken Hughes of the University of Wisconsin—Oshkosh, the tapes provide six hours of laboratory demonstrations. Many of the demonstrations are of high-interest experiments, too expensive or too dangerous to be performed in the typical introductory laboratory. Contact your local Wm. C. Brown Publishers sales representative for more details.
10. *How to Study Science*. Written by Fred Drews of Suffolk County Community College, this excellent workbook offers students helpful suggestions for meeting the considerable challenges of a science course. It offers tips on how to take notes and how to get the most out of laboratories, as well as how to overcome science anxiety. The book's unique design helps to stir critical thinking skills, while facilitating careful note taking on the part of the student.

Acknowledgments

The preparation of a textbook is a family effort, and the quality of the final product is a reflection of the dedication of all the family members. First, I would like to thank my own family, without whose patience and support this project would not have been possible. Second, I would like to thank the scores of my fellow chemists who have taught me much in the past and continue to do so. Learning is a never-ending process, and I continue to learn from my colleagues and students. I would also like to thank the members of my extended family at Wm. C. Brown Publishers, without whom there would not have been a text: my Developmental Editors, Brittany Rossman, Russ Lidberg, and Bob Fenchel, and my Acquisitions Editor, Craig Marty. I gratefully acknowledge the invaluable help of the following dedicated reviewers, who provided expert suggestions and the needed encouragement to improve the text:

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To the Student

This book is designed to help you learn the fundamentals of chemistry. To be successful, you must master the concepts of chemistry and acquire the mathematical skills that are necessary to solve problems in this quantitative science. If your algebra is rusty, you should polish it up. Appendix 1 reviews the algebra used in basic chemistry and also shows how to avoid mistakes while solving chemistry problems with your scientific calculator. The factor label method is introduced in Chapter 2 to show you how to use units to help with problem solutions. You can help yourself by using the standard symbols and abbreviations for various quantities (such as m for mass, m for meter, mol for moles, and M for molarity). Always use the proper units with your numerical answers; it makes a big difference whether your roommate's pet is 3 inches long or 3 feet long!

Many laws, generalizations, and rules are presented in the study of basic chemistry. Most students can master these. Successful students, however, not only know them, but also know *when to use each one*. Word problems are the biggest hurdle for most students who do have difficulty with chemistry. The best way to learn to do word problems is to practice intensively. Review the Examples and do the Practice Problems until you feel confident that you understand the concepts and techniques involved. (Do not try to memorize solutions; there are too many different ways to ask the same questions, and many similar-sounding questions are actually quite different.) Then, do as many of the end-of-chapter problems as you possibly can to see whether you have mastered the material.

You should not try to speed-read chemistry. Mere reading of a section will not generally allow full comprehension of the material. You must be able to solve the problems to be sure that you have really mastered the concepts. Many of the problems sound alike but are very different (for example, Problems 5.5, 7.6, 7.7, and 11.7), and many others sound different but are essentially the same (for example, 3.4, 5.13, 8.2, and 8.17). These will help you develop careful reading habits and prepare you for the questions asked on examinations.

Problems from everyday life that are analogous to scientific problems are included to help you understand certain points better. Other problems are first presented in parts to help you work through the solution and later appear as a single question, as is more likely to occur on examinations. Some of the problems are very easy; these are generally intended to emphasize an important point. After solving one of these problems, ask yourself why such a question was asked. Make sure you understand the point.

Make sure you understand the scientific meaning of each new term introduced. For example, the word *significant* as used in Chapter 2 means something entirely different from its meaning in everyday conversation; be sure you understand the difference. Key terms are **boldfaced** when they are first introduced in

the text. A list of these terms is given at the beginning of each chapter. A complete glossary of all important terms is provided at the end of the book.

Other materials to aid your study include lists of standard symbols and abbreviations for variables, units, and subatomic particles, found in Appendix 2. A summary of the mathematical equations used in the book is presented in Appendix 3. The solutions to all Practice Problems and selected end-of-chapter problems are provided in Appendices 4 and 5, respectively. The selected end-of-chapter problem numbers are printed in red. A periodic table is printed inside the front cover of the book, and a table of the elements appears inside the back cover. Let these tools help you succeed!

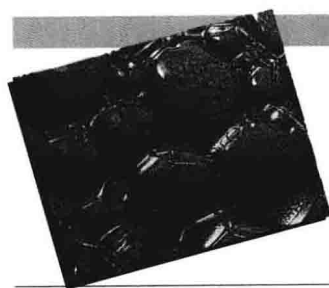
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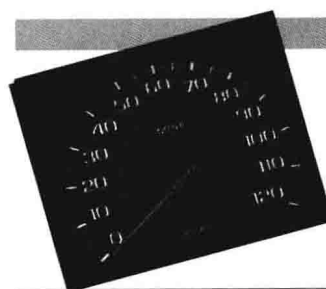


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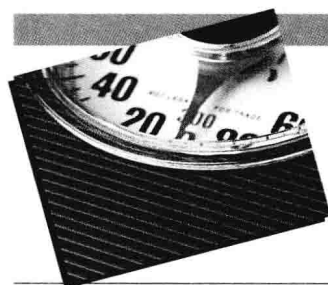
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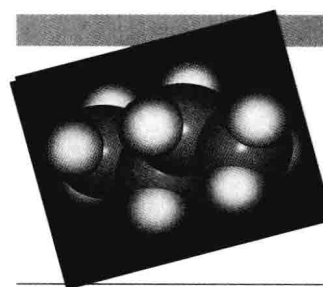
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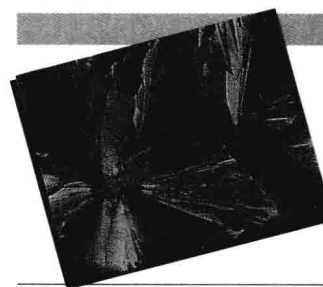
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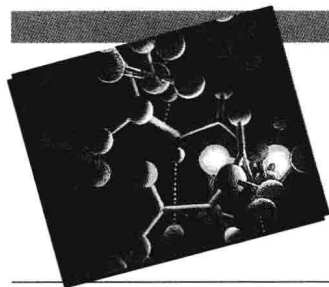


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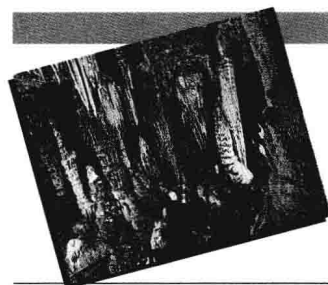
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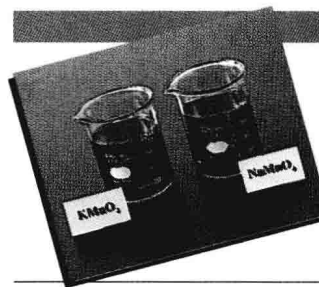
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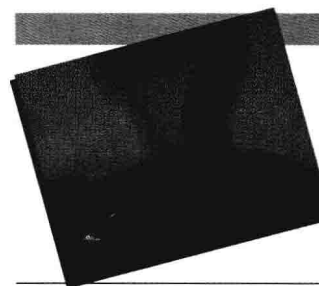
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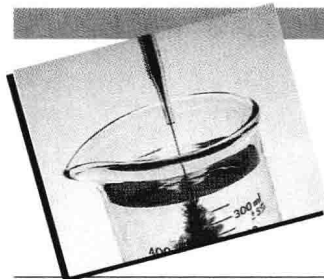
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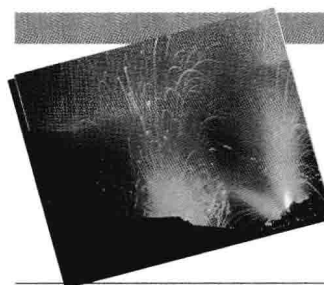
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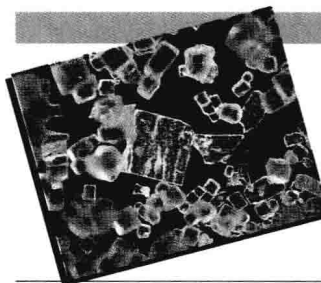
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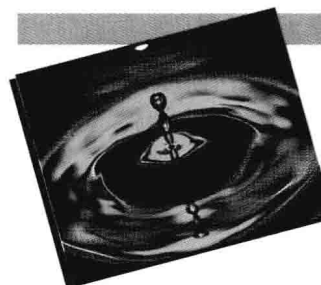
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