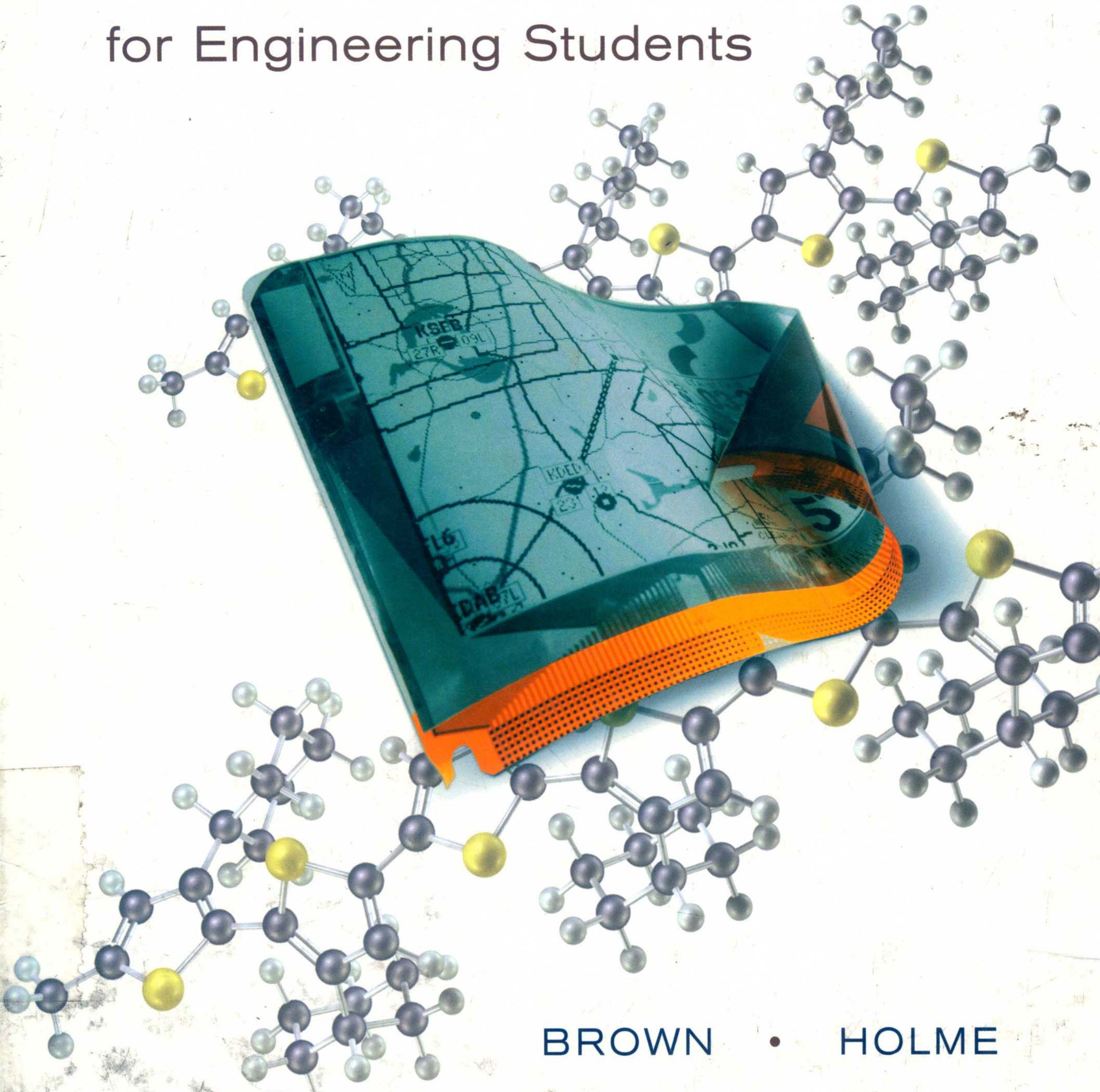
CHEMISTRY

for Engineering Students



BROWN • HOLME

Chemistry for Engineering Students

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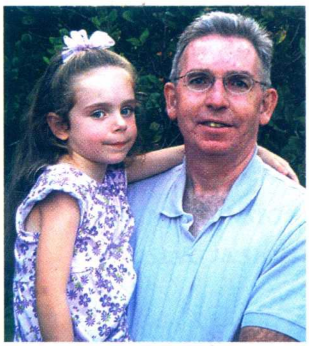


Larry Brown is a Senior Lecturer and coordinator for the General Chemistry for Engineering Students course at Texas A&M University. He received his B.S. in 1981 from Rensselaer Polytechnic Institute, and his M.A. in 1983 and Ph.D. in 1986 from Princeton University. During his graduate studies, Larry spent a year working in what was then West Germany. He was a Postdoctoral Fellow at the University of Chicago from 1986 until 1988, when he began his faculty career at Texas A&M. Over the years, he has taught roughly 6000 general chemistry students, most of them engineering majors. Larry's excellence in teaching has been recognized by awards from the Association of Former Students at Texas A&M at both the College of Science and University levels. A version of his class is broadcast on KAMU-TV, College Station's PBS affiliate. From 2001 to 2004, Larry served as a Program Officer for Education and Interdisciplinary Research in the Physics Division of the National Science Foundation. Larry also coordinates chemistry courses for Texas A&M's engineering program in Doha, Qatar. When not teaching chemistry, he enjoys road bicycling and playing with his daughter, Stephanie; now that this book is finished, he looks forward to doing more of both.

Tom Holme is a Professor of Chemistry at University of Wisconsin–Milwaukee and Director of the ACS Examinations Institute. He received his B. S. in 1983 from Loras College, and his Ph. D. in 1987 from Rice University. He began his teaching career as a Fulbright Scholar in Zambia, Africa, and has also lived in Jerusalem, Israel, and Suwon, South Korea. Tom is heavily involved with the American Chemical Society and is General Chair of the 2006 Great Lakes Regional Meeting. He also is active in chemical education research and has been involved with the general chemistry for engineers course at UW–M since its inception. He received a grant from the National Science Foundation to devise new assessment methods for this class, and the "*Focus on Problem Solving*" feature in this textbook grew out of that project. He served as an Associate Editor for the encyclopedia *Chemistry Foundations and Applications*. He is also a feature editor for the *Journal of Chemical Education*, overseeing the "Resources for Student Assessment" feature. In 1999, Tom won the ACS's Helen Free Award for Public Outreach for his efforts doing chemical demonstrations on live television in the Milwaukee area.

Preface

The Genesis of This Text

As chemists, we see connections between our subject and virtually everything. So the idea that engineering students should learn chemistry strikes most chemists as self-evident. But chemistry is only one of many sciences with which a practicing engineer must be familiar, and the undergraduate curriculum must find room for many topics. Hence, engineering curricula at more and more universities are shifting from the traditional year long general chemistry sequence to a single semester. And in most cases, these schools are offering a separate one-term course designed specifically for their engineering students. When schools—including our own—originally began offering these courses, there was no text on the market for them, so content from two-semester texts had to be heavily modified to fit the course. Although it is possible to do this, it is far from ideal. It became apparent that a book specifically geared for this shorter course was necessary. ***We have written this book to fill this need.***

Our goal is to instill an appreciation for the role of chemistry in many areas of engineering and technology and of the interplay between chemistry and engineering in a variety of modern technologies. For most engineering students, the chemistry course is primarily a prerequisite for courses involving materials properties. These courses usually take a phenomenological approach to materials rather than emphasizing the chemist's molecular perspective. Thus one aim of this text is to provide knowledge of and appreciation for the chemical principles of structure and bonding that underpin materials science. This does *not* mean that we have written the book as a materials science text, but rather that the text is intended to prepare students for subsequent study in that area.

The book also provides sufficient background in the science of chemistry for a technically educated professional. Engineering, after all, is the creative and practical application of a broad array of scientific principles, so its practitioners should have a broad base in the natural sciences.

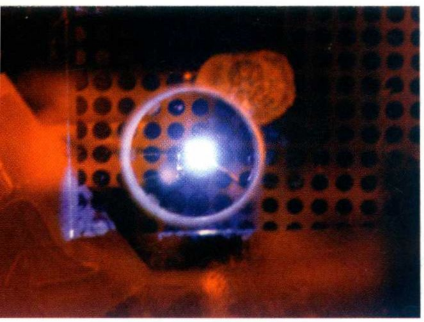
Content and Organization

The full scope of the traditional general chemistry course cannot be taught meaningfully in one semester or one or two quarters, so we have had to decide what content to include. There are basically two models used to condense the general chemistry curriculum. The first is to take the approach of an "essentials" book and reduce the depth of coverage and the number of examples but retain nearly all of the traditional topics. The second is to make more difficult and fundamental decisions as to what chemistry topics are proper and relevant to the audience, in this case future engineers. We chose the latter approach and built a 13-chapter book from the ground up to satisfy what we think are the goals of the course:

- Provide a concise but thorough introduction to the science of chemistry.
- Give students a firm foundation in the principles of structure and bonding as a foundation for further study of materials science.
- Show the connection between molecular behavior and observable physical properties.
- Show the connections between chemistry and the other subjects studied by engineering students, especially mathematics and physics.

Taken together, the 13 chapters in this book probably represent somewhat more material than can comfortably fit into a standard semester course. Thus departments or individual instructors will need to make some further choices as to the content that is most suitable for their own students. We suspect that many instructors will not choose to include all of the material on equilibrium in Chapter 12, for example. Similarly, we have included more topics in Chapter 8, on condensed phases, than we expect most faculty will include in their courses.

Topic Coverage



Courtesy of the U.S. Department of Energy's Ames Laboratory

The coverage of topics in this text reflects the fact that chemists constantly use multiple concepts to understand their field, often using more than one model simultaneously. Thus the study of chemistry we present here can be viewed from multiple perspectives: macroscopic, microscopic, and symbolic. The latter two perspectives are emphasized in Chapters 2 and 3 on atoms, molecules, and reactions. In Chapters 4 and 5, we establish more of the connection between microscopic and macroscopic in our treatment of stoichiometry and gases. We return to the microscopic perspective to cover more details of atomic structure and chemical bonding in Chapters 6 through 8. The energetic aspects of chemistry, including important macroscopic consequences, are considered in Chapters 9 and 10, and kinetics and equilibrium are treated in Chapters 11 and 12, respectively. Finally, we conclude with the treatment of electrochemistry and corrosion, an important chemistry application for many engineering disciplines.

Specific Content Coverage

We know that there are specific topics in general chemistry that are vital to future engineers. We've chosen to treat them in the following ways.

Organic Chemistry: Organic chemistry is important in many areas of engineering, particularly as related to the properties of polymers. Rather than using a single organic chapter, we integrate our organic chemistry coverage over the entire text, focusing on polymers. We introduce organic polymers in Section 2.1 and use polymers and their monomers in many examples in this chapter. Chapter 2 also contains a rich discussion of organic line structures and functional groups and ends with a section on the synthesis, structure, and properties of polyethylene. Chapter 4 opens and ends with discussions of fuels, a topic to which we return in Chapter 9. Chapter 8 contains more on carbon and polymers, and the recycling of polymers provides the context for consideration of the second law of thermodynamics in Chapter 10.

Acid–Base Chemistry: Acid–base reactions represent another important area of chemistry with applications in engineering, and again we have integrated our coverage into appropriate areas of the text. Initially, we define acids and bases in conjunction with the introduction to solutions in Chapter 3. Simple solution stoichiometry is presented in Chapter 4. Finally, a more detailed treatment of acid–base chemistry is presented in the context of equilibria in Chapter 12.

Nuclear Chemistry: Though not included in the text proper, we have written a chapter on nuclear chemistry, which is available through Cengage Learning's custom publishing division. Coverage in this chapter includes fundamentals of nuclear reactions, nuclear stability and radioactivity, decay kinetics, and the energetic consequences of nuclear processes.

Mathematics: The math skills of students entering engineering majors generally are stronger than those in the student body at large, and most of the students taking a course of the type for which this book is intended will be concurrently enrolled in an introductory calculus course. In light of this, we include references to the role of calculus where appropriate via our **MathConnections** boxes. These essays expand and review math concepts as they pertain to the particular topic being studied, and appear wherever the links between the topic at hand and mathematics seems especially strong. These boxes are intended to be unobtrusive, so those students taking a precalculus math course will not be adversely affected. The point of including calculus is not to raise the level of material being presented, but rather to show the natural connections between the various subjects students are studying.

Connections between Chemistry and Engineering

Because this book is intended for courses designed for engineering majors, we strive to present chemistry in contexts that we feel will appeal to the interests of such students. Links between chemistry and engineering are central to the structure of the text. Each chapter begins and ends with a section called ***INSIGHT INTO . . .***, which introduces a template or theme showing the interplay between chemistry and engineering. These sections are only the beginning of the connections, and the theme introduced in the initial *Insight* appears regularly throughout that chapter.

Lawrence S. Brown

We opt for currency in our engineering applications wherever possible, so throughout the book, we discuss recent key innovations in various fields. For example, Chapter 1 contains a brief discussion of OLEDs (organic light-emitting diodes), a new advance that may eventually replace the liquid crystal screen in devices such as digital cameras and flat-panel computer monitors. OLEDs are revisited later in Chapter 6. In Chapter 2, we discuss the new polymer UHMWPE (ultra-high molecular weight polyethylene), which is stronger and lighter than Kevlar™ and is replacing Kevlar as filling in bulletproof vests. In Chapter 3, we include an entire Insight section on fuel cells and their possible future applications in cars and laptop computers.

Approach to Problem Solving

Problem solving is a key part of college chemistry courses and is especially important as a broadly transferable skill for engineering students. Accordingly, this text includes worked problems throughout. All of our Example Problems include a *Strategy* section immediately following the problem statement, in which we emphasize the concepts and relationships that must be considered to work the problem. After the solution, we often include a section called *Analyze Your Answer* that is designed to help students learn to estimate whether or not the answer they have obtained is reasonable. In many examples, we also include *Discussion* sections that help explain the importance of a problem solving concept or point out common pitfalls to be avoided. Finally, each example closes with a *Check Your Understanding* problem or question to help the student to generalize or extend what's been learned in the example problem.

We believe that the general chemistry experience should help engineering students develop improved problem solving skills. Moreover, we feel that those skills should be transferable to other subjects in the engineering curriculum even though chemistry content may not be involved. Accordingly, we include a unique feature at the end of each chapter called **FOCUS ON PROBLEM SOLVING**. In these sections, the questions posed do not require a numerical answer, but rather ask the student to identify the strategy or reasoning to be used in the problem and often require them to identify missing information for the problem. In most cases, it is not possible to arrive at a final numerical answer using the information provided, so students are forced to focus on developing a solution rather than just identifying and executing an algorithm. The end-of-chapter exercises include additional problems of this nature so the *Focus on Problem Solving* can be fully incorporated into the course. This feature grew out of an NSF-funded project on assessing problem solving in chemistry classes.

Text Features

We employ a number of features, some of which we referred to earlier, to help students see the utility of chemistry and understand the connections to engineering.

***INSIGHT INTO* Sections** Each chapter is built around a template called *Insights Into . . . .* These themes, which both open and close each chapter, have been chosen to showcase connections between engineering and chemistry. In addition to the chapter opening and closing sections, the template themes are woven throughout the chapter, frequently providing the context for points of discussion or example problems. This special *Insight* icon is used throughout the book to identify places where ideas presented in the chapter opening section are revisited in the narrative.

FOCUS ON PROBLEM SOLVING Sections Engineering faculties unanimously say that freshman engineering students need practice in solving problems. However, it is important to make a distinction here between problems and exercises. Exercises provide a chance to practice a narrow skill, whereas problems require multiple steps and thinking outside the context of the information given. *Focus on Problem Solving* offers students the chance to develop and practice true problem solving skills. These sections, which appear at the end of every chapter, include a mix of quantitative and qualitative questions that focus on the *process* of finding a solution to a problem, not the solution itself. We support these by including additional similar problems in the end-of-chapter material.

MathConnections In our experience, one trait that distinguishes engineering students from other general chemistry students is a higher level of comfort with mathematics. Typically most students who take a class of the sort for which this book has been written will also be taking a course in calculus. Thus it seems natural to us to point out the mathematical underpinnings of several of the chemistry concepts presented in the text because this should help students forge mental connections between their courses. At the same time, we recognize that a student taking a precalculus math course should not be precluded from taking chemistry. To balance these concerns, we have placed any advanced mathematics into special *MathConnections* sections, which are set off from the body of the text. Our hope is that those students familiar with the mathematics involved will benefit from seeing the origin of things such as integrated rate laws, whereas those students with a less extensive background in math will still be able to read the text and master the chemistry presented.

Example Problems Our examples are designed to illustrate good problem solving practices by first focusing on the reasoning behind the solution before moving into any needed calculations. We emphasize this "think first" approach by beginning with a *Strategy* section, which outlines a plan of attack for the problem. We find that many students are too quick to accept whatever answer their calculator might display. To combat this, we follow most solutions with an *Analyze Your Answer* section, which uses estimation and other strategies to walk students through a double check of their answers. Every example closes with a *Check Your Understanding* exercise to allow students to practice or extend the skill they have just learned. Answers to these additional exercises are included in Appendix J at the end of the book.

End-of-Chapter Features Each chapter concludes with a chapter summary, outlining the main points of the chapter, and a list of key terms, each of which includes the section number where the term first appeared. Definitions for all key terms appear in the Glossary.

Problem Sets Each chapter includes roughly 100 problems and exercises, spanning a wide range of difficulty. Most of these exercises are identified with specific sections to provide the practice that students need to master material from that section. Each chapter also includes a number of *Additional Problems*, which are not tied to any particular section and which may incorporate ideas from multiple sections. *Focus on Problem Solving* exercises follow, as described earlier. The problems for most chapters conclude with *Cumulative Problems*, which ask students to synthesize information from the current chapter with what they've learned from previous chapters to form answers. Answers for all odd-numbered problems appear at the end of the book in Appendix K.

Margin Notes Margin notes in the text point out additional facts, further emphasize points, or point to related discussion either earlier or later in the book.

Supplements

This text comes with a variety of ancillary materials for both the student and instructor. Supporting instructor materials are available to qualified adopters. Please consult your local Cengage Learning representative for details. Visit this book's Companion Website, accessed at **www.cengage.com/chemistry**, to:

- See samples of materials
- Locate your local representative
- Download electronic files of support materials and text art
- Request a desk copy
- Purchase a book online

Instructor's Manual/Test Bank Online (with images from the text)

The Instructor's Manual contains detailed solutions for all of the even-numbered end-of-chapter problems in the text, and the Test Bank features more than 500 multiple-choice questions for tests, quizzes, or homework assignments. Both were written by Charles Cornett of the University of Wisconsin–Platteville and can be easily accessed from the instructor's section of this book's Companion Website, accessed at **www.cengage.com/chemistry.** In addition, this site includes a library of resources valuable to instructors, such as text art and tables, in a variety of e-formats that are easily exported into other software packages.

OWL (Online Web-based Learning System)

Developed over the last several years at the University of Massachusetts, Amherst, and class-tested by thousands of students, OWL is a fully customizable and flexible web-based homework system and assessment tool with course management. With both numerical and chemical parameterization and useful, specific feedback built right in, OWL produces more than 100,000 general chemistry questions correlated with this text. The OWL system also features a database of simulations and guided tutorials. Instructors can customize the OWL program, use the grade book feature, and generate multiple reports to measure as much or as little information based upon each student's performance. OWL is currently available for faculty and students in North America only.

Student Solutions Manual and Study Guide

The Student Solutions Manual, written by Steve Rathbone of Blinn College, is a comprehensive guide to working the solutions to the odd-numbered end-of-chapter problems in the text. The best way for students to learn and understand the concepts is to work multiple, relevant problems on a daily basis. The Student Solutions Manual provides instant feedback to students not only by giving the answers but also by giving detailed explanations. The manual also contains Study Goals for each chapter of the text and Chapter Objective Quizzes.

JoinIn™ on TurningPoint® CD-ROM

Cengage Learning is now pleased to offer you book-specific JoinIn content for Response Systems, written by text author Tom Holme. JoinIn allows you to transform your classroom and assess your students' progress with instant in-class quizzes and polls. Our exclusive agreement to offer TurningPoint software lets you pose book-specific questions and display students' answers seamlessly within the Microsoft® PowerPoint® slides of your own lecture, in conjunction with the "clicker" hardware of your choice. Enhance your students' interaction with you, your lecture, and each other.

Acknowledgments

The creation of a new textbook is an enormous undertaking, involving more work than we would ever have guessed. Fortunately, we have had the help and support of a large and talented team. There are many people without whose help we literally could not have done this. But foremost among them are our families, to whom this book is dedicated.

The origin of this text can be traced back several years, and many people at Brooks/Cole have played important roles. Jennifer Laugier first brought the two of us together to work on a book for engineering students. Jay Campbell's work as our developmental editor has been nothing short of heroic. When Jay became involved, the project had been languishing for some time, and the subsequent gains in momentum were clearly not coincidental. The current editorial leadership team of Michelle Julet, David Harris, and Lisa Lockwood has also been instrumental in seeing this text through to production. The decision to launch a book in a market segment that has not really existed was clearly not an easy one, and we appreciate the confidence that everyone at Brooks/Cole has placed in us.

We also appreciate the role played by Ann Ratcliffe of the University of Northern Colorado in the development of this book. Ann worked on this project in its infancy and her contributions still resonate in the final product.

Although this is officially the first edition of the book, we've actually done class testing of two preliminary editions during the last two years. Our colleagues and students, who participated in these class tests at Texas A&M, UW–Milwaukee, and elsewhere, have played a vital role in the development of this text. Thus we wish to note our particular gratitude to Joe Mawk of Texas A&M, Kristen Murphy of UW–Milwaukee, Steve Rathbone of Blinn College, and Ben Hutchinson of Lipscomb University for being willing to teach with what might legitimately have been called a rough draft of the text.

As the book moved from that preliminary form into production, a small army of professionals joined our team. In this electronic age, we have never actually met most of these people, but clearly we could not have produced the book you are holding without their excellent work. As our production manager, Lisa Weber oversaw everything and kept the project moving on schedule. Linda Jupiter of Jupiter Productions supervised the day-to-day production work and supplied the gentle but steady pressure needed to keep us meeting a steady stream of deadlines. Mark Neitlich's keen copy editor's eye helped polish our writing. Carol Bleistine as art editor and Greg Gambino as illustrator transformed the primitive sketches and descriptions we supplied into the figures you see in the book. Both responded quickly to our every request, no matter how many times we had already modified a particular figure. Jane Sanders Miller served as our photo researcher. Mary Kanable proofread the entire book in page proofs, and Allen Apblett and David Shinn served as accuracy checkers. Their attention to detail has helped us avoid many errors.

Because this text is for a new and emerging course, we have been grateful for input from a broad range of our colleagues in chemistry departments around the country. Too many people to name individually responded to surveys about their courses for engineering students, and their feedback played an important role in decisions we made about the content coverage for this text. Finally, we would like to thank the following individuals who reviewed the text at various stages and provided vital feedback for its improvement.

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Larry Brown
Tom Holme
August, 2005

Student Introduction

Chemistry and Engineering

As you begin this chemistry course, odds are that you may be wondering "Why do I have to take chemistry anyway? I'll never really need to know any of this to be an engineer." So we'd like to begin by offering just a few examples of the many links between our chosen field of chemistry and the various branches of engineering. The most obvious examples, of course, might come from chemical engineering. Many chemical engineers are involved with the design or optimization of processes in the chemical industry, so it is clear that they would be dealing with concepts from chemistry on a daily basis. Similarly, civil or environmental engineers working on environmental protection or remediation might spend a lot of time thinking about chemical reactions taking place in the water supply or the air. But what about other engineering fields?

Much of modern electrical engineering relies on solid-state devices whose properties can be tailored by carefully controlling their chemical compositions. And although most electrical engineers do not regularly make their own chips, an understanding of how those chips operate on an atomic scale is certainly helpful. As the push for ever smaller circuit components continues, the ties between chemistry and electrical engineering will grow tighter. From organic light-emitting diodes (OLEDs) to single molecule transistors, new developments will continue to move out of the chemistry lab and into working devices at an impressive pace.

Some applications of chemistry in engineering are much less obvious. At 1483 feet, the Petronas Towers in Kuala Lumpur, Malaysia, were the tallest buildings in the world when they were completed in 1998. Steel was in short supply in Malaysia, so the towers' architects decided to build the structures out of something the country had an abundance of and local engineers were familiar with: concrete. But the impressive height of the towers required exceptionally strong concrete. The engineers eventually settled on a material that has come to be known as high strength concrete, in which chemical reactions between silica fume and portland cement produce a stronger material, more resistant to compression. The chemistry of concrete is complicated enough that it is beyond the scope of this text, but this example does illustrate the relevance of chemistry to even very traditional fields of engineering.

About This Text

Although this is the first edition of a new textbook, we've actually been working on this project for years. The book has been reviewed and revised several times, and hundreds of students have used two preliminary versions in class testing.

Both of us have taught general chemistry for many years, and we are familiar with the difficulties that students may encounter with the subject. Perhaps more importantly, for the past several years, we've each been teaching engineering students in the type of one semester course for which this text is designed. The approach to subjects presented in this text draws from both levels of experience.

We've worked hard to make this text as readable and student friendly as possible. One feature that makes this book different from any other text you could have used for this course is that we incorporate connections between chemistry and engineering as a fundamental component of each chapter. You will notice that each chapter begins and ends with a section called ***INSIGHT INTO*** . . . . These sections are only the beginning of the connections, and the theme introduced in the initial insight appears regularly throughout that chapter. This special icon identifies material that is closely related to the theme of the chapter opening *Insight* section. We've heard many students complain that they don't see what chemistry has to do with their chosen fields, and we hope that this approach might help you to see some of the connections.

Engineering students tend to take a fairly standard set of courses during their first year of college, so it's likely that you might be taking calculus and physics courses along with chemistry. We've tried to point out places where strong connections between these subjects exist, and at the same time to do this in a way that does not disadvantage a student who might be taking a precalculus math class. Thus we may refer to similarities between equations you see here and those you might find in a physics text, but we do not presume that you are already familiar with those equations. In the case of math, we use special sections called **MathConnections** to discuss the use of math, and especially calculus, in chemistry. If you are familiar with calculus or are taking it concurrently with this class, these sections will help you to see how some of the equations used in chemistry emerge from calculus. But if you are not yet taking calculus, you can simply skip over these sections and still be able to work with the needed equations.

Although our primary intent is to help you learn chemistry, we also believe that this text and the course for which you are using it can help you to develop a broad set of skills that you will use throughout your studies and your career. Foremost among them is problem solving. Much of the work done by practicing engineers can be characterized as solving problems. The problems you will confront in your chemistry class clearly will be different from those you will see in engineering, physics, or math. But taken together, all of these subjects will help you formulate a consistent approach that can be used to attack virtually any problem. Many of our students tend to "jump right in" and start writing equations when facing a problem. But it is usually a better idea to think about a plan of attack before doing that, especially if the problem is difficult or unfamiliar. Thus all of our worked examples include a *Strategy* section in which we outline the path to a solution before starting to calculate anything. The *Solution* section then puts that strategy into action. For most numerical examples, we follow the solution with a section we call *Analyze Your Answer*, in which we use estimation or comparison to known values to confirm that our result makes sense. We've seen many students who believe that whatever their calculator shows must be the right answer, even when it should be easy to see that a mistake has been made. Many examples also include a

Discussion section in which we might talk about common pitfalls that you should avoid or how the problem we've just done relates to other ideas we've already explored. Finally, each example problem closes with a *Check Your Understanding* question or problem, which gives you a chance to practice the skills illustrated in the example or to extend them slightly. Answers to these *Check Your Understanding* questions appear in Appendix J.

While we are thinking about the example problems, a few words about rounding and significant figures are in order. In solving the example problems, we have used atomic weights with the full number of significant figures shown in the Periodic Table inside the back cover. We have also used as many significant figures as available for constants such as the speed of light or the universal gas constant. Where intermediate results are shown in the text, we have tried to write them with the appropriate number of significant figures. But when those same intermediate results are used in a subsequent calculation, we have *not* rounded the values. Instead we retain the full calculator result. Only the final answer has actually been rounded. If you follow this same procedure, you should be able to duplicate our answers. (The same process has been used to generate the answers to numerical problems appearing in Appendix K.) For problems that involve finding the slope or intercept of a line, the values shown have been obtained by linear regression using the algorithms built into either a spreadsheet or a graphing calculator.

A unique feature of this text is the inclusion of a *Focus on Problem Solving* question at the end of each chapter. These questions are designed to force you to think about the *process* of solving the problem rather than just getting an answer. In many cases, these problems do not include sufficient information to allow you to reach a final solution. Although we know from experience that many beginning engineering students might find this frustrating, we feel it is a good approximation to the kind of problems that a working engineer might confront. Seldom would a client sit down and provide every piece of information that you need to solve the problem at hand.

One of the most common questions we hear from students is "How should I study for chemistry?" Sadly, that question is most often asked after the student has done poorly on one or more exams. Because different people learn best in different ways, there isn't a single magic formula to ensure that everyone does well in chemistry. But there are some common strategies and practices that we can recommend. First and foremost, we suggest that you avoid getting behind in *any* of your classes. Learning takes time, and very few people can master three chapters of chemistry (or physics, or math, or engineering) the night before a big exam. Getting behind in one class inevitably leads to letting things slide in others, so you should strive to keep up from the outset. Most professors urge students to read the relevant textbook material before it is presented in class. We agree that this is the best approach, because even a general familiarity with the ideas being presented will help you to get a lot more out of your class time.

In studying for exams, you should try to make a realistic assessment of what you do and don't understand. Although it can be discomforting to focus on the problems that you don't seem to be able to get right, spending more time studying things that you have already mastered will probably have less impact on your grade. Engineering students tend to focus much of their attention on numerical problems. Although such calculations are likely to be very important in your chemistry class, we also encourage you to try to master the chemical concepts behind them. Odds are that your professor will test you on qualitative or conceptual material, too.

Finally, we note that this textbook is information rich. It includes many of the topics that normally appear in a full year college chemistry course, but it is designed for a course that takes only one semester. To manage the task of paring down the volume of materials, we've left out some topics and shortened the discussion of others. Having the Internet available means that you can always find more information if what you have read sparks your interest.

We are excited that this book has made it into your hands. We hope you enjoy your semester of learning chemistry and that this book is a positive part of your experience.

Larry Brown
Tom Holme
August, 2005