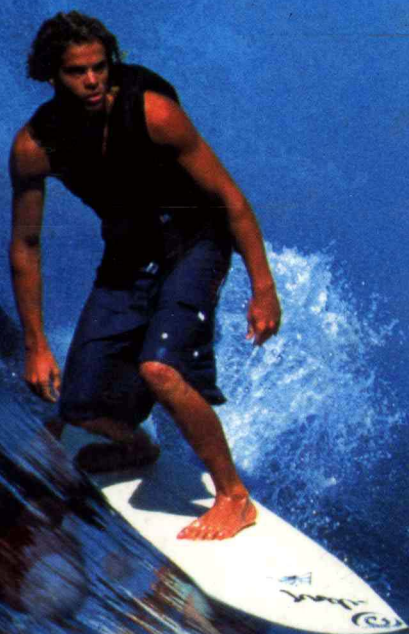


# *Conceptual* **Chemistry** *Second Edition*

*Understanding Our World of Atoms and Molecules*



**John Suchocki**

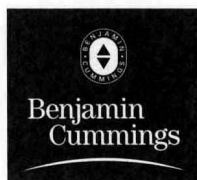
# Conceptual Chemistry

Understanding Our World of Atoms and Molecules

*Second Edition*

John Suchocki

Saint Michael's College



San Francisco Boston New York  
Capetown Hong Kong London Madrid Mexico City  
Montreal Munich Paris Singapore Sydney Tokyo Toronto



Publisher: Jim Smith  
Associate Editor: Lisa Leung  
Develomental Editor: Hilair Chism  
Senior Marketing Manager: Christy Lawrence  
Market Development Manager: Susan Winslow  
Media Managing Editor: Claire Masson  
Production Coordination: Joan Marsh  
Production Management and Composition: Joan Keyes, Dovetail Publishing Services  
Cover Design/Illustration: Blakeley Kim  
Text Design: Joan Keyes and Emiko-Rose Koike  
Artists: Emiko-Rose Koike, J. B. Woolsey and Associates  
Photo Research: Stuart Kenter, Yvos Riezebos  
Manufacturing Supervisor: Vivian McDougal  
Prepress House: H&S Graphics  
Printer and Binder: Von Hoffmann Press

Copyright © 2004 by John A. Suchocki

Published by Pearson Education, Inc., publishing as Benjamin Cummings/Addison Wesley, 1301 Sansome St., San Francisco, CA 94111. All rights reserved. Manufactured in the United States of America. This publication is protected by copyright and permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. To obtain permission(s) to use material from this work, please submit a written request to Pearson Education, Inc., Permissions Department, 1900 E. Lake Ave., Glenview, IL 60025. For information regarding permissions, call 847/486-2635.

Many of the designations used by manufacturers and sellers to distinguish their products are claimed as trademarks. Where those designations appear in this book, and the publisher was aware of a trademark claim, the designations have been printed in initial caps or all caps.

#### Library of Congress Cataloging-in-Publication Data

Suchocki, John.

Conceptual chemistry : understanding our world of atoms and molecules /  
John A. Suchocki. — 2nd ed.

p. cm.

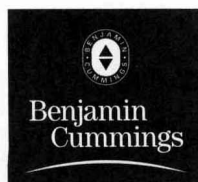
Includes index.

ISBN 0-8053-3228-6

1. Chemistry. I. Title.

QD33.2.S83 2003  
540—dc21

2002041603



1 2 3 4 5 6 7 8 9 10—VH—03 02 01 00

www.aw.com

To  
Tracy Suchocki

for more than I had ever dreamed,  
my first thought is with you

## Conceptual Chemistry Photo Album

*Conceptual Chemistry* is personalized with photographs of my family and friends. A photo of my uncle and mentor Paul Hewitt, appears on page xxx. On Uncle Paul's lap is my son Evan Suchocki (pronounced Su-hock'-ee, with a silent c) who, as a toddler, sums up the book with his optimistic message.

Taking advantage of water's high heat of vaporization is my wife, Tracy, who is seen fearlessly walking over hot coals on page 264. You will also find her on page 294 taking a close look at a set of marbles as their kinetic energy disperses into heat. Demonstrating the potential energy of a drawn bow and arrow on page 17 is our precious oldest son, Ian, who is also seen as a baby with his mom on page 88 letting us know that the closeness between us is in the heart. Our third child, Maitreya Rose, is proudly showcased both as a fetus and as a baby on page 445, as one of the models of Figure 13.18, on page 416, highlighting the value of proteins, and as a two-year-old holding the cellulose and color-rich Vermont autumn leaves on page 408. About to enjoy his favorite beverage—by the liter—is son Evan on page 11. The inverted image of Evan and his mom enjoying the balmy beaches of Hawaii can be seen on page 339 in the discussion on the chemistry of photography. Those are Ian's hands holding the mineral fluorite on page 181 and my fingers on page 151 lightly touching the strings of Betsy, my guitar since childhood. (FYI, there's an "Easter egg" of Betsy in action hidden on the *Conceptual Chemistry Alive!* CD-ROM.) Also of our immediate family is Rusty Cat, whom you will find on page 627 helping provide perspective for the propane tank to the side of our home. Our dog Sam demonstrates his panting skills on page 252.

A few members of our extended family have also made their way into *Conceptual Chemistry*. My nephew Graham Orr is seen on page 51 enjoying one of the most valuable resources this planet has to offer—fresh water. Exploring the microscopic realm with the uncanny resolution of electron waves is my cousin George Webster, who is seen on page 146 alongside his own scanning electron microscope. George's son, Christian, is the cute kid in the Chapter 3 opening photo. Christian is holding a model of the amino acid glycine in front of the multitude of stars from which most all atoms, other than hydrogen, arise. Friend and former housemate Rinchen Trashi is seen looking through the spectroscope on page 139. Tracy's brother, Peter Elias, is found on page 593 smelling the camphorous odor of a freshly cut Ping-Pong ball. Look carefully on page 612 and you will see Peter again along with his mom (my mother-in-law), Sharon Hopwood, as they perch on the branch of a tree made strong by its composite nature. Both Peter and Sharon were key players in the development of the *Conceptual Chemistry Alive!* CD-ROM tutorial.

In addition to family photographs, the photographs of many of our friends' children grace this book. Ayano Jeffers-Fabro is the adorable girl hugging the tree on page 10. Jill Rabinov and her daughter Michaela appear on page 45 demonstrating the chemical nature of biological growth. Cole Stevens, who is seen on page 238, helps us to be amazed by what happens to the volume of water as it freezes. Cole's sister, Maya Stevens, is seen pondering the organic chemicals within vanilla and chocolate ice cream on page 361. In the Chapter 13 opener on page 399 are Daniel Glassman-Vinci and his twin brother Jacob. I'll leave it to you to decide whether they are two people at the same time or two people at different times—read the opener carefully. Last, but certainly not least, is Makani Nelson, who on page 400 provides us with a fine example of a human body full of cells and biomolecules. Look also for Makani's cameo appearance in the opening montage video of *Conceptual Chemistry Alive!* We are born with the desire to learn about our environment and our place in it. Let the sparkle of curiosity in the eyes of our sons and daughters portrayed in this textbook serve as a reminder of this important fact.

# To the Student

---

Welcome to the world of chemistry—a world where everything around you can be traced to those incredibly tiny particles called atoms. Chemistry is the study of how atoms combine to form materials. By learning chemistry, you gain a unique perspective on what things are made of and why they behave as they do.

Chemistry is a science with a very practical outlook. By understanding and controlling the behavior of atoms, chemists have been able to produce a broad range of new and useful materials—alloys, fertilizers, pharmaceuticals, polymers, computer chips, recombinant DNA, and more. These materials have raised our standards of living to unprecedented levels. Learning chemistry, therefore, is worthwhile simply because of the impact this field has on society. More important, with a background in chemistry you can judge for yourself whether or not available technologies are in harmony with the environment and with what you believe to be right.

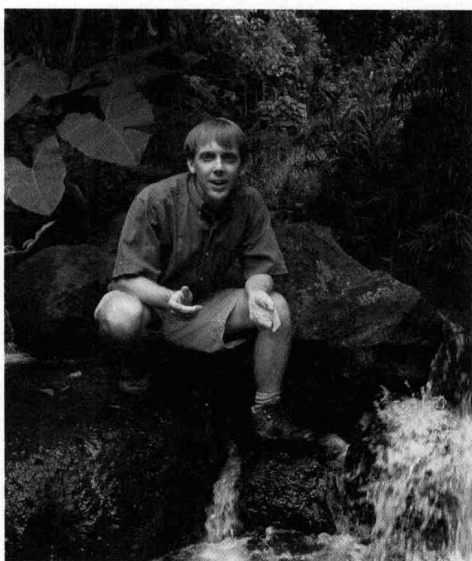
This book presents chemistry *conceptually*, focusing on the concepts of chemistry with little emphasis on calculations. Though sometimes wildly bizarre, the concepts of chemistry are straightforward and accessible—all it takes is the desire to learn. What you will gain from your efforts, however, may

be more than new knowledge about your environment and your personal relation to it—you may improve your learning skills and become a better thinker! But remember, just as with any other form of training, you'll get out of your study of chemistry only as much as you put in.

I enjoy chemistry, and I know you can, too. So put on your boots and let's go explore this world from the perspective of its fundamental building blocks.

Good chemistry to you!

*John Surchock*



# To the Instructor

---

As instructors, we share a common desire for our teaching efforts to have a long-lasting positive impact on our students. We focus, therefore, on what we think is most important for the student to learn. For students taking liberal arts chemistry courses, certain learning goals are clear. They should become familiar with and, perhaps, even interested in the basic concepts of chemistry, especially the ones that apply to their daily lives. They should understand, for example, how soap works and why ice floats on water. They should be able to distinguish between stratospheric ozone depletion and global warming, and also know what it takes to ensure a safe drinking water supply. Along the way, they should learn how to think about matter from the perspective of atoms and molecules. Furthermore, by studying chemistry, students should come to understand the methods of scientific inquiry and become better equipped to pass this knowledge along to future generations. In short, these students should become citizens of above-average scientific literacy.

These are noble goals, and it is crucial that we do our best to achieve them. Judging from my encounters with former liberal arts students in the midst of their daily lives, however, I have come to conclude that this is not what they usually cherish most from having taken a course in chemistry. Rather, it is the personal development they experienced through the process.

As all science educators know, chemistry—with its many abstract concepts—is fertile ground for the development of higher-thinking skills. Thus, it seems reasonable for us to share this valuable scientific offering—tempered to an appropriate level—with all students. Liberal arts students, like all other students, come to college not just to learn about specific subjects but for personal growth as well. This growth should include improvements in their analytical and verbal-reasoning skills along with a boost in self-confidence from having successfully met well-placed challenges. The value of our teaching, therefore, rests not only on our ability to help students learn chemistry but also on our ability to help them learn about themselves.

These are the premises upon which *Conceptual Chemistry* was written. You will find the standard discussions of the applications of chemistry, as shown in the table of contents. True to its title, this textbook also builds a conceptual base from which nonscience students may view nature more perceptively by helping them visualize the behavior of atoms and molecules and showing them how this behavior gives rise to our macroscopic environment.

Numerical problem-solving skills and memorization are not stressed. Instead, chemistry concepts are developed in a story-telling fashion with the frequent use of analogies and tightly integrated illustrations and photographs. Follow-up exercises are designed to challenge the students' understanding of concepts and their ability to synthesize and articulate conclusions. Concurrent with helping students learn chemistry, *Conceptual Chemistry* aims to be a tool by which students can learn how to become better thinkers and reach their personal goals of self-discovery.

## Organization

The basic concepts of chemistry are developed in the first 12 chapters of *Conceptual Chemistry*. Threaded into the development, real-life applications facilitate the understanding and appreciation of chemistry concepts. In the remaining seven chapters, students have the opportunity to exercise their understanding of earlier material as they explore numerous chemistry-related topics.

## Features

Key features of *Conceptual Chemistry* include the following:

- A conversational and clear writing style aimed at engaging student interest.
- In-text **Concept Checks** that pose a question and provide an answer immediately. These questions primarily reinforce ideas just presented before the student moves on to new concepts.
- **Hands-On Chemistry** activities that allow students to witness chemistry outside a formal laboratory setting. These activities can be performed using common household ingredients and equipment. Most chapters have two or three Hands-On features, which lend themselves well to distance learning or to in-class activities.
- **Calculation Corners** appear in selected chapters. They are included so that students can practice the quantitative-reasoning skills needed to perform chemical calculations. In each Calculation Corner, an example problem and answer show students how to perform a specific calculation; then their understanding is tested in a Your Turn section. None of the calculations involve skills beyond fractions, percentages, or basic algebra.

Extensive end-of-chapter material includes:

- **Key Terms and Matching Definitions** providing a short summary of important terms that appear boldfaced in the text.
- **Review Questions** designed to guide the student through the essentials of the chapter. They are grouped by chapter section to help the student stay focused while reviewing the material.
- **Hands-On Chemistry Insights** that follow up on the Hands-On Chemistry activities. These Insights are designed to ensure that the



student is getting the most out of performing the Hands-On activities and also to clear up any misconceptions that may have developed.

- **Exercises** are designed to challenge student understanding of the chapter material and to emphasize critical thinking rather than mere recall. In many cases, the Exercises link chemistry concepts to familiar situations. The solutions to all odd-numbered exercises and problems appear in Appendix C. Thus, you can consider assigning even-numbered exercises for group studies, in-class discussions, or exams.
- **Problems** featuring concepts that are more clearly understood with numerical values and straightforward calculations. They are based on information presented in the Calculation Corners and therefore appear only in chapters containing this feature.
- **Discussion Topics** in the topical chapters (13–19) prompt students to express their opinions on issues that have no definitive answers. These topics may promote student debate about controversial ideas.
- **Exploring Further** references appear in every chapter, but are particularly important for the topical chapters for which you may be more inclined to assign research papers or poster presentations.

## New to the Second Edition

The many positive comments on *Conceptual Chemistry*'s readability have been inspiring. Building on this strength, a major focus of this second edition was placed on streamlining the narrative and altering sentence structures to take *Conceptual Chemistry*'s user-friendliness to an even higher level. Another major focus was on correcting a number of content inaccuracies discovered by users of the first edition.

This second edition maintains the organizational structure of the first edition, with but one exception. Each chapter now ends with a section entitled "In Perspective." This feature serves both as a chapter summary and as food for thought. Many examples of this feature were present in the first edition, but for this second edition more were developed, and all are now highlighted.

Content changes include the introduction of breeder reactors in Chapter 4, The Atomic Nucleus. Also, the first section of Chapter 6, Chemical Bonding, was substantially reworked to support a course syllabus in which the atomic models of Chapter 5 are not emphasized. Perhaps the most significant change is the addition of a section on the second law of thermodynamics, which you will find as the last section of Chapter 9, An Overview of Chemical Reactions. This section was developed with the great assistance of Frank L. Lambert, Professor Emeritus of Occidental College. Frank aptly points out that entropy is merely a gauge of the natural tendency of energy to disperse. For more on this fresh and simple approach, be sure to explore [www.secondlaw.com](http://www.secondlaw.com).

Other modifications to this edition include an updating of the Web references found at the end of each chapter. The topical chapters, such as Chapter 15, Optimizing Food Production, have also been updated based on current events. Also, you will find that each chapter opens on an odd-numbered page. This feature facilitates the production of custom-published

versions of *Conceptual Chemistry*. Let your sales representative know which chapters you would like your students to have, and four-color custom copies will quickly be available.

The ancillaries that accompany the second edition have also been reworked. Most notably, the test bank has been expanded to include a vast number of new questions as well as multiple-choice versions of all the Exercises and Problems that appear at the end of each chapter. These multiple-choice versions of the Exercises and Problems also appear on the textbook's Web site. The intent is to provide a mechanism for rewarding students who have taken the time to work through the short-answer Exercises and Problems in the textbook.

Last but not least, you will find that each copy of the second edition comes with the first CD-ROM of *Conceptual Chemistry Alive!* which is a self-guided tutorial designed to help your students come to class prepared for a student-centered learning experience.

## Support Package

The *Conceptual Chemistry* instructional package provides complete support materials for both students and faculty.

### For the Student

- *Conceptual Chemistry Alive!* is a semester-length student tutorial presented by the author through a series of 12 CD-ROMs—one for each of the first 12 chapters. This tutorial features mini-lectures, demonstrations, animations, home chemistry projects, and explorations of chemistry in the community. Students browse through Quicktime movies in an interactive environment that follows the *Conceptual Chemistry* table of contents. After viewing a segment, students answer Concept Checks that encourage them to test their understanding of key material before progressing further. A student's answers to these Concept Checks are recorded in an electronic notebook that can be submitted to an instructor for assessment. More than a study supplement, *Conceptual Chemistry Alive!* is a textbook companion suitable for distance-learning programs and for instructors seeking to free up class time for student-centered curricula.

A complimentary demonstration copy of the first CD is included in the back of each textbook. The full set of 12 discs is available to the student at a price that is affordable when bundled with a new textbook. A full set may also be purchased separately from the textbook through [www.ConceptChem.com](http://www.ConceptChem.com), which is the technical support Web site for all *Conceptual Chemistry Alive!* users.

For further information, please visit [www.ConceptChem.com](http://www.ConceptChem.com) or contact your local sales representative, whom you may find through [www.awl.com/relocator](http://www.awl.com/relocator).

- *The Chemistry Place* Web site (<http://www.aw.com/chemplace>) is a unique study tool that offers detailed learning objectives, practice quizzes, flash cards, and Web links for each chapter of the text. The Chemistry Place

also includes 30 new interactive tutorials, for a total of 41, featuring simulations, animations, and 3-D visualization tools. Also new at The Chemistry Place is the Research Navigator, a special portal to topical chemistry news and Web links.

- *Student Laboratory Manual for Conceptual Chemistry* (ISBN 0-8053-3238-3) co-authored with Donna Gibson, Chabot College, features laboratory activities tightly correlated to the chapter content.

### For the Instructor

- The *Instructor's Manual for Conceptual Chemistry* is very different from most others. More than 400 pages in length and written by the author, it includes a variety of sample syllabi, lecture ideas and topics not treated in the book, teaching tips, and suggested step-by-step lectures and demonstrations. Answers to the Matching Key Terms and Review Questions and complete solutions to the Exercises and Problems are available to instructors in a format suitable for photocopying and posting for students to review. (ISBN 0-8053-3232-4)
- The *Chemistry Place* Web site (<http://www.aw.com/chemplace>) contains areas accessible only by the course instructor. These areas provide an on-line syllabus manager and a link to the complete *Instructor's Manual* on-line.
- A set of 250 four-color acetates of figures and tables from the text is available (ISBN 0-8053-3233-2).
- A CD-ROM contains the book's art library in a high-resolution format for electronic presentation (ISBN 0-8053-3231-6).
- A test bank comes in both printed format (ISBN 0-8053-3234-0) and on a cross-platform CD-ROM (ISBN 0-8053-3230-8).
- Course management technologies:  
WebCT: [cms.aw.com/webct](http://cms.aw.com/webct)  
Blackboard: <http://cms.aw.com/blackboard>  
CourseCompass™: [www.coursecompass.com](http://www.coursecompass.com)

In addition to offering Blackboard, we also offer CourseCompass™—a nationally hosted on-line course management system. All CourseCompass™ and Blackboard courses offer preloaded content, including testing and assessment, interactive Web-based activities, animations, Web links, illustrations, and photos. To view a demonstration of any course, go to <http://cms.awlonline.com>.

# Acknowledgments

---

As every author knows, no words can express the debt one owes to the members of one's immediate family. My family's tireless support and belief in me have been an invaluable gift. To my wife, Tracy, to whom this book is dedicated, I am grateful for her endless patience and for the love and time she gives to me daily. Our late-night conversations and her countless paragraph edits have helped shape the scope and focus of this book. To Ian, Evan, and Maitreya, who have grown knowing only a dad who pours hours over his computer, thank you for reminding me of the important things in life.

There are numerous other individuals I am grateful and indebted to for their assistance in the development of *Conceptual Chemistry*. Standing at the head of this crowd is my uncle, mentor, and friend, Paul G. Hewitt. He planted the seed for this book in the early 1980s and has lovingly nurtured its growth ever since. Forever encouraging, patient, and inspirational, I thank you, Uncle Paul, for your guidance and more.

I am also blessed with a very capable extended family. Thanks to Uncle Paul and cousin Leslie Hewitt Abrams for allowing me to use their material from *Conceptual Physical Science*. Thanks to my pharmacist sister, Joan Lucas, for helping with the early drafts of Chapter 14 and to my chemical engineer brother-in-law, Rick Lucas, for consultations regarding the petroleum industry. To Bill Candler, rock collector and husband to my dear sister Cathy, thank you for supplying various minerals for photographing. I would like to thank my molecular geneticist step-brother, Nicholas Kellar, for assistance in the Chapter 13 laboratory for isolating DNA from plant material. Thanks also to my electron microscopist cousin, George Webster, and his wife, Lolita, for supplying photos of their SEM.

Special thanks are extended to my mother, Marjorie Hewitt Suchocki, and my father, John M. Suchocki, for their love and for instilling in me a positive attitude about life's work. Personal thanks are also extended to all my friends and other relatives for their support throughout the years, most notably to my mother-in-law, Sharon Hopwood, for photo research and for being a wonderful grandmother. Personal thanks also go to my past mentors, Professors Everette May and Albert Sneden of Virginia Commonwealth University.

I am particularly grateful for the past support of the faculty and staff of Leeward Community College, especially during my frequent book-writing sabbatical leaves. I am notably indebted to Michael Reese, Bob Asato,



George Shiroma, Patricia Domingo, Manny Cabral, Mike Lee, Kakkala Mohanan, Irwin Yamamoto, Stacy Thomas, Sharon Narimatsu, and Mark Silliman. To Alayne Schroll and the other faculty of the chemistry department at St. Michael's College, and to John Kenney, Dean of the College, thank you for welcoming me to your campus. Special thanks are extended to Frank L. Lambert, Professor Emeritus Occidental College, for his much-appreciated assistance in the development of *Conceptual Chemistry's* presentation of the second law of thermodynamics.

For developing the *Conceptual Chemistry Laboratory Manual*, I am forever grateful to Donna Gibson of Chabot College. It has been a privilege to work with Donna—a remarkable woman and highly skilled instructor. For developing the *Conceptual Chemistry* test bank, I am indebted to Pam Marks of Arizona State University. To Pam's graduate students, Debbie Leedy and Rachel Morgan, I give thanks for creating answers to the matching terms and review questions in the *Instructor's Manual*.

The first chapter of this textbook is graced by the research efforts of Professors Jim McClintock of the University of Alabama, Birmingham, and Bill Baker of the University of South Florida, who were quick to provide not only their permissions but some beautiful photographs of the Antarctic. A big *mahalo* to them both.

There were many individuals in the publishing world who played vital and often pivotal roles in the early development of *Conceptual Chemistry*. These people include Doug Humphrey, Shelly McCarthy, Cathleen Petree, Mary Castellion, Richard Stratton, Paul Corey, and John Challice, and the late John Vondeling. I am grateful for their generous support and sound advice.

For making the publication of the first edition of *Conceptual Chemistry* possible, I owe special thanks to Ben Roberts, who has been all things to this textbook from acquisitions editor to senior editor. Ben's commitment to providing students with the best possible learning tools is unwavering and runs bone deep. We've been through a lot together, and I regard him as a close friend. Thanks, Ben, for your vision and for these opportunities.

Working with me on the nitty-gritty of each paragraph over the course of many years was my developmental editor, Hilair Chism, whose brilliant mind was able to keep track of the many details that my own mind was quick to forget. To Hilair I send my deepest appreciation, especially for her focus on integrating the text with the art program. Working with Hilair over the years has been a tremendous learning experience as well as a joy. I will always treasure our kinship.

*Conceptual Chemistry* has benefitted from the efforts of not just one, but two great developmental editors. In addition to Hilair's input, I had the input of the very talented Irene Nunes, my developmental editor for *Conceptual Physical Science*.

For this second edition, I am grateful for the support of my chemistry editor, Jim Smith, and senior editor, Frank Ruggirello. Thanks to Jim and Frank, as well as to Linda Baron Davis, for their trust and confidence in me as an author. I am also indebted to Lisa Leung and Sharon Hopwood, who were of great assistance in the preparation of the manuscript.

For overseeing the production of *Conceptual Chemistry*, I send a heartfelt thanks to Joan Marsh. For rendering the art, thanks to Emi Koike,

Blakeley Kim, and the artists at J. B. Woolsey and Associates. Special thanks to Jean Lake and Tony Asaro for managing the ancillary materials and to Margot Otway for providing valuable input throughout the project. Joan Keyes and Jonathan Peck of Dovetail Publishing Services did a superior job of composing pages and keeping track of the work flow. My deep gratitude goes to Stuart Kenter and Rachel Epstein of Stuart Kenter Associates for their remarkable photo research. As for marketing, I am excited to know that *Conceptual Chemistry* is in the very capable hands of Stacy Treco, Christy Lawrence, and Chalon Bridges. Thanks to you all. An author couldn't possibly ask for more support than this.

The development of *Conceptual Chemistry* relied heavily on the comments and criticisms of numerous reviewers. These people should know that their input was carefully considered and most often incorporated. A tremendous thanks goes to the reviewers listed here, who contributed immeasurably to the development of the first and second editions of the book:

Pamela M. Aker, University of Pittsburgh  
Edward Alexander, San Diego Mesa College  
Sandra Allen, Indiana State University  
Susan Bangasser, San Bernardino Valley College  
Ronald Baumgarten, University of Illinois, Chicago  
Stacey Bent, New York University  
Richard Bretz, University of Toledo  
Benjamin Bruckner, University of Maryland, Baltimore County  
Kerry Bruns, Southwestern University  
Patrick E. Buick, Florida Atlantic University  
John Bullock, Central Washington University  
Barbara Burke, California State Polytechnical University, Pomona  
Robert Byrne, Illinois Valley Community College  
Richard Cahill, De Anza College  
David Camp, Eastern Oregon University  
Jefferson Cavalieri, Dutchess Community College  
William J. Centobene, Cypress College  
Ana Ciereszko, Miami Dade Community College  
Jerzy Crosowski, Florida State University  
Richard Clarke, Boston University  
Cynthia Coleman, SUNY Potsdam  
Virgil Cope, University of Michigan-Flint  
Kathryn Craighead, University of Wisconsin/River Falls  
Jack Cummini, Metropolitan State College of Denver  
William Deese, Louisiana Tech University  
Rodney A. Dixon, Towson University  
Jerry A. Driscoll, University of Utah  
Melvyn Dutton, California State University, Bakersfield  
J. D. Edwards, University of Southwestern Louisiana  
Karen Eichstadt, Ohio University  
David Farrelly, Utah State University  
Ana Gaillat, Greenfield Community College  
Patrick Garvey, Des Moines Area Community College  
Shelley Gaudia, Lane Community College

Donna Gibson, Chabot College  
Palmer Graves, Florida International University  
Jan Gryko, Jacksonville State University  
William Halpern, University of West Florida  
Marie Hankins, University of Southern Indiana  
Alton Hassell, Baylor University  
Barbara Hillery, SUNY Old Westbury  
Angela Hoffman, University of Portland  
John Hutchinson, Rice University  
Mark Jackson, Florida Atlantic University  
Kevin Johnson, Pacific University  
Stanley Johnson, Orange Coast College  
Joe Kirsch, Butler University  
Louis Kuo, Lewis and Clark College  
Frank Lambert, Occidental College  
Carol Lasko, Humboldt State University  
Joseph Lechner, Mount Vernon Nazarene College  
Robley Light, Florida State University  
Maria Longas, Purdue University  
David Lygre, Central Washington University  
Art Maret, University of Central Florida  
Vahe Marganian, Bridgewater State College  
Irene Matusz, Community College of Baltimore County—Essex  
Robert Metzger, San Diego State University  
Luis Muga, University of Florida  
B. I. Naddy, Columbia State Community College  
Donald R. Neu, St. Cloud State University  
Larry Neubauer, University of Nevada, Las Vegas  
Frazier Nyasulu, University of Washington  
Frank Palocsay, James Madison University  
Robert Pool, Spokane Community College  
Brian Ramsey, Rollins College  
Kathleen Richardson, University of Central Florida  
Ronald Roth, George Mason University  
Elizabeth Runquist, San Francisco State University  
Maureen Scharberg, San Jose State University  
Francis Sheehan, John Jay College of Criminal Justice  
Mee Shelley, Miami University  
Vincent Sollimo, Burlington County College  
Ralph Steinhaus, Western Michigan University  
Mike Stekoll, University of Alaska  
Dennis Stevens, University of Nevada, Las Vegas  
Anthony Tanner, Austin College  
Joseph C. Tausta, State University College at Oneonta  
Bill Timberlake, Los Angeles Harbor College  
Margaret A. Tolbert, University of Colorado  
Anthony Toste, Southwest Missouri State University  
Carl Trindle, University of Virginia  
Everett Turner, University of Massachusetts Amherst  
George Wahl, North Carolina State University

M. Rachel Wang, Spokane Community College  
Karen Weichelman, University of Southwestern Louisiana  
Bob Widing, University of Illinois at Chicago  
Ted Wood, Pierce University  
Sheldon York, University of Denver

To the struggling student, thank you for your learning efforts—you are on the road to making this world a better place.

Much effort has gone into keeping this textbook error-free and accurate. It is possible, however, that some errors or inaccuracies may have escaped our notice. Your forwarding such errors or inaccuracies to me would be greatly appreciated. Your questions, general comments, and criticisms are also welcome. I look forward to hearing from you.

*John Suchocki*  
*ConceptChem@aol.com*



# Brief Contents

---

<b>1</b>	<b>Chemistry Is a Science</b>	<b>1</b>
	<i>Looking at the World of Atoms and Molecules</i>	
<b>2</b>	<b>Elements of Chemistry</b>	<b>37</b>
	<i>Understanding Chemistry Through Its Language</i>	
<b>3</b>	<b>Discovering the Atom and Subatomic Particles</b>	<b>69</b>
	<i>Where We've Been and What We Know Now</i>	
<b>4</b>	<b>The Atomic Nucleus</b>	<b>99</b>
	<i>Know Nukes</i>	
<b>5</b>	<b>Atomic Models</b>	<b>133</b>
	<i>Virtual Handles on the Very Real</i>	
<b>6</b>	<b>Chemical Bonding and Molecular Shapes</b>	<b>173</b>
	<i>How Atoms Connect to One Another</i>	
<b>7</b>	<b>Molecular Mixing</b>	<b>205</b>
	<i>How Molecules Attract One Another</i>	
<b>8</b>	<b>Those Incredible Water Molecules</b>	<b>237</b>
	<i>Macroscopic Consequences of Molecular Stickiness</i>	
<b>9</b>	<b>An Overview of Chemical Reactions</b>	<b>271</b>
	<i>How Reactants React to Form Products</i>	
<b>10</b>	<b>Acids and Bases</b>	<b>307</b>
	<i>Transferring Protons</i>	
<b>11</b>	<b>Oxidation and Reduction</b>	<b>337</b>
	<i>Transferring Electrons</i>	
<b>12</b>	<b>Organic Compounds</b>	<b>361</b>
	<i>A Survey of Carbon-Based Molecules</i>	
<b>13</b>	<b>Chemicals of Life</b>	<b>399</b>
	<i>The Nutrients That Make Up Our Bodies</i>	
<b>14</b>	<b>The Chemistry of Drugs</b>	<b>451</b>
	<i>Understanding Drug Action</i>	
<b>15</b>	<b>Optimizing Food Production</b>	<b>495</b>
	<i>From the Good Earth</i>	
<b>16</b>	<b>Fresh Water Resources</b>	<b>531</b>
	<i>Our Roles and Responsibilities</i>	
<b>17</b>	<b>Air Resources</b>	<b>559</b>
	<i>One Planet, One Atmosphere</i>	