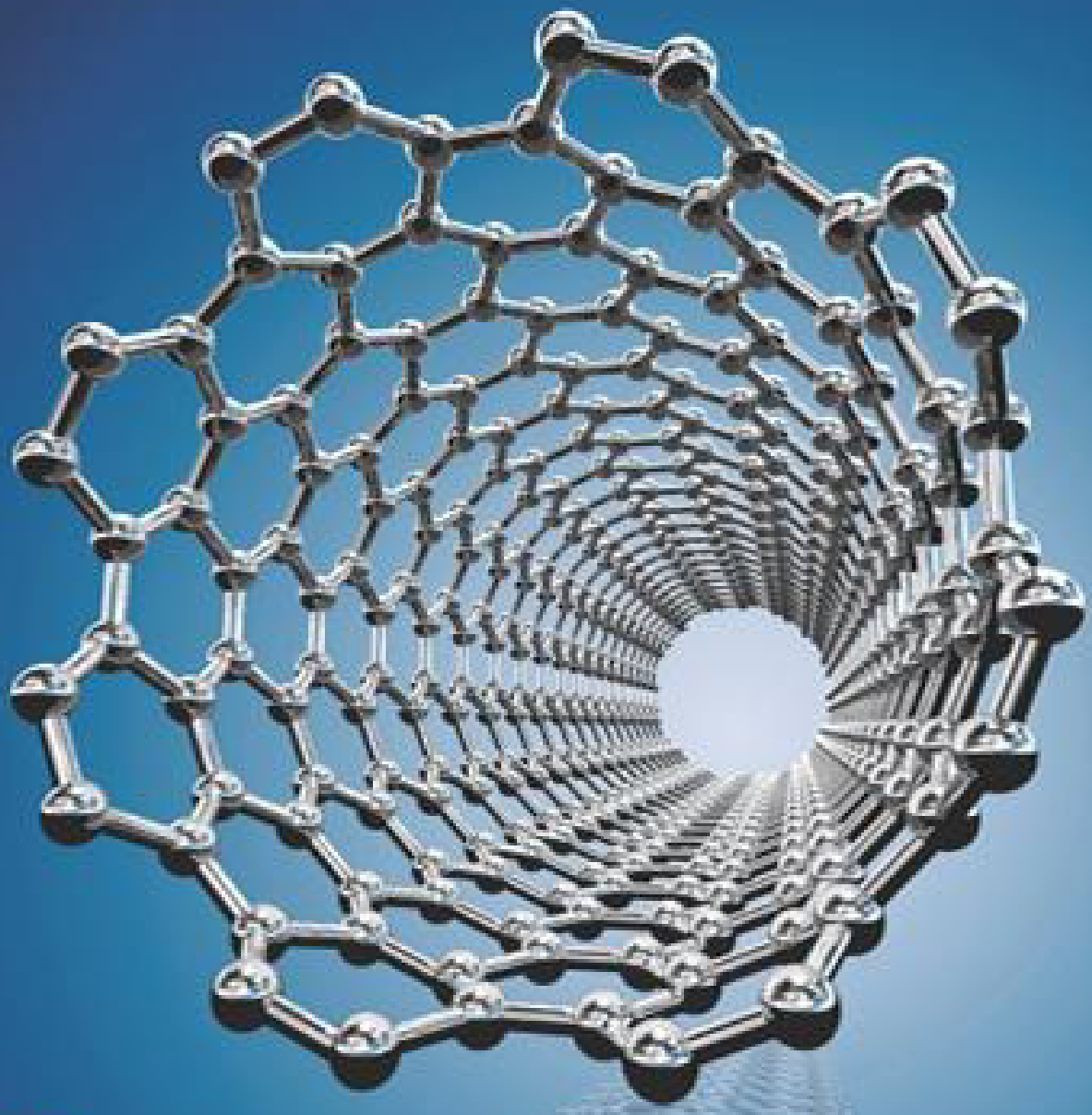
This International Student Edition is for use outside of the U.S.

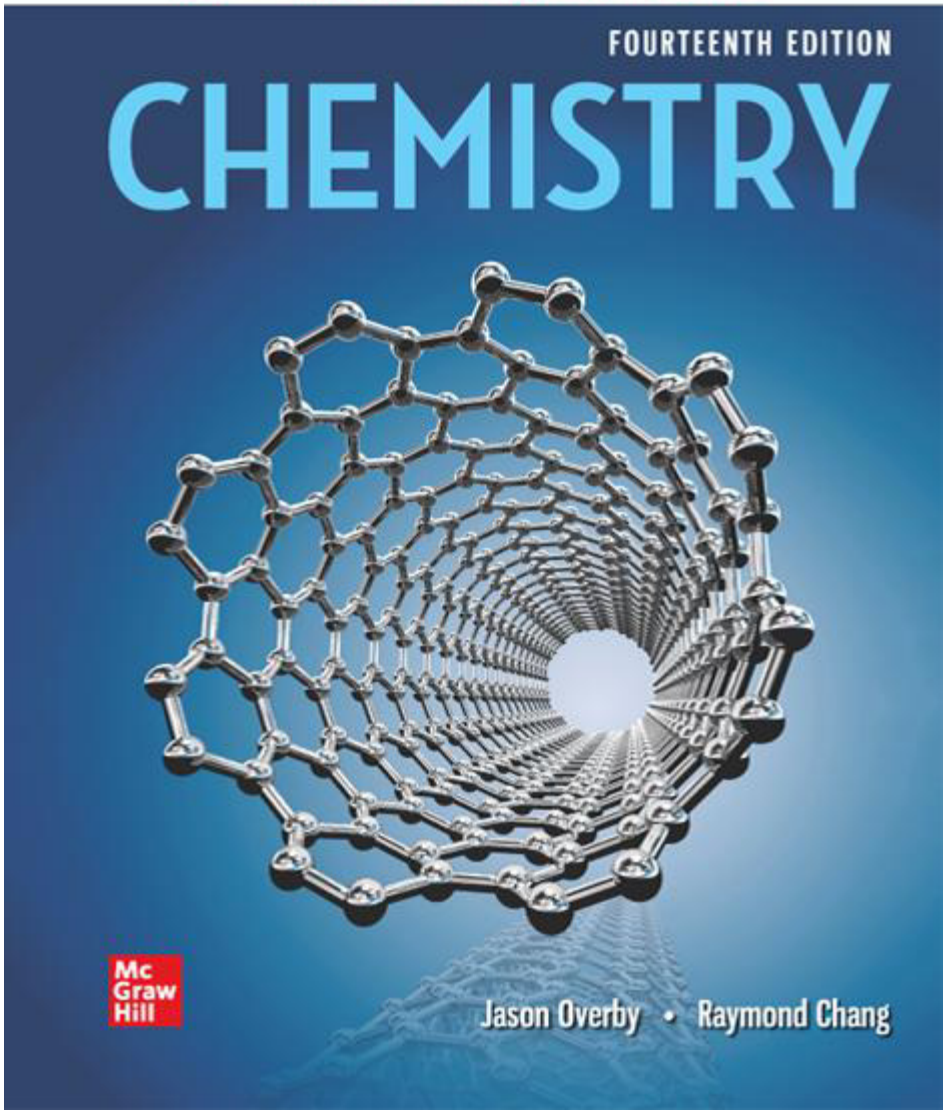
FOURTEENTH EDITION

CHEMISTRY

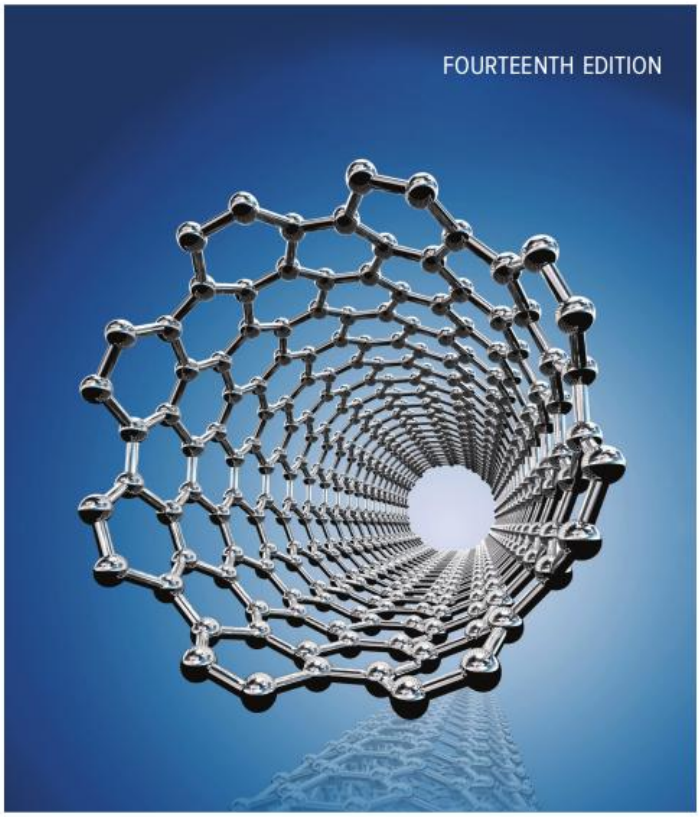


Jason Overby • Raymond Chang

Mc Graw Hill



Chemistry



Jason Overby
College of Charleston

Raymond Chang
Williams College

Mc Graw Hill

CHEMISTRY

This book is printed on acid-free paper.

1 2 3 4 5 6 7 8 9 LWI 26 25 24 23 22 21

ISBN 978-1-265-57756-8
MHID 1-265-57756-0

Cover Image: *Miriam Maslo/Science Photo Library/Alamy Stock Photo*

The Internet addresses listed in the text were accurate at the time of publication. The inclusion of a website does not indicate an endorsement by the authors or McGraw Hill LLC, and McGraw Hill LLC does not guarantee the accuracy of the information presented at these sites.

mheducation.com/highered

About The Authors

Courtesy Lisa Jensen

Jason Overby was born in Bowling Green, Kentucky, and raised in Clarksville, Tennessee. He received his B.S. in chemistry and political science from the University of Tennessee at Martin. After obtaining his Ph.D. in inorganic chemistry from Vanderbilt University, Jason conducted postdoctoral research at Dartmouth College.

Since joining the Department of Chemistry and Biochemistry at the College of Charleston, South Carolina, Jason has taught a variety of courses ranging from general chemistry to advanced inorganic chemistry. He is also interested in the integration of technology into the classroom, with a particular focus on adaptive learning. Additionally, he conducts research with undergraduates in inorganic and organic synthetic chemistry as well as computational organometallic chemistry.

In his free time, he enjoys boating, bowling, and cooking. He is also involved with USA Swimming as a nationally certified official. He lives in South Carolina with his wife Robin and two daughters, Emma and Sarah.

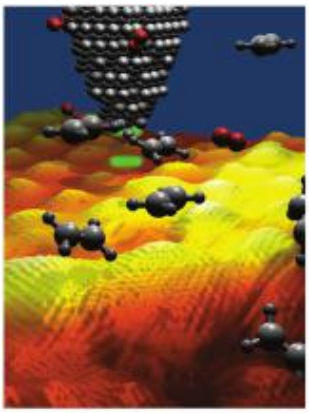
Courtesy Lisa Jensen

Raymond Chang was born in Hong Kong and grew up in Shanghai and Hong Kong. He received his B.Sc. degree in chemistry from London University, and his Ph.D. in chemistry from Yale University. After doing postdoctoral research at Washington University and teaching for a year at Hunter College of the City University of New York, he joined the chemistry department at Williams College.

Professor Chang served on the American Chemical Society Examination Committee, the National Chemistry Olympiad Examination, and the Graduate Record Examination (GRE) Committee. He wrote books on physical chemistry, industrial chemistry, and physical science. He also coauthored books on the Chinese language, children's picture books, and a novel for young readers.

Contents in Brief

Contents



©Science Source

Atoms, Ions, and Molecules 40

NASA

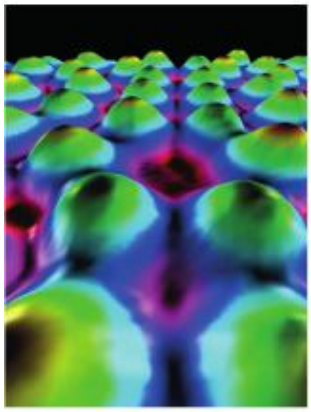
Reactions in Aqueous Solutions 124

Source: NASA

Gases 175

©Ian Cumming/Getty Images

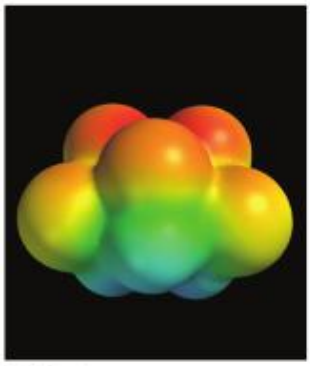
Thermochemistry 230

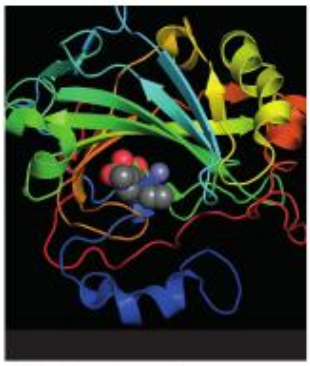


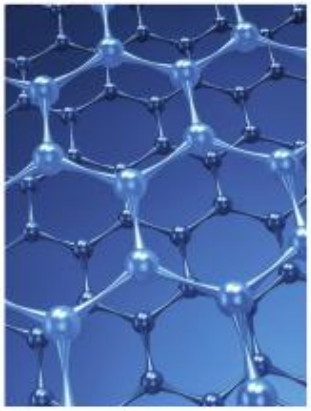
©Lawrence Berkeley National Laboratory/

Quantum Theory and the Electronic Structure of Atoms 273

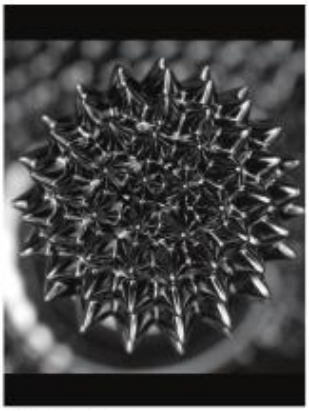
Periodic Relationships Among the Elements 328







©Anna Kireieva/Shutterstock

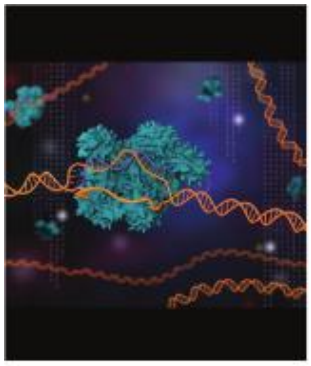


Physical Properties of Solutions 527

Chemical Kinetics 567

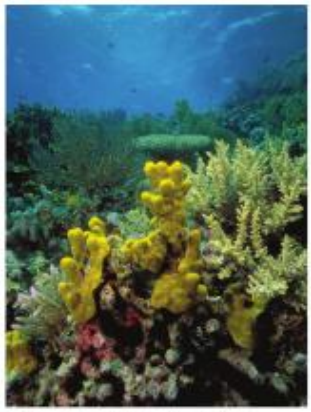
©yadiyim/Shutterstock

Chemical Equilibrium 629

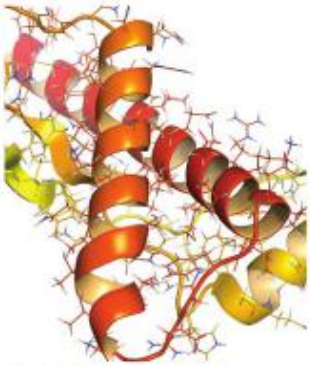


©Michigan Nanotechnology Institute for Medicine and Biological Sciences

Acids and Bases 672



Acid-Base Equilibria and Solubility Equilibria 725



©Feng Wei Photography/Getty Images

Entropy, Gibbs Energy, and Equilibrium 777

©GeneChutka/Getty Images

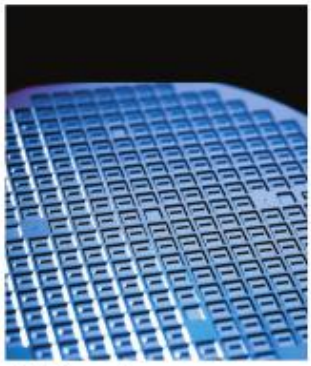
Electrochemistry 815

Nuclear Chemistry 863

Chemistry in the Atmosphere 904

© James L. Dye

Metallurgy and the Chemistry of Metals 934



©NASA/Science Source

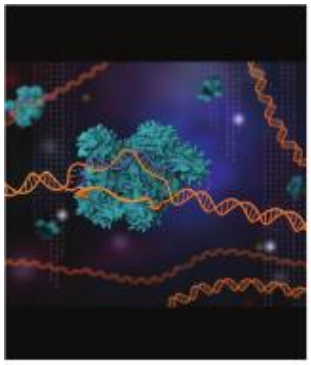
Nonmetallic Elements and Their Compounds 963

©J. D. Barrie and C. H. Barrie, Jr.

Coordination Chemistry 1001

©Jeff Gilbert/Alamy Stock Photo

Organic Chemistry 1030



©Michigan Nanotechnology Institute for Medicine and Biological Sciences

Synthetic and Natural Organic Polymers 1062

List of Applications

 The opening sentence of this text is, "Chemistry is an active, evolving science that has vital importance to our world, in both the realm of nature and the realm of society." Throughout the text, Chemistry in Action boxes and Chemical Mysteries (digital only) give specific examples of chemistry as active and evolving in all facets of our lives.

Chemistry in Action

Chemical Mystery (digital only)

List of Videos

 The following videos are correlated to *Chemistry*. Within the chapter are icons letting the student and instructor know that a video is available for a specific topic. Videos can be found in the ebook.

Electron Configurations (7.8)
Equilibrium Vapor Pressure (11.8)
Formation of a Covalent Bond (9.4)
Formation of an Ionic Compound (2.7)
Galvanic Cells (18.2)
The Gas Laws (5.3)
Heat Flow (6.2)
Hybridization (10.4)
Hydration (4.1)
Influence of Shape on Polarity (10.2)
Ionic and Covalent Bonding (9.4)
Ionic vs. Covalent Bonding (9.4)
Le Châtelier's Principle (14.5)
Limiting Reagent (3.9)
Line Spectra (7.3)
Millikan Oil Drop (2.2)
Molecular Shape and Orbital Hybridization (10.4)
Neutralization Reactions (4.3)
Nuclear Fission (19.5)
Operation of a Voltaic Cell (18.2)
Orientation of Collision (13.4)
Osmosis (12.6)
Oxidation-Reduction Reactions (4.4)
Packing Spheres (11.4)
Phase Diagrams and the States of Matter (11.9)
Polarity of Molecules (10.2)
Properties of Buffers (16.2)
Radioactive Decay (19.3)
Reaction of Cu with $AgNO_3$ (4.4)
Reaction of Magnesium and Oxygen (9.2)
Resonance (9.8)
Rutherford's Experiment (2.2)

Sigma and Pi Bonds (10.5)

Strong Electrolytes, Weak Electrolytes, and Nonelectrolytes (4.1)

VSEPR Theory (10.1)

VSEPR (10.1)

Preface

The fourteenth edition continues a long tradition of providing a firm foundation in the concepts of chemical principles while instilling an appreciation of the important role chemistry plays in our daily lives. We believe that it is our responsibility to assist both instructors and students in their pursuit of this goal by presenting a broad range of chemical topics in a logical format. At all times, we strive to balance theory and application and to illustrate principles with applicable examples whenever possible.

As in previous editions, our goal is to create a text that clearly and concisely explains abstract concepts yet comprehensive enough that students are prepared to make the move forward in the chemistry curriculum. Encouraging feedback from instructors and students alike reaffirm that our approach is effective.

Learning Objectives and Summary of Concepts and Facts

In the previous edition, a new listing of Learning Objectives was added to each chapter. To better help instructors and students focus on relevant topics and ideas in a given section, we are providing Learning Objectives at the beginning of each section followed by a Summary of Concepts & Facts at the end of each section. We believe that this perfectly introduces the pertinent idea(s) to be covered and finishes with a reinforcement of those ideas at the end of a section.

13.2 Rate Law

Learning Objectives

- Summarize reaction order and provide examples of a zeroth-, first-, and second-order reaction rate law.
- Write the rate law of a reaction given experimental data.
- Express the units of the rate constant *k* for a reaction.

Summary of Concepts & Facts

- The rate law expresses the relationship of the rate of a reaction to the rate constant and the concentrations of the reactants raised to appropriate powers. The rate constant *k* for a given reaction changes only with temperature.
- Reaction order is the power to which the concentration of a given reactant is raised in the rate law. Overall reaction order is the sum of the powers to which reactant concentrations are raised in the rate law. The rate law and the reaction order cannot be determined from the stoichiometry of the overall equation for a reaction; they must be determined by experiment. For a zero-order reaction, the reaction rate is equal to the rate constant.

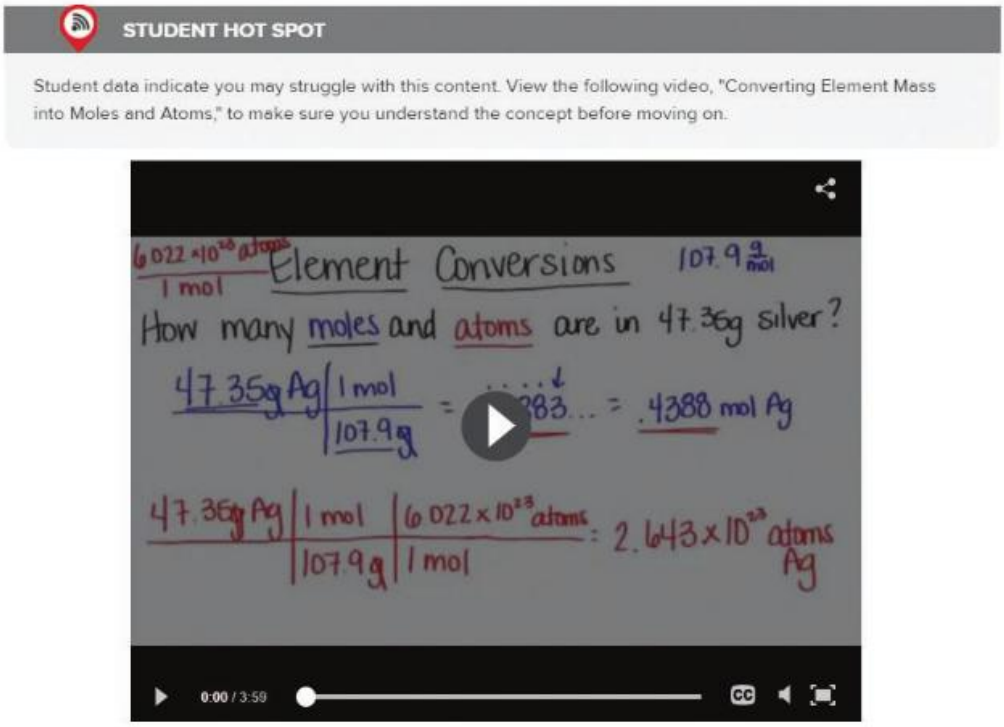
Student Hot Spots

The adaptive reading tool SmartBook® now gives authors a detailed analysis of student performance on various learning objectives and concepts. With this powerful insight into the ideas and concepts students struggle with, we are now able to provide strategically placed notifications about access to additional learning resources. Identified areas of particularly difficult content are now denoted with a margin note called "Student Hot Spot." These are intended to direct students to additional learning resources specific to that content. Students now have access to over 1,000 digital learning resources throughout the SmartBook® version of this text. Included in these learning resources are over 200 videos of chemistry faculty solving actual problems or explaining concepts.

Student Hot Spot

Student data indicate you may struggle with significant figures. Access your eBook for additional Learning Resources on this topic.

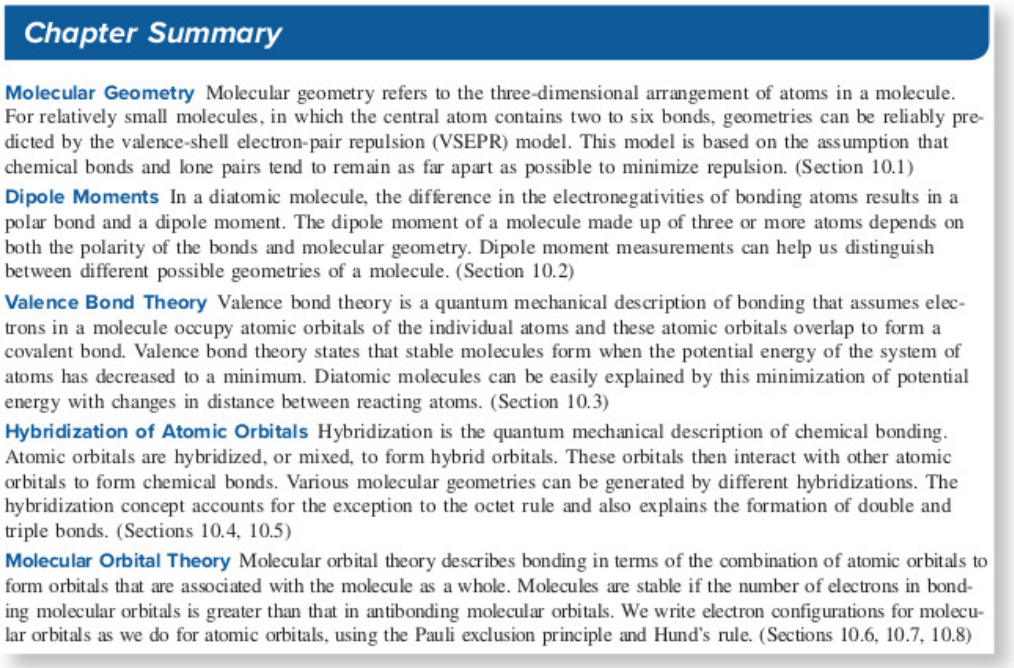
In the electronic version of this text, all the learning resources for the Student Hot Spots are readily available.



Further, access to student results has guided the editing of content in many chapters. While many of the changes are subtle, some are more comprehensive. The ability to edit based on real-time assessment data from students is the new paradigm for textbook authoring. Undoubtedly this changes how we provide and enhance learning materials for our students in the future!

Chapter Summary

A Chapter Summary is now provided at the end of every chapter with a succinct overview of all sections in the chapter. These are intended to be a reinforcement of the important ideas a student will have seen in the chapter. These can easily be used as study guides as well.



Chapter Summary

Molecular Geometry Molecular geometry refers to the three-dimensional arrangement of atoms in a molecule. For relatively small molecules, in which the central atom contains two to six bonds, geometries can be reliably predicted by the valence-shell electron-pair repulsion (VSEPR) model. This model is based on the assumption that chemical bonds and lone pairs tend to remain as far apart as possible to minimize repulsion. (Section 10.1)

Dipole Moments In a diatomic molecule, the difference in the electronegativities of bonding atoms results in a polar bond and a dipole moment. The dipole moment of a molecule made up of three or more atoms depends on both the polarity of the bonds and molecular geometry. Dipole moment measurements can help us distinguish between different possible geometries of a molecule. (Section 10.2)

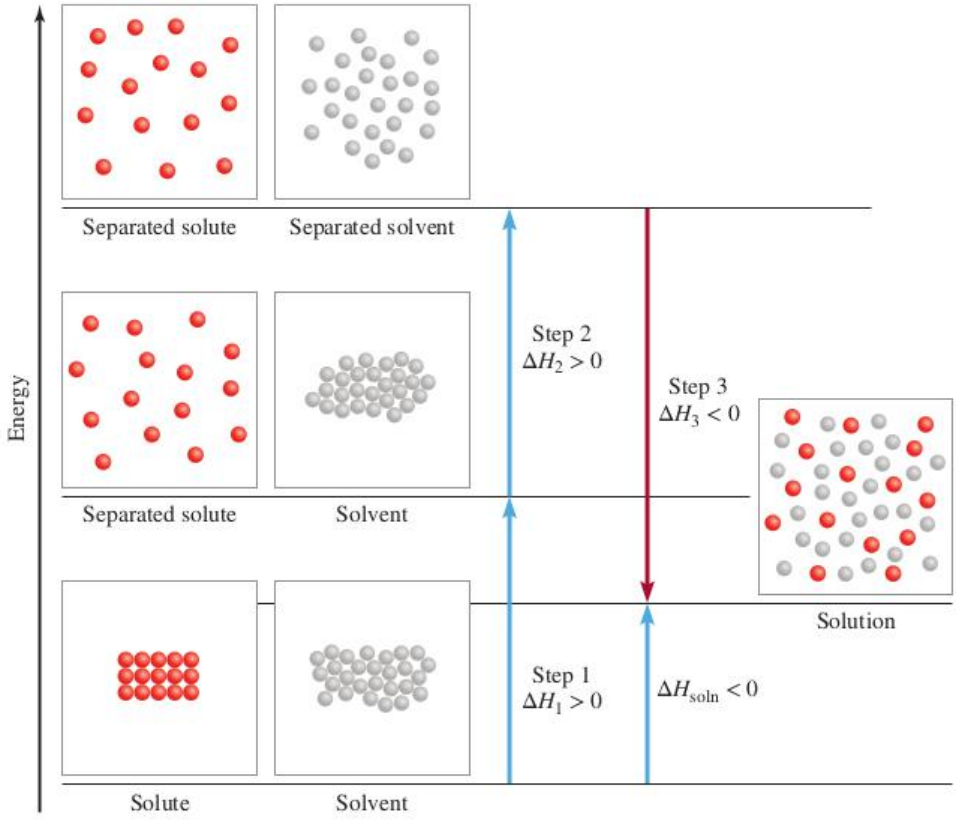
Valence Bond Theory Valence bond theory is a quantum mechanical description of bonding that assumes electrons in a molecule occupy atomic orbitals of the individual atoms and these atomic orbitals overlap to form a covalent bond. Valence bond theory states that stable molecules form when the potential energy of the system of atoms has decreased to a minimum. Diatomic molecules can be easily explained by this minimization of potential energy with changes in distance between reacting atoms. (Section 10.3)

Hybridization of Atomic Orbitals Hybridization is the quantum mechanical description of chemical bonding. Atomic orbitals are hybridized, or mixed, to form hybrid orbitals. These orbitals then interact with other atomic orbitals to form chemical bonds. Various molecular geometries can be generated by different hybridizations. The hybridization concept accounts for the exception to the octet rule and also explains the formation of double and triple bonds. (Sections 10.4, 10.5)

Molecular Orbital Theory Molecular orbital theory describes bonding in terms of the combination of atomic orbitals to form orbitals that are associated with the molecule as a whole. Molecules are stable if the number of electrons in bonding molecular orbitals is greater than that in antibonding molecular orbitals. We write electron configurations for molecular orbitals as we do for atomic orbitals, using the Pauli exclusion principle and Hund's rule. (Sections 10.6, 10.7, 10.8)

Art Program and Design

For this edition, the art program was completely revised to impart a more modern look and enhance visibility as well as provide better ADA compliance for vision-impaired students. Clear graphics are a vital component of the student learning process and as such, all molecular models, graphs, periodic tables, and other figures have been updated with a new look and color scheme. In some instances, illustrations have been replaced with scientifically accurate photographs for enhanced chemical context. Many chapter-opening photographs have been updated for new insights into various chemical topics and applications.



Content Changes

The following are just a few of the highlights of the fourteenth edition content revision.

Chapter 1

- This chapter has been reorganized to better accommodate the study of measurements versus the study of matter in a more logical presentation.
- Updated definitions of the fundamental SI units are now given based on the revisions in 2019.
- The significant digit rules for logarithmic values are now discussed.
- Information on systematic and random errors has been added in conjunction with accuracy and precision.
- A more detailed discussion of the phases of matter is provided to further dispel the misconception that there are only four or five phases of matter.

Chapter 2 This edition of the text now exclusively uses the IUPAC designation of 1-18 for groups on the periodic table.
Chapter 3 A new discussion of the concept of atom economy has been added. This important idea in green chemistry adds a counter point-of-view to percent yield while adding an environmental focus in synthetic chemistry.
Chapter 4 We have now combined the two separate sections on acid-base and redox titrations to illustrate that titrations are simply a technique regardless of the type of chemical reaction occurring.
Chapter 5 New information about the bar pressure unit has been included.
Chapter 6 The description of energy to open the chapter has been reorganized for a more logical presentation. We now use *c* for specific heat capacity as noted by the IUAPC Gold Book instead of *s*.

Chapter 7

- New information about the foundation-building double-slit experiment, as well as interference of waves, is now provided.
- The discussion of the photoelectric effect has been expanded.
- New insight into the importance of the Planck constant is provided.
- New material on the importance of the Heisenberg uncertainty principle is given.
- The idea of spin correlation has been introduced.
- The correct IUPAC nomenclature lanthanoids and actinoids are now used.

Chapter 8 The inert pair effect is now introduced.
Chapter 9 The discussion of lattice enthalpy has been rearranged as well as expanded. Additionally, the discussion of electronegativity has been updated and reorganized.
Chapter 10 The discussion of orbital hybridization has been updated for a more logical flow. And a disclaimer has now been added to the discussion on the controversial topic of *d*-orbital hybridization.
Chapter 11 New material on intermolecular forces has been added along with a new table illustrating the relative strengths of the various types of intermolecular forces. Also, the discussion of phase diagrams has been updated with a more thorough introduction.

Chapter 13

- New material on units in rate laws has been added.
- Updated material on the temperature dependence of reactions is included.
- The discussion of reaction mechanisms has been reorganized.
- New insights on catalytic activity and enzymes are provided.

Chapter 16 The discussion of factors affecting solubility has been completely reorganized for a more logical flow of material.
Chapter 17 The entire discussion of entropy has been reorganized and updated to better reflect our current understanding of entropy as the dispersal of energy. Numerous new figures to help illustrate this concept are now provided. Further, we now exclusively use Gibbs energy given its IUPAC designation for the thermodynamic quantity ΔG.

Chapter 19

- Extensive rewriting and updating of the material on radioactive particles and balancing nuclear reactions has been done.
- There is now a small discussion of the strong nuclear force in relation to the idea of nuclear stability.
- An expanded discussion on radioactive processes relative to the belt of stability has been added.
- New information has been added on particle accelerators.

Chapter 21 The entire section of the chemistry of iron and copper has been moved from Chapter 23 to Chapter 21 to better fit in the discussion of metallurgy.
Chapter 23 The discussion of coordination chemistry geometry has been updated.

Problem Solving

The development of problem-solving skills has always been a major objective of this text. The two major categories of learning are shown next.

Worked examples follow a proven step-by-step strategy and solution.

- **Problem statement** is the reporting of the facts needed to solve the problem based on the question posed.

- **Strategy** is a carefully thought-out plan or method to serve as an important function of learning.
- **Solution** is the process of solving a problem given in a stepwise manner.
- **Check** enables the student to compare and verify with the source information to make sure the answer is reasonable.
- **Practice Exercise** provides the opportunity to solve a similar problem to become proficient in this problem type. The Practice Exercises are available in the Connect electronic homework system. The margin note lists additional similar problems to work in the end-of-chapter problem section.

End-of-Chapter Problems are organized in various ways. Each section under a topic heading begins with Concept Review questions followed by Problems. The Additional Problems section provides more problems not organized by section, followed by the problem type Interpreting, Modeling, & Estimating.

Many of the examples and end-of-chapter problems present extra tidbits of knowledge and enable the student to solve a chemical problem that a chemist would solve. The examples and problems show students the real world of chemistry and applications to everyday life situations.

Visualization

Graphs and Flow Charts are important in science. In *Chemistry,* flow charts show the thought process of a concept and graphs present data to comprehend the concept. A significant number of Problems and Review of Concepts & Facts, including many new to this edition, include graphical data.

Molecular art appears in various formats to serve different needs. Molecular models help to visualize the three-dimensional arrangement of atoms in a molecule. Electrostatic potential maps illustrate the electron density distribution in molecules. Finally, there is the macroscopic to microscopic art helping students understand processes at the molecular level.

Photos are used to help students become familiar with chemicals and understand how chemical reactions appear in reality.

Figures of apparatus enable the student to visualize the practical arrangement in a chemistry laboratory.

Study Aids

Setting the Stage

Each chapter starts with the Chapter Outline and a brief opening discussion of the chapter.

Chapter Outline enables the student to see at a glance the big picture and focus on the main ideas of the chapter.

Tools to Use for Studying

Useful aids for studying are plentiful in *Chemistry* and should be used constantly to reinforce the comprehension of chemical concepts.

Worked Examples along with the accompanying Practice Exercises are very important tools for learning and mastering chemistry. The problem-solving steps guide the student through the critical thinking necessary for succeeding in chemistry. Similar problems in the end-of-chapter problems section are listed at the end of the examples, enabling the student to apply new skill to other problems of the same type. Answers to the Practice Exercises are listed at the end of the chapter problems.

Key Equations are highlighted within the chapter, drawing the student's eye to material that needs to be understood and retained. The key equations are also presented in the chapter summary materials for easy access in review and study.

Chapter Summary provides a quick review of concepts presented and discussed in detail within the chapter.

Key Words are a list of all important terms to help the student understand the language of chemistry.

Testing Your Knowledge

Review of Concepts & Facts lets students pause and check to see if they understand the concept presented and discussed in the section. Answers to the Review of Concepts can be found in the Student Solution Manual.

End-of-Chapter Problems enable the student to practice critical thinking and problem-solving skills. The problems are broken into various types:

- By chapter section. Starting with Review Questions to test basic conceptual understanding, followed by Problems to test the student's skill in solving problems for that particular section of the chapter.
- Additional Problems use the knowledge gained from the various sections and/or previous chapters to solve the problem.

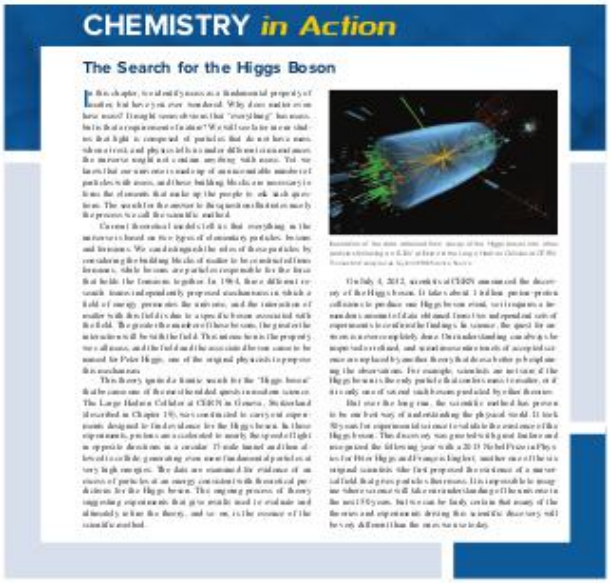
- Interpreting, Modeling, & Estimating problems teach students the art of formulating models and estimating ballpark answers based on appropriate assumptions.

Real-Life Relevance

Interesting examples of how chemistry applies to life are used throughout the text. Analogies are used where appropriate to help foster understanding of abstract chemical concepts.

End-of-Chapter Problems pose many relevant questions for the student to solve. Examples include: Why do swimming coaches sometimes place a drop of alcohol in a swimmer's ear to draw out water? How does one estimate the pressure in a carbonated soft drink bottle before removing the cap?

Chemistry in Action boxes appear in every chapter on a variety of topics, each with its own story of how chemistry can affect a part of life. The student can learn about the science of scuba diving and nuclear medicine, among many other interesting cases.


CHEMISTRY *in Action*

The Search for the Higgs Boson

Chemical Mystery (digital only) poses a mystery case to the student in online format. A series of chemical questions provide clues as to how the mystery could possibly be solved. Chemical Mystery will foster a high level of critical thinking using the basic problem-solving steps built up throughout the text.

Page xxiv

Page xxv

Page 18

The Disappearance of the Dinosaurs

Dinosaurs dominated life on Earth for millions of years and then disappeared very suddenly. To solve the mystery, paleontologists studied fossils and skeletons found in rocks in various layers of Earth's crust. Their findings enabled them to map out which species existed on Earth during specific geologic periods. They also revealed no dinosaur skeletons in rocks formed immediately after the Cretaceous period, which dates back some 65 million years. It is therefore assumed that the dinosaurs became extinct about 65 million years ago.

Chuck Eckert/Alamy Stock Photo

Page 19

Among the many hypotheses put forward to account for their disappearance were disruptions of the food chain and a dramatic change in climate caused by violent volcanic eruptions. However, there was no convincing evidence for any one hypothesis until 1977. It was then that a group of paleontologists working in Italy obtained some very puzzling data at a site near Gubbio. The chemical analysis of a layer of clay deposited above sediments formed during the Cretaceous period (and therefore a layer that records events occurring *after* the Cretaceous period) showed a surprisingly high content of the element iridium (Ir). Iridium is very rare in Earth's crust but is comparatively abundant in asteroids.

Mc Graw Hill ALEKS®

Create More Lightbulb Moments.

Every student has different needs and enters your course with varied levels of preparation. ALEKS® pinpoints what students already know, what they don't and, most importantly, what they're ready to learn next. Optimize your class engagement by aligning your course objectives to ALEKS® topics and layer on our textbook as an additional resource for students.

ALEKS® Creates a Personalized and Dynamic Learning Path

ALEKS® creates an optimized path with an ongoing cycle of learning and assessment, celebrating students' small wins along the way with positive real-time feedback. Rooted in research and analytics, ALEKS® improves student outcomes by fostering better preparation, increased motivation and knowledge retention.

*visit **bit.ly/whatmakesALEKSunique** to learn more about the science behind the most powerful adaptive learning tool in education!

Preparation & Retention

The more prepared your students are, the more effective your instruction is. Because ALEKS® understands the prerequisite skills necessary for mastery, students are better prepared when a topic is presented to them. ALEKS® provides personalized practice and guides students to what they need to learn next to achieve mastery. ALEKS® improves knowledge and student retention through periodic knowledge checks and personalized learning paths. This cycle of learning and assessment ensures that students remember topics they have learned, are better prepared for exams, and are ready to learn new content as they continue into their next course.

Flexible Implementation: Your Class Your Way!

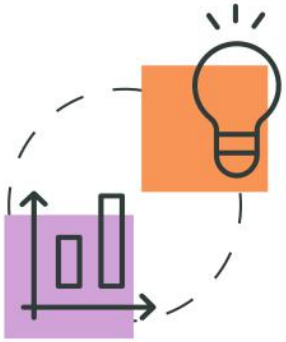
ALEKS® enables you to structure your course regardless of your instruction style and format. From a traditional classroom, to various co-requisite models, to an online prep course before the start of the term, ALEKS® can supplement your instruction or play a lead role in delivering the content.

*visit **bit.ly/ALEKScasestudies** to see how your peers are delivering better outcomes across various course models!

Outcomes & Efficacy

Our commitment to improve student outcomes services a wide variety of implementation models and best practices, from lecture-based to labs and co-reqs to summer prep courses. Our case studies illustrate our commitment to help you reach your course goals and our research demonstrates our drive to support all students, regardless of their math background and preparation level.

*visit **bit.ly/outcomesandefficacy** to review empirical data from ALEKS® users around the country



Turn Data Into Actionable Insights

ALEKS® Reports are designed to inform your instruction and create more meaningful interactions with your students when they need it the most. ALEKS® Insights alert you when students might be at risk of falling behind so that you can take immediate action. Insights summarize students exhibiting at least one of four negative behaviors that may require intervention including Failed Topics, Decreased Learning, Unusual Learning and Procrastination & Cramming.

DIGITAL EDGE50 AWARDS 2019

Winner of 2019 Digital Edge 50 Award for Data Analytics!

bit.ly/ALEKS_MHE

Instructor and Student Resources

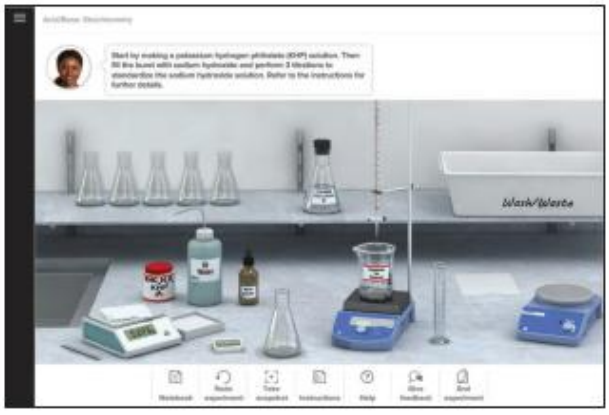
ALEKS (Assessment and LEarning in Knowledge Spaces) is a web-based system for individualized assessment and learning available 24/7 over the Internet. ALEKS uses artificial intelligence to accurately determine a student's knowledge and then guides her to the material that she is most ready to learn. ALEKS offers immediate feedback and access to ALEKSPedia—an interactive text that contains concise entries on chemistry topics. ALEKS is also a full-featured course management system with rich reporting features that allow instructors to monitor individual and class performance, set student goals, assign/grade online quizzes, and more. ALEKS allows instructors to spend more time on concepts while ALEKS teaches students practical problem-solving skills. And with ALEKS 360, your student also has access to this text's eBook. Learn more at **www.aleks.com/highered/science**

Instructors have access to the following instructor resources:

- **Art** Full-color digital files of all illustrations, photos, and tables in the book can be readily incorporated into lecture presentations, exams, or custom-made classroom materials. In addition, all files have been inserted into PowerPoint slides for ease of lecture preparation.
- **Animations** Numerous full-color animations illustrating important processes are also provided. Harness the visual impact of concepts in motion by importing these files into classroom presentations or online course materials.
- **PowerPoint Lecture Outlines** Ready-made presentations that combine art and lecture notes are provided for each chapter of the text.
- **Computerized Test Bank** Over 3,000 test questions that accompany *Chemistry* are available for creating exams or quizzes.

- **Instructor's Solutions Manual** This supplement contains complete, worked-out solutions for *all* the end-of-chapter problems in the text.

McGraw Hill Virtual Labs is a must-see, outcomes-based lab simulation. It assesses a student's knowledge and adaptively corrects deficiencies, allowing the student to learn faster and retain more knowledge with greater success. First, a student's knowledge is adaptively leveled on core learning outcomes: Questioning reveals knowledge deficiencies that are corrected by the delivery of content that is conditional on a student's response. Then, a simulated lab experience requires the student to think and act like a scientist: recording, interpreting, and analyzing data using simulated equipment found in labs and clinics. The student is allowed to make mistakes—a powerful part of the learning experience! A virtual coach provides subtle hints when needed, asks questions about the student's choices, and allows the student to reflect on and correct those mistakes. Whether your need is to overcome the logistical challenges of a traditional lab, provide better lab prep, improve student performance, or make your online experience one that rivals the real world, LearnSmart Labs accomplishes it all.



McGraw Hill Create™

With **McGraw Hill Create,** you can easily rearrange chapters, combine material from other content sources, and quickly upload content you have written, like your course syllabus or teaching notes. Find the content you need in Create by searching through thousands of leading McGraw Hill textbooks. Arrange your book to fit your teaching style. Create even allows you to

personalize your book's appearance by selecting the cover and adding your name, school, and course information.
Order a Create book and you'll receive a complimentary print review copy in three to five business days or a complimentary electronic review copy (eComp) via email in minutes. Go to www.mcgrawhillcreate.com
today and register to experience how McGraw Hill
Create empowers you to teach *your* students *your* way. www.mcgrawhillcreate.com

Student Solutions Manual

Students will find answers to the Practice Exercises and detailed solutions for selected problems from the text in the Student Solutions manual. In addition, there are problem-solving strategies and tutorial solutions that surround each chapter's most important topics and problem types.

Acknowledgments

We would like to thank the following reviewers and symposium participants of this and the previous editions:

Ramesh Arasasingham, *University of California at Irvine*
Kathryn S. Asala, *University of North Carolina, Charlotte*
Mohd Asim Ansari, *Fullerton College*
Keith Baessler, *Suffolk County Community College*
Christian S. Bahn, *Montana State University*
Mary Fran Barber, *Wayne State University*
H. Laine Berghout, *Weber State University*
Feri Billiot, *Texas A&M University Corpus Christi*
Julie Biteen, *University of Michigan*
John Blaha, *Columbus State Community College*
Marco Bonizzoni, *University of Alabama–Tuscaloosa*
Christopher Bowers, *Ohio Northern University*
Bryan Breyfogle, *Missouri State University*
Steve Burns, *St. Thomas Aquinas College*
Mark L. Campbell, *United States Naval Academy*

Tara Carpenter, *University of Maryland*
David Carter, *Angelo State*
Joel Caughran, *University of Georgia*
Daesung Chong, *Ball State University*
Elzbieta Cook, *Louisiana State University*
Robert L. Cook, *Louisiana State University*
Colleen Craig, *University of Washington*
Brandon Cruickshank, *Northern Arizona University–Flagstaff*
Elizabeth A. Clizbe, *SUNY Buffalo*
Mohammed Daoudi, *University of Central Florida*
Jay Deiner, *New York City College of Technology*
Dawn Del Carlo, *University of Northern Iowa*
Milagros Delgado, *Florida International University, Biscayne Bay Campus*
Michael Denniston, *Georgia Perimeter College*
Stephanie R. Dillon, *Florida State University*
Anne Distler, *Cuyahoga Community College*
Bill Donovan, *University of Akron*
Mathilda D. Doorley, *Southwest Tennessee Community College*
Jack Eichler, *University of California–Riverside*
Bradley D. Fahlman, *Central Michigan University*
Lee Friedman, *University of Maryland–College Park*
Tiffany Gierasch, *University of Maryland–Baltimore County*
Cameon Geyer, *Olympic College*
John Gorden, *Auburn University*
Tracy Hamilton, *University of Alabama–Birmingham*
Tony Hascall, *Northern Arizona University*
Lindsay M. Hinkle, *Harvard University*
Rebecca Hoenigman, *Community College of Aurora*
T. Keith Hollis, *Mississippi State University*
Byron Howell, *Tyler Junior College*
Michael R. Ivanov, *Northeast Iowa Community College*
David W. Johnson, *University of Dayton*