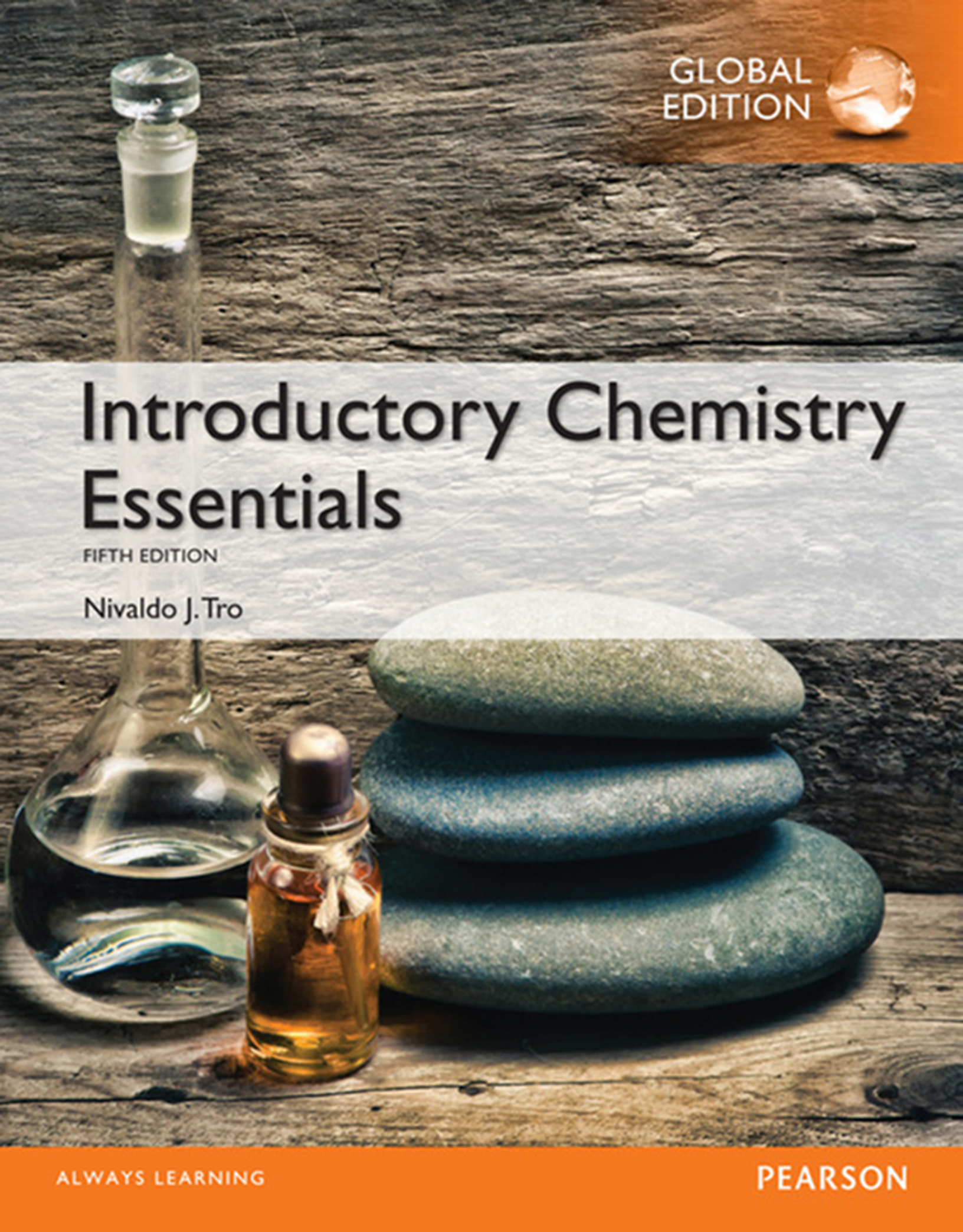
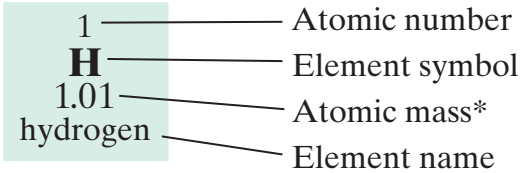

GLOBAL EDITION
Introductory Chemistry Essentials
FIFTH EDITION
Nivaldo J. Tro
ALWAYS LEARNING
PEARSON

Periodic Table of the Elements



PERIOD	GROUP 1 1A	2 2A	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 8B
1	1 **H** 1.01 hydrogen								
2	3 **Li** 6.94 lithium	4 **Be** 9.01 beryllium							
3	11 **Na** 22.99 sodium	12 **Mg** 24.31 magnesium							
4	19 **K** 39.10 potassium	20 **Ca** 40.08 calcium	21 **Sc** 44.96 scandium	22 **Ti** 47.88 titanium	23 **V** 50.94 vanadium	24 **Cr** 52.00 chromium	25 **Mn** 54.94 manganese	26 **Fe** 55.85 iron	27 **Co** 58.93 cobalt
5	37 **Rb** 85.47 rubidium	38 **Sr** 87.62 strontium	39 **Y** 88.91 yttrium	40 **Zr** 91.22 zirconium	41 **Nb** 92.91 niobium	42 **Mo** 95.95 molybdenum	43 **Tc** (99) technetium	44 **Ru** 101.07 ruthenium	45 **Rh** 102.91 rhodium
6	55 **Cs** 132.91 cesium	56 **Ba** 137.33 barium	57 **La** 138.91 lanthanum	72 **Hf** 178.49 hafnium	73 **Ta** 180.95 tantalum	74 **W** 183.85 tungsten	75 **Re** 186.21 rhenium	76 **Os** 190.23 osmium	77 **Ir** 192.22 iridium
7	87 **Fr** (223) francium	88 **Ra** (226) radium	89 **Ac** (227) actinium	104 **Rf** (261) rutherfordium	105 **Db** (262) dubnium	106 **Sg** (263) seaborgium	107 **Bh** (262) bohrium	108 **Hs** (265) hassium	109 **Mt** (266) meitnerium
Lanthanide series				58 **Ce** 140.12 cerium	59 **Pr** 140.91 praseodymium	60 **Nd** 144.24 neodymium	61 **Pm** (147) promethium	62 **Sm** 150.36 samarium	63 **Eu** 151.97 europium
Actinide series				90 **Th** (232) thorium	91 **Pa** (231) protactinium	92 **U** (238) uranium	93 **Np** (237) neptunium	94 **Pu** (244) plutonium	95 **Am** (243) americium

*The mass number of an important radioactive isotope—not the atomic mass—is shown in parentheses for those elements with no stable isotopes.

Metals

Metalloids

Nonmetals

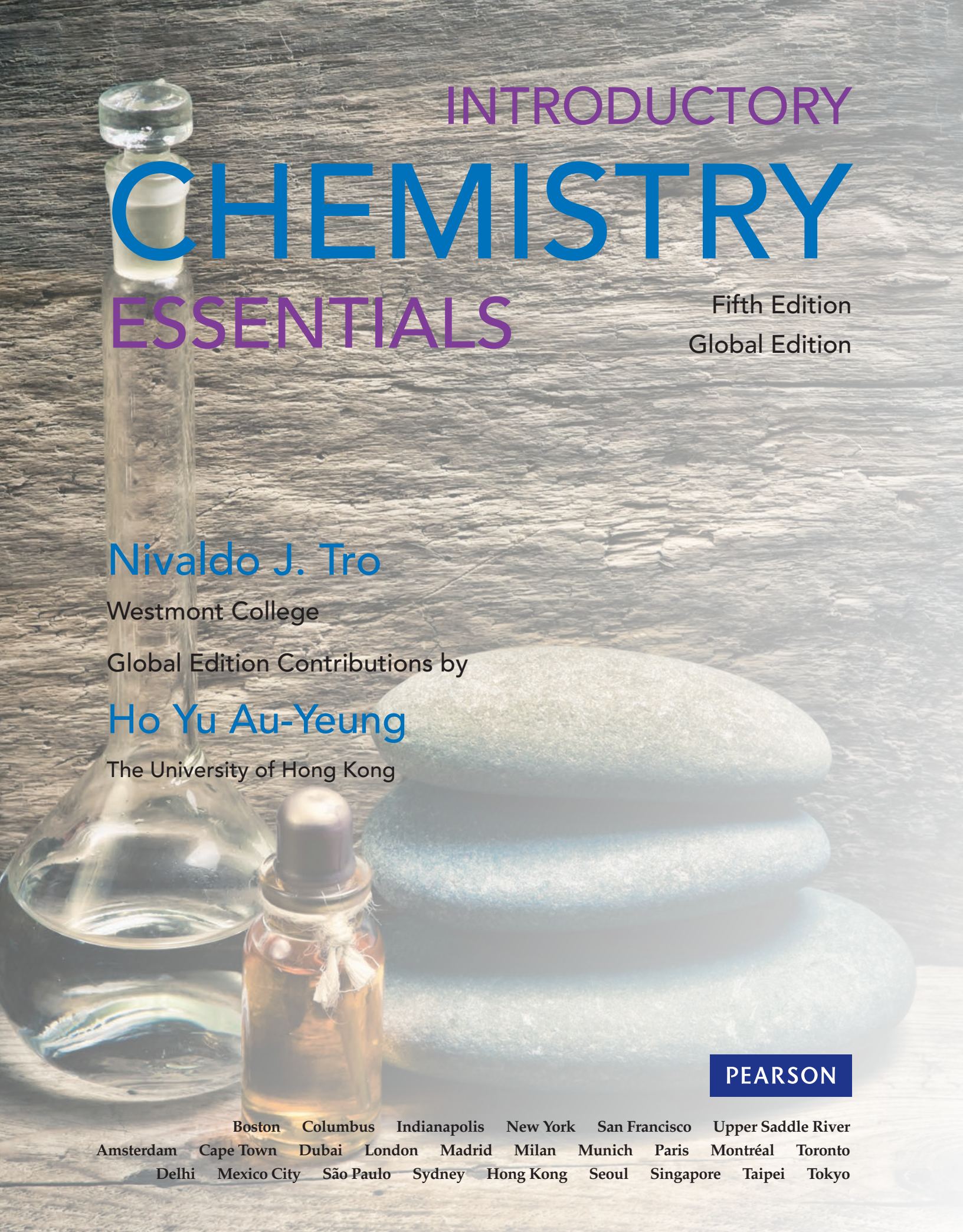
10 8B	11 1B	12 2B	13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
			5 **B** 10.81 boron	6 **C** 12.01 carbon	7 **N** 14.01 nitrogen	8 **O** 16.00 oxygen	9 **F** 19.00 fluorine	2 **He** 4.00 helium
			13 **Al** 26.98 aluminum	14 **Si** 28.09 silicon	15 **P** 30.97 phosphorus	16 **S** 32.06 sulfur	17 **Cl** 35.45 chlorine	10 **Ne** 20.18 neon
28 **Ni** 58.69 nickel	29 **Cu** 63.55 copper	30 **Zn** 65.39 zinc	31 **Ga** 69.72 gallium	32 **Ge** 72.63 germanium	33 **As** 74.92 arsenic	34 **Se** 78.97 selenium	35 **Br** 79.90 bromine	18 **Ar** 39.95 argon
46 **Pd** 106.42 palladium	47 **Ag** 107.87 silver	48 **Cd** 112.41 cadmium	49 **In** 114.82 indium	50 **Sn** 118.71 tin	51 **Sb** 121.75 antimony	52 **Te** 127.60 tellurium	53 **I** 126.90 iodine	36 **Kr** 83.80 krypton
78 **Pt** 195.08 platinum	79 **Au** 196.97 gold	80 **Hg** 200.59 mercury	81 **Tl** 204.38 thallium	82 **Pb** 207.2 lead	83 **Bi** 208.98 bismuth	84 **Po** (209) polonium	85 **At** (210) astatine	54 **Xe** 131.29 xenon
110 **Ds** (281) darmstadtium	111 **Rg** (280) roentgenium	112 **Cn** (285)	113 **—** (284)	114 **Fl** (289)	115 **—** (288)	116 **Lv** (293)	117 ****** (292)	86 **Rn** (222) radon

64 **Gd** 157.25 gadolinium	65 **Tb** 158.93 terbium	66 **Dy** 162.50 dysprosium	67 **Ho** 164.93 holmium	68 **Er** 167.26 erbium	69 **Tm** 168.93 thulium	70 **Yb** 173.04 ytterbium	71 **Lu** 174.97 lutetium
96 **Cm** (247) curium	97 **Bk** (247) berkelium	98 **Cf** (251) californium	99 **Es** (252) einsteinium	100 **Fm** (257) fermium	101 **Md** (258) mendelevium	102 **No** (259) nobelium	103 **Lr** (260) lawrencium

**Discovered in 2010, element 117 is currently under review by IUPAC.

INTRODUCTORY CHEMISTRY ESSENTIALS

This page is intentionally left blank.



INTRODUCTORY CHEMISTRY ESSENTIALS

Fifth Edition
Global Edition

Nivaldo J. Tro
Westmont College

Global Edition Contributions by

Ho Yu Au-Yeung
The University of Hong Kong

PEARSON

Boston Columbus Indianapolis New York San Francisco Upper Saddle River
Amsterdam Cape Town Dubai London Madrid Milan Munich Paris Montréal Toronto
Delhi Mexico City São Paulo Sydney Hong Kong Seoul Singapore Taipei Tokyo

Editor in Chief: Adam Jaworski
Acquisitions Editor: Chris Hess, Ph.D
Director of Development: Jennifer Hart
Executive Marketing Manager: Jonathan Cottrell
Associate Team Lead, Program Management, Chemistry and Geosciences: Jessica Moro
Program Manager: Coleen Morrison
Development Editor: Erin Mulligan
Editorial Assistant: Caitlin Falco
Marketing Assistant: Nicola Houston
Team Lead, Project Management, Chemistry and Geosciences: Gina M. Cheselka
Project Manager: Beth Sweeten
Head of Learning Asset Acquisition, Global Edition: Laura Dent
Senior Acquisitions Editor, Global Edition: Priyanka Ahuja
Project Editor, Global Edition: Anuprova Dey Chowdhuri
Media Production Manager, Global Edition: M. Vikram Kumar
Senior Manufacturing Controller, Global Edition: Trudy Kimber
Production Management: Lumina Datamatics
Compositor: Lumina Datamatics
Illustrator: Precision Graphics
Image Lead: Maya Melenchuk
Photo Researcher: Peter Jardim, PreMedial Global
Text Permissions Manager: Michael Farmer
Text Permission Researcher: Electronic Publishing Services Inc.
Interior Design Manager: Mark Ong
Interior Designer: Wanda Espana, WeeDesign
Cover Design Manager: Jonathan Boylan
Cover Designer: Shree Mohanambal Inbakumar, Lumina Datamatics
Operations Specialist: Christy Hall
Cover Art: © Laborant/Shutterstock

Credits and acknowledgments borrowed from other sources and reproduced, with permission, in this textbook appear on the appropriate page within the text or on p. PC-1.

Pearson Education Limited
Edinburgh Gate
Harlow
Essex CM20 2JE
England

and Associated Companies throughout the world

Visit us on the World Wide Web at:
www.pearsonglobaleditions.com

ISBN 10: 1-292-06133-2
ISBN 13: 978-1-292-06133-7 (Print)
ISBN 13: 978-1-488-68349-7 (PDF)

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library

10 9 8 7 6 5 4 3 2 1

Typeset in Minion Pro by Lumina Datamatics®

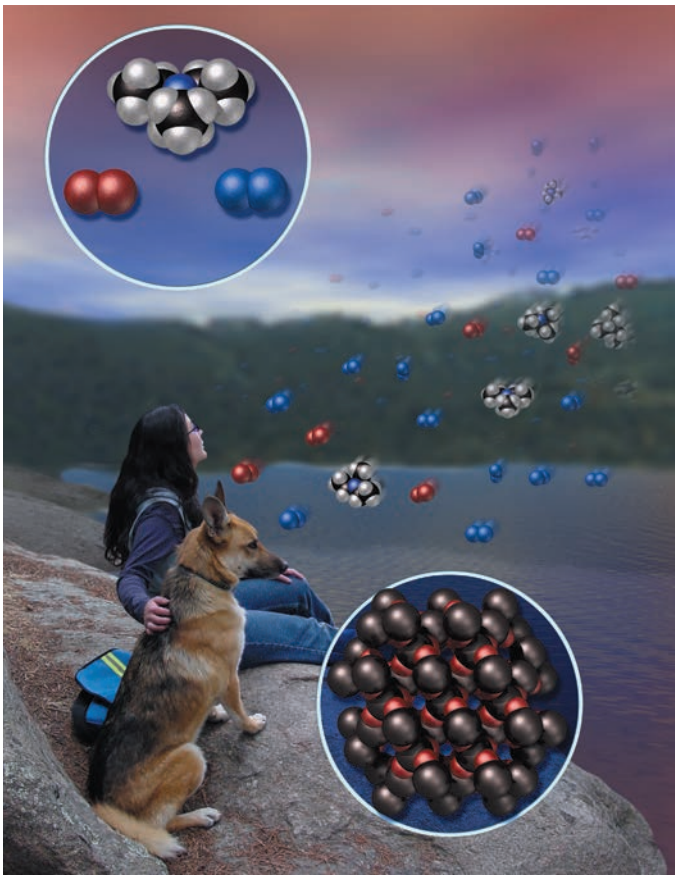
Printed and bound by CTPS in China

About the Author

Nivaldo Tro, *is a Professor of Chemistry at Westmont College in Santa Barbara, California, where he has been a faculty member since 1990. He received his Ph.D. in chemistry from Stanford University for work on developing and using optical techniques to study the adsorption and desorption of molecules to and from surfaces in ultra high vacuum. He then went on to the University of California at Berkeley, where he did post doctoral research on ultrafast reaction dynamics in solution. Since coming to Westmont, Professor Tro has been awarded grants from the American Chemical Society Petroleum Research Fund, from Research Corporation, and from the National Science Foundation to study the dynamics of various processes occurring in thin adlayer films adsorbed on dielectric surfaces. He has been honored as Westmont's outstanding teacher of the year three times and has also received the college's outstanding researcher of the year award. Professor Tro lives in Santa Barbara with his wife, Ann, and their four children, Michael, Ali, Kyle, and Kaden. In his leisure time, Professor Tro enjoys mountain biking, surfing, reading to his children, and being outdoors with his family.*

Brief Contents

Contents

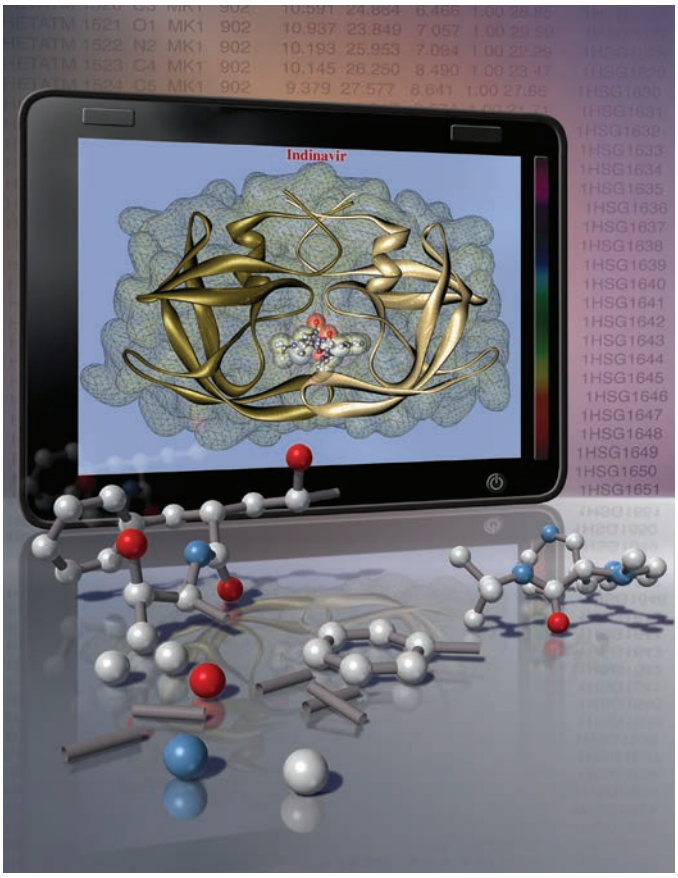


6 Chemical Composition 200

7 Chemical Reactions 238

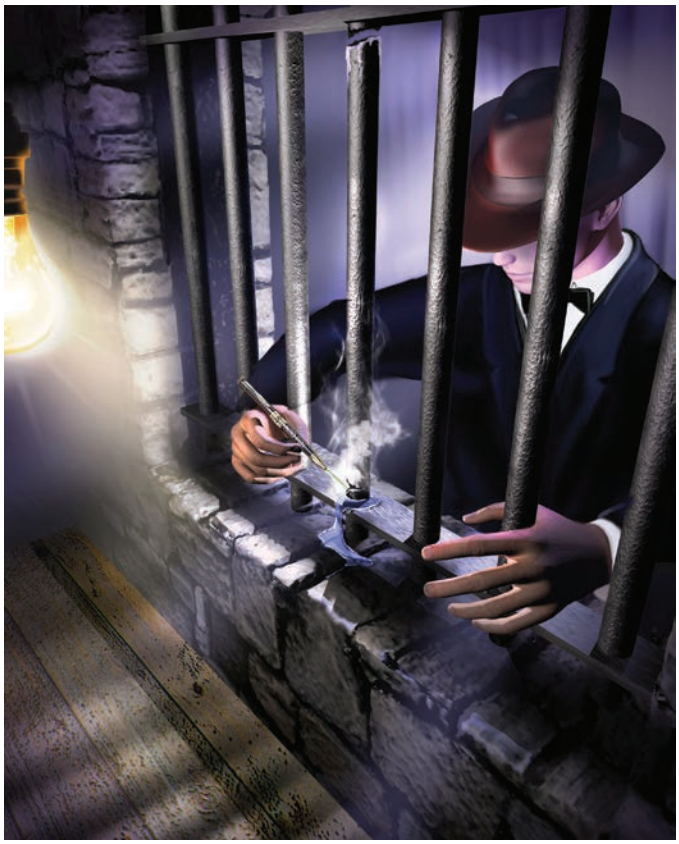
8 Quantities in Chemical Reactions 282

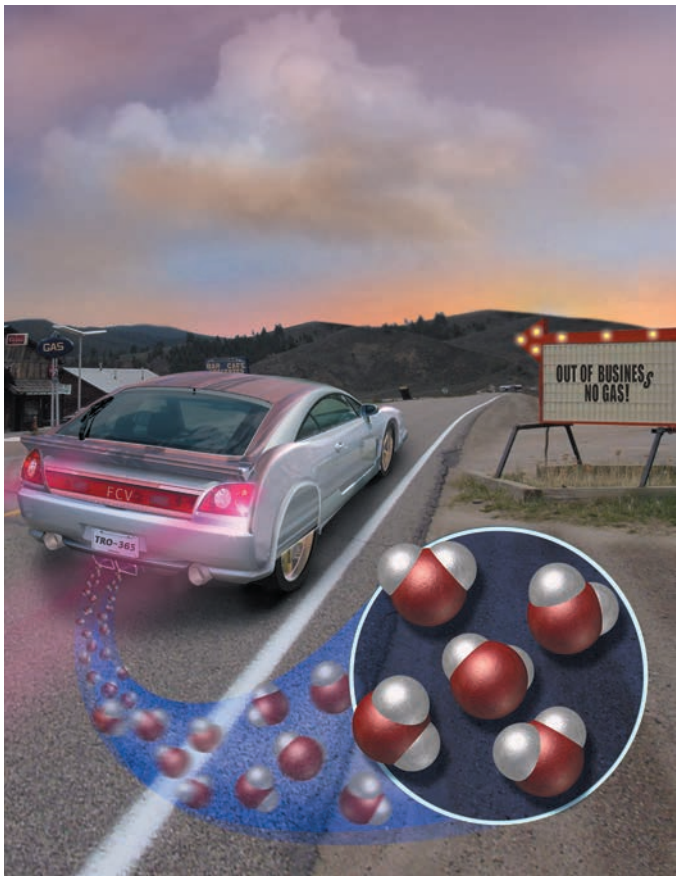
9 Electrons in Atoms and the Periodic Table 318



12 Liquids, Solids, and Intermolecular Forces 444

13 Solutions 480





Problem-Solving Procedures

This page is intentionally left blank.

To the Student

This book is for *you*, and every text feature is meant to help you learn. I have two main goals for you in this course: to see chemistry as you never have before and to develop the problem-solving skills you need to succeed in chemistry.

I want you to experience chemistry in a new way. I have written each chapter to show you that chemistry is not just something that happens in a laboratory; chemistry surrounds you at every moment. I have worked with several outstanding artists to develop photographs and art that will help you visualize the molecular world. From the opening example to the closing chapter, you will *see* chemistry. My hope is that when you finish this course, you will think differently about your world because you understand the molecular interactions that underlie everything around you.

My second goal is for you to develop problem-solving skills. No one succeeds in chemistry—or in life, really—without the ability to solve problems. I can't give you a formula for problem solving, but I can give you strategies that will help you develop the *chemical intuition* you need to understand chemical reasoning.

Look for several recurring structures throughout this book designed to help you master problem solving. The most important ones are (1) a four-step process (Sort, Strategize, Solve, and Check) designed to help you learn how to solve problems; (2) the solution map, a visual aid that helps you navigate your way through problems; (3) the two-column Examples, in which the left column explains in clear and simple language the purpose of each step of the solution shown in the right column; and (4) the three-column Examples, which describe a problem-solving procedure while demonstrating how it is applied to two different Examples. In addition, you will find a For More Practice feature at the end of each worked Example that directs you to the end-of-chapter problems that provide more opportunity to practice the skill(s) covered in the Example. In this edition, I have added a new tool for you at the end of each chapter: a Self-Assessment Quiz. These quizzes are designed to help you test yourself on the core concepts and skills of each chapter. You can also use them as you prepare for exams. Before an exam, take the quiz associated with each chapter that the exam will cover. The questions you miss on the quiz will reveal the areas you need to spend the most time studying.

Lastly, I hope this book leaves you with the knowledge that chemistry is *not* reserved only for those with some superhuman intelligence level. With the right amount of effort and some clear guidance, anyone can master chemistry, including you.

Sincerely,

Nivaldo J. Tro
tro@westmont.edu

To the Instructor

I thank all of you who have used any of the first four editions of *Introductory Chemistry*—you have made this book the most widely selling book in its market, and for that I am extremely grateful. The preparation of the fifth edition has enabled me to continue to refine the book to meet its fundamental purpose: teaching chemical skills in the context of relevance.

Introductory Chemistry is designed for a one-semester, college-level, introductory or preparatory chemistry course. Students taking this course need to develop problem-solving skills—but they also must see *why* these skills are important to them and to their world. *Introductory Chemistry* extends chemistry from the laboratory to the student's world. It motivates students to learn chemistry by demonstrating the role it plays in their daily lives.

This is a visual book. Wherever possible, I have used images to help communicate the subject. In developing chemical principles, for example, I worked with several artists to develop multipart images that show the connection between everyday processes visible to the eye and the molecular interactions responsible for those processes. This art has been further refined and improved in the fifth edition, making the visual impact sharper and more targeted to student learning. For example, you will note a hierarchical system of labeling in many of the images: The white-boxed labels are the most important, the tan-tint boxes are the second most important, and unboxed labels are the third most important. This allows me to treat related labels and annotations within an image in the same way, so that the relationships between them are immediately evident. My intent is to create an art program that teaches and that presents complex information clearly and concisely. Many of the illustrations showing molecular depictions of a real-world object or process have three parts: macroscopic (what we can see with our eyes); molecular and atomic (space-filling models that depict what the molecules and atoms are doing); and symbolic (how chemists represent the molecular and atomic world). The goal is for the student to begin to see the connections between the macroscopic world, the molecular world, and the representation of the molecular world with symbols and formulas.

I have also refined the problem-solving pedagogy to include four steps: Sort, Strategize, Solve, and Check. The *solution map*, which has been part of this book since the first edition, is now part of the *Strategize* step. This four-step procedure is meant to guide students as they learn chemical problem solving. Extensive flowcharts are also incorporated throughout the book, allowing students to visualize the organization of chemical ideas and concepts. The color scheme used in both the solution maps and the flowcharts is designed to have pedagogical value. More specifically, the solution maps utilize the colors of the visible spectrum—always in the same order, from violet to red.

Throughout the worked Examples in this book, I use a *two- or three-column* layout in which students learn a general procedure for solving problems of a particular type as they see this procedure applied to one or two worked Examples. In this format, the *explanation* of how to solve a problem is placed directly beside the actual steps in the *solution* of the problem. Many of you have said that you use a similar technique in lecture and office hours. Since students have specifically asked for connections between Examples and end-of-chapter problems, I include a For More Practice feature at the end of each worked Example that lists the review examples and end-of-chapter problems that provide additional opportunities to practice the skill(s) covered in the Example.

A successful new feature in the second edition was the Conceptual Checkpoints, a series of short questions that students can use to test their mastery of key concepts as they read through a chapter. Emphasizing understanding rather than calculation, they are designed to be easy to answer if the student has grasped the essential concept but difficult if he or she has not. Your positive remarks on this new feature prompted me to continue adding more of these to the fifth edition, including questions that highlight visualization of the molecular world.

This edition has allowed me to add four new global features to the book: Learning Outcomes (LOs), Group Questions, Self-Assessment Quizzes, and Interactive Worked Examples. You will find the learning outcomes underneath most section heads—many of the LOs are repeated in the end of chapter material with an associated worked example. You will find the Group Questions following the chapter exercises. You can assign these as homework if you would like, but you can also use them as in class activities to encourage active learning and peer-to-peer engagement. The Self-Assessment Quizzes are at the very beginning of the chapter review material. These quizzes are designed so that students can test themselves on the core concepts and skills of each chapter. I encourage my students to use these quizzes as they prepare for exams. For example, if my exam covers Chapters 5–8, I assign the quizzes for those chapters for credit (you can do this in MasteringChemistry®). Students then get a sort of pretest on the core material that will be on the exam. The Interactive Worked Examples are a new digital asset that we created for this edition. These examples are available in MasteringChemistry® and at the following website: www.pearsonglobaleditions.com/tro. Each Interactive Worked Example walks the student through a key example from the book (the examples that have been made interactive are marked with a play icon in the book). At a key point in the Interactive Worked Example, the video pauses and the student is asked a question. These questions are designed to encourage students to be active in the learning process. Once the student answers the question, the video resumes to the end. A follow-up question can then be assigned for credit in MasteringChemistry®.

My goal in this new edition is to continue to help you make learning a more active (rather than passive) process for your students. The new Group Questions can help make your classroom more active. The new Conceptual Checkpoints, along with the new Self-Assessment Quizzes, make reading the book a more active process. The addition of the Interactive Worked Examples makes the media experience active as well. Research consistently shows that students learn better when they are actively engaged in the process. I hope the tools that I have provided here continue to aid you in teaching your students more effectively. Please feel free to e-mail me with any questions or comments you might have. I look forward to hearing from you as you use this book in your course.

Sincerely,

Nivaldo J. Tro
tro@westmont.edu

Preface

New to This Edition

NEW! Key Learning Outcomes have been added to each chapter section. Learning outcomes correlate to the Chemical Skills and Examples in the end-of-chapter material and to MasteringChemistry®. Each section (after the introductory sections) has at least one learning outcome that summarizes the key learning objective of the material to help students focus their learning and assess their progress.

NEW! Self-Assessment Quizzes. Each chapter contains a 10-15 question multiple choice self-assessment quiz. These quizzes are designed to help students review the chapter material and prepare for exams.

NEW! 3–4 Questions for Group Work have been added to the end-of-chapter problems in each chapter to facilitate guided-inquiry learning both inside and outside the classroom.

NEW! 20 Interactive Worked Examples. Interactive Worked Examples are digital versions of the text's worked examples that make Tro's unique problem-solving strategies interactive, bringing his award-winning teaching directly to all students using his text. In these digital versions, students are instructed how to break down problems using Tro's proven Sort, Strategize, Solve, and Check technique. The Interactive Worked Examples can be accessed by scanning the QR code on the back cover allowing students to quickly access an office-hour type experience.

These problems are incorporated into MasteringChemistry® as assignable tutorial activities and are also available for download and distribution via the Instructor Resource Center (IRC) for instructional and classroom use.

More than 20 New Conceptual Checkpoints are in the fifth edition and are designed to make reading the book an active process. The checkpoints encourage students to stop and think about the ideas just presented before moving on and also provide a tool for self-assessment.

Interest Box Questions are now numbered in the Everyday Chemistry, Chemistry in the Environment, Chemistry in the Media, and Chemistry and Health boxes so that they can easily be assigned.

Cross-references to the Math Appendix, now indicated by a +/− icon in the fifth edition, are more visible and allow students to locate additional resources more easily.

Additional Features

- **A student-friendly, step-by-step, problem-solving approach is presented throughout** the book (fully introduced and explained in Chapter 2): Tro's unique two-and three-column examples help guide students through problems

step-by-step using Sort, Strategize, Solve, and Check. "Relationships Used" are also included in most worked examples.

- **In all chapters, figure labels follow a consistent hierarchy**. Three types of labels appear in the art. The most important information is in white shadow boxes; the second most important is in tinted boxes (with no border); and the third level of labels is unboxed.
- **All figures and figure captions have been carefully examined, and images and labels have been replaced or revised when needed** to improve the teaching focus of the art program.
- **Every end-of-chapter question has been carefully reviewed** by the author and editor and accordingly revised and/or replaced when necessary.

Some significant improvements have been made to key content areas as well. These include:

- To reflect recent changes made by IUPAC that introduce more uncertainty in atomic masses, the periodic tables on the inside front cover of the book and all subsequent periodic tables in the text containing atomic masses now include the modified following atomic masses: Li 6.94; S 32.06; Ge 72.63; Se 78.97; and Mo 95.95.
- In Chapter 1, *The Chemical World*, key wording about chemicals as well as the definition of chemistry have been changed to more strongly reflect particles and properties connection.
- In Section 2.3, *Significant Figures: Writing Numbers to Reflect Precision*, clarification has been added about trailing zeros in the significant digits discussion in Section 2.3.
- In Section 3.8, *Energy,* a new schematic has been added to the photo of the dam to better illustrate the concept of potential energy, and there is a new figure, Figure 3.15, *Potential Energy of Raised Weight*.
- Several new subheadings have been added to Chapter 5 to help students better navigate the material; Table 5.3, *Some Common Polyatomic Ions*, has been moved to an earlier place in Chapter 5; and fourth edition Example 5.7, *Writing Formulas for Ionic Compounds*, has been replaced with fifth edition Example 5.7, *Writing Formulas for Ionic Compounds Containing Polyatomic Ions*.
- In Chapter 6, Chemistry in the Environment box *Chlorine in Chlorofluorocarbons* has been revised and updated. Figure 6.3, *The Ozone Shield*, has been updated and revised to include a molecular perspective and be a better teaching tool and Figure 6.4, *Growth of the Ozone Hole*, has been updated with 2010 data.
- The transition between balancing chemical equations to investigating types of reactions at the beginning of Section 7.5, *Aqueous Solutions and Solubility: Compounds Dissolved in Water*, has been sharpened to help students relate Section 7.5 to the previous section.
- Figure 7.7, *Solubility Rules Flowchart*, has been edited so that Ca^{2+}, Sr^{2+}, and Ba^{2+} are in periodic table order throughout for easier memorization.
- The phrase "global warming" has been replaced with "climate change" throughout Chapter 8, *Quantities in Chemical Reactions*, and Figure 8.2, *Climate Change*, has been updated to include global temperature data for 2011 and 2012.
- In Section 9.1, *Blimps, Balloons, and Models of the Atom*, more emphasis has been placed on the relationship between atomic structure and properties in the discussion of helium and hydrogen.
- In Section 9.4, *The Bohr Model: Atoms with Orbits,* new introductory material has been added to emphasize the relationship between light emission and electron motion.

- Orbital representations in figures throughout Chapter 9 have been modified to be more accurate.
- Throughout Chapter 10, *Chemical Bonding*, the term *Lewis theory* has been replaced with *Lewis model*.
- In Chapter 11, *Gases,* an update about how newer jets pressurize their cabins has been added to the Everyday Chemistry box, *Airplane Cabin Pressurization*, and Table 11.5, *Changes in Pollutant Levels for Major U.S. Cities, 1980–2010*, has been updated to include the most recent available data.
- Content has been revised and material has been added to improve clarity in the subsection entitled *Surface Tension* in Section 12.3, *Intermolecular Forces in Action: Surface Tension and Viscosity*. Also, the caption for Figure 12.5, *Origin of Surface Tension*, has been revised and the phase inset figures in Figure 12.16, *Heating Curve during Melting*, have been corrected to show the phases more accurately.
- The new title for Section 12.6, *Types of Intermolecular Forces: Dispersion, Dipole–Dipole, Hydrogen Bonding, and Ion–Dipole*, reflects new content and new material about ion–dipole forces, including new Figure 12.25, *Ion–Dipole Forces*. Also, ion–dipole forces have been added to Table 12.5, *Types of Intermolecular Forces*, and the art in the table now depicts space-filling models of the molecules.
- Content in Section 13.3, *Solutions of Solids Dissolved in Water: How to Make Rock Candy*, links the discussion of solvent–solute interactions to the discussion of intermolecular forces in Chapter 12.
- Figure 14.19, *How Buffers Resist pH Change*, has been changed to be more useful and easier for students to understand.
- Section 14.11, *Acid Rain: An Environmental Problem Related to Fossil Fuel Combustion*, has been cut.
- New, brief introductory statements have been added to Section 15.6, *Calculating and Using Equilibrium Constants*, and in Section 15.10, *The Effect of a Temperature Change on Equilibrium*, numbers that indicate sequence have been added to the three unnumbered equations that indicate how equilibrium changes when heat is added or removed from exothermic and endothermic reactions.
- The title of Figure 16.12, *Used Voltaic Cell*, has been corrected, and the art has been slightly modified.
- Figure 16.18, *Schematic Diagram of a Fuel-Cell Breathalyzer*, in the box Everyday Chemistry: *The Fuel-Cell Breathalyzer* has also been modified for accuracy.

The design and features of this text have been conceived to work together as an integrated whole with a single purpose: to help students understand chemical principles and to master problem-solving skills in a context of relevance. Students must be able not only to grasp chemical concepts and solve chemical problems, but also to understand how those concepts and problem-solving skills are relevant to their other courses, their eventual career paths, and their daily lives.

Teaching Principles

The development of basic chemical principles—such as those of atomic structure, chemical bonding, chemical reactions, and the gas laws—is one of the main goals of this text. Students must acquire a firm grasp of these principles in order to succeed in the general chemistry sequence or the chemistry courses that support the

allied health curriculum. To that end, the book integrates qualitative and quantitative material and proceeds from concrete concepts to more abstract ones.

Organization of the Text

The main divergence in topic ordering among instructors teaching introductory and preparatory chemistry courses is the placement of electronic structure and chemical bonding. Should these topics come early, at the point where models for the atom are being discussed? Or should they come later, after the student has been exposed to chemical compounds and chemical reactions? Early placement gives students a theoretical framework within which they can understand compounds and reactions. However, it also presents students with abstract models before they understand why they are necessary. I have chosen a later placement for the following reasons:

1. **A later placement provides greater flexibility.** An instructor who wants to cover atomic theory and bonding earlier can simply cover Chapters 9 and 10 after Chapter 4. However, if atomic theory and bonding were placed earlier, it would be more difficult for the instructor to skip these chapters and come back to them later.
2. **A later placement allows earlier coverage of topics that students can more easily visualize.** Coverage of abstract topics too early in a course can lose some students. Chemical compounds and chemical reactions are more tangible than atomic orbitals, and their relevance is easier to demonstrate to the beginning student.
3. **A later placement gives students a reason to learn an abstract theory.** Once students learn about compounds and reactions, they are more easily motivated to learn a theory that explains compounds and reactions in terms of underlying causes.
4. **A later placement follows the scientific method.** In science, we normally make observations, form laws, and then build models or theories that explain our observations and laws. A later placement follows this ordering.

Nonetheless, I know that every course is unique and that each instructor chooses to cover topics in his or her own way. Consequently, I have written each chapter for maximum flexibility in topic ordering. In addition, the book is offered in two formats. The full version, *Introductory Chemistry*, contains 19 chapters, including organic chemistry and biochemistry. The shorter version, *Introductory Chemistry Essentials*, contains 17 chapters and omits these topics.

Print and Media Resources

For the Instructor

MasteringChemistry®

MasteringChemistry® is the first adaptive-learning online homework and tutorial system. Instructors can create online assignments for their students by choosing from a wide range of items, including end-of-chapter problems and research-enhanced tutorials. Assignments are automatically graded with up-to-date diagnostic information, helping instructors pinpoint where students struggle either individually or for the class as a whole. These questions can be used asynchro-

nously outside of class as well. For the fifth edition, 20 new Interactive Worked Examples have been added to the Study Area. Icons appear next to examples indicating that a digital version is available.

NEW! Learning Catalytics™

Learning Catalytics™ is a "bring your own device" student engagement, assessment, and classroom intelligence system. With Learning Catalytics™ you can:

- Assess students in real time, using open-ended tasks to probe student understanding.
- Understand immediately where students are and adjust your lecture accordingly.
- Improve your students' critical-thinking skills.
- Access rich analytics to understand student performance.
- Add your own questions to make Learning Catalytics™ fits your course exactly.
- Manage student interactions with intelligent grouping and timing.

Learning Catalytics™ is a technology that has grown out of twenty years of cutting edge research, innovation, and implementation of interactive teaching and peer instruction. Learning Catalytics™ is included with the purchase of Mastering with eText. Michael Everest of Westmont College has written a set of questions in Learning Catalytics™ that correlates directly to the topics and concepts in *Introductory Chemistry,* 5e and encourages group-based inquiry learning.

NEW! Adaptive Follow-up Assignments in MasteringChemistry®

Instructors now have the ability to assign adaptive follow-up assignments to students. Content delivered to students as part of adaptive learning will be automatically personalized for each individual based on strengths and weaknesses identified by his or her performance on Mastering parent assignments.

NEW! Dynamic Study Modules, designed to enable students to study effectively on their own, as well as help students quickly access and learn the nomenclature they need to be more successful in chemistry. These modules can be accessed on smartphones, tablets, and computers and results can be tracked in the MasteringChemistry® Gradebook. How it works:

1. Students receive an initial set of questions and benefit from the metacognition involved with asking them to indicate how confident they are with their answer.
2. After answering each set of questions, students review their answers.
3. Each question has explanation material that reinforces the correct answer response and addresses the misconceptions found in the wrong answer choices.
4. Once students review the explanations, they are presented with a new set of questions. Students cycle through this dynamic process of test-learn-retest until they achieve mastery of the material.

Instructor's Manual by Mark Ott of Jackson Community College, and Matthew Johll of Illinois Valley Community College. This manual features lecture outlines with presentation suggestions, teaching tips, suggested in-class demonstrations, and topics for classroom discussion. It also contains full solutions to all the end-of-chapter problems from the text.

TestGen Testbank by Michael Hauser of St. Louis Community College. This download-only test bank includes more than 2000 questions and is available on the Instructor's Resource Center.

Instructor's Resource Materials This resource provides an integrated collection of resources to help instructors make efficient and effective use of their time and is available for download from the Instructor's Resource Center. The package features the following:

- All the art from the text, including figures and tables in JPG and PDF formats; movies; animations; Interactive Molecules; and the Instructor's Resource Manual files.
- Four PowerPoint™ presentations: (1) a lecture outline presentation for each chapter, (2) all the art from the text, (3) the worked Examples from the text, and (4) clicker questions.
- TestGen, a computerized version of the Test Item File that allows instructors to create and tailor exams to fit their needs.

Instructor's Guide for Student's Guided Activity Workbook by Michael Everest of Westmont College. This manual features assessible outcomes, facilitation tips, and demonstration suggestions to help integrate guided-inquiry learning in the classroom and is available for download on the Instructor's Resource Center.

For the Student

Pearson eText offers students the power to create notes, highlight text in different colors, create bookmarks, zoom, and view single or multiple pages. Access to the Pearson eText for *Introductory Chemistry*, Fifth Edition, is available for purchase within MasteringChemistry®.

Study Guide (0-321-94905-6) by Donna Friedman of St. Louis Community College—Florissant Valley. Each chapter of the Study Guide contains an overview, key learning outcomes, a chapter review, as well as practice problems for each major concept in the text. Each chapter is followed by two or three self-tests with answers so students can check their work.

NEW! Student's Guided Activity Workbook (0-321-94908-0) by Michael Everest of Westmont College. This set of guided-inquiry activities enables students to construct chemical knowledge and related skills on their own. Each activity begins by presenting some information (as a table, figure, graph, text, etc.). Students, working in groups of 3–4, answer questions designed to draw their attention to the important concepts and trends exemplified in the information. Through their active participation in the learning process, students learn not only chemistry, but also a wide range of additional skills such as information processing, problem solving, deductive reasoning, and teamwork. There are approximately three complete worksheets to accompany each chapter in *Introductory Chemistry*, and each worksheet should take students from 50–60 minutes to complete. The activities can be used in place of, or as a supplement to, a lecture-based pedagogy. This supplement is available through Pearson Custom Library www.pearsoncustomlibrary.com.