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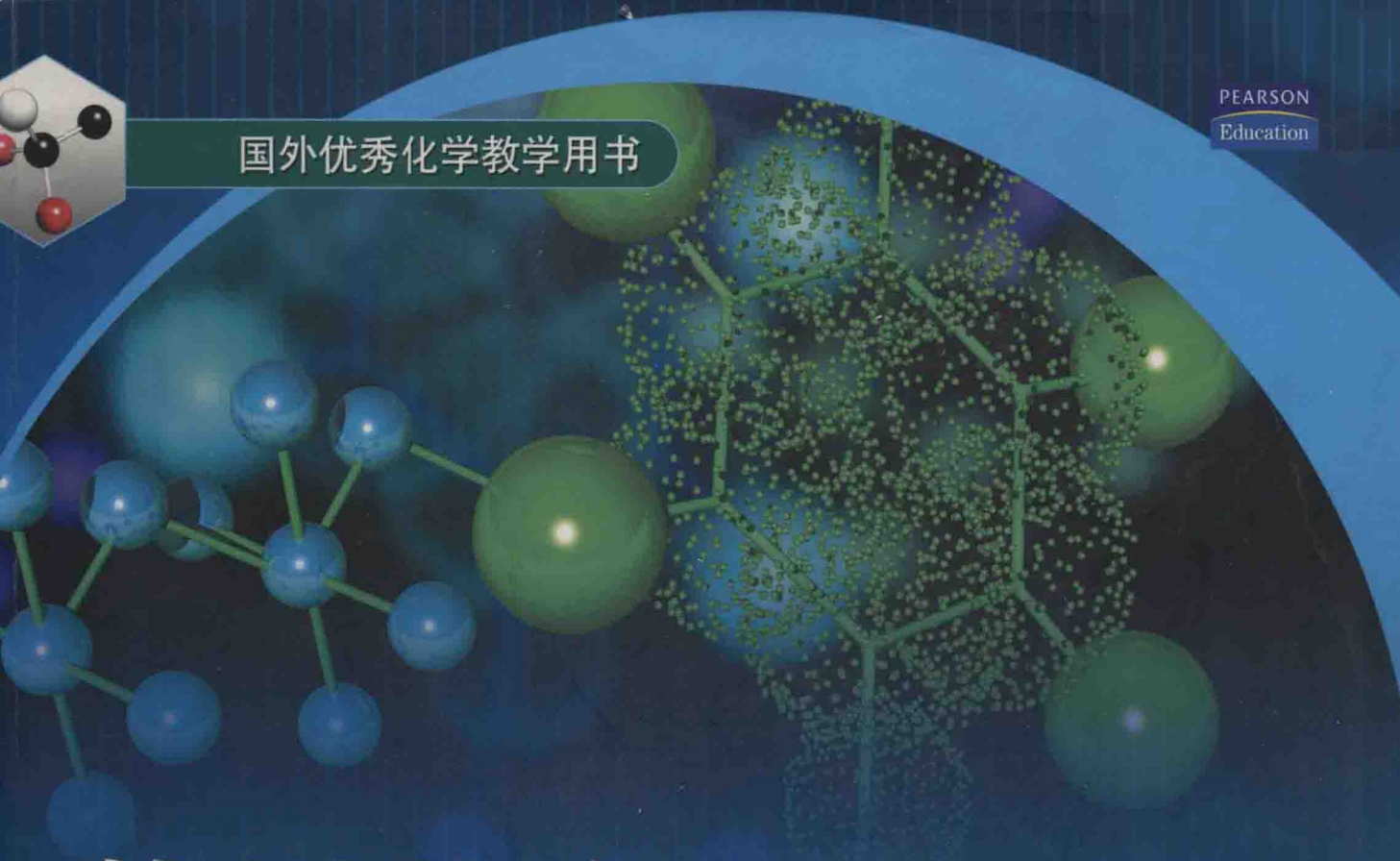


普通化学原理与应用

第8版 影印版

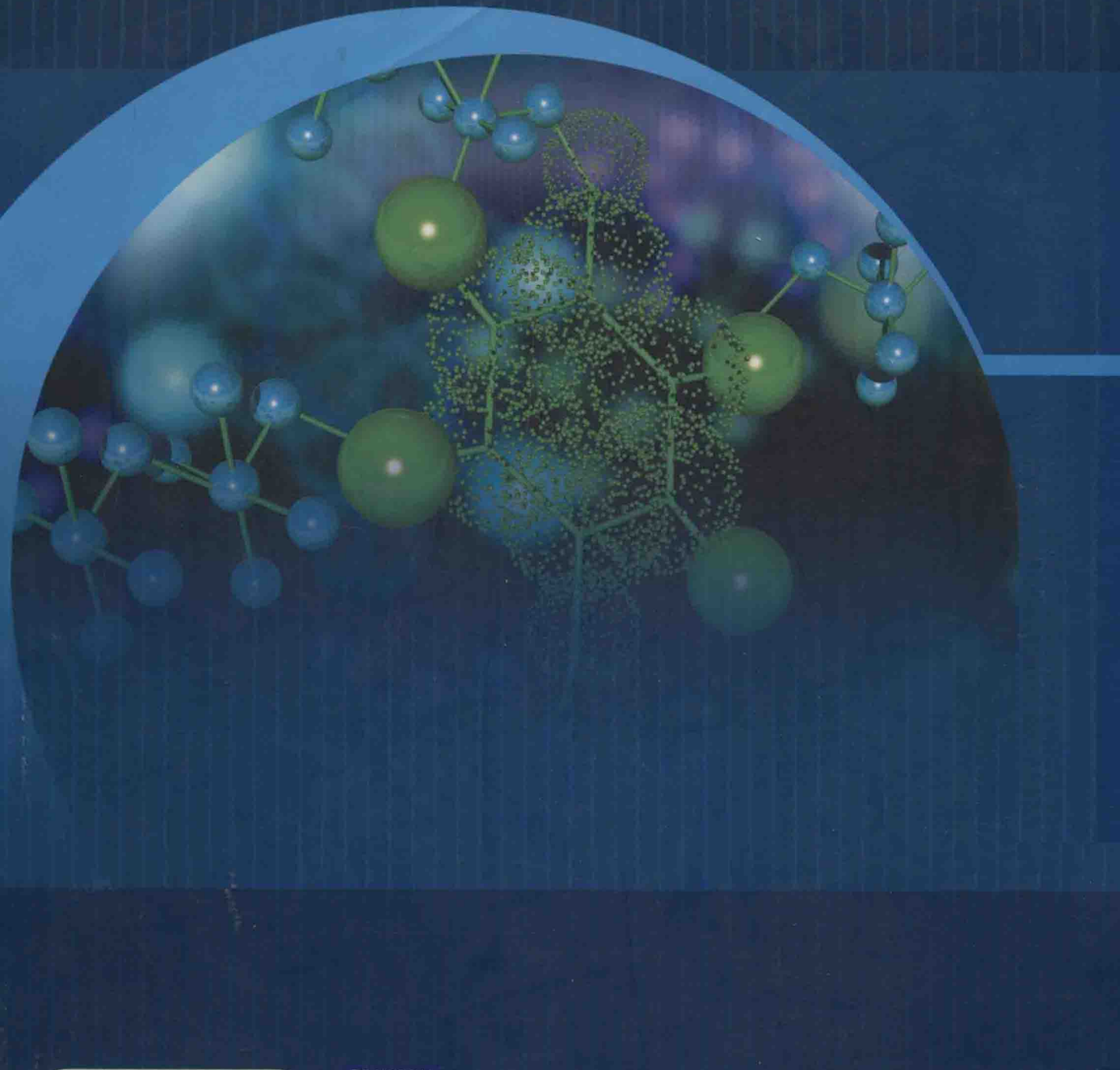
General Chemistry

Principles and Modern Applications

Eighth Edition

- Ralph H. Petrucci
- William S. Harwood
- F. Geoffrey Herring

高等教育出版社
Higher Education Press



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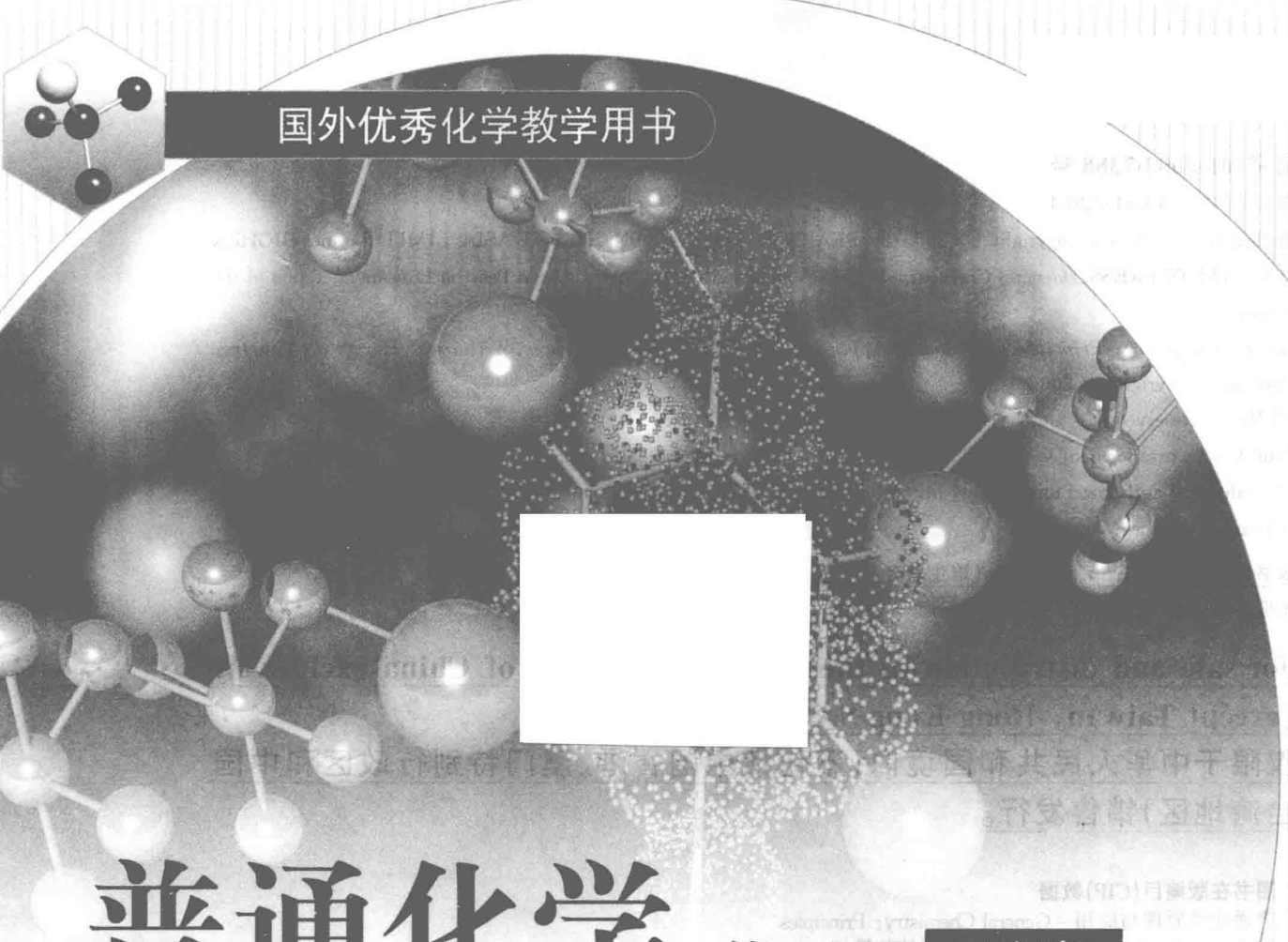

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Periodic Table of the Elements

1 1A	2 2A	3 3B	4 4B	5 5B	6 6B	7 7B	8	9 8B	10	11 1B	12 2B	13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1 H 1.00794																	2 He 4.00260
3 Li 6.941	4 Be 9.01218											5 B 10.811	6 C 12.011	7 N 14.0067	8 O 15.9994	9 F 18.9984	10 Ne 20.1797
11 Na 22.9898	12 Mg 24.3050											13 Al 26.9815	14 Si 28.0855	15 P 30.9738	16 S 32.066	17 Cl 35.4527	18 Ar 39.948
19 K 39.0983	20 Ca 40.078	21 Sc 44.9559	22 Ti 47.88	23 V 50.9415	24 Cr 51.9961	25 Mn 54.9381	26 Fe 55.847	27 Co 58.9332	28 Ni 58.693	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.9216	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.4678	38 Sr 87.62	39 Y 88.9059	40 Zr 91.224	41 Nb 92.9064	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.906	46 Pd 106.42	47 Ag 107.868	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.757	52 Te 127.60	53 I 126.904	54 Xe 131.29
55 Cs 132.905	56 Ba 137.327	57 *La 138.906	72 Hf 178.49	73 Ta 180.948	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.967	80 Hg 200.59	81 Tl 204.383	82 Pb 207.2	83 Bi 208.980	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.025	89 Ac 227.028	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 (269)	111 (272)	112 (272)		114 (287)		116 (289)		118 (293)

*Lanthanide series	58 Ce 140.115	59 Pr 140.908	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.965	64 Gd 157.25	65 Tb 158.925	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.967
Actinide series	90 Th 232.038	91 Pa 231.036	92 U 238.029	93 Np 237.048	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)

Atomic masses are relative to carbon-12. For certain radioactive elements, the numbers listed (in parentheses) are the mass numbers of the most stable isotopes. The scheme for numbering of groups is explained on page 50. The metals are and the nonmetals are . Metalloids are indicated by . The noble gases are Elements 110, 111, and 112 have not yet been named.

The Elements

Name	Symbol	Atomic Number	Relative Atomic Weight
Actinium	Ac	89	227.028
Aluminum	Al	13	26.9815
Americium	Am	95	(243)
Antimony	Sb	51	121.757
Argon	Ar	18	39.948
Arsenic	As	33	74.9216
Astatine	At	85	(210)
Barium	Ba	56	137.327
Berkelium	Bk	97	(247)
Beryllium	Be	4	9.01218
Bismuth	Bi	83	208.980
Bohrium	Bh	107	(262)
Boron	B	5	10.811
Bromine	Br	35	79.904
Cadmium	Cd	48	112.411
Calcium	Ca	20	40.078
Californium	Cf	98	(251)
Carbon	C	6	12.011
Cerium	Ce	58	140.115
Cesium	Cs	55	132.905
Chlorine	Cl	17	35.4527
Chromium	Cr	24	51.9961
Cobalt	Co	27	58.9332
Copper	Cu	29	63.546
Curium	Cm	96	(247)
Dubnium	Db	105	(262)
Dysprosium	Dy	66	162.50
Einsteinium	Es	99	(252)
Erbium	Er	68	167.26
Europium	Eu	63	151.965
Fermium	Fm	100	(257)
Fluorine	F	9	18.9984
Francium	Fr	87	(223)
Gadolinium	Gd	64	157.25
Gallium	Ga	31	69.723
Germanium	Ge	32	72.61
Gold	Au	79	196.967
Hafnium	Hf	72	178.49
Hassium	Hs	108	(265)
Helium	He	2	4.00260
Holmium	Ho	67	164.930
Hydrogen	H	1	1.00794
Indium	In	49	114.818
Iodine	I	53	126.904
Iridium	Ir	77	192.22
Iron	Fe	26	55.847
Krypton	Kr	36	83.80
Lanthanum	La	57	138.906
Lawrencium	Lr	103	(260)
Lead	Pb	82	207.2
Lithium	Li	3	6.941
Lutetium	Lu	71	174.967
Magnesium	Mg	12	24.3050
Manganese	Mn	25	54.9381
Meitnerium	Mt	109	(266)
Mendelevium	Md	101	(258)
Mercury	Hg	80	200.59
Molybdenum	Mo	42	95.94
Neodymium	Nd	60	144.24
Neon	Ne	10	20.1797
Neptunium	Np	93	237.048
Nickel	Ni	28	58.693
Niobium	Nb	41	92.9064
Nitrogen	N	7	14.0067
Nobelium	No	102	(259)
Osmium	Os	76	190.23
Oxygen	O	8	15.9994
Palladium	Pd	46	106.42
Phosphorus	P	15	30.9738
Platinum	Pt	78	195.08
Plutonium	Pu	94	(244)
Polonium	Po	84	(209)
Potassium	K	19	39.0983
Praseodymium	Pr	59	140.908
Promethium	Pm	61	(145)
Protactinium	Pa	91	231.036
Radium	Ra	88	226.025
Radon	Rn	86	(222)
Rhenium	Re	75	186.207
Rhodium	Rh	45	102.906
Rubidium	Rb	37	85.4678
Ruthenium	Ru	44	101.07
Rutherfordium	Rf	104	(261)
Samarium	Sm	62	150.36
Scandium	Sc	21	44.9559
Seaborgium	Sg	106	(263)
Selenium	Se	34	78.96
Silicon	Si	14	28.0855
Silver	Ag	47	107.868
Sodium	Na	11	22.9898
Strontium	Sr	38	87.62
Sulfur	S	16	32.066
Tantalum	Ta	73	180.948
Technetium	Tc	43	(98)
Tellurium	Te	52	127.60
Terbium	Tb	65	158.925
Thallium	Tl	81	204.383
Thorium	Th	90	232.038
Thulium	Tm	69	168.934
Tin	Sn	50	118.710
Titanium	Ti	22	47.88
Tungsten	W	74	183.84
Uranium	U	92	238.029
Vanadium	V	23	50.9415
Xenon	Xe	54	131.29
Ytterbium	Yb	70	173.04
Yttrium	Y	39	88.9059
Zinc	Zn	30	65.39
Zirconium	Zr	40	91.224

Atomic masses in this table are relative to carbon-12 and limited to six significant figures, although some atomic masses are known more precisely. For certain radioactive elements the numbers listed (in parentheses) are the mass numbers of the most stable isotopes.

About the Authors

Ralph H. Petrucci

Ralph Petrucci received his B.S. in Chemistry from Union College and his Ph.D. from the University of Wisconsin–Madison. Following several years of teaching, research, consulting, and directing the NSF Institutes for Secondary School Science Teachers at Case Western Reserve University, Dr. Petrucci joined the planning staff of the new California State University campus at San Bernardino in 1964. There, in addition to his faculty appointment, he served as Chairman of the Natural Sciences Division and Dean of Academic Planning. Professor Petrucci, now retired from teaching, is the author of several books, including *General Chemistry* with John W. Hill.

William S. Harwood

Bill Harwood received his B.Sc. from the University of Massachusetts, Amherst and his Ph.D. in Inorganic Chemistry from Purdue University in 1986. He is currently a Professor of Science Education at Indiana University, Bloomington. Previously, Dr. Harwood was at the Department of Chemistry and Biochemistry at the University of Maryland, College Park. In his current role, Dr. Harwood continues to teach chemistry and conduct research in chemical education. He has received several awards for teaching excellence. Dr. Harwood is also active in the American Chemical Society and the Division of Chemical Education and was a consultant to AAAS project 2061. He is involved in the science reform efforts at both the precollege and college levels. His research focuses on how best to use technology to improve learning in chemistry.

F. Geoffrey Herring

Geoff Herring received his B.Sc. and his Ph.D. in Physical Chemistry, both from the University of London. He is currently a Professor in the Department of Chemistry of the University of British Columbia, Vancouver. Dr. Herring has research interests in the area of biophysical chemistry and has published over 100 papers in the area of physical chemistry and chemical physics. Recently, Dr. Herring has undertaken studies in the use of information technology and interactive engagement methods in teaching general chemistry with a view to improving student comprehension and learning. Dr. Herring has taught chemistry from undergraduate to graduate levels for 30 years and has been the recipient of the Killam Prize for Excellence in Teaching.

Preface

"Know your audience." For this new edition, we have tried to follow this important advice to writers by attending more to the needs of those students who are taking a serious journey through the material. We also know that most general chemistry students have career interests not in chemistry, but in biology, medicine, engineering, environmental and agricultural sciences, and so on. And we understand that general chemistry will be the only college chemistry course for some students, and thus their only opportunity to learn some practical applications of chemistry. We have designed this book for all these students.

Students of this text should have already studied some chemistry. But those with no prior background and those who could use a refresher will find that the early chapters develop fundamental concepts from the most elementary ideas. Students who do plan to become professional chemists will also find opportunities in the text to pursue their own special interests.

The typical student may need help identifying and applying principles and visualizing their physical significance. The pedagogical features of this text are designed to provide this help. At the same time, we hope the text serves to sharpen student skills in problem solving and critical thinking. Thus, we have tried to strike the proper balances between principles and applications, qualitative and quantitative discussions, and rigor and simplification.

Throughout the text we provide real-world examples to enhance the discussion. Examples relevant to the biological sciences, engineering, and the environmental sciences will be found in numerous places. This should help to bring the chemistry alive for these students, and help them understand its relevance to their career interests. It also, in most cases, should help them master core concepts.

Organization

In this edition we retain the core organization of the sixth and seventh editions of this text, but with additional coverage of material, in depth and breadth, in a number of chapters. After a brief overview of core concepts in Chapter 1, we introduce atomic theory, including the periodic table, in Chapter 2. The periodic table is an extraordinarily useful tool, and presenting it early allows us to use the periodic table in new ways throughout the early chapters of the text. In Chapter 3 we introduce chemical compounds and their stoichiometry. Organic compounds are included in this presentation. The early introduction of organic compounds allows us to use organic examples throughout the book. Chapters 4 and 5 introduce chemical reactions. We discuss gases in Chapter 6, partly because they are familiar to students (which helps them build confidence), but also because some instructors prefer to cover this material early to better integrate their lecture and lab programs. Note that Chapter 6 can easily be deferred for coverage with the other states of matter, in Chapter 13. In Chapter 9 we delve more deeply into wave mechanics than in earlier editions, although we do so in a way that allows excision of this material at the instructor's discretion. As with previous editions, we have emphasized real-world chemistry in the final chapters that cover descriptive chemistry (Chapters 22–25), and we have tried to make this material easy to bring forward into earlier parts of the text. Moreover, many topics in these chapters can be covered selectively, without requiring the study of entire chapters. The text ends with heavily revised, comprehensive chapters on organic chemistry (Chapter 27) and biochemistry (Chapter 28).

Changes to This Edition

We have made a number of smaller organizational changes to improve the flow of information to the student and to reflect contemporary thoughts about how best to teach general chemistry. In Chapter 7 (Thermochemistry), the order in which heat and work are presented has been reversed from that of the 7th edition. Also, the concept of standard states is introduced earlier, so that most data in the chapter can be standard-state data. In Chapter 20 (Thermodynamics), the sections on entropy have been reorganized so that all of them precede the introduction to free energy.

▶ Increased level of detail and much more problem-solving pedagogy this edition.

Major changes in this edition have focused on increasing the depth of coverage and adding some more challenging end-of-chapter exercises. Specifically, in Chapter 3 (Chemical Compounds) we have added a section introducing organic compounds, including nomenclature. This allows more reference to organic compounds throughout the book and also suits those who chose to introduce organic chemistry earlier in the course. In Chapter 6 (Gases) there is greater emphasis on the use of SI units and more detail on the kinetic-molecular theory of gases. In Chapter 7 (Thermochemistry) the calculation of quantities of work and the discussion of state functions and path-dependent functions are more extensive than in the previous edition. Chapter 9 (Electrons in Atoms) has been significantly revised to include new sections dealing with wave mechanics and more information on the treatment of wave functions, quantum numbers, orbitals, and radial probability distributions. Chapter 10 (The Periodic Table and Some Atomic Properties) draws more on ideas from Chapter 9 than in earlier editions, permitting a fuller discussion of screening, penetration, and Z_{eff}. Chapter 11 (Basic Concepts of Chemical Bonding) has been rearranged to provide a clearer exposition of the general strategy for writing Lewis structures. In Chapter 12 (Additional Aspects of Chemical Bonding), the new ideas developed in Chapter 9 are applied to the hybridization of atomic orbitals and the treatment of molecular orbitals. Molecular orbital theory is extended to cover heteronuclear molecules.

Chapter 13 (Liquids, Solids, and Intermolecular Forces) features an expanded section on crystal structures. In Chapter 15 (Chemical Kinetics) the IUPAC-recommended definition of a general rate of reaction is used in the treatment of reaction rates. Also, reaction mechanisms and enzyme catalysis are presented in more detail.

A new feature in Chapter 17 (Acids and Bases) is a discussion of a general method for equilibrium calculations based on equilibrium constant expressions, material balances, and electroneutrality. In Chapter 20 (Thermodynamics), the concept of entropy is introduced in a new way, and the relationship between ΔG and $\Delta G°$ is developed and explained more fully. The chapters on descriptive inorganic chemistry (Chapters 22-24) have been updated and now include electrode potential (Latimer) diagrams. Chapter 27 (Organic Chemistry) now includes an introductory discussion of S_N1 and S_N2 reactions and other topics of interest to those covering more organic chemistry in this course. Discussions of metabolism and enzyme reactions have been added to Chapter 28 (Chemistry of the Living State).

In-Text Learning Aids for Students

As with previous editions, we have tried to create the most useful possible text for students. Here are some of the things that should make this so:

Important Expressions. The most significant equations, concepts, and rules are highlighted with colored panels so that students can readily find them.

Summary/Key Terms/Glossary. Each chapter concludes with a comprehensive verbal *Summary* of important concepts and factual information. The *Summary* is followed by a list of *Key Terms*—terms that appear in boldface type in the text and are defined again in the *Glossary* (Appendix E). Students can use *Key Terms* lists and the *Glossary* to help them master the terminology of general chemistry.

▶ Are You Wondering …?, probing questions asked by good students, are enhanced in this edition.

Are You Wondering …? To help clarify matters that often puzzle students, we pose and then answer questions under this special heading. For obvious pedagogical reasons, these questions are cast in the form in which students typically ask them. Some are designed to help students avoid common misconceptions; others provide analogies or alternative explanations of a concept; still others address apparent inconsistencies in the material they are learning. In response to reviewer and student comments and suggestions, these have been expanded considerably in this edition. Specifically, the *Are You Wondering …?* format is used in a number of instances to introduce material directed at the better-prepared students. Some of these topics are pursued further in end-of-chapter exercises. These topics can be assigned or omitted at the discretion of the instructor.

▶ Keep in Mind margin notes are new to this edition.

Keep in Mind margin notes. To help students appreciate the significance of earlier ideas, or to warn them about common pitfalls, we have added to this edition *Keep in Mind* margin notes. As the name suggests, these notes ask students to recall key information about concepts and problem-solving skills. At times, we use these in conjunction with worked examples to forewarn students about common mistakes.

▶ Detailed applications of chemistry are covered at the end of the chapter in a non-distracting way.

Focus On boxes. We believe that relevant applications should be an integral part of the text and that asides should be limited to margin notes and *Are You Wondering …?* features. With this in mind, we have concluded the text of each chapter with a short essay on a practical topic appropriate to the chapter content. These essays, which may be considered optional reading, focus on ideas introduced in the chapter.

The Strongest Available Problem-Solving Focus

You probably won't become a better golfer just by watching Tiger Woods play; you have to get onto the course yourself, and often. To give students the support they need to develop strong problem-solving skills, we offer extensive in-text examples that cover all the key concepts introduced in the book, each accompanied by two practice examples. We also provide integrative problems as concluding in-text examples in each chapter and a very large selection of end-of-chapter exercises, including a set that integrate the student media:

▶ Many worked examples, carefully developed, step-by-step.

In-Text Illustrative Examples. In each chapter, most concepts—especially those that students will be expected to apply in homework assignments and examinations—are illustrated with worked-out examples. To aid visual learners and to emphasize abstract concepts, in many cases a line drawing or photograph accompanies an example to help students visualize what is going on in the problem.

▶ **Two** practice examples after every in-text example.

Practice Examples. These are designed to give students immediate practice in applying the principle(s) illustrated in the example. We offer two for every illustrative example. The first, Practice Example A, provides immediate practice in a problem very similar to the illustrative example. The second, Practice Example B, generally takes the student one step further than the illustrative example. This combination helps students to integrate and extend their knowledge and problem-solving skills. Answers to all Practice Examples are given in Appendix F. Complete solutions are given in the *Selected Solutions Manual*.

▶ Integrative Examples, designed to help students learn how to solve these more complicated problems, are new to this edition.

Integrative Examples. The text includes a special category of problems that requires students to link various important problem types introduced in the chapter—with each other and with problem types from earlier chapters. These problems are meant to be challenging for students, and to help them learn how to solve such problems. Each chapter concludes with a multi-part *Integrative Example*, sometimes of a practical nature. In each case, the problem is broken down into parts, each part is solved, and intermediate results are combined into a final solution and answer.

End-of-Chapter Exercises. Each chapter ends with five categories of exercises. *Review Questions* require straightforward application of principles introduced in the chapter, each generally involving a single concept, and either a numerical, symbolic, or short written (or verbal) answer. *Exercises* are grouped by categories related to the text sections, and they are of a broader nature than the *Review Questions*. The *Exercises* are paired, so that there are two problems of the same type. The *Integrative and Advanced Exercises* are not grouped by type. These are generally more difficult than those in the previous sections. They tend to integrate material from multiple sections, or multiple chapters, and they may introduce new ideas or pursue certain ideas further than is done in the text. *Feature Problems* are of special interest. These problems generally require the highest level of cognitive skill on the part of students to solve. Some of these problems retrace aspects of the history of chemistry; a few deal with classic experiments; others require students to interpret data or graphs; some present new material; some suggest alternative techniques for problem solving; and a few summarize main points of the chapter in a comprehensive manner. The *Feature Problems* are a resource that can be used in several ways: as discussion points in class, as assigned homework for individuals, or for collaborative group work. Finally, the *eMedia Exercises,* new to this edition, are questions that can only be solved using the interactive media accompanying this text. This permits the instructor to mandate the use of the media by simply assigning one or more of these problems.

▶ Integrative and Advanced Exercises are enhanced this edition.

▶ Feature Problems, the most challenging in the book, are expanded this edition.

▶ eMedia Exercises are new to this edition.

Answers to all red-numbered problems are given in Appendix F. Full solutions to all red-numbered problems are found in the *Selected Solutions Manual.*

Supplements

For the Instructor

Annotated Instructor's Edition (with Guide to Media Resources) (ISBN 0-13-017677-X). This special edition of the text provides marginal notes and information for instructors and TAs, including teaching tips, suggested lecture demonstrations, references to the chemical education literature, and icons identifying all art that appears on overhead transparencies and on the Media Portfolio CD-ROM for instructors.

▶ New instructor's supplement.

Media Portfolio: Your Presentation Resource CD-ROM (dual platform; ISBN 0-13-017686-9). Specific to Petrucci/Harwood/Herring, this CD includes almost all art and photos from the book, over 61 short animations, 31 video demonstrations, and Java and Flash simulations from the Student iBook. All these pieces are presented in a thumbnail catalog format that allows easy porting of the files to presentation software such as MS PowerPoint®. Also included are electronic versions of suggested course outlines (which can be edited), a set of pre-built MS PowerPoint slides, and a special chemistry font that lets you quickly edit and add to the electronic files on the CD.

▶ New instructor's supplement. Includes prebuilt MS PowerPoint® slides.

The ***Instructor's Resource Manual (ISBN 0-13-017678-8)*** by Michael L. Denniston, Georgia Perimeter College and Robert K. Wismer, Millersville University. Ideal for novice instructors or others using this text for the first time, this book integrates all ancillary material, offers Notes for the Instructor, lists key concepts, itemizes Chapter Objectives, and contains the solutions to the Advanced and Integrative Problems not found in Appendix F of the text.

Transparencies (ISBN 0-13-017685-0) Includes over 250 full-color images from this text. Each of these is also provided in electronic form on the MediaPortfolio Instructor's CD.

▶ 50% more overhead transparencies this edition.

Test Item File (ISBN 0-13-017679-6) by C. Alton Hassell, Baylor University. This hardcopy test bank includes over 2000 unique questions, each accuracy checked for

this new edition and not available to students. These questions are also available in WebCT format for adopting institutions.

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Solutions Manual (ISBN 0-13-017683-4) by Lucio Gelmini and Robert Hilts, both of Grant MacEwan College, and Robert K. Wismer, Millersville University. Contains completely revised, step-by-step solutions to all end-of-chapter (exercises except for eMedia exercises and the Advanced and Integrative Problems found in Appendix F of text). With instructor permission, these manuals may be made available to students.

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For the Laboratory

Experiments in General Chemistry (ISBN 0-13-017688-5) by Gerald S. Weiss, Thomas G. Greco and Lyman H. Rickard, all at Millersville University. A comprehensive laboratory manual containing 37 experiments that parallel the text, including a final group of six experiments on qualitative cation analysis. There is an accompanying instructor's manual ***(ISBN 0-13-017689-3).***

For the Student

▶ Powerful new student supplement—an interactive electronic version of the text.

Student iBook (ISBN 0-13-017680-X) by Scott Perry, University of Houston. This interactive version of the text includes hundreds of animations, simulations, manipulable molecular models, movies, and interactive glossary terms, all integrated in-context within an electronic version of the text. Accessed easily using a web browser, this product allows students to see and discover chemistry in ways never before possible. Each interactive exercise is followed by a self-assessment question so students can make sure they understand the key points before moving on to the next topic. Organized exactly like the book, this product is available free with every new copy of the text.

▶ Enhanced student website features algorithmic questions.

The Petrucci/Harwood/Herring Companion Website **www.prenhall.com/petrucci** by Narayan S. Hosmane, Northern Illinois University. Now in its "second edition," this innovative online resource center is designed to specifically support and enhance students use of Petrucci/Harwood/Herring 8/e. It features

- A Problem Solving Center, where student have access to more than 2000 additional problems, including algorithmically generated questions and non-multiple-choice problems—all organized by chapter, with hints and specific feedback.

- A Visualization Center, where students can view hundreds of pre-built 3-D molecular models using Chime.
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Student Study Guide (ISBN 0-13-032567-8), by Dixie Goss of Hunter College and Robert K. Wismer of Millersville University, guides students through the text's coverage with discussion of chapter learning objectives, drill problems, self quizzes, and sample tests.

Student Solutions Manual (ISBN 0-13-017684-2), by Lucio Gelmini and Robert Hilts, both of Grant MacEwan College, and Robert Wismer of Millersville University. Contains full, step-by-step solutions to the red-numbered problems from the text (those answered in Appendix F of the textbook).

▶ New student supplement.

Math Review Toolkit (ISBN 0-13-032568-6), by Gary Long, Virginia Polytechnic Institute and State University. Contains a chapter-by-chapter review of the essential math skills required for each chapter as well as a brief review of writing in chemistry. Ideal for students for whom math is a major obstacle to success in the course. Available free with a new book; please see your Prentice Hall representative for details.

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Responding to feedback from our colleagues and students is the most important element in keeping this book on target from one revision to the next. Your comments are most welcome.

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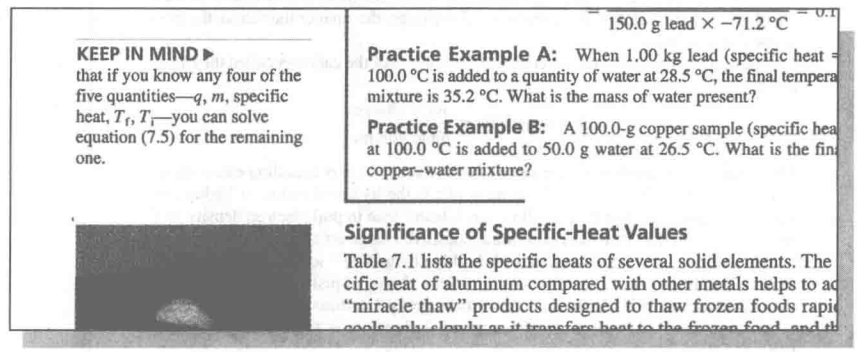
WARNING: Many of the compounds described or pictured in this text are hazardous, as are many of the chemical reactions. Do not attempt any experiment pictured or implied in the text except with permission, in an authorized laboratory setting, and under adequate supervision.

Student's Guide to Using this Text

The next six pages walk you through some of the main features of this text and its integrated media resources. Using this text as designed will help you develop the essential knowledge and skills you need to succeed in chemistry. Good luck!

Keep in Mind Margin Notes ▶

These will help to remind you of ideas introduced earlier in the text that are important to understand what's currently being discussed.



KEEP IN MIND ▶
that if you know any four of the five quantities—q, m, specific heat, T_f, T_i—you can solve equation (7.5) for the remaining one.

150.0 g lead × −71.2 °C

Practice Example A: When 1.00 kg lead (specific heat = 100.0 °C is added to a quantity of water at 28.5 °C, the final tempera mixture is 35.2 °C. What is the mass of water present?

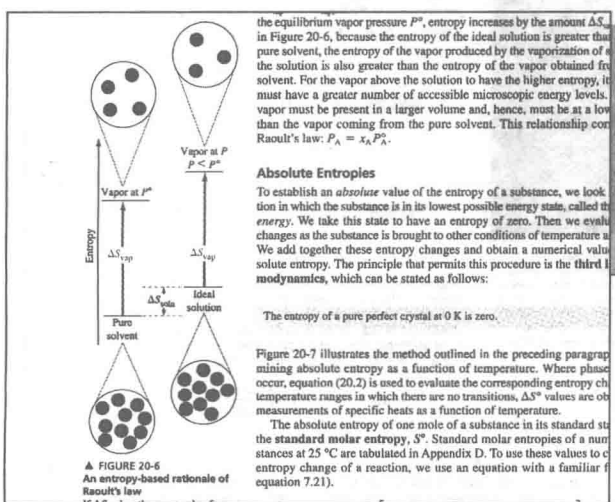
Practice Example B: A 100.0-g copper sample (specific hea at 100.0 °C is added to 50.0 g water at 26.5 °C. What is the fin copper–water mixture?

Significance of Specific-Heat Values

Table 7.1 lists the specific heats of several solid elements. The cific heat of aluminum compared with other metals helps to ac "miracle thaw" products designed to thaw frozen foods rapi

Student iBook icon ▶

This icon tells you that there is an activity on the Student iBook related to what you're learning about. Look at the material on the iBook for a dynamic presentation.



▲ FIGURE 20-6
An entropy-based rationale of Raoult's law

the equilibrium vapor pressure $P°$, entropy increases by the amount ΔS_{vap} in Figure 20-6, because the entropy of the ideal solution is greater than pure solvent, the entropy of the vapor produced by the vaporization of the solution is also greater than the entropy of the vapor obtained fr solvent. For the vapor above the solution to have the higher entropy, it must have a greater number of accessible microscopic energy levels. vapor must be present in a larger volume and, hence, must be at a lo than the vapor coming from the pure solvent. This relationship co Raoult's law: $P_A = x_A P_A^\circ$.

Absolute Entropies

To establish an *absolute* value of the entropy of a substance, we look tion in which the substance is in its lowest possible energy state, called th *energy*. We take this state to have an entropy of zero. Then we evalu changes as the substance is brought to other conditions of temperature a We add together these entropy changes and obtain a numerical valu solute entropy. The principle that permits this procedure is the **third l modynamics**, which can be stated as follows:

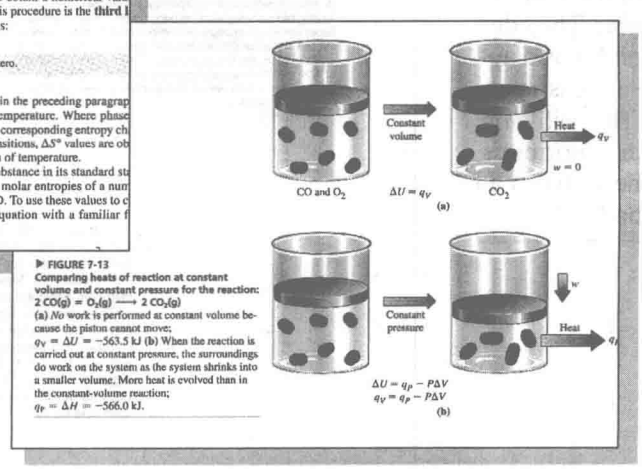
The entropy of a pure perfect crystal at 0 K is zero.

Figure 20-7 illustrates the method outlined in the preceding paragrap mining absolute entropy as a function of temperature. Where phase occur, equation (20.2) is used to evaluate the corresponding entropy ch temperature ranges in which there are no transitions, $\Delta S°$ values are ob measurements of specific heats as a function of temperature.

The absolute entropy of one mole of a substance in its standard st the **standard molar entropy**, $S°$. Standard molar entropies of a nun stances at 25 °C are tabulated in Appendix D. To use these values to c entropy change of a reaction, we use an equation with a familiar f equation 7.21).

Molecular Art ▼

It is sometimes difficult to visualize molecules and processes that can't be seen directly. To help you understand what's going on at the molecular level, carefully review and make sure you understand the molecular depictions provided in the text.



▶ FIGURE 7-13
Comparing heats of reaction at constant volume and constant pressure for the reaction: $2\,CO(g) + O_2(g) \longrightarrow 2\,CO_2(g)$
(a) *No* work is performed at constant volume because the piston cannot move; $q_V = \Delta U = -563.5$ kJ (b) When the reaction is carried out at constant pressure, the surroundings do work on the system as the system shrinks into a smaller volume. More heat is evolved than in the constant-volume reaction; $q_P = \Delta H = -566.0$ kJ.