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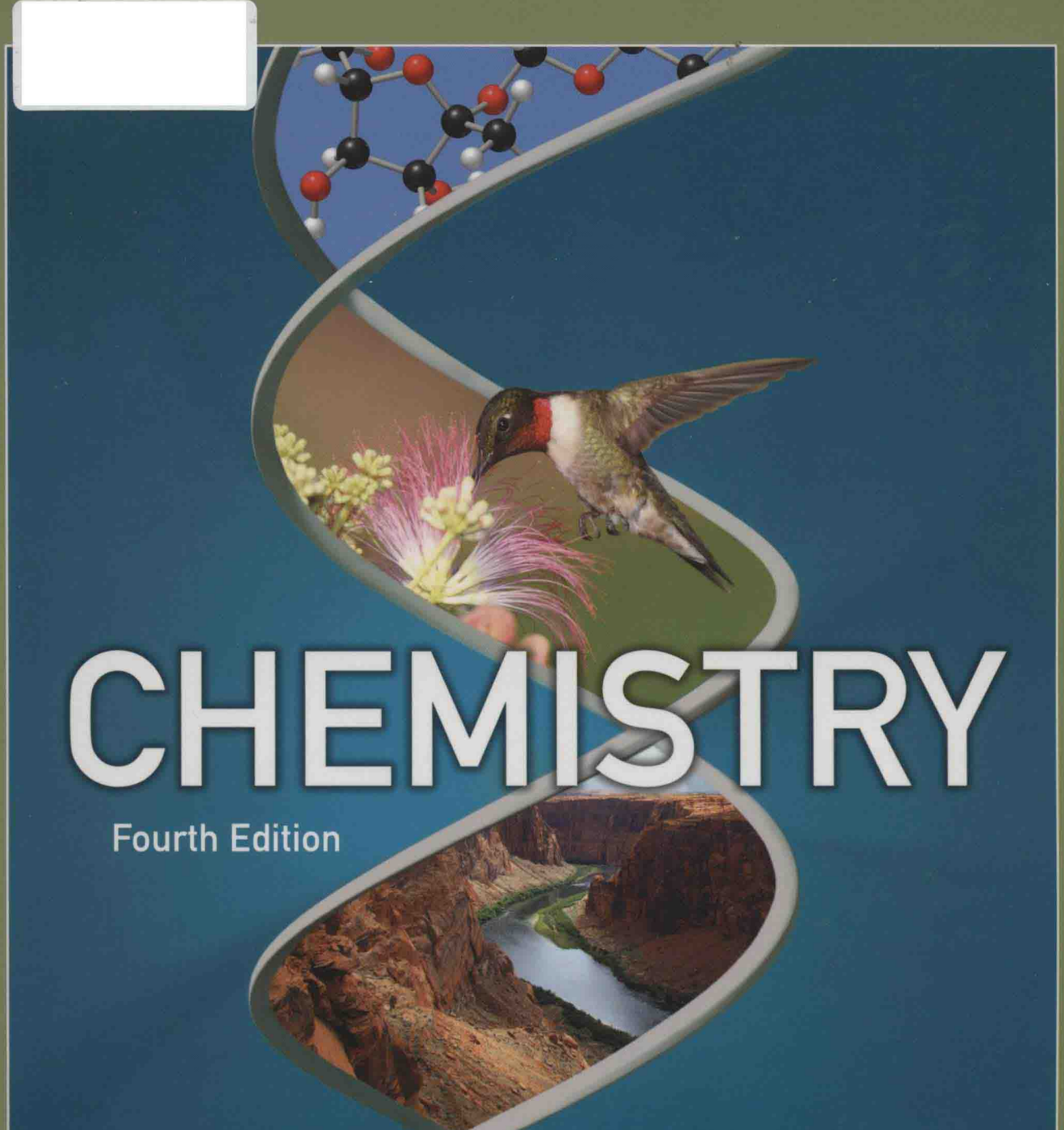

CHEMISTRY

Fourth Edition

GILBERT • KIRSS • FOSTER • DAVIES

CHEMISTRY

THE SCIENCE IN CONTEXT

FOURTH EDITION

Thomas R. Gilbert
NORTHEASTERN UNIVERSITY

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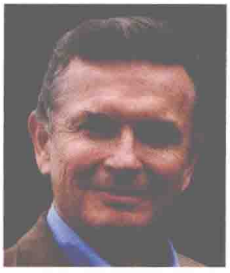
About the Authors



Thomas R. Gilbert has a BS in chemistry from Clarkson and a PhD in analytical chemistry from MIT. After 10 years with the Research Department of the New England Aquarium in Boston, he joined the faculty of Northeastern University, where he is currently associate professor of chemistry and chemical biology. His research interests are in chemical and science education. He teaches general chemistry and science education courses and conducts professional development workshops for K–12 teachers. He has won Northeastern's Excellence in Teaching Award and Outstanding Teacher of First-Year Engineering Students Award. He is a fellow of the American Chemical Society and in 2012 was elected to the ACS Board of Directors.

Rein V. Kirss received both a BS in chemistry and a BA in history as well as an MA in chemistry from SUNY Buffalo. He received his PhD in inorganic chemistry from the University of Wisconsin, Madison, where the seeds for this textbook were undoubtedly planted. After two years of postdoctoral study at the University of Rochester, he spent a year at Advanced Technology Materials, Inc., before returning to academics at Northeastern University in 1989. He is an associate professor of chemistry with an active research interest in organometallic chemistry.

Natalie Foster is emeritus professor of chemistry at Lehigh University in Bethlehem, Pennsylvania. She received a BS in chemistry from Muhlenberg College and MS, DA, and PhD degrees from Lehigh University. Her research interests included studying poly(vinyl alcohol) gels by NMR as part of a larger interest in porphyrins and phthalocyanines as candidate contrast enhancement agents for MRI. She taught both semesters of the introductory chemistry class to engineering, biology, and other nonchemistry majors and a spectral analysis course at the graduate level. She is the recipient of the Christian R. and Mary F. Lindback Foundation Award for distinguished teaching.

Geoffrey Davies holds BSc, PhD, and DSc degrees in chemistry from Birmingham University, England. He joined the faculty at Northeastern University in 1971 after postdoctoral research on the kinetics of very rapid reactions at Brandeis University, Brookhaven National Laboratory, and the University of Kent at Canterbury. He is now a Matthews Distinguished University Professor at Northeastern University. His research group has explored experimental and theoretical redox chemistry, alternative fuels, transmetalation reactions, tunable metal–zeolite catalysts and, most recently, the chemistry of humic substances, the essential brown animal and plant metabolites in sediments, soils, and water. He edits a column on experiential and study-abroad education in the *Journal of Chemical Education* and a book series on humic substances. He is a Fellow of the Royal Society of Chemistry and was awarded Northeastern's Excellence in Teaching Award in 1981, 1993, and 1999, and its first Lifetime Achievement in Teaching Award in 2004.

Preface

Dear Student,

We wrote this book with three overarching goals in mind: to make chemistry interesting, relevant, and memorable; to enable you to see the world from a molecular point of view; and to help you become an expert problem-solver. You have a number of resources available to help you succeed in your general chemistry course. This textbook will be a valuable resource, and we have written it with you, and the different ways you may use the book, in mind.

If you are someone who reads a chapter from the first page to the last, you will see that *Chemistry: The Science in Context*, Fourth Edition, introduces the chemical principles within a chapter using contexts drawn from daily life as well as from other disciplines including biology, environmental science, materials science, astronomy, geology, and medicine. We believe that these contexts make chemistry more interesting, relevant, understandable, and memorable.

We begin each chapter with an introduction that is meant to pique your interest but also to set the stage for the concepts to come. These sections provide glimpses of how the chemistry in the chapter connects to the world. We have used topics that should be familiar to you, but we place them in chemical contexts that we hope will intrigue you.

If you want a quick summary of what is most important in a chapter to direct your studying on selected topics, check the **Learning Outcomes** listed on the first page of each chapter. Whether you are reading the chapter from first page to last, moving from topic to topic in an order you select, or reviewing material for an exam, the Learning Outcomes can help you focus on the key information you need to know and the skills you should acquire.

Learning Outcomes

LO1 Explain kinetic and potential energies at the molecular level
Sample Exercise 5.1

LO2 Identify familiar endothermic and exothermic processes
Sample Exercise 5.2

LO3 Calculate changes in the internal energy of a system
Sample Exercises 5.3, 5.4

LO4 Calculate the amount of heat transferred in physical or chemical processes
Sample Exercises 5.5, 5.6, 5.7, 5.8

LO5 Calculate thermochemical values using data from calorimetry experiments
Sample Exercises 5.9, 5.10, 5.11

LO6 Calculate enthalpies of reaction
Sample Exercises 5.12, 5.13, 5.15

LO7 Recognize and write equations for formation reactions
Sample Exercises 5.14, 5.16

LO8 Calculate and compare fuel and food values and fuel densities
Sample Exercises 5.17, 5.18

In every section, you will find **key terms** in boldface in the text and in a **running glossary** in the margin. We have inserted the definitions throughout the text, so you can continue reading without interruption but quickly find key terms when doing homework or reviewing for a test. All key terms are also defined in the Glossary in the back of the book.

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Approximately once per section, you will find a **Concept Test**. These short, conceptual questions provide a self-check opportunity by asking you to stop and answer a question relating to what you just read. We designed them to help you see for yourself whether you have grasped a key concept and can apply it. You will find answers to Concept Tests in the back of the book.

CONCEPT TEST

The energy lost by the beverages inside the 72 cans in the preceding discussion was more than 100 times the heat lost by the cans. What factors contributed to this large difference between the energy lost by the cans and the energy lost by their contents?

(Answers to Concept Tests are in the back of the book.)

CONNECTION In Chapter 3, we introduced the sugar glucose as a carbohydrate: a compound composed of carbon, hydrogen, and oxygen.

New concepts naturally build on previous information, and you will find that many concepts are related to others described earlier in the book. We point out these relationships with **Connection** icons in the margins. These reminders will help you see the big picture and draw your own connections between the major themes covered in the book.

Chemists' unique perspective of natural processes and insights into the properties of substances, from high-performance alloys to the products of biotechnology, are based on understanding these processes and substances at the atomic and molecular levels. A major goal of this book is to help you develop this microscale perspective and link it to macroscopic properties. To help you develop this perspective, we use molecular art to enhance photos and figures and to illustrate what is happening at the atomic and molecular levels. All of the molecular art has been updated, and the fourth edition has more molecular art than previous editions of this book.

CHEMTOUR Hess's Law

If you're looking for additional help visualizing a concept, we have more than 100 **ChemTours**, denoted by the ChemTour icon. The ChemTours, available at wwnpag.es/chemtours, demonstrate dynamic processes and help you visualize events at the molecular level. Many ChemTours are interactive, allowing you to manipulate variables and observe resulting changes in a graph or a process. Questions at the end of the ChemTour tutorials offer step-by-step assistance in solving problems and provide useful feedback.

Whereas the biochemical properties of elements and their roles in medicine are the focus of Chapter 22, near the end of many chapters is a **Descriptive Chemistry** box. Descriptive Chemistry boxes throughout the textbook summarize the properties and uses of individual elements or groups of elements that are highlighted in a particular chapter. We discuss where the substances occur in nature and how they are used in ways that touch our lives and shape our world.

Another goal of the book is to help you improve your problem-solving skills. Sometimes the hardest parts of solving a problem are knowing where to start and distinguishing between information that is relevant and information that is not. Once you are clear on where you are starting and where you are going, planning for and carrying out a solution become much easier.

To help you hone your problem-solving skills, we have developed a framework that is introduced in Chapter 1 and used consistently throughout the book. It is a four-step approach we call **COAST**, which is our acronym for (1) **C**ollect and **O**rganize, (2) **A**nalyze, (3) **S**olve, and (4) **T**hink About It. We use these four steps in *every* Sample Exercise and in the solutions to *odd-numbered*

problems in the Student's Solutions Manual. They are also used in the hints and feedback embedded in the SmartWork online homework program. To summarize the four steps:

Collect and Organize helps you understand where to begin. In this step we often point out what is given and what you must find, and identify the relevant information that is provided in the problem statement or available elsewhere in the book.

Analyze is where we map out a strategy for solving the problem. As part of that strategy we often estimate what a reasonable answer might be.

Solve applies our analysis of the problem from the second step to the information and relations from the first step to actually solve the problem. We walk you through each step in the solution so that you can follow the logic as well as the math.

Think About It reminds us that an answer is not the last step in solving a problem. Checking if the solution is reasonable in light of an estimate is imperative. Is the answer realistic? Are the units correct? Is the number of significant figures appropriate? Does it make sense with our estimate from the Analyze step?

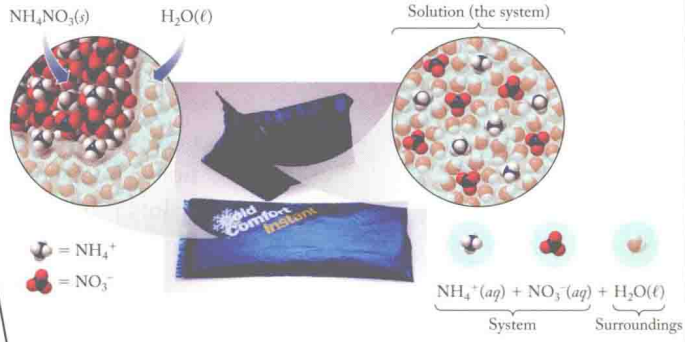
Many students use the **Sample Exercises** more than any other part of the book. Sample Exercises take the concept being discussed and illustrate how to apply it to solve a problem. We hope that repeated application of COAST will help you refine your problem-solving skills and become an expert problem-solver. When you finish a Sample Exercise, you'll find a **Practice Exercise** to try on your own. If you have the ebook, the Practice Exercises are "live," meaning that you can solve them and receive hints and answer-specific feedback in SmartWork to guide you. Notice that the Sample Exercises and the Learning Objectives are connected. We think this will help you focus efficiently on the main ideas in the chapter.

Students sometimes comment that the questions on an exam are more challenging than the Sample Exercises in a book. To address this, we have added an Integrating Concepts Sample Exercise near the end of each chapter. These exercises require you to use more than one concept from the chapter and may expect you to use concepts from earlier chapters to solve a problem. Please invest your time working through these problems because we think they will further enhance your problem-solving skills and give you an increased appreciation of how chemistry is used in the world.

If you use the book mostly as a reference and problem-solving guide, we have a learning path for you as well. It starts with the **Summary** and a **Problem-Solving Summary** at the end of each chapter. The first is a brief synopsis of the chapter, organized by Learning Outcomes. Key figures have been added to this Summary to provide visual cues as you review. The Problem-Solving Summary

SAMPLE EXERCISE 5.6 The Sign of ΔH in a Chemical Reaction LO4

A chemical cold pack (Figure 5.24) contains a small pouch of water inside a bag of solid ammonium nitrate. To activate the pack, you press on it to rupture the pouch, allowing the ammonium nitrate to dissolve in the water. The result is a cold, aqueous solution of ammonium nitrate. Write a balanced chemical equation describing the dissolution of solid NH_4NO_3. If we define the system as the NH_4NO_3 and the surroundings as the water, what are the signs of ΔH_{sys} and q_{surr}?



Collect and Organize The solution's temperature drops when we dissolve NH_4NO_3 in water. We want to write a balanced chemical equation for the dissolution of ammonium nitrate and determine the sign of ΔH for the solution (the system) and q_{surr}.

Analyze The first law of thermodynamics says energy must be conserved, so all the energy must be accounted for between system and surroundings.

Solve The solubility rules in Table 4.5 tell us that all ammonium salts are soluble. We can write a balanced chemical equation for the dissolution of NH_4NO_3 (the system) as

$$NH_4NO_3(s) \rightarrow NH_4^+(aq) + NO_3^-(aq)$$

The low temperature of the cold pack (the system) means that heat flows into it from its warmer surroundings. Therefore, the sign of ΔH_{sys} is positive ($\Delta H_{sys} > 0$), and the sign of q_{surr} is negative ($q_{surr} < 0$).

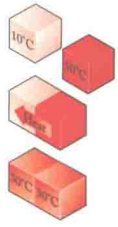
Think About It The first law of thermodynamics tells us that the signs of ΔH_{sys} and q_{surr} must be opposite.

Practice Exercise Potassium hydroxide can be used to unclog sink drains. The reaction between potassium hydroxide and water is quite exothermic. What are the signs of ΔH_{sys} and q_{surr}?

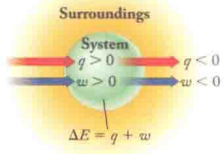
(Answers to Practice Exercises are in the back of the book.)

SUMMARY

Learning Outcome 1 **Potential energy (PE)** is the energy of position or composition and is a **state function**. **Kinetic energy (KE)** is the energy of motion. Heating a sample increases the average kinetic energy of the atoms in the sample. Energy is stored in compounds, and energy is absorbed or released when they are transformed into different compounds or when a change of state occurs. (Section 5.1)



Learning Outcome 2 In an **exothermic process** the system loses energy by heating its surroundings ($q < 0$); in an **endothermic process** the system absorbs energy ($q > 0$) from its surroundings. (Section 5.2)



PROBLEM-SOLVING SUMMARY

TYPE OF PROBLEM	CONCEPTS AND EQUATIONS		SAMPLE EXERCISES
Kinetic and potential energy	$KE = \frac{1}{2}mu^2$ $E_{el} \propto \frac{Q_1 \times Q_2}{d}$	(5.3)	5.1
Identifying endothermic and exothermic processes, and calculating internal energy change (ΔE) and P–V work	For the system: $\Delta E = q + w$ where $w = -P\Delta V$.	(5.5)	5.2, 5.3, 5.4
Predicting the sign of ΔH_{sys} for physical and chemical changes	Exothermic, $\Delta H_{sys} < 0$ Endothermic, $\Delta H_{sys} > 0$		5.5, 5.6

organizes the chapter by problem type and summarizes relevant concepts and equations you need to solve each type of problem. The Problem-Solving Summary also points you back to the Sample Exercise that models how to solve each problem and cross-references the Learning Outcomes at the beginning of the chapter.

Following the summaries are groups of questions and problems. The first group consists of **Visual Problems**. In many of them, you are asked to interpret a molecular view of a sample or a graph of experimental data.

Concept Review Questions and Problems come next, arranged by topic in the same order as they appear in the chapter. Concept Reviews are qualitative and often ask you to explain why or how something happens. Problems are paired and can be quantitative, conceptual, or a combination of both. **Contextual problems** have a title that describes the context in which the problem is placed. **Additional Problems** can come from any section or combination of sections in the chapter. Some of them incorporate concepts from previous chapters. Problems marked with an asterisk (*) are more challenging and often require multiple steps to solve.

We want you to have confidence in using the answers in the back of the book as well as the Student's Solutions Manual, so we used a rigorous triple-check accuracy program for the fourth edition. Each end-of-chapter question and problem has been solved independently by at least three separate PhD chemists. For the fourth edition the team included Solutions Manual author Bradley Wile and two additional chemical educators. Brad compared his solutions to those from the two reviewers and resolved any discrepancies. This process is designed to ensure clearly written problems and accurate answers in the appendices and Solutions Manual.

No matter how you use this book, we hope it becomes a valuable tool for you and helps you not only understand the principles of chemistry but also apply them to solving global problems, such as diagnosing and treating disease or making more efficient use of Earth's natural resources.

Changes to the Fourth Edition

Dear Instructor,

Whether you used the third edition of this book or not, we want you to know how the fourth edition compares to its predecessor. Here are some of the general changes we made throughout this edition:

- We have closely connected the Learning Outcomes, Sample Exercises, and Summary in each chapter, and problems in SmartWork can now be filtered by Learning Objective. This should make studying from the book easier for students and assessing students easier for you.

- Most Sample Exercises were revised to improve clarity and continuity. We also added 50 Sample Exercises to the fourth edition, based on reviewer feedback.
- Each chapter has a new type of Sample Exercise called Integrating Concepts. These are placed near the end of the chapter and require students to use more than one concept from the chapter, and occasionally concepts from preceding chapters, to solve real-world problems.
- We have significantly revised and expanded the art program by updating all of the molecular art, adding more molecular views, and making people, glassware, and equipment more photorealistic.
- We have revised or replaced approximately 20% of the end-of-chapter problems. We used feedback from users and reviewers to address areas where we needed more problems or additional problems of varying difficulty.
- More than 1000 new problems have been added to SmartWork to support the fourth edition, including more math review problems, visual problems, and more multi-step tutorials. In response to user feedback, most of these problems are written *for* the book but are not *in* the book.
- Chapter 14 in the third edition (Thermodynamics) is now Chapter 18 and follows kinetics and equilibrium. This organization more closely matches the order taught at most colleges and universities.

Other changes include moving most of the nuclear chemistry from Chapter 2 to Chapter 21 and rebalancing the material in Chapters 10 and 11. Chapter 10, on intermolecular forces, now concentrates primarily on the behavior and properties of pure materials, whereas Chapter 11 deals with solutions and interactions among particles of different substances. The unique behavior of water is a unifying feature of both chapters.

Because a discussion of the ways chemistry touches our daily lives is part of the fabric of the text, we have routinely incorporated new information in the story lines of the chapters. From the landing of *Curiosity* on Mars to the most recent results on the role of the survival advantage conveyed by sickle-cell anemia in regions where malaria is endemic, current events have supplied us with new contextual examples to enrich our discussions of chemical concepts.

Teaching and Learning Resources

SMARTWORK ONLINE HOMEWORK FOR GENERAL CHEMISTRY

wwnorton.com/smartwork/chemistry

Created by chemistry educators, SmartWork is the most intuitive online tutorial and homework management system available for general chemistry. The many question types, including graded molecule drawing, math and chemical equations, ranking tasks, and interactive figures, help students develop and apply their understanding of fundamental concepts in chemistry.

Every problem in SmartWork includes response-specific feedback and general hints using the steps in COAST. Links to the ebook version of *Chemistry: The Science in Context*, Fourth Edition, take students to the specific place in the text where the concept is explained. All problems in SmartWork use the same language and notation as the textbook.

SmartWork also features Tutorial Problems. If students ask for help in a Tutorial Problem, SmartWork breaks the problem down into smaller steps, coaching

them with hints, answer-specific feedback, and probing questions within each step. At any point in a Tutorial, a student can return to and answer the original problem.

Assigning, editing, and administering homework within SmartWork is easy. SmartWork allows the instructor to search for problems using both the text's Learning Objectives and Bloom's taxonomy. Instructors can use pre-made assignment sets provided by Norton authors, modify those assignments, or create their own. Instructors can also make changes in the problems at the question level. All instructors have access to our WYSIWYG (What You See Is What You Get) authoring tools—the same ones Norton authors use. Those intuitive tools make it easy to modify existing problems or to develop new content that meets the specific needs of your course.

Wherever possible, SmartWork makes use of algorithmic variables so that students see slightly different versions of the same problem. Assignments are graded automatically, and SmartWork includes sophisticated yet flexible tools for managing class data. Instructors can use the Item Analysis features to assess how students have done on specific problems within an assignment. Instructors can also review individual students' work on problems.

SmartWork for *Chemistry: The Science in Context*, Fourth Edition, features the following problem types:

- End-of-Chapter Problems. These problems, which use algorithmic variables when appropriate, all have hints and answer-specific feedback to coach students through mastering single- and multi-concept problems based on chapter content. They make use of all of SmartWork's answer-entry tools.
- Multistep Tutorials. These problems offer students who demonstrate a need for help a series of linked, step-by-step subproblems to work. They are based on the Concept Review problems at the end of each chapter. Tutorials make use of student-focused artwork from the Student's Solutions Manual.
- Math Review Problems. These problems can be used by students for practice or by instructors to diagnose the mathematical ability of their students.
- Ranking Task Problems. These problems ask students to make comparative judgments between items in a set.
- Visual and Graphing Problems. These problems challenge students to identify chemical phenomena and to interpret graphs. They use SmartWork's Drag-and-Drop and Hotspot functionality.
- Reaction Visualization Problems. Based on both static art and videos of simulated reactions, these problems are designed to help students visualize what happens at the atomic level—and why it happens.
- Nomenclature Problems. New matching and multiple-choice problems help students master course vocabulary.
- ChemTour Problems. These are based on Norton's popular animations.

www.nortonebooks.com

EBOOK

An affordable and convenient alternative to the print text, the ebook retains the content and design of the print book. Students can highlight and take notes with ease, print chapters as needed, and search the text.

The online version of *Chemistry*, Fourth Edition provides students with standalone Interactive Practice Exercises. These are self-grading SmartWork problems that allow students to practice solving problems and receive hints and feedback without being penalized for making multiple attempts. The online ebook also allows students one-click access to the 100 ChemTour animations.

The online ebook is available bundled with the print text and SmartWork at no extra cost, or it may be purchased bundled with SmartWork access.

Norton also offers a downloadable PDF version of the ebook as well as a format optimized for delivery to any device—laptop, tablet, or smartphone.

STUDENT'S SOLUTIONS MANUAL by Bradley Wile, Ohio Northern University

The Student's Solutions Manual provides students with fully worked solutions to select end-of-chapter problems using the **COAST** four-step method (**C**ollect and **O**rganize, **A**nalyze, **S**olve, and **T**hink About It). The Student Solutions Manual contains several pieces of art for each chapter, designed to help students visualize ways to approach problems. This artwork is also used in the hints and feedback within SmartWork.

CLICKERS IN ACTION: INCREASING STUDENT PARTICIPATION IN GENERAL CHEMISTRY by Margaret Asirvatham, University of Colorado, Boulder

An instructor-oriented resource providing information on implementing clickers in general chemistry courses. *Clickers in Action* contains more than 250 class-tested, lecture-ready questions, with histograms showing student responses, as well as insights and suggestions for implementation. Question types include macroscopic observation, symbolic representation, and atomic/molecular views of processes.

INSTRUCTOR'S SOLUTIONS MANUAL by Bradley Wile, Ohio Northern University

The Instructor's Solutions Manual provides instructors with fully worked solutions to every end-of-chapter Concept Review and Problem. Each solution uses the **COAST** four-step method (**C**ollect and **O**rganize, **A**nalyze, **S**olve, and **T**hink About It).

INSTRUCTOR'S RESOURCE MANUAL by Timothy Zauche, University of Wisconsin-Platteville

Each chapter in this complete resource manual for instructors begins with a brief overview of the text chapter, suggestions for integrating the contexts featured in the book into a lecture, and alternate contexts. Each chapter also contains an overview of using selected *Clickers in Action* questions with the chapter and instructor notes for suggested activities from the *ChemConnections* and *Calculations in Chemistry* workbooks. Summaries of the ChemTours and suggested laboratory exercises round out each chapter.

TEST BANK by David Hanson, Stony Brook University

Norton uses an innovative, evidence-based model to deliver high-quality and pedagogically effective quizzes and testing materials. Each chapter of the Test Bank is structured around an expanded list of student learning objectives and evaluates student knowledge on six distinct levels based on Bloom's Taxonomy: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating.

Questions are further classified by section and difficulty, making it easy to construct tests and quizzes that are meaningful and diagnostic, according to each instructor's needs. More than 2200 questions are divided into multiple-choice and short answer.

Beginning in the fall of 2015, there will also be an annual update to the digital Test Bank files found on the downloadable instructor's resource site. Every year, for the life of the fourth edition, new questions will be added, and edits to existing questions will be made based on the author use of the Test Bank questions.

The Test Bank is available in ExamView Assessment Suite, Word RTF, and PDF formats.

INSTRUCTOR'S RESOURCE DISC

This helpful classroom presentation tool features:

- Stepwise animations and classroom response questions. Developed by Jeffrey Macedone of Brigham Young University and his team, these animations, which use native PowerPoint functionality and textbook art, help instructors to "walk" students through more than 100 chemical concepts and processes. Where appropriate, the slides contain two types of questions for students to answer in class: questions that ask them to predict what will happen next and why, and questions that ask them to apply knowledge gained from watching the animation. Self-contained notes help instructors adapt these materials to their own classrooms.
- Lecture PowerPoint (David Ballantine, Northern Illinois University) slides that include integrated figures from the text, ChemTours, and stick-or-switch clicker questions. These are particularly helpful to first-time teachers of the introductory course.
- All ChemTours and multi-level visualizations.
- *Clickers in Action* clicker questions for each chapter provide instructors with class-tested questions they can integrate into their course.
- Photographs, drawn figures, and tables from the text, available in PowerPoint and JPEG.

DOWNLOADABLE INSTRUCTOR'S RESOURCES

wwnorton.com/instructors

This password-protected site for instructors includes:

- Stepwise animations and classroom response questions. Developed by Jeffrey Macedone of Brigham Young University and his team, these animations, which use native PowerPoint functionality and textbook art, help instructors to "walk" students through more than 100 chemical concepts and processes. Where appropriate, the slides contain two types of questions for students to answer in class: questions that ask them to predict what will happen next and why, and questions that ask them to apply knowledge gained from watching the animation. Self-contained notes help instructors adapt these materials to their own classrooms.
- Lecture PowerPoints with stick-or-switch clicker questions.
- All ChemTours and multi-level visualizations.
- Test bank in PDF, Word RTF, and *ExamView* Assessment Suite formats.
- Solutions Manual in PDF and Word, so that instructors may edit solutions.
- All of the end-of-chapter questions and problems, available in Word along with the key equations.
- Photographs, drawn figures, and tables from the text, available in PowerPoint and JPEG.
- *Clickers in Action* clicker questions.
- BlackBoard and WebCT materials.

BLACKBOARD AND WEBCT COURSE CARTRIDGES

Course cartridges for BlackBoard and WebCT include access to the ChemTours, a Study Plan for each chapter, multiple-choice tests (Stephen Wuerz, Highland Community College), and links to premium content in the ebook and SmartWork.

Acknowledgments

As authors of a textbook we are very often asked: "Why is a fourth edition necessary? Has the science changed that much since the third edition?" Although chemistry is a vigorous and dynamic field, most basic concepts presented in an introductory course have not changed dramatically. However, two areas tightly intertwined in this text—pedagogy and context—have experienced significant changes, and those areas are the drivers of this new edition. The review process that involves you, the users of this text, plays a major role in triggering the perfect storm of activity required to produce a new version of a book. The suggestions, comments, critiques, and general feedback you have provided based on previous editions of this book encouraged us to commit to a revision with an eye on making the content work better for you and for all your students. Our deepest thanks and gratitude go to you, the users, for sharing your experiences with us. Your comments at meetings, at focus groups, in emails, and during office visits with the Norton travelers about what works well, what needs to be improved pedagogically, and the new stories and current real-world examples of chemistry that capture your students' interest are the mainstays of this revision. We begin our acknowledgments by thanking all of you.

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