Preface

The fourth edition of *Thermodynamics, Statistical Thermodynamics, and Kinetics* includes many changes to the presentation and content at both a global and chapter level. These updates have been made to enhance the student learning experience and update the discussion of research areas. At the global level, changes that readers will see throughout the textbook include:

- **Review of relevant mathematics skills.** One of the primary reasons that students experience physical chemistry as a challenging course is that they find it difficult to transfer skills previously acquired in a mathematics course to their physical chemistry course. To address this issue, contents of the third edition Math Supplement have been expanded and split into 11 two- to five-page Math Essentials, which are inserted at appropriate places throughout this book, as well as in the companion volume *Quantum Chemistry & Spectroscopy*, just before the math skills are required. Our intent in doing so is to provide "just-in-time" math help and to enable students to refresh math skills specifically needed in the following chapter.
- **Concept and Connection.** A new Concept and Connection feature has been added to each chapter to present students with a quick visual summary of the most important ideas within the chapter. In each chapter, approximately 10–15 of the most important concepts and/or connections are highlighted in the margins.
- **End-of-Chapter Problems.** Numerical Problems are now organized by section number within chapters to make it easier for instructors to create assignments for specific parts of each chapter. Furthermore, a number of new Conceptual Questions and Numerical Problems have been added to the book. Numerical Problems from the previous edition have been revised.
- **Introductory chapter materials.** Introductory paragraphs of all chapters have been replaced by a set of three questions plus responses to those questions. This new feature makes the importance of the chapter clear to students at the outset.
- **Figures.** All figures have been revised to improve clarity. Also, for many figures, additional annotation has been included to help tie concepts to the visual program.
- **Key Equations.** An end-of-chapter table that summarizes Key Equations has been added to allow students to focus on the most important of the many equations in each chapter. Equations in this table are set in red type where they appear in the body of the chapter.
- **Further Reading.** A section on Further Reading has been added to each chapter to provide references for students and instructors who would like a deeper understanding of various aspects of the chapter material.
- **Guided Practice and Interactivity**
  - **Mastering™ Chemistry** with a new enhanced eBook, has been significantly expanded to include a wealth of new end-of-chapter problems from the fourth edition, new self-guided, adaptive Dynamic Study Modules with wrong answer feedback and remediation, and the new Pearson eBook which is mobile friendly. Students who solve homework problems using Mastering™ Chemistry obtain immediate feedback, which greatly enhances learning associated with solving homework problems. This platform can also be used for pre-class reading quizzes linked directly to the eText that are useful in ensuring students remain current in their studies and in flipping the classroom.
  - **NEW! Pearson eText, optimized for mobile,** gives students access to their textbook anytime, anywhere.
    - Pearson eText mobile app offers offline access and can be downloaded for most iOS and Android phones/tablets from the Apple App Store or Google Play.
    - Configurable reading settings, including resizable type and night-reading mode
    - Instructor and student note-taking, highlighting, bookmarking, and search functionalities
  - **NEW! 66 Dynamic Study Modules** help students study effectively on their own by continuously assessing their activity and performance in real time.
  - Students complete a set of questions with a unique answer format that also asks them to indicate their confidence level. Questions repeat until the student can answer them all correctly and confidently. These are available as graded assignments prior to class and are accessible on smartphones, tablets, and computers.
  - **Topics** include key math skills, as well as a refresher of general chemistry concepts, such as understanding matter, chemical reactions, and the periodic table and atomic structure. Topics can be added or removed to match your coverage.

In terms of chapter and section content, many changes were made. The most significant of these changes are as follows:

- A new chapter entitled Macromolecules (Chapter 20) has been added. The motivation for this chapter is that assemblies of smaller molecules form large molecules, such as proteins or polymers. The resulting macromolecules can exhibit new structures and functions that are not reflected by the individual molecular components. Understanding the factors that influence macromolecular structure is critical in understanding the chemical behavior of these important molecules.
- A more detailed discussion of system-based and surroundings-based work has been added in Chapter 2 to help clarify the confusion that has appeared in the chemical education literature about using the system or surroundings pressure in calculating work. Section 6.6

has been extensively revised to take advances in quantum computing into account.

- The discussion on entropy and the second law of thermodynamics in Chapter 5 has been substantially revised. As a result, calculations of entropy changes now appear earlier in the chapter, and the material on the reversible Carnot cycle has been shifted to a later section.
- The approach to chemical equilibrium in Chapter 6 has been substantially revised to present a formulation in terms of the extent of reaction. This change has been made to focus more clearly on changes in chemical potential as the driving force in reaching equilibrium.

For those not familiar with the third edition of *Thermodynamics, Statistical Thermodynamics, and Kinetics*, our approach to teaching physical chemistry begins with our target audience—undergraduate students majoring in chemistry, biochemistry, and chemical engineering, as well as many students majoring in the atmospheric sciences and the biological sciences. The following objectives outline our approach to teaching physical chemistry.

- **Focus on teaching core concepts.** The central principles of physical chemistry are explored by focusing on core ideas and then extending these ideas to a variety of problems. The goal is to build a solid foundation of student understanding in a limited number of areas rather than to provide a condensed encyclopedia of physical chemistry. We believe this approach teaches students how to learn and enables them to apply their newly acquired skills to master related fields.
- **Illustrate the relevance of physical chemistry to the world around us.** Physical chemistry becomes more relevant to a student if it is connected to the world around us. Therefore, example problems and specific topics are tied together to help the student develop this connection. For example, fuel cells, refrigerators, heat pumps, and real engines are discussed in connection with the second law of thermodynamics. Every attempt is made to connect fundamental ideas to applications that could be of interest to the student.
- **Link the macroscopic and atomic-level worlds.** One of the strengths of thermodynamics is that it is not dependent on a microscopic description of matter. However, students benefit from a discussion of issues such as how pressure originates from the random motion of molecules.
- **Present exciting new science in the field of physical chemistry.** Physical chemistry lies at the forefront of many emerging areas of modern chemical research. Heterogeneous catalysis has benefited greatly from mechanistic studies carried out using the techniques of modern surface science. Atomic-scale electrochemistry has become possible through scanning tunneling microscopy. The role of physical chemistry in these and other emerging areas is highlighted throughout the text.
- **Provide a versatile online homework program with tutorials.** Students who submit homework problems using Mastering™ Chemistry obtain immediate feedback, a feature that greatly enhances learning. Also, tutorials with wrong answer feedback offer students a self-paced learning environment.
- **Use web-based simulations to illustrate the concepts being explored and avoid math overload.** Mathematics is central to physical chemistry; however, the mathematics can distract the student from "seeing" the underlying concepts. To circumvent this problem, web-based simulations have been incorporated as end-of-chapter problems in several chapters so that the student can focus on the science and avoid a math overload. These web-based simulations can also be used by instructors during lecture. An important feature of the simulations is that each problem has been designed as an assignable exercise with a printable answer sheet that the student can submit to the instructor. Simulations, animations, and homework problem worksheets can be accessed at www.pearsonhighered.com/advchemistry.

Effective use of *Thermodynamics, Statistical Thermodynamics, and Kinetics* does not require proceeding sequentially through the chapters or including all sections. Some topics are discussed in supplemental sections, which can be omitted if they are not viewed as essential to the course. Also, many sections are sufficiently self-contained that they can be readily omitted if they do not serve the needs of the instructor and students. This textbook is constructed to be flexible to your needs. We welcome the comments of both students and instructors on how the material was used and how the presentation can be improved.

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