INTERNATIONAL EDITION

Silberberg

CHEMISTRY

The Molecular Nature of Matter and Change

3rd Edition

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This icon in the text indicates a related application, study aid, or historical note appearing in the margin.

PREFACE

Sometimes, when a new edition is in the works, a friend will ask, with a disbelieving tone, "Is there really anything new in chemistry?" What a question! As in any dynamic, modern science, theories in chemistry are refined to reflect new data, established ideas are applied to new systems, and connections are forged with other sciences to uncover new information. But chemistry, as the science of matter and its changes, is central to so many sciences—physical, biological, environmental, medical, and engineering—that it must evolve continuously to allow their progress. Designing safer, "greener" ways to make medicines, fuels, and other commodities; modeling our atmosphere and oceans to predict changes and their effects; and synthesizing new materials with revolutionary properties are among the countless areas in which chemistry is evolving.

In fact, just since the *Second Edition* of this text, hybrid gasoline-electric cars are already on the roads, and cars powered by hydrogen-based fuel cells are being developed by every automobile company. Numerous university and industrial web sites detail research efforts in the amazing field of nanotechnology, exploring the development of molecular-scale computers and biosensors. And, behold, our genes have now been mapped, and the clues they hold to disease, aging, and the miracle of our biology are there to be uncovered.

On the other hand, the basic concepts of chemistry still form the essence of the course. The mass laws and the mole concept still inform the amounts of substances in a chemical reaction; atomic properties, and the periodic trends and types of bonding emerging from them, still determine molecular structure, which in turn still governs the forces between molecules and the resulting physical behavior of substances; and the central concepts of kinetics, equilibrium, and thermodynamics still account for the dynamic aspects of chemical change.

The challenge for a modern chemistry text, then, is to do two jobs at once: to present the fundamental principles clearly and to apply them to the emerging areas of chemistry today. Like chemistry itself, the *Third Edition* of *Chemistry: The Molecular Nature of Matter and Change* has evolved in important ways to meet this challenge. This Preface explains these changes, and the Guided Tour that follows shows actual pages from the book that demonstrate its features.

OVERALL APPROACH TO TEACHING CHEMISTRY

As a species evolves, most of the structures that work well and keep it thriving and successful stay the same. And so it is with an evolving textbook. The three essential themes developed in the first two editions—visualizing chemical models, thinking through a quantitative problem, and demonstrating the amazing relevance of chemistry to society—continue to help students learn chemistry.

Visualizing Chemical Models

Because chemistry deals with observable changes in the world around us that are caused by unobservable atomic-scale events, a size gap of mind-boggling proportions must be spanned. Throughout the text, concepts are explained at the macroscopic level and then from a molecular point of view, with the text's well-known, ground-breaking illustrations placed next to the discussion to bring the point home to today's visually oriented students.

Thinking Logically to Solve Problems

The problem-solving approach, based on a widely accepted, four-step method, is introduced in Chapter 1 and employed consistently throughout the text. It encourages students to first plan a logical approach to a problem, and only then proceed to solve it quantitatively. The Check, a step unique to this text and universally recommended by instructors, fosters the habit of assessing the reasonableness and magnitude of the answer. For practice and reinforcement, each worked problem is followed immediately by a similar one, for which an abbreviated solution is given at the end of the chapter.

Applying Ideas and Skills to the Real World

An understanding of modern chemistry influences a person's attitudes about public policy issues, such as the environment, health care, and energy use, while at the same time explains everyday phenomena, such as the spring in a running shoe, the workings of a ballpoint pen, and the fragrance of a rose. Today's students may enter one of the emerging chemically related, hybrid fields—biomaterials science, nanotechnology, or planetary geochemistry, for example—and their text should keep them abreast of such career directions. But this content is only useful if it advances understanding of a principle being discussed. In addition to countless passages in the main text, four key displayed features seen in the previous two editions—Chemical Connections, Tools of the Laboratory, Galleries, and Margin Notes—provide relevant handles for what may seem abstract ideas.

INNOVATIVE TOPIC TREATMENT

A look at the Detailed Contents shows another aspect of this evolving text that has helped it thrive and, thus, has not changed: a topic order common to most general chemistry courses that incorporates flexibility for instructors to customize their approach. Innovative topic treatments appear in each chapter, but the presentation of the chemistry of the elements, organic chemistry, and biochemistry are especially novel. Rather than leaving these important topics for the end of the course, they are optimally placed for relating principles just learned.

The Interchapter and Chapter 14 apply principles from Chapters 7–13 (atomic structure, periodicity, bonding, molecular shape and polarity, and physical states) to all the main-group elements, thus emphasizing the gradation in element properties, rather than fostering misleading divisions between metals and nonmetals. Chapter 15 is a natural extension of descriptive chemistry, showing how the chemistry of organic and biological compounds arises from the atomic properties of carbon and its few bonding partners. Chapter 22 follows the example of Chapter 14 by applying the principles of kinetics, equilibrium, thermodynamics, and electrochemistry from Chapters 16–21 to the geochemistry, environmental chemistry, and industrial chemistry of the elements. The extensive coverage of biochemistry, more than in any other mainstream text, forms a major portion of Chapter 15 and is integrated into many other chapters in the text, margin notes, and boxed essays. Topics explore molecular shape in physiology, solubility factors in the structures of cell membranes and the action of antibiotics, principles of catalysis that apply to enzymes, principles of equilibrium that relate to metabolic control, electrochemical processes that produce and utilize ATP, and many more.

WHAT'S NEW IN THE *THIRD EDITION*?

This edition evolved from extensive and very positive reviewer feedback, which indicated no need for major structural change. Nevertheless, to improve the overall usability for both student and instructor, several changes were made to improve the pedagogy and enhance the content.

Improving the Pedagogy

My guiding principle throughout the conception, writing, and illustrating of all three editions has been to create a "teaching" text, one with thorough explanations that foresee student confusion before it arises. In addition, the text is replete with learning aids, which are highlighted in the Guided Tour and in the comments to the student that follow this Preface. This edition has these improvements:

- Every paragraph was examined for clarity and directness.
- A cleaner, more open page layout improves readability. Many figures now appear in the text column to help clear the margins.
- The Plan sections of the sample problems are designed to simulate an interchange between student and instructor as they think through the solution. To clarify the process, every Plan now begins explicitly with the known, incorporating data from the problem statement, and points toward the unknown.
- More challenging problems have been added to each end-of-chapter problem set.
- Every figure or table is placed as close to the related text as possible; in only one or two instances must a student turn a page to see a figure being discussed.
- Many new figures that depict the observable and molecular levels simultaneously have been added, and many more molecular models have been included.
- All chapter end matter is now keyed to the text pages on which the items appear.
- Unit canceling is now color-coded for clarity.
- The worked sample problems are now attractively set off to delineate them clearly.
- Nearly every chapter now includes multimedia features—animation, demonstration, or movie—indicated by a margin icon.

Multimedia Icon

An icon indicates a multimedia feature is available. Click on www.mhhe.com/silberberg3. Multimedia features are available for instructors on the Chemistry Animations Library 2003 CD-ROM.

Enhancing the Content

Many detailed changes have been made to achieve the highest standards of accuracy and pedagogy, ranging from clarifying a definition to simplifying a calculation step to correcting a mineral source. But several significant changes were made in order to emphasize a concept, include a topic that was lacking, or make coverage more consistent and up-to-date. Here are the most extensive changes:

- Chapter 4 has been redesigned. Following a presentation of the polar nature of water, the chapter covers ionic equations and then devotes a section to each of the three reaction types—precipitation, acid-base, and redox. Focusing on elements as reactants or products allows a discussion of types of redox reactions and greater emphasis on activity series. The brief introduction to equilibrium now includes the idea of a constant ratio of products to reactants.
- Chapter 12 includes two topics in advanced materials. The first is the physical behavior of polymers, and the discussion highlights their mass, shape, crystallinity, and viscosity—quantitative concepts that allow meaningful homework problems. The second is an overhaul of the earlier coverage of nanotechnology, this time based on the latest material from government, industrial, and academic research labs.
- Chapter 16 now includes a more complete treatment of reaction order. Because of their importance in catalyzed processes, zero-order reactions are now covered alongside first- and second-order reactions.
- Chapter 20 now includes an exceptionally consistent treatment of entropy, and the concept of reversibility is used to clarify the relationship between free energy and work.
- Chapter 21 now employs the most widely approved method for calculating cell potential, based consistently on the half-cell potentials of the cathode and anode compartments.
- Discussions of ozone depletion (Chapter 16), acid rain (Chapter 19), batteries (Chapter 21), and radioactive tracers (Chapter 24) have been thoroughly updated using input from experts.

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A small army of exceptional people from publishing, academia, and industry helped give life to the *Third Edition*. Deepest thanks go, as always, to my team of consultants—Randy Duran, Peter Gold, Chuck Haas, and Arlan Norman—for their continued support and expert advice on countless points of content. I am extremely grateful to Bob Loeschen of California State University—Long Beach for his superb consulting on past editions.

In the final days of this revision, I was deeply saddened to learn that Peter Gold had passed away. From the beginning, Peter was a guiding force in shaping the content and pedagogy of the text; his insight, wit, and friendship will be sorely missed.

Many other professors played essential roles in creating this edition. Most fortunately, I again had the exceptional talents of Dorothy B. Kurland for the project, this time as in-depth reviewer of the entire manuscript. And I was privileged to have Jim Horvath of the University of Florida supply excellent advice and comments for three-quarters of the chapters. Expert contributors helped me keep key topics as up-to-date as possible: Randy Duran for the discussion of polymers (Ch. 12), Robert M. Metzger of the University of Alabama for the nanotechnology discussion (Ch. 12), Jonathan Kurland of Dow Chemical Company for the boxed essays on ozone depletion (Ch. 16) and acid rain (Ch. 19), Perla B. Balbuena of the University of South Carolina and John S. Newman of the University of California—Berkeley for the gallery on batteries (Ch. 21), and Sherry Yennello of Texas A&M University for the discussion of radioactive tracers (Ch. 24). The wide range of homework problems has been universally praised by users of the first two editions, and Joseph Bularzik of Purdue University—Calumet, S. Walter Orchard of Tacoma Community College, and Royale S. Underhill of the University of Florida helped me generate many excellent new ones for this edition. Thanks also to Scott Perry of the University of Houston for his general advice and guidance on media issues.

Modern texts are served by a battery of supplements, and this one is very lucky to have supplement authors so committed to accuracy and clarity for student and instructor. Once again, Elizabeth Bent Weberg wrote a superb *Student Study Guide*. Deborah Wiegand of the University of Washington and Tristine Samberg devoted themselves to creating an excellent *Student Solutions Manual*. Then, Brenda Woodward and Marcia Gillette of Indiana University—Kokomo created the *Instructor's Solutions Manual*, interacting continuously with the student manual authors to ensure consistency.

I am especially grateful for the support of the Board of Advisors, a select group of chemical educators dedicated to helping make this text the optimum teaching tool. The Board was formed during the revision and contributed insightful comments that shaped the edition in many significant ways. I look forward to working together on upcoming editions:

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Several excellent print and multimedia supplements have been prepared to accompany the text and make learning chemistry as meaningful and up-to-date as possible. You can order supplemental study materials by contacting your bookstore or the McGraw-Hill Customer Service Department at 1–800–338–3987.

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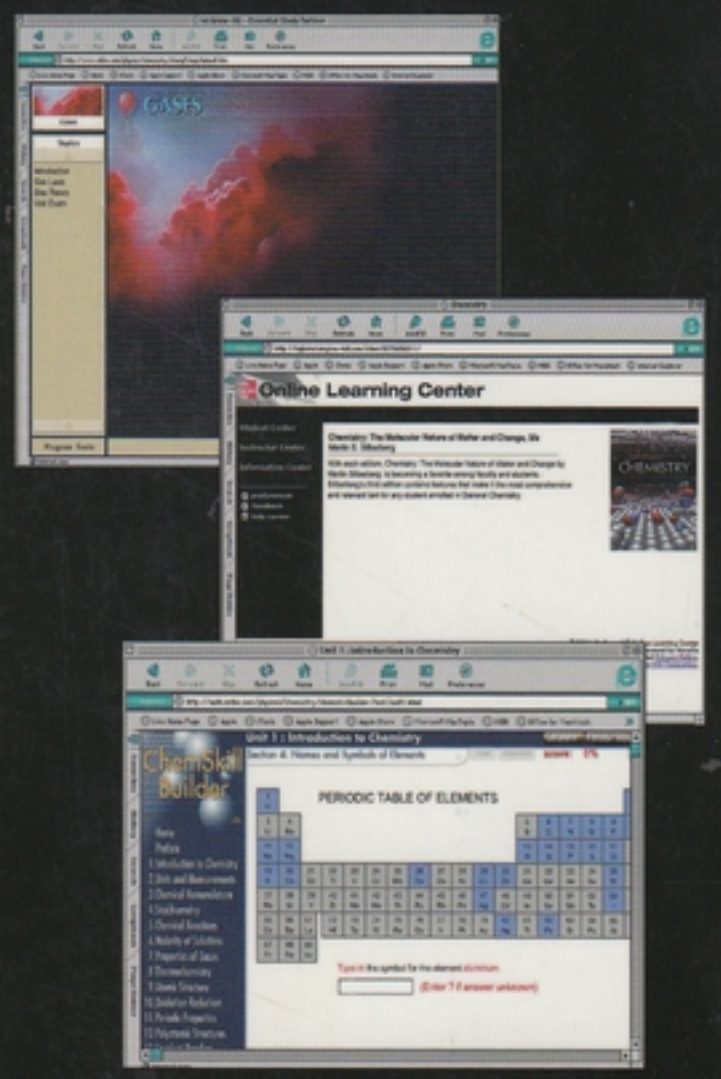

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This manual contains complete worked-out solutions to all follow-up problems and about one-half of all the chapter problems.

Student Study Guide, ISBN 0–07–241051–5

The guide contains numerous worked-out examples, key points to keep in mind, and a large number of additional problems (with answers) for self-test purposes.

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