The second edition of Silberberg’s Chemistry retains the clear writing style, strong problem-solving approach, and outstanding art program that received such high praise from users of the first edition. Some of the many improvements include:

• Every chapter extensively revised for clarity and directness.
• Opening Chapter Outline shows detailed list of topics.
• Concepts and Skills to Review from earlier chapters displayed at first paragraph of chapter.
• Discussions include many more subheads, displayed summaries, and lists of key ideas.
• All Chemical Connections and Tools of the Chemistry Laboratory boxes updated.
• New Margin Notes and Galleries.
• Every Sample Problem, Plan, and Check revised for clarity and updated to include more informative roadmaps.
• Numbered list of learning objectives end every chapter.
• End-of-chapter problems divided explicitly into types, with many molecular problems added and hundreds of new problems written.
• Highlighted Figures and Tables clearly displayed and listed at the end of each chapter.
• Numbered list of learning objectives end every chapter.
• End-of-chapter problems divided explicitly into types, with many molecular problems added and hundreds of new problems written.
• Enhanced art program.
• Many macro-to-molecular figures added to enhance pedagogy.
• Many molecular figures added that employ advanced modeling software to simultaneously display space-filling shape, ball-and-stick arrangement, and regions of relative electron density.
• Many photos added to demonstrate relevance.
• Page layout places figure and text nearby, with many figures wrapped by related text so students read and see simultaneously.

Organizational Changes

The text retains a flexible topic sequence perfectly suited to most modern courses, but several changes in chapter sequence and organization enhance the presentation:

• Discussion of Lewis structures moved from Chapter 9 to Chapter 10. Thus, Chapter 9 compares three types of bonding, and Chapter 10 focuses on depicting molecules.
• Discussion of valence-bond and molecular-orbital theories moved from Chapter 10 to its own new Chapter 11.
• Discussion of element behavior in nature and industry moved up to immediately follow and apply electrochemical principles.
• Nuclear chemistry moved back to (Chapter 24) the end of the text.

Major Content Changes

• Chapter 1 introduces macro-molecular theme in discussion of physical states.
• Chapter 2 introduces Coulomb’s Law in bonding discussion for later use in Chapters 8 and 9.
• Chapter 4 completely revised to highlight the three major reaction types (precipitation, acid-base, and redox). Introduction of Bronsted-Lowry proton transfer concept. Major new subsection on activity series of metals.
• Chapter 5 includes discussion of planetary atmospheres.
• Chapter 8 includes revised discussion on shielding and penetration that applies Coulomb’s law.
• Chapter 9 compares ionic, covalent, and metallic bonding models.
• Chapter 10 covers molecular shape from Lewis structure to VSEPR and molecular dipole. New Gallery on unusual new molecular shapes (fullerenes, nanotubes, cubanes, dendrimers).
• Chapter 11 devoted to valence-bond and molecular-orbital theories of covalent bonding.
• Chapter 12 includes major new section on advanced ceramics (liquid crystals, electronic semiconductors, modern nanotechnology).
• Chapter 13 contains more explicit coverage of entropy in solution behavior. New Gallery on colligative properties in nature and industry.
• Chapter 16 has greater emphasis on molecular visualization of transition state.
Overview of Chapter Content

Chapters 1-6: Chemical Fundamentals. The first block of chapters introduces the science of chemistry and covers some of the key concepts and skills students will use throughout the course. Topics include:

- The origins of chemistry, the scientific approach, the use of units in calculations, and the relevance of chemistry in everyday life.
- The historical development of atomic structure, an introduction to chemical bonding in the context of the periodic table, and the chemical language of compound names and formulas.
- Balancing equations and the quantitative relationships among amount, mass, and number of chemical entities of a substance.
- A first look at the types and essential nature of chemical change, with emphasis on precipitation, acid-base, and redox reactions.
- The physical behavior of gases and the molecular models that explain it.
- The relationship between heat released or absorbed and chemical change.

Chapters 7-13: Atomic and Molecular Structure. The second block of chapters highlights the emergence of physical and chemical behavior from the properties of atoms and molecules. Each chapter in this block builds upon the previous one. Topics include:

- The development of quantum theory and its application to modern atomic structure.
- The electronic structure of the atoms and how element properties recur throughout the periodic table.
- A comparison of ionic, covalent, and metallic bonding, their basis in atomic properties, and their manifestation in the properties of substances.
- The visualization of molecular shape and polarity from Lewis structures to VSEPR theory.
- The valence-bond and molecular-orbital treatments of covalent bonding.
- The influence of atomic properties and molecular shape on intermolecular forces and the physical properties of liquids and solids.
- The impact of intermolecular forces on the properties of solutions and the quantitative treatment of concentration.

The Interchapter and Chapters 14 and 15. Descriptive Inorganic and Organic Chemistry. Learning how the elements and their compounds actually behave makes concepts from earlier chapters come alive. This novel approach to descriptive chemistry can be covered here or at any later point in the course

- The Interchapter consists of concise text and summarizing illustrations to provide a unique conceptual overview of the major points from Chapters 7-13.
- Chapter 14 applies these earlier principles to all the main-group elements. Attractive, informative Family Portraits highlight key properties, reactions, and uses of the elements.
- Chapter 15 grounds organic chemistry in the atomic properties of carbon. Names, structures, and reaction patterns are covered, with a focus on common themes and major discussions of synthetic and biopolymers.

Chapters 16-21: Dynamic aspects of chemical change. The fourth block of chapters covers essential areas of physical chemistry and their applications. Topics include:

- The field of chemical kinetics, with emphasis on the information sequence of a kinetic study, how to devise reaction mechanisms, and the action of catalysts.
- The reversibility of reactions is covered in three chapters: the first emphasizes the nature of equilibrium in gaseous systems, the second deals with the three key models of acid-base behavior, and the third examines buffers, slightly soluble salts, and complex ions.
- The thermodynamic driving force behind all reactions and its connection with free energy and the work obtainable from a spontaneous change.
- The application of thermodynamic principles to electrochemical cells in the laboratory, in everyday practical devices, and in organisms.

Chapters 22-24: Special Topics. A final block of chapters covers specialized applications of chemistry. Topics include:

- The principles of kinetics, equilibrium, and thermodynamics (Chapters 16-21) applied to key environmental and industrial aspects of the elements.
- The principles of atomic trends and molecular structure applied to the transition elements and their unique types of compounds.
- The exploration of nuclear behavior, with applications to medicine, engineering, energy production, and many other fields.

Biochemistry extensively integrated. Instead of presenting biochemistry in a final, often-skipped chapter, the text includes more central biochemical ideas than other texts and incorporates them throughout to exemplify concepts in discussions, margin notes, boxed essays, and chapter problems. Moreover, a major portion of Chapter 15 is devoted to the structure and function of biological macromolecules.
Thinking Logically to Solve Problems

A critical aspect of Silberberg’s *Chemistry: The Molecular Nature of Matter and Change* employs modern learning strategies that enable students to develop a logical approach to solving problems by reasoning toward, not memorizing, a solution.

Four-Part Approach to Solving Problems

1) **Plan**

After a Problem is stated, it is analyzed and the steps are verbally planned to show how to move from what is known to what is unknown. Thus, the student thinks through the solution before performing calculations. Many solution plans include “roadmaps”, block diagrams that guide the student visually through the calculation steps.

2) **Solve**

Next, the plan is executed by naming each step and then carrying out the calculation.

3) **Check**

The next step is to check that the answer makes sense both chemically and mathematically. Sometimes a “Comment” appears about common pitfalls or alternative approaches.

4) **Practice**

A Follow-up Problem that requires the same procedure to solve appears immediately after the sample problem.

wherever an important new skill or concept is introduced, a worked-out sample problem appears. It incorporates a four-part problem-solving approach that helps the student analyze the given information and plan a strategy, work out a solution, check its reasonableness, and practice the skills learned.

5.3 The Gas Laws and Their Experimental Foundations

**Sample Problem 5.2** Applying the Volume-Pressure Relationship

**Problem** An apprentice of Boyle finds that the air trapped in a J tube occupies 24.8 cm³ at 1.12 atm. By adding mercury to the tube, he increases the pressure on the trapped air to 2.64 atm. Assuming constant temperature, what is the new volume of air (in L)?

**Plan** We must find the final volume ($V_2$) in liters, given the initial volume ($V_1$), initial pressure ($P_1$), and final pressure ($P_2$). The temperature and amount of gas are fixed. We convert the units of $V_1$ from cm³ to mL and then to L, rearrange the ideal gas law to the appropriate form, and solve for $V_2$. We can predict the direction of the change since $P$ increases, $V$ will decrease; thus, $V_2 < V_1$. (Note the two-part roadmap.)

**Solution** Summarizing the gas variables:

- $P_1 = 1.12 \text{ atm}$
- $V_1 = 24.8 \text{ cm}^3$ (convert to L)
- $P_2 = 2.64 \text{ atm}$
- $V_2 =$ unknown
- $T$ and $n$ remain constant

Converting $V_1$ from cm³ to L:

$$V_1 = 24.8 \text{ cm}^3 \times \frac{1 \text{ mL}}{1 \text{ cm}^3} \times \frac{1 \text{ L}}{1000 \text{ mL}} = 0.0248 \text{ L}$$

Arranging the ideal gas law and solving for $V_2$:

$$\frac{P_1V_1}{P_2V_2} = \frac{n_1}{n_2}$$

$$V_2 = \frac{P_1V_1}{P_2} = 0.0248 \text{ L} \times \frac{1.12 \text{ atm}}{2.64 \text{ atm}} = 0.0105 \text{ L}$$

**Check** As we predicted, $V_2 < V_1$. The pressure more than doubled, so $V_2$ should be less than $\frac{1}{2}V_1$ ($0.0105/0.0248 < \frac{1}{2}$).

**Comment** Predicting the direction of the change provides another check on the problem setup. To make $V_2 < V_1$, we must multiply $V_1$ by a number less than 1. This means the ratio of pressures must be less than 1, so the larger pressure ($P_2$) must be in the denominator, $P_1/P_2$.

**Follow-up Problem 5.2** A sample of argon gas occupies 105 mL at 0.871 atm. If the temperature remains constant, what is the volume (in L) at 26.3 kPa?

Answers to Follow-up Problems

<table>
<thead>
<tr>
<th>Problem</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1 (a) Moles of C = $\frac{335 \text{ mmol}}{12 \text{ mol C}} \times \frac{1 \text{ mol C}}{12 \text{ mol C}} = 0.028 \text{ mol C}$</td>
<td>3.2 (a) Mass (g) of $\text{P}_2\text{O}_5$ = $4.65 \times 10^{23} \times \frac{6.022 \times 10^{23} \text{ molecules P}_2\text{O}_5}{281.88 \text{ g P}_2\text{O}_5} = 21.9 \text{ g P}_2\text{O}_5$</td>
</tr>
<tr>
<td>(b) Mass (g) of Mn = $3.22 \times 10^{23} \times \frac{1 \text{ mol Mn}}{6.022 \times 10^{23} \text{ molecules Mn}} \times \frac{54.94 \text{ g Mn}}{1 \text{ mol Mn}} = 2.94 \times 10^{-5} \text{ g Mn}$</td>
<td>(b) No. of P atoms = $\frac{4 \text{ atoms P}}{1 \text{ molecule P}_2\text{O}_5} = 1.86 \times 10^{23} \text{ P atoms}$</td>
</tr>
</tbody>
</table>

End-of-Chapter Solutions to Follow-Up Problems

Answers to the Follow-Up Problems are actually brief solutions, not just the numerical answers seen in other texts. This feature effectively doubles the number of worked-out sample problems.
The second edition of *Chemistry*, like the first, is based on the central theme that matter and its changes are ultimately molecular in nature. A powerful illustration program works together with clear text discussions to emphasize this theme. The interplay between words and art helps students learn to magnify scenes in their imagination, as chemists do, thus bridging the mind-boggling gap between the events we see and those that cause them. The art program is so conceptual that, together with extensive figure legends, it provides another way for students to study.

### Three-Level Depictions of Chemical Events

Expanding upon the innovative approach originated in the first edition, the art program frequently juxtaposes photographs of a chemical process with accurate molecular views of it. The equation that symbolically and quantitatively describes it is also presented.
The Formation of Ionic Compounds

Ionic compounds are composed of ions, charged particles that form when an atom (or small group of atoms) gains or loses one or more electrons. The simplest type of ionic compound is a binary ionic compound, one composed of just two elements. It typically forms when a metal reacts with a nonmetal. Each metal atom loses a certain number of its electrons and becomes a cation, a positively charged ion. At the same time, the nonmetal atoms gain the electrons lost by the metal atoms and become anions, negatively charged ions. The resulting cations and anions attract each other through electrostatic forces and form the ionic compound. A cation or anion derived from a single atom is called a monatomic ion; we'll discuss polyatomic ions, those derived from a small group of atoms, later.

The formation of the binary ionic compound sodium chloride, common table salt, is depicted in Figure 2.18, from the elements through the atomic-scale electron transfer to the compound. In the electron transfer, a sodium atom, which is neutral because it has the same number of protons as electrons, loses one electron and forms a sodium cation, Na⁺. (The charge on the ion is written as a right superscript.) A chlorine atom gains the electron and becomes a chloride anion, Cl⁻. (The name change from the nonmetal atom to the ion is discussed in the next section.) Even the tiniest visible grain of

**Figure 2.18** The formation of an ionic compound. A, The two elements as seen in the laboratory. B, The elements as they might appear on the atomic scale. C, The neutral sodium atom loses 1 electron to become a sodium cation (Na⁺). The charge on the ion is written as a right superscript. A chlorine atom gains the electron and becomes a chloride anion, Cl⁻. (The name change from the nonmetal atom to the ion is discussed in the next section.) Even the tiniest visible grain of...
Applying Chemistry to the Real World

No other science is as relevant to everyday life as chemistry, and numerous examples of this relevance are woven throughout the text discussions, some of which are highlighted by these displayed features.

Boxed Essays

Tools of the Chemistry Laboratory essays describe key instruments and techniques in modern practice to show students that models depend on careful measurement.

To show the interdisciplinary nature of chemistry, Chemical Connections essays relate principles to topics in related fields (and possible student career goals)—including physiology, biochemistry, engineering, and environmental science.

Picturing Molecules

Tools of the Chemistry Laboratory essays describe key instruments and techniques in modern practice to show students that models depend on careful measurement.

More than 140 short, lively marginal essays focus on everyday and industrial examples, fascinating analogies, comparisons of scale, and historical themes, all consistently played out in the context of the chemical principles.

Marginal Notes

These illustrated summaries show how molecules and products in everyday life relate to chemical principles. Students will see how molecules range in size, how ball-point pens work, why gas bubbles are round, how flashlight batteries operate, and many other interesting applications of chemical ideas.
Reinforcing the Concepts of Chemistry

Education experts advise that reinforcement of concepts is crucial to learning. Some of the ways Chemistry provides this reinforcement are shown by these features.

End-of-Chapter Problem Solving

An exceptionally large number of problems follow each chapter. Three types of problems are keyed by chapter section:

- Concept Review Questions
- These test students’ qualitative understanding of key ideas in the chapter.

- Skill-Building Exercises
- Written in pairs, with one of each pair answered in the back of the book, these exercises begin simply and increase in difficulty, gradually weaning the student from multi-step directions.

This W eaning Process is a distinguishing feature of the text and demonstrates the pedagogy consciously built into the sequence of problems. For example, within a series of stoichiometry problems in Chapter 3, the first pair gives balanced equations and numbered steps, the second pair gives unbalanced equations and numbered steps, the third gives unbalanced equations and no steps, the fourth gives word equations and no steps, and the fifth pair requires a sequence of two equations and word equations and no steps.

- Problems in Context
- These problems apply the learned skills to interesting scenarios, including examples from industry, medicine, and the environment.

- Comprehensive Problems
- Following the section-based problems is a large group of more challenging problems based on concepts and skills from any section and/or earlier chapter.

Key Terms, Key Equations, and Highlighted Figures and Tables

This chapter end matter lists important displayed material from in-chapter discussions, including bold-faced terms (also defined in the Glossary), numbered equations, and figures/tables that cover major concepts.

Section Summaries

To explain the line spectrum of atomic hydrogen, Bohr proposed that the atom’s energy is quantized because the electron’s motion is restricted to fixed orbits. The electron can move from one orbit to another only if the atom absorbs or emits a photon whose energy equals the difference in energy levels (orbits). Line spectra are produced because these energy changes correspond to photons of specific wavelengths. Bohr’s model predicted the n = 1 atom spectrum but could not predict that of any other atom because electrons do not have fixed orbits. Despite this, Bohr’s idea that atoms have quantized energy levels is a cornerstone of our current model. Spectrophotometry is an instrumental technique in which emission and absorption spectra are used to identify and measure concentrations of substances.