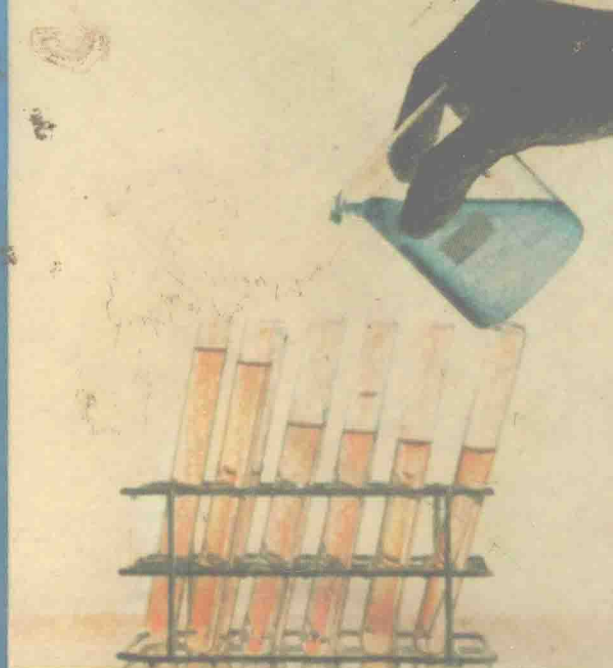
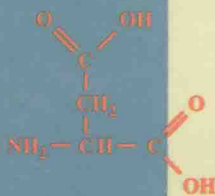
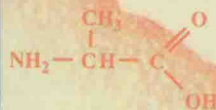


# Chemistry

*An Introduction to General, Organic,  
and Biological Chemistry*



Fifth Edition



Karen C. Timberlake



Fifth Edition

# Chemistry

*An Introduction to General, Organic,  
and Biological Chemistry*

Karen C. Timberlake

*Los Angeles Valley College*



HarperCollins Publishers

## TO MY FAMILY, FRIENDS, AND STUDENTS

*The whole art of teaching is only the art of awakening the natural curiosity of young minds.*—ANATOLE FRANCE

*One must learn by doing the thing; though you think you know it, you have no certainty until you try.*—SOPHOCLES

*Discovery consists of seeing what everybody has seen and thinking what nobody has thought.*—ALBERT SZENT-GYORGI

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# Preface

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Welcome to the Fifth Edition of *Chemistry: An Introduction to General, Organic, and Biological Chemistry*. It is my hope that the reshaping of this text over five editions has resulted in a book that makes teaching and learning chemistry an enthusiastic and positive experience for both the teacher and the student. It remains my goal to assist students in their development of critical thinking and to establish a scientific framework to give students the concepts and problem-solving techniques they will need to make decisions about major issues related to the environment, medicine, and health.

Over the years I have learned that many students find chemistry a formidable subject, and thus I have made a practice of associating chemistry concepts with applications from the health sciences and related fields. This bridge between chemistry and the world of the student is designed to help students recognize the chemistry that affects their lives and future careers. I have found discussions of applications of chemistry valuable in increasing student interest, motivation, concentration, and performance in class.

## New in This Edition

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In response to the needs of my own students and the suggestions of teachers and reviewers, several changes have been made in this Fifth Edition.

### Sample Problems

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Many sample problems with complete solutions are included in every chapter. Study Checks have been added to each sample problem to give students a chance to practice the illustrated problem types. This format continually involves the student with the immediate material through active participation in the patterns of problem solving it requires.

### Problem Sets

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The end-of-chapter problem sets have been expanded to engage the student in solving problems with a greater range of difficulty. The more difficult problems are identified by an asterisk (\*). A continuing feature is the keying of problems to the section heads and learning goals for easy reference to the chapter material. This also allows the student to select appropriate problems for any section. All of the answers to the end-of-chapter problems are given at the end of the book.

### Applications

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More applications to health in the form of Health Notes have been added, along with new Environmental Notes that relate chemistry to current concerns about the environment.



## Appendices

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Several new appendices have been included to provide additional reference material for the student. These appendices review common equalities and conversion factors, scientific (exponential) notation, percents as conversion factors, and some basic operations with the calculator including changing signs and recognizing scientific notation.

## Art Program

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Pedagogical changes include the use of full color to highlight major ideas. Illustrative photographs and new graphics add depth to the topics and enhance the learning experience. A larger page size allows a more attractive visual presentation. The wider margins include diagrams, tables, and photographs that illustrate the concepts.

## Content

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In each chapter, more difficult topics or extensions to the topics are placed at the end so they can be covered or omitted by the instructor without affecting the flow of learning throughout the chapter.

Chapter 1 incorporates the discussion of significant figures into the discussion of measurements. Chapter 2 covers temperature in conjunction with states of matter, energy, and calculations of heat energy. Chapter 3 has been reworked and includes a discussion of subshells and orbitals. Chapter 4 on bonding in compounds has been restructured to place polyatomic ions after covalent bonding. Chapter 5 covers chemical reactions and their equations and includes reactions in the atmosphere that produce smog. Also in Chapter 5, the process of writing conversion factors for the mole relationships in equations is carefully explained and then utilized in calculating quantities in reactions. Chapter 6 expands the discussion of imaging to include PET (positron emission tomography), CT (computerized tomography), and MRI (magnetic resonance imaging).

In Chapter 7 on gases, new graphics illustrate the gas relationships more clearly. All of the discussions of gas laws have been rewritten to clarify concepts. A discussion of the depletion of the ozone layer has been added. Chapter 8 covers the composition of solutions as well as their concentrations. The discussion of electrolytes and new material on solubility of salts is placed in Chapter 9 along with acids and bases and their reactions. The discussion of pH includes instructions for calculating the pH of solutions whose  $[H^+]$  do not have a coefficient of 1.

Chapter 10 introduces organic chemistry by discussing the alkanes. Chapter 11 covers the unsaturated hydrocarbons and the aromatic compounds, including a new section on some chemical reactions of benzene. Chapter 12 introduces oxygen- and sulfur-containing functional groups and Chapter 13 discusses carboxylic acids and their derivatives, esters and amides. Physical properties of many classes of organic compounds are now included.

Chapter 14 begins the biomolecular section with a rewritten chapter on carbohydrates, including a new explanation of chirality of sugars and a new section on the formation of glycosidic bonds by monosaccharides. The introduction to hemiacetals and acetals now precedes Haworth structures. The formation of glycosides now precedes disaccharides. More biochemical applications have been

incorporated into these chapters for classes that do not complete the biochemistry portion of the text. Chapter 15 discusses the lipid family and includes cerebro-sides in glycolipids. Chapter 16 on proteins has information on sequencing of amino acids in the primary protein structure. New features include coverage of endorphins, a summary of protein structural levels, and classification of proteins by composition. Chapter 17 contains a rewritten section on classification of enzymes and enzyme inhibition. Included in this chapter is a discussion of hormones and their effects on enzyme action. The classification of enzymes, vitamins, and protein and steroid hormones is now presented in tabular form. Chapter 18, on nucleic acids, now follows enzymes and proteins to complete the biomolecules and protein synthesis. Recombinant DNA is included in the discussion of DNA replication. New features include coverage of viruses and cancer. Chapter 19 provides an exploration of metabolic pathways that produce energy in the cell and a discussion of the ways in which energy is utilized. New features include ATP energy in muscle contraction, the fermentation of pyruvic acid by yeast, and the synthesis of fatty acids and nonessential amino acids.

## To Accompany the Text

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### Study Guide

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The *Study Guide* reviews the basic concepts, provides learning drills, and gives a practice exam, all with answers, for each chapter. All sections are keyed to the learning goals in the text so students may cross-reference working tools. Students can grade their own practice exams and then check to determine whether they have mastered the material. In this way, they can identify areas of difficulty and review the material again.

### Laboratory Manual

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The early experiments in the *Laboratory Manual* introduce students to basic laboratory skills. Students then learn to do laboratory investigations, developing the skills of manipulating laboratory equipment, gathering and reporting data, problem solving, calculating, and drawing conclusions. In this edition, as in the past, there is an emphasis on safety in the laboratory. Hazardous chemicals and procedures that are regarded as dangerous have been omitted. For each experiment, there is a report page and a set of questions that relate the laboratory to the corresponding information in the text. Some questions require essay-type answers to promote writing skills in science.

### Instructor's Manual

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The *Instructor's Manual* gives chapter overviews, suggestions for lecture demonstrations, and selected solutions to worked-out problems. Experiments related to each chapter are described, and the materials required for 10 students are listed. Instructions for preparing any special solutions are included, and the laboratory skills to be demonstrated for the students are described. A complete set of sample laboratory reports from the laboratory manual completes the instructor's manual.

## Test Bank

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The printed **Test Bank** contains more than 500 multiple-choice, true-false, and matching questions and their answers. The test bank is also available on **Harper-Test** for the IBM-PC or Macintosh computer. This software allows you to scramble questions, add new questions, and select questions based on level of difficulty.

## Transparencies

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Instructors who adopt the test will receive a set of 100 two- and four-color transparency acetates providing figures and illustrations from the text.

## Acknowledgments

---

I wish to thank my husband Bill for his invaluable assistance, repeated reviews of manuscripts and supplements, and continued support. Thanks to my son John for his cooperation and help in the preparation of this edition of the text and supplements.

The following people provided outstanding reviews that were extremely helpful with their constructive and helpful criticism and support, for which I am most grateful:

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Many thanks to the people at HarperCollins Publishers who believe in my approach to teaching chemistry and continually encourage and support me: Jane Piro, Editor; Louise Howe, Developmental Editor; Kristin Syverson, Project Editor; and Heidi Fieschko, Designer.

Writing a chemistry text is an ongoing process as students, teachers, and concepts change. I believe that teaching chemistry involves more than a transmission of chemical facts; teaching also means fostering positive attitudes toward science, encouraging students to use new thinking patterns and problem-solving techniques, and helping students to develop their reasoning powers. With this aim, I have revised *Chemistry*. I look forward to your use of this text and to hearing from both you and your students. I welcome any suggestions, criticism, or overall comments on this revision.

Karen C. Timberlake  
Los Angeles Valley College  
Van Nuys, CA 91401



# To the Student

**H**ere you are in chemistry, perhaps because you need a science course or just because you want to find out something about chemistry. Maybe you want to be a nurse or respiratory therapist or to enter some profession in the health sciences. If so, as you progress through this text, you will discover that chemistry is indeed exciting to learn and that it has an important relationship to the world around you. Every chapter in this Fifth Edition includes many applications of chemistry to health, medicine, and the environment. Your interest in the sciences will help you learn chemistry, and by learning chemistry you will gain a deeper understanding of physiology, medical care, and major issues of today, including pollution, global warming, the ozone layer, acid rain, nuclear energy, and recombinant DNA.

I have designed this text with you in mind. To aid your learning process, each chapter begins with a set of learning goals that tell you what to expect in the chapter and what you need to accomplish. Also at the beginning of each chapter is a section called **Scope** that relates experiences that involve the text material to your life or to specific health science areas and sets the stage for the chemical concepts discussed throughout the chapter.

As you progress through each chapter, take time to consider the learning goal for each section. To see if you have mastered the goal, do the example problems and study checks in the section. If you have difficulty with an example, study that part of the unit again before you proceed. For further self-testing, work the problems that are keyed to each section at the end of the chapter. You can check your answers by referring to the answer section in the back of the text. It is not necessary to study a chapter all the way through at one time. Instead, you may wish to cover only a few of the goals each time you study. Also, you can prepare for lecture by reading ahead in the text.

To review your knowledge of the important ideas in a chapter, read over the glossary at the end of the chapter. Study the tables and figures, which emphasize important concepts.

The study of chemistry involves some hard work, but I hope that you will find the effort rewarding when you see and understand the role of chemistry in many related fields. If you would like to share your feelings about chemistry or comments about this text, I would appreciate hearing from you.



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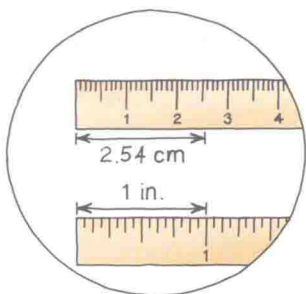
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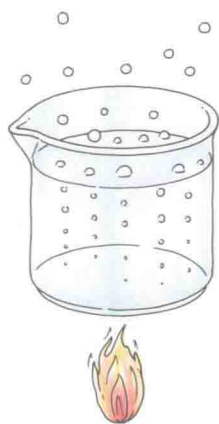
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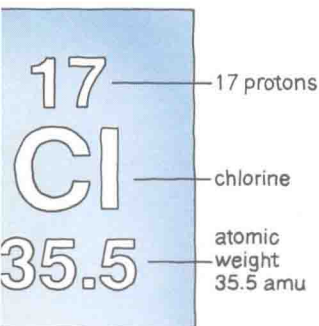
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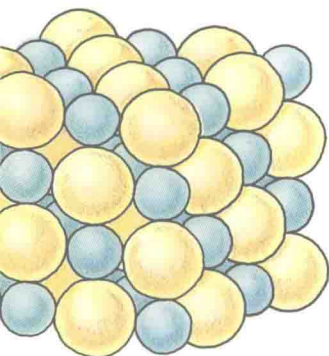
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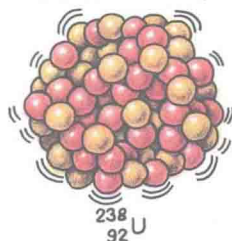
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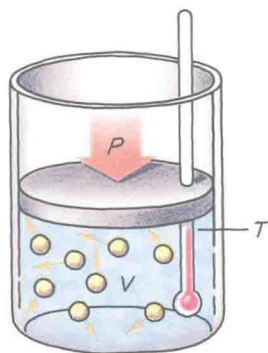
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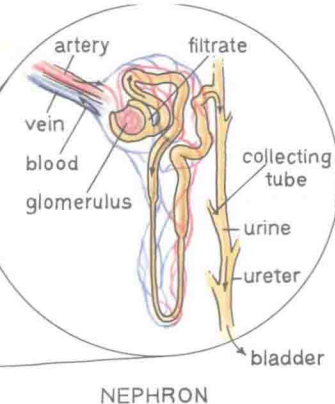
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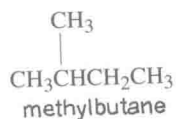
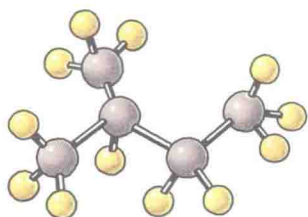
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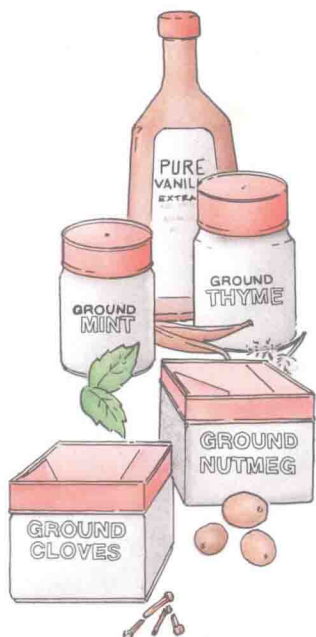
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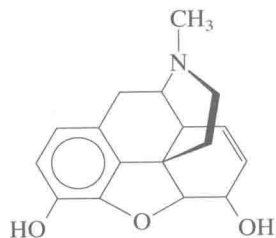
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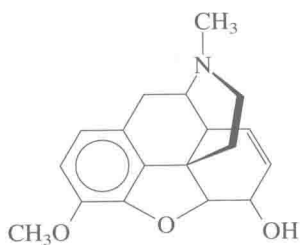


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Morphine  
(opium)



Codeine

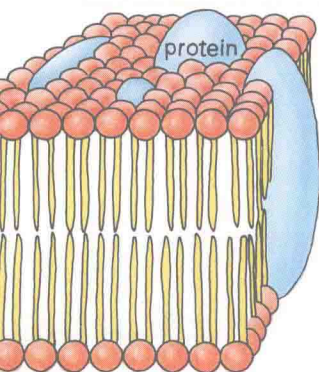
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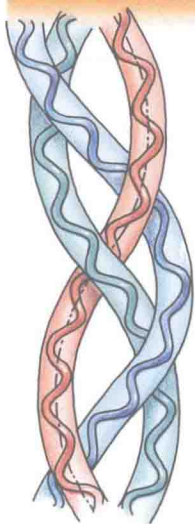
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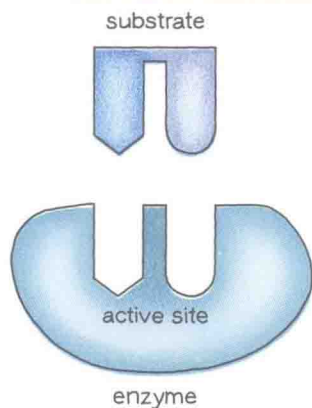
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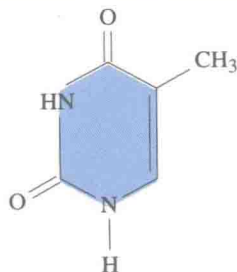
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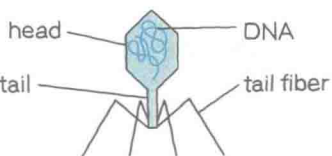


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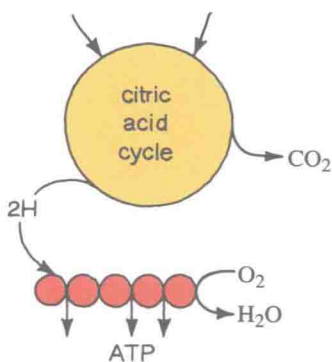


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1L = 10dL  
1L = 1000mL  
1dL = 100mL

# 1

## Measurements

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### *Learning Goals*

- 1.1 Write the names and symbols for the metric units used in measurements of length, volume, and mass.
- 1.2 Write the numerical value or name of a metric prefix.
- 1.3 Write an equality for two metric units used in measurements of length, volume, or mass.
- 1.4 Report answers to calculations using the correct number of significant figures.
- 1.5 Write a conversion factor for two units that describe the same quantity.
- 1.6 Set up a problem using one or more conversion factors to change from one unit to another.
- 1.7 Calculate the density or specific gravity of a substance, and use the density or specific gravity to calculate the mass or volume of a substance.

*The metric system has been adopted by scientists and health professionals all over the world. In many countries, it is used in everyday settings as well.*