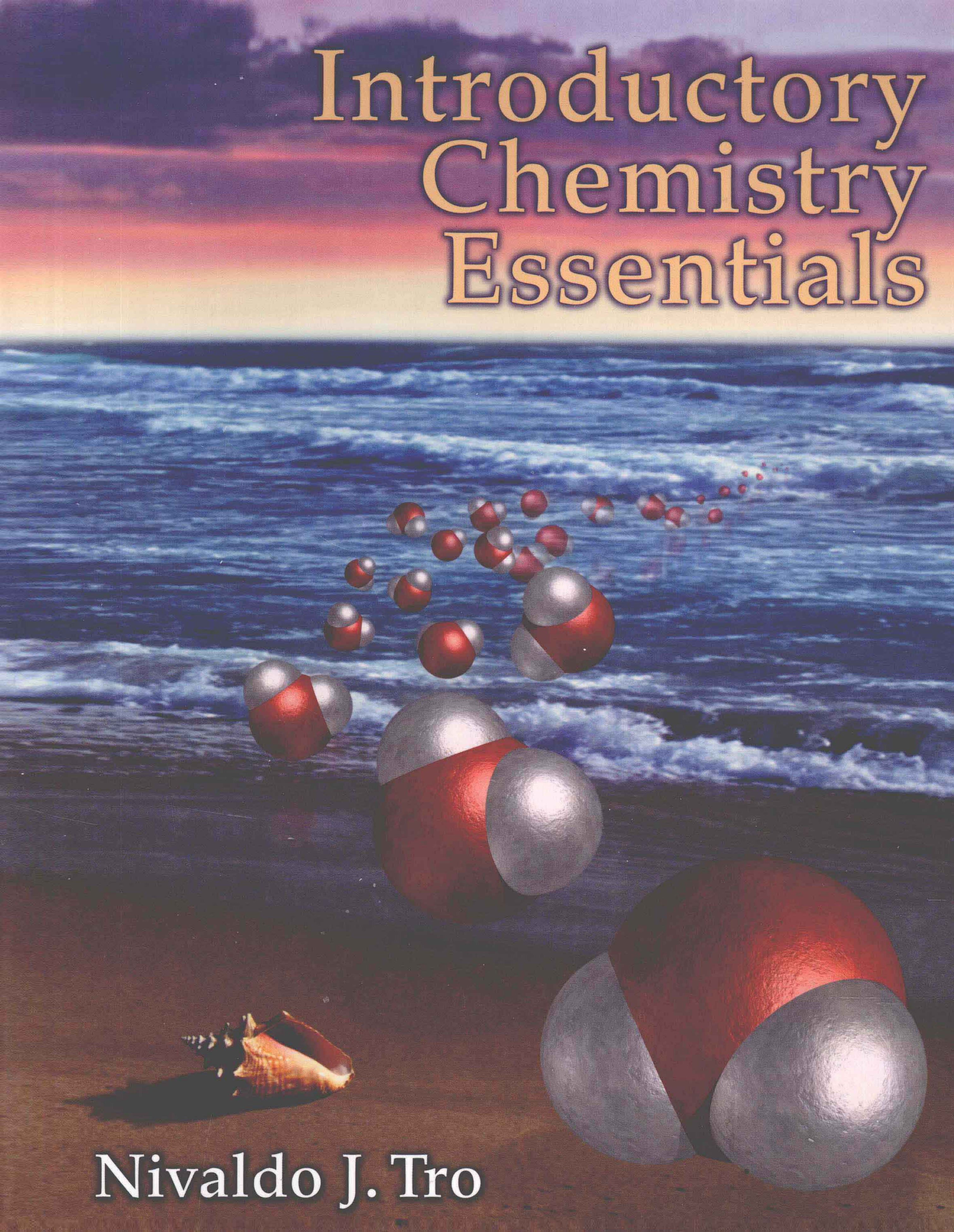
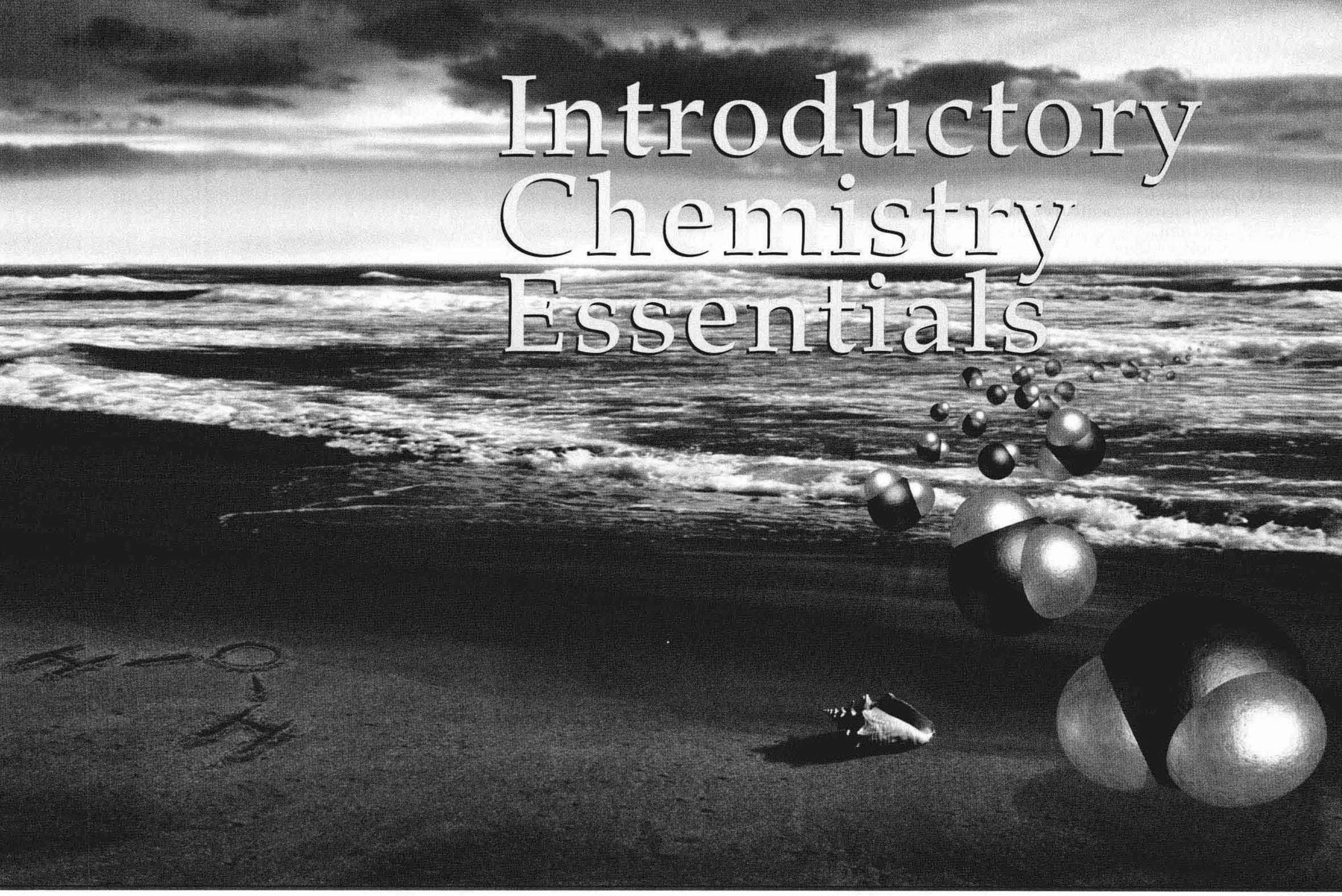
Introductory Chemistry Essentials



Nivaldo J. Tro



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Nivaldo J. Tro

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Prentice Hall

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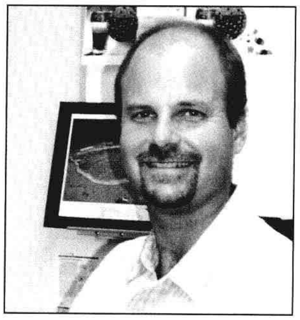
Introductory Chemistry Essentials

TO ANNIE

ABOUT THE AUTHOR



Professor Tro has been a faculty member at Westmont College in Santa Barbara, California, since 1990. He received his B.A. degree in chemistry from Westmont College in 1985 and his Ph.D. from Stanford University in 1989. He performed post-doctoral research at the University of California at Berkeley. He was honored as Westmont's outstanding teacher of the year in 1994 and again in 2001. He was also honored as Westmont's outstanding researcher of the year in 1996.

Professor Tro lives in Santa Barbara with his wife, Ann, and their three children, Michael, Alicia, and Kyle. For leisure, he enjoys snowboarding, camping, biking, and wakeboarding with his family.

TO THE STUDENT

This book is for you, and every text feature has you in mind. I have two main goals for you in this course: to see chemistry like you never have before, and to develop the problem-solving skills you need to succeed in introductory chemistry.

I want you to experience chemistry in a new way. Each chapter of this book is written to show you that chemistry is not just something that happens in a laboratory, but that chemistry surrounds you at every moment. I have worked with several outstanding artists to develop photographs and art that help you visualize the molecular world. From the opening example to the closing chapter, you will see chemistry. I hope that, when you finish this course, you think differently about your world because you understand the molecular interactions that lurk beneath everything around you.

I also want you to develop problem-solving skills. No one succeeds in chemistry—or in life, really—without the ability to solve problems. I can't give you a formula for problem solving, but I can give you strategies and help you to develop the chemical intuition you need to understand chemical reasoning. Look for several recurring structures throughout this book designed to help you master problem solving. The two most important ones are the solution map, a visual aid that helps you navigate your way through a problem, and the multi-column examples, where you learn a problem-solving procedure as you see it applied to two different examples.

Lastly, know that chemistry is not reserved only for those with some special talent or special capability. With the right amount of effort and some clear guidance, anyone can master chemistry, including you.

Sincerely,

Nivaldo J. Tro
tro@westmont.edu

TO THE INSTRUCTOR

Introductory Chemistry Essentials is designed for a one-semester, college-level, introductory or preparatory chemistry course. The goal of the book is to teach chemical principles and build chemical skills in a truly relevant context. Students taking this course need to develop problem-solving skills—but they also must see *why* these skills are important to them and to their world. *Introductory Chemistry Essentials* extends chemistry from the laboratory to the student's world. It motivates students to learn chemistry by demonstrating how chemistry plays out in their everyday lives.

This is a visual book. Today's students often learn by seeing, so wherever possible, I have used images to help communicate the subject. For example, in developing problem-solving skills, I use a solution map to help students see the general logic of working through a multi-step problem. I have also developed multi-column examples, where students learn a problem-solving procedure as they see it applied to two different examples at once. In developing chemical principles, I have worked with several artists to develop multi-part images that show the connection between everyday processes visible to the eye and the molecular interactions responsible for these processes. This book is designed to meet the students where they are and bring them to the level that they need to be.

I hope that you find as much joy in using this book as I have in teaching students the fundamental principles of the chemistry that surrounds them. It is a worthwhile cause, even though it requires constant effort. Please feel free to email me (tro@westmont.edu) with any questions or comments you might have. I look forward to hearing from you as you use this book in your course.

Sincerely,

Nivaldo J. Tro
tro@westmont.edu

PREFACE

The design and features of this book represent a conscious, deliberate, and sustained effort to achieve, in our students, the goals of the book—teaching chemical principles, and building chemical skills in the context of relevance. Students must understand chemical concepts, solve chemical problems, and understand why they are important.

Chemical Principles

The understanding of basic chemical principles and concepts in topics such as atomic structure, chemical bonding, chemical reactions, and gas laws is critical to the success of the introductory chemistry student. Students should understand the principles they need to succeed in the normal general chemistry sequence. The book integrates qualitative and quantitative material and proceeds from concrete concepts to more abstract ones.

The main divergence in topic ordering among instructors teaching preparatory chemistry courses is the placement of electronic structure and chemical bonding. Should these topics come early, at the point where models for the atom are being discussed? Or should they come later, after the student is exposed to chemical compounds and chemical reactions? Early placement gives the student a theoretical framework out of which they can understand compounds and reactions. However, it might also present students with abstract models before they understand why they are necessary. I have chosen a later placement for the following reasons:

1) *A later placement seems more flexible.* An instructor who wants to cover atomic theory and bonding earlier can simply cover Chapters 9 and 10 after Chapter 4. However, if atomic theory and bonding were placed earlier, it would be more difficult for the instructor to skip these chapters and come back to them later.
2) *A later placement allows earlier coverage of topics that students can more easily visualize.* Coverage of abstract topics too early in a course can lose some students. Chemical compounds and chemical reactions can be more tangible than atomic orbitals, and the relevance of these is easier to demonstrate to the beginning student.
3) *A later placement gives students a reason to learn an abstract theory.* Once students learn about compounds and reactions, they are more easily motivated to learn a theory that explains the underlying causes behind them.
4) *A later placement follows the scientific method.* In science, we normally make observations, form laws, and then build models or theories that explain our observations and laws. A later placement reflects this ordering.

Nonetheless, I know that every course is unique and that each instructor chooses to cover topics in his or her own way. Consequently, I have written each chapter for maximum flexibility in topic ordering. In addition, the book is offered in two formats. ***Introductory Chemistry***, the full version, contains 19 chapters and includes organic chemistry and biochemistry. Since some courses do not cover these two topics, we offer ***Introductory Chemistry Essentials***, which contains 17 chapters and omits these topics.

Problem-Solving Skills ▶

The development of problem-solving skills is the other main goal of this text; it is often the primary reason that students take introductory/preparatory chemistry. To this end, *Introductory Chemistry* develops a systematic approach to problem solving. Problem-solving skills are emphasized throughout each chapter, developed through many in-chapter examples, reinforced with *skillbuilder* exercises immediately following each example, reviewed in unique chapter summaries, and practiced and synthesized in end-of-chapter exercises.

EXAMPLE 2.11 **Solving Multistep Unit Conversion Problems**

A running track measures 0.250 mi per lap. To run 10.0 km, how many laps should you run?

We set up the problem in the standard way.

Given: 10.0 km

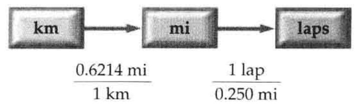
Find: laps

Conversion Factors: 1 lap = 0.250 mi

0.6214 mi = 1 km

We then build our solution map, focusing on the units and how to get from km to laps.

Solution Map:



We then follow the solution map to solve the problem.

Solution:

$$10.0\ \text{km} \times \frac{0.6214\ \text{mi}}{1\ \text{km}} \times \frac{1\ \text{lap}}{0.250\ \text{mi}} = 24.856\ \text{laps} = 24.9\ \text{laps}$$

The intermediate answer (blue) in blue is rounded to three significant figures as limited by the given quantity, 10.0 km. The units of the answer are correct and the value of the answer makes sense—a lap is shorter than a km, so the value in laps should be larger than the value in km.

SKILLBUILDER 2.11 **Solving Multistep Unit Conversion Problems**

A running track measures 1056 ft per lap. To run 15.0 km, how many laps should you run? 1 mi = 5280 ft

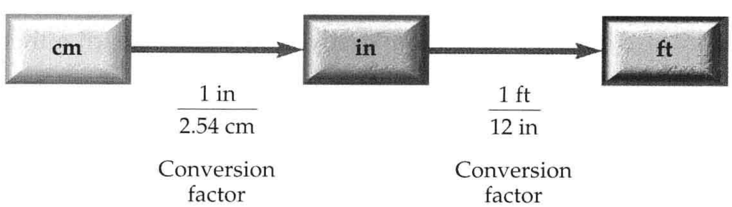
SKILLBUILDER PLUS

Convert 5.72 nautical mi to meters. A nautical mile is equal to 1.151 mi.

Solution Maps

Many problems in this course can be solved using dimensional analysis, so this is an emphasis of the early chapters. The text presents students with a basic procedure for solving most chemical problems. Part of this procedure uses a unique visual approach in which students draw a *solution map* to the problem. In this map, students outline the steps—using conversion factors and equations—that are required to get from the information they are given to the information they are trying to find. They can follow their map to solve the problem. The map is a good way for students to get an overview of how the problem is solved. ▼

Solution Map:



Once the solution map is complete, we follow it to solve the problem.

Solution:

$$194\ \text{cm} \times \frac{1\ \text{in.}}{2.54\ \text{cm}} \times \frac{1\ \text{ft}}{12\ \text{in.}} = 6.3648\ \text{ft}$$

Multi-Column Examples

Unique to this book are the multi-column examples, where students learn a problem-solving procedure as they see it applied to two different examples simultaneously. The student can then use the same procedure to solve the two accompanying skillbuilder exercises. ▼

Solving Unit Conversion Problems

1. Write down the *given* quantity and its unit(s).
2. Write down the quantity that you are asked to *find* and its unit(s).
3. Write down the appropriate *conversion factor(s)*. Some of these will be given in the problem. Others you find in tables within the text.
4. Write a *solution map* for the problem. Begin with the *given* quantity and draw an arrow symbolizing each conversion step. Below each arrow, write the appropriate conversion factor for that step. Focus on the units. The solution map should end at the *find* quantity.
5. Follow the solution map to solve the problem. Begin with the *given* quantity and its units. Multiply by the appropriate conversion factor(s), canceling units, to arrive at the *find* quantity.
6. Round the answer to the correct number of significant figures. Follow the significant figure rules in Sections 2.3 and 2.4. Remember that exact conversion factors do not limit the number of significant figures in your answer.
7. Check your answer. Make certain that the units are correct and that the magnitude of the answer makes physical sense.

EXAMPLE 2.8

Unit Conversion

Convert 7.8 km to miles.

Given: 7.8 km

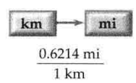
Find: mi

Conversion Factors:

$$1\ \text{km} = 0.6214\ \text{mi}$$

(This conversion factor is from Table 2.3.)

Solution Map:



The conversion factor is written so that km, the unit we are converting *from*, is on the bottom and mi, the unit we are converting *to*, is on the top.

Solution:

$$7.8\ \cancel{\text{km}} \times \frac{0.6214\ \text{mi}}{1\ \cancel{\text{km}}} = 4.84692\ \text{mi}$$

$$4.84692\ \text{mi} = 4.8\ \text{mi}$$

We round to two significant figures since the quantity given has two significant figures. (If possible, obtain conversion factors to enough significant figures so that they do not limit the number of significant figures in the answer.)

The units, mi, are correct. The magnitude of the answer is reasonable. A mi is longer than a km, so the value in mi should be smaller than the value in km.

SKILLBUILDER 2.8

Unit Conversion

Convert 56.0 cm to inches.

EXAMPLE 2.9

Unit Conversion

Convert 0.825 m to millimeters.

Given: 0.825 m

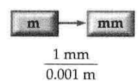
Find: mm

Conversion Factors:

$$1\ \text{mm} = 10^{-3}\ \text{m}$$

(This conversion factor is from Table 2.2.)

Solution Map:



The conversion factor is written so that m, the unit we are converting *from*, is on the bottom and mm, the unit we are converting *to*, is on the top.

Solution:

$$0.825\ \cancel{\text{m}} \times \frac{1\ \text{mm}}{10^{-3}\ \cancel{\text{m}}} = 825\ \text{mm}$$

$$825\ \text{mm} = 825\ \text{mm}$$

We leave the answer with three significant figures since the quantity given has three significant figures and the conversion factor is a definition, which therefore does not limit the number of significant figures in the answer.

The units, mm, are correct and the magnitude is reasonable. A mm is shorter than a m, so the value in m should be smaller than the value in mm.

SKILLBUILDER 2.9

Unit Conversion

Convert 5,678 m to kilometers.

Molecular Art

Many chemical principles involve making a connection between atoms and molecules and the properties of the substances they compose. For example, electronic structure shows how the reactivity of elements is related to the electron configuration of their atoms. The gas laws show how pressure, volume, and temperature are related to gas particles and their motions and collisions. The art program helps students visualize this connection between the molecular world and the macroscopic world. Many concepts are portrayed using a two-part visual image. One part of the image is a photograph of a real world object or process, such as an inflated balloon, for example. The second part, either superimposed on the photograph or shown as a magnification window, shows what the molecules magnified by many orders of magnification are doing in the photograph. For the balloon, molecules are superimposed on the photograph to show how their collisions with the balloon's walls keep it distended. Many molecular formulas will be portrayed, not only with structural formulas, but also with space-filling drawings of the molecule; the idea is to portray the beauty and form of the molecular world. ▼

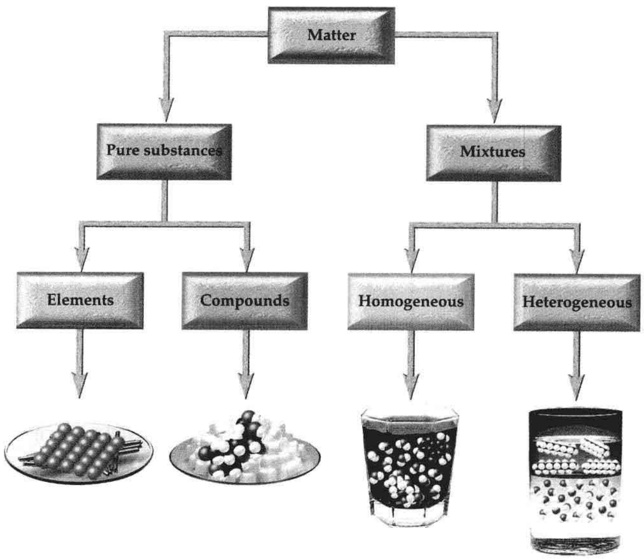


Figure 3.8 Classification of matter. Matter may be a pure substance or it may be a mixture. A pure substance may either be an element or a compound, and a mixture may be either homogenous or heterogeneous.

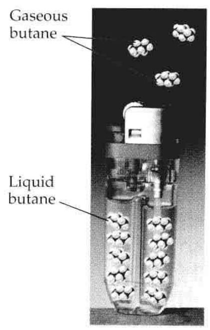


Figure 3.11 If you push the button on a lighter without turning the flint, some of the liquid butane vaporizes to gaseous butane. Since the liquid butane and the gaseous butane are both composed of butane molecules, this is a physical change.

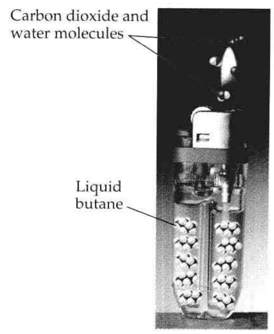


Figure 3.12 If you push the button *and* turn the flint to create a spark, you produce a flame. The butane molecules react with oxygen molecules in air to form new molecules, carbon dioxide and water. This is a chemical change.

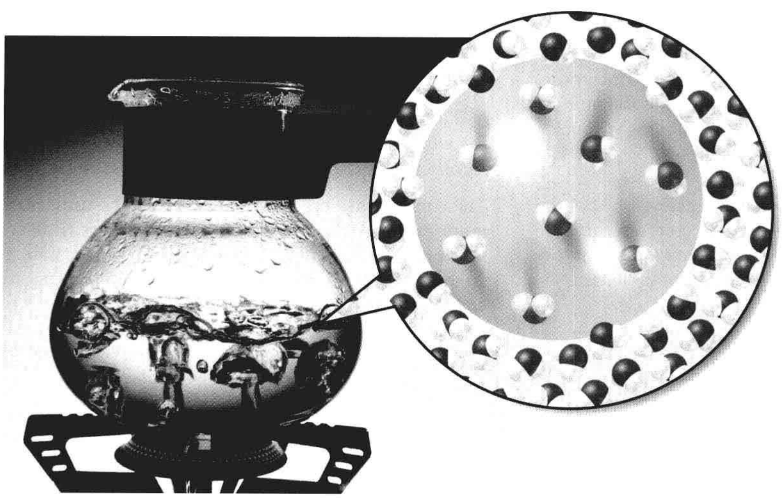


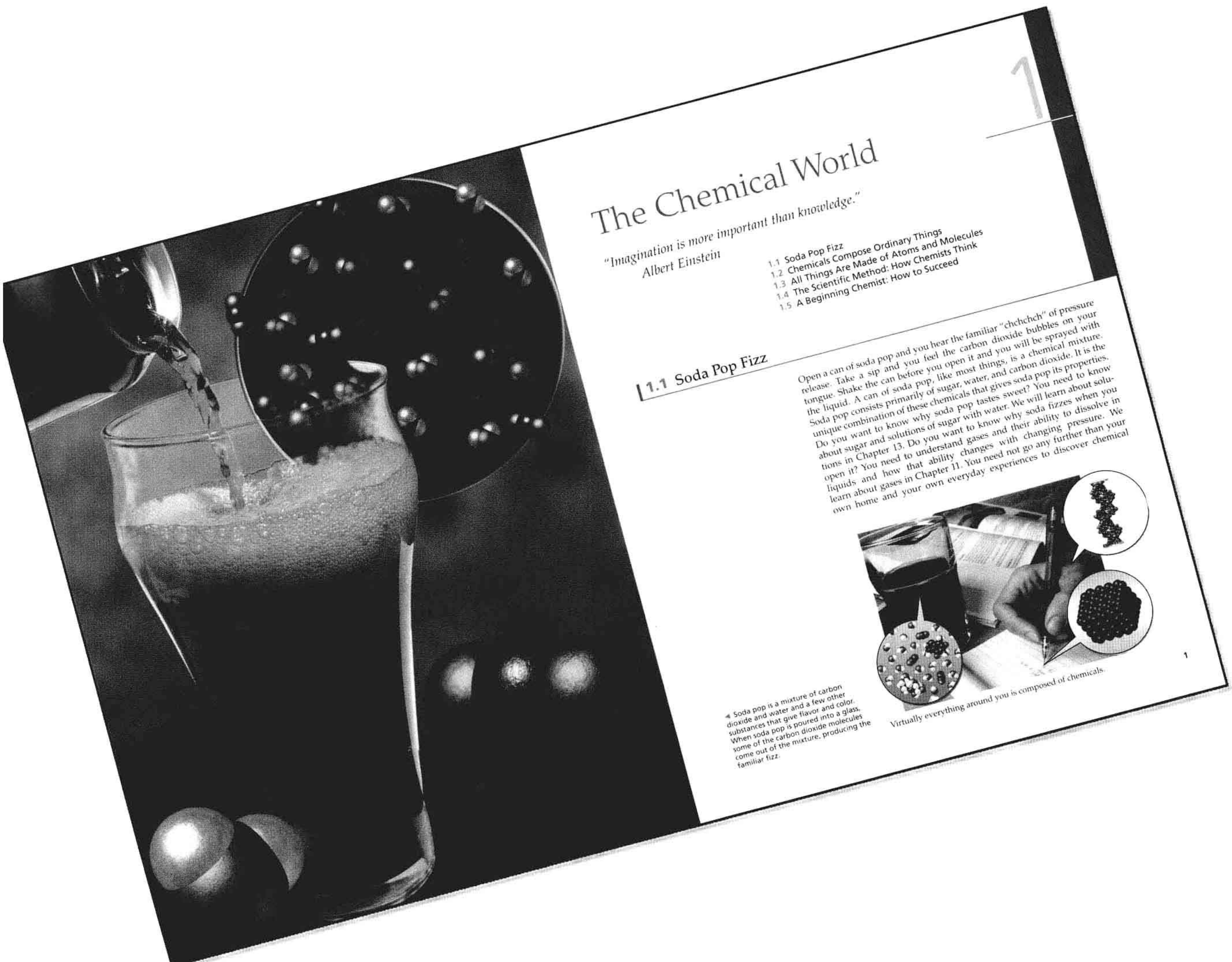
Figure 12.13 During boiling, thermal energy is enough to cause water molecules in the interior of the liquid to become gaseous, forming bubbles containing gaseous water molecules.

Generating Interest in Chemistry

Interest in the field of chemistry and in the topic under study is generated using two recurring features: the chapter openers and interest boxes.

Chapter Openers

The first feature in the opening section of every chapter presents a description of something practical and applied that clearly demonstrates the need for the material covered in that chapter. These openers often involve consumer, environmental, or societal issues. For example, the chapter on stoichiometry opens by making the connection between how much gasoline is burned each year and how much carbon dioxide, the most significant greenhouse gas, is emitted into the atmosphere. The chapter on chemical bonding begins with a description of how bonding theories helped scientists develop AIDS drugs. These narrative chapter introductions are accompanied by a striking piece of art by Quade Paul that portrays visually the chemistry underlying an everyday event. Chapter openings such as these give students a clear reason for why they are learning the current topic. The topics in preparatory chemistry are foundational to so many important things—we simply need to show students examples so that they can make a connection between the principles and skills they are learning and the real world. ▼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The Chemical World

"Imagination is more important than knowledge."
Albert Einstein

1.1 Soda Pop Fizz
1.2 Chemicals Compose Ordinary Things
1.3 All Things Are Made of Atoms and Molecules
1.4 The Scientific Method: How Chemists Think
1.5 A Beginning Chemist: How to Succeed

1.1 Soda Pop Fizz

Open a can of soda pop and you hear the familiar "chchchch" of pressure release. Take a sip and you feel the carbon dioxide bubbles on your tongue. Shake the can before you open it and you will be sprayed with the liquid. A can of soda pop, like most things, is a chemical mixture. Soda pop consists primarily of sugar, water, and carbon dioxide. It is the unique combination of these chemicals that gives soda pop its properties. Do you want to know why soda pop tastes sweet? You need to know about sugar and solutions of sugar with water. We will learn about solutions in Chapter 13. Do you want to know why soda fizzes when you open it? You need to understand gases and their ability to dissolve in liquids and how that ability changes with changing pressure. We learn about gases in Chapter 11. You need not go any further than your own home and your own everyday experiences to discover chemical

◀ Soda pop is a mixture of carbon dioxide and water and a few other substances that give flavor and color. When soda pop is poured into a glass, some of the carbon dioxide molecules come out of the mixture, producing the familiar fizz.

Virtually everything around you is composed of chemicals.

1

Interest Boxes

The second feature is the frequent use of interest boxes. ***Introductory Chemistry*** has four types of interest boxes:

- Everyday Chemistry
- Chemistry in the Media
- Chemistry in the Environment
- Chemistry and Health

The *Everyday Chemistry* boxes describe what is happening with molecules and atoms in common, everyday processes. For example, a number of recent children's toys and clothing will change color based on temperature changes. A bowl changes from green to yellow when filled with warm oatmeal, or a shirt becomes two-toned because of body warmth. The *Everyday Chemistry* box describes, in chemical terms, what molecules do that explain these phenomena. *Chemistry in the Media* boxes describe chemical topics that have gained recent media attention. For example, a discussion on limiting reagent has a *Chemistry in the Media* box discussing the controversy over oxygenated fuels and MTBE. *Chemistry in the Environment* boxes describe environmental issues relevant to the subject under study. *Chemistry and Health* boxes describe chemistry and health related topics. Often interest boxes such as these are contrived, or they show little relevance to the topic under study. The interest boxes in ***Introductory Chemistry*** all contain questions that relate directly to the chapter material. The students benefit from reading the box because they can apply what they have just learned to something that is clearly relevant. ▼

CHEMISTRY AND HEALTH

Hydrogen Bonding in DNA

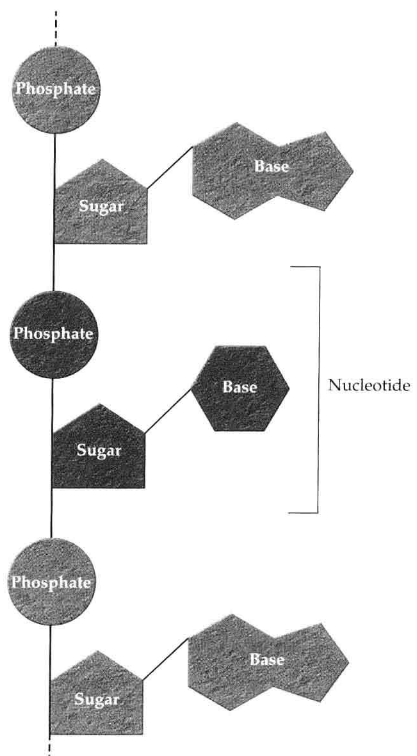


Figure 12.21 DNA is composed of repeating units called nucleotides. Each nucleotide is composed of a sugar, a phosphate, and a base.

DNA is a long chain-like molecule that acts as a blueprint for living organisms. Copies of DNA are passed from parent to offspring, which is why we inherit traits from our parents. A DNA molecule is composed of thousands of repeating units called *nucleotides* (Figure 12.21). Each nucleotide contains one of four different bases: adenine, thymine, cytosine, and guanine (abbreviated *A, T, C,* and *G*). The order of these bases along DNA contains the code that specifies how proteins—the workhorse molecules in living organisms—are made. Proteins determine many human characteristics including how we look, how we fight infections, and even how we behave. Consequently, human DNA is a blueprint for how humans are made.

Each human cell actually contains two complete and complementary copies of DNA, both necessary for replication. The replicating mechanism is related to the structure of DNA, discovered in 1953 by James Watson and Francis Crick. DNA consists of two complementary strands wrapped around each other in the now famous double helix. Each strand is held to the other by hydrogen bonds that occur between the bases on each strand. DNA replicates because each base (A, T, C, and G) has a complementary partner with which it hydrogen bonds (Figure 12.22). Adenine (A) hydrogen bonds with thymine (T) and cytosine (C) hydrogen bonds with guanine (G). The hydrogen bonds are so specific that each base will pair only with its complementary partner. When a cell is going to divide, the DNA unzips across the hydrogen bonds that run along its length. Then new bases, complementary to the bases in each half, add along each of the halves, forming hydrogen bonds with their complement. The result is two identical copies of the original DNA (See Chapter 19).

CAN YOU ANSWER THIS? *Why would dispersion forces not work as a way to hold the two halves of DNA together? Why would covalent bonds not work?*

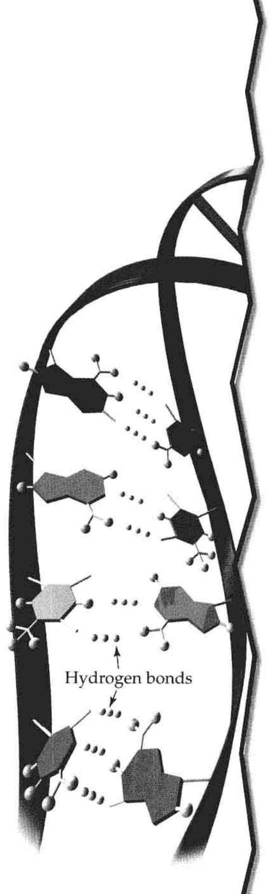


Figure 12.22 The two halves of th

End-of-Chapter Review and Assessment

Chapter in Review

Each chapter ends with a review consisting of two sections. The first section reviews chemical principles and the second one reviews chemical skills. Each section is itself divided into two columns. In the chemical principles review section, one column summarizes the principle, and the other column tells why it is important. ▼

CHAPTER IN REVIEW

Chemical Principles	Relevance
Uncertainty: Measured quantities are reported so that the number of digits reflects the certainty in the measurement. Write measured quantities so that every digit is certain except the last, which is estimated.	**Uncertainty:** Measurement is a hallmark of science and the precision of a measurement must be communicated with the measurement so that others know how reliable the measurement is. When you write or manipulate measured quantities you must show and retain the precision with which the measurement was made.

In the chemical skills section, one column describes the skill, while the other column shows a worked example. The last Chapter in Review section has a list of key terms whose definitions can be found in the chapter. ▼

Chemical Skills

Scientific Notation (Section 2.2)

To express a number in scientific notation:

- Move the decimal point to obtain a number between 1 and 10.
- Write the decimal part multiplied by 10 raised to the number of places you moved the decimal point.
- The exponent is positive if you moved the decimal point to the left and negative if you moved the decimal point to the right.

Reporting Measured Quantities to the Right Number of Digits (Section 2.3)

Report measured quantities so that every digit is certain, except the last, which is estimated.

Examples

EXAMPLE 2.18 Scientific Notation

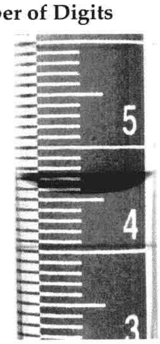
Express the number 45,000,000 in scientific notation.

45,000,000
7 6 5 4 3 2 1

4.5×10^7

EXAMPLE 2.19 Reporting Measured Quantities to the Right Number of Digits

Record the volume of liquid in the graduated cylinder to the correct number of digits. Laboratory glassware should be read from the bottom of the meniscus (See figure).



Since the graduated cylinder has markings every 0.1 mL, the measurement should be recorded to the nearest 0.01 mL. In this case, that is 4.57 mL.

Student Exercises

All chapters contain exercises divided into four types: Questions, Problems, Cumulative Problems, and Highlight Problems. The *Questions* are qualitative and require the student to summarize important chapter concepts. The *Problems* section is the longest, containing quantitative problems arranged in pairs and divided with subheadings into the major categories of the chapter. ▼

Problems

(Note: The exercises in this section of Problems are paired and the answers in the odd-numbered exercises appear in Appendix 3.)

Scientific Notation

27. Express each of the following numbers in scientific notation.
a) 32,667,000 (population of California)
b) 1,193,000 (population of Hawaii)
c) 18,175,000 (population of New York)
d) 481,000 (population of Wyoming)

28. Express each of the following numbers in scientific notation.
a) 5,926,467,000 (population of the world)
b) 1,236,915,000 (population of China)
c) 11,051,000 (population of Cuba)
d) 3,619,000 (population of Ireland)

Cumulative Problems, also arranged in pairs, require students to synthesize several of the skills they have learned in the chapter and in previous chapters to solve the problem. ▼

Cumulative Problems

89. A thief uses a bag of sand to replace a gold vase that sits on a weight-sensitive, alarmed pedestal. The bag of sand and the vase are exactly the same volume, 1.75 L.
a) Calculate the mass of each object. (density of gold = 19.3 g/cm^3, density of sand = 3.00 g/cm^3)
b) Did the thief set off the alarm? Explain.

90. One of the particles that compose atoms is called the proton. The proton has a radius of approximately 1.0×10^{-13} cm and a mass of 1.7×10^{-24} g. Determine the density of a proton. For a sphere $V = 4/3\pi r^3$;

93. The density of aluminum is 2.7 g/cm^3. What is its density in pounds per cubic inch?

94. The density of platinum is 21.4 g/cm^3. What is its density in pounds per cubic inch?

95. A typical backyard swimming pool holds 150 yd^3 of water. What is the mass in pounds of the water?

96. An iceberg has a volume of 8975 ft^3. What is the mass of the ice (in kilograms) composing the iceberg?

97. Honda has recently produced a hybrid electric car called the Honda Insight. The Insight has both a gasoline-powered engine and an electric motor and

All paired *Problems* and *Cumulative Problems* have one problem answered in the back of the book and another similar problem without an answer. All answers are available in the instructor's full Solutions Manual. *Highlight Problems* are within a relevant or well-known context that will often include photographs or art. ▼

Highlight Problems

99. In 1999, NASA lost a $94-million orbiter because one group of engineers used metric units in their calculations while another group used English units. Consequently, the orbiter pushed too far into the Martian atmosphere and burned up. Suppose that the orbiter was to have established orbit at 155 km and that one group of engineers specified this distance as 1.55×10^5 m. Suppose further that a second group of engineers programmed the orbiter to go to 1.55×10^5 ft. What was the difference (in kilometers) between the two altitudes? How low did the probe go?

For the Instructor

Instructor's Resource & Full Solutions Manual (0-13-100202-3) by Mark Ott, Jackson Community College and Matthew Johll, St. Norbert College, features lecture outlines with presentation suggestions, teaching tips, suggested in-class demonstrations, and topics for classroom discussion.

Test Item File (0-13-100213-9) by Matthew Johll, St. Norbert College, is a test bank of over 1200 questions.

TestGen-EQ (0-13-100206-6) The computerized version of the Test Item File is available on a dual-platform CD-ROM. The software available with this database allows you to create and tailor exams to your specific needs.

Transparency Pack (0-13-100203-1) This set contains 150 full-color transparencies chosen from the text. This select group of transparencies put principles into visual perspective and save you time while you are preparing your lectures.

Instructor's Resource CD-ROM (0-13-100205-8) An Instructor CD-ROM that contains almost all of the art from the text. Using the included MediaPortfolio software, instructors can browse for figures and other media elements by thumbnail and description as well as search by keyword or title. This CD also contains two pre-built PowerPoint™ Presentations for each chapter; one contains the illustrations, one per slide, for easy incorporation into your lecture. The other contains a complete lecture outline including selections from the available media assets. Also included are PDF files of each image as well as the Word™ files for the Instructor's Resource Manual.

For the Student

Study Guide (0-13-141192-6) This book assists students through the text material with chapter overviews and practice problems applied to each major concept in the text, followed by two or three self-tests with answers at the end of each chapter.

Selected Solutions Manual (0-13-100201-5) by Matthew Johll, St. Norbert College, provides solutions only to those problems that have a short answer in the text's Selected Answer Appendix (problems numbered in red in the text).

Math Review Toolkit (0-13-100202-3) by Gary L. Long, Virginia Polytechnic University. This free book reinforces the skills necessary to succeed in chemistry. It is keyed specifically to chapters in ***Introductory Chemistry***, and includes additional mathematics review, problem-solving tools and examples.

Companion Website http://chem.prenhall.com/trointro
Built to complement ***Introductory Chemistry*** as part of an integrated course package, the easy to use Companion Website features the following modules for each chapter:

- a gallery of animated *student tutorials,*
- a collection of interactive *live examples,*
- a selection of *3D molecular models,*
- multiple choice and true/false *practice quizzes,*
- a *math tutorial,*
- a library of chemistry-related *web links,* and
- a useful *reference center* consisting of an interactive periodic table and a conversion table.