Chapter 1 Introduction to Chemistry; Introduction to Active Learning

Welcome to your first college chemistry course! Chemistry is the gateway to careers in scientific research and human and animal health. You may be wondering why you, as a biology, pre-medicine, pharmacy, nursing, or engineering major-or as someone with any major other than chemistry-are required to take this course. The answer is that all matter is made up of **molecules**, and chemistry is the science that studies how molecules behave. If you need to understand matter, you need to know chemistry.

What lies before you is a fascinating new perspective on nature. You will learn to see the universe through the eyes of a chemist, as a place where you can think of all things large or small as being made up of extremely tiny molecules. Let's start by taking a brief tour of some of the amazing variety of molecules in our world.

First consider the simple hydrogen molecules in Figure 1.1 (a). This shows what you would see if you could take a molecular-level look at a cross section from a cylinder filled with pure hydrogen. The individual molecule is two hydrogen atoms attached by the interaction between minute, oppositely charged particles within the molecule. Even though the hydrogen molecule is simple, it is the fuel that powers the sun and other stars. It is the ultimate source of most of the energy on earth. Hydrogen is found everywhere in the universe. It is part of many molecules in your body. Hydrogen is also the favorite molecule of theoretical chemists, who take advantage of its simplicity and use it to investigate the nature of molecules at the most fundamental level.

Now look at the DNA molecule. DNA is nature's way of storing instructions for the molecular makeup of living beings. At first glance, it seems complex, but on closer inspection, you can see a simple pattern that repeats to make up the larger molecule. This illustrates one of the mechanisms by which nature works. A simple pattern repeats many times to make up a larger structure. DNA stands for deoxyribonucleic acid, a compound name that identifies the simpler patterns within the molecule. Even this relatively large molecule is very, very tiny on the human scale. Five million DNA molecules can fit side-by-side across your smallest fingernail. (By the way, if you are a life sciences major, we think you'll agree that understanding the DNA molecule is a critical part of your education!)

Speaking of fingernails, they are made of the protein keratin. The human body contains about 100,000 different kinds of protein molecules. Many protein molecules in living organisms act to speed up chemical reactions. Figure 1.1 (c) shows one such molecule, known as chymotrypsin. Proteins have many other essential biological functions, including being the primary components of skin, hair, and muscles and serving as hormones.

Before you can truly understand the function of complex molecules such as DNA or proteins, you will have to understand and link together many fundamental concepts. This book and this course are your first steps on the journey toward understanding the molecular nature of matter.

Now that you've had a look into the future of your chemistry studies, let's step briefly back to the past and consider the time when chemistry began.

1.1 Lavoisier and the Beginning of Experimental Chemistry

Antoine Lavoisier (1743-1794) is often referred to as the father of modern chemistry. His book Traite Elementarie de Chime, published in 1789, marks the beginning of chemistry as we know it today, in the same way as Darwin's Origin of Species forever changed the science of biology.

Lavoisier's experiments and theories revolutionized thinking that had been accepted since the time of the early Greeks. Throughout history, a simple observation defied explanation: When you burn a wooden log, all that remains is a small amount of ash. What happens to the rest of the log? Johann Becher (1635-1682) and Georg Stahl (1660-1734) proposed an answer to the question. They accounted for the "missing" weight of the log by saying that phlogiston was given off during burning. In essence, wood was made up of two things, phlogiston, which was lost in burning, and ash, which remained after. In general, Becher and Stahl proposed that all matter that had the ability to burn was able to do so because it contained phlogiston.

Lavoisier doubted the phlogiston theory. He knew that matter loses weight when it burns. He also knew that when a candle burns inside a sealed jar, the flame eventually goes out. The larger the jar, the longer it takes for the flame to disappear. How does the phlogiston theory account for these two observable facts? If phlogiston is given off in burning, the air must absorb the phlogiston. Apparently a given amount of air can absorb only so much phlogiston. When that point is reached, the flame is extinguished. The more air that is available, the longer the flame burns.

So far, so good; no contradictions. Still, Lavoisier doubted. He tested the phlogiston theory with a new experiment. Instead of a piece of wood or a candle, he burned some phosphorus. Moreover, he burned it in a bottle that had a partially inflated balloon over its top. When the phosphorus burned, its ash appeared as smoke. The smoke was a finely divided powder, which Lavoisier collected and weighed. Curiously, the ash weighed more than the original phosphorus. What's more, the balloon collapsed; there was less air in the jar and balloon after burning than before (Fig 1.2[b]).

What happened to the phlogiston? What was the source of the additional weight? Why did the volume of air go down when it was supposed to be absorbing phlogiston? Is it possible that the phosphorus absorbed something from the air, instead of the air absorbing something (phlogiston) from the phosphorus? Whatever the explanation, something was very wrong with the theory of phlogiston.

Lavoisier needed new answers and new ideas. He sought them in the chemist's workshop, the laboratory. He devised a new experiment in which he burned liquid mercury in air. This formed a solid red substance (Fig. 1.3). The result resembled that of the phosphorus experiment: The red powder formed weighed more than the original mercury. Lavoisier then heated the red powder by itself. It decomposed, re-forming the original mercury and a gas. This gas turned out to be oxygen, which had been discovered and identified just a few years earlier.

These experiments-burning phosphorus and mercury, both in the presence of air and both resulting in an increase in weight-disproved the phlogiston theory. A new hypothesis took its place: When a substance burns, it combines with oxygen in the air. This hypothesis has been confirmed many times. It is now accepted as the correct explanation of the process known as burning.

But wait a moment. What about the ash left after a log burns? It does weigh less than the log. What happened to the lost weight? We'll leave that to you to think about for a while. You probably have a pretty good idea about it already, but, also probably, you aren't really sure. If you were Lavoisier, and you wondered about the same thing, what would you have done? Another experiment, perhaps? We won't ask you to perform an experiment to find out what happens to the lost weight. We'll tell you—but not now. The answer is given in Chapter 9.

Before leaving Lavoisier, let's briefly visit a spinoff of his phosphorus experiment. Lavoisier was the first chemist to measure the weights of chemicals in a reaction. The concept of measuring weight may seem obvious to you today, but it was revolutionary in the 1700s. We have already noted that the phosphorus gained weight. Lavoisier also noticed that the air in which the burning occurred lost weight. The weight gained by the phosphorus was "exactly" the same as the weight lost by the air. "Exactly" is in quotation marks because the weighings were only as exact as Lavoisier's scales and balances were able to measure. As you will see in Chapter 3, no measurement can be said to be "exact." In Chapter 2, you will see the modern-day conclusion of Lavoisier's weight observations. It is commonly known as the Law of Conservation of Mass. It says that mass is neither gained nor lost in a chemical change.

1.2 Science and the Scientific Method

We have selected a few of Antoine Lavoisier's early experiments to illustrate what has become known as the **scientific method** (Fig 1.4). Examining the history of physical and biological sciences reveals features that occur repeatedly. They show how science works, develops, and progresses. They include

1. Observing. A wooden log loses weight when it burns.
2. Proposing a hypothesis. A **hypothesis** is a tentative explanation for observations. For example: Wood-and everything else---contains phlogiston. When something burns, it loses phlogiston.
3. Being skeptical. Lavoisier didn't go along with the idea that the loss in weight in a burning log could be explained by the departure of some never-seen and never described substance called phlogiston.
4. Predicting an outcome that should result if the hypothesis is true. When phosphorus burns, it should lose weight.
5. Testing the prediction by an experiment. Lavoisier burned phosphorus. It gained weight in tead of losing it. The new observation required ...
6. Revising the hypothesis. Lavoisier proposed that burning combines the substance burned and oxygen from the air. (How did Lavoisier know about oxygen?)
7. Testing the new hypothesis and a new predicted outcome by an experiment. The new hypothesis was confirmed when Lavoisier burned mercury and it gained weight.
8. Upgrading the hypothesis to a theory by more experiments. Lavoisier and others performed many more experiments. (How did the others get into the process?) All the experiments supported the explanation that burning involves combining with oxygen in the air. When a hypothesis is tested and confirmed by many experiments, without contradiction, it becomes a **theory**.

The scientific method is not a rigid set of rules or procedures. When scientists get ideas, they most often try to determine if anyone else has had the same idea or perhaps has done some research on it. They do this by reading the many scientific journals in which researchers report the results of their work. Modern scientists communicate with each other through technical literature. Scientific periodicals are also a major source of new ideas.

Communication is not usually included in the scientific method, but it should be. Lavoisier knew about oxygen because he read the published reports of Joseph Priestley and Carl Wilhelm Scheele, who discovered oxygen independently in the early 1770s. In turn, other scientists learned of Lavoisier's work and confirmed it with their own experiments. Today, communication is responsible for the explosive growth in scientific knowledge (Fig 1.5). It is estimated that the total volume of published scientific literature in the world doubles every eight to ten years.

Another term used to describe science in a general way is law. In science, a law is a summary of repeated observations. Probably the best known is the law of gravity. If you release a rock above the surface of the earth, it will fall to the earth. No rock has ever "fallen" upward. In physics, the law of gravity is expressed precisely in a mathematical equation.

A scientific law does not try to explain anything, as a hypothesis or theory might. A law simply states what is. Although laws cannot be proved, we do rely on them. The only justification for such faith is that in order for a law to be so classified, it must have no known exceptions. Water never runs uphill.

1.3 The Science of Chemistry Today

Chemists study matter and its changes from one substance to another by probing the smallest basic particles of matter to understand how these changes occur. Chemists also investigate energy gained or released in chemical change-heat, electrical, mechanical, and other forms of energy.

Chemistry has a unique, central position among the sciences (Fig. 1.6). It is so central that much research in chemistry today overlaps physics, biology, geology, and other sciences. You will frequently find both chemists and physicists, or chemists and biologists, working on the same research problems. Scientists often refer to themselves with compound words or phrases that include the suffix or word chemist: biochemist, geochemist, physical chemist, medicinal chemist, and so on.

Chemistry has five subdivisions: analytical, biological, organic, inorganic, and physical. Analytical chemistry studies what (qualitative analysis) and how much (quantitative analysis) is in a sample of matter. Biological chemistry-biochemistry is concerned with living systems and is by far the most active area of chemical research today. Organic chemistry is the study of the properties and reactions of compounds that contain carbon. Inorganic chemistry is the study of all substances that are not organic. Physical chemistry examines the physics of chemical change.

You will find the people who practice chemistry—chemists—in many fields. Probably the chemists most familiar to you are those who teach and do chemical research in colleges and universities. Many industries employ chemists for research, product development, quality control, production supervision, sales, and other tasks. The petroleum industry is the largest single employer of chemists, but chemists are also highly visible in medicine, government, chemical manufacturing, the food industry, and mining.

Chemical manufacturers produce many things we buy and use and take for granted today. However, much of the chemical industry's output rarely reaches the public in raw form. Instead, it is used to make consumer products. Tables 1.1 and 1.2 list the top five inorganic chemicals and fertilizer materials produced in 2003. Most of the names may be familiar to you, but you cannot buy any of the chemicals at a local store.

You will see many of the chemicals in these tables repeatedly throughout this course. Other familiar names are among the top ten makers of industrial chemicals listed in Table 1.3.

1.4 Learning How to Learn Chemistry

Here is your first chemistry "test" question:

Which of the following is your primary goal in this introductory chemistry course?

A. To learn all the chemistry that I can in the coming term.
B. To spend as little time as possible studying chemistry.
C. To get a good grade in chemistry.
D. All of the above.

If you answered A, you have the ideal motive for studying chemistry-and any other course for which you have the same goal. Nevertheless, this is not the best answer.

If you answered B, we have a simple suggestion: Drop the course. Mission accomplished.

If you answered C, you have acknowledged the greatest short-term motivator of many college students. Fortunately, most students have a more honorable purpose for taking a course, although sometimes they hide it quite well. If you answered D, you have chosen the best answer.

Let's examine answers A, B, and C in reverse order.

C: There is nothing wrong in striving for a good grade in any course, just as long as it is not your major objective. A student who has developed a high level of skill in cramming for and taking tests can get a good grade even though he or she has not learned much. That helps the grade point average, but it can lead to trouble in the next course of a sequence, not to speak of the trouble it can cause when you graduate and aren't prepared for your career. It is better to regard a good grade as a reward earned for good work.

B: There is nothing wrong with spending "as little time as possible studying chemistry," as long as you Learn the needed amount of chemistry in the time spent. Soon we'll show why the amount of time required to Learn (not just study) chemistry depends on when you study and learn. They should occur simultaneously. Reducing the time required to complete any task satisfactorily is a worthy objective. It even has a name: efficiency.

A: There is nothing wrong with learning all the chemistry you can learn in the coming term, as long as it doesn't interfere with the rest of your schoolwork and the rest of your Ijfe. The more time you spend studying chemistry, the more you will learn. But maintain some balance. Mix some of answer B in your endeavor to learn. Again, the key is efficiency.

To summarize, the best goal for tills chemistry course-and for all courses-is to learn as much as you can possibly learn in the smallest reasonable amount of time.

The rest of tills section identifies special active learning skills that will help you reach your goal.

Learning Skill 1: Schedule Your Time and Hold to Your Schedule

You must spend the amount of time it takes to learn chemistry. When you spend it is the key. To keep time to a minimum, you must spend it regularly, doing each assignment each day. Chemistry builds on itself. If you don't complete today's assignment before the next lecture, you will not be ready to learn from that lecture. Some students find it helpful to schedule regular study time, just as they would schedule a class. Falling behind is the biggest problem when it comes to Learning chemistry.

Learning Skill 2: Concentrate on Chemistry When Studying Chemistry

This means studying without distractions-without sounds, sights, people, or thoughts that take your attention away from chemistry. Every minute your mind wanders while you study must be added to your total study time. Your time is limited, and that wasted minute is lost forever.

Learning Skill 3: Learn Your Instructor's Expectations

Each instructor has a unique way of presenting a course and a unique set of expectations. These may or may not be clearly stated or otherwise made evident at the beginning of the term. Either way, find out all you can about them and mold your learning program to match. Don't hesitate to ask. If your instructor holds office hours, take advantage of them. If your instructor offers specific advice on how to learn chemistry, and it differs from what you get from other sources, including tills textbook, it is probably better to follow the instructor's recommendations. If you are in a very large class on a university campus and there are teaching assistants, use them, but make sure their methods match those of the lecturing professor.

Learning Skill 4: Be Familiar with All the Learning Resources Available to You and Use Them as Needed

Lecture – If you know the topic of the next lecture, scan that topic in your textbook beforehand. Listen carefully during the lecture and take good notes. Review, revise, and clarify your lecture notes as soon after the lecture as humanly possible. Studies have shown that about half of what is presented in lecture is *not learned* if you wait more than 24 hours to study your lecture notes. If you wait a week, you will retain about 35%. The same studies show that about 90% of the lecture material is retained if you review the lecture the same day. It is a huge waste of time to postpone studying and learning from your lecture notes.
Textbook – This book contains many learning aids. Become familiar with them and use them. The next section describes them.
OWL – OWL is a valuable and flexible web-based homework system and assessment tool. Using a question-creation format that varies the amount and type of chemical substance for each online session, OWL can generate more than 100,000 chemistry questions correlated to the book. Instant feedback helps you immediately assess your progress. (OWL is available for use only within North America.)
Introductory Chemistry NOW™ -- This powerful online companion helps you manage and maximize the efficiency of your study time. Here you will find interactive resources that cannot be included in a conventional textbook, such as full-motion videos, three-dimensional molecular models, and particulate-level animations.
Laboratory – If your course includes a laboratory, learn what each experiment is designed to teach. Relate the experiment to the lecture and textbook coverage of the same topic. Seeing something in the laboratory is often just what you need to fully understand what you read in the textbook and hear in the lecture.
Library/Learning Center – Many college libraries and learning centers have computer programs, audiotapes, workbooks, and other learning aids that are particularly helpful for practice with using chemical formulas, balancing equations, solving problems, and other routine skills. Find out what is available for your course and use it as needed. Some instructors will also put supplementary materials on reserve. Take advantage of these, if provided.

Learning Skill 5: Learn It Now!

Efficient learning means learning now! It doesn't mean studying now and learning later. It takes a little longer to learn now than it does to study now, but the payoff come in all the time you save in not having to learn later. We'll give some specific suggestions on how to learn now in the next section.

1.5 Your Textbook

The most important tool in most college courses is the textbook. It is worth taking a few minutes to examine the book and look for its unique learning aids. In this section we'll show you the features of this book that are designed specifically to help you learn chemistry.

Section-by-Section Goals

GOAL

1. Read, write, and talk about chemistry using a basic chemical vocabulary.
2. Write routine chemical formulas and write names of chemicals when their formulas are given.
3. Write and balance ordinary chemical equations.
4. Set up and solve elementary chemical problems.
5. "Think" chemistry in some of the simpler theoretical areas and visualize what happens on the atomic or molecular level.

As you approach most sections in this text, you will find one or more goals, as you did here. They tell you exactly what you should be able to do after you study the section. If you focus your attention on learning what is in the goals, you will learn more in less time. All the goals in a chapter are assembled as a Chapter in Review section at the end of the chapter.

The goals listed here are not for a section, but for this entire book and the course in which you will use it. They tell you exactly what you will be able to do when you have completed the course.

Few general chemistry textbooks include section-by-section goals, although they sometimes appear in study guides that accompany those books. When you move on to the general chemistry course, it becomes your responsibility to write the goals yourself—to figure out what understanding or ability you are expected to gain in your study. Literally writing your own goals is an excellent way to prepare for an exam.

Learn It Now!

Learning Skill 5 from Section 1.4 appears in this book as Learn It Now! reminders that are printed in blue. Most are printed in the margin, but longer entries run the full width of the page.

When you come to a Learn It Now! entry, stop. Do what it says to do. Think about it. Make a conscious effort to understand, learn, and, if necessary, memorize what is being presented. When you are satisfied that this idea is firmly fixed in your mind, then go on. In short, learn it-now! Tomorrow it will take longer. Tomorrow is too late.

Examples

As you study this book, you will acquire certain "chemical skills." These include writing chemical names and formulas, writing chemical equations, and solving chemical problems-the things listed previously as Goals 2, 3, and 4. You will develop these skills by studying and working the examples in the text.

EXAMPLE 1.1

This is not an example, but this sentence and the following paragraph are written in the form of the examples throughout the book.

All examples begin with the word "Example," followed by the example number, in a light orange band. The end of the example is signaled by a gold line.

Most examples in this book take you through a series of questions and answers. Space is provided for you to actually write in a formula or equation or to solve a problem yourself. One such example appears in Section 3.2. At that point you will find detailed instructions for working this kind of example problem.

If you are to learn from examples, you need to work through each one as you come to it. Never postpone an example and read ahead. Learn it now! Quite often, what you learn in an example is used immediately in the next section. You will not be able to understand that next section without understanding the example.

Target Checks

Chemical principles and theories are introduced with words and illustrations. Ideally, you will learn and understand these ideas as you study the text and figures. Use a Target Check to find out if you have caught on to the main ideas immediately after they appear in the text. A Target Check is identified by the heading *Target Check.*

Like examples, Target Checks should be completed as you reach them. Answers to Target Checks are at the end of the book. If you answer a Target Check incorrectly, go back and restudy the targeted material before moving on to the next section or example.

The best thing that you can do to maximize your learning from the textbook is to take written notes, complete the Target Checks, and work the programmed examples while you study. This means writing in the book and not simply highlighting the textbook. A heavily highlighted textbook is nothing more than a brightly colored list of things you plan to learn later. It is just the opposite of Learn It Now! The very act of reading something, thinking about what it means, summarizing it, and writing it down in your own words produces learning-now!

P/Review

Often in the study of chemistry you see some term or concept that was introduced earlier in the course. To understand the idea in its new context, you may wish to review it as presented earlier. At other times a topic is introduced briefly, to meet a present need, even though it may not be necessary to understand it fully. That comes later; the present introduction is a preview.

This book has an optional order of topics, so the same item may be a preview with one instructor and a review with another. We therefore identify this kind of cross-reference as a P/Review. Each P/Review is carefully worded so that as a review it gives you the information you must recall immediately, but not so much that it will be confusing if read as a preview. A P/Review usually appears in the margin, and it always includes a specific chapter or section number that you may refer to if you wish.

In-Chapter Summaries and Procedures

Throughout this book, you will find summaries and step-by-step procedures that are headed as follows:

SUMMARY

Each Summary or Procedure is printed inside a box, as this paragraph is printed. These give you, in relatively few words, the main ideas and methods you should learn from a more general discussion nearby. They should help you clinch your understanding of the topic. Occasionally, summaries are in the form of a table or illustration; some even combine the two. These forms are particularly helpful in reviewing for a test. ot only do they review the topic briefly, they also create a mental image that is easy to recall during an exam.

Thinking About Your Thinking

You will find passages throughout the text that look like this:

Thinking About Your Thinking

Name of Skill

One goal of this textbook is to help you learn the thinking skills that chemists and other scientists commonly use. In these boxes, we discuss thinking skills themselves, somewhat removed from the content of the surrounding text, so that you can clearly see the skill, learn it, and apply it in any context. These boxes will help you learn to think about chemistry—and about many other subjects-far beyond the days you spend in this course.

When you come to a Thinking About Your Thinking discussion, take a few moments to read it and reflect on the thinking skill it discusses. Ask yourself, "Could I apply this skill in any other context?" Perhaps you've used the skill before in math or physics. Maybe you've used it in before in this course. The greater the number of contexts in which you can imagine applying a skill, the more generalizable your thinking skills will become. In this way, you grow intellectually.

Introductory Chemistry NOW™

The Introductory Chemistry NOW™ Web site contains videos, three-dimensional illustrations, and animations that help you learn in a new way. A subscription to the site is included with every new copy of Introductory Chemistry: An Active Learning Approach. Whenever you can supplement your learning with the Web site as you are studying the text, we print a note in the margin that looks like the one next to this paragraph. We provide a brief description of what you'll find on the site.

The Web site also contains valuable progress-monitoring tools. Each chapter has a pre-test that you can take as an assessment before you take your in-class exam. Use the results of your pre-test to design a personalized learning plan to correct any deficiencies that remain. You then take a post-test to make sure you have mastered the material.

Study Hints and Pitfalls to Avoid

Following the Chapter in Review and Key Terms and Concepts, you will find a brief section suggesting study methods that should make learning easier or more efficient. Some of these are "Remember" statements. Their purpose is to remind you of some word, method, or concept that students often overlook. "Pitfalls" identify the most common errors students make in exams. If you are forewarned of a common mistake, you are less likely to make it.

Concept-Linking Exercises

After completing your study of a chapter, but before you begin to work the Questions, Exercises, and Problems (described next), you will need to have a firm understanding of the key terms and concepts from the chapter and the relationships among them. To help you learn the relationships among the concepts, most chapters include Concept-Linking Exercises. These exercises consist of groups of concepts that you link together with a brief description of how they are related. Answers to the Concept-Linking Exercises can be found after the answers to the Target Checks at the end of the book.

End-of-Chapter Questions, Exercises, and Problems

At the end of all chapters except this one, you will find Questions, Exercises, and Problems. They are grouped by the section in the chapter to which they apply. Some questions are relatively straightforward, similar to the examples and Target Checks. Others are more demanding. You may have to analyze a situation, apply a chemical principle, and then explain or predict some event or calculate some result. General Questions that may be drawn from any section in the chapter follow the section-identified questions. After these are More Challenging Questions designed to stretch you beyond the goals listed for the chapter.

The Questions, Exercises, and Problems generally are in matched pairs in which consecutive odd-even numbered combinations involved similar reasoning and, in the case of exercises, similar calculations. Mo t of the odd-numbered questions out of the matched-pair groups are answered at the end of the book. Answers to exercises and problems include calculation setups. Most General Questions and More Challenging Questions, odd-numbered and even, are answered at the end of the book. Numbers of answered questions are printed in blue; numbers of unanswered questions are printed in black.

As you solve problems in the textbook, remember that your main objective is to understand the problem, not to get a correct answer. Even when your answer is correct, stop and think about it for a moment. Don't leave the problem until you feel confident that you will recognize any new problem that is worded differently but requires reasoning based on the same principle. Then be confident that you can solve such a problem.

Even more important is what you do when you do not get the correct answer to a problem. You will be tempted to return to the examples and Target Checks, find one that matches your problem, and then solve the assigned problem step by step as in the example. *You should resist this temptation*. If you get stuck on a problem, it means you did not truly learn from the earlier examples. Leave the problem. Turn back to the example. Study it again, by itself, until you understand it thoroughly. Then return to the assigned problem with a fresh start and work on it to the end without further reference to the example. Finally, work the remainder of the problems in the group until you are confident that you can solve this problem type.

Appendices

The Appendix of this book has three parts.

1. *Appendix I: Chemical Calculations*. Here you will find suggestions on how to use a calculator specifically to solve chemistry problems. There is also a general review of the arithmetic and algebraic operations used in this book. You will find these quite helpful if your math skills need dusting off before you can use them.
2. *Appendix II: The SI System of Units*. This explains the units in which quantities are measured and expressed in current science textbooks and other scientific publications.
3. *Glossary*. Like other fields of study, chemistry has its own special language, in which common words have very specialized and specific meanings. The Glossary lists these words in alphabetical order so you can find them easily and learn to use them correctly. The Glossary contains most of the boldfaced words in the text, as well as many other terms. Use the Glossary regularly; it's a real time saver.

Reference Pages

Some reference items should be available quickly, without searching through pages in the book. Two of these are the periodic table, introduced in Section 5.6, and alit of elements. You will find these on the Reference Pages, which are printed on heavier paper so you can find them easily, remove them from the book, and keep them with you whenever you study. You also will find lists of important values, equations, and other information on the inside covers of the book.

1.6 A Choice

You have a choice to make. You can choose to continue learning as before, or you can choose to improve your learning skills. Even if those skills are already good, they can be improved. This chapter gives you some specific suggestions on how to do this. It also helps you upgrade your study habits, beginning here and continuing throughout the book.

If you ever begin to feel that chemistry is a difficult subject, read this chapter again. Then ask yourself, and give an honest answer: "Do I have trouble because the subject is difficult, or is it because I did not choose to improve my learning skills?" Your honest answer will tell you what to do next. A pertinent quote from an anonymous source is, "Discipline is the bridge between goals and accomplishments."

At all stages of our lives we make choices. We then live with the consequences of those choices. Choose wisely-and enjoy learning chemistry.