STUDYING FOR CHEMISTRY

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Dedication

This book is dedicated to the memory of my parents—Gillis Dowling Little and Ida Mae Holley Little—and to my brothers and sisters: Kenneth Little, Carl Little, Sharon Little Riggs, and Vickie Little Harris.

TO THE STUDENT

This book is written for you. The purpose of this book is to provide you with a resource to use along with your textbook in studying and learning chemistry. The primary goal of this textbook is twofold:

1. to provide you with models for learning chemistry concepts, and

2. to help you develop problem solving strategies to apply to chemical quantitative concepts.

Throughout this textbook you will find suggestions on how to apply different types of thinking skills for learning and understanding challenging chemical concepts.

Many beginning chemistry students have difficulty analyzing and solving chemistry problems. One feature of this textbook is the development of solution pathways for solving many kinds of chemistry problems. You will find detailed descriptions of the thinking process, as well as plans for setting up and solving many of the quantitative problems associated with beginning chemistry.

Another feature of this textbook is Applying the Concept: Exercises. These exercises are found after each topic or concept discussed in the textbook. The questions allow you to practice or apply the skill or concept presented in the topic, thereby evaluating or monitoring your comprehension of the topic. The answers to all Exercises are found in the Appendix so that you can check your progress.

Learning chemistry is an active process. Hopefully, this textbook will help you in developing learning strategies that will allow you to become more active in reading your text, note-taking in lecture, and studying for lecture tests and exams. I wish you a very positive experience in your study of chemistry!

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CHAPTER 1

WHAT IS CHEMISTRY ALL ABOUT?

GETTING FOCUSED

- *As you begin your study of chemistry, what are your biggest concerns or apprehensions about being academically successful in your chemistry class?*
- *How do you think your approach to studying chemistry will be different from the way you study and prepare for other classes?*
- *Are there other thinking skills besides memorization that you will need to use and apply to learning chemical concepts and solving chemical problems?*
- *What are higher-order thinking skills (HOTS) and how do you apply these thinking skills to learning chemical concepts and solving chemical problems?*

CHEMISTRY AS CONTENT AND PROCESS

It is absolutely amazing and wonderful how the science of chemistry impacts the quality of our everyday lives. Chemists are responsible for the development of plastics, artificial sweeteners, Freon used in air conditioners to keep us cool, synthetic rubber, and synthetic fibers such as rayon and polyester. Synthetic fertilizers and insecticides developed in chemistry laboratories greatly increase crop yields, thus increasing food supplies. Chemists working in the field of biochemistry and pharmacology have made important contributions in the development of drugs that save the lives of millions of children and adults every year. Biochemists are in the forefront of recombinant DNA engineering that has the potential to increase the world's food supply, alter the devastation of genetically inherited diseases such as muscular dystrophy and cystic fibrosis, and to help put violent criminals behind bars. This list is only a tiny fraction of the many contributions chemists have given to the world—and the future holds many more secrets waiting for another generation of research chemists to unravel.

Even if you are not planning to be a research chemist, a working knowledge of chemistry is still important in the study of many other fields, such as biology, nursing and health sciences, nutrition, and medicine. Whether you are taking a course in chemistry as a chemistry major or whether you are taking it to meet the requirements for another field of study does not matter; the most important thing is to get the most from your first chemistry course. Getting the most from your first chemistry course means that you leave the classroom and laboratory with chemical knowledge, skills, and an appreciation for chemistry as a science as well as a process of discovery.

You probably already have a pretty good idea of what the study of chemistry is all about. If you have been reading in your textbook, you probably came across the old standby definition of chemistry: the study of matter and the changes it undergoes. Don't be fooled by this overly simplistic definition of chemistry. The study of **chemistry** involves learning and using terminology, concepts, theories, models, and problem solving to understand chemical phenomena. The study of chemistry also involves scientific inquiry. The chemistry laboratory will allow you to be involved in the process of chemistry; that is, investigating the physical and chemical changes that matter undergoes. Hopefully, in the laboratory the standard textbook definition of chemistry will take on new meaning as you actually see some of the changes that matter undergoes.

GOING BEYOND MEMORIZING

A research study was undertaken several years ago to determine how students used their textbook in learning a particular subject. The researchers found that the vast majority of students believed the most important thing to study in each chapter were definitions. Consequently, most of their efforts went into memorizing terms. Many chemistry students also share this viewpoint and are disappointed and upset when quizzes and exams prepared by their professors require them to go beyond vocabulary. Instead of solely defining terms, chemistry students are frequently asked to explain physical and chemical phenomena, predict outcomes, apply knowledge in problem-solving situations, draw valid conclusions from data sets, and defend answers to both qualitative and quantitative problems.

Let's be honest! The simple truth is that you, as well as thousands of other students sitting in introductory chemistry classes, *cannot* memorize your way to "success" in learning chemistry. To be successful in chemistry you are going to have to learn to "think" like a chemist. Granted, you have to know facts in order to think in any discipline. An important part of learning chemistry is becoming familiar with the terms and concepts that comprise the language of chemistry. Yet there are many qualitative (descriptive) and quantitative (numerical) concepts in chemistry that require mental strategies other than "recall" or knowledge level learning in order to fully understand the chemistry involved. Chemistry is an "active science" and requires "active mental participation" in the classroom, in reading the text, in working homework problems, and in the laboratory.

Cognitive psychologists (scientists who study how people learn) call these active mental strategies used in hypothesizing, predicting, controlling variables, defending arguments, drawing valid conclusions, and problem solving "higher-order thinking skills" because they require the learner to go beyond memorizing. When using higher-order thinking skills, a learner takes information and applies it in many different ways to get new information or to find answers to problems. Knowing about higher-order thinking skills and how to apply them appropriately to solving chemical problems is the key to success in learning chemistry.

TYPES OF HIGHER-ORDER THINKING SKILLS

Benjamin Bloom and his assistants conducted an analysis of items used by teachers to determine students' achievement in subject matter. Using the results of the study, the researchers grouped the learning tasks into

six levels of difficulty, thereby creating a hierarchy of tasks similar to the arrangement used in biology to classify plants and animals. Instead of using Kingdom, Phylum, Class, Family, Genus, and Species, Benjamin Bloom and his associates identified knowledge, comprehension, application, analysis, synthesis, and evaluation as the different levels of thinking required to answer various types of questions found on classroom tests and exams. In this hierarchy, knowledge questions are considered the least difficult to answer, and evaluation questions are considered the most difficult. These learning tasks or skills are referred to as the **higher-order thinking skills** or HOTS. Table 1.1 describes the six levels of learning tasks and gives a description and examples of each. It is important that you take the time to understand the different levels of higher-order thinking skills so that you may make use of the appropriate skill when it is needed for understanding chemical concepts and problems you will encounter during your study of chemistry.

You might be a little confused about the types of higher-order thinking skills listed in Table 1.1. When can you tell if a topic or concept requires a higher-order thinking skill for understanding the topic or concept? How do you specifically apply the thinking skill for comprehension? These are very important and legitimate questions to ask. The answer is of course you have to be taught this skill. You need to be able to analyze each topic in your textbook, your lecture notes, your laboratory textbook, and the printed handouts that your professor might use as lecture supplements and rate them as to the type of thinking skill required. Then you need to apply the appropriate thinking skill to your reading, studying, writing, and problem-solving activities. Each of the following chapters in this study skill book will give you examples of when and how to apply specific higher-order thinking skills in learning and comprehending chemical topics and concepts.

APPLYING THE CONCEPT: EXERCISE 1.1

Suppose you are studying for a chemistry test, or completing a lecture, or a laboratory assignment. What kind of thinking skill would you use or apply to fully understand or complete the following tasks? Some of the tasks require the use of several higher-order thinking skills in order to complete the task. Use Table 1.1 in Chapter 1 as a resource. Pay particular attention to the second and third columns in this table.

1. Defining the term *osmosis.*
2. Performing a titration in the lab to determine the percentage of acetic acid in a vinegar sample.

TABLE 1.1 HIGHER-ORDER THINKING SKILLS

LEVEL OF THINKING SKILL	WHAT THE STUDENT KNOWS OR DOES USING THE SKILL	ACTION VERBS FOR SPECIFIC OUTCOMES
Knowledge or recall (Giving it back)	Knows terms Knows rules Knows specific facts Knows classifications and categories Knows criteria Knows methods and procedures Knows principles and generalizations Knows theories and structure	Defines Names States Identifies Describes Distinguishes
Comprehension (Translating it)	Translates communications Interprets relationships Extrapolates from given data	Interprets, converts, explains, predicts, generalizes, infers
Application (Trying it on problems)	Applies principles	Uses, solves, constructs, prepares, demonstrates
Analysis (Taking it apart)	Analyzes organizations and relationships	Discriminates, outlines, diagrams, differentiates, infers, explains
Synthesis (Creating a new work)	Produces new arrangement	Designs, organizes, rearranges, compiles, modifies, creates
Evaluation (Making a professional judgment)	Judges on basis of external criteria Judges on basis of evidence	Appraises, compares, contrasts, discriminates, criticizes, detects

3. Writing a report on the impact of heavy metallic ions on the environment.
4. Reading a description of a chemical experiment and determining which variable described is the:

   independent variable.

   dependent variable.

   controlling variable(s).
5. Completing a set of assigned problems on concentrations of solutions after attending a lecture where your instructor explains and

demonstrates the techniques of problem solving relating to concentration of solutions.

6. Your instructor calls on you to go to the chalkboard and write in detail, the solution to a chemistry problem. You are then asked to give an oral explanation to the class on how to solve the problem.
7. On a quiz, you are asked to list four criteria for determining whether or not a chemical reaction has occurred.
8. For a laboratory assignment, you are asked to design and outline a plan to separate a solution containing several cations and to identify each cation in the solution.
9. For an essay question on a lecture exam, you are asked to discuss the difference between *covalent* and *ionic bonding.*
10. You are assigned to read an article on causes of air pollution and to critique the article on the basis of:
    - the accuracy of the chemistry discussed in the article.
    - the feasibility of the author's suggestions for reducing air pollution.
    - your own recommendations for ways to clean up the atmosphere.

TERMS TO KNOW

chemistry
higher-order thinking skills

CHAPTER 2

TAKING CONTROL OF LEARNING CHEMISTRY

GETTING FOCUSED

- *How can you use your textbook more efficiently to extract and retain chemical terms, concepts, and problem-solving skills?*
- *What is the purpose of taking lecture notes? Is there a better way to organize your lecture notes to help you in preparing for tests and exams?*
- *How can you improve your thinking strategies for solving chemical problems?*

MAKING THE MOST OF YOUR TEXTBOOK

Just like many other beginning chemistry students, you will depend heavily on your textbook to provide you with basic information needed to build a knowledge base in chemistry. True, you will attend lectures, listen, participate in class, and take notes, but obviously you cannot take your instructor home or back to the dorm to refresh your memory or fill in the "gaps" in your lecture notes. Consequently, it will be to your benefit to learn how you use your textbook as an effective learning tool. There is a great deal of information in your chemistry textbook. Your job is to recognize the different types of prose found in science textbooks and to apply the appropriate thinking skill in order to retain and recall the major concepts presented. This is no easy task! Research has shown that the major reason science students have trouble reading scientific textbooks is that they lack a framework to guide them in selecting what is important and in organizing information so that it can be recalled and used.

In *Thought and Knowledge: An Introduction to Critical Thinking,* Diane Halpern, a cognitive psychologist at California State University at San Bernardino, cites research that supports the fact that students can be taught to use their textbooks more efficiently. Dr. Halpern describes a method known as **structure training**—a method by which students are taught strategies for recognizing, comprehending, and organizing the type of expository prose that is found in science textbooks.

What are the types of expository prose found in science textbooks? The best way to find the answer to this question is to open your chemistry textbook to the beginning of a chapter and find examples of the types of prose that are discussed below.

Macrostructure

Every chapter in your textbook is broken down into units of prose describing a main idea or concept. These units or main ideas constitute the **macrostructure** of the chapter. The macrostructures are usually printed in large, bold colored text and are easy to recognize. The macrostructures correspond to the chapter outline as listed in the table of contents of your textbook. Take a moment and look at the Chapter 3 outline in the table of contents of your chemistry textbook. Now, go to Chapter 3 and locate each macrostructure. You will notice that each macrostructure presents a new topic, idea, or concept and is followed