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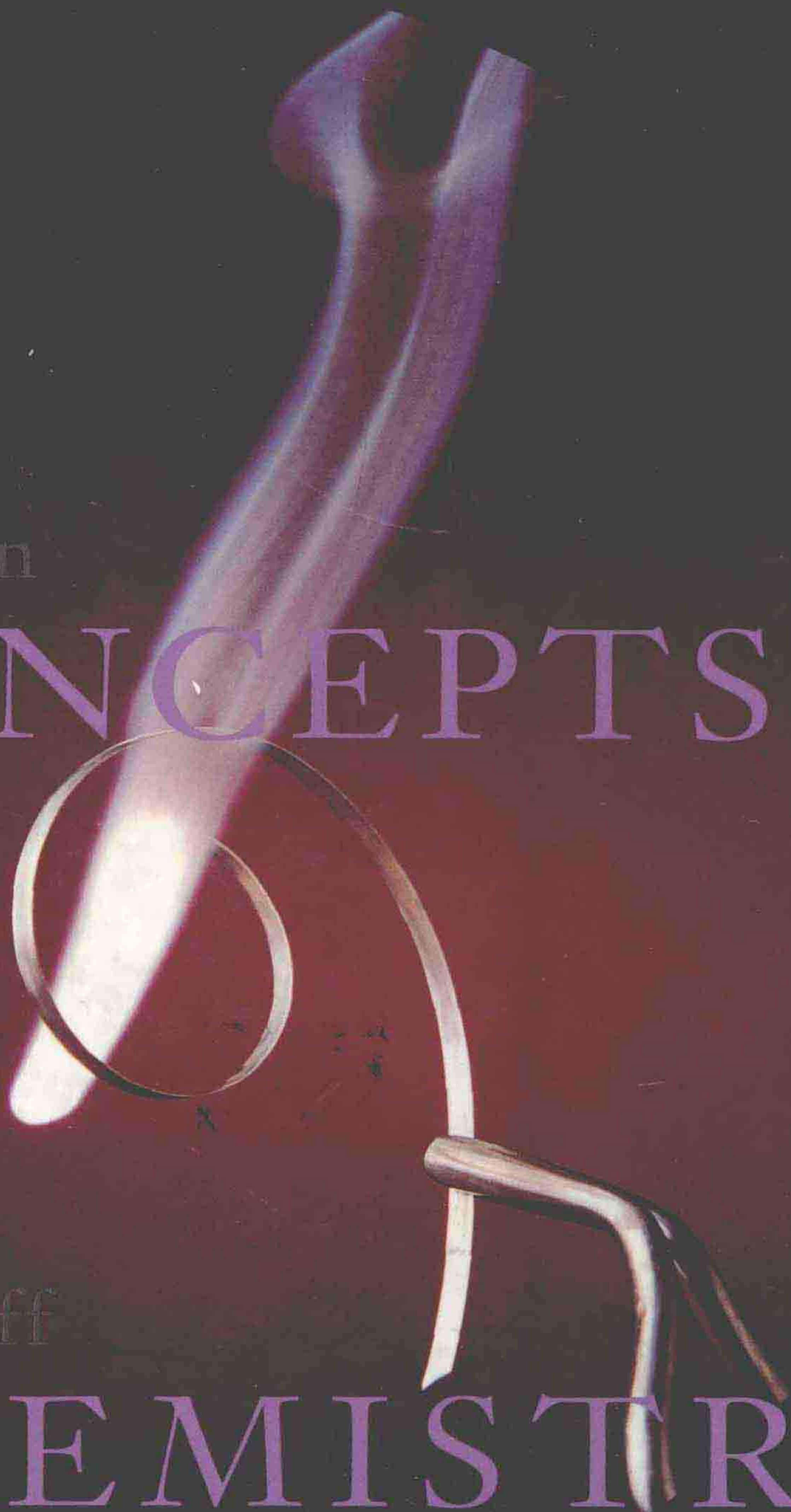
Sixth Edition

Sherman

CONCEPTS OF

Russikoff

CHEMISTRY



Sixth Edition

BASIC CONCEPTS OF CHEMISTRY

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To Robert and Michael and their grandparents

PREFACE

For more than 20 years, users of *Basic Concepts of Chemistry* have commented positively on the student-oriented approach that has been our trademark in the previous five editions. Intended for use in the one-quarter, one-semester, or two-quarter introductory or preparatory chemistry course, *Basic Concepts of Chemistry* is a text that professors tell us their students enjoy reading. This sixth edition of *Basic Concepts of Chemistry* is characterized by an easily understandable, conversational writing style, a sound problem-solving strategy, numerous examples worked out step by step, excellent figures, new appendices, and connections of chemistry to everyday life. As in the past editions, we built on the strengths of the previous edition by adding new features and strengthening the pedagogical aids.

New to This Edition

Applications of Chemistry in Today's World

In each of the previous five editions, exciting and interesting examples of chemistry in everyday life have helped students connect chemistry and the world around them. In the sixth edition this theme has been strengthened in three ways. First, many new *Chemical Frontiers* have been added to present areas of recent research that hold important applications for the future. Topics covered in this series include using microalgae to produce fuel for vehicles, discovering new ways to kill tumors, and using diamonds to create vaccines. Second, the boxed essays entitled *Career Sketch*, which describe occupations that draw upon skills in and knowledge of chemistry, have been updated. New career sketches that show opportunities for women and underrepresented groups in chemistry and related professions are included. Topics that provide the chemical basis for understanding important natural processes, such as osmosis and buffers, have been retained.

Finally, new to this edition are chapter-opening vignettes that introduce the topic of the chapter. Many of these tell a story in which knowledge of basic chemistry plays a role in everyday life, for example, the case of a mother using the scientific method to determine the source of her child's allergy. Others relate the chapter's topic to a pivotal event in the history of chemistry, like Lavoisier's work to determine that air is a mixture of substances. Each vignette is an interesting story in its own right and one that leads the student into the chapter by demonstrating its relevance.

Polya's Problem-Solving Framework

In addition to the strong program of problem-solving aids that have been a part of previous editions, in the sixth edition we strengthen the general problem-solving framework of the late George Polya of Stanford University, which was first introduced in the fifth edition. The four-step method is introduced in Chapter 2. Estimation skills are included; the student is taught to examine a solution to assess the reasonableness of the answer. In most chapters, at least one problem is solved using Polya's method. Students are encouraged to apply this method as they solve problems.

Cooperative Learning Opportunities

For nearly a century research has shown that students working in small groups do improve their academic performance. They can solve problems together, and as part of that process, they discuss the material being studied. Areas that need clarification are identified as students teach one another.

Opportunities for cooperative problem solving, new to the fifth edition, are expanded in the sixth edition. Several exercises at the end of each chapter have been marked with a blue triangle (◄), indicating that they may be used as conventional problems or for cooperative problem solving. This may be done in class under the direction of the instructor or independently in small study groups. Additional suggestions on implementing cooperative learning are included in the *Instructor's Resource Manual*.

Study Skills Section

A completely revised section on study skills appears at the beginning of the sixth edition. The section includes information about how to study chemistry, how to manage time effectively, as well as how to set realistic goals. An expanded section on basic study skills is followed by specifics on how to study chemistry. Other topics include how to take good notes and how to take a chemistry test.

Readability

We have maintained the readability of our text by using concise and direct sentences, a conversational tone, and paragraphs of manageable length. Students are provided with concrete examples of applications of chemistry to everyday life to help them connect chemistry to society. In addition, line drawings and many new diagrams and photographs are used to emphasize important points.

Problem Solving

In each edition of *Basic Concepts of Chemistry*, we have sought to address the difficulties students encounter in problem solving. In this edition, we have maintained the high number of worked-out examples, with solutions provided. Each example is followed by a practice exercise that offers an

immediate opportunity to apply the skill just demonstrated. Answers to all practice exercises are provided at the end of the book.

End-of-chapter problems are divided into two groups: self-test exercises and extra exercises. More difficult problems are marked with an asterisk. Self-test exercises are keyed to the specific learning goals of each chapter and appear in matched pairs, with odd-numbered problems, in most cases, answered in the back of the book. These problems help reinforce the learning of individual skills. Extra exercises are not keyed to learning goals; these exercises help students review skills in a format resembling a quiz or an exam. Answers to most of these problems appear at the end of the book.

Cumulative review problems appear after every two or three chapters. They are designed to test the student's knowledge of each set of chapters and to reinforce material from earlier chapters in the course. These exercises are also useful in studying for tests, midterms, and final examinations.

Study Aids

Our text has been planned to suit the backgrounds and needs of a wide variety of students. Each chapter begins with a series of learning goals. Throughout each chapter the learning goals appear in the margin next to the discussion of the corresponding material. Key terms appear in boldface and are accompanied by concise definitions. These definitions reappear in the Glossary at the end of the book. A list of key terms appears at the end of each chapter, along with a summary that reviews the most important points discussed in the chapter.

As in the previous editions, a unit on mathematics (Appendix A) is included at the end of the book. It can be treated as a reference or used at the beginning of a course as a review of skills.

Complete Instructional Package

Basic Concepts of Chemistry, Sixth Edition, is part of a complete instructional package for introductory chemistry. Our *Laboratory Experiments for Basic Chemistry* contains 25 experiments and two laboratory exercises. The sixth edition of the laboratory manual also contains the important safety and chemical hazards guide, which discusses potential hazards and stresses safety in the laboratory. The sixth edition also contains a chemical disposal guide with suggestions for disposing of various chemicals used in the experiments. New to the sixth edition is a section on keeping journals to accompany each experiment. Each journal page has a particular journal prompt, which helps clarify the thinking process. Once again *Laboratory Experiments* includes the copyrighted game CHEM-DECK, which teaches the student how to write and name chemical compounds while playing card games that are variations of gin rummy and poker.

The *Instructor's Resource Manual* accompanies both the book and the laboratory manual. It includes a test bank containing more than 900 test

questions and answers, including a math pre-test, and a broad selection of final examination questions. Each lab experiment description includes a discussion of the experiment's purpose, answers to questions, and a list of the quantities of chemicals needed to conduct the experiment for a class of 24 students.

The *Solutions Manual* to the sixth edition contains step-by-step solutions to the more than 2,000 problems in the text.

This edition includes a set of 52 two-color *Transparencies* of figures and tables taken from the text.

As before, the sixth edition of the text is accompanied by a *Study Guide* by James Braun of Clayton State College in Morrow, Georgia, which offers extra explanations and problems for students who need more practice. Each chapter in the *Study Guide* corresponds to a chapter in the textbook and contains additional worked-out examples and extra exercises for the student to solve. The opportunity for further study is offered in special review exercises that cover groups of chapters.

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TO THE STUDENT

Tips on Studying Chemistry

Chemistry is an exciting subject. It affects our lives each day in many ways. The foods we eat, the clothes we wear, the materials used to construct our homes, the medications that cure our illnesses, and the energy we depend on are all products of the science of chemistry coupled with technology.

As you learn chemistry, you will gain knowledge that will help you understand more about our technological society. You'll be able to apply your understanding of chemistry to help solve some of the problems you will face in the real world. You'll be able to approach familiar situations with new insight and be able to make decisions based on the knowledge acquired in this course.

Study Skills for Chemistry

How to Use this Book

Your textbook can be an important tool in helping you master the ideas and problem-solving skills you will learn in this course, especially if you know how to use it. Take a minute now to become familiar with the parts of the book. What follows are our suggestions for how you can best use the book to help you succeed in your course.

Begin each chapter by reading the learning goals and the introduction. The learning goals will help you organize the material you'll need to master; they identify topics that are likely to have special emphasis in class.

After you've read the introduction and learning goals, flip through the chapter to get a general sense of the topics it covers. Notice that the learning goals are repeated in the margins near the material to which they apply. The numbered headings in the text will alert you to the major topics of the chapter. Look also at the figures and tables in the chapter.

After your brief flip through the chapter, return to the beginning and start reading. Read each section thoroughly and take notes as you read. At the end of each section, pause to think about what you have just read; if you are not sure you understand everything in the section, go back and read again.

While some of the material in this course requires memorization, a large part of chemistry involves learning how to solve problems. *Basic Concepts of Chemistry* has been written with a major focus on developing problem-solving skills. Throughout the text, you'll find worked-out examples. When you come to them, stop and read through them carefully. Each example presents a problem and then shows you the solution, step by step. Once you have read the worked-out example, try the practice exercise that follows. Check your answers against the answers given at the back of the book. Problem-solving skills are among the most important things you will learn in this course, and working the exercises in the chapter will give you practice and immediate feedback on how well you are mastering them.

At the end of the chapter, you'll find a summary and a list of key terms. Review these, testing yourself to see if you understand the terms. If you need help, the numbers following the terms tell you which section to review. (There is also a glossary at the back of the book giving definitions of the terms.) Finally, work the self-test exercises at the end of the chapter. You will see that they are grouped by learning goal, to help you organize the material. The answers to selected exercises are at the back of the book, to help you test your progress.

How can you be sure, as you study, that you have mastered the material in the chapter? If you are able to work through the examples, practice exercises, and self-test exercises at the end of the chapter, you will have mastered the necessary problem-solving skills. For sections that require you to memorize reactions or descriptive material, self-test exercises are designed to help you master this content.

You'll get the best results if you read the relevant chapter before going to the lecture. Survey the material to be covered and examine the types of problems to be solved. Know what the chapter is about. This preparation will help you get the most from your instructor's lecture.

If you find at the beginning of the course that you need some review of mathematics, turn to Appendix A at the end of this book. It reviews the mathematical skills you'll need in this course.

Taking Good Notes

Note taking is one of the most important skills for a student to develop. In class you will take notes. Review them the next time you study and reread each section of the textbook slowly for understanding. Combine what you learned in class with what you read in the textbook. Where problem solving takes place, go over the step-by-step solutions in the textbook. Then answer the practice exercises to be sure that you understand how to find the solutions yourself. If you're stuck, ask the instructor for help. Do not ignore material that you do not understand.

We have written *Basic Concepts of Chemistry* in a simple, conversational, readable style. You should not have a difficult time understanding the book. Spend some time being sure that you can recall what you have learned.

Sometimes it helps to write as you read, recalling what you have learned in your own words on paper. The last step is to reread the entire chapter and go over all of your notes.

Many students find it useful to keep a journal to write about the material being studied. A simple lined notebook can serve as a journal. After each lesson, summarize the point of the lesson. After reading a section in the textbook, write about what you thought was the point of the reading. Read your journal notes to a classmate or, if possible, to a teaching assistant or to the professor. Writing about a topic is an excellent way to find out if you understand the material being studied.

Your notes must be accurate to be useful. You will have to develop your own shorthand in order to take notes quickly. There are many symbols and abbreviations that you can use in devising your own shorthand. Mathematical symbols such as $>$ (greater than) and $<$ (less than), the plus sign (+), and the equals sign (=) are useful. Spelling a word phonetically by leaving out the vowels also speeds things up.

As you work through the exercises in each chapter of the book, clearly indicate each type of problem you are solving. Write a short description of the type of problem and explain why you are solving this particular problem. When there are several variables in a problem, be sure you can solve for each of the variables, depending on the information given.

Combine your lecture notes with your textbook notes. Be sure you understand your notes. To test your knowledge, turn to the end of the chapter and do the self-test exercises. If you can answer them, you're on your way.

The Importance of Attending Class

There is nothing more important than attending class to help you learn chemistry. Regular attendance allows you to have all of the lecture notes you'll need to organize your studies, and the experiments you perform in the laboratory give you hands-on experience in chemistry. Instructors are experts in teaching their subjects. They teach to a variety of learning styles, and you will benefit greatly from the classroom and laboratory experience and the personal interaction with the instructors and teaching assistants. If you need extra help, see your instructor after class and set up an appointment. Some instructors set aside time for weekly review sessions, and you will learn about these in class.

Making the Most of Your Study Group

Becoming part of a study group is one of the best ways to learn the material in the course. When people work together they can share their skills and resources. In this way they can get more done than by working alone. In addition, people often draw strength from groups. Setting a meeting with the study group is like making an appointment to study. It's an appointment that you are more likely to keep, as compared with a solo study session, which can be more easily skipped. With three or four classmates you can

practice problem solving and reasoning. Study groups can be organized in many ways. Here are some suggestions for you to try.

The first step in making the most of your study group is to form a group that works for you. Find people who share some of your goals and who face similar challenges. Find people who are as serious about school as you are. This might include those who attend class regularly, take good notes, and keep up in class. If you are a single parent who supports a family, it might be helpful to form a group that contains at least one other member who has similar time constraints and obligations.

At the first meeting of the study group, set a method of operation. It is likely that one member will emerge as the leader. You might decide to have this person remain the leader, or you might share and rotate the leadership role. Decide what material the group will cover during each session. Set an assignment for the next session, so that everyone will be prepared and the time is used efficiently and effectively. Set time limits for discussion of each topic, so that all of the topics that must be covered are addressed. Practice teaching each other the material.

Solving problems as a group is an important task. At the end of each chapter in the self-test exercises, you will find certain problems marked with a triangle. These problems are good for discussion and are ideal for use in the study group. Once each member learns the material, the problems can be solved by the group. The next step is to have each member solve problems individually and then discuss them as a group.

Once the material is discussed and everyone understands the subject matter, you will be ready to test each other. Have each group member choose several questions, make a sample test of your own, and test each other. You might also try to predict what questions or types of question will be on the test. Don't forget that even with a study group, it is necessary to do a great deal of studying on your own. Working individually is an important part of the learning process.

Taking a Test

Being well prepared and confident is the first step in taking a test. Cramming doesn't work in chemistry. You cannot open the book the night before the exam and learn a few weeks worth of material in one sitting. Chemistry must be studied gradually. If you have trouble solving a particular type of problem, you may need to consult the instructor. That's difficult to do if you try to study all at once.

Try to study a little each day. You'll find this method more effective and less stressful. *Basic Concepts of Chemistry* contains an entire package of helpful materials. Besides the textbook, there is a study guide for students, written by James R. Braun, and a solutions manual, containing solutions for all of the problems in the textbook. These ancillary materials can give you the extra practice you might need to achieve success in the course.

Before an exam, it is important to speak with your instructor and find out what material will be covered on the test. Instructors emphasize important concepts in class. Some instructors will help guide your studies, by offering information on material that deserves special attention.

Get a good night's sleep before an exam. Be as relaxed as possible so you can think easily. You'll know whether you're prepared or not. If you've studied properly, you should do well.

Once you begin the exam, glance through it to see how long it is and determine how to budget your time. If a problem gives you trouble, skip it and come back to it later. That way you'll have time to get to all of the questions.

Maintaining Good Study Habits

You can successfully complete basic chemistry if you develop good study habits. The sections that follow discuss some common-sense methods of achieving success in college and offer additional advice that can be applied to your day-to-day study of chemistry. As you become a well-prepared and successful student, you will approach examinations with confidence. The successful habits you form will stay with you as you complete your education and will benefit you throughout your life.

Time Management for College Students

You've got an exam on Friday and a paper due on Monday. You know you've got to get to work. Just then the phone rings. A group of friends from your dorm is going out for a snack. You know you shouldn't join them, but you've got to eat anyway, so you go along. When you return home you need a little time to unwind. You turn on the television. Two hours later you're relaxed, but you're also tired. You decide to call it a night. There's always tomorrow!

If this scenario sounds familiar, it should. It happens to all of us now and then. As a college student, however, it's very important to learn to manage your time effectively. The first step in managing your time effectively is to know where you're going. It helps to set goals for yourself. Although we may have vague notions of what we want from life, like being happy, or being a credit to society, or being financially secure, these generalized plans should be made concrete. Goals must be real. They must be examined closely. There are three different types that you should consider: long-range goals, medium-range goals, and short-range goals.

Long-range goals are usually personal wishes. They have to do with your career aims, your educational plans, and your social desires. Think about where you would like to be 5 or 10 years from now. The education you are now receiving in college should be a stepping stone to help you achieve your long-range goals. Besides achieving the benefit of learning, a college

education pays off in dollars. College graduates earn about \$700,000 more during their lifetimes than their counterparts who have no degrees. Depending on your career plans, the grades you earn in your courses will help determine whether or not you will be able to fulfill your long-range goals. To achieve long-range goals, they need to be broken into smaller parts and examined closely.

Medium-range goals, sometimes called mid-term goals, can be accomplished in one to five years. They help you achieve your long-range goals. They can be set two or three times a year. For example, if you plan to enter medical school after graduation, you will need a considerable number of A's in your courses. A medium-range goal would be to get four or five A's in your courses for four years. Another medium-range goal might be to join a club or improve your skills in your favorite sport. Let's say that your grades last semester weren't the best. A medium-range goal for you might then be to improve your grades. If you're saving money to buy a car, then watching your budget more carefully might be a reasonable goal to set.

Short-range goals, also called short-term goals, can be accomplished in a year or less. These goals involve taking care of your daily tasks and keeping up with your assignments. Reading a chapter in a book, completing an assignment, or writing a paper are examples of short-term goals.

Achieving your goals often requires setting up a plan. Although we'd like to think that we have the willpower to do all that we have to, very often we become distracted. A well planned, flexible schedule is a useful tool to help us get things done more effectively.

The first step to managing your time is to know yourself. When do you function the best? If you're a morning person, it's best to try and get done as much as you can in the morning, when you are at your best. If you function better late in the day, then you should try to schedule most of your work in the afternoon or evening.

Setting up a monthly plan is the next step in becoming organized. Obtain a calendar and write in, on the appropriate date, the important assignments and events you're responsible for each month of the semester (Figure 1). Term papers, exams, sports meets, and social activities can be handled better if you look at the overall picture. If you know you have two exams scheduled and a paper due close to each other, then you'll have to keep your schedule free to allow for your school work.

After you've completed your monthly plan, devise a weekly plan. Map out a schedule for each day of the week. Think over how much time you need to complete each assignment and to study for your exams, in order to fit all of your responsibilities into your schedule (Figure 2).

It's usually best to find a quiet place to work. Accomplish your tasks in priority order, breaking the large tasks into smaller ones. Don't try to do too much in one day. It's better to do a little less than to do too much. Complete one task at a time and avoid working on two projects at once.

You may find that after a month or so, you can manage your time effectively without a written schedule. For some students having a written

■ FIGURE 1

Monthly planning calendar

Month _____ Year _____

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY

schedule is a necessity. When you are designing your plan, don't forget that you need time for enjoyment and for work. Giving yourself positive reinforcement is a good idea. Reward yourself when you've accomplished something worthwhile. It is important to enjoy what you're doing and to set enough time for rest and relaxation.

While some people find it difficult to socialize, there are others who become overly involved in social activities. Attending college can be very exciting, and for some young adults the endless opportunities to work for a cause, socialize with friends, or attend frequent parties are irresistible. It is not uncommon for some college students to use study time for socialization.

Around the time of midterms panic sets in and lasts until final exam time. Don't get caught in this trap. Be sure that you are not becoming involved in too many social activities in order to avoid your studies. If you're serious about receiving a college education, then your study time will be important to you.

School-related stress usually results when you allow yourself to become overwhelmed and overloaded. Taking on too much responsibility at one time often results in a high stress level. This can cause a whole range of physical, emotional, and social problems.

When you register for your courses, be sure that you're not taking on too much. Most colleges schedule a full load for you. This means that you sign up for a set number of credits that school personnel believe a full-time student can handle successfully. The full load is calculated so that a full-time

■ FIGURE 2

Weekly plan

My main goal this week: _____

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
6 A.M.							
7 A.M.							
8 A.M.							
9 A.M.							
10 A.M.							
11 A.M.							
12 NOON							
1 P.M.							
2 P.M.							
3 P.M.							
4 P.M.							
5 P.M.							
6 P.M.							
7 P.M.							
8 P.M.							
9 P.M.							
10 P.M.							
11 P.M.							
12 MID.							

student can finish the requirements for an associates’ degree in two years, or a bachelor’s degree in four years.

Students who work diligently and have good study skills and few other demands on their time can normally handle a full load. Problems often arise when a student signs up for more credits than are recommended for a full load or when there are other important time-consuming responsibilities. When you have too much responsibility to handle at once, stress can readily develop. Instead of completing your course work with ease, you may find yourself playing “catch-up” all semester.

Arranging a course load to fit your needs is one of the most important items to think about as a college student. You can avoid overloading yourself by taking a night course during the summer at a local college or by attending summer school. Spending an extra semester or two in college is a reasonable price to pay in order to achieve success and avoid stress while you’re in college.