

Third Edition



CHEMISTRY

The Central Science

THEODORE L. BROWN

H. EUGENE LEMAY, JR.

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**To those from whom we have learned,
and to our wives and children**

Preface

The preface is almost always the last part of a textbook to be written. Only when the book has assumed its final form can the author declare to the reader what he thinks he has accomplished. Thus, what is for students the beginning is, in one sense, for authors the culmination of a long, often difficult journey. In this preface we want to give you some feeling for the ideas and concepts that have informed our writing of the text. We also wish to suggest how you can best make use of this book in your study of chemistry.

You will notice that this is the third edition of *Chemistry: The Central Science*. The first two editions have been very successful; apparently many teachers of chemistry (and many students as well, to judge from letters we have received) felt that we had developed a good book. But, as with any human effort, there is bound to be room for improvement. During the past few years, with the help of our publisher we have asked a great many teachers and students for suggestions as to how the book might be improved. In addition, we have watched carefully for the need to make changes to keep the book up to date. This third edition represents the end result of more than 2 years of work. The changes we have made are numerous, and some of them are important, but they need not concern you. What you should know is that we have adhered to the general approach and style that distinguished the first two editions. Our aim has been to present chemistry to you in a clear, readable fashion. We have tried continually to keep in mind the audience for whom the book is intended—you, the student.

Most of you are studying chemistry because it has been declared an essential part of the curriculum in which you are enrolled. That curriculum may be agriculture, dental hygiene, electrical engineering, geology, microbiology, metallurgy, paleontology, or one of many other related areas of study. It is fair to ask why it is that so many diverse areas of study should all relate in an essential way to chemistry. The answer is that chemistry is, by its nature, the *central science*. In any area of human

activity that deals with some aspect of the material world, there must inevitably be a concern for the fundamental character of the materials involved—their endurance, their interactions with other materials, and their changes under a given set of conditions. This is true whether the materials involved are a polymer used to coat electronics components, the color used by a Renaissance painter, or the blood cells of a child born with sickle-cell anemia. It is very likely that chemistry plays an important role in the profession to which you now aspire, or may decide later to pursue. You will be a better professional, a more creative and knowledgeable person, if you understand the chemical concepts applicable to your work and are able to apply these concepts as needed.

The relationship of chemistry to professional goals is important, and this factor provides reason enough for you to study chemistry. There is, however, an even more important reason. Because chemistry is so central and so intimately involved in almost every aspect of our contact with the material world, this science is an integral part of our culture. The involvement of chemistry in our lives goes much deeper than the well-known advertising slogan, “Better things for better living through chemistry.” In addition to all the obvious ways in which we use the products of chemical research and production—plastic bags, children’s toys, counter tops, weed and insect killers, photographic films—we indirectly use thousands of chemical products via the foods we eat, the cars we drive, the medical care we receive, and so forth. During the past several years, we have become increasingly aware that our use of chemicals has had a profound and frightening effect on our environment. Indeed, many scientists are convinced that we have so intensely polluted this planet and so unthinkingly sowed the seeds of future pollution that the fate of civilization is all but sealed. Whether this is so remains to be seen; however, if you are to be a responsible citizen, you will surely need to be informed on many complex issues involving chemistry and the use of chemicals. Because vested interests have a powerful stake in public policy, the public often is presented with conflicting information and claims. You can more fully appreciate and analyze the complex issues put before you if you understand the fundamental principles involved and keep them in mind during your reading and study.

With all of these considerations in mind, you should now be impatient and eager to begin your study of chemistry. Now that you are ready to go, we should say something about how this book can best help you. You might first take a few minutes to glance through the table of contents. The particular sequence of chapters that we have chosen is one that we feel promotes a natural unfolding of the science of chemistry. However, the order in which the chapters of the book are covered in the classroom will be determined by your instructor. You should not be disturbed if the order is not the same as the order in the book. The book has been written so as to make allowance for alternative chapter orders and, in some instances, for the complete omission of certain chapters. Notice that some materials interspersed throughout the book deal with the chemical aspects of the world in which we live: the air, the earth, and the waters on the earth’s surface. In these materials we have attempted to connect the chemical facts and principles introduced in other, usually earlier, chapters to the familiar (and sometimes not so familiar) aspects of our

surroundings on earth. Your instructor, the person who will guide you through this book, may not feel that there is sufficient time to cover some or all of these environmental topics. We suggest that you read them anyway; they will help you appreciate the many ways in which chemical concepts and observations are related to contemporary life.

If you should at some point encounter a term or concept you are expected to know but can't remember, use the index at the back of the book. A good index is a rarity; we have worked hard to make your index in this book as complete and accurate as possible. Use it often. (Remember the index also when you later use the book as a reference, after having finished the course. It can help you find what you want more quickly than any other means.)

The difficulties that many chemistry students experience often can be traced to faulty exposition and confusing explanations in their text. This book has been worked on very thoroughly by many people to ensure that it is as clear, concise, and free of confusion as possible. However, you may find that a single reading of a chapter will not suffice if you are to use the book effectively as a learning tool. We suggest that you read every assigned chapter as early as possible, preferably before the material is covered in lecture. This will make you aware of important concepts and terms even before they are treated by the lecturer. Later, you will need to go through the assigned sections of the book much more carefully, making sure that you understand the new terms and problems put before you. We have inserted a great many *sample exercises* into the text, so that you might have clearly worked-out examples of problem solving of various types. You should study these exercises carefully, noting every aspect of them, especially if numerical problem solving is involved.

The review section at the end of each chapter is an integrated package designed to help you determine whether you have in fact learned all the material assigned you in each chapter. The *summary* points out the highlights of the chapter; sometimes we say things a little differently in the summary in order to add an extra element of understanding to what you have gotten from the chapter itself. The *key terms* that you should know are also collected for your convenience. The *learning goals* are placed at the end of the chapter to enable you to test yourself. You should make sure that you can meet each learning goal. This can best be done if you state a definition and then check it, write a formula and then check it, or solve a problem and then check it. It may happen, of course, that your instructor will not have covered part of the material in a chapter. You can then skip over the learning goals for this material, but you should still read the complete summary and learn all the key terms. By learning even nonrequired terms and concepts you can expand your chemical vocabulary with little effort.

The *exercises* at the back of each chapter are designed to test your understanding of the materials covered in the chapter. They are grouped according to topic, except for a number of additional exercises. The purpose of the additional exercises is to test your ability to solve a problem when it is not clearly identified as to topic. Also, some of the questions in this category require the application of material from more than one topic area. Problems marked with brackets are, in general, a little more difficult to solve than the others. We have prepared a solutions

manual that contains detailed answers to all the end-of-chapter exercises; you should consult this manual only after working out problems on your own.

Finally, you should note that there are several appendices following Chapter 26. These are designed to aid you in various ways. You should get acquainted with what is there by glancing through them before the course gets under way. In particular, note that answers are provided to many of the end-of-chapter exercises. Color question numbers in the text indicate that the answer to the question is in the answer section following the appendices.

Your instructor may have elected to have you purchase the *Student's Guide* designed for use with the text. This guide, written by Professor James C. Hill, of California State University, Sacramento, is a nicely organized and well-written supplement to the text. You will find it filled with helpful ideas, problem-solving techniques, and fresh insights into the materials presented in the text. We are very happy that Jim has agreed to write the study guide; we feel that it is a valuable learning aid for use with the text.

Most general chemistry courses involve laboratory as well as classroom work. There is a very good reason for this. Chemistry is an experimental science; the entire theoretical structure of chemistry is based on the results of laboratory experiments. As you study chemistry, you should try to relate what you learn in the classroom and from the text to operations and observations made in the course of your laboratory work. A very fine laboratory manual for use with this text has been written by Professors John H. Nelson and Kenneth C. Kemp of the Department of Chemistry, University of Nevada, Reno. We believe that it is also an important learning tool in your study of chemistry.

During the many years that we have been practicing chemists, we have found chemistry to be an exciting intellectual challenge and an extraordinarily rich and varied part of our human cultural heritage. We hope that all the hassles you must face regarding course grades will not keep you from sharing with us some of that enthusiasm and appreciation. We have, in effect, been engaged by your instructor to help you learn chemistry. We are confident that we've done that job well. In any case, we would appreciate your writing us, either to tell us of the book's shortcomings, so that we might do better, or of its virtues, so that we'll know where we have helped you most.

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