general chemistry

principles and modern applications

second edition

ralph h. petrucci

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preface

The first edition of this text was based on certain assumptions about the students who study general chemistry and the courses that have been designed to serve them. These assumptions were apparently shared by many users of the first edition, and they have been adopted again, with some modifications, as the pedagogical basis of the current edition. The modifications are two or three in number.

To me it seems still that most students are interested in the practical applications, social significance, and historical roots of the subject areas they study, as well as in conceptual frameworks and bodies of facts and theories. Of these several aspects, probably the historical background of a subject is the most difficult to pursue successfully in an introductory text of necessarily limited length and scope. The idea that the patterns of thought that underlie modern theory can be traced through their historical development has not been abandoned in this edition, but historical aspects of chemistry have been deemphasized.

Although the typical student of this text is not likely ever to be called upon to pursue the quantitative aspects of chemistry to the extent that current theory permits, additional emphasis has been placed on quantitative subject matter. It is probably still true that students learn best by doing, and this edition provides more opportunities for "doing chemistry." The number of worked-out examples in the text has been more than doubled, as has the number of end-of-chapter exercises. In addition, each of the text examples is keyed to several similar end-of-chapter exercises, and the exercises are grouped according to the major concept illustrated. Answers to more than half of the exercises are provided in Appendix 6, and complete solutions of all exercises are available in a separate *Solutions Manual.* As in the first edition, exercises that are either more difficult

or that require an extension of concepts presented in the text are designated by a bold star ★. Also as in the first edition, marginal notes are employed to provide additional background, clarification, or elaboration of ideas introduced in the text.

Despite the fact that chemistry is among the most highly organized and formal of academic disciplines, the approaches to teaching chemistry can be quite varied. I believe that instructors who prefer an approach different from mine will be able to adjust the order in which topics are considered to suit their own preferences. The general format is that of the first edition: consideration first of a number of basic ideas, particularly those related to stoichiometry, followed by a discussion of the structure of matter, and then chemical reactions. Practical applications are given throughout the text, but primary emphasis on applications is deferred to the later chapters.

Some of the topics that were introduced in the opening chapters of the first edition have been deferred in this edition to later chapters where they can be discussed in full; for example, solution stoichiometry is considered with other topics in solution chemistry instead of with the stoichiometry of chemical reactions, and oxidation-reduction concepts are similarly deferred. The discussion of states of matter has been divided into two chapters—one on gases and one on liquids and solids—and these have been moved forward (Chapters 5 and 6) to provide some background on the observable macroscopic behavior of matter prior to a study of the microscopic structure of matter. Properties of solutions (Chapter 12) are considered after the structure of matter because the theoretical approach involves intermolecular forces. However, some may prefer to consider solutions after the states of matter and before the structure of matter, and this can easily be done. Chemical bonding is covered in two chapters instead of one. The first of the two (Chapter 9) emphasizes Lewis structures, oxidation states, and valence-shell electron-pair repulsion theory; the second (Chapter 10) deals with atomic and molecular orbital theory. Selective study of topics in Chapter 10 should be possible in courses where molecular structure is not strongly emphasized. Another change in organization from the first edition is the inclusion of separate chapters on nuclear chemistry and on coordination chemistry. SI units are introduced in the text but are not used exclusively. Many fields related to chemistry continue to use different systems of units, and it will probably be necessary for students to become familiar with a variety of units for some time to come.

I wish to thank students and instructors alike who used the first edition and offered helpful suggestions. Whatever improvements are to be found in this edition are largely the result of these suggestions. In particular I am grateful to the several individuals who provided critiques of the first edition and/or read parts or all of the manuscript of the second edition: Professors Geoffrey Davies and William E. Cass (Northeastern University); Captain Walter P. Menzies, Jr. (United States Air Force Academy); Professor Michael F. Farona (University of Akron); Professor Gardiner H. Myers (University of Florida); Professor Galen L. Ober (Clarion State College); Professor Kay O. Watkins (Adams State College). I am especially indebted to Professor Davies for his very careful reading of the entire manuscript of this edition and his detailed suggestions for

its improvement, and to my colleague Professor James D. Crum for his continuing counsel. Finally, I am happy to have had the opportunity to work with James L. Smith and Leo Malek of Macmillan Publishing Company; their efforts in the production of this text have been tireless.

The professional assistance of the aforementioned individuals has been invaluable in the preparation of this edition; but the encouragement, forbearance, and sacrifice that have made possible both editions of this text are those of my wife and family. To them I owe the most gratitude of all.

Ralph H. Petrucci

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detailed contents

matter—its properties and measurement

Interaction with the environment is crucial to human existence. At the most elementary level this means breathing air and consuming food to maintain metabolism, a process in which one set of materials is transformed into another. The most basic and all-inclusive definition of chemistry is the study of the transformations of matter. Principles of chemistry are fundamental to an understanding of all processes of the living state, as we shall discover in due course.

A powerful agent for effecting chemical transformations discovered in ancient times was fire, which made possible the cooking of food, the baking of pottery, the manufacture of glass, and the smelting of ores to produce metals—first copper, and then lead, tin, and iron. Among other chemical processes discovered long ago were the making of butter, cheese, wine, beer, and soap; the tanning of hides; and the dyeing of fabrics.

Despite these many early applications, an understanding of the principles of chemistry has developed only in recent times, principally in the nineteenth and twentieth centuries. And it is from this theoretical base that the profound changes we are now able to effect on the environment have arisen. For example, as basic knowledge of the field of organic chemistry has grown, more and more ways have been found to exploit the natural resource, petroleum, not only as a source of fuels but also for the production of plastics, drugs, and pesticides.