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**General
Chemistry
with
Qualitative
Analysis**

Second Edition

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with
Qualitative Analysis
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Preface

This second edition is based on four editions of another text written by one of us (R. H. Petrucci, *General Chemistry: Principles and Modern Applications*, Macmillan, New York, 1972, 1977, 1982, 1985), complemented by a revised group of eight chapters on qualitative analysis written by the other (R. K. Wismer). As in the first edition, we have made certain assumptions about the students who will study general chemistry from this book. Most, we believe, are not preparing for careers in chemistry but are acquiring the chemical background required in other fields—biology, the health sciences, engineering, and the agricultural sciences, to name but a few—while some may study chemistry simply to add to their general education in the sciences. Not only should a general chemistry text provide these students with the modern chemical background they need for their specialized studies, but it should also be as readily understandable as possible, for these students have limited amounts of time available to study the subject. As in the previous edition, we have attempted to strike the balances between principles and applications, between qualitative and quantitative discussions, and between rigor and simplification that seem most appropriate for these typical general chemistry students. We have been guided in this revision by comments from users and reviewers of the previous edition; we have given special attention to all suggestions, even minor ones, that might in some way improve the clarity of the presentation.

Perhaps the major changes between the previous edition and this one are the increased coverage of applications and descriptive inorganic chemistry and the more extensive integration of these topics throughout the text. Numerous applications are presented at the points where their underlying principles are considered. In addition, a new feature of this text is the inclusion of special "Focus" sections at the ends of certain chapters (sixteen in all). For example, a discussion of the key chemicals of industry is included in Chapter 1, aspects of industrial chemistry in Chapter 4, semiconductors in Chapter 10, liquid crystals in Chapter 11, and polymers in Chapters 9 and 26. Descriptive inorganic chemistry is introduced in the middle of the text (Chapter 13) with a consideration of the first 20 elements. The topics chosen for this discussion are those that can be presented through principles developed in the first twelve chapters. The chemistry of these elements is revisited in Chapters 21 and 22 in a discussion of the representative elements that employs the full range of principles developed in the first twenty chapters of the text. Chapter 23 deals with the transition elements, Chapter 24 with coordination chemistry, and Chapter 25 with nuclear chemistry. As in the first edition, one chapter (Chapter 26) is devoted to organic chemistry and one (Chapter 27) to biochemistry.

Topics related to qualitative analysis of cations appear in several chapters (18, 19, 21, 23, and 24), each at a point appropriate to the principle involved. The final eight chapters on qualitative analysis feature complete, pretested procedures (and some alternate procedures) for the analysis of 24 cations and 15 anions. These procedures are illustrated with detailed flowcharts for each of the five cation groups and each of the

four anion groups. The basis of each laboratory procedure is established through theoretical discussion and, as appropriate, chemical equations and illustrative calculations. Also discussed thoroughly are the possible interferences in the tests for ions and other conditions that may cause difficulties in performing analyses.

The qualitative analysis section is closely coordinated with the first 27 chapters, containing numerous references to relate qualitative analysis theory and practice to general principles. For example, many of the 43 illustrative examples in this section review and extend principles of reaction and solution stoichiometry (first introduced in Chapters 4 and 12), chemical equilibrium (Chapter 15), thermodynamics (Chapter 16), acids and bases (Chapter 17), buffer solutions (Chapter 18), solubility and complex ion equilibria (Chapter 19), and oxidation–reduction (Chapters 4 and 20). Moreover, some of these examples require a synthesis of two or more concepts, such as E°_{cell} of one reaction and ΔG° of another to calculate the equilibrium constant, K , for the net reaction obtained by combining the two.

We continue to believe that there exists no single ideal organizational scheme for a general chemistry text. This edition, like the first, is so structured that a number of alternative orders of presentation are possible. For example, the "Focus" features can be studied as encountered, or some features may be deferred to later contexts (such as considering the features on key chemicals and industrial chemistry together at the close of Chapter 4). Also, some of these features can be made optional, for although they relate closely to fundamental principles from the portions of the text that precede them, these features introduce no material that is crucial to the development of later subject matter. Instructors who wish to combine the material on thermodynamics into a single presentation may defer Chapter 6 until Chapter 16 is reached. Those who wish to limit organic chemistry to a description of bonding, structure, and nomenclature can take up these matters at any time after Chapters 9 and 10 on chemical bonding. Instructors who favor dealing with systematic descriptive inorganic chemistry as a single unit will find that Chapter 13 can easily be deferred and taken up together with Chapters 21–23. None of the material introduced in Chapter 13 is fundamental to the subject matter of Chapters 14–20. The choices offered for treating qualitative analysis range from methods of simplifying the qualitative analysis scheme to providing for a full treatment of qualitative analysis by foregoing certain earlier chapters. For example, Chapters 13, 21–23, and 25–27 can be omitted and systematic inorganic chemistry presented from the standpoint of the descriptive chemistry in the qualitative analysis chapters, with the addition of the portions of earlier chapters as cited. In the separate *Instructor's Manual* that accompanies this text, these and several other alternative organizational schemes are described in detail.

As in the first edition, each chapter concludes with a number of study aids. First is a brief chapter summary, which is followed by a set of learning objectives. These objectives are stated in fairly general terms, and individual instructors

may choose to emphasize some more than others or to add specific objectives of their own. The third end-of-chapter feature is a set of definitions of important new terms introduced in the chapter. Reference to each end-of-chapter definition is made through a **boldface** page number in the Index. The collection of these Index listings and end-of-chapter definitions constitutes a glossary of the entire text. New to this edition is a listing of a small number of references for each chapter. These "Suggestions for Further Study" are typically of several sorts: Some offer an alternative, often more elementary, approach to important concepts considered in the chapter. Some carry the subject matter beyond the level of the text. Many of the references deal with interesting applications of topics discussed in the chapter. A few provide historical background. Practically all of these references are from journals and magazines, rather than texts or monographs, in the belief that students are more likely to refer to supplementary materials if they are rather brief.

Each chapter has four categories of exercises. The first category, "Review Problems," is new to this edition. These problems require straightforward applications of principles introduced in the chapter, each problem usually involving just a single concept. In the category "Exercises," exercises are grouped by subject matter and are of a broader nature than the "Review Problems"; those that either are more difficult or require an extension beyond the concepts presented in the chapter are designated by a star *. The "Additional Exercises" are not grouped by type. The final category, "Self-Test Questions," presents a group of multiple-choice items, together with brief essay questions and/or problems, that are typical of examination questions. Answers to most of the "Review Problems" and the "Self-Test Questions" are provided at the end of the book. About one-half of the "Exercises" are similarly answered, but answers for the "Additional Exercises" are not given. Complete solutions to all but the "Additional Exercises" are provided in a separate *Solutions Manual*. Solutions to the "Additional Exercises" are available in the *Instructor's Manual*.

If we have succeeded in improving this edition over the previous one, it is largely as a result of the diligence with which reviewers have studied and commented on what we have written and of their willingness to share some of their own pedagogical ideas. The following have provided critiques of the first 26 chapters of the published first edition: R. Kent Murmann, University of Missouri, Columbia;

Saul I. Shupack, Villanova University; Joseph Topich, Virginia Commonwealth University; and Mary S. Vennos, Essex Community College of Baltimore County (Maryland). Charles W. J. Scaife of Union College supplied helpful commentary on the Answers to Exercises of those 26 chapters. Those who read and commented on portions of the manuscript of the first 27 chapters of this edition are O. T. Beachley, SUNY, Buffalo; Billy L. Stump, Virginia Commonwealth University; and Carl Trindle, University of Virginia. Those who commented on the entire manuscript of the first 27 chapters were Michael F. Golde, University of Pittsburgh; Philip S. Lamprey, University of Lowell; and William H. McMahan, Mississippi State University. The following colleagues at California State University, San Bernardino, helped by reviewing manuscript, passing along student comments, and being available for consultation on various matters that arose during the preparation of this edition: Dennis Pederson, Arlo Harris, Kenneth Mantei, Lee Kalbus, and James Crum. Those who commented on the qualitative analysis chapters and made helpful suggestions were O. T. Beachley, SUNY, Buffalo; Robert Brasted, University of Minnesota; Norman Duffy, Kent State University; George Schenk, Wayne State University; and Donald Williams, Hope College. Donald W. Gauntlett and Thomas G. Greco of Millersville University helped class test analytical procedures and provided advice and assistance in practical analytical chemistry.

We have continued to receive assistance from many individuals associated with Macmillan Publishing Company, including a number, we are sure, who are not even known to us. However, our editor, Peter Gordon, and our production supervisor, Elisabeth Belfer, deserve special mention for the good cheer and professional manner with which they handled the numerous tasks that befell them in the preparation of this edition.

Our greatest debt is to our wives (Ruth Petrucci and Debbie Wismer) and families (especially three- and seven-year-old Mary and Michael Wismer) who have had to endure our neglect at the same time that they were asked to assist in many ways, large and small. Their forbearance was indispensable to the completion of our task.

San Bernardino, CA
Millersville, PA

R. H. P.
R. K. W.

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