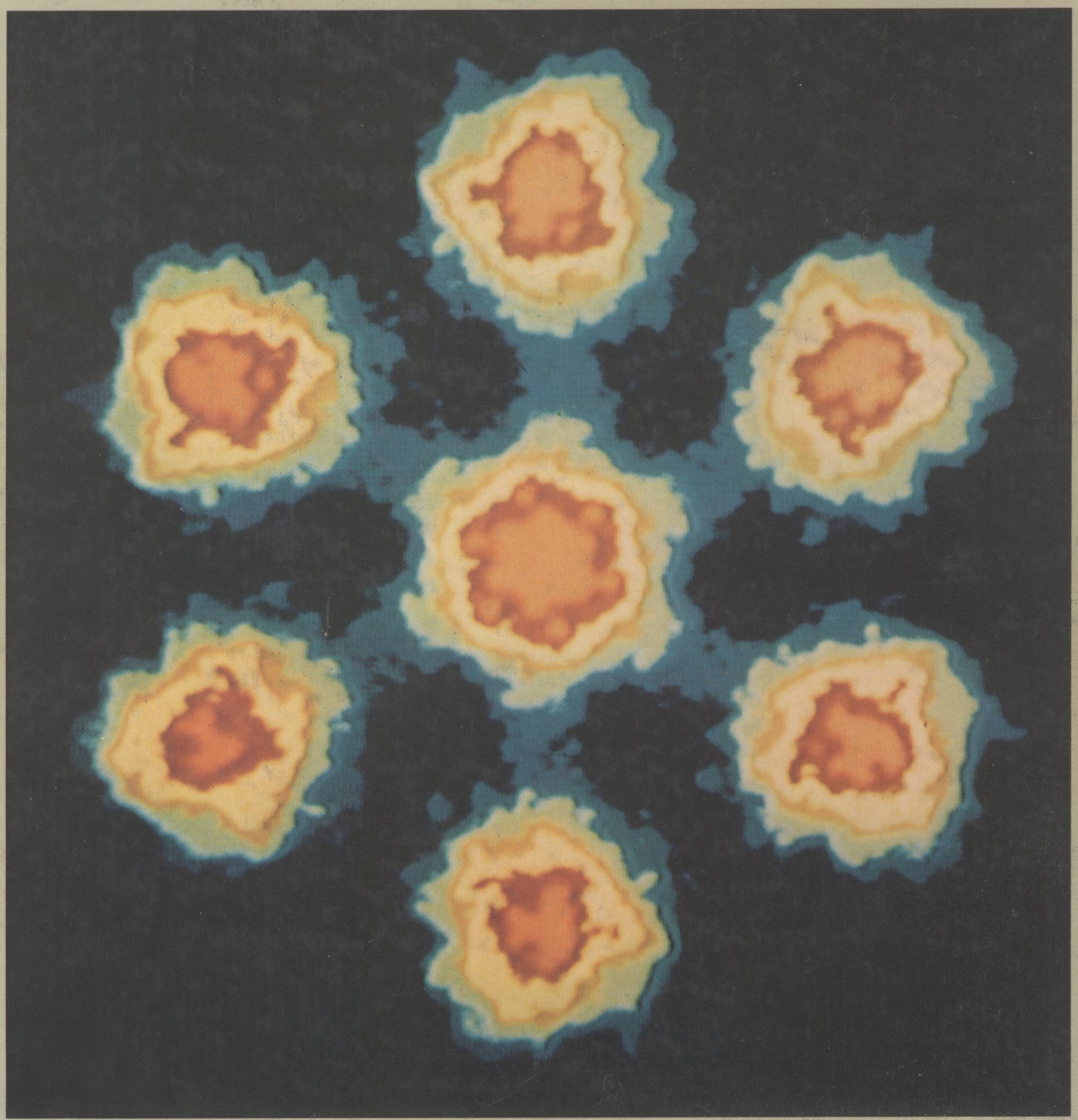
Ralph H. Petrucci Robert K. Wismer

General Chemistry with Qualitative Analysis



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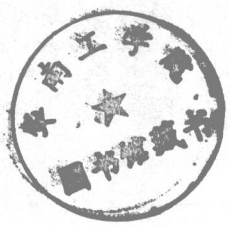

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Preface

This book is based on three editions of an earlier text written by one of us (R. H. Petrucci, *General Chemistry: Principles and Modern Applications,* Macmillan, New York, 1972, 1977, 1982), complemented by nine chapters on qualitative analysis written by the other (R. K. Wismer). As in the earlier text 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, medicine, and engineering, to name but a few—while some may study chemistry simply to add to their general education in the sciences. Our objective in writing this text has been to present the important principles and applications of general chemistry and the theory and practice of qualitative analysis in as understandable a manner as we can. To do so 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 the typical student of general chemistry.

Generally, applications are considered in a context where students will have acquired an understanding of the basic principles involved. This means that applications are emphasized in later chapters of the book. However, numerous applications are considered in earlier chapters, such as an overview of analytical chemistry (Chapter 3), ideas concerning industrial chemistry (Chapter 4), the structure of the atmosphere (Chapter 5), synthetic fuels (Chapter 6), colloids (Chapter 12), heterogeneous catalysis (Chapter 13), the Haber process (Chapter 14), heat engines and thermal pollution (Chapter 15), fractional precipitation in quantitative analysis (Chapter 16), and the electrometric determination of pH (Chapter 19). In addition, applications are noted throughout the text in the form of marginal notes and end-of-chapter exercises. The *Instructor's Manual* includes a chapter-by-chapter guide to these exercises, citing some of the specific extensions of theory and/or applications to be found there. As with practical applications, traditional descriptive chemistry is featured in later chapters; but some topics are considered in earlier chapters, starting with an introduction to descriptive chemistry in Chapter 8. In Chapter 11, within the context of intermolecular forces, the physical properties of numerous elements and compounds are considered.

The nine chapters on qualitative analysis feature complete, pretested procedures (and some alternate procedures) for the analysis of 25 cations and 16 anions. These procedures are illustrated through detailed flowcharts for each of the five cation groups, each of the four anion groups, and the techniques for dissolving alloys and ionic solids. 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 26 chapters, containing numerous references to these earlier chapters to relate qualitative analysis theory and practice to general principles. For example, many of the 55 illustrative examples in this section review and extend principles of reaction and solution stoichiometry (first introduced in Chapters 4 and 12), chemical equilibrium (Chapter 14), thermodynamics (Chapter 15), solubility equilibria (Chapter 16), acids and bases (Chapter 17), buffer solutions (Chapter 18), oxidation–reduction (Chapter 19), and complex ion equilibria (Chapter 22). Moreover, some of these examples require a synthesis of two or more concepts, such as E°_{cell} of one reaction and $\Delta\overline{G}^\circ$ of another to calculate the equilibrium constant, K, for the net reaction obtained by combining the two.

We have attempted to organize the subject matter of this text in such a way as to provide opportunities for instructors to reorder topics according to their preferences. For example, those who wish to combine the material on thermodynamics into a single presentation may defer Chapter 6 until Chapter 15 is reached. An instructor who wishes to limit organic chemistry to a discussion of bonding, structure, and nomenclature and to take up these topics following chemcal bonding may do so. Additional examples of alternative organizational plans for a general chemistry course based on this textbook are outlined in the *Instructor's Manual.* 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 20, 21, and 23–26 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 that are cited there.

Each chapter of the text concludes with some study aids—a brief summary, a set of learning objectives, definitions of important new terms, two sets of exercises (Exercises and Additional Exercises), and a set of Self-Test Questions. Each end-of-chapter definition of a term is referred to by a **boldface** page number in the index. The combination of these index listings and end-of-chapter definitions thus constitutes a glossary of the entire text. Exercises that are more difficult or require an extension of concepts presented in the text are designated by a star ⋆. Answers to many of the Exercises and Self-Test Questions are provided at the end of the book. Complete solutions are available in a separate *Solutions Manual.* Solutions to the Additional Exercises are available in the *Instructor's Manual.*

We wish to thank all the individuals who have helped in the preparation of this text. They have reviewed what we have written with care—at times in great detail—and they have shared freely of their own views on teaching chemistry. Our efforts in producing this text have been aided greatly by their contributions. Each of the following has commented on early versions of selected chapters: Luther K. Brice, Jr. (Virginia Polytechnic Institute and State University), K. R. Fountain (Northeast Missouri State University), Milton E. Fuller (California State University, Hayward), Henry Heikkinen (University of Maryland), William H. McMahan (Mississippi State University), Randall J. Remmel (University of Alabama in Birmingham), Donald E. Sands (University of Kentucky), W. P. Tappmeyer (University of Missouri, Rolla), and Milton J. Wieder (Metropolitan State College). Each of the following has reviewed and commented on the first 26 chapters of the final manuscript: Jimmie G. Edwards (University of Toledo), Lawrence Epstein (University of Pittsburgh), Joseph M. Kanamueller (Western Michigan University), Curtis T. Sears (Georgia State University), and Richard S. Treptow (Chicago State University).

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Those who reviewed the qualitative analysis chapters are Londa L. Borer (California State University, Sacramento), Joseph A. Topich (Virginia Commonwealth University), and Donald H. Williams (Hope College). George H. Schenk (Wayne State University) reviewed and commented in detail on the qualitative analysis chapters. Robert C. Brasted (University of Minnesota) reviewed and commented at length on the entire text. Thanks are due to colleagues at California State College, San Bernardino: Kenneth A. Mantei provided many helpful ideas for dealing with kinetics, thermodynamics, and equilibrium; James D. Crum offered advice in the areas of organic and biochemistry. And thanks are also due to colleagues at Millersville State College: Thomas G. Greco shared his knowledge of practical analytical chemistry; Michael S. Smith spent many hours in the laboratory checking and correcting procedures.

We are happy to have had the opportunity to work with Elisabeth Belfer, Kate Moran, Gregory Payne, John Snyder, and Thomas Vance of Macmillan Publishing Company. They have helped us in ways too numerous to mention, but all of importance.

Our greatest debt is to our wives (Ruth Petrucci and Debbie Wismer) and families (especially four-year-old 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 good cheer was indispensable to the completion of our task.

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