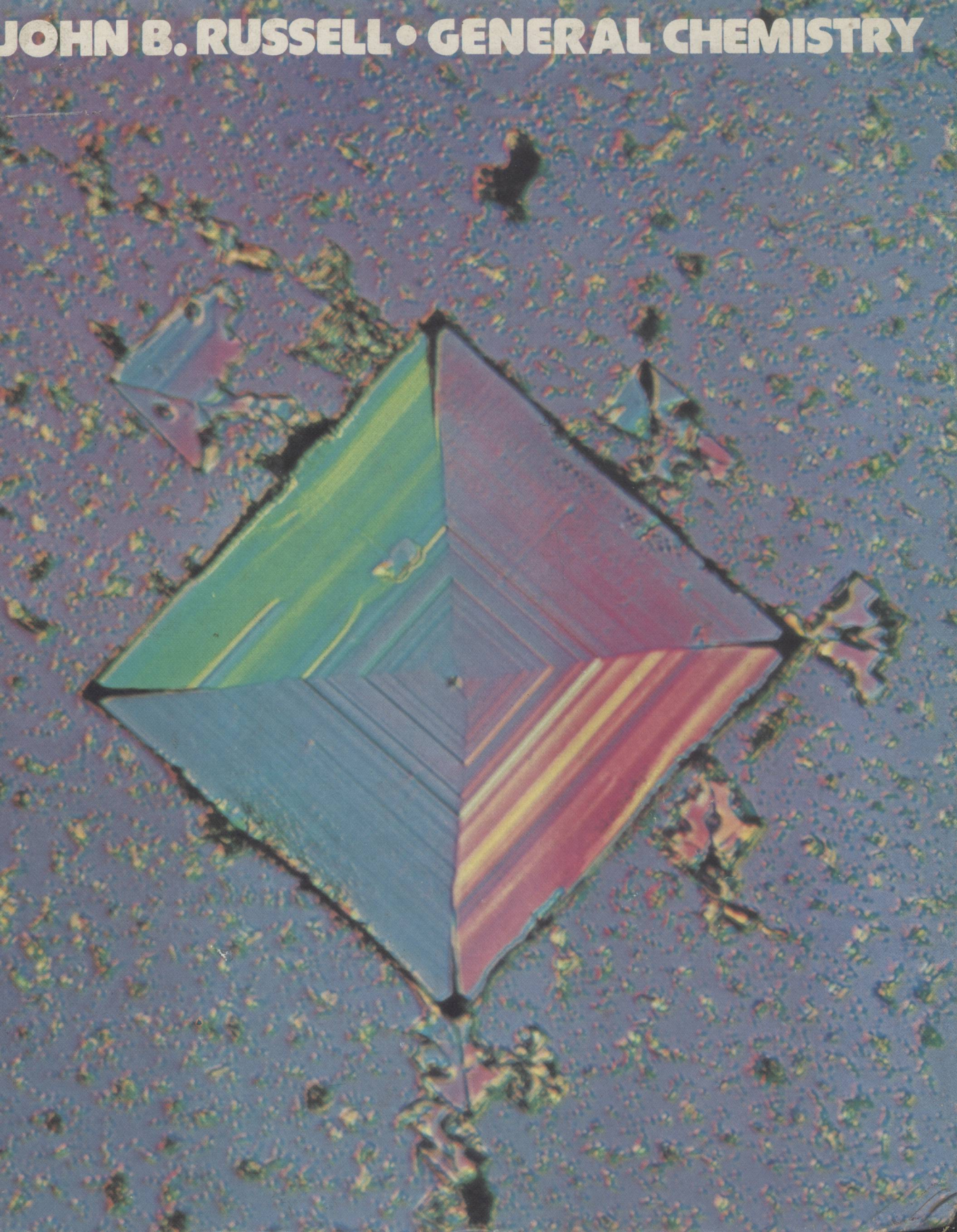
JOHN B. RUSSELL • GENERAL CHEMISTRY



GENERAL CHEMISTRY

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GENERAL CHEMISTRY

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To My Mother and Father

PREFACE

This text is intended for use in a full-year introductory chemistry course designed for students majoring in chemistry and other sciences, for students majoring in science-related disciplines, and for students who for any number of reasons simply wish to learn about chemistry. Among the students who take "freshman chemistry" today the spectrum of vocational goals, educational backgrounds, and motivations seems to be broader than ever before, and throughout the book I have kept this in mind. The effectiveness of this book depends upon the student's ability to read with comprehension at the college freshman level and to handle simple quantitative problems. To be specific, the student who has in high school followed a balanced, college-preparatory program which included two years of algebra should be able to handle this book. I have not assumed that the reader has studied any calculus, physics, or chemistry. But I have assumed that the text will be read and studied with considerable care.

Those of us who teach chemistry are aware that chemistry looms as an awesome challenge to many students. I believe an important reason is that chemical terms and concepts often seem so strange and abstract that the very language of chemistry tends to intimidate the student. Accordingly, I have tried to compensate for the natural human tendency to be wary of the unfamiliar by presenting chemistry in a way which is straightforward, clear, and logical. Above all, I have tried to help students see that chemical concepts are *reasonable* concepts. Those students who do their part should become almost as comfortable talking about antibonding orbitals and octahedral complexes as about apples and oranges.

The first twelve chapters of this book emphasize the structures of chemical systems and the dependence of properties on structure. With a few exceptions the progression of topics leads from the microscopic to the macroscopic. Atomic structure and bonding are presented from a descriptive quantum-mechanical perspective, and four chapters are devoted to these topics. Stoichiometry and ideal-gas behavior are introduced early, partly to allow students to cut their teeth early on chemical calculations, and partly to assist instructors in planning concomitant laboratory work. The properties of *ideal* gases, liquids, and solids are thoroughly discussed before *real* matter, and deviations from ideal behavior and perfect structure are considered. Except for the early coverage of mixtures of gases, solutions are not discussed until the properties of pure matter have been thoroughly described.

Chapters 13 to 24 cover aspects of chemical change and descriptive chemistry. One chapter is devoted to the special characteristics of aqueous-solution reactions. The topic of chemical kinetics is discussed in considerable detail, but without the use of calculus. Equilibrium is covered in three chapters, two of which are devoted to aqueous-solution equilibria. Chemical thermodynamics is discussed in a separate chapter and then used to introduce the topic of electrochemistry. Three chapters are devoted to descriptive inorganic chemistry and one to organic chemistry. The final chapter describes some important properties of nuclear change.

This text incorporates a number of features which should prove useful to the student. Each chapter is prefaced by a short section entitled *To the student* in which the purpose of the chapter is informally described. *Added comments* have been set off at many places which always seem to give difficulty to some students. These are brief digressions which point out potential trouble spots or provide alternative descriptions of relationships or concepts. About 200 *examples* of calculations are included within the chapters, and approximately 1200 *questions and problems* are provided at the chapter ends. Each chapter also concludes with a *summary* and a list of *key terms.* The *appendixes* are extensive; perhaps the most important of these is Appendix A, a *glossary of important terms* used throughout the book. *Answers to selected numerical problems* are given in Appendix J.

Supplements to this book which are available from the publisher include a *Student/Instructor Solution Supplement* by Roger Weiss, a *Study Guide* by Norman Eatough, and an *Instructor's Manual.* Vincent Sollimo has prepared an accompanying laboratory manual, *General Chemistry in the Laboratory.*

Prefaces are intended to be read first but are usually written last. As I reach the conclusion of what has turned out to be a three-year task, I am more aware than ever of the debt I owe to my teachers. I am fortunate to have been able to study and work under people such as Werner Bromund, Arthur Campbell, Paul Flory, Clyde Mason, Michell Sienko, and Luke Steiner. Their influence on my teaching has been considerable, and I wish to express my appreciation to them at this time. I also owe a debt of gratitude to another chemist, my father, who was the first to teach me what chemistry is really all about.

In writing this book I have relied heavily on the advice of my colleagues at Humboldt State University. I am greatly indebted to Tom Borgers, Greg Bowman, Thomas Clark, Clyde Davis, Mervin Hanson, Richard Paselk, M. G. Suryaraman, Robert Wallace, Roger Weiss, and William Wood, all of the Department of Chemistry, and to Frederick Cranston, of the Department of Physics and Physical Science, each of whom more than once kept me from going astray. I also wish to thank the reviewers Edwin H. Abbott, David L. Adams, John L. Burmeister, Gregory J. Exarhos, Norman Eatough, William A. Johnson, Fred H. Redmore, and Joseph R. Wiebush whose critical evaluations of the manuscript resulted in many large and small improvements. Especially valuable were the comments of David Adams whose ability to solve pedagogical problems was phenomenal. Lastly, I would like to express my unbounded gratitude to the staff at McGraw-Hill, and especially to Anne T. Vinnicombe, for whom the word indefatigable seems to have been coined.

John B. Russell

CONTENTS

PRELIMINARIES AND PREMISES

TO THE STUDENT

This chapter is an introductory one. It begins with a discussion of chemistry as a science and follows with a brief outline of the history of chemistry. This historical perspective in itself is not of overwhelming importance, but some knowledge of how chemical ideas were developed gives greater significance to the ideas themselves. Following that is a short discussion of scientific methodology and definitions and explanations of some important terms. Knowing exactly how scientific terms are used is essential for accurate, efficient communication of ideas. Finally, numerical calculations are considered. Emphasis is placed on keeping track of significant figures, on using numbers written in exponential form, and on the SI system of metric units. Chemistry is a quantitative science, and it is therefore important for you to learn how to perform calculations correctly and to express your results properly.

1-1 Chemistry: what, why, and how?

What is chemistry?

At one time it was easy to define chemistry. The traditional definition goes something like this: Chemistry is the study of the nature, properties, and composition of matter, and how these undergo changes. That served as a perfectly adequate definition as late as the 1930s, when natural science (the systematic knowledge of nature) seemed quite clearly divisible into the physical and biological sciences, with the former being comprised of physics, chemistry, geology, and astronomy and the latter consisting of botany and zoology. This classification is still used, but the emergence of important fields of study such as oceanography, paleobotany, meteorology, and biochemistry, for example, have made it increasingly clear that the dividing lines between the sciences are no longer at all sharp. Chemistry, for instance, now overlaps so much with geology (thus we have *geochemistry*), astronomy (*astrochemistry*), and physics (*physical chemistry*) that it is probably impossible to devise a really good modern definition of chemistry, except, perhaps, to fall back on the operational definition: chemistry is what chemists do. (And what chemists do is what this book is all about!)