Ninth Edition

GENERAL CHEMISTRY *with* QUALITATIVE ANALYSIS

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GENERAL CHEMISTRY *with* QUALITATIVE ANALYSIS

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Preface

How does a text that is in its ninth edition retain its freshness? With a new author, Professor Jerome D. Odom, who is an inorganic chemist and chair of the Chemistry Department at the University of South Carolina; with new approaches to content that reflect the input of students, instructors, colleagues, and collaborators; with an inviting new design that uses illustrations and photographs to complement the content pedagogically; with close attention paid to both chemical and chemical education literature; and with a commitment on the part of the authors and the publisher to produce the best text available. At the same time, we have not in any way compromised the solid foundation of the previous editions, which are highly recognized and respected for their clarity, accuracy, and concern for the student.

Our Philosophy

As is evident in previous editions, we believe it is essential that the concepts and models of chemical behavior be presented clearly before applying them to various other systems, where additional considerations may mask the chemical principles involved. Thus, we have consistently paid careful attention to the introduction and development of chemical concepts before extending them to different situations. Because the changes in the treatment of several major topics in this revision reflect this philosophy, we will address them individually.

Our philosophy of working from simple to complex in the development of concepts is evident also in the exercises at the end of the chapters; many simple drill-and-practice problems are provided, followed by more complicated or involved exercises. We also believe that it is important to include questions that challenge a student to think about the meaning of the concepts and not simply grind out calculations. As a result, many of the exercises are much more than just calculations or recall questions.

Chemical Behavior

The most obvious organizational change is in Chapter 2, the chapter that introduces the language of chemistry—atoms, molecules, and ions; chemical reactions; and nomenclature. This chapter presents the concepts that students need in order to understand how chemists talk about chemical behavior and reinforces these concepts in a discussion of the chemistry of some important industrial compounds. The way in which molecules, chemical reactions, nomenclature, and supporting concepts are introduced will give students sufficient background for understanding an instructor's use of these concepts as well as their laboratory applications. Because this material is presented near the beginning of the text, we took a great deal of care to describe it at a level that is appropriate to the early part of a general chemistry course. Consequently, some topics are, of necessity, covered again in subsequent sections of the text in more detail.

Stoichiometry

Stoichiometry remains early in the text so it, too, is available for laboratory use. Because atoms, molecules, and chemical equations are introduced in Chapter 2, the discussion of

stoichiometry is consolidated into Chapter 3 without losing any content. This chapter retains the style of problem solving that was well received by students using the text. In particular, we are careful to discuss how to solve the problems in the examples before the calculations themselves are presented. It is well established that students who are successful with mathematical problems usually can describe the steps in the solution of a problem without using the numbers in the problem. We present two different techniques (written and schematic) that students can use to describe the logic of a problem before carrying out the calculations.

Atomic Structure, Periodicity, and Bonding

In this edition, we cover atomic structure and chemical periodicity in two separate chapters: Chapter 5 on atomic structure, and Chapter 6 on the periodic behavior of the physical and chemical properties of the elements. Both chapters are completely coordinated with the introduction in Chapter 2. As in previous editions, a discussion of chemical bonding follows the introduction of atomic theory and periodicity. Chapters 7, 8, and 9 discuss Lewis structures, valence shell electron-pair repulsion and valence bond theory, and molecular orbital theory, respectively. In addition, we present in Chapter 7 a general procedure for use in predicting the products of simple chemical reactions, based on acid–base behavior, oxidation–reduction behavior, common oxidation numbers, and the metallic or nonmetallic nature of the elements involved. This procedure provides a framework that enables students to begin to master a subject that can often seem uncoordinated or incomprehensible. This can be a source of considerable satisfaction and encouragement for students.

Intermolecular Forces

The concept of intermolecular forces is important in discussions of biochemistry, polymers, soil science, materials science, and other areas that draw on chemical principles. We have expanded our discussion of these forces in the introductory sections of Chapter 11 and have used them in Chapter 12 to describe the energy factors responsible for dissolution.

Equilibrium

The discussion of equilibrium in Chapters 15, 17, and 18 is significantly different from that in the previous editions. The introduction to the state of equilibrium is now presented in terms of constant concentrations at equilibrium rather than equality of forward and reverse rates. A change in concentration is a more concrete concept (you can see color changes as some concentrations change, for example); equality of rates is a more formal, abstract concept. In this edition, we present the idea of equality of rates specifically to explain why the concentrations do not appear to change at equilibrium.

The discussion of the reaction quotient has been strengthened. It is very helpful in predicting which way a reaction will shift to reach equilibrium. Moreover, the concept of a reaction quotient is very important in thermodynamics and electrochemistry.

Many introductions to equilibrium treat the subject in a way that makes various kinds of equilibria seem unrelated and each type of equilibrium calculation seem different. Our introduction discusses equilibrium in a way that can be readily extended to all types of equilibria and equilibrium problems. The presentation in the three chapters on equilibrium is consistent. Thus, a new solution process does not have to be learned for each type of system.

We have focused on the change in concentration (or pressure) as the general approach for solving all problems in which the student is given initial concentrations and asked to calculate equilibrium concentrations. Change lines are used in all examples. In addition, the introduction to equilibrium presents the mathematical strategies for solving equilibrium problems in a separate section, with the strategies presented from the simplest to the most complex. If the easy solution strategy proves satisfactory, students can stop there. If not, they can move up to the next strategy.

In the discussion of acid–base equilibria in aqueous solution, we are careful to point out that water can contribute to the hydronium or hydroxide concentrations in solutions of very dilute or very weak acids or bases. Students should develop the understanding that in most circumstances the ionization of water need not be taken into account, but that in some cases it can be a significant factor and must be taken into account.

It appears to be a small point, but we believe it is important to distinguish carefully the statement "assume $x = 0$" from "assume $1.00 - x = 1.00$" in solving equilibrium equations. The latter assumption is the correct statement and avoids confusion; students are often puzzled by the question, "How can I solve for x if I assume that it is 0?"

Descriptive Chemistry

Examples and applications in the descriptive chemistry chapters have been updated. In addition, these chapters now recall the principles involved in the chemistry discussed. Environmental chemistry has been retained as a separate chapter, not just mentioned in passing in other chapters, and the chapter has been wholly revised. The nuclear chemistry chapter has been expanded and now includes radioactive dating; applications of nuclear chemistry in medicine, agriculture, and industry; environmental concerns; and biological effects of radiation.

Qualitative Analysis

We are particularly proud of our qualitative analysis chapters. The qualitative analysis scheme is introduced in the chapter that presents the chemistry involved in the separation and identification of the cations in the scheme and the principles upon which the scheme is based. This is followed by well-tested qualitative analysis procedures that include a useful and unique set of color photographs of the precipitates, solutions, and tests present in most steps of the scheme.

Additional Changes in Topical Coverage

There are also many smaller, less obvious changes. The concept of oxidation number, introduced in Chapter 2, is expanded in terms of the distribution of electrons in bonds in

Chapter 7. We added a section on formal charge to Chapter 7. The discussion of polar molecules occurs in Chapter 8 after molecular structures have been discussed. We added brief introductions to infrared spectroscopy to illustrate an experimental means of identifying relative bond strengths (Section 7.10) and to NMR to illustrate an experimental technique for determining structure and hybridization (Section 8.12). Chapter 8 now contains a more specific introduction to valence bond theory in addition to hybridization and molecular structure; it precedes the molecular orbital chapter (Chapter 9), which now contains an application of MO theory as a way of explaining the conductivity of metals, semiconductors, and insulators. The introduction to electrochemistry in Chapter 20 starts with galvanic cells using spontaneous reactions; this approach fits better with the students' understanding because they are familiar with spontaneous reactions and batteries. Additionally we pay close attention to relating the behavior in a galvanic cell to half-reactions, which is important in making the half-reactions used in balancing oxidation–reduction reactions seem less abstract.

Supplements for the Texts

The following comprehensive teaching and learning package accompanies both *General Chemistry,* Ninth Edition and *General Chemistry with Qualitative Analysis,* Ninth Edition.

- **Instructor's Guide,** William H. Breazeale, Jr., *Francis Marion College*
- **Study Guide,** Norman E. Griswold, *Nebraska Wesleyan University*
- **Solutions,** John H. Meiser and Frederick K. Ault, *Ball State University*
- **Complete Solutions,** John H. Meiser; Christian A. Clausen III, *University of Central Florida;* and Frederick K. Ault
- **Basic Laboratory Studies in General Chemistry with Semimicro Qualitative Analysis,** Grace R. Hered, *Olive-Harvey College, City College of Chicago*
- **Instructor's Guide for Basic Laboratory Studies in General Chemistry with Semimicro Qualitative Analysis,** Grace R. Hered
- **D. C. Heath Exam: Computerized Testing for IBM PC, Apple II, and Macintosh**
- **Test Item File,** Christian A. Clausen III
- **Chemical Lecture Demonstrations** (Videotape), Paul B. Kelter, *University of Wisconsin—Oshkosh*
- **Transparencies**

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About the Authors

Henry F. Holtzclaw, Jr. is Foundation Regents Professor of Chemistry Emeritus at the University of Nebraska—Lincoln. He received the A.B. degree from the University of Kansas and M.S. and Ph.D. degrees in inorganic chemistry from the University of Illinois. He served as Guest Professor at the University of Konstanz (Germany) in 1973–74. He was Dean for Graduate Studies at the University of Nebraska for nine years (1976–85) and was Interim Chairman of the Department of Chemistry in 1985–86.

His research is in synthesis, stereochemistry, and bonding of metal chelates, including metal chelates of 1,3-diketones and nitrogen- and sulfur-substituted 1,3-diketones. He has also worked with metal chelate polymers of various dihydroxyquinoid ligands.

Professor Holtzclaw has served as a member of the National Committee of Examiners (Advanced Chemistry Test) for the Graduate Record Examination and as a member of the Graduate Record Examination Board. He has also served on the TOEFL Policy Committee (Test of English as a Foreign Language) and on its Executive Committee and Research Committee, including a term as Chairman of the Research Committee. In the American Chemical Society, he is a Councilor and has served on the Publications Committee, the Committee on Committees, and the Nominations and Elections Committee.

He recently completed a term as President of *Inorganic Syntheses* and was Editor-in-Chief of Volume VIII of that series. He is a member of the American Chemical Society and Sigma Xi, an Associate Member of the Committee on Chemical Abstracts (for the American Chemical Society), and a Fellow in the American Association for the Advancement of Science.

William R. Robinson is a Professor of Chemistry at Purdue University. He received his B.S. and M.S. degrees in chemistry from Texas Technological College (now Texas Tech University) and the Ph.D. degree from the Massachusetts Institute of Technology. In 1973 he spent six months as an Adjunct Associate Professor in the Department of Earth and Space Sciences at the State University of New York at Stony Brook.

Professor Robinson has been active in the General Chemistry program at Purdue since joining the faculty in 1967. He has served as Director of General Chemistry and has assisted with preliminary and developmental reviews of freshman texts. He has published in *The Journal of Chemical Education*. He is a member of the American Chemical Society General Chemistry Examinations Committee. As a consequence of his interest in how students learn chemistry, he has joined the Division of Chemical Education in Purdue's Department of Chemistry and has an active research program in this area.

Professor Robinson's other interests include the structure, properties, and reactivity of transition metal compounds. His published research includes thermal studies of classical coordination compounds of cobalt and chromium, synthetic and structural studies of heavy transition metal compounds containing metal–metal bonds, and synthetic and structural studies of organometallic compounds. At present he is engaged in the study of the solid state chemistry and structure of transition metal oxides, sulfides, and phosphates. He is on the Editorial Board of *The Journal of Solid State Chemistry,* and a member of the American Association for the Advancement of Science, the American Chemical Society, the American Crystallographic Association, National Association for Research in Science Teaching, and Sigma Xi.

Jerome D. Odom is Professor and Chairman of Chemistry at the University of South Carolina. He received his B.S. degree from the University of North Carolina—Chapel Hill and the Ph.D. degree from Indiana University. He spent a postdoctoral year at Bristol University in Bristol, England, and in 1975–76 was a Fellow of the Alexander von Humboldt Foundation at the University of Stuttgart, Germany.

Professor Odom has taught general chemistry at the University of South Carolina since joining the faculty in 1969. In 1984 he was awarded the Amoco Foundation Award for Outstanding Teaching, the university's highest award for undergraduate teaching. He has also been an instructor for many years in National Science Foundation workshops for small-college and high school chemistry teachers. He has served as a member of the Inorganic Subcommittee of the American Chemical Society Examinations Committee.

His research involves syntheses and studies of compounds of the representative elements, particularly compounds of boron, germanium, selenium, and tellurium. Professor Odom has been instrumental in developing and using selenium-77 nuclear magnetic resonance spectroscopy in the study of organoselenium compounds as well as biological molecules containing selenium. At present he is engaged in studies directed toward the incorporation of selenium and tellurium into biochemical systems and the use of the derivatized systems as structural probes. He has written over 125 refereed publications and has also published numerous review articles and book chapters.

He is a member of the American Chemical Society, Sigma Xi, Phi Lambda Upsilon, and Alpha Chi Sigma. He is an avid water skier, snow skier, and racquetball player.

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