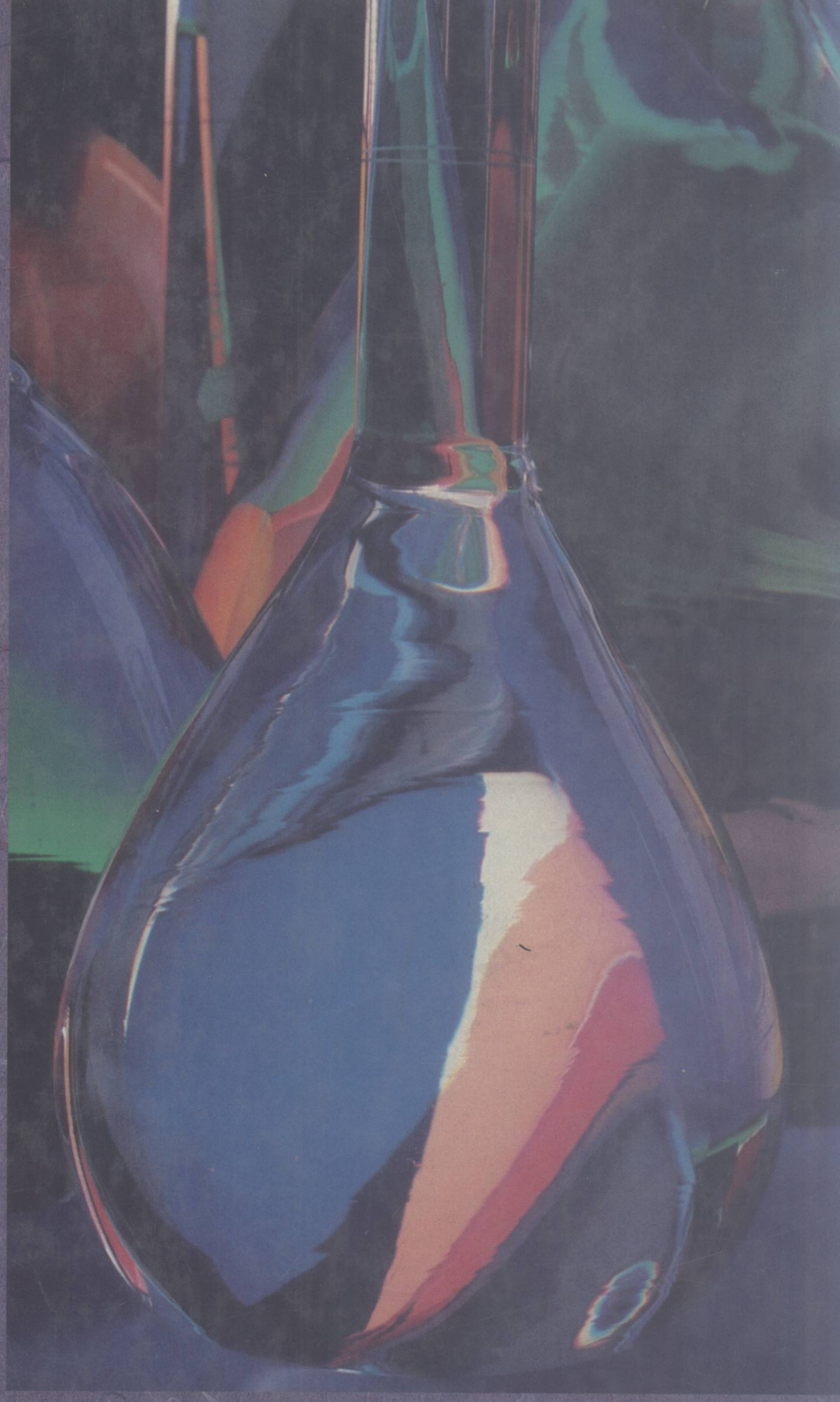
H. STEPHEN STOKER

Introduction to Chemical Principles

FOURTH EDITION



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FOURTH EDITION

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WEBER STATE UNIVERSITY

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INTRODUCTION TO CHEMICAL PRINCIPLES

Preface

Introduction to Chemical Principles is a text for students who have had little or no previous instruction in chemistry or who had such instruction long enough ago that a thorough review is needed. The text's purpose is to give students the background (and confidence) needed for a subsequent successful encounter with a main sequence college level general chemistry course.

Many texts written for preparatory chemistry courses are simply "watered down" versions of general chemistry texts; they treat almost all topics found in the general chemistry course, but at a superficial level. *Introduction to Chemical Principles* does not fit this mold. The author's philosophy is that it is better to treat fewer topics extensively and have the student understand those topics in greater depth. The very real temptation to include "lots and lots" of additional concepts in this new edition of the text was resisted. Instead the focus for the revision was on rewriting selected portions to improve the clarity of presentation.

Important Features of This Textbook

1. Because of the varied degrees of understanding of chemical principles possessed by students taking a preparatory chemistry course, development of each topic in this text starts at "ground level" and continues step by step until the level of sophistication required for a further chemistry course is attained.
2. Problem solving receives major emphasis. Over twenty years of teaching experience indicate to the author that student "troubles" in general chemistry courses are almost always centered in the inability to set up and solve problems. Whenever possible, dimensional analysis is used in problem solving. This method, which requires no mathematics beyond arithmetic and elementary algebra, is a powerful and widely applicable problem-solving tool. Most important, it is a method that an average student can master with an average amount of diligence. Mastering dimensional analysis also helps build the confidence that is so valuable for future chemistry courses.
3. Significant figure concepts are emphasized in all problem-solving situations.

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Routinely, electronic calculators display answers that contain more digits than are needed or acceptable. In all worked-out examples, students are reminded about these "unneeded digits" by the appearance of two answers to the example: the calculator answer (which does not take into account significant figures) and, in color, the correct answer (which is the calculator answer adjusted to the correct number of significant figures).

4. Numerous worked-out example problems are found within the textual material with detailed commentary accompanying each such example. In addition an unworked practice exercise is coupled to each example. It is intended that students will work this exercise immediately after "working through" the example. For immediate feedback, the answer to each practice exercise follows the exercise.
5. All end-of-chapter exercises occur in "matched pairs". In essence, each chapter has two independent, but similar, problem sets. Counting subparts to problems, there are over 5000 questions and problems available for a student to use in his or her "struggle" to become proficient at problem solving. Answers to all of the odd-number problems are found at the end of the text. Thus, two problem sets exist, one with answers and one without answers.
6. Each end-of-chapter problem set, except for Chapters 1 and 2, is divided into four sections: (1) Practice Problems, (2) Additional Problems, (3) Cumulative Problems, and (4) Grid Problems. The practice problems are categorized by topic and are arranged in the same sequence as the chapter's textual material. These problems, which are always single-concept, are "drill" problems which most students will find "routine". The additional problem section contains problems that involve more than one concept from the chapter and are usually more difficult than the practice problems. The cumulative-skills section draws not only on materials from the current chapter but also on concepts discussed in previous chapters. The working of problems in this third group allows students to continue to use, rather than forget, problem-solving techniques presented earlier. Finally, each chapter ends with four grid problems. Here students apply the principles from the chapter in a setting where multiple concepts are examined at the same time. Answers are selected from a three-by-three grid of choices; most often multiple answers are correct.

Supplements

A Student Solutions Manual has been prepared to accompany this text, and an Instructor's Resource Manual with Test Bank is available to adopters.

Acknowledgments

As always, the valuable contributions of reviewers are gratefully acknowledged: Paul E. Jacobson, Tacoma Community College; L. A. Kuprenas, California State University, Long Beach; and George Schenk, Wayne State University.

H. S. S.

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Mathematical Review A.1

CHAPTER ONE

The Science of Chemistry

1.1 Chemistry—A Scientific Discipline

During the entire time of their existence on Earth, human beings have been concerned with and fascinated by their surroundings. This desire to understand their surroundings—an attribute that distinguishes them from all other living organisms—has led them to accumulate vast amounts of information concerning themselves, their world, and the universe. **Science** is the study in which humans attempt to organize and explain in a systematic and logical manner knowledge about themselves and their surroundings.

The enormous range of types of information covered by science, the sheer amount of accumulated knowledge, and the limitations of human mental capacity relative to mastering such a large and diverse body of knowledge have led to the division of the whole of science into smaller subdivisions called scientific disciplines. A **scientific discipline** is a branch of scientific knowledge limited in its size and scope to make it more manageable. Chemistry is one of the scientific disciplines. Astronomy, botany, geology, physics, and zoology are some of the others.

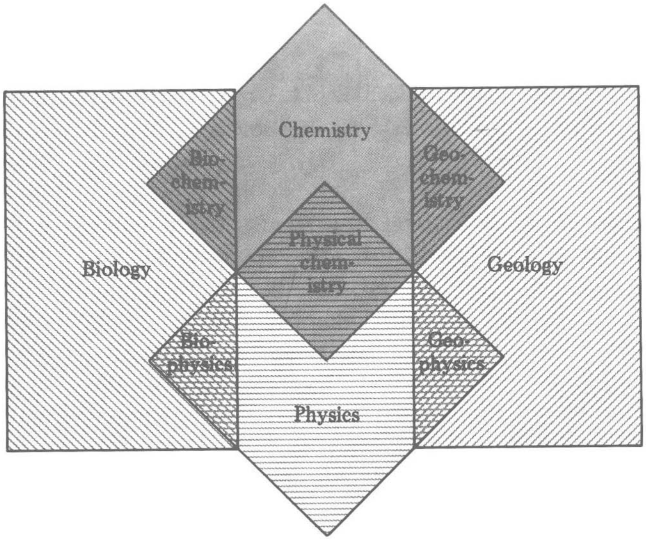

FIGURE 1.1 Interrelationship of scientific disciplines.

In a sense, the boundaries between scientific disciplines are artificial, because all scientific disciplines borrow information and methods from each other. No scientific discipline is totally independent. This overlap requires that scientists, in addition to having in-depth knowledge of a selected discipline, also have limited knowledge of other disciplines. Problems scientists have encountered in the last decade have particularly pointed out the interdependence of disciplines. For example, chemists attempting to solve the problem of chemical contamination of the environment find that they need some knowledge of geology, zoology, and botany. Because of this overlap, it is now common to talk not only of chemists, but also of geochemists, biochemists, chemical physicists, and so on. Figure 1.1 shows how chemistry merges with some of the other scientific disciplines.

The overlap of the various scientific disciplines affects not only practicing scientists but also today's college students. It means that students must necessarily study in disciplines other than those of primary interest to them. The knowledge they gain from such studies is often useful and even essential if they are to be competent in their chosen field. Many students in courses for which this textbook is written are studying chemistry because of its applicability to other disciplines in which they have a more specific interest.

1.2 Scientific Disciplines and Technology

Scientific disciplines represent abstract bodies of knowledge. The abstractness of such knowledge is modified by technology. **Technology** is the physical application of scientific knowledge to the production of new products to improve human survival, comfort, and quality of life. Technology manipulates nature for advantage. Technological advances began affecting our society about 200 years ago, and new advances still continue, at an accelerating pace, to have a major impact on human society. Section 1.3 considers numerous contributions of chemical technology to human well-being.

Technology, like science, involves human activities. Whether or not a given piece of scientific knowledge is technologically used for good or evil purposes depends on the motives of those men and women, whether in industry or government, who have the decision-making authority. In democratic societies, citizens (the voters) can influence many technological decisions. Therefore, it is important for everyone to be informed about scientific and technological issues.

1.3 The Scope of Chemistry and Chemical Technology

Although chemistry is concerned with only a part of the scientific knowledge that has been accumulated, it is in itself an enormous and broad field. Chemistry touches all parts of our lives.

Many of the clothes we wear are made from synthetic fibers produced by chemical processes. Even natural fibers, such as cotton or wool, are the products of naturally occurring chemical reactions within living systems. Our transportation usually involves vehicles powered with energy obtained by burning chemical mixtures, such as gasoline. The drugs used to cure many of our illnesses are the result of much chemical research. The paper on which this textbook is printed was produced through a chemical process, and the ink used in printing the words and illustrations is a mixture of many chemicals. The movies we watch are possible because of synthetic materials called film. The images on film are produced through the interaction of selected chemicals. Almost all of our recreational pursuits involve objects made of materials produced by chemical industries. Skis, boats, basketballs, bowling balls, musical instruments, and television sets all contain materials that do not occur naturally, but are products of human technological expertise.

Our bodies are a complex mixture of chemicals. Principles of chemistry are fundamental to an understanding of all processes of the living state. Chemical secretions (hormones) produced within our bodies help determine our outward physical characteristics such as height, weight, and appearance. Digestion of food involves a complex series of chemical reactions. Food itself is an extremely complicated array of chemical substances. Chemical reactions govern our thought processes and how knowledge is stored in and retrieved from our brains. In short, chemistry runs our lives.

A formal course in chemistry can be a fascinating experience because it helps us understand ourselves and our surroundings. We cannot truly understand or even know very much about the world we live in or about our own bodies without being conversant with the fundamental ideas of chemistry.

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