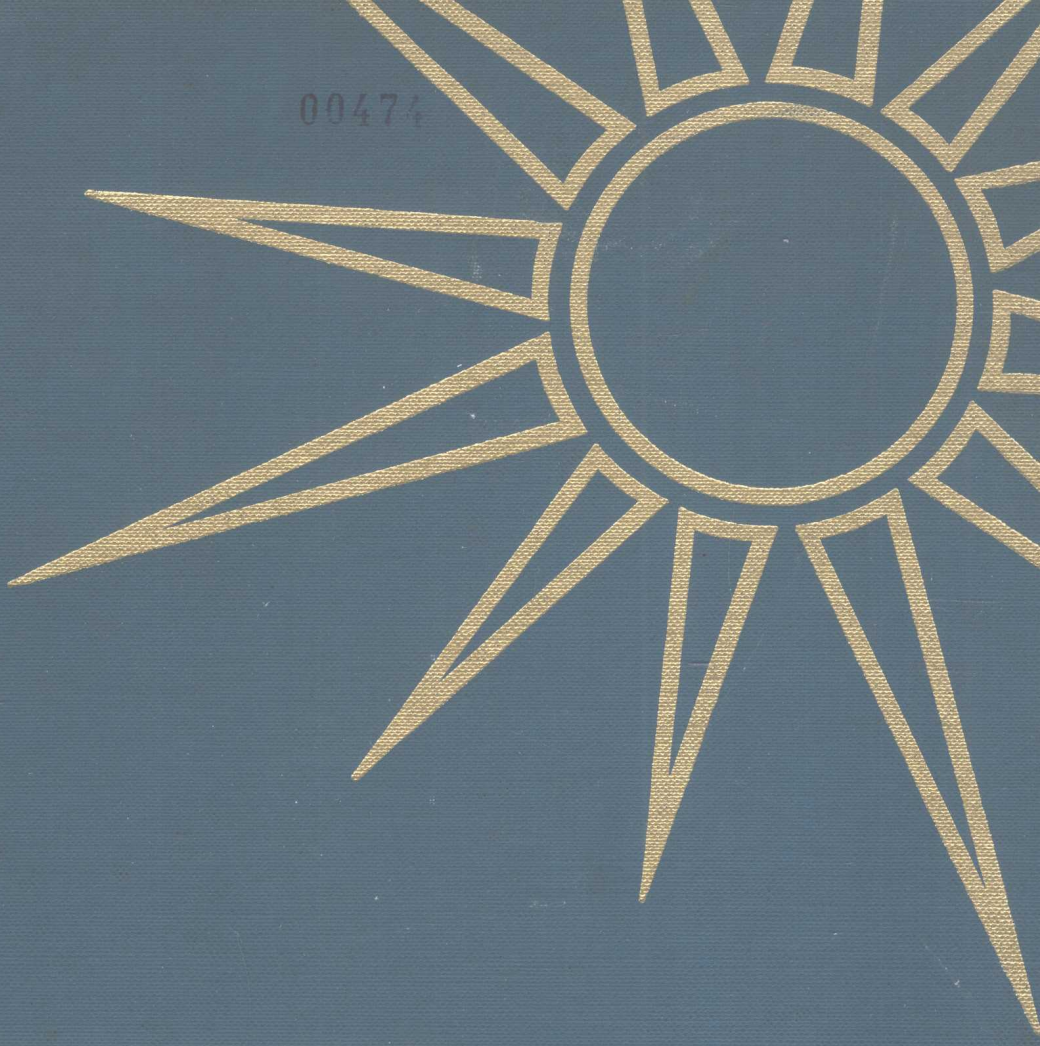

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Jerome K. Holmes
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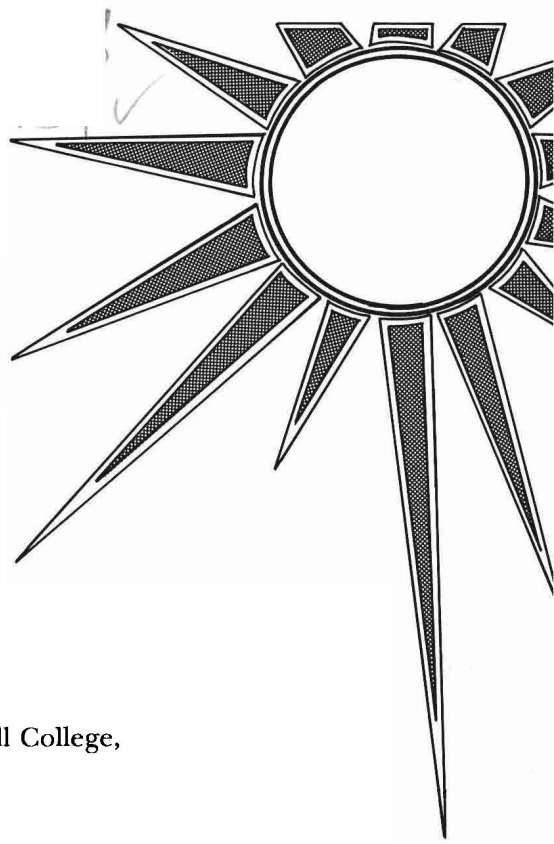

INTRODUCTION TO
General chemistry

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To

SYLVIA

and

DAVID ARLO

Preface

THE COURSE

In this revision of *Introduction to General Chemistry* the primary objective continues to be the preparation of students for a first-year course in college chemistry. The book's particular focus is the community (or junior) college audience, and it is most appropriate for a one-semester or two-quarter course.

THE EDUCATIONAL PLAN

In an introductory course we begin with students who presumably have no background in chemistry. We therefore have a good chance to develop a logical construct in the minds of these students. Rather than attempt to cover every detail of chemistry, we select our materials so that the general picture of the chemical world emerges bit by bit with no great leaps of logic and no long digressions from the main picture.

A good textbook is much like a symphony, with the sequence of events laid out so that each theme enters at the appropriate point, intertwining with the other themes, and building to a natural climax at the proper time. The sequential structure of *Introduction to General Chemistry* presents several important themes in chemistry, their order carefully planned to achieve the maximum impact for each unit in the sequence. I believe that the contents of this textbook, coupled with a solid laboratory program (such as that in the accompanying lab manual), will provide students with the necessary background to continue their chemical education successfully.

THE BOOK

The organization of the text is logical and rather simple. Following a brief introductory chapter on the relevance of chemistry, Chapter 2, on measurement, provides the student with the tools needed to make quantitative observations in

the laboratory. Chapters 3 through 8 form a self-contained unit on atomic and molecular structure. The unit begins in Chapter 3 with an overview of matter, including a look at such aspects of atoms and molecules as atomic and molecular weights, empirical formulas, and the mole. Chapter 3 establishes a foundation for the discussion of the nuclei of atoms (fundamental particles and isotopes) in Chapter 4, which is followed by a discussion of electronic structure in Chapters 5 and 6. These two chapters introduce some fundamental concepts of energy, laying the groundwork for later discussions of chemical energetics. Explanation of the electronic structure of atoms prepares for the study of chemical bonding in Chapters 7 and 8. The presentation of ions at this point permits naming of chemical compounds, as well as laboratory investigation of ionic reactions.

Ordinarily the gas laws can be discussed at any point in a chemistry course. Their presentation in Chapter 9 serves two purposes. Chapter 10, on stoichiometry, requires an understanding of the mole. The concept of the mole is often best understood as it relates to the gas laws, since equal volumes of different gases under identical conditions contain equal numbers of moles. Hence the gas laws are presented in Chapter 9 to reinforce that concept (introduced in Chapter 3) in preparation for Chapter 10. Further, the discussion in Chapter 9 of the effect of temperature on molecular motion is essential to an understanding of molecular collisions and reaction rates, which are covered in Chapter 12, an optional chapter on equilibrium.

Stoichiometry (Chapter 10) is truly the cornerstone of any quantitative treatment of chemistry, and this chapter emphasizes the importance of the mole in doing chemical calculations and explores the relationship between energy and chemical reactions. It leads into the discussion of solution concentrations in Chapter 11. (For those who prefer to cover any or all of these topics earlier, gas laws, stoichiometry, and solutions can all be covered at any point after Chapter 3.)

In the first eleven chapters, several themes are built side by side, offering students all of the tools needed to understand an optional chapter on reaction rates and equilibrium (Chapter 12). Their understanding of the various relationships between energy, temperature, and molecular motion will be drawn on in a brief discussion of collision theory. In addition, their understanding of molar concentrations will enhance that discussion and permit a logical development of reaction rates and equilibrium. Once a general understanding of equilibrium is established, topics need not be discussed quantitatively, but rather may be discussed in terms of the general principles of equilibrium. In this regard instructors will have the flexibility to be as quantitative or as descriptive as they choose.

The discussion of solutions in Chapter 11 leads into acids and bases in Chapter 13, and these in turn provide a sound introduction to ionic reactions. The discussion of ionic reactions in Chapter 14 includes precipitation reactions and the writing of total and net ionic equations, which prepares the student for the development of oxidation-reduction reactions in Chapter 15.

This completes the core portion of the book. From the remaining chapters the instructor may select specialized topics to develop the natural interests of each class, enriching the core program. These topics include nuclear chemistry (Chapter 16), organic chemistry (Chapter 17), and biochemistry (Chapter 18).

The sequence of events outlined here builds logically, step by step. In addition, difficult concepts are presented in such an order that ideas can simmer as the course progresses. Because each topic provides the foundation for the next, concepts are established firmly through continual review.

THE LABORATORY MANUAL

In any laboratory course the relationship between the laboratory program and the lecture material is quite important. In an introductory chemistry course the selection of meaningful experiments can be a problem during the early portion of the course when lecture material is not easily adapted to experimental work. The experimental program put forth in the accompanying laboratory manual (*Introduction to General Chemistry: Laboratory Manual* by Krimsley, Skerritt, Holmes, and Criswell) is designed to overcome this difficulty. In addition, through hands-on experience provided by this program, the student learns a considerable amount of descriptive material not easily retained by rote memorization from a textbook. For those who wish more information about this laboratory program the preface to the laboratory manual provides greater detail about our philosophy concerning these and other laboratory-related matters and explains the relationship between the textbook and the laboratory program.

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Victor S. Krimsley

To the instructor

In this revision of *Introduction to General Chemistry,* the text has been reorganized to increase its flexibility. Several key features of that flexibility are pointed out here for those who are using the text or considering its adoption.

The text consists in part of a "core" program containing the basics that we believe beginning chemistry students should cover before proceeding to a first-year college chemistry course. In addition, the text includes many supplementary topics that can be skipped without interfering with the understanding of future chapters. Throughout the text, these sections are labeled optional; this is not to recommend their omission, but rather to make clear that their omission will not affect the continuity of the text. The most significant of these optional sections is an entire chapter, Chapter 12, on equilibrium. Each optional section permits enrichment of the core program according to the personal tastes of the instructor, the time constraints that vary so widely from school to school, and the particular abilities of students in a given class.

In addition to this flexibility in what is covered, the text offers considerable flexibility in the arrangement of chapters. Many instructors prefer to cover Chapter 9 on the gas laws, Chapter 10 on stoichiometry, and/or Chapter 11 on solutions quite early, while others prefer development of these topics later. Any or all of these chapters may be covered at any point after Chapter 3 with no loss of continuity, although insertion after Chapter 4 is probably best, since some knowledge of atomic structure is desirable prior to discussion of any of these topics. The following sequence is an option to consider: 1, 2, 3, 4, 9, 10, 11, 5, 6, 7, 8, 12, 13, 14, and 15. Other options involve moving only one or two of the chapters forward.

Those instructors using the text or considering its adoption are urged to look through the Teacher's Guide, which is intended to be truly that. The various options as well as the rationale behind the organization of each chapter and its

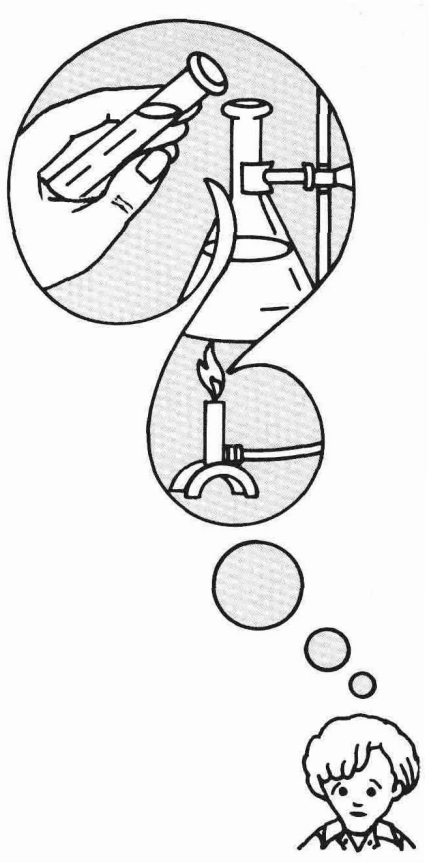
relationship to the book as a whole are discussed in more detail there. In addition, the Teacher's Guide suggests ways to coordinate laboratories with the text, lists such supplementary materials as audiovisual aids, and provides sample quizzes and exams and the answers to the supplementary problems in the text.

Certain topics have necessarily been omitted or treated only briefly due to the limitations of space and time. These topics generally lend themselves to supplementary material that can be incorporated into lectures. However, it is our belief that beginning chemistry students who do not learn the fundamental principles well enough to solve problems are inadequately prepared for subsequent chemistry courses. Thus, rather than attempt to cover every minor topic that might be worth knowing later, we have tried to provide the student with a text that clearly explains the fundamental principles of chemistry and presents a model for problem solving.

The large number of sample calculations throughout the text enables the student to use the book at home to learn how to solve the problems within each chapter. To facilitate this learning, the text heavily emphasizes simple routine calculations, since many students run into trouble because of inadequate grounding in these computations. Because the problems are encountered within rather than at the end of each chapter, the text becomes almost programmed in its nature, providing the student with immediate practice in each skill following its development in the text. Supplementary problems appear at the end of each chapter.

In addition to the fundamental principles of chemistry, it is important for students to begin learning that body of facts we sometimes call *descriptive chemistry.* As much as possible, appropriate descriptive chemistry accompanies theory in the text. However, much of the descriptive material we wish students to learn is best taught in a vigorous laboratory program. Clearly, the student who believes that silver chloride is a pale green gas is deficient in descriptive chemistry. Few students make such an error after a laboratory unit on precipitation reactions and writing balanced equations. Similarly, students who design and carry out a laboratory experiment on the preparation of salts are more likely to retain information about the preparation and properties of these substances than those whose experience is limited to a textbook reading assignment. The laboratory manual that accompanies this text provides students with such hands-on experiences to enrich their knowledge of descriptive chemistry as well as sharpen the problem-solving skills being developed in the textbook.

Contents



CHAPTER 1

To the student

1.1 WHY STUDY CHEMISTRY

Most textbooks include a section in the introductory material that is addressed to the student. In that section the author(s) attempts to sell the subject matter to the student; but weathered students realize that such a section requires independent reading (on their own time!). Therefore, to avoid having our readers feel cheated, we are including this material in the first chapter so that it can be read as part of an assignment.

In fact, while the preceding remarks were made in jest, there can be no doubt that this material is extremely important. If one is to expend the effort to learn a substantial body of knowledge, there must be some purpose to the learning, or the learning is folly. A student who studies chemistry simply because it is a requirement for medical school or nursing school is likely to view it as a dull topic, a hurdle to be crossed. There must be some justification for engaging in the study of a subject with the "reputation" chemistry enjoys. This chapter will briefly attempt to explain what the "payoff" is for even the most casual student of chemistry. For indeed, chemistry is the subject matter of which the world about us is made.

Chemistry has the ability to answer the ultimate question, "What is life?" Although all of the facts are not yet in and much remains to be understood, a knowledge of chemistry is essential for any student who wishes to know what

the life process is and to understand the latest theories of how life came about in the first place. In an introductory course it is not possible to make any detailed attempt to answer these questions. Nevertheless, a brief discussion of the chemical origins of life is undertaken in the last chapter.

However, even if the student never reads the last chapter, chemistry is all about us in the physical world. We observe events daily that are evidence of the chemical nature of our everyday existence. Here are just a few of the events the student will be able to understand if he completes this course in chemistry: why does a candle burn, what is burning, what is color, why is ultraviolet light dangerous to look at, what is salt, what is sugar, how does a pressure cooker work, why won't boiling eggs cook at the top of the mountain, why does ice melt, why does a flag wave in the breeze, how does a battery work, why doesn't water flow uphill, how does soap work, what is boiling, what is the metric system, how does a barometer work, and why do I float (unless you don't, in which case you might ask, "Why do I sink?").

These are just a few of the everyday occurrences you will be able to understand after completing a course in chemistry. Incidentally, if you *are* taking this course because it is a requirement for medical or nursing school, you will be a lot closer to understanding what "life" is.

In addition to answering questions about sundry everyday experiences, chemistry will help you to understand some of the critical problems facing our society today. Individuals who have a basic knowledge of chemistry are far more likely to understand the energy crisis and the many problems related to it. How is one to make a sound judgment about the safety of nuclear power plants if one does not know what nuclear energy is. Similarly, solutions to the problems of air and water pollution can only be formulated by individuals who have a working knowledge of chemistry. Problems of worldwide food shortages will ultimately be solved with the help of chemistry.

Students today ask that their courses be "relevant." It is often assumed that only courses dealing directly with people are relevant. However, if you consider the most critical problems facing the world today, it may be that chemistry is the most relevant course you will ever take.