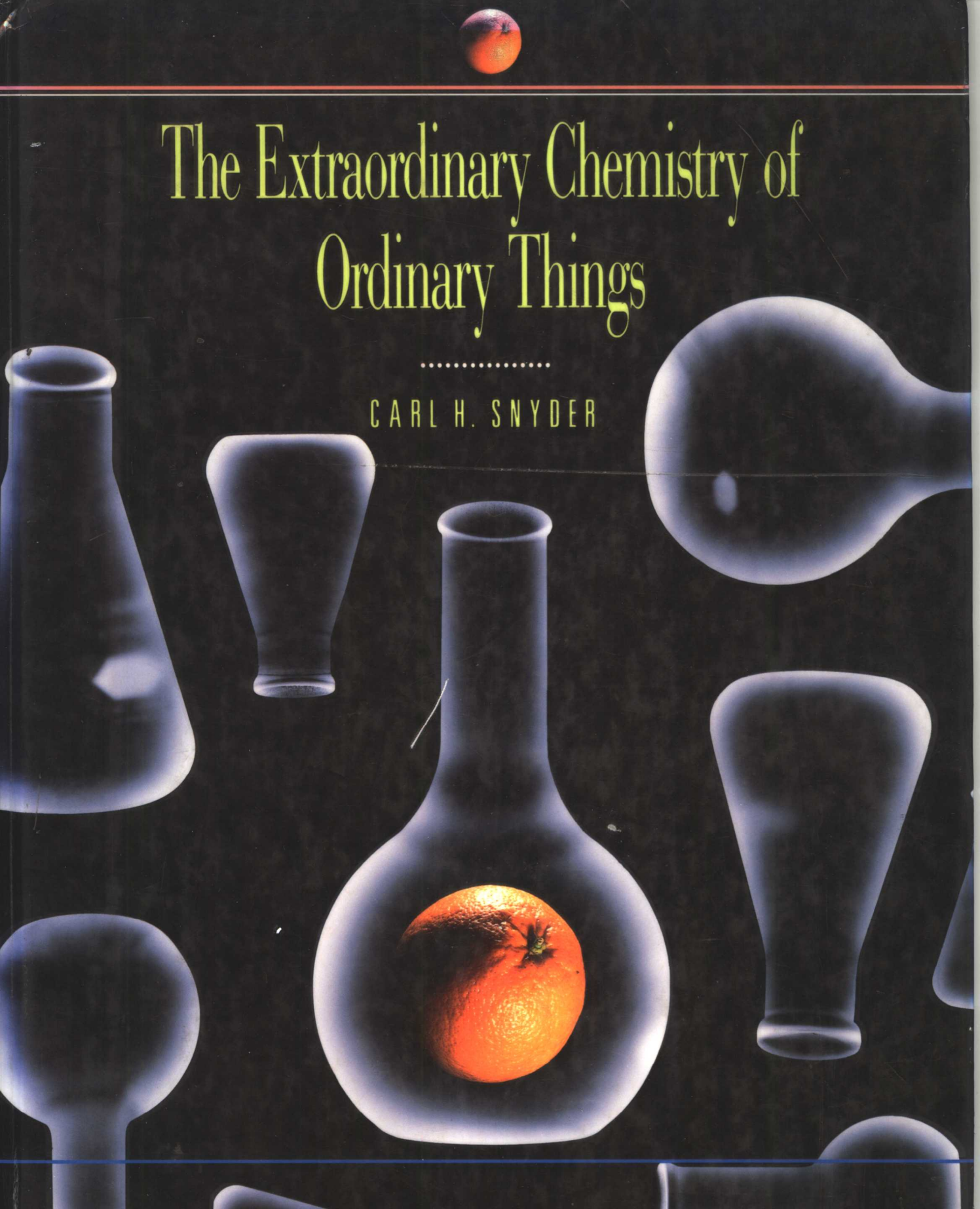
The Extraordinary Chemistry of Ordinary Things

CARL H. SNYDER



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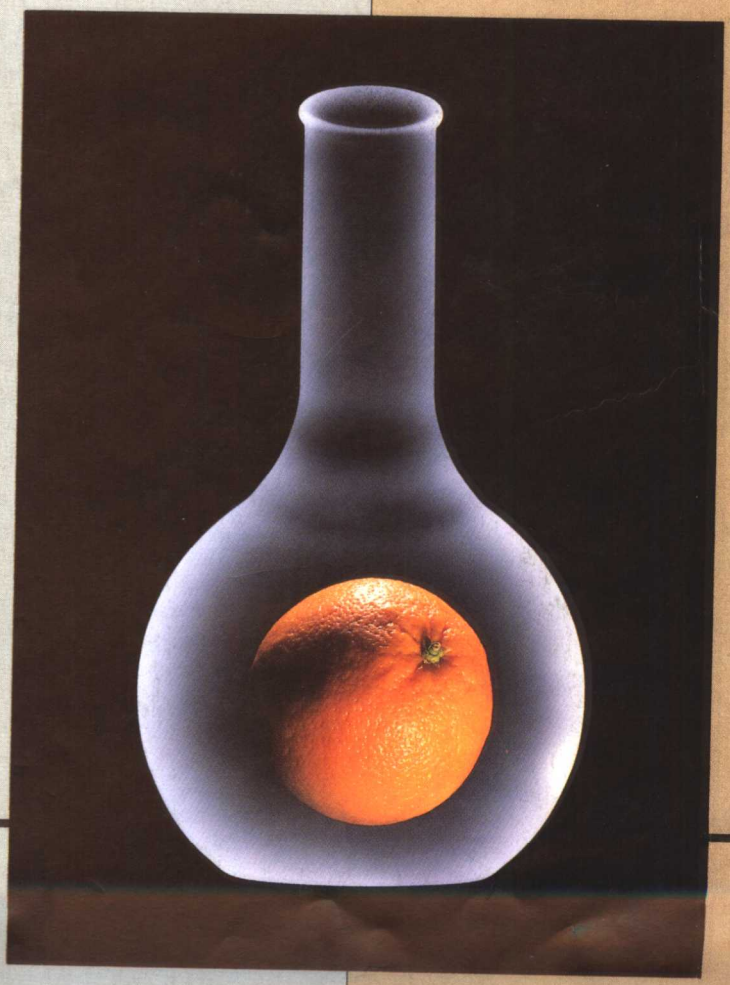
University of Miami



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About the Cover

One hundred and sixty years ago, photography was invented when an object, left on top of a paper specifically treated to be sensitive to light, left its image on the paper. Over 100 years later, the Surrealists used a similar technique, called *photogramming*, to startle the world.

For the cover photo, we created our own photogram by placing several glass flasks on a piece of black and white photo paper and using an enlarger light to cast shadows of them on the paper. The shadows left behind their image. After the print was processed and dried, it was copied onto color film in a double exposure, carefully arranged so that the orange, from a second exposure, appeared to be inside one of the flasks.

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Preface

This book was written for a course in which nonmajors learn chemistry in the context of the things that can or do affect them in their everyday lives.

Its origin lies in a course originally titled "Consumer Chemistry." In the early 1970s, at a time of severe inflation, it occurred to me that such a course combining chemistry with consumerism and directed at nonscience students was badly needed. I developed this as a one-credit, one-semester course in which I taught chemistry through its applications to consumer products and used consumer products to illustrate chemical principles. Each reinforced the other in examinations of gasoline and petroleum, detergents, foods and food additives, plastics, and the like.

With time, the course expanded beyond consumerism and the more common of our consumer products, but without ever losing sight of either. Although radioactive substances, for example, aren't commonly classified as consumer products, we do encounter them as consumers of medical care. Although ozone isn't itself a consumer product, our use of the gasoline engine and of chlorofluorocarbons affects both the undesirable generation of ozone (in the air we breathe) and the undesirable destruction of ozone (in the stratospheric ozone layer). In evolving, the course content came to include not only such topics as nuclear chemistry and the chemistry of gases, including ozone, but other facets of chemistry as well, facets that aren't easily defined in terms of consumer goods.

It evolved into a course about the chemistry of the substances of our everyday world, from the banal to the contentious, from table salt to perception-altering drugs, from drinking water to nuclear power. It evolved to include questions of safety, of the meaning and measurement of pollution, and particularly of the ambiguity of terms like "good" and "bad" as they are applied to chemicals. It evolved to bring the students themselves into the realm of chemistry, not only to demonstrate that we ourselves are constructed physically of chemicals but also to show that we can and must have the power of choice in how we use the chemicals of our universe. Appropriate choices require wisdom, and wisdom is founded on knowledge.

The course changed in other ways as well. It grew in steps from a one-credit, one-semester offering into a two-semester sequence of two three-credit courses, acceptable toward the science requirement for graduation. With these changes I have tried always to remain true to my original goal: teaching chemistry through illustrations taken from the common substances, objects,

and processes of the world around us. Each hand—chemistry as one, and the things and substances of our everyday world as the other—shakes the other.

OBJECTIVES

The objectives of this approach are to teach chemistry:

- In the context of the ordinary things of our everyday lives, and some that aren't quite so ordinary but that nonetheless can and do affect our lives.
- In the context of the larger realm of science, drawing on chemical principles and examples to illustrate the workings of science as a whole and the scientific method.
- In the context of the need for science literacy to enable all, scientist and nonscientist alike, to make reasoned judgments on societal issues that are founded on the processes and fruits of science in general and chemistry in particular.
- In the context of chemistry as an experimental science.

CHEMISTRY, AN EXPERIMENTAL SCIENCE

The fourth of these objectives deserves further comment. I, and perhaps others as well, have long taught chemistry as we know it to be, with an understanding shaped by many years, even decades of study. We see chemistry as a coherent, rational whole and we transmit this model of the chemical universe to our students. Yet I have found, and I suspect many others agree, that transmitting this model alone is insufficient and unsatisfying, to both the teacher and the student. It's important to teach not only the coherent model of the universe that the science of chemistry presents to us, but to demonstrate why we are forced to accept it.

I use the word "forced" because the model of the world that chemistry presents to us is one that we are absolutely and unconditionally required to mold and to accept. We are forced to this particular model by our contact with physical reality, by our tests of physical reality, by the questions we frame as we test this real universe experimentally, and by the answers we receive from our experimental tests. Chemistry is, above and beyond all else, an experimental science.

We are forced to mold the universe into one particular intellectual construct because of our commitment to the scientific method and its experimental approach to knowledge. To teach chemistry, I am convinced, requires teaching the broad outlines of the scientific method, explicitly or implicitly. We have no choice, for example, but to acknowledge that atoms, subatomic particles, and chemical bonds do actually exist. But *why* are we forced to this view of the world? This is what students must come to understand if they are to learn chemistry in its richest context: why we are forced to see the physical universe as we do.

We accept the reality of atoms and all the other structures and concepts of chemistry because we have no other rational choice. Our experimental tests of our universe, through the scientific method, lead us to them and only

to them. Let us then give our students hard, physical, real, demonstrable evidence that what we are about to tell them is, indeed, true chemistry, real chemistry. Let us show them in lectures and in textbooks that what we tell them is true not because we say it is, but because they see it is.

DEMONSTRATIONS

To emphasize the experimental basis of chemistry, all but two chapters begin with a demonstration or an action of some sort that the students themselves can perform with simple equipment and common substances. The first chapter, for example, begins with an illustration of the electrical conductivity of salt water and the nonconductivity of sugar water that employs table sugar, table salt, and a simple flashlight. The materials of the demonstration are about as common and ordinary as any we can find. Yet we see, at the first moment of contact with this realm of chemistry, that there's something demonstrably different about these two substances other than mere taste, something different that *forces* us to the concept of ions. Ions are real not because we say they are, but because students see that they are.

All the other demonstrations, vignettes, and historical sketches that start off chapters lead us to observations and conclusions about the chemistry of (mostly) ordinary things that we run across again, as textbook chemistry, somewhere in the chapter. These can be used as lecture demonstrations, but they are more than that. All of these demonstrations can be repeated by students, using common household goods. (Some chapters, like the two on nuclear chemistry, are better off without descriptions of hands-on experiments.)

SEQUENCE OF CHAPTERS

The sequence of chapters allows the text to be used for either a one- or a two-semester course. Of the 22 chapters, the first 11 cover most topics considered to be fundamental to the science of chemistry. The first three are introductory, dealing with atoms, ions, molecules, elements, compounds and the periodic table. The next several chapters carry the student from the nucleus, through the valence shell, to the covalent bond. Chapters 9, 10, and 11 round out the introductory material with the mole concept and solutions, acids and bases, and an introduction to the three phases of matter. With applications intimately tied to concepts throughout, there is no sacrifice of applications if the book is used in a one-semester course. Furthermore, any of the chapters in the set 13–22 can be included in a one-semester course with little or no modification. Organic chemistry appears in both the first set with a discussion of hydrocarbons, petroleum, and gasoline (Chapters 7 and 8), and the second set with an examination of the components of food and additives.

ORGANIZATION OF CHAPTERS

Every chapter but the two on nuclear chemistry starts with a demonstration or activity of some sort that leads to the substance of the chapter. In the spirit

of the experimental approach, the results of the demonstration are explained in the context of the principles of chemistry developed within the chapter.

Virtually every section is followed by a question designed to induce the student to reflect on or review the material just covered. Exercises at the end of each chapter are divided into three categories: 1) review, written for a straightforward re-examination of the factual material of the chapter; 2) mathematical, for those who wish to emphasize the mathematical aspects of chemistry; and 3) thought-provoking. Exercises in this last category sometimes have no "right" answer but are intended to stimulate thought about the interconnection of chemistry, society, and individual values.

Many of the chapters, especially the earlier ones, contain worked examples to ease the student's way through the more difficult concepts.

Other characteristics of the presentation include the introduction of definitions, concepts, symbols, and the like largely on a need-to-know basis. It seems to me to make more sense to explain and describe the world about us as we encounter it, rather than to start by defining and categorizing ideas well before we need to use them. It's also clear that I like etymologies. I've found that students learn technical terms more easily if they know where they came from. I have other preferences that I'm unaware of, and I'm sure they show up in the book here and there, beneficially I hope. The major themes of the text are spelled out in Chapter 1 and need not be repeated here.

SUPPLEMENTS

An innovative package of supplements to accompany *The Extraordinary Chemistry of Ordinary Things* is available to assist both the instructor and the student.

1. **Study Guide,** by David Dever of Macon College. This Guide is an invaluable tool for the student, containing unusual, illustrative scenarios as well as the more traditional study guide features such as chapter overviews and solutions to in-text questions. Dr. Dever has also included worked-out solutions to the problems in the text's "A Little Arithmetic" sections, along with additional exercises of the same nature and level of difficulty.
2. **Laboratory Manual,** by Thomas Chasteen of Sam Houston State University and Bruce Richardson of Highline Community College. Twenty-five laboratory exercises are included in this manual, all written in a clear, concise, and unintimidating fashion. The themes emphasized in the Laboratory Manual closely parallel those of the text, incorporating experiments with both consumer and environmental applications.
3. **Instructor's Manual,** by Sharmaine Cady of East Stroudsburg University. In addition to lecture outlines, chapter overviews, and additional class demonstrations for each chapter in the text, the Manual also contains background information and suggestions for using the *The Extraordinary Chemistry of Ordinary Things* videotape.
4. **Test Bank.** Written by the text author, the Test Bank contains over 1000 multiple-choice questions.
5. **Computerized Test Bank.** IBM, Apple II, and Macintosh versions of the entire Test Bank are available with full editing features to help you customize texts.

6. **Full-Color Overhead Transparencies.** Over 100 full-color illustrations are provided in a form suitable for projection in the classroom.
7. **Videotape.** Over 15 experiments are demonstrated by the author on this videotape. A few selected chapter-opening experiments are brought to life; other demonstrations illustrate other pertinent chapter material. In addition, the author and two chemists from the Dade County Department of Environmental Resource Management discuss air and water quality control, pollution tracking, and other vital environmental issues.

THE MAGIC OF CHEMISTRY

Some of the chapters start with what appear to be demonstrations of magic. Household bleach, for example, mysteriously makes colors appear rather than disappear, exhaled breath mysteriously causes colors to change, we mysteriously "squeeze" air out of a glass bottle, and so on. As each of these chapters unfolds, the "magic" is explained as the operation of a chemical principle and the "magic" is seen to be no more than the rational operation of the laws of the universe. The "magic" is transformed into "chemistry" as the student comes to understand how the chemical universe about us works. In this way I illustrate to students one of the most important contributions that science in general and chemistry in particular have made to the development of our civilization: the conversion of superstition into understanding, of fearsome magic into useful science, all through the acquisition of knowledge. After all, *the difference between "magic" and "science" is knowledge.*

ACKNOWLEDGMENTS

I wrote down all the material on the pages that follow, mostly because of my former department chairman, Harry P. Schultz. After my initial suggestion that we introduce a course for nonscientists, Harry gave me unreserved support, encouragement, and recognition. Harry also asked, repeatedly, "Why don't you put all this down on paper?" He asked once too often, and so here it is. With his enthusiastic support for the course, and, I must add, for our students as well, and his repeated urgings that I put it all on paper, this book owes its existence more to Harry Schultz than to any other person. Without Harry neither the course nor the book would exist.

From a more personal point of view, I thank my wife Jean for her patience, unfailing good humor, and astute suggestions and comments that eased the effort of a work like this. In addition, she also did much of the research into nonchemical documents that round out this work, and she proofread the entire first draft of the manuscript with better effect that any word processor's spell checker. Invariably she was there when needed.

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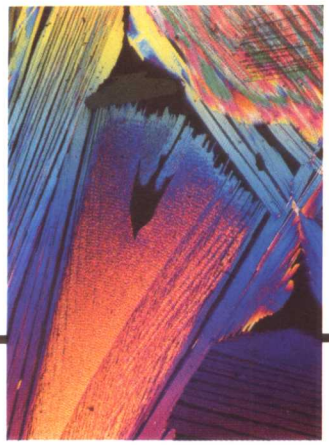

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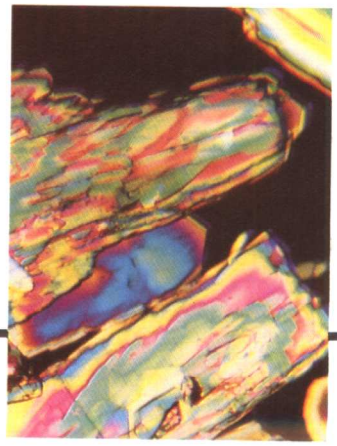

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