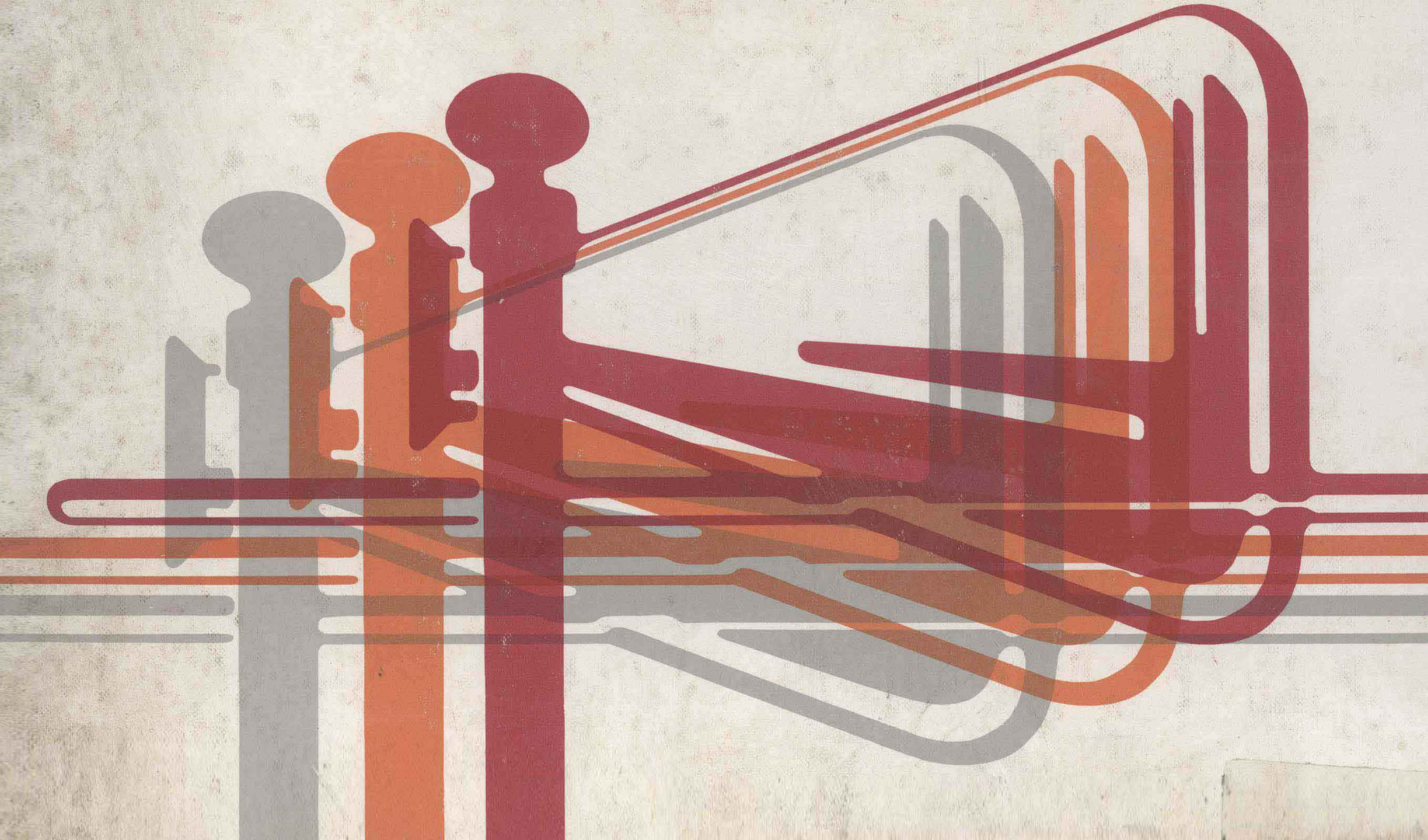
Chemistry

An Introduction • **Sydney B. Newell**



Chemistry
An Introduction

SYDNEY B. NEWELL

Library of Congress Catalog Card No. 76–29282

Fourth Printing

Published simultaneously in Canada
by Little, Brown & Company (Canada) Limited

Printed in the United States of America

Book design: Clint Anglin
Art editor: Tonia Noell-Roberts
Art: Vantage Art
Cover design: Richard Emery

TO THE INSTRUCTOR

I enjoy chemistry. I enjoy teaching it, and I enjoy seeing students learn it. Like most chemists, I find chemistry vital and exciting—a fascinating window on the world. Communicating even a small part of this excitement to students is one of my great pleasures as a chemistry teacher. Teaching chemistry majors has been rewarding and fun, but for me the real delight has been in conveying chemical concepts to nonchemists.

Like most chemistry teachers, I've found that some students don't come with a built-in interest in chemistry. These students have stimulated my creativity and ingenuity over many years of teaching. They have taught me to see chemistry from many perspectives. In return, I have taught them that chemistry is one of many interesting ways of looking at life.

I have written this book for students who need to know chemistry, those who want to know chemistry, and those who may yet become chemistry majors. The book's content and coverage is flexible enough to allow selectivity in topics, whether for a course to satisfy a science or chemistry requirement or as preparation for a more rigorous course in chemistry.

In this book, it is my aim to make chemistry accessible to more students by lowering the learning barrier. Traditional treatments of chemistry often assume a prior interest of their audience. Without this interest, a historical approach can raise the learning barrier through boredom; an approach that builds from basics can raise it through anxiety. To provide interest and motivation, I've used an approach that parallels but does not formalize the scientific method and the history of chemistry—a history that reflects a continual progression from the macroscopic to the microscopic. Elements and compounds were discovered before atoms, which were discovered before electrons. Electrons were discovered before anyone knew how they were arranged in atoms or even that they were part of atoms. In the same way, this book frequently begins with the macroscopic and proceeds toward the microscopic. The macroscopic can take the form of a familiar situation where chemistry is at work, such as blood and its ability to carry oxygen. This leads inward to an explanation of pH and finally to buffers and how they work.

Instead of telling the whole story about every concept as soon as it's introduced, it often makes sense to treat a topic more than once, in increasing levels of detail. This philosophy is in keeping with the "outside-in," macro-to-micro approach described above. For example, the Periodic Table is initially introduced as a convenient means of keeping track of the elements and their properties, then as a tool for predicting formulas, then to explain bonding, and finally in relation to atomic structure. Likewise, some terms and concepts, such as energy or chemical reaction, receive at first a simple definition that is expanded on later as students acquire more sophistication.

The subject matter in the second half of the book (from changes in states of matter through biochemistry) lends itself well to interesting applications that motivate the learning of the material. But it's in the organization of the first half of the book, where the basics are established, that I've used the "what-before-why" approach on a larger scale. Here, the macroscopic is the reality (the "what") of chemistry—the elements and their behavior, names, formulas, the Periodic Table, equations, calculations; these are covered in Chapters 1–6. Then, after having seen that ionic and covalent compounds behave differently, we find out "why" in the discussion of bonding. Moving still further inward, we see that even bonding is a "what" compared with the "why" of atomic structure. An added bonus of this organization is that it provides necessary background for laboratory work early in the course. However, instructors who prefer to begin with atomic structure and bonding may do so, by using Chapter 9 at an earlier time.

To most chemists, chemistry without quantity is incomplete. But to many students, mathematics is a stumbling block. I have tried to give students an appreciation for the answers mathematics can provide by first presenting specific applications and then expanding on those applications in step-by-step example problems. The mathematics of problem solving is supported by a math review in Appendixes A and B, which deal with numbers and units. The motivational approach used in the text extends also to the Appendixes, where I have drawn on day-to-day experiences—including the use of the now-familiar hand-held calculator—to support the explanations. The Appendixes and their exercises can be used as introductory chapters or just as places where students can go for help. For maximum clarity and simplicity, I use the factor-unit and mole-ratio methods to solve problems with conversion factors.

My own experience, coupled with the constructive criticism of many colleagues and reviewers, has led me to use a number of other teaching and learning aids. A set of review questions at the end of each chapter emphasizes the important points of the chapter section-by-section, while the exercises serve to test skills learned in the chapter. Appendix C lets students check and correct their own work by providing answers and numerical solutions to the odd-numbered exercises. Defined terms are printed in italics in the text and in boldface type in the margin opposite the text where they first appear. In the index, page references to these terms appear in boldface type so that they can be located in the text where they are defined, rather than in an out-of-context glossary.

A complementary instructor's manual accompanies the text. It contains various supplementary materials and suggestions for lectures and demonstrations.

Acknowledgments

As always in a project of this nature, many people contributed to the final product. My own students at Lowell Technological Institute (now the University of Lowell) and at Carnegie-Mellon University inspired me to write this book and helped me to improve it. Students at Santa Barbara Community College, Schoolcraft College, and Catonsville Community College also provided valuable input. Detailed advice that contributed to the structure and direction of the work came from Margaret E. Goodrich, Seattle Central Community College; E. Park Guymon, Weber State College; George Kewish, De Anza College; Miriam Malm, University of New Mexico; Stanley Manahan, University of Missouri; Raymond F. O'Connor, Santa Barbara City College; Lee Pederson, University of North Carolina, Chapel Hill; Grace S. Petrie, Nassau Community College; Robert O. Reynard, Catonsville Community College; Eugene Roberts, City College of San Francisco; George H. Schenk, Wayne State University; John Searle, College of San Mateo; Judith K. Tilden, University of Lowell; Martin A. Volkar, Community College of Allegheny County; William J. Wasserman, Seattle Central Community College; Andrew C. Watson, Schoolcraft College; and Leverett J. Zompa, University of Massachusetts, Boston. To all these, my thanks.

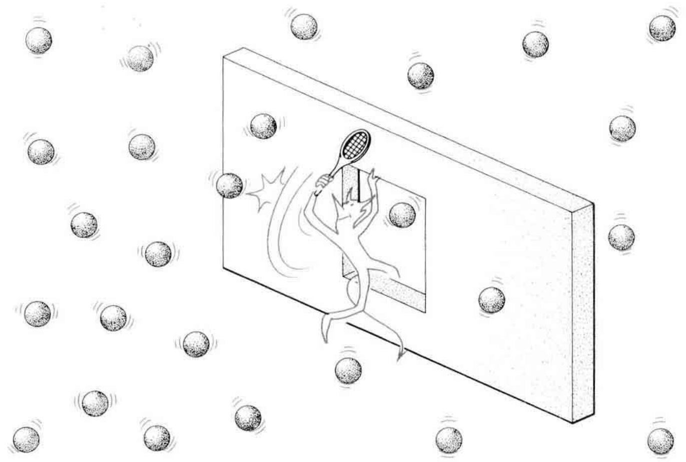
The staff of Little, Brown and Company has my appreciation for the completion of the project. Cynthia Chapin capably supervised the whole production process. Key to the project's success was Jane Aaron, who performed the herculean task of seeing the book through from start to finish, and who had primary responsibility for it. Not only did she provide excellent and thorough suggestions for reworking, reorganization, and rendering my prose less convoluted, but in the course of the work she became an excellent chemical critic as well. In many instances her questions and suggestions prompted major changes for the better.

Finally, I am indebted to Dr. Ronald Rohrer, whose constant surveillance from a technical but nonchemical point of view provided essential feedback on clarity, relevance, and readability.

The preface comes last for the author, but first for the reader. This book has required the best of many people, including myself. I hope that reading and using it will be an enjoyable experience for students and instructors alike.

S.B.N.

TO THE STUDENT: INTRODUCING MAXWELL'S DEMON



Much of chemistry involves changes—many dramatic, most very fast—from one condition to another. We could see better how chemical processes work if we could slow them down or take them apart and look at them piece by piece. But we mortals can't do that, so in this book I use the services of a cartoon character, Maxwell's Demon.

I didn't invent the demon. He was invented in 1871 by James Clerk Maxwell, a scientist who made contributions in the fields of mathematics, physics, and chemistry. Maxwell conjured up a tiny creature who could reverse natural processes in a way impossible for human beings to do. Many of us would like to undo things that have been done, such as unbreaking a glass, un-burning a forest, or collecting smoke that has spread through the air and stuffing it back into a factory smokestack. We'd also like to make things happen the way we want them to, like having the right horse win the race or making a chemical process happen in a certain way. These are the kinds of things Maxwell's Demon can do.

Maxwell's Demon allows me to be present in this book. Through him, I can talk more conversationally than I feel would be appropriate in the text's running narrative. He'll help us to share the experience of observing chemical principles as he illustrates them in a way that only a demon can.

S.B.N.

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