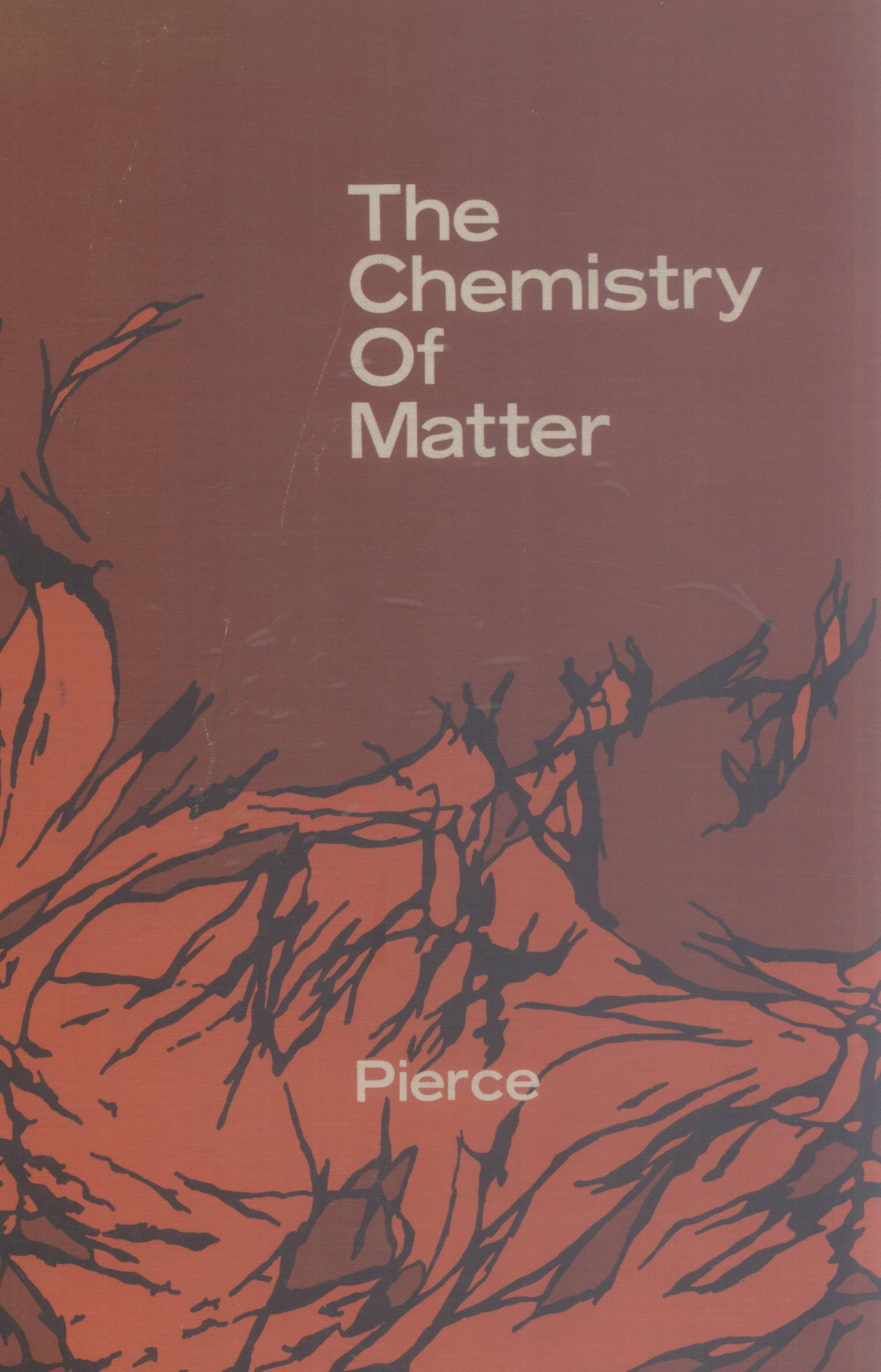
The Chemistry Of Matter



Pierce

the chemistry of matter

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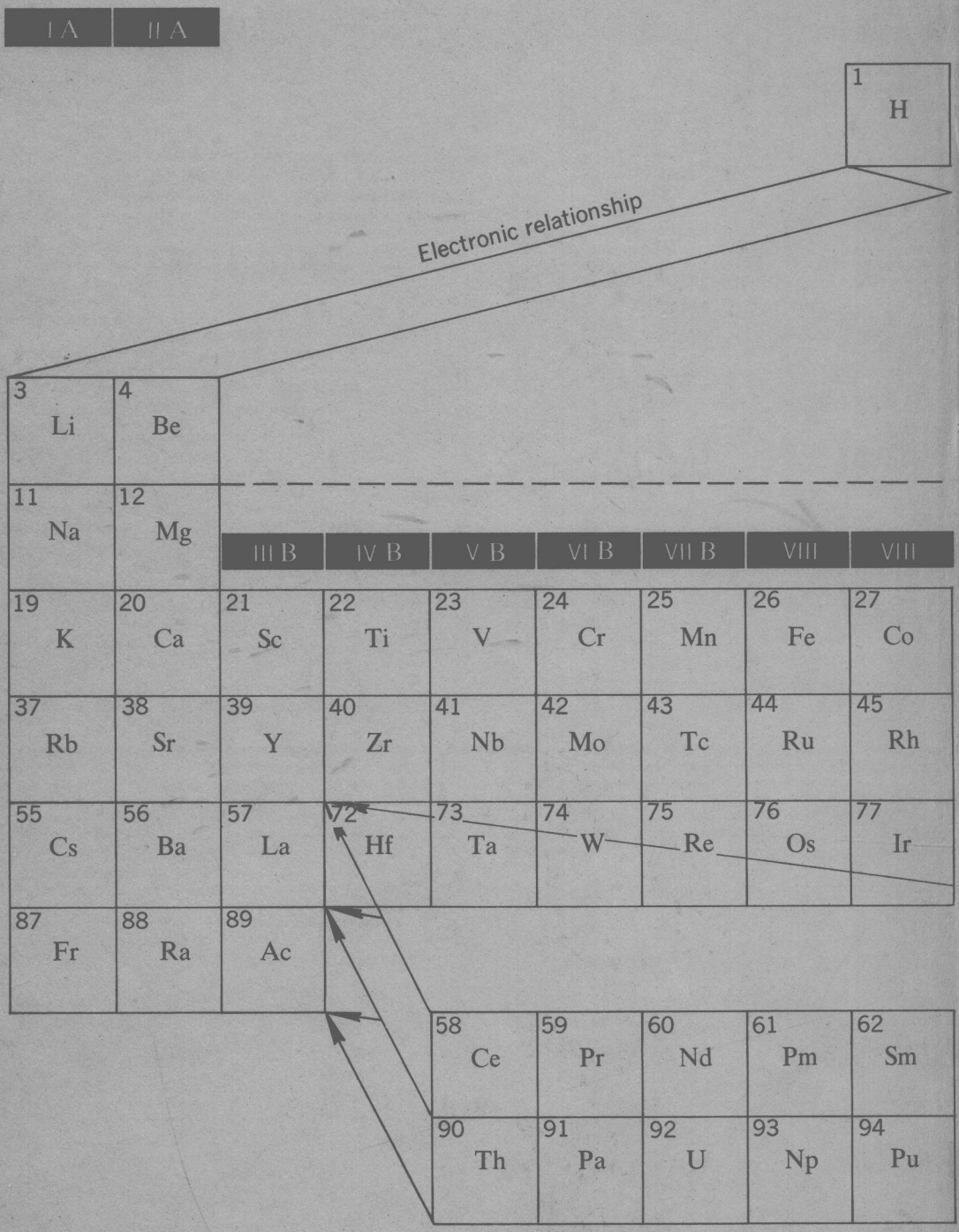
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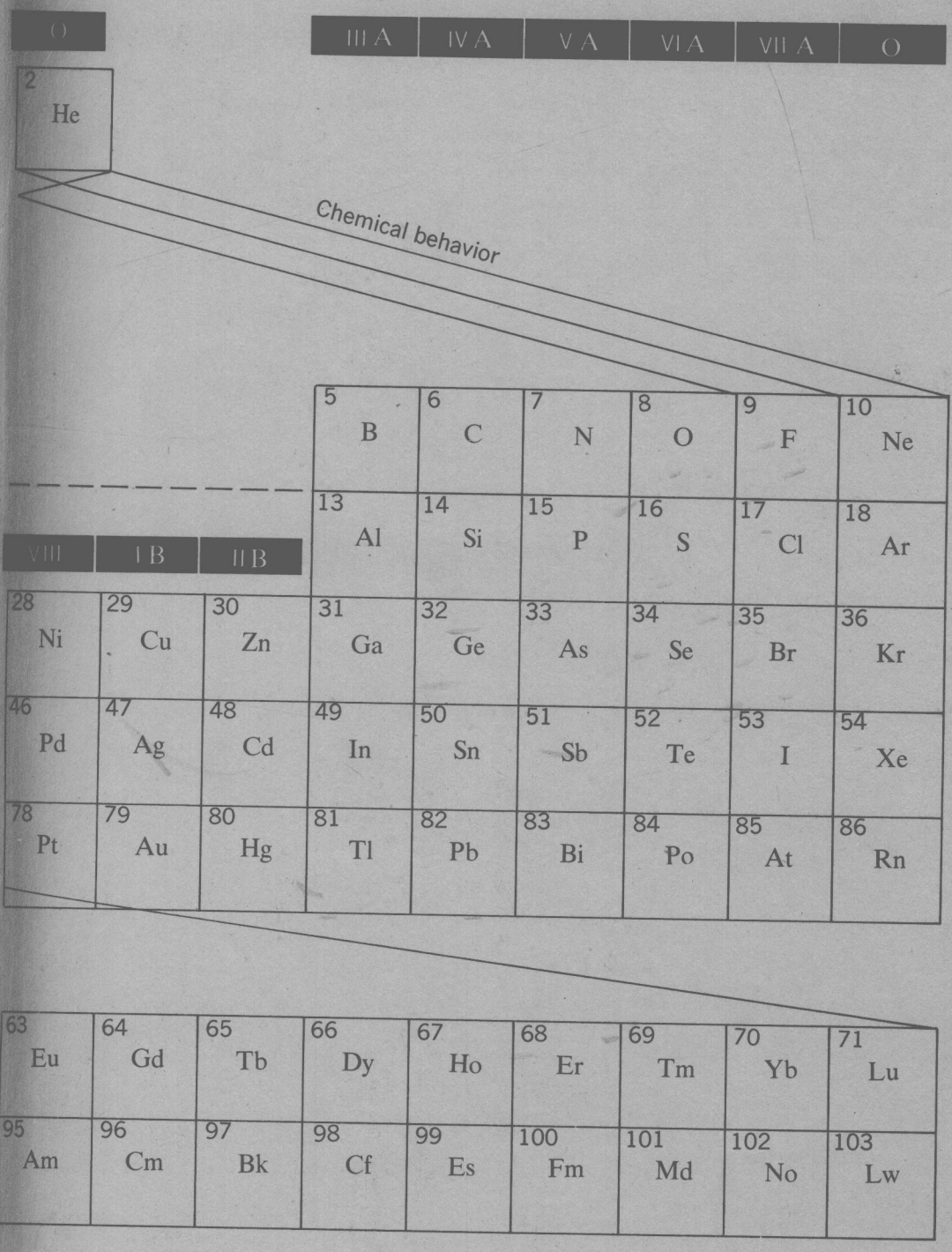
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V A
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Md
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the chemistry of matter

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Lowell Technological Institute

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To Mildred
for her continuous encouragement and assistance
in preparing the manuscript for this book.

editor's introduction

The dedicated student of science today must struggle with change. Unlike his father who could pass a basic course by memorizing a body of descriptive chemistry, he must contend—from high school on—with a wave of increasingly sophisticated theories, meant to explain, not describe, the reactions he witnesses in the laboratory. To him, an understanding of atomic and molecular structure is essential to his visualization of static and dynamic chemical systems; and a knowledge of thermodynamics is the basis of his comprehension of equilibrium, kinetics, electrochemistry, and acid-base behavior.

In the past few years, the trend away from descriptive chemistry has become apparent to professor, student, and future employer alike. Everyone realizes that introductory chemistry is changing, and must change, but the question of how to direct that change is still of major concern.

Tradition has long locked the subjects of the "new" chemistry —wave mechanics, thermodynamics, kinetics, equilibrium—in the splendid solitude of upper-level academia. There they have sat, imprisoned by their complex mathematics and the even more complex nature of their theories. So now, when all of this is altered and the walls are falling away from the sacred empires, the bright young professors of chemistry are asking, "What form should our alterations take? How can we make this advanced, physically oriented material comprehensible to the student who knows little or no calculus? Just how much does he need to understand to comprehend the physical phenomena of today's chemistry?" The search for answers to these questions has created an entirely new genre of introductory chemistry texts; each successive book clarifies one point a bit further but, as is inevitable in any new research, none offers the final solution.

I would like to think that Professor Pierce has extended this search more than one step further. He has elucidated thermodynamics, and thereby kinetics and chemical equilibrium, by his non-classical approach; he has burrowed more deeply than ever before in his discussion of structure; he treats coordination compounds in unusual detail. . . .

What the conclusion of this search will be, we cannot know but we can assert that students today, whether they continue in science or not, will have a more solid background than ever.

Robert C. West
University of Wisconsin

preface

We are privileged to live in an era of unparalleled technological and economic growth. As we enjoy the benefits of this experience, we must also recognize and accept the many problems it causes. It is to one of these problems—the rapid expansion of our store of knowledge—that the content of this book is addressed.

At each level in our society pressure is mounting upon the individual to know more and more about his government, his economy, his heritage, and his environment. Acquisition of this knowledge is both necessitated and facilitated by our accelerated rate of advancement in modes of travel and communication. Fifty years ago the horse was important in our transportation system. Now, we may fly across this vast country in four hours. In 1876 Alexander Graham Bell patented his telephone; at the end of the century (1897) Guglielmo Marconi patented his wireless telegraph—the forerunner of modern radio and television. Today we not only communicate with the speed of light, we use electronic devices to perform our will at remote distances and employ computers in the routine solution of problems that a few years ago were insoluble.

The impact of these changes has made educators aware of the need to upgrade courses and curricula. In chemistry there has been a proliferation of introductory books each displaying its author's solution to the problem of offering an adequate, but understandable, course. Some of these books are directed to the able student; some to the less prepared. All fill a need. For the most part each is written at a uniform level of rigor.

In this book the degree of rigor varies by design. Each subject is developed from familiar ideas and carried to a degree of rigor that should satisfy the more demanding student. This approach bridges the information gap between high-school and college work; it allows the talented, but poorly prepared, student to compete with those who have received a sound background prior to entering college. By this means the great variety of backgrounds displayed by the beginning class can be effectively amalgamated and brought to an adequate level of comprehension before a topic is pursued to the required degree of rigor. This technique is a great aid to the weaker student and at the same time enhances the background of the better student.

Desirable prerequisites for studying this book include high-school level courses in chemistry, physics, and mathematics. In mathematics, algebra is most important; trigonometry and geometry are helpful. Strangely, at Lowell some of our most successful students have never before studied chemistry. Other than intelligence the most essential traits of a successful student seem to be a sincere desire to learn and the efficient use of his study time.

A knowledge of calculus will be of value in Chapters 14 and several that follow. However, a dual development of important mathematical relationships in terms of algebra as well as calculus should make the information understandable to those who are not familiar with the calculus. In many colleges calculus is

studied concurrently with introductory chemistry. This plan is desirable but not necessary.

For convenience, logarithms, exponents, roots, use of the slide rule, calculations involving units, and trigonometry are reviewed in Appendix B. Polar coordinates are discussed in Chapter 4. In our experience students have been able to learn these topics as rapidly as they are required in the course.

The book is divided into four parts as follows:

Part 1	The Mole	Chapters 1–9;
Part 2	States of Matter	Chapters 10–12;
Part 3	Energetics	Chapters 13–20;
Part 4	Reactions	Chapters 21–25.

The professor may use this classification as a guide if he wishes to present the material in a different sequence. For instance, he may wish to intermesh Chapters 21–25 with the others rather than leave them to the end of the year. Perhaps he would like to begin with Chapter 8 or 10 and consider the earlier chapters at a later date. Many will wish to use selected topics in each chapter and delete the rest. Some will wish to delete Chapter 7. In any event, a judicious choice of topics and order of presentation will permit the use of this text in courses having different degrees of rigor and sequences of topical coverage.

Understanding the fundamental language of chemistry requires a broad understanding of chemical principles and a detailed knowledge of certain central ideas. This book contains a panoramic overview of chemical theory and practice. More than this, for an introductory treatment atomic and molecular structure and thermodynamics are probed in depth and applied in practical ways to chemical systems. The continuing lack of student proficiency in stoichiometry and inorganic nomenclature is recognized by the inclusion of a chapter dealing with each of these subjects. The modern importance of chemical kinetics is reflected in an extensive chapter, which interrelates many of the facets of that interesting subject. A later chapter treats isomerism as a general phenomenon and not as one characteristic of organic compounds alone. The book concludes with several chapters of reaction chemistry in which carbon, hydrogen, oxygen, and water are singled out for special attention and the nonmetals, metalloids, noble gases, and metals are discussed.

Great attention has been given to the careful wording and development of subject matter. Wherever desirable the text is illustrated with carefully prepared drawings most of which are original. They were designed specifically for this book and have been classroom tested for efficacy. Coordinated with the subject matter of each chapter is a set of original exercises, which eliminates the need for a separate workbook. The student is assisted in his study plan by a study guide at the end of each chapter. Collateral readings are also suggested. Classroom testing of three preliminary editions of this book has proven it to be an effective presentation.

A task of this magnitude requires the cooperation of many

people. Among these recognition must be given to Dr. Harry A. Eick, Michigan State University; Dr. Karl H. Illinger, Tufts University; Dr. Carol Kandall, formerly of Boston University; Dr. Leonard C. Labowitz, Yeshiva University; and Dr. Robert C. West, University of Wisconsin, for their contributions in reading and criticizing portions of the manuscript. A special note of gratitude must be given to Dr. Philip S. Lamprey of Lowell Technological Institute for having read and criticized the entire final manuscript as well as the preliminary editions.

Helpful discussions involving topical coverage and pedagogy were enjoyed with Dr. Malcolm E. Kenney, Case-Western Reserve University, and with Dr. Sydney S. Biechler, Dr. Martin Isaks, Dr. Lamprey, Dr. Allen Scattergood, Dr. Arthur Watterson, Prof. Judith A. Horine, Miss Barbara L. Brooks, Miss Judith A. Kelley, and Mr. Sami A. Shama, who have assisted in proving the text at Lowell Technological Institute.

To the forgotten people, the competent, efficient staffs at the Houghton Mifflin Company and their subcontractors, many thanks are due. It has, indeed, been a pleasure to work with them. And last, for having sacrificed four years of normal social and family life, for having typed the several drafts of the manuscript, and for supplying encouragement when it was most needed, I am especially grateful to my wife.

J. B. P.
Lowell, Massachusetts

contents

part four / **reactions**

appendices