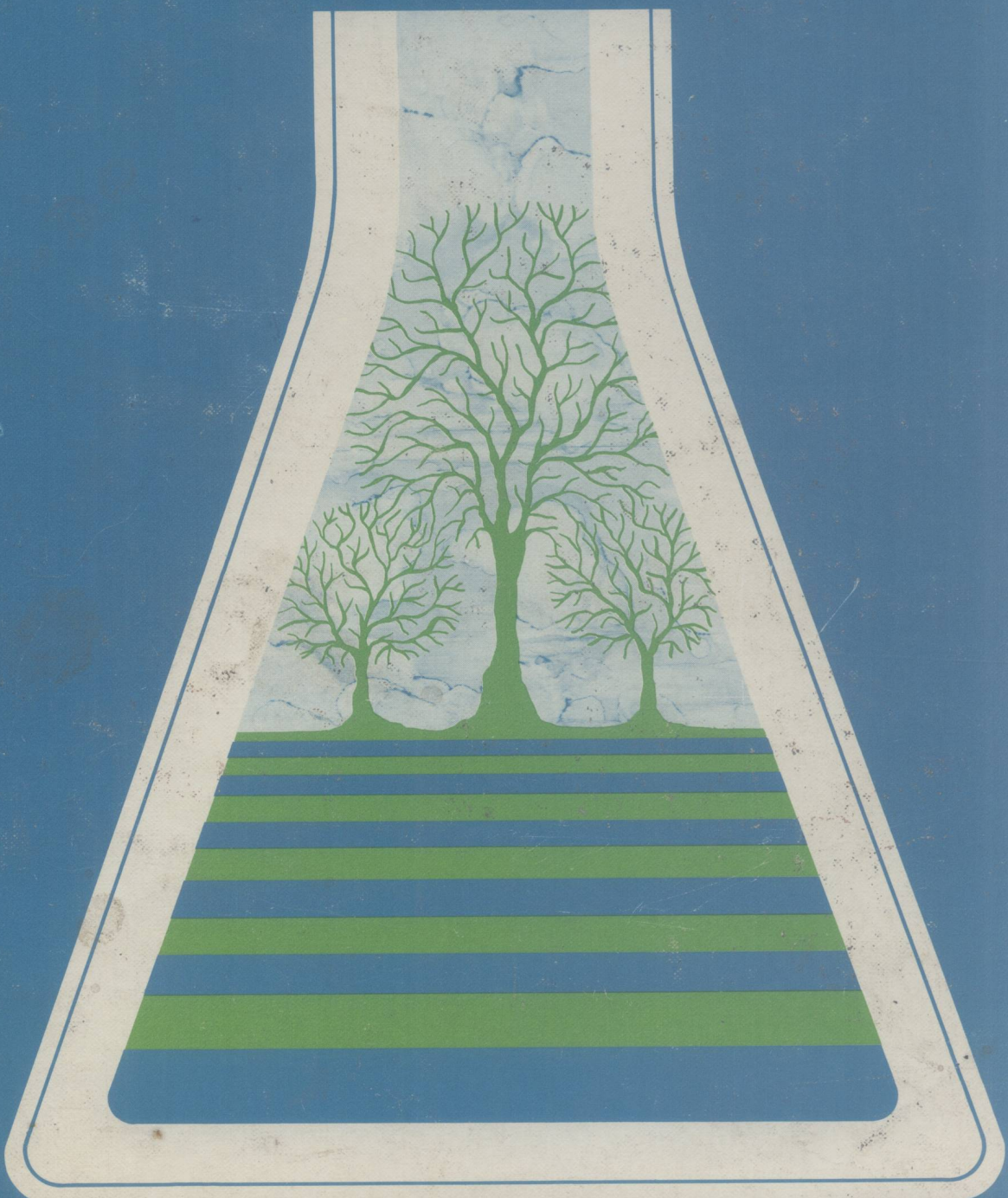
T. R. DICKSON

UNDERSTANDING CHEMISTRY:
FROM ATOMS TO ATTITUDES



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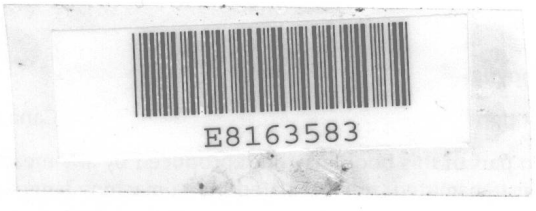

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TO CHILDREN OF THE EARTH

PREFACE

This book is designed for a beginning or survey course in chemistry for non-science or parascience students. The major objective of the book is to provide the student with a chemical view of the environment. The basic concepts and models of chemistry are fundamental to the development of such a chemical description of the environment. That is, the ideas of atoms, molecules, and ions as structural components of matter and the rearrangement of these particles in chemical reactions is the basis of a description of the static and dynamic aspects of physical reality. Once such a chemical view is established, it is possible to explore how natural chemical processes and the use of chemistry and chemical technology by humans can affect the environment.

To facilitate this approach, basic chemical concepts are discussed followed by expositions of some of the chemical factors which influence the world. The reason for this is that the principles of chemistry provide an elegant description of reality and are intellectually interesting apart from environmental concerns. However, the practical significance of these principles certainly revolves around the chemical phenomena occurring in the environment which influence our lives. Consequently, these chemical principles are used to discuss such topics as air pollution, water pollution, energy sources, agricultural endeavors, population control, biochemistry of life processes, and medicines. The discussions are presented to serve as a foundation for the development of values and attitudes concerning environmental dilemmas. Knowledgeable attitudes are a necessity for citizens of today who will undoubtedly be involved in many political and social decisions revolving around environmental issues.

Some mathematical concepts are fundamental in chemistry. The metric system, atomic weights, and the mole concept involve numbers. Furthermore, a quantitative description of chemistry and chemical processes involves numbers. We are all constantly being fed numerical information about the things that go on around us. In this book the use of such numbers is explained where applicable. Some of the mathematical concepts are also explained, but these descriptions carefully separated from the other material.

Each chapter has a selective bibliography of books, pamphlets, and articles. These references are provided as sources of information on environmental topics from popular and semitechnical books and journals. The bibliography at the end of Chapter 1 includes books of general interest.

(*Note to Instructors:* Some of the questions at the end of certain chapters are designed to have the students express their feelings concerning various topics. Since these questions involve personal feelings, the decision to reveal any responses to the questions should be left to the individual. The intent of these questions is to help the students recognize their values, and the privacy of individual feelings should be guarded.)

I would like to thank all of those individuals involved in the preparation of this book. They have helped me express my hope for the world through this message to students who comprise the world's most precious resource.

Aptos, California

T. R. Dickson

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THE PHYSICAL ENVIRONMENT

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1-1 ENVIRONMENTAL ATTITUDES

Of the many creatures on earth, humans alone have been able to rise above the forces of nature to exercise a certain amount of control over the environment. In a sense, humans have found it possible to manipulate the natural environment in a fashion which appears to be, and often is, beneficial. It cannot be denied that many of the triumphs of humans over nature are necessary and provide needed comfort. On the other hand, it cannot be denied that humans in their dominion over nature have assaulted and upset the environment. As we are beginning to realize, many of the intricate and interrelated processes which are continuously occurring in nature are being affected by human activity. Such realizations come from a study of the structure of the environment and an understanding of relevant human activities which affect the environment. Citizens of today will be involved in numerous decisions involving the environment. You may be involved in deciding whether or not a nuclear power plant should be built near your community or if a particular insecticide should be banned. Are these decisions to be left to the experts? Realistically, we will all participate in solving various environmental dilemmas.

When dealing with environmental problems you will be confronted with a variety of physical facts, statistics, opinions or value judgments, and predictions of the future. For example, it is a fact that carbon monoxide is a poisonous gas which can accumulate in the atmosphere and be a dangerous air pollutant. It is a statistic that 59 percent of man-made carbon monoxide produced in the United States comes from automobiles. What should be done about this air pollution problem is a matter of opinion, values, and priorities. Most of us have attitudes or values concerning such problems, or we can develop opinions when we learn about a problem. This book is intended to provide you with facts and information, but it does not presume to give solutions to our problems.

The statement that carbon monoxide emissions from automobiles are expected to rise from the current 65 million tons per year to 100 million tons per year by 1980 is a prediction of the future based on current statistics and trends of the past. Keep in mind that such predictions may or may not prove valid and,

thus, should be viewed as educated opinions. Usually, too many factors and variables are involved in a problem to allow accurate predictions of the future. However, we often use these predictions to form opinions, priorities, and modes of action. In fact, it is likely that with the installation of emission control devices on automobiles, stimulated by federal emission standards established by the 1970 amendments to the Clean Air Act, carbon monoxide emissions should be drastically reduced. It is important to be aware that predictions made by scientists, nonscientists, government agencies, industrial representatives, and politicians are opinions. By collecting facts and sorting out various statements and predictions concerning an environmental issue we can develop our own attitudes and values upon which decisions can be based.

1-2 SCIENCE AND TECHNOLOGY

Science is the attempt to describe physical reality in a systematic and logical manner. Physical reality refers to the physical objects which exist and phenomena which occur within our space–time environment. The practice of science seems to spring from the desire of humans to know about and describe physical reality and to accumulate knowledge. Scientific thought has evolved within the realm of human thought to the highly organized, extensively communicated, and somewhat domineering discipline which includes all fields of science today.

Pure science and scientific research are in a sense concerned only with the development of new knowledge. However, the evolution of scientific knowledge provides a better understanding of physical reality and reveals ways in which the environment can be manipulated to serve humans. **Technology** is the application of science to the manipulation of the physical environment especially for industrial or commercial purposes. It can be argued that technological advances have improved the lives of humans, but it also can be argued that technology has been used to destructive ends.

It is important to distinguish between pure science and technology which is applied science. These two aspects of science are closely allied and practically inseparable. That is, many scientific advances have stimulated technological applications of the advances. Similarly, many technological advances have stimulated scientific thought. For instance, scientific knowledge of the chemical nature of materials and the chemical function of the body has stimulated the technology of the production of man-made chemicals to fight disease. An example of the influence of technology on science is the development of the steam engine, which stimulated the creation of a field of scientific thought called thermodynamics.

Throughout the ages, the application of science has been a two-edged sword. The discovery of the technology of the refining of iron ore to make iron established the iron age, and iron serves as a backbone of the industrial societies which exist today. However, iron brought new dimensions to the production of weapons of war. The technological production of ammonia is necessary to the production of fertilizers needed by a hungry world, but the technique was developed for purposes of making explosives. The development of the knowledge of nuclear energy has led to many promising uses of this energy, but the development was stimulated by the quest for nuclear bombs as the ultimate weapons of war. The list of useful and reprehensible applications of technology could go on and on. It is true that technology can be used for constructive and destructive purposes, but certainly the decisions concerning such uses are made by humans.

It is somewhat nonproductive to argue whether or not science and technology have been responsible for the many environmental dilemmas which exist today. It is important to realize that scientific advances and the proper use of technology will play an important part in the resolution of environmental problems.

1-3 CHEMISTRY

Chemistry as a science is based on observations of events that occur and objects (matter) that exist within our space–time environment. Chemistry is a dynamic science which deals with the structure and behavior of matter. Chemistry involves finding out what things are made of and how they undergo changes. We are surrounded by material objects, and human beings as living organisms have a material existence. Chemistry is concerned with investigating the nature of all matter ranging from substances such as water to complex biological material such as deoxyribonucleic acid (DNA). The science of chemistry has developed from the desire of man to describe what objects are made of and how the structure of these objects causes them to have certain properties. From a practical point of view, desirable properties of matter are sought. Substances that are useful (to cure disease, explode, intoxicate, and smell or taste good) and capable of being fabricated into things (clothing, utensils, and tools) are isolated from nature or manufactured from other substances. Chemists explore nature and experiment with substances to develop and refine theories concerning the structure and behavior of matter.

We all benefit from the practical applications of chemistry. Synthetic and natural chemicals are used as drugs and medicines. Agricultural productivity is greatly enhanced by the use of chemical fertilizers and pesticides. Many important consumer products such as foods, gasoline, and plastics are derived from chemical processing. Actually, modern living would not be as convenient as it is without chemical technology. Moreover, we are learning that when we utilize substances in our environment for convenience, the environment is altered and can become polluted. An understanding of environmental problems requires knowledge of the chemical processes involved. Furthermore, solutions to problems will require the development of appropriate chemical technology. It is important to learn some chemistry to understand the nature of our environment and the forces that threaten it.

1-4 MATTER AND MASS

We use our senses—sight, hearing, taste, smell, and touch—to observe those objects which surround us and the changes which continuously occur in and around us. We see the sizes and colors of objects and see changes in the positions of objects (i.e., a moving automobile). We hear the sounds of certain phenomena involving the interaction of objects (i.e., the sound of a musical instrument or a jet airplane). We taste and smell pleasant and obnoxious things (i.e., good food and foul air). We detect heavy or light objects using the sense of touch. We also use our sense of touch to discern hot and cold objects.

A simple description of what we see in our environment is that it consists of objects having substance. We call such objects matter. **Matter,** of course, makes up the material things around us which we conceive of as occupying space and having mass. **Mass** is a property of matter that determines its resistance to being set in motion or resistance to any change in motion. A baseball is much easier to throw than a more massive shotput ball and, obviously, more desirable to catch. It is not too difficult to develop feeling for the idea of mass, since we are familiar with objects in our environment. The useful aspect of mass is that it can be used to compare different objects. For example, when you pick up two objects, you can often say that one feels heavier and therefore has a mass which is greater than the other.

As we observe, the environment is not static but rather involves dynamic changes. Day and night come and go, sunlight replaces rain and snow, plants and animals grow. Another aspect of our environment which is related to the