

**THE GENERAL PRINCIPLES OF
PHYSICAL SCIENCE: AN
INTRODUCTION TO THE STUDY
OF THE GENERAL PRINCIPLES OF
CHEMISTRY**

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The General Principles of Physical Science: An Introduction to the Study of the General Principles of Chemistry by Arthur A. Noyes

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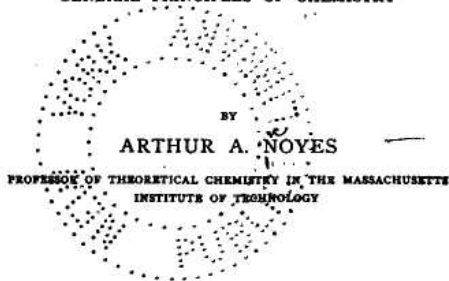
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ARTHUR A. NOYES

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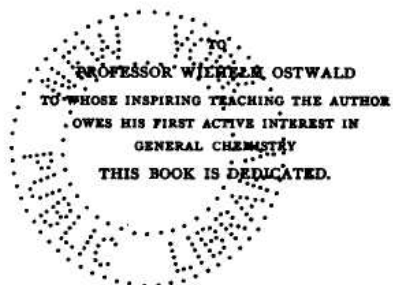
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PREFACE.

As the title of this book indicates, its purpose is to present the general concepts and laws of physics and chemistry which lie at the basis of the modern science of theoretical chemistry. It forms the first, introductory part of a projected work upon this science, to be entitled the General Principles of Chemistry, the later parts of which are to treat, in succession, of the General Theories of Chemistry, of the Relations between Physical Properties and Chemical Composition, of the Principles relating to the Occurrence and Equilibrium of Chemical Changes, and of the Principles relating to the Energy-changes Attending Chemical Changes. As the work has had to be discontinued, it has been thought advisable to publish the part already completed, in the hope that it may assist students of theoretical chemistry by supplying, in a concise and consistent form, the essential preliminary knowledge of the fundamental principles of physical science. The method of presentation of these principles may also be of interest to teachers of general physics and chemistry, since an effort has been made to attain precision in the statement of laws and definitions, since the energy-concept has been employed, as far as seemed possible, as the basis of the consideration of other physical concepts, and since the difficult subject of the Second Law of Energetics has been very fully discussed from a non-mathematical standpoint.

The treatment throughout is a systematic, not a historical one. It is essentially non-mathematical, but it is assumed that the reader knows the significance of differential and integral expressions, and that he is acquainted with a few of the simpler operations of the Calculus. On the purely physical side, the treatment is complete and intelligible in itself, in the sense that each term employed is first defined; but it has been necessary to so condense it, that it can hardly be fully appreciated except by one who has had a fairly

thorough course in general physics: on this side, the book is intended to serve as a systematic review of the important physical concepts and principles, and as an aid in acquiring a definite and precise conception of them. It is the practice of the author to emphasize their significance by requiring of his classes the solution of numerous problems. On the other hand, those considerations which have an especially important chemical bearing are very fully presented. This is true, for example, of the characteristics of chemical substances, of the concepts of combining, equivalent, and molecular weights, of the physical properties and energy-relations of gases, of the work involved in volume-changes, of Faraday's Law, and of the First and Second Laws of Energetics. Theories are not discussed at all in this book; for, in the author's opinion, it is desirable, in order to avoid producing an exaggerated idea of their significance, to present fundamental principles independently of them.

References are not inserted in the body of the book, but are given in an appendix. Their purpose is to bring to the attention of the reader more extended discussions of the subjects treated in the text, to give the authorities for the numerical data cited, and to indicate the works to which the author is especially indebted. The notation employed is summarized in a second appendix; for much attention has been devoted to this matter, with the view of devising for physico-chemical purposes a system consistent in itself and yet according as nearly as possible with common usage.

In conclusion, the author wishes to express his great indebtedness to many friends for criticisms and suggestions, especially to Dr. H. M. Goodwin, Prof. H. E. Clifford, Dr. W. D. Coolidge, Dr. E. Weintraub, Mr. J. G. Coffin, and Mr. M. Rosenberg.

ARTHUR A. NOYES.

Boston, June, 1902.

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CHAPTER I.

THE OBJECT, THE METHODS, AND THE SUBDIVISIONS OF SCIENCE.

1. **The Object of Science.**—It is the object of science to facilitate the acquirement of a knowledge of the phenomena of nature by devising means for their mental representation, thus replacing by simple operations of thought the slow, laborious process of acquiring that knowledge by the observation of the innumerable isolated phenomena. *It is therefore the object of science to make the completest possible presentation of natural phenomena in such a manner that a knowledge of them can be acquired with the least possible expenditure of effort.*

It is to be noted that the acquirement of this knowledge has two distinct aspects: on the one hand, science aims to make as easy as possible the comprehension on the part of individuals of the knowledge already acquired by mankind; and, on the other, it aims to add to the total sum of human knowledge by leading to the discovery of previously unknown phenomena.

This statement of the object of science should be carefully noted, in order that the reader may fully appreciate the significance of the various principles and hypotheses employed for the mental representation of phenomena, it being evident that the value of such means of representation is to be estimated solely through a consideration of the extent to which they assist in attaining that object—that is, in facilitating the acquirement of a knowledge of natural phenomena.

It will be clear from this statement that, however abstract or theoretical the methods of science may be, its object, the saving of labor in the acquirement of knowledge, is a concrete and highly practical one. Moreover, the

