

now out of date, is first to study the transformations of some one substance, such as alcohol, which lends itself to many changes, which are easily traced experimentally, and subsequently to deal with series. This leads naturally and easily to the great object of the detailed study of carbon compounds. Apart from their practical utility and the application of knowledge gained by this detailed study to the purposes of the vegetable and animal physiologist, the great aim of the organic chemist is surely to trace the relation of chemical constitution to physical properties, and so to shed light upon the wider question of the constitution of matter generally; but this is just the aspect of the study which, in most of the textbooks, is kept in the background. W. A. T.

PRACTICAL PHYSICS.

Physikalisches Practicum, mit besonderer Berücksichtigung der physikalisch-chemischen Methoden. Von Eilhard Wiedemann und Hermann Ebert. Zweite verbesserte und vermehrte Auflage. Pp. xxiv. 455. 279 Woodcuts. (Braunschweig, Viewig, 1893.)

RECENT years have seen a great development in the teaching of practical physics, and a great increase in the number of laboratories in which instruction in the elementary parts of the subject can be given to large classes of students. So much has this been the case, that now practical physics is taught in a good many of our schools, and forms one of the subjects in numerous examinations. Those who have been largely concerned in the establishment of classes for practical instruction in physics, and have had some experience in actual teaching, have often felt the need of a suitable book to put into the hands of their students, and have endeavoured, each for himself, to supply this want. This is the origin of several books on practical physics, such as Glazebrook and Shaw's manual (to take an English example), and the work before us. The authors of such books are able to employ the MS. or the proof-sheets in the instruction of their students, and thus are able to obtain a practical test of their work before sending it forth to the public, with the result that the books are generally very satisfactory for the purposes for which they are designed. The only drawback is that each book is apt to appeal only to a particular type of students, and to give descriptions of the apparatus in a particular laboratory.

The "Practical Physics" of Wiedemann and Ebert has been designed for a special class of students, viz. those who are chiefly interested in acquiring a knowledge of chemistry. Particular attention has therefore been devoted to those parts of physics which are of most use in a study of chemistry, while several parts of the subject of great interest to physicists have been either omitted or only very briefly dealt with. Thus experiments on rigid dynamics and on the magnetic properties of iron and steel are completely passed over.

The authors have not attempted to give an account of the methods of precision which may be employed in the experiments selected by them, and consequently have taken no notice of the small corrections which become of so great importance in an accurate research. In

those cases where it seemed desirable that some source of error should be brought prominently before the student's notice, the experiment is so arranged that the correction shall not be too small.

To each section there is an introduction wherein the general laws to be employed are stated, and the quantities to be measured are sometimes defined; but, as a rule, no account whatever is given of the reasoning by which the formulæ are arrived at. This is bound to be unsatisfactory, and must lead the student to be continually asking for explanations of the formulæ, unless indeed he be a person of little mental vigour, when he will accept formulæ without a murmur. In many instances no explanation or definition whatever of the quantity to be measured is vouchsafed to the student. For example, he is informed that the coefficient of viscosity of a liquid can be determined by the formula

$$\eta = \frac{\pi p r^4 t}{8 V l}$$

where V is the volume of liquid which is driven through a fine tube of radius r and length l in time t by a pressure p , but there is absolutely no definition of the coefficient of viscosity, although it might have been given in a few lines. The same complaint may be made about several other sections. The authors are surely mistaken in their idea that by their method the use of books on "the higher mathematics" may be dispensed with, and the "Practicum" become a self-contained treatise on practical physics, wherein the student may find all he requires without the trouble of searching through special textbooks. Besides, it is in every way better that the student should endeavour to acquaint himself with the methods by which the formulæ have been deduced. He gains in this way a grasp of the principles of the subject which is hardly attainable in any other manner; and if he does learn a little mathematics, he may hope that it will not seriously injure his ability for chemistry.

Before dealing with the contents of the book, it may be well to mention some points in which the book is far less satisfactory than the authors were capable of making it. The first complaint is that the results of the sample experiments are frequently set down without any statement of the units in which they are expressed. For instance, the modulus of rigidity of brass is found by an experiment to be 4770 *some things*, but what the *some things* are is not stated. The student who happened to express the linear magnitudes in centimetres instead of millimetres, would doubtless be much perplexed when he found by his experiment the value 477,000 instead of the result in the book. If, on the other hand, the value of the modulus had been expressed as 4770 kilogrammes per square millimetre, all the difficulty would have been avoided. The student should be so trained to state precisely the units in which his results are expressed, that the bare statement that the modulus of rigidity is 4770 should produce an unsatisfied feeling, in his mind, much the same as is called up by the conundrum, Why is a house? In some instances where units are given, they are given wrongly, as when the velocity of sound is found to be 331.5 *metres*, and the average velocity of hydrogen molecules is stated to be 1698 *metres*.

A minor defect is that one system of units is not

adhered to throughout. Sometimes centimetres are employed, and sometimes millimetres. This is of no consequence, except so far as it tends to keep alive and propagate the state of confusion from which the C.G.S. system might have been expected to deliver the scientific world.

The first part of the book deals with the mechanics of solids, liquids, and gases. The usual methods of measuring lengths, &c., are described, and an account is given of experiments on the balance, on the laws of the pendulum, on elasticity, and on acoustics. The greater portion of the space is devoted to experiments with liquids and gases. The full account which is given of the methods of making measurements of a mechanical nature upon matter in these two states, should be very useful to the students for which the book is designed.

The second division, which is devoted to heat, is excellent. A large number of experiments are described, most of them of great importance to the modern chemist. In this connection may be mentioned specially the sections dealing with melting points, the effect of dissolved substances on the freezing and boiling points of liquids, and the amount of heat evolved in solution and chemical combination. A section is devoted to the determination of the mechanical equivalent of heat by the aid of what is practically a model of Joule's apparatus.

Optical measurements and observations occupy the next portion. Some simple experiments with reflecting surfaces, lenses, and prisms are given, so as to form an introduction to the subject. A few simple experiments with combinations of lenses with lenses or mirrors would have been of much use here, for students generally find difficulty with such experiments, and require some little experience before they can deal practically with the real or virtual images which are seen in mid-space, and not down the tube of a telescope. A large part of the section is devoted to spectrum analysis, and there are some excellent plates of emission and absorption spectra. A short account of the phenomena of polarisation leads up to a chapter on the rotation of the plane of polarisation by various substances, and the use of this property for saccharimetry and other purposes.

The last division of the book, which is devoted to electricity and magnetism, is somewhat abbreviated, only those parts of the subject being included which are supposed to be of interest to the chemist. Voltaic electricity practically takes up the whole of the space. The same omission of definitions, which has been already noticed, shows itself strongly here, no definition being given of either the ampere, the volt, or the ohm, while the enunciation of Ohm's Law is just what a schoolboy might be expected to put down. Although a tangent galvanometer is described, no hint is given that it is possible to calculate its "reduction factor" if the value of "H" is known, and, in fact, the electromagnetic definitions of the units seem quite kept out of sight. From a physical point of view, this division compares quite unfavourably with the three other divisions.

The volume is brought to a conclusion by a useful collection of numerical tables, physical and mathematical.

In spite of the defects which have seemed to call for notice, the book is undoubtedly a useful one, the defects

being such as the teacher can very easily remove. If a third edition is called for, it is to be hoped that the authors may see their way themselves to remove them.

The book will often be of service to those teachers who are engaged in the task of conducting classes in practical physics, for it will often suggest fresh experiments to be added to those forming the regular course of the laboratory. But it must be remembered that although a demonstrator in the course of a few years may acquire a knowledge of a large number of experimental methods, yet the students who come under his care for a year or so have only time to acquire a very limited acquaintance with the subject, so that if a new experiment is added to the course, it practically displaces some old one. The course of experiments which is most suitable for students of a particular type working for a particular end, very soon settles itself by a process of selection, and then must remain practically unchanged, although there may be a gradual evolution in the employment of improved methods.

G. F. C. SEARLE.

OUR BOOK SHELF.

Object Lessons in Elementary Science. By Vincent T. Murché. Three volumes. (London: Macmillan and Co., 1894.)

WHEN a child is shown any object, he usually asks "What is it?" and then "What does it do?" If these questions are sensibly answered the child learns much about the properties of common things while he is very young, and, what is more, his faculty of observation is developed. Evidently, then, an excellent grounding for a scientific education can be obtained from object lessons. Simple objects are brought under the children's notice, and their peculiarities observed. For instance, liquids such as water, oil, wine, milk, and quicksilver are taken and used to show that they flow, break up into drops, have no shape of their own, and keep a level surface. Physical properties of solids can then be treated; but whatever the subject of the object lesson, the aim of the teacher must be to let the class come to their own conclusions upon the points illustrated. This principle of sound instruction is well exemplified by the lesson on hard and soft bodies in the first of the three volumes before us. The aim of the lesson is to enable a child to express clearly (1) what he understands by "hard" and "soft"; (2) that hardness and softness are merely relative terms; (3) how to test the hardness of a body. Such objects as an apple, a turnip, a potato, cork, chalk, wood, lead, iron, flint, steel and glass are taken, and children are asked to scratch them with the finger-nail. It is then found that some of the objects can be scratched easily, others not so easily; a third class can only be scratched with difficulty, and a fourth cannot be marked at all with the finger-nail. The experiments are afterwards repeated with a knife, and then the objects are rubbed against one another, and the results noticed. By these means the pupils learn that there are many degrees of hardness, some bodies which are commonly called hard being really soft when compared with others; e.g. lead is hard when compared with wood, but soft when compared with iron, and so on. To our minds, this method of teaching elementary science is admirable. It must not be supposed however, that Mr. Murché only deals with physical conditions. His excellent little volumes are also concerned with the chemistry of common things, with the mechanics of every-day life, with zoology, botany, and physiology, and with various arts and manufactures. The volumes follow a scheme of object teaching in elementary science