

THURSDAY, JANUARY 12, 1888.

## PHYSICAL CHEMISTRY.

*Lehrbuch der Allgemeinen Chemie.* Von Dr. Wilh. Ostwald. In Zwei Bänden. (Leipzig: W. Engelmann, 1885-87.)

THE larger text-books of chemistry have generally been devoted to describing and roughly classifying the facts which form the foundation of the science. These facts are so numerous, varied, and important, that when one has spent years in arranging, cataloguing, and reciting them, his chemical vision has generally acquired a fixed downward direction, and he is almost unable to lift his eyes from the foundation-stones to look on the buildings which other workers have been raising.

But, whether such a one will look at the building or not, the building is surely rising. The walls already are massive; there are adornments of conceits, perhaps sometimes too quaint; windows there are in plenty to admit light and air: the house will never be completed, because nature is inexhaustible, but even now there is promise of a goodly building. Nor shall the House Beautiful want fit interpreters, among whom an honourable place will be held by the Professor of Physical Chemistry at Leipzig.

It has generally been admitted that chemistry is a branch of physical science. Individual chemists by their researches have shown that the relation of chemistry to physics is that of the less to the greater; but most of the attempts to set forth this relationship in its entirety have failed. To treat chemistry as a branch of physics requires one who is almost as much a physicist as a chemist, but one whose physical training has waited on his chemical judgment. Some books on physical chemistry have been books on descriptive chemistry, with scraps of physical facts thrown in; others have been books on physics to which the use of chemical illustrations has given an ill-defined but not unpleasing chemical tone. Only of late years has it become possible to set forth the connections between the parent science and the greatest of her children in a fairly satisfactory manner; and this possibility has come through the recent advances made in the study of these connections.

It was therefore fitting that one of the men whose work forms no small part of all of first-class importance that has been done in recent years in the sphere of physical chemistry should be the man to write the first good text-book on general chemistry considered as a branch of physics. Ostwald prefers to call his work "*Lehrbuch der Allgemeinen*," rather than "*physikalischen*," "*Chemie*." The title very happily expresses the scope and character of the book; but the treatment of chemical principles in a general manner is made possible in this treatise by regarding chemistry as a special branch of physics. The book is intended for fairly advanced students who have already a tolerable knowledge both of descriptive chemistry and of physical principles. Some of the higher forms of mathematical analysis are freely employed. The form in which the author has chosen to present his treatise is the historical-critical; he justly remarks that

the historical coincides with the logical development of many chemical ideas.

As the object of the work is to enable the student to gain a firm hold of the principles of chemistry, and more especially to teach him that very many of these principles have been reached by the application of physical methods to chemical phenomena, much care is taken to distinguish generalized statements of facts from hypotheses, to indicate the need of using hypotheses, to trace the merging of several hypotheses into one general theory, and to avoid mere speculation.

The first volume is devoted to stoichiometry. The laws of chemical combination, which form the basis of the whole science, are laid down in a singularly clear and succinct manner; the atomic theory of Dalton is sketched; the chemical methods by which combining weights are determined are classified, and this is followed by a short critical exposition of the results obtained for each element. The second, third, and fourth books of the first volume are devoted to accounts of the properties of gaseous, liquid, and solid bodies, respectively. The relations between the volume, temperature, and pressure of gases, are considered; this leads to a statement of the law of Gay-Lussac, and a consideration of Avogadro's hypothesis; then follows an account of the kinetic theory of gases, the specific heats, and the optical properties of gases. The book on liquid bodies is devoted to a consideration of (1) the general properties of liquids; (2) the relations between the liquid and gaseous states; (3) the volume-relations of liquids; (4) solution; (5) optical properties of liquids; (6) capillarity, diffusion, and osmosis; (7) electrical conductivities and electrolysis of liquids; (8) specific heats of liquids. The book on the stoichiometry of solid bodies includes the consideration of crystallography, especially in its chemical bearings, the optical and electrical properties of solids, &c. The first volume concludes with a sketch of the relations between atomic weights and chemical properties, a general account of the molecular theory as applied in chemistry, and a short but very suggestive chapter on theories of chemical composition and constitution.

The second volume deals with the vast and widely ramifying subject of chemical affinity. The first part, on chemical energy, comprises what is really a comprehensive treatise on thermo-chemistry, and also full critical accounts of photo-chemistry and electro-chemistry. The second part, dealing more distinctly with chemical affinity, begins with an historical sketch; this is followed by about 150 pages on chemical dynamics; and the whole concludes with an account of the various methods whereby measurements of the relative affinities of various bodies, especially acids and bases, have been obtained; the last chapter deals with the relations between the nature, composition, and constitution of bodies, and the values of their affinity-constants.

Ostwald has undertaken and brought to a conclusion a task of great difficulty. His book has removed the sting from the taunt so often cast at the chemist that chemistry is the pursuit of the mere fact-finder and formula-monger. If Ostwald's "*Lehrbuch*" had only made evident the fact that chemistry is one of the exact sciences it would have done much; but it has done more than this; it is a repository of the general and abstract truths of the

science arranged in logical sequence; it is a guide to the student and the investigator (for in chemistry these two are one); and it is full of suggestions alike to the physicist and the chemist.

That part of the second volume which deals with the recent developments of the study of chemical affinity will probably be found by many to be the most interesting portion of the book. Everyone knows how unsatisfactory is the treatment of this subject in the standard text-books. Who has not been perplexed as he attempted to gain clear conceptions about affinity? Affinity is one of those terms that escape one as soon as one tries to grasp it: it is protean, and each form which it assumes scarcely lasts long enough for one to distinguish it from the others.

The work of Guldberg and Waage, published twenty years ago, did not bring forth much fruit for some time; perhaps because these naturalists were obliged to go back sixty years to find in the writings of Berthollet the germs of a really exact treatment of the subject of affinity. But within recent years great advances have been made—and made, speaking broadly, on the lines laid down by the Norwegian professors. No one has had more part in these advances than Ostwald; to him we are indebted for several new experimental methods for finding values for the affinity-constants of acids and bases—indeed the proof of the existence of a measurable affinity-constant for each acid and base is, for the most part, due to him. It is one thing to know that memoirs are to be found in the journals wherein the subject of affinity is gradually advanced stage by stage, but it is quite another thing to have a clear, logically arranged, and condensed account of these memoirs in a text-book. It is one thing to be told that the modern development of affinity is the outcome of the views which Berthollet published, in 1803, in the *Essai de Statique Chimique*; it is quite another thing to have this historical and logical development set before one in detail in a masterly manner.

The subject of affinity is largely involved in the wider conception of chemical equilibrium. Ostwald gives a short account of the attempts which have been made to formulate the laws of chemical equilibrium. He then narrows the meaning of affinity, at least as applied to acids and bases; by doing this it becomes possible to extricate the notion of affinity from the mass of more or less connected facts which had threatened to swamp it, and to give it a quantitative meaning.

The affinity-constants of acids and bases are numbers which tell how much of a definite chemical action those bodies are capable of performing under definite conditions. The formulæ of the same acids and bases exhibit the composition of definite masses of these compounds, which masses are in many respects chemically comparable. The goal of chemistry has always been to trace definite connections between the composition of bodies and their chemical properties; but of all the chemical properties of a body the most important is its affinity-constant, inasmuch as we are apparently justified in saying that this value quantitatively conditions all the chemical reactions in which the body takes part: hence the importance of accurately tracing the connections between the changes of compositions of bodies, as represented by their formulæ, and the variations in the values of the affinity-constants of these bodies, must be very

great. The data are as yet insufficient to allow of more than a beginning in this direction: such a beginning is made in the last chapter of Ostwald's book.

To everyone who hopes to make chemistry the business of his life I would say—get Ostwald's "Lehrbuch," read it, study it, become acquainted with it, use it; for by doing this you must become more fitted for doing your work as a chemist.

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#### BRITISH AND IRISH SALMONIDÆ.

*British and Irish Salmonidæ.* By Francis Day. 12 Plates. (London and Edinburgh: Williams and Norgate, 1887.)

IN this work Mr. Day expounds in greater detail the views he made known in his "British and Irish Fishes," concerning the characters and affinities of the several British forms belonging to the genus *Salmo*. He also includes in the volume the consideration of many other important problems connected with the natural history of British Salmonoids. On p. 9 he gives a synopsis of the British genera of the family, viz. *Salmo*, *Thymallus*, *Coregonus*, *Osmerus*, and *Argentina*, and then proceeds to consider Genus 1, *Salmo*, while at p. 278, is the heading Genus 2, *Thymallus*, Cuvier. For the designation of species and varieties English names are generally used, but with each is given a copious list of the Latin Linnean synonyms, and references to the works where they occur. The species considered are as follows: the Salmon, Trout, British Char, American Char or *Salmo fontinalis*, and the Grayling. Thus *Coregonus*, *Osmerus*, and *Argentina* are left outside the scope of the book, notwithstanding its comprehensive title.

Very elaborate descriptions, including enumerations and dimensions, are detailed for each separate form, but concise diagnostic analysis is entirely wanting. In the synopsis of species of *Salmo* given in the earlier work, "British and Irish Fishes," we find that the only trustworthy specific character differentiating *Salmo salar* from *Salmo trutta* is the presence in the former of eleven rows of scales in an oblique row from the adipose fin to the lateral line, all forms of *Salmo trutta* having fourteen or more of such scales. In the work before us one has to wade through two pages and a half of description of the salmon before reaching a mention of this diagnostic feature.

The views here expressed concerning the forms of sea-trout are somewhat different from those published in the "British and Irish Fishes." In the latter work Mr. Day described *Salmo trutta* and two varieties, *S. albus* and *S. cambricus*. In the present he describes *Salmo albus* (with the same synonymy) as the immature stage or grilse of the northern sea race of trout, *S. cambricus* being the southern sea race. Here again the want of a short diagnosis of the two races is much felt by the reader. From the numerical formulæ of the two races, which are separated by several pages, it is seen that the range of variation in the number of pyloric cæca in the one race is different from that in the other. In the northern form it is 33-61, in the southern 33-52. But it is extremely difficult, by reading and comparing the two lengthy descriptions, to discover what is the exact amount of difference between the two races. However,