

after the wings have been singed in a charcoal fire, used as an article of food by the aborigines. These moths sometimes invade the cities and crowd into houses and stores for the sake of darkness. At Melbourne, in a large sugar store, I have noticed *M. decumanus* collect the moths and eat the bodies, rejecting the wings.

There came under my notice lately at Pennant Hills, near Sydney, a case of a curious article of food for a rat. A rat gained access to the laundry attached to my house, and for some weeks it used to drag pieces of common soap behind any shelter and devour them. That the soap was really eaten was evident, because no particles were left lying about. Ultimately I succeeded in trapping the rat, which was a half-grown male, *M. decumanus*. An empty spring trap was placed open in a box having an opening just over the jaws. A piece of tissue-paper was arranged over the jaws and the whole covered with a thin layer of bran, a bait being laid at the far end of the box. On examination I found the intestines empty and the stomach gorged with fresh bran, which the rat had scooped up before entering the trap. Although I searched carefully I could never find any means of exit from the laundry or see the rat, but I presume it must have got other food somewhere, for absolutely nothing edible was ever placed in the laundry. The rats' excreta were always quite normal.

THOS. STEEL.

Sydney, April 28.

#### SOME RECENT ATOMIC WEIGHT DETERMINATIONS.

THE story, adequately told, of the evolution of ideas and the development of knowledge concerning the stoichiometrical constants we term atomic weights forms a most interesting chapter in the history of the philosophy of chemistry. In point of time it would extend over no very long span. There are men living who are personally cognisant of its most important phases, and some of them in early life were acquainted with others who may be said to have connected their own epoch with that of those who witnessed the beginning of experimental efforts to obtain quantitative estimations of their values.

The formulation of the laws of chemical combination involved the necessity for exact knowledge of the relative weights with which substances enter into such combination, and, as is well known, Dalton himself made tentative trials to obtain some definite conception of their measure. But Dalton was not a particularly skilful or accurate experimenter; his apparatus and methods of quantitative work were very crude and even below the standard of his time. This was fully recognised by his contemporaries, particularly by Berzelius, who may be said to have been the first to attempt precise determinations of atomic weights. The work of Berzelius and his coadjutors marks, in fact, an epoch in the history of the subject.

Of course, as is now well understood, the germ of Dalton's ideas, although he probably was unconscious of it, is to be found in the work of his predecessors, but it does not seem to be generally known that Cavendish, in effect, postulated and

put into practice the fundamental conceptions expressed in the laws of constant, multiple, and reciprocal proportions. He appears to have convinced himself years before the time of Proust and Berthollet that the same substance is invariably composed of the same elements united in the same proportion, and, as can be shown from his published writings, he made quantitative analyses on the implicit assumption of the other laws. This was first pointed out by George Wilson, and has been more fully developed in the course of a critical examination of Cavendish's memoirs in the Phil. Trans. for 1786 and 1788 on "Freezing Mixtures," contained in an annotated edition of his complete papers, published and unpublished, which it is to be hoped the Cambridge University Press may soon be in a position to issue.

It would occupy more space than is available to attempt to trace the several phases, which, like milestones, mark successive stages in the progress and development of knowledge concerning atomic weights, nor is it necessary to set out in detail the various reasons which have led chemists to recognise the imperative necessity of knowing these constants with the highest attainable precision. Philosophers like Berzelius always desired the utmost accuracy in the abstract interests of truth. But, to begin with, the only practical use of atomic weights, or combining proportions as they were called by Davy, was in quantitative efforts to elucidate the chemical composition of substances, and, considering the imperfections of quantitative methods, an approximation to exactitude sufficed. When substances began to be bought and sold on the results of analysis, atomic weights became of importance in commercial transactions, but even then, for the purpose of trade, no very high degree of accuracy was required. Even the numbers of Berzelius's time sufficed for the determination of exact formulæ, and enabled the nature and progress of a chemical change to be traced with precision.

But in recent time, and with the development of chemical theory, atomic weights have acquired a wider importance and a new significance, and a much higher degree of accuracy is demanded. It is, in fact, almost useless to discuss certain questions unless these constants have been rigorously determined. Very much now depends upon little differences—the little difference, indeed, frequently makes all the difference. But, unless this is established with reasonable certainty, it is a waste of time to base an argument upon it. We thus enter upon another and the latest phase in the development of the subject.

For this new departure, which may be said to start with Stas, the chemical world is greatly indebted to American chemists, such as J. P. Cooke and his colleagues, Oliver Huntington and Theodore Williams; and to J. W. Mallet, Morley, and Noyes. Prof. Theodore Williams has worthily maintained the traditions of the Harvard school, and it is largely to his work and example that the present high standard has been reached. We



owe to him in great measure the enormous improvement in technique which distinguishes modern determinative work of this kind. Such work will not pass muster to-day unless it is performed with the scrupulous regard to detail and conscientious search for causes of error and for means to avoid them which characterise the determinations he has directed.

America, moreover, is to be congratulated in possessing a publishing agency like the Carnegie Institution of Washington, which undertakes the printing and distribution of important scientific memoirs which might seriously tax the means of most scientific societies, and which, on account of their specialised character, no ordinary publisher would be likely to accept as a business proposition.

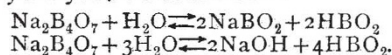
A recent publication by the Carnegie Institution is concerned with the results of a determination of the atomic weights of boron and fluorine by Messrs. Edgar F. Smith and Walter K. van Haagen.<sup>1</sup> As it presents some features of general interest, an account of the work may not be unacceptable.

The redetermination of the atomic weight of boron has revealed the unexpected fact that the value for this constant hitherto accepted is at least 1 per cent. too high—a remarkable circumstance, all things considered. Boron, of course, is a common and widely distributed element, and the estimation of its atomic weight has been made by at least half-a-dozen experimenters since the time of Berzelius with such concordant results that it might be assumed that it was fairly well known. But there are certain considerations connected with these determinations which might occasion doubt. To begin with, there is no great choice of methods in this particular case of a sufficiently valid character upon which to base determinations. Practically all the numbers depend upon the analysis of borax, either hydrated or anhydrous. We have here an instance of what has been frequently deprecated in atomic weight work. A determination based upon the amount of water in a hydrated salt rests upon a faulty principle. It presupposes that the amount of water in a hydrated salt is absolutely definite and constant, and that adventitious water can be separated from that which is supposed to be normal to the constitution of the salt, of which there is no absolute proof. It further assumes that the salt can be completely dehydrated under the particular conditions of the experiment, which may or may not be the case. Now, as all the previous determinations of the atomic weight of boron rest upon practically the same basis, they may involve the same fortuitous errors, and Messrs. Smith and van Haagen's investigation shows that, as a matter of fact, they do. The substantial uniformity of the previous results is therefore misleading. It is a recognised canon in atomic weight work that a value can be accepted

<sup>1</sup> "The Atomic Weights of Boron and Fluorine." By Edgar F. Smith and Walter K. van Haagen. (Washington: The Carnegie Institution of Washington, 1918.)

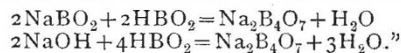
with confidence only if it is based upon methods involving different principles and modes of manipulation free from known sources of error. In these analyses of borax the manipulative processes were of the simplest possible character, and of themselves not liable to introduce error if properly conducted. The main error is traceable to the water and to an imperfect knowledge of the conditions under which the borax could be completely dehydrated.

The persistent retention of water by substances, even when exposed to high temperatures, is, of course, no new fact, and many instances might be given of it. No rational explanation of the phenomenon is known. In the case of borax Messrs. Smith and van Haagen offer an explanation which has at least the merit of ingenuity, if not of generality. In effect it is as follows: When the hydrated salt is heated the water of crystallisation is evolved, and at first passes through the liquid state before escaping as steam, forming droplets of an aqueous solution of borax, which is then hydrolysed as follows:—

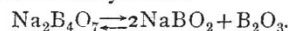


This process is known to occur in weak aqueous solutions of borax. The sodium metaborate and hydroxide on concentration slowly recombine with the boric acid, reforming borax. It may be that on heating the borax the expulsion of water takes place more rapidly than the recombination of base and acid, and therefore heated borax may contain more or less sodium metaborate or hydroxide and free boric acid, and that the recombination is only complete after prolonged fusion.

"According to this view," say the authors, "the last traces of water expelled from fused borax are not merely the last portions of the water of crystallisation proper, but are to be looked upon as water of neutralisation, resulting from the recombination of sodium metaborate (or hydroxide) with boric acid; both of which were produced by a transient hydrolysis during the earlier stages in the dehydration; and this view explains why the last traces of water should be removed with greater difficulty than the bulk. Hence the final loss of water in the dehydration of borax may in all probability be due to the completion of such reactions as the following:—



In support of this hypothesis the authors point to other instances in which salts which are extensively hydrolysed in solution retain the last traces of water with great tenacity. There are, however, cases to which this reasoning scarcely applies. Indeed, even in the particular instance of borax the authors point out that it is not necessary to assume this hydrolytic action. Borax in a state of fusion may dissociate into sodium metaborate and boric anhydride:—



This dissociation may begin before the water is completely expelled, and the hygroscopic boric



anhydride may combine with this water and so retard the final dehydration.

But, whatever may be the true explanation, it cannot be doubted that this obstinate retention by heated, and even fused, borax of about 0.2 per cent. of water is the main cause of error in all previous attempts to determine the atomic weight of boron by means of this salt. That the complete dehydration of borax is difficult was recognised by Dobrovolsky so far back as 1869, and was known to Hoskyns Abraham, who concluded that the dehydration of borax was untrustworthy for ascertaining an atomic weight ratio.

In 1893 the late Sir William Ramsay and Miss Emily Aston published the results of a redetermination of the atomic weight of boron which appeared to them to confirm the commonly accepted value of 11.0. Their methods consisted (1) in ascertaining the water of crystallisation in borax, and (2) in converting dehydrated borax into sodium chloride by repeated distillation with hydrochloric acid and methyl alcohol, according to the process of Gooch and Rosenblatt. All the weighings are given in their paper to seven places of decimals—an assumption of precision scarcely warranted by the circumstances, and an instance of what Kopp was wont to call *Decimalspielerei*. The results of the first method varied from 11.04 to 10.85; the mean value adopted was 10.921. Two series were made by the distillation method; the first gave values varying between 11.015 and 10.879: adopted mean = 10.952; in the second the extreme values were 10.992 and 10.936: adopted mean 10.966. In the last series the amount of chlorine in the common salt was determined by gravimetric analysis in the usual way, which afforded a new ratio. The numbers thus obtained were uniformly above 11 (11.003–11.091: adopted mean 11.052).

The details given by Ramsay and Aston permit of a discussion of their observations in the light of the facts obtained by Messrs. Smith and van Haagen, and it is satisfactory to find that the two sets of observations can be brought into complete harmony. Indeed, certain inconsistencies among the results of the English observers, on which they themselves commented, but were unable to explain, are now cleared up, and serve to corroborate the results of the American chemists.

The recalculation of Ramsay and Aston's experimental numbers by means of the best-determined ratio of AgCl:NaCl shows that the inconsistency referred to becomes slightly greater. From the weight of NaCl,  $B = 10.951$ ; from that of AgCl,  $B = 11.061$ , or a difference of fully 1 per cent. Now the method which they adopted to dehydrate borax combined with their low value for the density of vitreous borax—2.29, as against the proper value, 2.357—makes it practically certain that the fused borax still contained approximately 0.3 per cent. of water, and that the sodium chloride, although heated to 350°, still retained water the amount of which may be computed from the ratios. It was 0.214 per cent. By introducing these corrections, which are not

arbitrary, but fully warranted by the facts, Ramsay and Aston's first series leads to the value  $B = 10.901$ , and their second series to  $B = 10.909$ . They agree, therefore, among themselves, and are in conformity with the result of 10.900 obtained by Messrs. Smith and van Haagen.

As regards the new determination of the atomic weight of fluorine, it must suffice to say that it depends on the ratios of sodium fluoride to sodium borate and sulphate, and on a cross-ratio between sodium chloride and sodium fluoride. Eight determinations varying between 19.002 and 19.008 gave  $F = 19.005$ , which completely confirms the present international value.

T. E. THORPE.

#### THE PEACE TREATY AND MINERAL FIELDS.

THE Treaty of Peace has taken into account the economic relations of the contracting parties and the effect upon these of the peace conditions to a degree that has never been approached in any previous document of the kind. It is not too much to say that, whereas all previous peace treaties have been essentially diplomatic, the present one is essentially industrial in its outlook. The only mineral rights specifically referred to are those involved in the cession of the coal basin of the Sarre to France; it is difficult to understand, by the way, why, in the published English version of the treaty, the German spelling of the name has been used instead of the French. This cession bulks very large in the Treaty, but is of far less importance than would appear at first sight. It is estimated that the total quantity of coal contained in the Sarre basin is only 5.7 per cent. of the total quantity owned by Germany, so that the loss to Germany in respect of coal reserves is insignificant. From the point of view of annual output, it is somewhat more important; Germany produced in 1913 about 191½ million tons of bituminous coal, out of which the Sarre district produced about 14 millions, or rather more than 7 per cent. On the other hand, the possession of this coal-field means a great deal to France.

Before the war the total coal output of France was about 42½ million tons, so that the Sarre coal-field will increase the ultimate producing capacity by about 33 per cent. Of the total production nearly 22 million tons came from the Pas-de-Calais district, whilst the Nord district produced nearly 8 millions—about 70 per cent. of the entire production. These two districts have been almost wholly wrecked by the Germans; owing to the configuration of this coal-field, in which the coal-measures are overlain by Secondary, highly water-bearing strata, it was easy to do very serious damage by merely blowing in the watertight shaft linings and thus drowning out the pits; owing, further, to the fact that many of the more important collieries are connected by drifts with each other, recovering merely a few of the shafts or even sinking new ones will not suffice, and practically all the old