JEAN SERVAIS STAS.*

Born at Louvain, August 21st, 1813. Died at Brussels, December 13th, 1891.

The magnificent services rendered to science by the great Belgian chemist, were mainly investigations into the foundation in fact of certain speculations as to the unity of matter. They are divided into two groups; one relating to the atomic weights of many elements, the other to the spectra of elements when volatilized. The latter have not yet been published, and are therefore known but imperfectly through brief accounts by friends of Stas. The former have been published; most of them as fully as could be asked. Of them we may well say what Stas said of Berzelius: "His works remain as imperishable monuments of his penetration and genius. His analytical skill has never been surpassed, in fact has never yet been equalled."

The first important work of Stas was an investigation of phloridzine, which had been discovered by him and his friend De Koninck. The existence of this substance had been indicated by Professor Geiger, but it had not been isolated. A fortunate accident put De Koninck in possession of a considerable quantity of the bark of trees containing the new substance, and gave occasion to an investigation, which included the preparation of phloridzine in a pure state, a study of its properties, and a determination of its composition. The share of Stas in this part of the work does not appear from the printed memoirs and abstracts, which were published in the name of the De Koninck; Stas afterwards wrote of it as a joint discovery.

The young physicians of Louvain in these early experiments had good success in determining the properties of their new substance, but their ultimate analysis was less satisfactory. De Koninck afterwards turned his attention to paleontology, though producing a few papers on chemistry. Stas abandoned the practice of the

* Elected an honorary member of the American Chemical Society October 2, 1891.

medical profession, for which he had prepared himself, and resolved to follow the inclination towards chemical investigation which he now so strongly felt.

If the year had been 1823 a student of chemistry might have gone to Berzelius. Now, Liebig had been at Giessen since 1824, and Dumas was teaching, in various capacities, at Paris. To Paris Stas went. There was no vacancy in the laboratory of Dumas, and Dumas was too busy even to receive a vain application for admission to it. Stas showed the same unconquerable patience and perseverance here as afterwards in chemical investigation. He went again and again to visit Dumas; finally the servant who opened the door, while again answering "M. Dumas is not at home," by some gesture invited the resolute young man to enter, and showed where to find Dumas. Some weeks later, Stas was a pupil in the laboratory of Dumas, in the company of other students who were afterwards to take honorable places in the ranks of science.

Here Stas continued the investigation of phloridzine. He determined its formula, and the formula of some of its principal derivatives. He found that dilute acids acted upon it to produce glucose and phloretin. Liebig and Woehler had, two years before, noticed a similar reaction in case of amygdalin, and Piria, a fellow student in the laboratory of Dumas, had found that salicin also belonged to the class of compounds now called glucosides. This work on phloridzine formed the subject of an article of forty pages in the *Annales de Chimie et de Physique*, which was translated into the journals conducted by Liebig and by Erdman. Berzelius, in his *Jahresbericht* for 1838, devotes no less than twenty-three pages to an abstract of this paper, being one-eighteenth of the whole space devoted to organic chemistry. The great Swedish chemist, always somewhat chary of praise as he was, remarks, near the close of this abstract, "From a chemist who begins like this, much may be expected."

Under the direction of Dumas, Stas studied the action of alkalis on alcohols. A paper, entitled "*Premier Mémoire sur les Types Chimiques*", appears under the name of Dumas in the *Annales* for 1840; the second memoir appears under the names of Dumas and Stas, and describes the experiments made by the latter. They examined the reaction in the case of three well characterized alcohols; methyl, ethyl and cetyl alcohols. They found that fusel oil was converted into valeric acid; a fact of considerable interest at a time when but very few compounds occuring in plants and animals had been produced artificially, and of further interest because it showed that fusel oil contained an alcohol. Valeric acid was thoroughly studied, its vapor density determined, some of its salts and some of its subtitution products prepared and analyzed, and the new product was shown to be identical with the acid of the *Valeriana officinalis*, L. They converted the supposed alcohol into valeraldehyde, and also studied the action of a mixture of potassa and lime on many ethers.

Dumas and Stas now began an investigation which was of great importance in itself and still more important in that it may almost be said to have given direction to nearly all the subsequent course of Stas. In 1838 Dumas had expressed the conviction that the atomic weight of carbon then accepted was in error. The amount of the error he then supposed might be about six parts in one thousand. The reason for this opinion was the fact that, in the ultimate analysis of hydrocarbons rich in carbon, the sum of the amounts of carbon and hydrogen computed from the results of the analysis was greater than the weight of substance taken for analysis. For instance, in three series of analyses of naphthalene, Dumas found an excess of seven parts in one thousand, and Liebig made a similar observation. Berzelius had first computed the atomic weight of carbon from the density of carbon dioxide as determined by Biot and Arago; from which resulted the number 75.33 (O=100.) He saw reason to doubt the accuracy of this density, and so Dulong and Berzelius re-determined the density in Berthollet's laboratory at Arcueil, with the apparatus which had been used by Biot and Arago. From the result of these experiments he computed the atomic weight of carbon as 76.43 (O=100), and this number was generally accepted with the confidence which Berzelius' great skill and accuracy in analysis had inspired in the minds of all chemists.

After Dumas' expression of doubt in 1838, Berzelius examined the subject again, determining the atomic weight of carbon, by analysis of lead carbonate and lead oxalate, and found no reason to suppose that his previous determination was in error. Much interest was of course felt in a matter of so much practical importance. Dumas and Stas therefore made many determinations of the atomic weight of carbon, by the most direct possible method, involving the atomic weight of no other element, and involving no assumption of the exactness of the laws of Boyle and Charles. Some notice of their result was read before the Academy in August, 1840, and the complete memoir was read in December and was published in the first number of the first volume of the new series of the *Annales*. They made three series of determinations, in which natural graphite, artificial graphite, and diamond, were successively burned in a current of oxygen. The oxygen was purified from carbon dioxide by being kept over milk of lime and by passing over potassium hydroxide, and dried by passing over sulphuric acid. The graphite or diamond was placed in a platinum boat in a porcelain tube; and the water formed, if any, and the carbon dioxide, were absorbed in the usual way, after proving that, in both cases, the absorption was complete. No graphite, and no diamond of the quality used for experiment, failed to leave an incombustible residue, the amount of which was determined in each case. The mean error of a determination was one part in twelve hundred, and the mean of all the results was 74.97 (O=100). They considered the determination made by the combustion of diamond to be the most trustworthy, and assigned the number 75.02 as the result of their experiment. It may be said that two determinations by other chemists have been made since and have given precisely the latter number; and also that Stas himself later attempted a determination of the atomic weight of carbon by burning carbon monoxide to carbon dioxide, and found that the number is between 12.00 and 12.01 (O=16). This later investigation seems not to have been published except in a too brief abstract.

Dumas and Stas planned a determination of the composition of water, and Stas assisted in the preliminary experiments; at this time he was appointed professor of chemistry in L'Ecole Militaire at Brussels, and the scientific partnership was dissolved. After this time by far the most important work of Stas related to atomic weights and to the constitution of matter.

In 1815 an anonymous article was published in Thompson's *Annals of Philosophy*, which the editor two years later ascribed to Dr. William Prout. Its title was, "On the Relation between the Specific Gravity of Bodies in their Gaseous State, and the Weights of their Atoms." Its doctrine was that all atomic weights are multiples of the atomic weight of hydrogen, and it was suggested that all the other elements are compounds. Now, Dumas and Stas had found the atomic weight of carbon to be 12.00. Dumas found the atomic weight of oxygen to be 16. Dumas and Boussingault satisfied themselves, during their analysis of air, that the atomic weight of nitrogen is very nearly 14, and Dumas computed from his analysis of Iceland spar that the atomic weight of calcium was precisely 40. Berzelius had judged that the splendid series of determinations of atomic weights which science owed to his skill had disproved Prout's hypothesis; but Dumas and Stas had now shown that Berzelius' determinations of the atomic weights of oxygen and of carbon were in error by one-sixtieth and one-fiftieth respectively. So Dumas wrote, "I have said, and I repeat, that all the atomic weights need careful revision; that, neither accepting nor rejecting the hypothesis of Dr. Prout, I am forced to grant that it agrees with my own experiment, and that therefore there is here a promising opportunity for research, where one might have thought that further determinations were needless." A similar opinion may be fairly ascribed to Stas, who wrote, in 1860, that when he began his work in atomic weights he felt an almost absolute confidence in the truth of the hypothesis of Prout. Dumas added that he was too much occupied with other matters to labor in the new field suggested, and hoped that others would enter upon it; his hope was well justified by the career of his able pupil.

The time when Stas began his work cannot be exactly stated with the memoranda at hand at the present writing, but some important determinations were made as early as 1843. All the work accomplished up to 1860 was published at once. In 1842 and 1843 Marignac had enriched science with his masterly determinations of the atomic weights of chlorine, bromine, iodine, nitrogen, potassium and silver, and in 1857 Dumas published determinations of the atomic weights of no less than twenty-six elements. "Marignac," says Stas, "stoutly declared that, considering the extreme difficulty of arriving by experiment at absolutely accurate results, the atomic weights which he had found for silver, potassium, bromine, iodine and nitrogen should not be considered contrary to Prout's hypothesis." Dumas expressed himself even more strongly in favor of the hypothesis. It was to this problem, so interesting in itself; and enlisting at the time so much attention from so great masters in science, that Stas devoted all his leisure for many years. On this subject he published a paper of 128 pages in the *Bulletin of the Academie des Sciences*, 1860; a paper of 311 quarto pages in *Memoires de l'Academie Royale * * * de Belgique*, 1865; a paper of 165 pages in the *Annales de Chimie et de Physique*, 1872 and 1873; and a paper of 103 quarto pages in the same *Memoires*, read in 1876 and printed in 1881. The third of these papers may be regarded as preliminary to the fourth and contains no determination of atomic weights. The greatest part of the work of Stas up to 1880 is contained in these admirable papers. In them he has not given any details excepting those necessary to enable a reader to judge of the value of his experiments and of the confidence which might properly be felt in them. Such details are given in the most clear and lucid manner.

He used four balances. One was made by Gambey, and carried one kilogramme in each pan, and turned, with this load, with an excess of five-tenths of a milligramme. A second was made by Sacré, could carry five kilogrammes, turning then with one milligramme; when loaded with two or three kilogrammes in each pan it turned with three-tenths or four-tenths of a milligramme. A third carried five hundred grammes in each pan, then turning with two-tenths of a milligramme. A fourth carried twenty-five grammes in each pan, and then turned with one-thirtieth of a milligramme. Stas says, "I do not believe there exists another set of balances which for sensibility and constancy are to be compared with these. Every chemist who has had occasion to examine them has come to the same conclusion."

Stas used every refinement as to accuracy of weights and methods of weighing, but these need not be described. His study of vessels suitable for use in his determination was most accurate and thorough. As a result of much painstaking, he was able to heat flasks for a whole day to such a degree that the glass became milky and white without in the least altering their weight. He proved that below 300° to 350° C. neither hydrochloric acid nor nitric acid had any appreciable action on the glass used by him. Berzelius had doubted the inalterability of glass and porcelain employed in analysis, and his doubts were pronounced by Stas to be well founded. No one will ever know the amount of labor involved in removing this source of error.

The reagents used in determinations had to be prepared in a state of such purity that they would not alter the weight or composition of the bodies formed or decomposed. Stas describes minutely the pains taken to secure and prove the purity of his reagents. He found that all ordinary water distilled twice, using a platinum condenser for the second distillation, contains organic matter, volatile at first, but afterwards becoming non-volatile. Such water leaves a residue of carbon on evaporation. At first he obtained pure water by slowly passing steam over hot copper oxide. In after years he devised a process with permanganate which was much more rapid, and gave equally pure water. So his method for obtaining hydrochloric, nitric and sulphuric acids, ammonium chloride and sodium carbonate were models of patient care to eliminate every source of systematic error.

In the first paper there are contained 112 determinations of ratios giving atomic weights. These are in twelve series; nine of these series contain silver in one term of the ratio. The amount of care taken to secure pure silver has never been equalled in any chemical investigation whatever, and does not at present seem likely ever to be much surpassed. He left nothing undone which it was possible to conceive as being of advantage. He used every method ever suggested; he found that all methods capable of being used on a sufficiently large scale failed to give pure silver except as these methods were modified by himself. He found how to get silver chloride free from copper and iron, but when it was reduced by Gay Lussac's method the metal contained silicon. Several facts led him to believe that silver acts upon silicon.

especially in presence of carbon. By fusing silver chloride with sodium carbonate and potassium nitrate with many precautions and fusing the metals again with nitrate and borax he obtained a pure metal. Stas prepared many kilogrammes in this way. He prepared three kilogrammes of pure silver by reducing an alkaline silver solution with lactose and fusing the reduced metal with nitre and borax. This gave a silver always having the same properties, and having the same properties as pure silver prepared in other ways.

In order to know whether the silver prepared in those ways was pure, pure silver was prepared by other processes. Silver was deposited by electrolysis upon a porcelain plate and fused with nitre and borax. Silver was reduced from the nitrate by phosphorus; the action is very slow; it is the reaction by which Stas obtained the first pure silver he ever possessed. Silver was also prepared by heating the pure acetate and subsequent fusion with nitre and borax; but it was not so pure as the preceding.

A simple plan for discovering the purity of silver consisted in heating the metal in air to a temperature sufficient to volatilize it. The pure metal then shows no scum and no colored vapor. But if it contains two-millionths of iron, copper, or silicon, it becomes covered with a very strong, mobile scum when so heated. Silicon with a trace of copper gives a colored flame.

The purity of silver was originally tested by converting from 100 to 200 grammes into the nitrate, fusing, and dissolving in water, when ferric oxide and silica were left. The objection to sacrificing so much of the hardly obtained pure metal led to the use of the wet assay of Gay Lussac.

The silver before being used was cast in moulds lined with pipe clay and then the surface was cleaned by an elaborate process. Smaller lumps were obtained by cutting and then removing iron by a proper solvent. Sheets were obtained by rolling pure silver between silver plates; since otherwise silver, which before was pure, became contaminated with iron which could not be removed. Stas for a long time thought silver so obtained was pure, but when using 400 grammes of silver for a synthesis of the nitrate, he found it still contained one part in fifty thousand of silica. In after years he found a better process.

With silver of this purity, Stas made seven syntheses of silver chloride by four different methods. With unsurpassed insight he detected sources of minute constant error and found that some promising methods are open to grave doubts unless confirmed by other methods. The difference between the maximum and minimum of these seven results was one part in sixteen thousand. With a sagacity justified by subsequent determinations, he judged that a number a little larger than the maximum was the truth.

Next are detailed eight syntheses of silver nitrate, made on such quantities as two hundred, three hundred, and even four hundred grammes; and five syntheses of silver sulphide, on quantities but little smaller. Then came the details of a piece of work of almost unparalleled accuracy: twenty-four determinations of the ratio between silver and potassium chloride of which the mean error is one part in 48,000; ten of the ratio of silver to sodium chloride, with a mean error of one part in 61,000; ten of the ratio of silver to ammonium chloride, with a mean error of one part in 14,600; and ten of the ratio of silver nitrate to potassium chloride, with a mean error of one part in 10,000; shortly after are ten determinations of the ratio of lead to lead nitrate with a mean error of one part in 30,000. Determinations of a single ratio have been made by other chemists with even a smaller mean error; as for instance, in Crooke's work on thallium; but it is safe to say that so accurate and so numerous determinations of so many ratios, by processes so varied for each ratio, will long remain an unequalled achievement of indomitable courage and patience combined with the highest scientific attainments and the clearest insight. Of these experiments Stas says, "In order to make the results control each other, I have repeated the determinations so great a number of times that I much doubt whether there exists in the annals of chemical science an example of a greater endeavor to discover the truth. I have devoted a whole year to [one part of] these experiments which appear so simple."

The work of 1860 contained some twenty other determinations which there is not space to mention in detail, and ends with a clear summary of the facts obtained by experiment, and of the conclusions as to the validity of Prout's hypothesis which they justify.

His opinion is stated in these words; "I therefore conclude by saying, so long as our recourse must be made to experiment to establish the laws which govern matter, we must consider Prout's hypothesis as a pure illusion, and must regard the undecomposed bodies of our globe as distinct entities having no simple relations of weight among themselves."

Stas was his own most rigorous critic; but some other criticism was not wanting. Marignac made some comments on the work of Stas which were important in their results. He argued, from the fact that the difference was so small between his own results and the results of work in which infinitely more minute precautions were taken, that, if some one in the future should greatly surpass even Stas in the precautions taken against error, the atomic weights then determined would not agree sensibly better with Prout's hypothesis. But he did not therefore abandon the hypothesis as ill-founded. He suggested that just as sulphuric acid contains an excess of water when it is in its most stable condition, so the compounds analyzed, or prepared by synthesis, in the experiments of Stas, might contain an excess of one of the elements, slight indeed, but perceptible in such delicate experiments. For instance, perhaps silver sulphide or silver nitrate may contain an excess of sulphur or of nitrogen and oxygen.

This led Stas to undertake his second great work on atomic weights. He attempted first to supply the proof that *stable* bodies have rigorously the same composition; and this by two methods. He prepared ammonium chloride under varying conditions of temperature and pressure, from ammonia derived from the most different sources, and proved that its composition is constant. He also proved that silver chloride is of constant composition, notwithstanding difference of temperature in its preparation. For use in some of his experiments, he prepared silver by reducing the chloride with potassium hydroxide and lactose; in others, he reduced an ammoniacal solution of silver with ammonium sulphite. The purity of the metal was proved by distillation in a lime retort with the oxy-hydrogen blowpipe, and the pure silver thus obtained was used as a standard with which all other silver was compared by titration.

Then he showed that the ratio of silver to chlorine, bromine, and iodine, is the same in the halides and the oxy-salts of these elements. Great difficulties were surmounted in this investigation. The preparation of the pure compounds of silver needed was exceedingly laborious; but this was not unexpected. But one difficulty was such that even Stas would not have had the courage to go on in the face of it, except that he did not know of it beforehand. He found, *after his experiments were made*, that the solution of sulphur dioxide used in these experiments is altered by the action of light. While the fresh solution acting in darkness simply reduces the oxy-salts to halides, the solution exposed to light not only reduces, but also forms sulphur compounds of silver. Chance, he says, served him wonderfully well; his luck was better than his lookout. It happened that he always used either a current of gaseous sulphur dioxide, or a solution prepared in darkness and used at once before the change could take place. These most laborious determinations seem to have consumed over two years; they proved that the proportion of silver to the halogen is the same in the halide and the oxy-salt. From the two series of investigation he concludes that when compounds are formed in normal conditions, they contain their elements in rigorously constant ratio.

Next Stas attacked again the question whether the atomic weight of silver is the same, whether it be determined by means of chlorine, of bromine, or of iodine; and whether these four atomic weights agree with Prout's hypothesis. In this research, he practiced what he called a *complete* synthesis, or *complete* analysis. That is to say, in a synthesis of the two bodies A and B, he weighed A, weighed B, and weighed the resulting compound AB. In an analysis of ABC, he weighed ABC, and weighed each of the products AB and C, into which it was decomposed. In this way he could exactly estimate the limits of error of the experiment. The labor was immense. He wrote: "The manipulations which I have briefly described were so long, so laborious, and so painful, that now, after a year, the rememberance of the fatigue they cost me is still vivid; and courage to undertake them again would fail me. There does not exist in the annals of science, an analysis made upon an equal amount of a salt so difficult to obtain pure."

Unexampled pains were taken in preparing pure iodine and pure bromine by different processes. Sometimes iodine was prepared by precipitating it from a saturated solution of potassium iodide. Sometimes iodine was converted into nitrogen iodide, and this was decomposed and iodine set free. Stas used to produce five hundred grammes of nitrogen iodide at one operation ; he prepared several kilogrammes of it without the slightest accident. Iodine prepared in either of these ways was distilled with barium oxide. A weighed quantity of the pure iodine was made to act upon a weighed quantity of pure silver and the resulting iodide was weighed. This was done in some cases by transforming the silver first into the sulphate, in others, by transforming the iodide into ammonium iodide. Eight determinations were made, with a mean error of about one part in 20,000.

Bromine was prepared by distilling with sulphuric acid a mixture of bromide and bromate of potassium, or of barium. A weighed quantity of bromine was combined with a weighed quantity of silver, and the resulting bromide was weighed ; five determinations being completed.

Silver iodate, bromate and chlorate, were prepared with all imaginary care to obtain pure salts. The iodate was decomposed by heating, the oxygen was collected in a tube filled with heated copper, and weighed, and a little water from which it was impossible to free the iodate was also collected and weighed. Such was the stupendous care and skill with which these manipulations were conducted, that the sum of the products agreed with the weight of the iodate taken within one part in 60,000.

When Stas attempted to decompose the bromate in the same way, for eight hours the evolution of oxygen was regular, but then, without obvious cause, one part of the mass became incandescent, a rapid evolution of oxygen began, and the apparatus exploded with much violence. Some other way must therefore be used for this analysis, and the hope of collecting and weighing the oxygen was abandoned. In this part of the work, seven analyses were made.

Stas next determined the atomic weights of nitrogen, chlorine, bromine, silver, potassium, lithium and sodium, by processes different from those which he had used before, in order to subject his former results to a rigorous control. He prepared the chlorides of sodium, potassium and lithium, with the most scrupulous care, by every available method, and then transformed a weighed quantity of one of these chlorides into the corresponding nitrate. He had to make a laborious study in order to find a mixture for making a glass which would resist the action of nitric acid in the necessary evaporations. In preparing the potassium chloride needed in these investigations, Stas prepared platinum-potassium chloride in large quantity. Hoping to determine the atomic weight of platinum, he took his usual care to prepare pure platinum, but in this hope he was disappointed, for it was impossible completely to dry the double chloride, and the immense care spent in the purification of the platinum was entirely lost. This part of the work contains thirty-four determinations.

Stas had thus submitted Prout's hypothesis to the test of experiment even more rigorous than that of his earlier work. He had himself become the chemist hoped for by Marignac, who, with "new improvements in the method of purifying bodies and in the methods of experiment, should undertake again the same series of experiments with yet greater guarantees of accuracy." The agreement of the later results with the earlier is nothing less than astonishing; and if it were not for subsequent work of Stas, one would say the limit of human accuracy had been here attained. But more was to come.

In 1872 and 1874, Stas published some 150 pages on the properties of the different modifications of silver chloride and silver bromide. One object was to study the means of determining with the greatest possible accuracy the relation between silver and either of these halogens by the method of Gay Lussac, and then to use the perfected method for a re-determination of some atomic weights These re-determinations were submitted to the Academie Royale in 1876 and published in 1881. The long labor spent in studying facts which at first seemed anomalous had made him so familiar with the method that what was once an almost insurmountable difficulty had become easy, and errors had become measurable. Some of the titrations by his perfected method occupied six persons for nine hours in determining the point where silver and chlorine were equivalent in the solution used in experiment ; the mean error of these experiments was one part in 400,000, notwithstanding the fact that the halide was prepared by different methods. Twenty-four experiments are contained in this series. It also contained an explanation of the way to obtain pure hydrobromic acid, with the object of replacing chlorine by bromine in the wet assay of silver, since it is easy to determine the point where silver and bromine are equivalent in a liquid, for silver bromide is less soluble than silver chloride.

At the close of this tremendous series of labors, Stas appealed again to chemists to repeat some one of his determinations. "If," he said, "such investigation should confirm my own persevering investigations, perhaps those who believe in the existence of one primary form of matter will tell us how they conceive that the products of aggregation of this primary matter afford masses having to each other incommensurable ratios. Until this explanation is given, the hypothesis of the existence of one primary form of matter cannot take any place in science, because it cannot be considered as possibly true." He had proven, if human labor can ever prove anything, that the atomic weights which he studied are not in the ratio of whole numbers.

But he was to continue his inquiry into the ultimate nature of matter by a very different method. The account of these labors has been presented to the Belgian Academy ; but, so far as known to the writer, it is not yet published, so that our knowledge of them is rather general.

In 1878 Lockyer published some facts, which appeared to him to show that several of the supposed elements are compounds capable of dissociation by heat. The facts related to the spectra of these elements at different temperatures. Lockyer argued that the facts fairly led us to suppose, that, as a compound gives a spectrum at a low temperature, but at a high temperature breaks up into its elements and gives their spectra, so elements themselves, at still higher temperatures, break up into simpler forms of matter, giving spectra different from those of the elements supposed to undergo the decomposition. Such a theory could not fail to interest Stas, and he set himself to find whether the observed appearances would be seen with bodies purified as he had learned to purify. It took eleven years, we are told, to prepare substances which Stas would call pure. He obtained potassium chloride which he called perfectly pure; especially was it absolutely free from sodium. He experimented on silver, sodium, potassium, lithium, calcium, strontium, barium, thallium. He found that at the highest temperatures at which he worked, even at the melting point of iridium, the lines of the spectra of these elements remained the same, and these elements were not dissociated or decomposed. This work, costing so immense an amount of labor, may well be considered the crowning work of Stas.

Stas was a member for Belgium of the International Committee of Weights and Measures; and some of the most difficult labors of the committee fell to him. For instance, he took an active part in the analyses and investigations which led to the selection of the alloy of ninety parts of platinum and ten parts of iridium used for the standard weights and measures. The results of this labor are contained in the *Procés-Verbaux du Comité.* In the analyses of the alloy used in order to determine whether its composition was that intended, the duplicate analyses by Stas agreed with the same accuracy as his determinations of atomic weight.

Stas performed many services for his country and for his fellow citizens which were of more immediate and direct advantage. On the occasion of a murder by poisoning, he developed the method of separating and detecting the poisonous alkaloids, which, with some modifications by Otto, is a standard method. He performed important services for the Ordnance Department of thé Belgian Government. He studied the methods of saponification of fats and perfected the method which is now in use.

The work of Stas was not such as to bring him any popular recognition at all commensurate with the very great merit and importance of his work. But of the kind of recognition which was no doubt more acceptable to him he had abundance. For instance Clarke, speaking of the work of Stas, uses the phrase "magnificent accuracy." Meyer and Seubert speak of the "unsurpassed precautions, painstaking care and admirable skill" of the work of Stas.

All who have had occasion to look into the matter would agree with the writer that even stronger expressions of admiration would have been appropriate. The opinion of competent judges was also expressed in the bestowal of academic honors; he was President of the Royal Belgian Academy of Science; Foreign Member of the Royal Society of London; Corresponding Member of the Academy of Science at Paris; he received the Davy Medal of the Royal Society in 1885. President Huxley, in presenting the medal, said: "The indefatigable and conscientious care which M. Stas has devoted to the re-determining of a certain number of the most important atomic weights, and the marvelous skill with which he has overcome the various difficulties which successively presented themselves, render his memoir on the subject one of the most remarkable and valuable of chemical monographs." He was an honorary member of the German Chemical Society, and of the American Chemical Society; he was a Grand Officer of the Belgian Order of Leopold, of the French Legion of Honor, and Knight of many other orders throughout Europe.

More than twenty-five years of his life Stas was professor of chemistry in the Military School at Brussels; the salary was small. An affection of the larynx made it necessary for him to resign, and this before the thirty years of service which would have entitled him to a pension. He afterwards had a post in connection with the mint at Brussels, but he soon resigned the post rather than countenance a decision which he knew to be contrary to public interests.

Stas was elected a member of the Royal Belgian Academy of Science in 1841. In 1891 the completion of fifty years of connection with the Academy was celebrated by a brilliant manifestation. The three classes of the Academy met in joint session. The President of the Academy and the Director of the Class of Science made addresses. Spring pronounced an oration on the life and work of Stas. A medal was struck and presented to him; the city of his birth sent its mayor with an address of congratulation; the many learned societies of which Stas was a member sent felicitations; three universities sent him the diploma of Doctor, *Honoris Causa*. A memorial of this manifestation was printed in ninety-eight pages.

The place of Stas on the roll of scientific men will doubtless long continue to be unique. The gift of so many admirable qualities, in so high a degree, and in such well ordered balance, can recur but seldom. Many may possess patience as unwearied and wonderful. Many may be as resolute in endurance of hard labor ; though to not many is given to work without interruption for sixty consecutive hours in circumstances of extreme physical discomfort without some fatal oversight or momentary failure of attention. Many may attain a love of the truth as conscientious, as simple minded, and a forgetfulness of self-interest as entire. Many may as thoroughly grasp the whole amount of knowledge related to a given research so far acquired by men. Some may possess as sound a judgment ; many, as clear and true a penetration into the nature and causes of phenomena ; many, as acute insight into sources of error ; some, a manipulative skill as unerring. But patience so wise and resolute, combined with so high a love for the truth and so entire forgetfulness of personal relations to the truth, combined also with such insight and acuteness, assisted by skill so unerring, and balanced and rounded out by so much soundness of judgment, will not quickly be seen again. Not soon can so much work, of such unsurpassed accuracy, be accomplished by one of the human race in its present stage of attainment. So his name will long stand in a position in many respects unique ; always will it be remembered, by those who are interested in pushing our knowledge of the ultimate nature of matter to the utmost range of possibility, with admiration and with enthusiastic gratitude. As was said on the medal struck in honor of his jubilee,

Servatus Stas et usque in memoria stabis.

EDWARD W. MORLEY.