OBITUARY NOTICE.

ALEXANDER SCOTT.

1853—1947.

[Abridged, by permission, from the Notice by the late Sir Robert Robertson in *Obituary Notices of Fellows of the Royal Society*, 1948, **6**, 251—262.]

On 10 March 1947, at the great age of ninety-three, Dr. Alexander Scott, inorganic chemist, died at Ringwood, Hampshire. He was born in the county town of Selkirk on 28 December 1853, the son of Alexander Scott and the eldest of a family of four sons and four daughters, some of whom are now living.

The family appears to have migrated from the Scott Border country, for there are records of forebears being settled in Fife, in Kilconquhar or its neighbourhood, in the middle of the eighteenth century, evidently as farmers.

It was thus a return to the Scott country that the father of the subject of this Notice made when he was appointed Rector of Selkirk Academy in 1851, a post he held for thirty-three years. He was also Kirk Session Clerk for twenty-eight years and an Elder for nine. To a testimonial in 1883, one hundred and sixty-five of his former pupils put their names and among these is Andrew Lang, who was Selkirk-born. It is however as a botanist that the Rector had the greatest influence over his son, for he was a field botanist of repute, identifying wild plants scientifically by the Flora and making excursions after the rarer kinds. Not only had this a profound effect on the son as is shown by his love of flowers, by his choice of botanists as friends and by his selection of plants in his London garden, but in the opinion of the writer, who has had a similar fortunate experience, it was an early introduction to practice in scientific method.

In those days it was the custom to send boys to the University at an age which seems to us somewhat immature. Accordingly, young Scott matriculated at Edinburgh University in November 1868 at the age of fifteen. At first he had the idea of becoming an engineer, and towards this end studied under Tait and Fleeming Jenkin. Nor was botany neglected, for he attended the lectures of Balfour who had brought from the school of Sachs physiological botany, a supplement to the field botany in which he had been hitherto interested. These studies were, however, soon subordinated to chemistry when he came under the influence of Crum Brown and of Dewar. Crum Brown not only devoted himself to those questions of structural chemistry with which we associate him, but ran large classes of over a hundred. It was a source of pleasure to Scott that in such a class he had the distinction of being Senior Medallist. In 1876 he graduated B.Sc. in Experimental Philosophy, his Doctorate following in 1884 with a thesis " On the atomic weight of manganese." During this time, as also later, he was noted for his phenomenal knowledge of the materials of inorganic chemistry.

From 1872 to 1875 Dewar was lecturer at the Dick Veterinary College and Scott was his student assistant.

In 1875 Dewar was elected Jacksonian Professor of Natural Experimental Philosophy at Cambridge, whither Scott followed him in the same year, having been appointed assistant to the Jacksonian Professor. Here he lectured on physical and organic chemistry and supervised advanced students engaged in research. In 1876 he obtained a Clothworkers' Exhibition in physical science, and in 1878 a Foundation Scholarship in natural science at Trinity College. In 1879 he took his B.A. with first-class Honours in natural science, and graduated M.A. in 1882. He also examined for Tripos and other examinations.

Influenced by Dr. Fearon, the headmaster of Durham School, in June 1884, Scott undertook the entire management of the science teaching in Durham School in a new laboratory erected by the Governors under his supervision. He was further induced to make the change as opportunity of time for original research was offered. Later, in a new chemical and metallurgical laboratory erected and equipped under his direction at Middlesbrough, by the Trustees of the High School, he lectured to large classes—with great acceptance according to Sir Hugh Bell. Scott welcomed this opportunity of developing scientific teaching in the North of England, for, as he says in his first Presidential Address to the Chemical Society (1916), educational matters always interested him profoundly.

It was while here that Scott found the teaching of science in poor case, being handicapped by science masters either ill-trained or having to subordinate their efforts to preparing their pupils for answering the highly specialised questions of scholarship examinations. In the same

Alexander Scott

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[*To face p.* 762.

Presidential Address, the opportunity of successful careers for science students is compared with the rewards open to classical or mathematical students, and an appeal is made for a change of outlook.

Scott while at Durham must have led a strenuous life, for not only had he the supervision of the teaching of science at Durham and Middlesbrough schools, but he was busy at his experimental work, especially with his apparatus for determining the combining volumes of hydrogen and oxygen, towards which he received a grant from this Society, but in addition he found time to write a textbook, "Introduction to Chemical Theory," A. and C. Black, 1891, which ran into a second edition.

In 1891 Scott returned to Cambridge as Demonstrator to the Jacksonian Professor (Dewar) and took up the threads of his experimental work and his tutorial activities. As before, the main topic of his research was connected with the determination of accurate atomic weights, and between 1891 and 1896 he presented several papers and wrote reviews of the subject to the scientific press.

In 1877 Dewar had become Fullerian Professor of Chemistry at the Royal Institution. This Institution took over the Davy-Faraday Research Laboratory in 1896 by Deed of Trust from Dr. Ludwig Mond who had munificently bought the next-door premises, furnished them as laboratories and had put £62,000 aside for running expenses. The Laboratory was opened with much ceremony on 22 December 1896 by H.R.H. the Prince of Wales. It was designed to afford opportunities for skilled workers who had the wish and time to devote to the solution of important problems. All laboratory facilities but no emoluments were provided for the workers. Professor Dewar and the third Lord Rayleigh were appointed Directors, and Dr. Alexander Scott Superintendent of the Laboratory. Here Scott worked for fifteen years on the determination of the atomic weights of various elements and methods for the preparation of substances in a state of high purity, but his advice was frequently asked by the workers in the Laboratory, who included Horace T. Brown, H. Debus, A. Liversidge, A. Mallock, Hugo Müller, Joseph Petavel, Charles E. S. Phillips, P. C. Ray, W. J. Russell, G. Senter, and Henry T. Tizard. With these his relations were very amicable and he held the respect of the staff. As one of the workers of that time has said, Scott had a kindly friendliness to the sincere worker. He was intolerant of slip-shod work.

This went on till 1910 when it was decided by the Managers to terminate the office of Superintendent in 1911. This led to much acrimony between Scott and Dewar, as might be expected between two personalities of such individualistic and independent character.

In 1898 Scott was elected into the Royal Society.

Scott now worked in his own laboratory at Upper Hamilton Terrace and devoted much time to the affairs of the Chemical Society. After having been two years on the Council (1897—1899) he held the post of Secretary until 1904 when he became Treasurer and held this office until his Presidency (1915—1917). More systematic arrangements for the conduct of its business were made by Scott, and under his leadership the first steps were taken which led to the formation and incorporation of the Association of British Chemical Manufacturers, a body which has done much to secure a prosperous chemical industry and had itself provided assistance to the Chemical Society.

During this period Scott delivered two Presidential Addresses to the Chemical Society: the one (1916) containing a sketch of the history of the Society, Scott's views on research and his strictures on the outlets for chemists, referred to above, and the other (1917) dealing with the atomic theory and Prout's hypothesis.

A new interest was aroused when, in 1919, at the request of the Department of Scientific and Industrial Research, Scott conducted an inquiry into the condition of objects at the British Museum alleged to have suffered deterioration by storage in London's Underground during the 1914—1918 war. A small laboratory was established at the Museum on his recommendation, sanctioned by H.M. Treasury on the condition of its being a "purely temporary experiment to come to an end in three years." Here, under his supervision, a scientific study was made of ancient materials and their reactions to various environments, and methods of preservation and restoration were worked out and in due course published. How successful was the work done may be judged by the subsequent development of the laboratory idea in museums in general, by the eventual incorporation of the original laboratory as a separate department of the British Museum (recommendation of the Royal Commission on Museums) and by the views of the parent Department expressed at the time of transfer recording cordial appreciation of the distinguished service of Dr. Scott, "service which has enhanced very considerably the value of our National Collections and works of art."

He retired in 1938, aged 85, mentally as alert as ever and able to maintain the keenest interest in science and in museum work to the very end. He was beloved by his staff at the Museum, and for them will remain a great tradition, a symbol of the dignity of science and of mental vigour and integrity.

SCIENTIFIC WORK.

Attainment of the highest possible accuracy in the determination of the atomic weights of elements was the method, but the philosophical inquiry underlying Scott's work was as to whether Prout's hypothesis was true in fact.

In Dalton's Atomic Theory it is postulated that all the atoms of an element are similar and equal in atomic weight. For many years this was fully accepted by chemists, with one exception, that of Crookes who, in 1886, suggested the idea of the heterogeneity of atoms, a conception at that time and for many years after considered as highly speculative, but which was nevertheless true, for many years later Aston showed that atoms are accompanied by other atoms of similar chemical properties but of slightly different weight called isotopes, whose relative abundance settles the atomic weight as determined by analysis.

Founding his speculation on Dalton, Prout, an English chemist and physician, sent in to the *Annals of Philosophy* in 1815 and 1817, papers in which, with the values then available, he calculated that the weights of a number of elements were multiples of that of hydrogen; this he considered the πρώτη ὕλη of the Greek philosophers. The validity of this hypothesis was a matter of contention among chemists for a hundred years.

The obvious course was to ascertain if it was true in fact, and the quest proved a very potent stimulus to inquiry, especially demanding the most careful determination of atomic weights. To this end chemists applied themselves, striving after more and more accuracy by using greater and greater precautions. Various compromises were suggested, for example, halving the unit on account of the uncomfortable value of 35½ for chlorine, and even quartering it. Dumas, in 1842, by a method used earlier by Berzelius and Dulong, that of passing a stream of hydrogen over a weighed quantity of heated copper oxide and weighing the water produced, got a result showing that 2 parts of hydrogen are combined with 15·96 parts of oxygen, but Dumas, on the basis of Prout's hypothesis, assumed the ratio 2 : 16.

The chemists were divided as to the validity of Prout's hypothesis. When, in 1860, Stas, the superb experimenter, began his researches, he undertook them as he said, with " an absolute belief in the exactness of the principle of Prout," but in a few years, as a result of his own work, he took the view " that the hypothesis of Prout is a pure illusion."

In 1880, Mallet stated that out of eighteen elements, ten approximate to integers within a range of 0·1 unit, and remarked that " not only is Prout's Law not as yet absolutely overturned, but a heavy increasing weight of probability in its favour or in favour of some modification of it exists and demands consideration."

It was thus at a time when unequivocal values were required for atomic weights that Scott started, at first in Cambridge with Dewar, then extramurally by himself at Durham, then again alone at Cambridge and finally at the Royal Institution, to provide accurate atomic weights, always having in mind the need to test Prout's hypothesis.

Atomic Weight of Potassium and Sodium.—During 1875—1884 published papers are in the names of Dewar and Scott, and in the first of these were determinations of the vapour densities of potassium and sodium (1879), as a clue to their atomic weights. The Victor Meyer displacement method was used, and in the first instance the metals were vaporised in a heated iron pot. As difficulties arose from the action of the vapour on iron, this was then replaced by a platinum vessel in spite of the " terrible waste " of the metal. It is concluded that in the state of vapour potassium and sodium are monatomic, but this method does not, of course, provide precise atomic weights.

Atomic Weight of Manganese.—Determination of the atomic weight of manganese follows (1881), values having been reported varying from 54 to 55. As objections could be seen to the reagents used by previous workers, a new one was chosen—silver permanganate, a substance having the advantages of being obtained pure by crystallisation and also of not being hygroscopic. The first experiments, in which the salt was decomposed with loss of oxygen, gave discrepant results, but good ones were got by titrating the silver by an acid solution of potassium bromide, all the precautions laid down by Stas for this kind of work being observed. The mean of eight concordant experiments was 55·038, taking oxygen at 16 and Stas's value for silver 107·93. This is very near the most recent value adopted by the International Committee on Atomic Weights, 54·93 (Silver 107·88).

This piece of accurate work was put forward in Scott's thesis for D.Sc. of Edinburgh University (1883).

Composition of Water by Volume.—Time was found for his researches while in the North, and the paper (1888) on the composition of water by volume comes from his laboratory in Durham School. In a later paper on the same subject from Cambridge, he refers to this as a preliminary note on a subject on which no work has been done since the time of Gay-Lussac and Humboldt.

In Professor Partington's book on " The Composition of Water " (London, G. Bell & Sons, 1928) will be found a historical account of the earlier work on this subject by Cavendish, Lavoisier, Monge, Priestley, Gay-Lussac, and Humboldt and details are given of the experimental methods of Dumas, Morley, Scott, and Burt and Edgar. Partington quotes from Scott's paper (1894) : " Throughout I have endeavoured to use the simplest apparatus possible and to prepare the gases themselves from only the purest materials, and those of the simplest composition that I could find, so that no purification should be required and all unnecessary contact with other chemical substances avoided, to work with an apparatus of glass throughout, so that no diffusion could take place, and finally, so to work, that with a given amount of materials, I might compare the gas given off in the first fractions continuously to the last fractions, and thus endeavour to detect any possible impurity, either by variation of the ratio, or by actual observation from the residual gas."

Then follow descriptions of the sources of the hydrogen and of the oxygen, and a sketch of Scott's apparatus is reproduced. Partington remarks on the high degree of precision, very pure gases being used, the gases measured with great accuracy, their temperature and pressure being carefully controlled throughout the experiment, and the analysis of the residual gas being exact.

Examples of typical experiments are given in the paper, and the ratio of oxygen to hydrogen by volume is found to be 1 : 2·0045 at temperatures of 14° to 18°, both gases being measured at the same temperature. If, however, the values for the coefficient of expansion of oxygen and hydrogen are taken into account the value of 2·00285 at 0° is found for the ratio of the combining volumes. This value, combined with the value 15·882 for the ratio of densities found by Lord Rayleigh, gives the atomic weight of oxygen 15·862, and, if oxygen is taken as 16, of hydrogen 1·008, the present accepted figure being 1·0078.

In a very accurate series of experiments in 1915 Burt and Edgar made use of facilities not available to Scott, and measured the gases actually at 0° and 1 atm., thus avoiding the correction for expansion. They obtained for the above ratio 1 : 2·00288.

Atomic Weight of Carbon.—In a review of the various determinations of the atomic weight of carbon (1897), Scott called attention to discrepancies among these and indicated possible sources of error. Already Dewar and Scott (1883) had employed another method—that of titrating with silver the bromine in the hydrobromide of triethylamine, but the results were disappointing on account of the difficulty of getting pure triethylamine together with a slight tendency of its hydrobromide to hydrolyse.

Scott returns to the subject (1909) when he uses the elegant method of titrating tetra-alkylammonium bromides, choosing these because of their relatively stable character and easy purification. This paper gives the details of his experiments on titrating tetra-alkylammonium bromide with silver and, with the same silver, ammonium bromide. By subtraction the equivalent of a hydrocarbon C_8H_{16} is derived. Thus with silver at 107·88, the atomic weight of carbon is found to be 12·017 from tetramethylammonium bromide, the present accepted figure being 12·010, silver being 107·880.

By another method in which carbon monoxide and oxygen were exploded in the apparatus used for determining the composition of water by volume (1894) a value of 11·99 was deduced for carbon (1904).

From a few experiments (1909) on the combustion of naphthalene and of cinnamic acid, the value of the atomic weight of carbon comes out at C = 12·00. " The cause of the discrepancy between these results and those derived from the alkylammonium bromides remains still to be discovered."

Atomic Weight of Nitrogen.—By the titration of ammonium chloride and bromide against silver Scott obtained results lower than those of Stas, and this has been confirmed especially by Lord Rayleigh and by Whytlaw-Gray who, using nitric oxide (*J.*, 1905, **87**, 1601), obtained 14·01, practically the same value as Scott. The most recent International Tables give N = 14·008.

Atomic Weight of Tellurium.—This is described as a preliminary notice (1902) and has the object of confirming the value for the atomic weight of tellurium, which has an anomalous position in the Periodic Table in being higher than that of iodine. Scott's method was to make careful determinations of the halogens in the stable salts trimethyltellurium bromide and iodide. Taking the values O = 16, C = 12·00, H = 1·0075, I = 126·85 and Br = 79·95 tellurium was found to have an atomic weight of 127·7, the value given in the recent tables being 127·61. Tellurium with its abundance and range of isotopes thus occupies an anomalous position in the Periodic Table with regard to iodine which has none.

Other Papers.—These are either of general interest such as a new series of mixed sulphates of the vitriol group (1897), a new sulphide of arsenic (1900), the vapour density of hydrazine hydrate (1904), correction of weighings in air to vacuum (1909); or are descriptions of methods for preparing substances used in determination of atomic weight, such as preparation of pure hydrobromic acid (1900), of alkyl derivatives of sulphur, selenium, and tellurium (1904), and of pure bromine (1913).

Services to Art and Archæology. (By Dr. H. J. Plenderleith.)—Scott's contribution to the problems of art and archæology was characteristically that of the experimenter and teacher rather than the writer of textbooks, and his aim was to discover and publish simple methods of treatment that would be safe in the hands of those not having the advantage of a technical or scientific background.

A great source of inspiration was his visit to Luxor for the winter season (1923—1924) at the invitation Howard Carter to act as consulting chemist in devising methods of preserving the objects from Tut-Ankh-Amun's tomb. It was this intimate study of antiquity in the field in all its frail beauty and the confidence that science had so much to contribute that provided him with the incentive to create a permanent scientific service in the the British Museum.

If primarily concerned with the problems of metallic corrosion or saline incrustations in exhumed material, work at the British Museum soon developed important off-shoots scarcely to be anticipated in the early days. For example, a body of knowledge was gradually acquired which could be applied to differentiate the genuine antiquity from the false or to classify types of ethnic culture and solve problems of age and provenance. The value of such work could be assessed in terms understood and appreciated by H.M. Treasury. Once established on a permanent basis it was possible to afford unstinting help to other institutions, museums, libraries and picture galleries.

It was not to be expected that intricate operations would be undertaken by a man of his years; what was of lasting value was the standing that science was given in museum and gallery circles by his great knowledge, his strong personality and his genius for friendship in all walks of life. His advice was sought from every quarter of the civilised world and freely and promptly given wherever it would be of value in the interests of art, archæology or science.

This was his contribution : to represent science as the servant of the arts, to disarm suspicion where it existed, to demonstrate what might by this fruitful liaison be achieved and thus to lay the foundation for a partnership between art and science of mutual benefit for all time.

Alexander Scott died at Ringwood, Hampshire, on 10 March 1947. In 1906 he married Agnes Mary, daughter of Dr. W. J. Russell, F.R.S., and leaves no family.

In the preparation of this Notice, I have been indebted to Dr. Scott's widow and his family for biographical material, and very notably to Dr. H. J. Plenderleith, Scott's successor as Director of the British Museum Laboratory, for his contribution on the period 1919 to 1938, and for his appreciation of Scott's "Services to Art and Archæology."

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