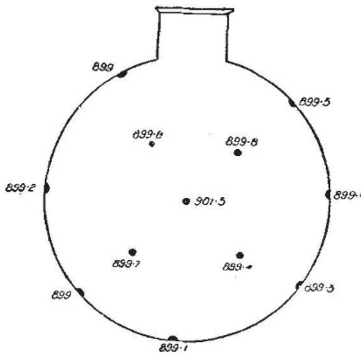

FIG. 7.—Gold 90 parts, zinc 10 parts; weight 4·200 kilograms.

This shows that there is still a tendency in this gold alloy with 10 per cent. of zinc to become enriched towards the centre.

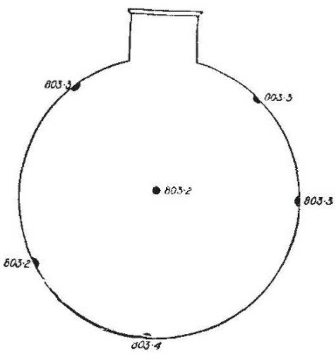

FIG. 9.—Gold 77·5 parts, silver 7·5 parts, zinc 15 parts; weight 3·930 kilograms.

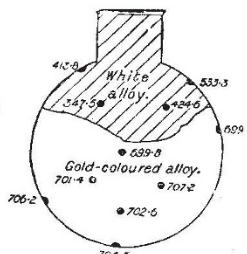

FIG. 11.—Gold 63 parts, silver 7 parts, lead 20 parts, zinc 10 parts.

Very marked separation takes place here, the difference at various points of the sphere being very remarkable, and forcibly illustrating the difficulties to which reference is made at the commencement of this paper.

As, however, it appears, that when a certain amount of silver is present, the irregularity in composition disappears, this mixture of—

Zinc...	10
Lead	20
Silver	7
Gold	63

was alloyed with more silver, so that it contained 15 per cent. of silver (nearly half the united amounts of zinc and lead present in the alloy).

This, cast into the 3-in. spherical mould, showed the following results at the points indicated. In *appearance*, the metal, when sawn in two, was homogeneous.

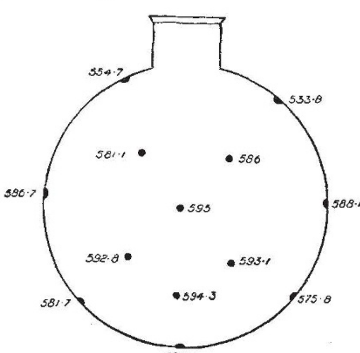

FIG. 12.—Alloyed so as to contain 15 per cent. silver; weight 3·450 kilograms.

There is here still evidence of liquation of gold towards the centre, but comparison of Fig. 12 with that which immediately precedes it will show how greatly the arrangement of the alloy has been modified by the presence of the additional 8 per cent. of silver. The proportion of silver in this alloy was proved by assay to be 15·5 per cent.

As there was still evidence of liquation, the metal was cast with still more silver, making 20 per cent. of silver in all. The alloy, when cast into a mould, proved to be almost uniform in composition, the difference between the centre and the extreme portions being very slight.

Liquation had practically ceased, a fact which proves incontestably that silver is the solvent for the base metals, zinc, and lead, when they are alloyed with gold.

Conclusions.—(1) Alloys of gold with base metals, notably with lead and zinc, now often met with in industry, have the gold concentrated towards the centre and lower portions, which renders it impossible to ascertain their true value with even an approximation to accuracy.

(2) When silver is also present these irregularities are greatly modified.

The method of obtaining "cooling-curves" of the alloys shows that the freezing points are very different when silver is present in the alloy and when it is absent from it.

(3) This fact naturally leads to the belief that if the base metal present does not exceed 30 per cent., silver will dissolve it and form a uniform alloy with gold.

(4) This conclusion is sustained by the experiments illustrated by Figs. 9, 11 and 12, which, in fact gradually lead up to it, and enable a question of much interest to be solved.

EDWARD MATTHEY.

THE ATOMIC WEIGHT OF OXYGEN.[1]

THIS monograph embraces a complete collection of the results obtained by Dr. Morley while working on this subject, and gives a detailed account of the various apparatus used. The experiments described extended over a very lengthened period. They consisted of the determination of the ratio between oxygen and hydrogen by two distinct methods, viz. by actually weighing the gases and by synthetising water. In all his experiments Dr. Morley dealt with far larger volumes of purer gases than previous experimenters had used, and in weighing them he reduced with surprising completeness every possible source of error. In his work on the synthesis of water, Dr. Morley succeeded in weighing the hydrogen and oxygen burned, and also the water produced thereby, achieving an exactness not attained by any previous experimenter, as none before had weighed all three factors. All experiments dealing quantitatively with gases are naturally extremely difficult, but Dr. Morley has, by paying attention to every detail, brought each process to a great pitch of accuracy.

The major corrections that were introduced into the determinations were as follows.

(1) The expansion of the glass of the globes.
(2) The errors of the mercurial thermometers.
(3) The deviation of the mercurial from the hydrogen thermometer.
(4) The difference between the coefficients of expansion of oxygen and hydrogen.
(5) The elevation of the cistern of the barometer above the centre of the globe when reading pressure.
(6) The correction of the scale of the barometer.
(7) The force of gravity at the laboratory.

In weighing the gases Dr. Morley employed large glass globes varying in capacity from nine to twenty-one litres. All data connected with the capacity of these were accurately determined. As the globes were so large it was found impossible to weigh them full of water to measure their capacity, and a different method had to be adopted. The globes were first weighed in air, then sunk in water, the weights being determined to keep the globes immersed; lastly the globes were filled with water, and again weighed in water. From these were obtained the external volume, the solid contents, and the capacity within ·02 per cent. In introducing a correction for the compression of the globes when exhausted, Dr. Morley devised an exceedingly ingenious plan. The compression itself was determined by placing the globe in a copper cylinder, which was then closed

1 "On the Densities of Oxygen and Hydrogen, and on the Ratios of their Atomic Weights," by Dr. E. W. Morley. *Smithsonian Contributions to Knowledge*, No. 980. (Washington, 1895.)

and filled with water. A small tube led from the cylinder to a burette containing water. When the globe was exhausted the compression was measured by the amount of water run into the cylinder from the burette. Each globe was provided with a counterpoise of equal external volume when exhausted. A pair of small flasks were then made, the difference between whose volumes was equal to the amount of compression just measured, and whose weights in vacuo were equal.

For example, the actual compression of one globe was 1·27 cc. The two small flasks were made 2·08 and ·81 cc. in volume and of the same weight when weighed in vacuo; therefore when weighed in air they differed in weight by the weight of 1·27 cc. of the air at the time, taking into account the true value of the weights employed. When the globe was exhausted it was weighed against the counterpoise which had the same volume. When it was full of gas it was tared with the ·81 cc. flask against the counterpoise and the 2·08 cc. flask; the *true* weights of the globes therefore suffered equal additions, with the result that the *apparent* difference in weight would be the *true* difference as expressed by brass weights in air.

The measurement of pressure and temperature, Dr. Morley took especial pains to make as accurate as possible. In the many series of experiments which are comprised in this great research, different methods were adopted of measuring these values. When thermometers were used great care was taken in determining their errors, and in the calculation of the pressures the value of the force of gravity as actually determined at Dr. Morley's laboratory was used.

Dr. Morley's determinations are divided into four series.

The first series consists of the determination of the weight of one litre of oxygen.

The second series consists of a similar determination for hydrogen.

The third series contains some experiments to determine the volumetric composition of water.

The fourth is a series of syntheses of weighed quantities of water from weighed quantities of oxygen and hydrogen.

The first series of determinations are those of the weight of a litre of oxygen under standard conditions. Three different methods were adopted.

In the first the temperature and pressure were directly determined by use of thermometers and a manobarometer.

In the second method the temperature and pressure were not directly determined, but made equal to those of a standard volume of hydrogen.

In the third method the pressure was alone read, the temperature being that of melting ice.

The oxygen for this series of experiments was obtained from potassium chlorate. The salt was placed in a hard glass tube in a combustion furnace; this tube was joined to the rest of the apparatus by means of a ground joint cemented with wax. Dr. Morley made a point of using no rubber connections in any of his experiments, rightly observing that even though the leakage may be exceedingly small, still the extra trouble entailed by fusing all joints together is worthily bestowed. Dr. Morley says there is no reason to doubt the purity of this oxygen; nitrogen he sought for particularly, and found quantities varying from 1/12,000th to 1/5,000,000th, which are quite negligible, considering the closeness of the atomic weights of the two gases.

Dr. Morley discusses the question of mercury vapour, and reasons from his experiments on hydrogen that the error is not greater than the ten- or twenty-thousandth part of the density of oxygen.

The pressure in these experiments was measured by means of a manobarometer, which consisted of a barometer and two gauges mounted in the same trough of mercury. One of these gauges was used for oxygen and the other for hydrogen, the experiments on which were carried out at the same time. The barometer and gauges were placed in a cistern of water with plate-glass sides. In front of each tube, and in contact with it, was a glass millimetre scale. The three scales were adjusted so that their zero points were all on the same level. The cathetometer used for reading had two telescopes, each with a micrometer eyepiece. The accuracy of reading was found to be within 1/100th mm.

In weighing the globes Dr. Morley met at first with great difficulty, owing to currents of air disturbing the globes. Their effect was, however, almost destroyed by hanging the globes in a sheet-iron box, which was in its turn placed in a non-conducting chamber under the balance. The balance was one of Becker's make, and had never been used for any other purpose.

The mean of nine determinations by this method of the weight of a litre of oxygen is

1·42879 gr. ± ·000034.

In the second method of weighing oxygen, the pressure and temperature were made equal to those of a standard volume of hydrogen. The preliminary part of this process was to fill a globe with pure hydrogen, and measure the pressure exerted by the gas on one leg of a differential manometer. This instrument was of the ordinary U shape, adjustment of the mercury being made to two needle-points, one in each limb. The globe containing the oxygen was then attached to the opposite limb, and the pressure adjusted till exactly equal to that of the hydrogen. A new balance was employed in these determinations, purchased especially for this work, and lent Dr. Morley by the Smithsonian Institution. Weighing was performed by reversal, the relative position of globe and counterpoise being changed by mechanical means.

Dr. Morley publishes fifteen determinations of the weight of a litre of oxygen by this method. The mean is

1·42887 gr. ± ·000048.

The method employed in the third series of determinations was to determine the pressure of the oxygen by means of the syphon barometer, the temperature being 0° C. The globe was immersed in ice, the layer of ice all round the globe being 30 centimetres thick. The globe was then exhausted and oxygen admitted, and its pressure measured. After weighing the globe was again exhausted and again weighed, the difference being taken as the weight of the oxygen. The reason for this procedure was the fact of the globe being exposed to the action of water for such a long time.

As a mean of twenty-four experiments, Dr. Morley gives

D = 1·42917 gr. ± ·000048.

We have, therefore, the following three mean results by the three different methods.

By use of thermometer and manobarometer	1·42879 ±	·000034
By compensation	1·42887	·000048
By use of ice and barometer ...	1·42917	·000048

In computing a final mean from these, Dr. Morley discusses the relative reliability of the results. He gives double weight to the third method, for, though involving more accidental errors, it involves no constant error common to the other methods.

Dr. Morley gives his final value for the weight of 1 litre of oxygen measured at 0° and 760 mm. at sea-level, and 45° lat., as 1·42900 gr. ± ·000034.

The second part of Dr. Morley's paper deals with his determinations of the weight of 1 litre of hydrogen under standard conditions.

Five series were made. In the first, pressure and temperature were measured; in the second, pressure only was measured, the temperature being equal to that of melting ice; in the third, the hydrogen was weighed in combination with palladium before introduction into the globe. The fourth and fifth were repetitions of the third.

The first series of determinations were carried out in exactly the same manner as the first series with oxygen, indeed at the same time. The hydrogen was prepared by the electrolysis of dilute sulphuric acid.

Dr. Morley adopted elaborate methods to measure the impurity in the hydrogen. He introduced a correction for the nitrogen found until, owing to an improvement of the apparatus, this percentage of nitrogen became so small as to be entirely negligible.

The mean of fifteen results obtained by this method is

D = ·089938 gr. ± ·000007.

The second method was to read pressure only, the temperature being 0° C. The details are exactly the same as in the similar case with oxygen.

The mean of nineteen experiments is

D = ·089970 ± ·000011.

The third method, that of weighing the hydrogen contained in palladium, is one that is far more likely to prove accurate than methods depending on the weighing directly of a known volume of hydrogen. For in the best case the weight of the globe was 600 times the weight of the hydrogen contained in it. The great advantage, however, to be gained from this method is the absence of any error introduced by mercury vapour, for it would have no effect on the weight of the hydrogen, and the volume and pressure of the residual mercury vapour are far too small to influence results. Dr. Morley has given especial attention to this method, and has brought it to a very great pitch of accuracy.

The palladium was placed in a tube which could be connected with the apparatus by a ground-glass joint. When the palladium was charged with hydrogen the tube was weighed. Connection being now made, a fusible metal plug, which took the place of a stop-cock, was melted, and the hydrogen passed into the globes. The tube was afterwards weighed, the difference giving the weight of hydrogen, usually about 3·7 grammes. This was found sufficient to fill three globes.

The mean of eight results in one series is

$$D = \cdot089886 \pm \cdot0000049.$$

The mean of four results in a second series is

$$D = \cdot089880 \pm \cdot0000088.$$

The mean of eleven results with a new apparatus,

$$D = \cdot089866 \pm \cdot0000034.$$

Dr. Morley gives as his final result for the weight of one litre of hydrogen under standard conditions,

$$\cdot089873 \pm \cdot0000027 \text{ gr.}$$

The third part of the paper deals with the determination of the volumetric composition of water. The electrolytic gas was produced in a voltameter, whose loss of weight gave the weight of gas used. This gas was admitted into globes of known volume, plunged in ice, where its pressure was measured. From these it was transferred to an eudiometer and exploded. The weight of gas usually dealt with was about 23 grammes. The explosion of the gases was carried on in a eudiometer, where all but 1/100th or 1/1000th part of the gas could be exploded out of contact with mercury. In all Dr. Morley's results he found excess of hydrogen, due to secondary reactions in the voltameter.

The mean value determined by ten experiments of the ratio of the excess of hydrogen to the whole combined volume of hydrogen and oxygen is ·000293. This value × 3 = ·00088 gives a correction to be applied to the ratio of hydrogen and oxygen, in order to obtain the ratio of volumes of hydrogen and oxygen that would combine without residue.

The mean of the ten experiments gives the value of the density of the electrolytic gas as

$$= \cdot535510 \pm \cdot000010.$$

In calculating the ratio of combining volumes, Dr. Morley takes into account the deviation of the mixed gases from the density computed by Boyle's law, and also the values of the constant a in Van der Vaals's equation. He obtains the ratio of mixture to be 2·000357, which, corrected for known excess of hydrogen, gives ratio of combining volumes to be

$$2\cdot00269.$$

The fourth and last portion of the experimental portion of the paper deals with the syntheses of water from weighed quantities of oxygen and hydrogen. The hydrogen was weighed, absorbed by palladium, the oxygen weighed in a globe, and the two were combined together in a combustion apparatus, whose gain in weight gave the weight of water produced. The quantity of hydrogen used was about 42 or 43 litres; the measured residue of uncombined gas varied from 1/100th to 1/10,000th of quantity concerned. The combustion apparatus was plunged in water during the union of the two gases, in order to keep it cool. This process took about one and a half hours, and was carried on as far as possible. The remaining gas in the various parts of the apparatus was pumped out and analysed, the combustion apparatus being kept in a freezing mixture, to keep as low as possible the vapour pressure of the water. The rest of the process needs no description.

As regards two possible sources of error which have been suggested, Dr. Morley proved conclusively that his hydrogen from palladium contained no water, and that his phosphorus pentoxide absorbed no oxygen.

As the mean of twelve experiments, Dr. Morley gives the atomic weight of oxygen to be very nearly

$$15\cdot879.$$

In collating all the results of his experiments, Dr. Morley gives the following values:

Weight of one litre of oxygen	1·42900
Weight of one litre of hydrogen	0·089873
Atomic weight of oxygen (chemical method) ...	15·879
Molecular weight of water (chemical method)...	15·879
Atomic weight of oxygen (physical method) ...	15·879

The probable accuracy of Dr. Morley's work appears to be exceedingly high, for he has in several cases spent especial trouble and time in eliminating hitherto constant sources of error. The extremely ingenious forms of apparatus he used for his many determinations are especially worthy of remark; and these, together with the extraordinary care bestowed in their use, combine to make the whole rank among the finest investigations of modern science.

E. C. C. Baly.

SCIENCE IN THE MAGAZINES.

The relation of complexion to disease is discussed by Dr. John Beddoe, F.R.S., in the course of a paper in *Science Progress*. Baxter's great work on the medical statistics of the Civil War contains evidence as to the greater liability of blonds to certain classes of disease (in America at least). It follows from this that the blonds in America have less chance than the brunets of contributing their due proportion to the next generation, and therefore the blonds ought to diminish relatively, and the brunets to increase.

As bearing upon this, it appears that of accepted soldiers from among the white natives of the United States, 66 per cent. were light and 34 dark complexioned, but the proportion for English, Irish, and Germans is 70 to 30. Thus, Dr. Beddoe points out, the men of American birth yielded a larger proportion of brunets than those of any of the nations that had contributed to their ancestry, which is nearly equivalent to saying that the Americans are more generally dark complexioned than their ancestors were. Statistics as to the colours of school children of Germany, Austria, Switzerland, and Belgium, and of adults in Italy and the British Isles, seem to furnish sufficient evidence that in a great part of Europe the citizens are darker than the peasantry. Why the blond type should be more susceptible than the brown to the malign influences of urban life is a difficult question to decide.

Other articles in *Science Progress* are:—"Prehistoric Man in the Eastern Mediterranean," by Mr. J. L. Myres; "The Graptolites," by Mr. J. E. Marr; "Insular Floras," by Mr. W. B. Hemsley; and "Recent Discoveries in Avian Palæontology," by Mr. C. W. Andrews.

There are several articles in the *Contemporary* to which attention may be directed here. Mr. Phil Robinson describes "The First Nest of a Rookery," in a pleasantly-written paper, but the interpretations of his observations are made too much from the humanistic point of view. Dr. Lennox Browne attacks "The Antitoxin Treatment of Diphtheria," his criticism being based mainly upon the Report of the Metropolitan Asylums Board, summarised in these columns in April last (vol. liii. p. 524). He claims that the mortality of cases treated by antitoxin at the London hospitals in 1895 is but a trifle lower than that of the previous year, and is in excess of what has been obtained in individual hospitals of the series whence the Report is issued; and, also, that this improvement has not been due to the serum treatment, but rather to increased vigilance and nursing care. Some "Girls' Technical Schools on the Continent" are described by Marion Mulhall. The article shows how the technical instruction of girls now takes a front rank in the cares and duties of many municipal authorities in Holland, Belgium, Germany and Austria.

Sir W. M. Conway describes in *Scribner* his walk of "A Thousand Miles through the Alps," and concludes his narrative with a comparison between Switzerland and the Tyrol from a traveller's point of view, much to the advantage of the latter. He says, and there are many ready to corroborate his statements, "Whereas travel in Switzerland is exploited by hotel-keepers and organised in their interests, the Tyrol is, through the agency of the powerful German and Austrian Alpine Club, organised by travellers themselves in their own interests. In Switzerland, traps are laid for the tourist's francs; in the Tyrol, every effort is made to spare his pocket." The Tyrol is far ahead of Switzerland in climber's food, in mountain huts,