Letters to the Editor

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NOTES ON POINTS IN SOME OF THIS WEEK'S LETTERS APPEAR ON P. 549.

CORRESPONDENTS ARE INVITED TO ATTACH SIMILAR SUMMARIES TO THEIR COMMUNICATIONS.

Masses of some Light Atoms determined by a New Method

IT has long been realised that the only really certain method of comparing masses by observations on mass spectra is by resolving and measuring naturally occurring doublets which represent small residual differences between the atoms and molecules concerned. The recent discovery of deuterium has enabled this method to be applied generally to the lighter elements, and for some time past I have been constructing parts of a new mass-spectrograph designed for this work. One of these, a new collimator with variable slits, has been tested on the instrument now in use, with results of great interest.

The first test object used in the experiments was the easily formed doublet O,CH_4. Under the improved conditions, this was widely and perfectly resolved, and when measured corresponded to a difference of mass as stated below. This result was very disturbing, as the much lower original estimate 0·0350 had been confidently used as a check on the value for H. On examination, it seems now fairly clear that the underestimate was due to imperfect resolution.

The fineness of the lines warranted an attempt on the doublet D,H_2, expected to be about half the width. Pure deuterium was introduced and the discharge manipulated in the hope of getting that equal intensity of the lines so necessary in this work. In a number of cases this object was attained and Fig. 1 shows a photometer graph of one of the exceedingly fine doublets photographed.

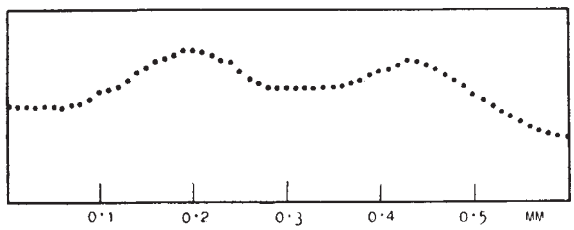

FIG. 1.

The apparent separation was estimated as below. The real separation will be probably higher, for the resolution is not yet perfect, but it seems impossible for it to be high enough to correspond to the difference 0·00187 expected from Bainbridge's determinations[1] of H and D each against the same atom He. It seems probable that the bulk of this discrepancy is to be ascribed to the ratio H,He, in which the lines were very unequal in intensity, rather than to that of D,He, in which the conditions were exceptionally favourable. To test that conclusion, I have made a provisional estimate of the wide doublet He,D_2, which within my experimental error agrees with that found by Bainbridge. That his and my estimates of the He,H ratio should have agreed so exactly seems to have been fortuitous.

The remaining link in the chain from H to O is the doublet $C{+}{+},D_3$. I have succeeded in photographing this, but only with lines of very different intensity and, like the He,D_2 doublet, it is too wide for really satisfactory treatment on my present apparatus. The results appear in the following table of doublets, giving the proportional differences in parts per 10,000 and the differences of mass on the atomic scale between the lighter and heavier components.

Doublet	Difference of Packing Fraction	Difference of Mass
D,H_2	7·1	0·00142
He,D_2	63·5	0·02550
$C{+}{+},D_3$	69·7	0·04195
O,CH_4	23·3	0·0374

I propose to measure all these doublets again with the proper refinements when my apparatus of higher dispersion is completed. In the meantime, the following values may be deduced for the masses relative to O^{16}.

$$\begin{aligned} H &= 1{\cdot}0081 \\ D &= 2{\cdot}0148 \\ He &= 4{\cdot}0041 \\ C &= 12{\cdot}0048 \end{aligned}$$

These must be regarded as provisional, and in no case is an accuracy greater than 1 in 10,000 claimed. They are considerably higher than my earlier ones and in better accord with the much more delicate but less direct calculations made from the energy relations in the equations of artificial disintegrations. At the meeting of the Royal Society on March 14 attention was directed by Dr. M. L. Oliphant to the discrepancies on the mass scale revealed by experiments of this kind and a provisional scale of values suggested.

I should like to give a word of warning to those using atomic masses determined by mass spectra. These figures may depend on a chain of relationships, and it is often found that the errors here have markedly cumulative effects. It will be well always to examine the complete data from which a single result has been derived. The results described in this letter are a good example of the dangers in this work. In conclusion, I may say that I am never likely to regret my underestimate of the mass of H made nine years ago, however serious it may ultimately turn out to be, since it played so fundamental a part in encouraging the search for deuterium.

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[1] *Phys. Rev.*, **43**, 103; 1933. **44**, 57; 1933.