THE DENSITY AND ATOMIC WEIGHT OF HELIUM. II

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In a recent report[1] we communicated preliminary results on the density of helium, obtained with one-liter globes, by a procedure previously tested with oxygen.[2] With the hope of increasing the accuracy of the experiments new determinations have been made with two-liter globes, and in order to obtain additional information concerning the compressibility of helium at low pressures, the density at a pressure of one-half atmosphere has been measured.

The apparatus used for the handling of the helium and for the density determinations was the same as that already described, except that larger globes were used and that two shorter barometers were added for use at the lower pressure. The larger globes proved considerably more difficult to weigh than the one-liter globes and necessitated much more careful thermostating of the balance room.

After nearly every series of density determinations the gas was subjected to an additional treatment with the adsorbent dehydrated chabazite chilled with liquid air, while the chabazite was out-gassed at 550° each time after it had been used. Gas lost in the operation was replaced with material which had been purified in exactly the same way.

Except in the case of the force of gravity the same constants are used in the calculations as in the earlier papers on oxygen and helium. In both the earlier papers an erroneous value for the force of gravity as determined at the Harvard College Observatory was used. The most recent observed value is 980.398,[3] which becomes 980.399 for the Coolidge Laboratory on account of a difference in level between the point of determination and the location of our apparatus of 3.3 meters, the two points being about 1.2 kilometers apart on a nearly east and west line. Because of this difficulty the earlier values for helium are given again. Four of the twelve original results are lowered by one unit in the fifth decimal place by the correction.

The Density of Helium

0° and 760 mm., at sea level, lat. 45°

Series	Number of treatments with adsorbent	Globe I 1031.51 ml.	Globe II 1029.30 ml.	Globe III 1038.48 ml.	Average
1	3	(0.17853)	(0.17850)	(0.17858)	(0.17854)
2	5	0.17840	0.17848	0.17844	0.17844
3	6	0.17844	0.17845	0.17848	0.17846
4	7	0.17848	0.17841	0.17848	0.17846
Average of Series		0.17844	0.17845	0.17847	0.17845

SERIES	NUMBER OF TREATMENTS WITH ADSORBENT	GLOBE IV 2111.0 ML.	GLOBE V 2117.6 ML.	AVERAGE
7	9	0.17853	0.17841	0.17847
8	10	0.17849	0.17851	0.17850
9	11	0.17846	0.17852	0.17849
10	11	0.17842	0.17843	0.17843
11	14	0.17846	0.17846	0.17846
12	14	0.17846	0.17845	0.17846
	Average	0.17847	0.17846	0.17847

The average of all the experiments, except the first series with one-liter globes in which slightly impure gas was used, is 0.17846, while that given in our preliminary paper was 0.17845.

THE DENSITY OF HELIUM

0° AND 380 MM. AT SEA LEVEL, LAT. 45°

SERIES	NUMBER OF TREATMENTS WITH ADSORBENT	GLOBE IV	GLOBE V	AVERAGE
13	14	(0.08931)	0.08922	0.08922
14	14	0.08924	0.08924	0.08924
15	16	0.08923	0.08923	0.08923
16	18	0.08925	0.08922	0.08924
	Average	0.08924	0.08923	0.08923

Since the average density of helium found at one-half atmosphere's pressure is exactly half that found at one atmosphere's pressure it is apparent that helium by some process of compensation obeys Boyle's Law over this range. Burt[4] has already come to the same conclusion. This method of following compressibility, because of the low density of helium, is not as satisfactory at lower pressures as with most other gases.

With the use of the density of helium, 0.17846, and that of oxygen recently obtained by us with similar apparatus, 1.42898,[5] the following table gives values for the atomic weight of helium computed on the basis of various possible values for $(PV)_0/(PV)_1$ for oxygen. The results are only slightly different from those given in the earlier paper.

$\frac{(PV)_0}{(PV)_1}$ (OXYGEN)	LIMITING VALUE OF MOLAL VOLUME IN LITERS	ATOMIC WEIGHT OF HELIUM
1.00080	22.4115	3.9996
1.00085	22.4126	3.9998
1.00090	22.4137	3.9999
1.00095	22.4149	4.0002
1.00100	22.4160	4.0004

It is apparent that on any basis the atomic weight of helium is remarkably near the value 4.000, with the uncertainty affecting the fourth decimal.

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[1] Baxter and Starkweather, these PROCEEDINGS, **11,** 231 (1925).

[2] Baxter and Starkweather, *Ibid.*, **10,** 479 (1924).

[3] *Special Pub. No. 40, U. S. Coast and Geodetic Survey,* p. 50 (1919).

[4] Burt, *Trans. Faraday Soc.*, **6,** 19 (1910).

[5] In the report on oxygen the final value 1.42901, was based on the erroneous value for *g* in the Coolidge Laboratory.

THE NATURE OF LIGHT

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The following views regarding the mode of transmission of light are of so unorthodox a character that I set them down with some reluctance; but it seems to be generally admitted that the paradox of quantum theory cannot be resolved without doing violence to one or more of our cherished common notions. Some of the consequences of the theory that I am going to advance are repugnant to common sense, yet, searching in vain for an alternative and finding no physical fact of optics or of thermodynamics in opposition to the theory, I have come to regard it as a natural and indeed inevitable extension of Einstein's principle of relativity. Let me start with two statements which seem now to be well supported by experiment, although perhaps not entirely demonstrated. They are, however, the postulates upon which the following theory is built.

1. When an emitting atom loses energy of the amount $h\nu$, a particle with the same energy, the momentum $h\nu/c$, and the mass $h\nu/c^2$ may be regarded as traveling from the atom by a definite path until it is absorbed by another atom. The particle travels in a straight line except in the immediate neighborhood of material particles (or perhaps of other light particles) by which it may be deflected or reflected. In each encounter between a particle of light and another mass the two obey the simple laws of conservation of energy, mass and momentum.

2. The phenomenon of interference does not become less marked as the intensity of light becomes feebler, and therefore we may conclude *that the emission of a single light particle from a single atom is subject to the laws of interference.* If an optical system is so arranged that the light from a certain source produces light and dark interference bands on a photographic plate, and the source is now replaced by one in which the individual atoms only rarely emit their particles of light, these particles