ON THE DENSITIES OF NITROGEN, OXYGEN AND ARGON, AND ON THE COMPOSITION OF ATMOSPHERIC AIR.

BY A. LEDUC.

Translated from Comptes Rendus de l'Académie, 1896, vol. cxxiii, page 805.

BY CHIEF ENGINEER ISHERWOOD, U. S. Navy.

As the discovery of argon has modified some numerical results concerning atomic weights, molecular volumes, and, chiefly, the density of nitrogen, which I have heretofore published, I have again been led to further experiment on some gases,* particularly oxygen, the density of which according to my previous experiments, seemed to me to be a little too low, relatively to that of chemical nitrogen.

Nitrogen.—Lord Rayleigh, who had already determined the density of nitrogen prepared in different ways, has done me the honor of communicating in writing his experiments, the chief object of which was to ascertain whether the density of this gas were independent of the process of preparation. I propose to find, as exactly as possible, the density of nitrogen, prepared by the following processes that seem best adapted to furnish it in a state of purity:

(1) Decomposition of the nitrite of ammonium by heat. The gas obtained contains considerable quantities of the oxides of nitrogen and of ammoniacal gas; it is purified by a long column of copper, followed by oxide of copper raised to incandescence.

(2) Decomposition of the nitrate of ammonium by heat. The impure nitrogen protoxide thus obtained is treated as above.

(3) Decomposition of nitric oxide by incandescent copper.

(4) Decomposition of ammoniacal gas by incandescent oxide of copper; which oxide is followed by a column of

* Executed in the Physical Laboratory of the Sorbonne.

copper that has for its object the decomposition of the oxides of nitrogen produced by the preceding reactions.

In all cases, the nitrogen obtained traverses, before entering the weighing globe, a column of potassa, and another of pumice stone saturated with H_2SO_4 , and a U-tube charged with phosphoric anhydride.

A vacuum is made in all parts of the apparatus, previous to the operations, in order to prevent the presence of argon.

The weights of nitrogen, at 0° and 76 cm. contained in the globe, are comprised between 2 gr. $\cdot 8467$ and 2 gr. $\cdot 8474$; their mean, 2 gr. $\cdot 8470$, corresponds, all corrections made, to the density $0\cdot 96717^*$ relatively to the density of air.

Oxygen.—I have previously found for the density of oxygen relatively to the density of air $1\cdot 10506$. Although this number is the result of only a single series of experiments—electrolysis of a solution of potassa—I have accepted it without hesitation because it harmonizes with other results obtained up to the present time.

After the discovery of argon this number appeared to me to be a little too low, and I then prepared the oxygen by decomposing by heat the crystallized permanganate of potassa. Before entering the weighing globe, the gas passed over potassa, acidified pumice and sulphuric anhydride. The density was found to be near $1\cdot 10527$.

I now prepared the oxygen by electrolysis, but instead of a short column of spongy platinum, I employed for eliminating the hydrogen a long column of oxide of copper at a dull red heat. Three very concordant experiments gave $1\cdot 10521$.

Convinced by these latter experiments of the insufficiency of the spongy platinum in the preceding ones, I accept for the density of oxygen $1\cdot 10523$.

Argon.—I have many times had occasion to remark that the close concordance of the numbers obtained by Lord Rayleigh and by myself for the density of atmospheric nitrogen, implied the constancy of the proportion of argon in the atmos-

* As I have remarked in previous publications, the last decimal may have an error of several units. Further, as the present number has much probability of being too great, it can, with prudence, be reduced to $0\cdot 9671$.

phere. This point has recently been put beyond doubt by Mr. Schloesing, Jr.,* who has found the proportion of argon in atmospheric nitrogen to be 0.0119.

Designate by d , d' and x , the densities of chemical nitrogen, atmospheric nitrogen and argon.

$$\begin{aligned} &\text{We have } (d' = 0.97203). \\ d' &= 0.0119 x + (1 - 0.0119) d. \\ &\text{Whence results } x = 1.376. \end{aligned}$$

Or, relatively to hydrogen, 19.80, instead of 19.9, heretofore accepted.

Résumé.—It will be useful to fix these results by giving the weight of a liter of each of these gases at 0°, both under the pressure of a bayre (10⁶ C. G. S.) and under the normal pressure of the atmosphere at Paris, as follows:

Pressure.	Oxygen.	Nitrogen.	Argon.
1 Bayre	1 gr. 4100	1 gr. 2338	1 gr. 755
1 Atmosphere	1 gr. 4293	1 gr. 2507	1 gr. 780

I shall return hereafter to the atomic weights of nitrogen and oxygen.

Composition of Atmospheric Air.—I have a great many times determined the composition of dry atmospheric air deprived of carbonic acid, etc., and have found that it contained in mean $\frac{232}{1000}$ of its weight of oxygen.

The consideration of the densities of oxygen and atmospheric nitrogen † leads to the number 232.08, which can be taken as identical with the preceding.

On the other hand, the $\frac{788}{1000}$ of atmospheric nitrogen divides proportionally to the numbers 9881×0.96717 and 119×1.376 , which gives $\frac{755}{1000}$ for the nitrogen and $\frac{13}{1000}$ for the argon.

The centesimal composition of mean atmospheric air is consequently represented by the following table:

	Nitrogen.	Oxygen.	Argon.
By weight	75.5	23.2	1.3
By volume	78.06	21.	0.94

* *Comptes Rendus*, November 2, 1896.

† A. Leduc. *Comptes Rendus*, August 4, 1890. The employment of the number 1.10506 for the density of oxygen led me, at that time, to 232.35. The difference seems to me to be due to experimental error.