THE MOBILITY OF ARGON AND HYDROGEN IONS IN AIR

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Abstract

The apparatus and method are the same as previously used to measure the mobilities of air, CO_2 and other ions in air, the freshly formed ions being driven across a stream of air by means of an electric field. Two positive ions and one negative ion were found in both argon and hydrogen as in the case of air. The initial positive hydrogen ion was found to transform into the second, and this is doubtless also true in the case of argon, though it was not proved. The mobilities are also the same as obtained for the air ions except in the case of the negative hydrogen ion which has a higher mobility than the negative air ion. It is thus found that the following monomolecular ions all have the same mobility in air at normal pressure: monatomic A, initial + and −; diatomic air, initial + and −; diatomic H_2, initial +; triatomic CO_2, initial + and −. Thus the mobility of these ions seems to be independent of the masses. The only exception so far found is the negative H_2 ion.

In earlier articles[1] are given the results obtained from measurements of the mobility of ions of air, CO_2 and actinium active deposit in air. In the case of air and CO_2 ions it was found that the negative ions have the same mobility in air and that in each case there is an initial positive ion

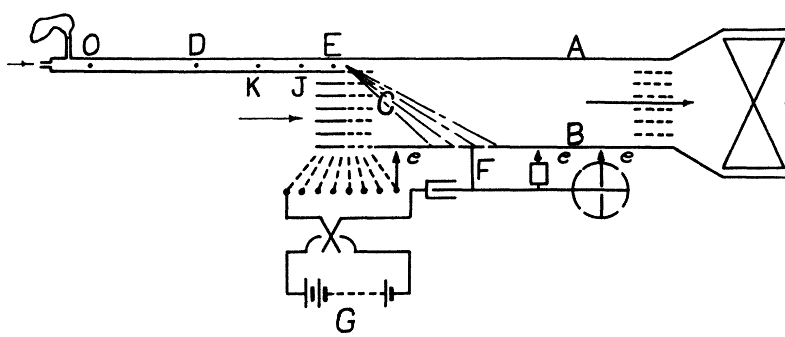

Fig. 1. Diagram of apparatus.

and a final positive ion, the former transforming into the second. In the case of actinium active deposit, two positive ions were found, one having a mobility of the order of that of the final positive air and CO_2 ions and the other a mobility of a higher order.

In this article will be given the results of similar measurements in the case of argon and hydrogen ions.

[1] Erikson, Phys. Rev. **20,** 117 (1922); **24,** 502 and 622 (1924);
Wahlin, Phys. Rev. **20,** 267 (1922).

The method used is essentially the same as in the earlier work. The argon or hydrogen was passed from the containers through the tube *OE* (Fig. 1) where the ions were produced by means of the α-rays from polonium. The rubber balloon at *O* served to indicate when the rate of flow was normal. The ions were carried with the stream and at *E* were drawn out of the argon and hydrogen gas by the electric field between *A* and *B* and passed through the air to the plate *B* where the current at

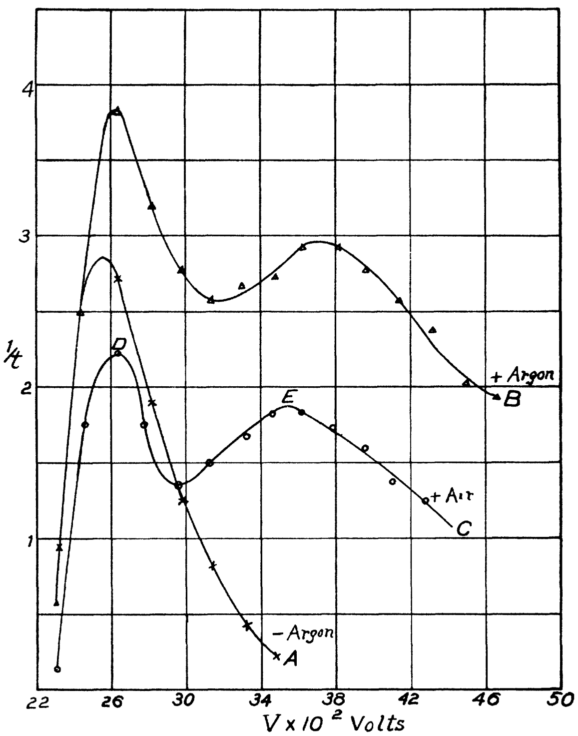

Fig. 2. Results for argon ions. Curve A for negative ion; Curve B for positive ion. Curve C is comparison curve for positive air ions.

F was measured for different potentials between the plates *A* and *B*. The velocity of the gases produced by the fan *H*, was of the order of 1500 cm/sec.

Results in the Case of Argon

The argon was supplied by the National Lamp Works of the General Electric Company, Cleveland, Ohio. The purity is given by the following analysis: argon 99 percent, nitrogen 0.9 percent, oxygen 0.1 percent. Curve A, Fig. 2, is for the negative argon ion and curve B is for the positive argon ion. Curve C is for the positive air ions and was obtained under similar conditions and is inserted for purposes of comparison. Maximum D is for the initial air ion and maximum E is for the final air ion. As the ion mobility determines the position of the maximum, it is seen that the negative argon ion has the same mobility in air as the initial positive air ion and, therefore, the same as the negative air ion. It is also seen that there is a positive argon ion which corresponds to the initial positive air ion; also, that there is a positive argon ion which corresponds to the final positive air ion. On account of the limited supply of argon, it was not possible to repeat the measurement using younger or older argon ions and thus show that the first transforms into the second. That the first transforms in time to the second is, however, quite certain.

Since argon is a monatomic gas, these results show that an ion one atom large moves through air with the same mobility as the negative and initial positive air ions which are each one diatomic molecule large and also with the same mobility as the negative and initial positive CO_2 ions which are each one triatomic molecule large. This is, therefore, additional evidence that all one molecule ions having equal charges have equal mobilities in air. The final argon ion is formed when the initial positive argon ion attaches itself to a neutral argon or air molecule.

Results in the Case of Hydrogen

The hydrogen used was electrolytic hydrogen for which the Commercial Gas Company reported a purity of 99.9 with a trace of CO_2, water vapor and oxygen. The gas passed from a commercial supply cylinder through the tube *OE*, Fig. 1, where it was ionized by means of the α-rays from polonium, and the current-voltage curve at *F*, Fig. 1, was obtained just as in the case of argon. The results obtained in the case of hydrogen are shown graphically in Fig. 3. Curves A and B were obtained with the polonium at *E*, Fig. 1. *A* is for the negative ions and *B* for the positive ions. For curves C and D the polonium was at *J*, for curves E and F at *K*, for curves G, H, at *D*, and for curves I, J at *O*.

The upper curves correspond to the same positions as the curves immediately below, but are for ions produced in air instead of hydrogen; otherwise, the conditions were identical. It is seen that also in the case of hydrogen there is an initial positive ion and that it transforms into a final ion. It is evident from the curves that the transition is more slow in the case of the hydrogen ion than in the case of the positive air ion. It is also seen that the mobility of the initial and final positive hydrogen ions in air are the same as the mobilities in air of the initial and final positive air ions and of the negative air ion.

It is further seen that only one negative ion is formed in hydrogen, the same as in air. A marked difference, however, comes into evidence here, in that the mobility of the negative hydrogen ion is higher than that of the initial positive hydrogen ion and the initial positive and negative air ions. The writer is unable to account for this difference. The negative ion, according to the author's view, is a hydrogen molecule which has gained an electron just as the initial positive hydrogen ion is the hydrogen molecule which lost an electron in the ionizing process. That the negative ion should move more rapidly in air than the initial positive hydrogen

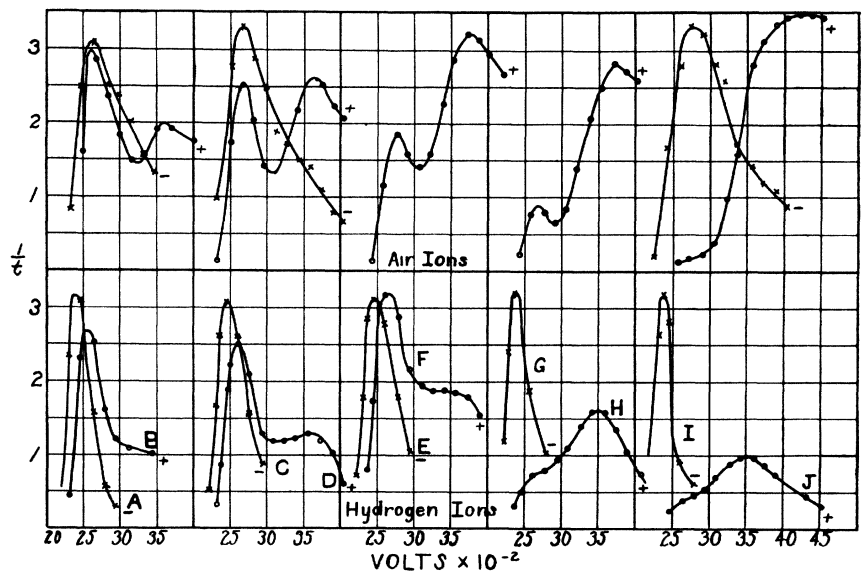

Fig. 3. Curves for hydrogen ions (below) and corresponding curves for air ions (above).

ions or the initial positive and negative air ions which are also each one molecule large is not, it would seem, to be expected, and is the first exception encountered by the writer to the view that all one molecule ions equally charged have the same mobility in air.

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