THE MOBILITY OF ACTINIUM ACTIVE DEPOSIT IONS

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Abstract

The mobility of the ions in actinium active deposit is determined by drawing them across an air stream having a speed of 20 m/sec., by means of an electric field of over 100 v/cm, and allowing them to deposit on a metal plate. The amount of deposit at various distances along the plate is determined by the ionization it produces through a slit in the wall of an ionization chamber. It is found that two positive ions are present, one of which has a mobility of about 4.35 cm/sec/volt/cm and the other 1.55. The first is greater than that of monomolecular ions of air and the second greater than that of bi-molecular ions of air (Phys. Rev. **24,** 1924). The interpretation advanced is that the more rapid ions are atomic actinium A and B, and that the slower ion is formed when the more rapid ion attaches itself to a neutral molecule (presumably air). A comparison of the results in the case of these heavy ions with those in the case of the air and CO_2 ions shows that the mobility of an ion is practically independent of its mass.

THE mobility in air of the ions composing the thorium active deposit was investigated by Rutherford[1] and by Franck.[2] The mobility values found were approximately the same as for the positive air ion.

It became of interest to determine the mobility of the active deposit of actinium by means of a method having a resolving power such as would lead to the detection of different ions if present.

The method is essentially that used to study the initial ions of air and CO_2.[3] It may be briefly described as follows.

A dish containing an actinium salt was placed at D inside a tube T (Fig. 1). Air containing the actinium emanation and its disintegration products was drawn into the space between two plates A and B by means of a fan H. The velocity of the air between the plates A and B was of the order of 2000 cm/sec. The air containing the active deposit entered at E through an opening $.25 \times 5$ cm. The rest of the air passing between the plates A and B was taken from the room and was free from emanation. The plate A was kept at a positive potential by means of the battery G; plate B was grounded. To secure a uniform field, wires whose potential varied in steps were placed at the sides of the space between A and B. Since the active deposit is positively charged it is repelled to the plate

[1] Rutherford, Phil. Mag. **95,** (1903)
[2] Franck, Ber. Deutsch. Phys. Ges. **7,** 397 (1909)
[3] Erikson, Phys. Rev. **24,** 502 (1924); **20,** 117 (1922)

B across the air stream and is deposited on B. If particles differing in mobility are present they will be deposited at different points on B. After exposure of plate B for a given time it was removed and placed beneath an ionization chamber in the bottom of which there was a slit at right angles to the plate as shown in Fig. 2. The relative amounts of active deposit at different points on B was determined by measuring the current produced in the ionization chamber A.

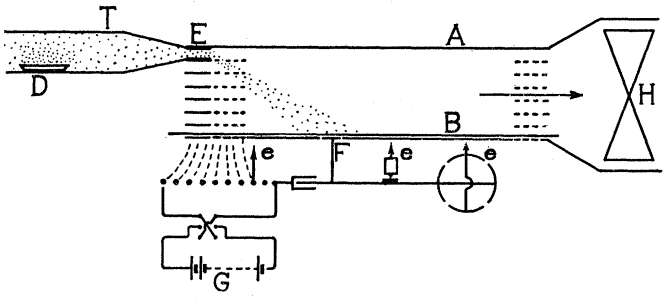

Fig. 1. Apparatus for getting ionic spectrum of actinium deposits.

The results obtained after an exposure of 30 minutes with 4500 volts between the plates A and B, Fig. 1, are given in Fig. 3.

The current obtained in the ionization chamber, Fig. 2 is plotted as ordinates against the down stream distances as abscissas. The order in which the readings of the upper curve were obtained was from right to left. The lower curve was obtained by immediately reversing the order in which the readings were taken. The diminished ordinates are due to the decay of the active deposit.

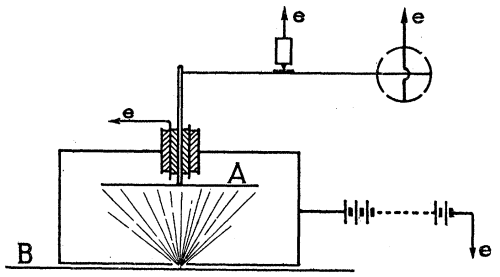

Fig. 2. Apparatus for determining activity on plate B (Fig. 1) as function of distance from one end.

It thus becomes evident from the two maxima that there are two active bodies present, both positively charged. The first maximum corresponds to a mobility of about 4.35 cm/sec/volt/cm and the second

to a mobility of about 1.55. The average mobility ratio found for these two active bodies is 2.80.

As to the nature of the two bodies no definite conclusion can as yet be advanced. The results however suggest the following discussion.

Actinium emanation has a half value period of 3.9 sec. and is an electrically neutral gas in the atomic form. The emanation atom disintegrates into actinium A which has a half value period of .002 sec. and is positively charged. The actinium A which results from the emanation which enters as such at E gives a continuous spectrum on plate B, Fig. 1. The actinium A which enters at E is due to the emanation which disintegrates in a distance of the order of 2 cm before E, as the air velocity towards the E end of the funnel is about 2000 cm/sec. The swifter of the two bodies passes from E to plate B in about .002 sec. It is thus seen that

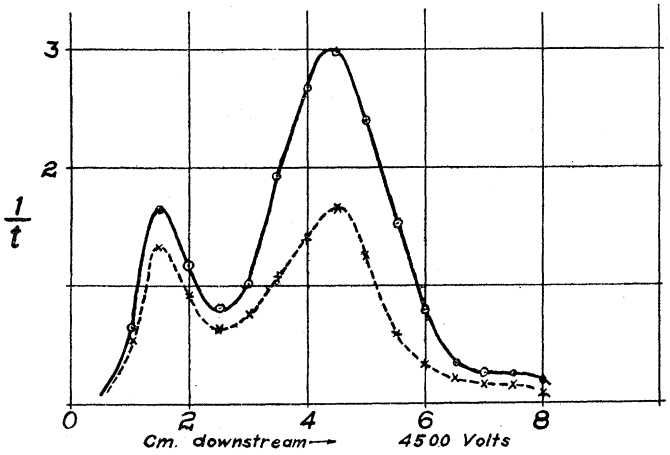

Fig. 3. Spectrum of actinium depositions.

it is possible for the actinium A which leaves E to reach plate B and that the chances are that it is in the atomic form, as owing to the short interval of time it is not able to unite with other molecules to any appreciable extent. The actinium A which changes into actinium B after leaving E will give a continuous spectrum which is denser at the down stream end. The positive actinium B which enters at E and which is also in the atomic form will come down with the atomic actinium A as the effect due to the difference in mass may be neglected. The first maximum therefore on this view is due to both atomic actinium A and B. As actinium B has a half value period of 36.3 min. it remains as such in the air for a considerable time and has a good chance of uniting with an air molecule so as to form a positive ion three atoms large. On this view the slower of the two

active bodies is a positive ion three atoms large and as stated above corresponds to a mobility of about 1.55.

In Fig. 4, curve B is for the positive air ions and is inserted for comparison. This curve was obtained by ionizing the air entering at E by means of α rays from polonium and by measuring the current to the strip F, Fig. 1, as a function of its position.[4] The maximum C is for the initial positive air ion and maximum D is for the final positive air ion. It is thus seen that the maximum for the slower active body comes between the initial and final air ions. In a study of the air ions,[3] the conclusion was reached that the negative and initial positive ions are each two atoms large and the final positive ion is four atoms large. If the slower active body found above is three atoms large, it should have, as the results show, a mobility value lying between the mobility of the two positive air ions,

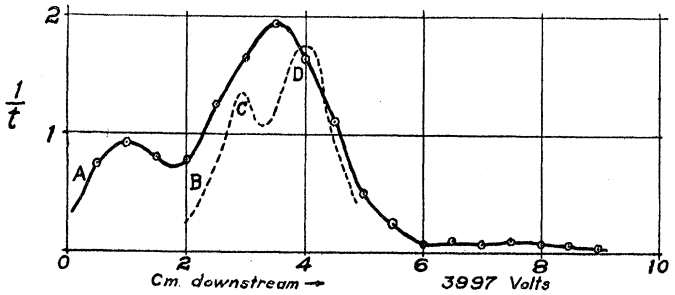

Fig. 4. Curve A, spectrum of actinium ions; curve B, spectrum of air ions, under the same conditions.

provided it has not a characteristic molecular structure[5]. That the first maximum is due to atomic actinium A and B and that the second maximum is due to actinium B and possibly A, after a union resulting in an ion three atoms large is therefore, it would seem, a probable conclusion.

It has not been found possible to show the transition with time of one of the active bodies into the other although the transition can quite easily be shown in the case of the initial positive air ion. The variation due to the decay of the emanation and recombination due to the heavy ionization interpose difficulties which have not as yet been overcome.

It is of interest to note that although these two active bodies have masses of the order of 15 times the masses of the air ions their mobilities

[4] See preceding paper, l.c.[3]

[5] Results obtained in the case of different ions seem to indicate a difference, for example, between a three atom ion formed through the loss of an electron by a three atom molecule and the three atom ion formed by the attachment of a positive atom to a neutral two atom molecule.

are of the same order, the swifter moving more rapidly than either of the air ions. This shows that the mass of the ion is not an appreciable factor. The mobility is determined chiefly by the charge, the structure of the ion and the nature of the medium through which it moves.

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