Title
ON THE HALF-LIFE OF ACTINIUM

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September 5, 1950

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ON THE HALF-LIFE OF ACTINIUM*

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The half-life of Ac^{227} has not been established with certainty. The most widely quoted[1] values are 21.7 years[2] and 13.5 years.[3] In the interest of resolving this discrepancy, we have followed the decay of a sample of actinium using the differential ionization chamber employed by Segrè, Wiegand, and Leininger in the course of their studies[4,5] of the influence of chemical binding upon the decay constant of Be^7.

The sample of actinium used in these measurements was produced and separated in 1947 from pile irradiated radium at the Argonne National Laboratory. Because of its age, the actinium can safely be assumed to be in secular equilibrium with the daughter products in its decay chain. A second sample, kindly furnished us by Dr. F. Hagemann in January, 1950, has also been observed. This sample, however, has not yet reached equilibrium and will be followed further. At present, therefore, the results obtained with the older sample alone should be considered as preliminary.

Determination of long periods by the differential technique rests upon the fact that during the course of the measurement, $\lambda t \ll 1$, and that the decay is essentially linear. By expansion of the exponential in the first order decay law $N(t) = N(0)\, e^{-\lambda t}$ and retention of only the linear term, one has

$$N(t) = N(0) - \lambda N(0)\, t$$

or in terms of activities,

$$A(0) - A(t) = A(0)\lambda t.$$

*This work was performed under the auspices of the U. S. AEC.

One uses a sample of actinium of strength $A_x(t)$ balanced in activity as closely as possible with a Bureau of Standards radium source of strength $A_r(t)$ such that $A_x(0) = A_r(0)$. Because of the constancy of the radium standard, $A_r(t) = A_r(0) = A_x(0)$. Thus, $A_r(t) - A_x(t) = A_x(0)\lambda t$. Defining the quantity $A_r(t) - A_x(t)$ as $\delta(t)$, the unbalance of the samples at time t, one has

$$\lambda = \frac{\delta(t)}{A_x(0) \cdot t}$$

One must therefore measure $\delta(t)$ as a function of time. Provided that $A_x(0)$ can be determined with comparable relative precision, the decay constant of the actinium may be found.

Differential measurement enjoys several advantages over separate measurement of standard and unknown: by measuring the samples at the same time and by interchanging them systematic errors are minimized; the readings on the difference of the two activities are always small and with ionization chambers are much more convenient to take than readings on the activities; it is practical to use considerably stronger samples than for single readings.

The differential chamber has been amply described by Segrè and Wiegand.[4]

Our measuring procedure was as follows: the actinium sample is placed in chamber 1 and the radium standard in chamber 2; the rate of drift of the galvanometer is then

$$p = A_x(t)\ S_1 - A_r(t)\ S_2$$

where S_1 and S_2 are the sensitivities of chambers 1 and 2, respectively, and are very nearly equal. By interchanging the samples, the rate of drift becomes

$$q = A_r(t)\ S_1 - A_x(t)\ S_2$$

from which

$$p - q = \left[A_x(t) - A_r(t)\right](S_1 + S_2)$$

$$\cong - 2\,\delta(t)\cdot S$$

$$\delta(t) \cong - \frac{(p - q)}{2\,S}$$

The initial rate of drift due to the actinium sample alone, a(0), is then measured. Since $a(0) = A_x(0)\cdot S$,

$$A_x(0) = \frac{a(0)}{S} .$$

But we had from the decay law that

$$t_{1/2} = \frac{0.693\ A_x(0)\cdot t}{\delta(t)}$$

Substituting from above for $\delta(t)$ and $A_x(0)$, we obtain

$$t_{1/2} = \frac{0.693\cdot a(0)}{\left(\frac{p - q}{2t}\right)}$$

We have measured (p - q) over a period of about 100 days and have found (p - q)/t to be -0.05916 ± 0.00020 (mm/sec.)/day. Also, the initial activity of the actinium sample, corrected for decay, was a(0) = 343.7 ± 2.9 mm/sec.

From these data, the half-life of actinium is calculated to be 22.0 ± 0.3 years, comparing favorably with the value offered by Curie and Bouissières.

We wish to thank Professors E. Segrè and I. Perlman for their helpful suggestions during the course of this experiment.

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[1]G. T. Seaborg and I. Perlman, Rev. Mod. Phys. 20, 585 (1948).

[2]I. Curie and G. Bouissières, Cahiers phys., No. 26, 1 (1944).

[3]St. Meyer, et al., Rev. Mod. Phys. 3, 427 (1931).

[4]E. Segrè and C. Wiegand, Phys. Rev. 75, 39 (1949).

[5]Leininger, Segrè, and Wiegand, Phys. Rev. 76. 897 (1949).