SHORT COMMUNICATIONS

THE HALF-LIFE OF THORIUM C″*

By D. L. Baulch,† H. A. David,‡ and J. F. Duncan†

The range in gases of Th C″ atoms produced by α-recoil from Th B sources has recently been investigated by Baulch and Duncan (1957). Th C″ decays with a short half-life to stable ^{208}Pb. Each time measurements were made, a decay curve was determined, for extrapolation to zero time. In the course of this work, some 268 observations of the decay were made. Although the experiments were not originally designed for such a purpose, they provide a sufficient body of data for estimation of the half-life of Th C″ by statistical analysis.

Experimental

Sources of Th B were prepared by exposing a negatively charged platinum plate to finely powdered thorium hydroxide, which provided a source of thoron. Sources of Th B in radioactive equilibrium with its decay products, Th C, Th C′, and Th C″, which gave about 4000 counts/min with 5 per cent. counting efficiency, could thus be prepared. Each of these sources was placed parallel to and $2 \cdot 90$ mm from a silver collector, usually maintained at a positive potential of 300 V (Baulch and Duncan 1957). After standing in a vacuum of about 10^{-3} mm Hg pressure for 20 min, the collector was removed. The decay of the Th C″ collected was followed by taking readings of the integral numbers of counts obtained under an end-windowed Geiger counter at 1-min intervals, in favourable cases up to 20 min. Initial readings ranging from 100 to 1000 counts/min were obtained. The background, determined daily over a period of 10 min, was about 10 counts/min. Corrections for the dead time of the counter assembly were less than $\frac{1}{2}$ per cent.

Statistical Method

Estimation of the half-life was based on the decay occurring in the first 9 min only, this being the duration of several of the shortest series. Some of the 268 series of observations recorded showed features which could not be attributed to chance fluctuations in the counting rate. The following test was made of the validity of the results. Let n_{ti} denote the count obtained during the tth min ($t=1, 2, \ldots, 9$) of the ith experiment ($i=1, 2, 3, \ldots, 268$). Each series of nine points with coordinates (t, $y_{ti}=\ln n_{ti}$) was plotted, and lines with common

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slope $\bar{l}$ were passed through the centroids $(5, \bar{y}_i)$. $\bar{l}$ is the average slope of the 268 least squares regression lines, and is the experimental estimate of λ, the disintegration constant. To control the deviations of points of a series from the regression line, parallel lines at a distance on the activity axis equal to $\pm 3\times(8/9)^{\frac{1}{2}}s$ from the line through the centroid were drawn; s^2 is the error mean square obtained by adding the 268 sums of squares of deviations from the individual regression lines and dividing by 268×7 (an estimate of the variance). Some 35 series which fell outside the areas bounded by these limits were rejected. The procedure was then repeated with new values of $\bar{l}$ and s. The new band was appreciably narrower, and another 22 series were rejected leaving 211 series. There was little further change in $\bar{l}$ and s in subsequent repetition of this procedure, which was therefore terminated.

The mean half-life, $\bar{t}_{\frac{1}{2}}$ is $\ln 2/\bar{l}$. The standard deviation in the half-life $\sigma_{\bar{t}_{\frac{1}{2}}}$ was estimated from

$$\sigma_{\bar{t}_{\frac{1}{2}}}=\frac{\sigma_{\bar{l}}\times\ln 2}{(\bar{l})^2}$$

$$=\frac{s\times\ln 2}{(\bar{l})^2[268\sum_{t=1}^{9}(t-\bar{t})^2]^{\frac{1}{2}}}\qquad(\bar{t}=5).$$

These estimates are not affected by the grouping of counts chosen, nor is the fact that individual readings are about 0·2 per cent. larger than the disintegration rate which would be observed if it were possible to determine the disintegration rate instantaneously at $t=\frac{1}{2}, 1\frac{1}{2}, 2\frac{1}{2}, 3\frac{1}{2}, \ldots$, since this correction is constant for all readings (Cook and Duncan 1952).

Results and Discussion

The value of 3·1 min recommended by the International Radium Standard Commission (1931) is based on early work with considerable experimental error

TABLE 1

HALF-LIFE OF Th C″

Authority	Value (min)
Hahn and Meitner (1909) . .	3·1
von Lerch and von Wartburg (1909)	3·0
Albrecht (1919)	3·2
International Radium Standard Commission (1931)	3·1
Present work	
268 Series	3·090±0·015*
211 Series	3·099±0·012*

* Standard deviation.

(see Table 1). The fact that in the present work the two estimates reported, based on (i) all the 268 results and (ii) a selected 211 series, differ by only 0·009 min, gives one confidence in accepting the second place of decimals as meaningful. The estimate from the 211 series is the more accurate. We therefore conclude that a safe estimate of the half-life is 3·10 min with a standard deviation of 0·015.

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THE DETERMINATION OF DEPOLARIZATION FACTORS WITH PHOTOELECTRIC RAMAN SPECTROMETERS*

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The introduction of photoelectric methods has resulted in a greatly increased accuracy of measurement of the intensity of Raman lines and this in turn has facilitated the determination of depolarization factors (Rank 1947; Douglas and Rank 1948; Rank and Kagarise 1950; Stamm, Salzmann, and Mariner 1953).

The method usually employed is based on that of Edsall and Wilson (1938). Two polaroid cylinders, arranged so that the plane of polarized light is parallel to the axis of the cylinder in one and at right angles to this axis in the other, are placed in turn around the sample tube and the intensity of the Raman light being studied is then determined for each. The depolarization factor is given by

$$\rho_s = I_{||}/I_{\perp},$$

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where ρ_s is defined as: "The intensity ratio of the scattered light polarized along the direction of propagation of the exciting beam over the scattered light polarized perpendicular to this direction, when the exciting light is polarized at right angles to the tube length."

As has been shown by Douglas and Rank (1948) and Rank and Kagarise (1950), the values so measured are subject to several errors, one of the most serious being the angle of convergence of the radiation on the cell. The depolarization factor usually quoted however is ρ_n defined as: "The intensity ratio of the scattered light polarized along the direction of propagation of the exciting beam over the scattered light polarized perpendicular to this direction, when the exciting light is unpolarized."

The last-named authors have suggested that values of ρ_n can be obtained for any particular instrument by plotting experimentally determined values against known values of ρ_n, which have been determined by the method of

TABLE 1

SELECTED RAMAN LINES FOR THE CONSTRUCTION OF A CALIBRATION CURVE FOR MEASUREMENT OF ρ_n

Compound	Raman Line (cm^{-1})	ρ_n
Carbon disulphide	654	0·25
Chloroform	366	0·13
	3020	0·32
Carbon tetrachloride	218	0·86
	313	0·86
	458	0·013
*cyclo*Hexane	802	0·063
Benzene	992	0·038
	606	0·86

parallel incident unpolarized light (no convergence of beam) and have been corrected for other errors which may occur. These authors further suggest that the correction curve should be a straight line.

Unfortunately, an examination of the available data for their suitability for use with photoelectric instruments has not previously been made. This has now been attempted by examining a large number of Raman lines for which ρ_n values have been reported. From these data a set has been selected (Table 1) which, it is believed, will enable a reliable estimate of ρ_n to be obtained from the measured values. The values given have been carefully chosen on the following basis:

(i) The Raman lines should be strong, so that a high signal-to-noise ratio can be maintained.