It is apparent that $\Delta \log_{10} i$ is the deviation of the experimental point from a line having the Schottky slope and an intercept, $\log_{10} i_0$. Since $\Delta \log_{10} i$ has been found experimentally[3] to be a periodic function of $E^{\frac{1}{2}}$, it becomes convenient to assign the symbols $\Delta \log_{10} i_m$ and $\Delta \log_{10} i_n$ to adjacent extreme values (whether maximal or minimal) of the deviation, and to define a quantity $\delta'_{(m,n)}$ by the relation,

$$\delta'_{(m,n)} = |(\Delta \log_{10} i_m - \Delta \log_{10} i_n)|. \quad (3)$$

$\delta'_{(m,n)}$ (abbreviated hereafter to δ') may be called "the oscillation of the $\Delta \log_{10} i$, $E^{\frac{1}{2}}$ function in the $E^{\frac{1}{2}}$ interval, (m, n)." It is easily seen that δ' is independent of the arbitrarily chosen intercept, $\log_{10} i_0$. The statement made in reference 3, pp. 657–658, namely, "the heights of the maxima and minima . . . decrease . . . with increasing temperature" could be restated thus: "$d\delta'/dT$ has a negative sign."

The quantity δ employed in reference 1 is defined by the equation,

$$\delta_{(m,n)} = 100 \left| \left[\frac{\Delta \log_{10} i_m}{\log_{10} i_m} - \frac{\Delta \log_{10} i_n}{\log_{10} i_n} \right] \right|. \quad (4)$$

It can readily be shown that $\delta_{(m,n)}$ (abbreviated hereafter to δ), though insensitive to the choice of the intercept, $\log_{10} i_0$, is not entirely independent of it. For this reason it is regrettable that the quantity δ should have been introduced; and it is suggested that δ' be employed in future discussions.

With regard to the temperature dependence of δ, the data of references 1 and 3 agree that $d\delta/dT$ is *positive.* With regard to the temperature dependence of δ', the data of references 1 and 3 indicate, but do not establish conclusively, that $d\delta'/dT$ is *negative.* In Table I appears a survey of $d\delta'/dT$ values, calculated from representative data of reference 3 (namely, that of Fig. 3), and of reference 1 (namely, that of Figs. 2 and 3).

The following comments may be made upon Table I.

TABLE I. Survey of values of $d\delta'/dT$.

		$(d\delta'/dT)\times 10^6$			
$E_m^{\frac{1}{2}}$	$E_n^{\frac{1}{2}}$	Ref. 3, Fig. 3 L.S.[a]	Ref. 3, Fig. 3 Schottky[b]	Ref. 1, Fig. 2 Schottky[b]	Ref. 1, Fig. 3 Schottky[b]
200	266	−2.4 (±1.0)	−0.3 (±0.7)	− 2.0 (±5.8)	
266	348	−4.9 (±1.2)	−7.7 (±1.8)	−15. (±3.0)	−10. (±2.0)
348	505	−7.6 (±1.4)	−1.7 (±3.8)*	− 2.8 (±4.0)*	− 5.4 (±1.5)
505	752			−38. (±12.)	

[a] L.S. indicates that slope and intercept were calculated by least squares.
[b] Schottky indicates that the Schottky slope was employed, with an arbitrary intercept.
* Data badly scattered.

1. In the $E^{\frac{1}{2}}$ interval (200, 266), large experimental error renders the sign and magnitude of $d\delta'/dT$ uncertain. 2. In the intervals, (266, 348) and (348, 505), (except for the two cases starred in Table I, in which the data were badly scattered) the sign of $d\delta'/dT$ is consistently negative. An average value of $d\delta'/dT$ is -7×10^{-6} deg.$^{-1}$. 3. In the interval (505, 752) the single very large negative value for $d\delta'/dT$ may point to an important effect of field upon this coefficient.

In conclusion, it would appear that more accurate data, especially at high fields where δ' is large, will be necessary to decide whether $d\delta'/dT$ is zero[4] as the observations of Nottingham[2] show; or whether it is negative (and possibly field-dependent) as the observations of references 1 and 3 indicate.

The second equation on page 667 of reference 1 should be corrected to read

$$d\delta = \frac{100}{\log_{10} i_m}[\pm\partial \log_{10} D_g \pm (Mq\partial V)/(2E_m^{\frac{1}{2}})] \pm \frac{100}{\log_{10} i_n}[\pm\partial \log_{10} D_g \pm (Mq\partial V)/(2E_n^{\frac{1}{2}})].$$

[1] D. Turnbull and T. E. Phipps, Phys. Rev. **56**, 663 (1939).
[2] W. B. Nottingham, Phys. Rev. **57**, 935 (1940).
[3] R. L. E. Seifert and T. E. Phipps, Phys. Rev. **56**, 652 (1939).
[4] It is assumed that Nottingham's "amplitude of the deviations" corresponds to δ'.

Gamma-Rays from Sc^{48}

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THE radioactive isotopes formed by the reaction Ca+deuterons have been investigated extensively, and the particles emitted by them have been studied in detail.[1–4] Walke[1] has ascribed with certainty a half-period of 44±1 hr. to Sc^{48}, and his absorption experiments have indicated that Sc^{48} emits two β-ray spectra, one intense and of maximum energy 0.50 Mev, the other weak and of maximum energy 1.4±0.1 Mev. He reported also a γ-ray of energy 0.9±0.1 Mev which appeared to be related to the two β-ray spectra. More recently, G. P. Smith[4] has examined the β-ray spectrum of Sc^{48} by means of a spectrometer and has found one continuous distribution of maximum energy 0.640±0.004 Mev. No conversion electrons arising from the γ-ray reported by Walke[1] were observed nor was there any evidence of the weak disintegration electron distribution of maximum energy 1.4±0.1 Mev.

Sc^{48} has been produced by Ca+deuterons and a further study made of its gamma-radiation. Compton recoils of the γ-rays from Sc^{48} have been observed with a γ-ray spectrograph which has been previously described.[5] The momentum distribution of the recoil electrons is given in Fig. 1. By comparison with earlier results,[5] it is seen that the γ-rays are monochromatic. Curve A was obtained on receipt of the radioactive sample and about 3 days after bombardment. Curve B was obtained 103.2 hr. after curve A, and curve C 175.5 hr. after curve A. The peaks of curves A, B, and C are in the ratio 134/27.0/8.5 to one another, and the half-life calculated from the ratios is 44±1.5 hr. It is to be noted that the shape of the curve remains unchanged with time. This suggests that only one half-period is present. The γ-rays from Ca isotopes of long half-lives formed by Ca+deuterons were not present in sufficient intensity to be measured by the spectrograph. The counting rate of the G-M counters of the spectrograph was checked throughout the time of the experiment with a radium source and was found to vary

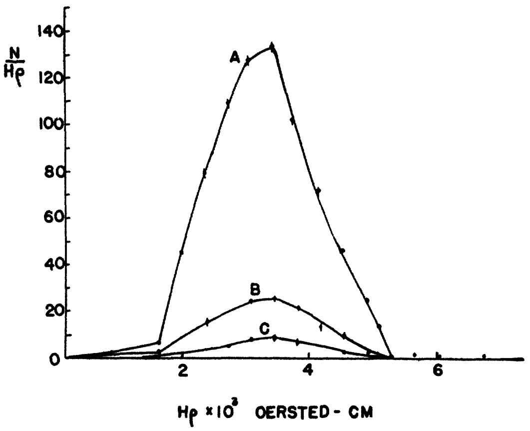

FIG. 1. Momentum distribution of the Compton recoils of the γ-rays from Sc^{48}.

by an amount less than the statistical probable error of the points on the curve of Fig. 1.

The end point of the Compton electron spectrum of Fig. 1 corresponds to a γ-ray energy of $1.35\pm.03$ Mev. It is probable, therefore, that one mode of disintegration of Sc^{48} would consist in the emission of a negative electron spectrum of maximum energy 0.640 Mev followed by a γ-ray of quantum energy $1.35\pm.03$ Mev, a more precise value than that of Walke's absorption method. In addition to information which this result gives with regard to the disintegration energy of Sc^{48}, an excitation level in the Ti^{48} residual nucleus is established at $1.35\pm.03$ Mev. Pollard[6] has reported a level at 1.1 Mev in the Ti^{48} nucleus. The absence of the electrons of a converted γ-ray in the case of Smith's experiment might be attributed to a low internal conversion coefficient arising from the energy of the γ-ray and a small spin difference between the level at 1.35 Mev and the ground state of Ti^{48}. The presence of this γ-ray indicates that the existence of the weak β-ray spectrum of high maximum energy reported by Walke[1] is possible and of maximum energy about 1.99 Mev.

It is a pleasure to thank Professor A. L. Hughes and the cyclotron group of Washington University, St. Louis, Missouri, for the preparation of the radioactive material. Their effective cooperation made possible this work. Experiments of a similar nature are in progress.

[1] H. Walke, Phys. Rev. **57**, 163 (1940).
[2] H. Walke, F. C. Thompson, and J. Holt, Phys. Rev. **57**, 177 (1940).
[3] D. R. Elliott and L. D. P. King, Phys. Rev. **60**, 489 (1941).
[4] Gail P. Smith, Phys. Rev. **61**, 578 (1942).
[5] C. E. Mandeville, Phys. Rev. **62**, 309 (1942).
[6] E. Pollard, Phys. Rev. **54**, 411 (1938).

The Diffusion Length of C Neutrons in Water

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THE diffusion length l of C neutrons in water, which is the average distance C neutrons will diffuse in water before being absorbed, has been obtained previously in two different ways. It has been computed either from the data given by Amaldi and Fermi[1] for paraffin or with the help of the equations

$$l=\lambda(n/3)^{\frac{1}{2}} \quad \text{and} \quad n\lambda=\bar{v}\tau,$$

where λ is the mean free path for scattering of C neutrons, n the average number of collisions a C neutron makes before being absorbed, and τ the mean lifetime of slow neutrons (all quantities measured for water). The average velocity $\bar{v}$ of thermal neutrons, is assumed to be 2.2×10^5 cm/sec.

Recent computations[2] have given $l=2.5$ cm, as deduced essentially from the early work of Amaldi and Fermi, and $l=2.22$ cm as deduced from the work of several authors on λ and τ.[3]

It seemed to us desirable to determine l in a somewhat more direct manner. For a point source of C neutrons, or at some distance from a spherical source, the density N of C neutrons in water at a distance R from the center of the source, should be given by the diffusion equation

$$NR=\text{const.}\times e^{-(R/l)}, \tag{1}$$

if the scattering is assumed to be isotropic.[4] Using this equation, we have measured l, with the help of a "virtual" source of C neutrons in the following way.

Inside a large water tank, at a distance of 6.35 cm from a 90 mg Ra-α-Be source, a graphite sphere of 1″ diameter was suspended. The relative slow neutron density N_1 was then measured as a function of the distance R from the center of the sphere on the far side from the Ra-α-Be

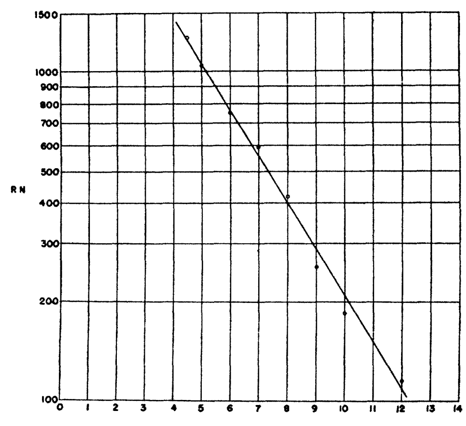

FIG. 1. N = number of counts per minute due to "C neutron source." The root-mean-square error of RN increases from about 5 percent for small values of R to about 30 percent for the larger values of R.

source. As a detector for the slow neutrons we used a small ionization chamber $\frac{1}{4}$″ in diameter, and $1\frac{1}{2}$″ high, lined with boron carbide and connected to a linear amplifier. A similar series of measurements was carried out with Cd (0.5 mm thick) covering the sphere, the slow-neutron density in this case being N_2. $N=N_1-N_2$ should then vary according to the diffusion Eq. (1) for C neutrons.

In Fig. 1 NR has been plotted on a semilog scale as a function of R. From the slope of the straight line fitted to the experimental points we obtain a value $l=3.1$ cm.