electrons (except possibly in the highest temperature range, where the curve (G) seems to flatten out and even rise).

Recently Mizushima and Okada[4] pointed out that the conductivity of baked carbons (B) is to be interpreted similarly to the conductivity of glasses.[5] The mean free path Λ of the elastic vibrations being limited by the size of the microcrystallites Λ_0 and being consequently independent on temperature, the conductivity κ has to vary proportionally to the specific heat C_v (according to Debye's formula $\kappa=\frac{1}{4}\cdot C_v\cdot v\cdot\Lambda$). The curve ($B$) seems to be reasonably similar in shape to the specific heat curve obtained by Magnus.[6]

It is expected that at very low temperatures a similar region should be observed for polycrystalline graphite. In general, for any sample, as long as the mean free path of the phonons Λ is limited by the microcrystalline dimensions Λ_0, the conductivity κ should increase proportionally to C_v. A maximum should be reached at temperatures for which the lattice scattering $1/\Lambda_L$ (phonon-phonon interactions) becomes comparable to the boundary scattering $1/\Lambda_0$. For still higher temperatures the conductivity should decrease as for large nonmetallic crystals ($\kappa\sim 1/T$). This general behavior is well known from the work of de Haas and Biermasz and of Casimir. Until now maxima have been observed only at very low temperatures. Carbons, however, can be made with microcrystalline sizes ranging from 25A up to several thousands, thus making possible a study of all intermediate cases between large nonmetallic crystals and such amorphous substances as discussed by Kittel.[5] A system of expected intermediate curves has been added in Fig. 1; since the positions of the maxima are determined by the microcrystalline sizes ($T_{\max}\sim 1/\Lambda_0$), it is estimated that for commercial carbons heat-treated to about 1800–2200°C ($\Lambda_0\sim$100–200A), maxima should be found somewhere in the range between room temperature and 500°C.

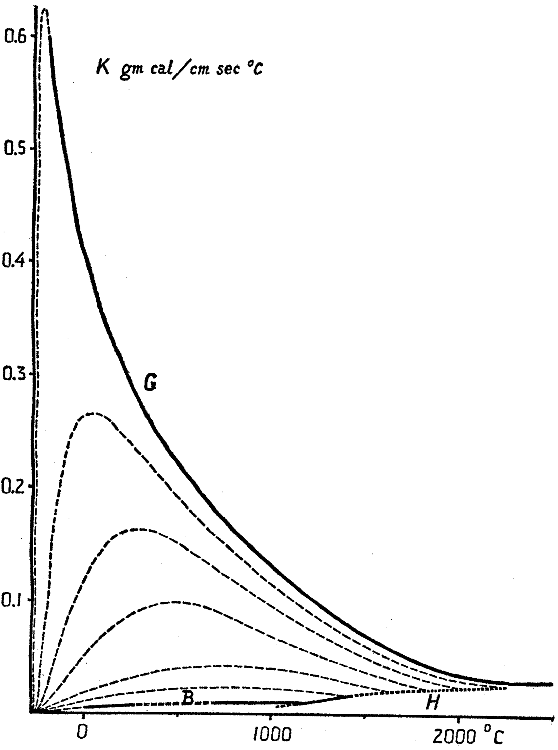

FIG. 1. Observed (continuous) and predicted (dashed) heat conductivities for variously heat-treated carbons as function of temperature. G—polycrystalline graphite, B—baked carbon, H—the heat-treatment curve.

The comparison of the low temperature part of the curve (G) (dashed) with curve (B) shows that the conductivity of baked carbons is smaller by a factor of 1000 (or more). Since crystallite sizes differ by a factor of not more than 100, and the specific heat and velocity of the waves v cannot depend very strongly on crystallite size, it is clear that in addition to the pure boundary scattering there must be present some other source of resistance to the heat flow in the baked carbons. It is easily seen that the transfer of heat from crystal to crystal is hampered by the relatively small number of valence bonds connecting the crystallites, the situation being quite similar to the case of the flow of electric current.[7] Consequently the conductivity curves do not join the graphitic curve at high temperatures, and no reliable estimate of the crystallite sizes can be made for baked carbons by application of the Debye formula.

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The Radiation Characteristics of Cm^{240} and Cm^{241}†

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IN an attempt to extend the earlier work on the neutron deficient curium isotopes,[1,2] the isotopes of mass numbers 242, 241, and 240 were produced in varying ratios by bombarding Pu^{239} with helium ions.

Carrier-free samples of curium which had been chemically purified by ion-exchange techniques were volatilized onto platinum counting disks for study. The decay of the alpha-particles, and also the conversion and Auger electrons accompanying orbital electron capture, were followed on a windowless proportional counter. Decay of alpha-particles of specific energies was followed on the 48-channel differential pulse analyzer.[3]

When the bombardment energy was between 30 and 40 Mev, activities with three different half-lives were observed. These were the 27-day 6.25-Mev alpha-activity previously reported[1] and assigned to Cm^{240}, a 35-day 5.89-Mev alpha and electron capture activity, and the well-known 162-day 6.08-Mev alpha-activity of Cm^{242}.

Some of the curium samples which were proportionately richer in Cm^{240} were allowed to decay for known periods of time and an americium fraction was separated chemically. Samples were prepared and counted in the same manner as those of the curium. No activity other than a small amount of Am^{241} (about 0.001 percent of that present in the target material) which had followed the curium chemistry in the initial separations was detected. Thus, less than 0.5 percent of the Cm^{240} decayed by electron capture to produce the 52-hour activity of Am^{240}.

When the bombardment energy was between 25 and 28 Mev, only the 35-day and 162-day activities were observed. At these energies the (α, $2n$) reaction would be expected to predominate, while the (α, $3n$) should be in such low incidence that products of it would not be detected. For this reason the 35-day activity was assigned to Cm^{241}.

The ratio of the number of electron capture disintegrations to the number of alpha-disintegrations in the 5.89-Mev group was calculated to be between 360 and 460. The number of electron capture disintegrations was determined by assuming the same counting efficiency for the radiations accompanying the electron capture disintegration process of Cm^{241} as for those of U^{231},[4] and the number of alpha-disintegrations was determined from geometrical considerations, assuming 100 percent counting efficiency.

The values above indicate only the precision of the measurements, and errors in the assumed counting efficiency could change the numbers by factors of two or more. The partial alpha half-lives calculated from these branching ratios are 35 and 45 years.

While the 5.89-Mev group apparently accounts for more than 75 percent of the observed alpha-disintegrations which decay with a 35-day half-life, it seems likely from the alpha-systematics[5] that the ground-state transition energy would be between that of Cm^{242} (6.08 Mev) and Cm^{240} (6.25 Mev), but particles in this energy range are as yet unobserved.

We wish to express our appreciation to Dr. Glenn T. Seaborg for his continued interest in this work.

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Short-Range Protons from the Deuteron Bombardment of Li^6*

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The 4.6-Mev state in Li^7 has been observed in the inelastic scattering of protons, deuterons, and alphas from Li^7 [1] and in the Be$^9(d,\alpha)$Li^7 reaction.[1,2] We have examined the spectrum of short-range protons from the Li$^6(d,p)$Li^7 reaction in a region corresponding to this excitation in Li^7. Thin targets of natural lithium, evaporated onto 1000A nickel foils, were bombarded with deuterons of energies 0.91 and 1.03 Mev, and the reaction products were observed at 90° and 110°. Detection was by means of nuclear plates in a magnetic spectrograph employing a second-order focus.[3] The observations reported here extend from an excitation energy of 4.30 to 4.80 Mev in Li^7.

In the first observation [Fig. 1(a)] a weak group of protons is observed in the correct location to be identified with the Li$^6(d,p)$Li^7 reaction. However, a search was made for the proton group from N$^{14}(d,p)$N^{15}, $Q=0.300\pm0.005$ Mev,[4] which would appear in this region. The observation was made with a lithium target, freshly prepared but then exposed to a pure nitrogen atmosphere. This procedure produces satisfactory nitrogen targets and the resulting nitrogen group appears in (*b*) in addition to the group attributed to lithium. Curves (*c*) and (*d*) were obtained at a lower bombarding energy, without and with a nitrogen contamination, respectively. In observation (*d*) the magnetic spectrograph was rotated to 110° to produce a further shift in energy of the proton groups. With the positive identification of the nitrogen group the relative shift in energy with angle and bombarding energy for the other group identifies it as a proton group from Li$^6(d,p)$Li^7. Each curve was obtained from a single three-inch nuclear plate, and the energy scale was determined from the deuterons scattered elastically from Li^7, which are shown (at reduced scale) in Fig. 1(c). The four observations yield an average $Q=0.410\pm0.015$ Mev for the lithium reaction and an excitation energy in Li^7 of 4.610 ± 0.020 Mev. This value agrees with our previous determination of 4.62 ± 0.02 Mev from the Be$^9(d,\alpha)$Li^7 reaction.[2] A value of $Q=0.296\pm0.015$ Mev is obtained for the nitrogen group, which agrees with the value obtained by Malm and Buechner.[4]

In all four spectra a continuous proton background is observed which is above the level expected from instrumental scattering alone. The rapid fall of the background below about 0.84 Mev in curve (*c*) is interesting in connection with a possible Li$^6(d,t)$Li$^5(p)$He^4 reaction. If the Q for Li$^5(p)$He^4 is taken as 1.8 Mev,[5] the mass of Li^5 becomes 5.01395 (instead of 5.0136[5]). This leads to a $Q=0.755$ Mev for the Li$^6(d,t)$Li^7 reaction. The minimum energy for a proton from the disintegration of a recoiling Li^5 nucleus is then 0.84 Mev for the conditions of curve (*c*). This is in excellent agreement with the observed point at which the background begins to fall, and the falling part of the curve is consistent with the great breadth of the Li^5 ground state. In curve (*d*) the minimum proton energy is calculated to be 0.73 Mev, and below this value the background is observed to decline, but the presence of the nitrogen peak makes the structure of the background above this value much less certain. In each graph the arrow marks the calculated position of minimum proton energy (neglecting the breadth of the Li^5 ground state). Unfortunately the measurements in (*a*) and (*b*) do not extend down to this value. The investigation of this background was extended to higher

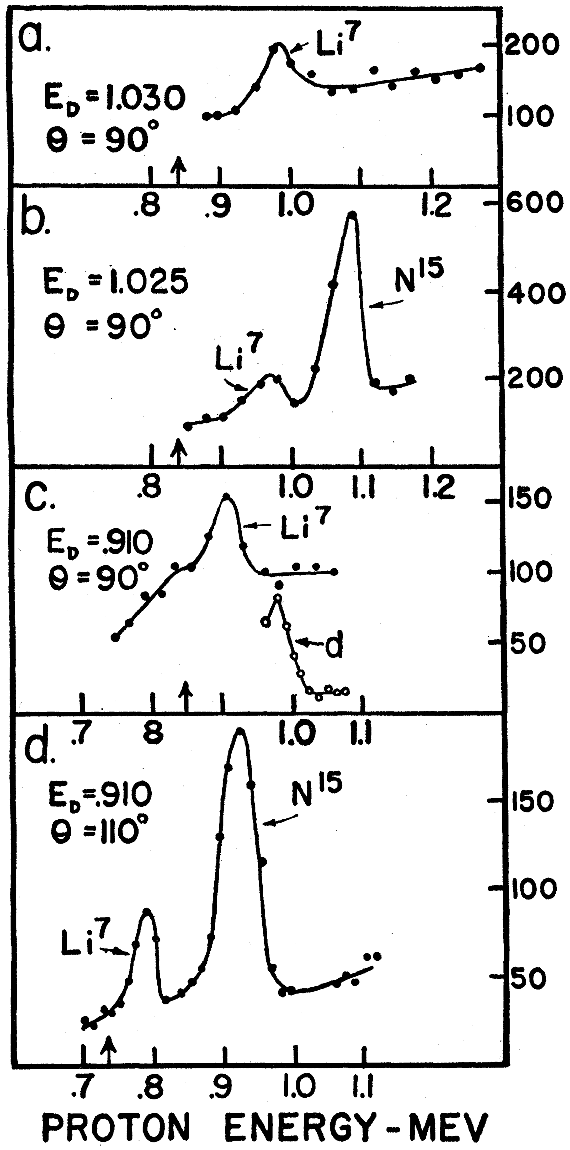

Fig. 1. Spectra obtained from the deuteron bombardment of natural lithium targets, curves (*a*) and (*c*), and of nitrogen contaminated lithium targets, curves (*b*) and (*d*). Li^7 and N^{15} designate, respectively, the Li$^6(d,p)$Li^7 and the N$^{14}(d,p)$N^{15} reactions.