The electron energies and their interpretations are shown in Table I, while the gamma-energies are tabulated in Table II. By the use of a recording microphotometer the densities of the photographic plates, and hence, the relative intensities have been found for certain of the lines as shown in Table II. By utilizing the data and tables as presented[5] by Goldhaber and Sunyar, the multipolarity of certain of the transitions appears to be as shown in Fig. 2. One unusual feature of the 129.8-kev isomeric transition seems to be that the intensity of the L_3 conversion is about equal to that for the L_1 line.

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Electrolysis of Thorium Oxide*

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THE electrolysis of homogeneous crystalline thorium oxide at elevated temperatures is being studied. Fused material obtained from the Norton Company is red when received and will bleach when heated in vacuum or hydrogen. The red color can be restored by heating in oxygen and, under certain circumstances, by radiation.

Optically clear specimens are cut with a diamond saw, ground and polished, and are mounted in a vacuum furnace in such a manner that visual observation is possible during passage of current. Preliminary studies have been made with tungsten electrodes and with molybdenum electrodes, the results being the same in both cases.

When a current of 100 ma/cm^2 is passed at a temperature of 1300°C, a darkening of the crystal is observed to form at the cathode end and to proceed toward the anode at a rate of approximately one mm per second. The crystal in the photograph is 10 mm long. After 7 seconds with 100 ma/cm^2 (and a field strength of about 50 v/cm) the dark region extends approximately 7 mm from the cathode end. Attention is drawn to the appearance of a metallic deposit on the crystal surface at the cathode end.

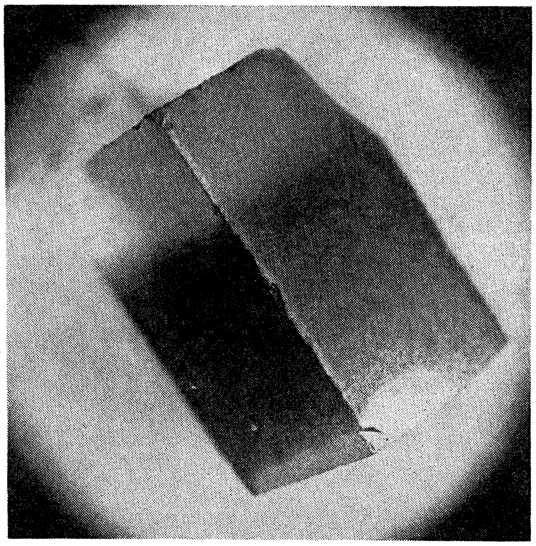

FIG. 1. A crystal of thorium oxide in an early stage of electrolysis.

When the drawing of current is continued the crystal becomes uniformly jet black and the metallic surface layer (presumably thorium) increases in area until it reaches the anode. This establishes an effective short circuit and electrolysis ceases.

If, starting with a specimen which has become completely covered with a metallic layer, one removes the layer by grinding, repolishes the crystal, and, subjects it to 1300°C for an hour or so, the black material diffuses to the surface and a metallic layer is again formed. It would appear, therefore, that the darkening is here associated with a stoichiometric excess of the metal, dispersed as ions, or possibly to some extent coagulated.

The particles responsible for the darkening are evidently charged since reversing the polarity of the applied field reverses the direction of motion of the dark region. However, wherever the dark region has reached the surface, a permanent discoloration remains. The charge responsible for the mobility appears to be neutralized (e.g., by stray electrons from outside) when the charge reaches the surface.

Certain evidence has led us to believe that the amount of thorium electrolyzed in the crystal in the photograph is not less than 10^{-2} mg. This is the result of the passage of 0.35 coulomb. If all the current were contributing to electrolysis, the quantity of thorium oxide electrolyzed by 0.35 coulomb would be 0.4 mg. This would indicate that, in single crystals, the fraction of current resulting in electrolysis is of the order of 10^{-2}.

It is of interest to compare the above result with that obtained from studies using finely divided thorium oxide. Measurements of the rate of disappearence of coated and sintered thoria cathodes show that the fraction of current producing electrolysis may be as low as 10^{-6}. The discrepancy may possibly be explained by a much higher electronic conduction in the activated cathodes than was present in the single crystals. It is also possible, however, that the large surface of the finely divided material plays an important part. The conductivity of the mass of particles may be of essentially different nature than that of a single crystal. Electrons in the surface region may possess higher mobility than in the interior. also it seems inescapable that metallic thorium will be liberated in the individual grains and migrate to their surfaces, giving rise to an even more involved electronic conductivity mechanism.

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Alpha-Particles from the Li^7+T Reactions

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THE interaction of tritons with Li^7 [1] may lead to the following exothermic reactions:

$$Li^7+T\rightarrow He^6+He^4+9.79\text{ Mev}, \qquad (1)$$

$$Li^7+T\rightarrow He^4+He^4+n+n+8.85\text{ Mev}, \qquad (2)$$

$$Li^7+T\rightarrow Be^9+n+10.43\text{ Mev}. \qquad (3)$$

In addition, reaction (2) may proceed as a two-step process via the formation of the unstable nuclei Be^8 or He^5. This letter discusses the energy distribution of the α-particles from the first two reactions and reports evidence for a new excited state of He^6.

Hydrogen, 15 percent tritium, was accelerated to 240 kev and the mass-three beam magnetically selected to bombard a $Li_2{}^7SO_4$ target.[2] The charged particles emitted at 90° to the beam were studied with a 90° magnetic analyzer by the technique previously reported[3] and also with a large proportional counter. This counter consisted of a dural cylinder 5 inches in diameter and 15 inches long provided with a side window of mica 1 mg per cm^2 thick. The inner conductor was a 0.010-inch diameter tungsten wire which passed through glass insulators supported by guard rings at each end. The counter was filled with A containing 1 percent CO$_2$ to a pressure of 70 cm of mercury and was usually operated at 2400 volts. The gas multiplication was about five. Under these

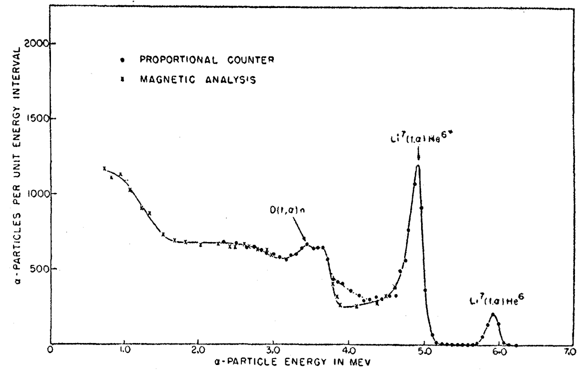

FIG. 1. The energy distribution of α-particles from the Li^7+T reactions observed at 90° to a 240-kev triton beam.

conditions and at the counting rates used, space charge did not noticeably affect the pulse heights obtained. The pulses from the counter were amplified and sorted according to size by a thirty-channel pulse-height analyzer. A correlation between pulse heights and α-particle energies was established by allowing α-particles of known energy to enter the counter immediately before and after each run. The following energy calibration points were obtained from the sources shown: $U^{233}-4.82$ Mev, $Pu^{240}-5.16$ Mev, $Am^{241}-5.47$ Mev, $Cm^{242}-6.11$ Mev, $T(d,\alpha)n-3.43$ Mev,[4] and $Li^7(p,\alpha)He^4-8.75$ Mev.[4]

In Fig. 1 is shown the energy distribution of the α-particles emitted at 90° to the beam. The data obtained by magnetic analysis have been corrected for charge exchange[5] in the target. At 5.95 Mev is a group attributed to α-particles associated with the formation of He^6 in its ground state. The energy of these α-particles was accurately determined by allowing them to enter the counter simultaneously with the α-particles from Cm^{242} which have nearly the same energy. An expanded portion of the pulse-height distribution (Fig. 2) shows the 6.11-Mev α-particles from the curium clearly resolved from the high energy group of α-particles from the reaction $Li^7(t,\alpha)He^6$. Using the measured separation of the two peaks of 0.165 ± 0.017 Mev, the Q of reaction (1) is calculated to be 9.79 ± 0.03 Mev. It can be shown that the energy equivalent of the mass difference He^6-Li^6 is $(Q_1+Q_2)-(Q_3+Q_4)$, where Q_1, Q_2, Q_3, and Q_4 are the Q values of the reactions $Li^7(p,\alpha)He^4$, $T(\beta^-)He^3$, $Li^6(p,\alpha)He^3$, and $Li^7(t,\alpha)He^6$, respectively. Taking 9.79 ± 0.03 Mev for Q_4 and using the data of Li *et al.*,[6] the He^6-Li^6 mass difference is computed to be equivalent to 3.55 ± 0.03 Mev. This value differs considerably from that of 3.215 ±0.015 Mev obtained by Perez-Mendez and Brown[7] for the end point of the He^6 β-spectrum. It is, however, in agreement with earlier determinations.[8] Knox[8] has found no evidence for a γ-ray associated with the He^6 β-particles.

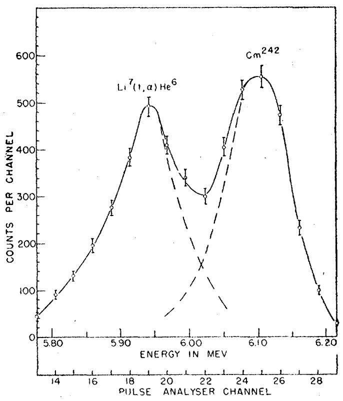

FIG. 2. The pulse-height distribution obtained when α-particles from the $Li^7(t,\alpha)He^6$ reaction and from Cm^{242} are admitted to the counter simultaneously through the same window. Observations at 90° to 240-kev triton beam.

The intense group of α-particles at 4.91 ± 0.02 Mev is believed to be associated with an excited state of He^6 formed in the reaction $Li^7(t,\alpha)He^{6*}$. From the measured energy of the α-group, the Q of this reaction is computed to be 8.08 ± 0.03 Mev. Thus the excited level in He^6 is 1.71 ± 0.01 Mev above the ground state and is unstable by 0.78 ± 0.03 Mev against break-up into an α-particle and two neutrons. The width of this level is probably less than 50 kev, as there is no observable broadening of the associated α-particle group.

In Fig. 1 the difference between the two sets of points in the neighborhood of 3.9 Mev represents the contribution of the ground state He^6 particles, whose ionization enables them to be detected in the proportional counter but whose magnetic rigidity is too great to permit their detection with the magnetic analyser. The small peak at about 3.4 Mev is due to α-particles from the $D(t,n)He^4$ reaction, which is usually present when low energy tritons are used as bombarding particles. Unless there are unresolved excited states of He^6, the broad continuum shown in Fig. 1 is composed of α-particles from reaction (2) proceeding via one or more steps and α-particles from the break-up of the observed excited state of He^6. If one subtracts the latter α-particles; the remaining continuum accounts for 80 percent of the disintegrations emitting particles at 90° to the beam.

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$p-n$ Junction Method for Measuring Diffusion in Germanium*

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THE diffusion of an n-type impurity into a p-type semiconductor creates a $p-n$ junction which can be detected electrically by the thermoelectric effect of a hot needle or by a rectification probe.[1] Study of the rate of penetration of the $p-n$ junction into the semiconductor can be used to measure the diffusion coefficients of various impurities in such semiconductors as germanium or silicon.

The object of the present study was to establish a foundation for the validity of this method by the direct measurement of diffusion, by the $p-n$ junction method, and by the radioactive tracer method. For this purpose, antimony 124 was chosen as the impurity to be used. This material served the double purpose of changing the conduction type from p to n as it diffused and, at the same time, creating a radioactive layer in which the concentration of the diffusing impurity could be evaluated by standard counting procedures.

Samples of single crystal p-type germanium were prepared in the form of wafers about 1 cm² in area and 50–60 mils thick. These samples were ground on a special grinder which made the surface flat and parallel to about 0.1 mil. After cleaning and etching with HF, a thin layer of the radioactive antimony (2–10 microgram/cm²) was evaporated onto one face of the sample.

The sample was then sealed in small quartz tubes containing argon at a pressure of 70-cm Hg at room temperature. Following heating in a carefully controlled oven (±5°C) for the desired time, the tubes were broken open, and the surface activity removed by grinding from all parts of the sample except for one face. The sample was then ground off on the same grinder with which the faces were originally prepared. The surface layers were ground into