Erbium^{163} and Thulium^{165}

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A 75-minute activity produced by bombarding Ho^{165} with protons is assigned to Er^{163}. A 24.5-hour activity produced by proton bombardment of erbium is assigned to Tm^{165}. Gamma-ray spectra are given for both isotopes.

ERBIUM^{163}

HIGHLY purified holmium oxide was bombarded with 24-Mev protons in the ORNL (Oak Ridge National Laboratory) 86-inch cyclotron.[1] Following bombardment, chemical separations were made by ion exchange techniques[2] and an activity of 75-minute half-life was found in the erbium fraction. The excitation function, Fig. 1, shows a threshold of 19 Mev which indicates that the activity was produced by a $(p,3n)$ reaction. This would assign to the 75-minute activity a mass of 163. An initial separation was made immediately following bombardment, then a second separation was made immediately on the erbium fraction from the first separation. An analysis of decay curves from the second separation places a limit of <30 minutes on the half-life of the daughter of Er^{163}, assuming it to be short. In another determination, the decay of the erbium fraction was followed for a sufficient time to place a limit of >1 year on the half-life of the daughter, assuming it to be long. Proton bombardment of dysprosium did not give a 5.2-day activity as previously reported[3] for Ho^{163}. From the yield of the 5.0-hour holmium activity, as determined by counting the electron capture activity on the x-ray peak with a scintillation spectrometer, it was determined that the production of any 5.2-day activity was less by a factor of 10^5 than for the 5.0-hour activity. These activities would have been produced from dysprosium isotopes of approximately equal abundance and, since the cross sections for these reactions are very nearly equal, it may be safely assumed that a 5.2-day activity is not a product of this reaction. Similar measurements were obtained by means of an end-window G. M. tube with the same results, thus eliminating the possibility of a positron emitter. This would eliminate the 5.2-day activity as a product of proton bombardment of dysprosium and also as the daughter of Er^{163}. The problem of holmium activities produced by proton bombardment of dysprosium is being investigated and will be reported at a later date. The 65-hour activity previously assigned[4] to Er^{163} was not observed as a product of proton bombardment of holmium oxide. A gamma spectrum was run with a scintillation spectrometer. In order to resolve the more energetic portion of the spectrum and to prevent jamming of the instrument with the more abundant x-rays, a lead absorber was used with a very strong sample. A much weaker sample was used to resolve the less energetic portion of the spectrum; this accounts for the break in the spectrum curve, Fig. 2. Gamma-ray peaks were found at 0.430 Mev and 1.10 Mev, and an x-ray peak at 0.053 Mev. The 0.51-Mev annihilation peak was not observed; if positrons are present they constitute a very small fraction of the activity.

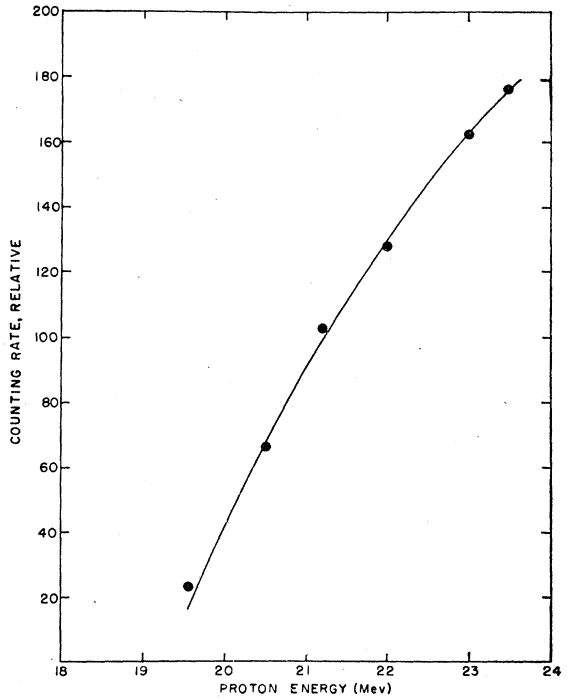

FIG. 1. Excitation function of the reaction $Ho^{165}(p,3n)Er^{163}$.

THULIUM^{165}

Highly purified erbium oxide was also bombarded with 24-Mev protons in the ORNL 86-inch cyclotron. In separations made by ion exchange, a 24.5-hour activity was found associated with the thulium fraction. When the energy of the protons was reduced to 12 Mev

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[2] B. H. Ketelle and G. E. Boyd, J. Am. Chem. Soc. **69**, 2800 (1947).
[3] G. Wilkinson and H. G. Hicks, Phys. Rev. **79**, 815 (1950).
[4] Folger, Stevenson, and Seaborg, University of California Radiation Laboratory Classified Report UCRL-1195, revised May, 1951 (unpublished).

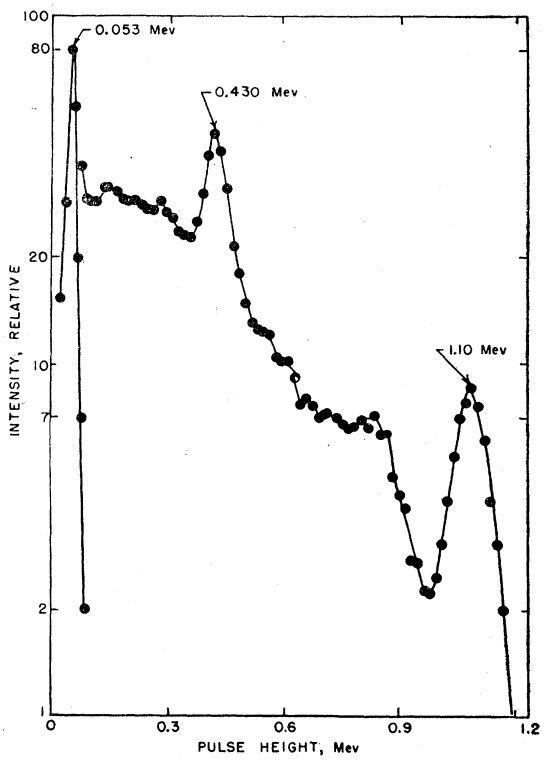

FIG. 2. Gamma-ray spectrum of Er^{163}.

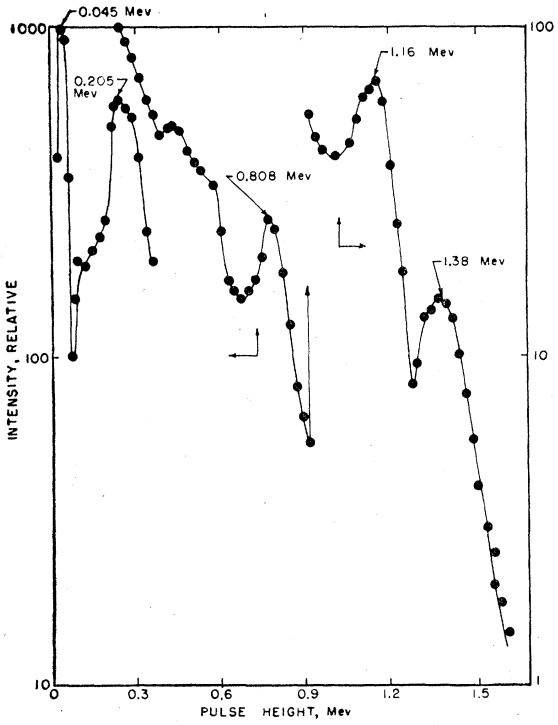

FIG. 3. Gamma-ray spectrum of Tm^{165}.

with aluminum absorbers, no 24.5-hour activity was obtained. This test excludes a (p,n) reaction for the formation of the 24.5-hour activity and therefore excludes all mass assignments higher than 165. In two other experiments, initial separations were made immediately following bombardment and a second separation was made three days later on the thulium fraction from the first separation. The only activity found with the erbium fraction was 10.5-hour Er^{165}. A third separation was made seven days after the second separation and again Er^{165} was found to have grown in. A fourth separation, made twenty days after the bombardment, did not show the presence of Er^{165}. Relative intensities of the 10.7-hour Er^{165} fraction indicated that the parent must have a half-life of the order of 25 hours. These separations also eliminate the possibility of the 7.7-hour or 9.5-day thulium activities as being the parent of Er^{165}, if they had previously been given incorrect mass assignments. Therefore, the 24.5-hour activity is assigned to Tm^{165} and it is the parent of 10.5-hour Er^{165}.

The gamma spectrum was resolved by waiting 80 hours following bombardment to allow the 7.7-hour Tm^{166} to decay before making a separation. The spectrum was run each day for twenty days and decay curves were plotted for each experimental point. These were analyzed for the 24.5-hour component and corrections were made in the low-energy range for the growth of 10-hour Er^{165}; the results are plotted in Fig. 3. The spectrum of the longer-lived background activity was very similar to the corrected spectrum for the 24.5-hour activity. The investigation is being continued in an effort to obtain spectra for Tm^{167} and Tm^{168}.

To prevent jamming of the spectrometer by the low-energy portion of the spectrum, an appropriate lead absorber was used with a very strong sample to resolve the more energetic portion of the spectrum since this constituted a very small fraction of the decay scheme. A much weaker source was used without absorbers to obtain the spectrum of the low-energy fraction. This accounts for the break in the spectrum curve, Fig. 3. It may be noted that gamma peaks were obtained at 1.38 Mev, 1.16 Mev, 0.808 Mev, and 0.205 Mev, with the x-ray peak at 0.045 Mev. The 0.51-Mev annihilation peak was not observed; if positrons are present, they constitute a very small fraction of the decay scheme.

ACKNOWLEDGMENTS

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