Nuclear Properties of Eu^{145}, Eu^{146}, Eu^{147}, Gd^{146}, and Gd^{147}†

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(Received 10 September 1962)

Samples of isotopically pure Eu^{145}, Eu^{146}, Eu^{147}, Gd^{146}, and Gd^{147} were prepared by bombardment of Sm^{144} and subsequent separation. The gamma spectrum of each is given and compared to the literature values.

SINCE there are several conflicting values for the gamma energies and half-lives of the light gadolinium and europium isotopes listed in the literature, it seemed pertinent to study the decays of the separated isotopes made available by use of the Argonne mass separator. A target of enriched Sm^{144} was bombarded in the alpha beam of the Argonne 60-in. cyclotron. The resulting products were chemically separated into elementally pure fractions and the gadolinium and europium fractions were isotopically separated on the mass separator. The decontamination factor between neighboring masses was estimated to be greater than three hundred.

The gamma spectrum of each isotopic fraction was observed by use of a 3-in.×3-in. sodium iodide crystal and a 400-channel analyzer. The decay of each fraction was followed by counting the conversion and Auger electrons in an internal proportional counter. Each fraction was also counted for positron decay by use of angularly correlated annihilation counting. Except for the Eu^{149}, counting was started 90 min after the end of the bombardment, in the case of the gadolinium isotopes, and 5 h after the end of the bombardment for the europium isotopes. The total activity of each isotopically pure fraction varied from 10^5 dis/min for the Gd^{146} to 5×10^6 dis/min for the Eu^{147} fraction. The over-all yield after chemical and electromagnetic separation was estimated to be about 1% assuming average thick target cross sections of 100 mb.

The properties of the various isotopes are summarized as follows:

I. Eu^{145} was first seen by Hoff *et al.*[1] and listed as having a half-life of 5±1 days and emitting electrons of about 0.2 MeV. No gamma spectra were listed. We obtained a half-life of 5.95±0.1 days. The gamma spectrum is shown in Fig. 1. The relative intensities are listed above the peak energies. The ratio of positron disintegrations to K x rays is 1/100, indicating a positron branching ratio of the order of 1%.

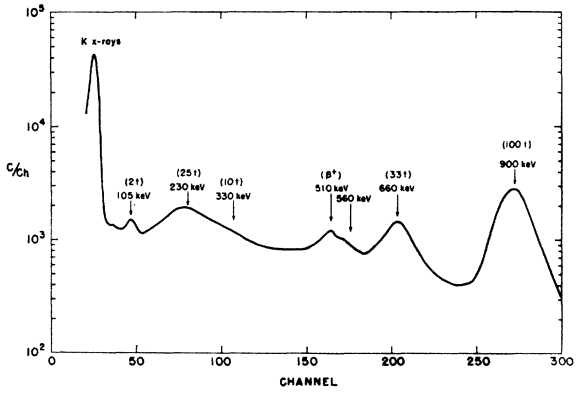

FIG. 1. γ spectrum of Eu^{145}. The ordinate is the number of counts per channel. Numbers followed by a dagger are relative gamma intensities. In all figures the individual points were not shown for the sake of clarity. The curve is a smooth curve through the points and none deviate from it by more than a few percent.

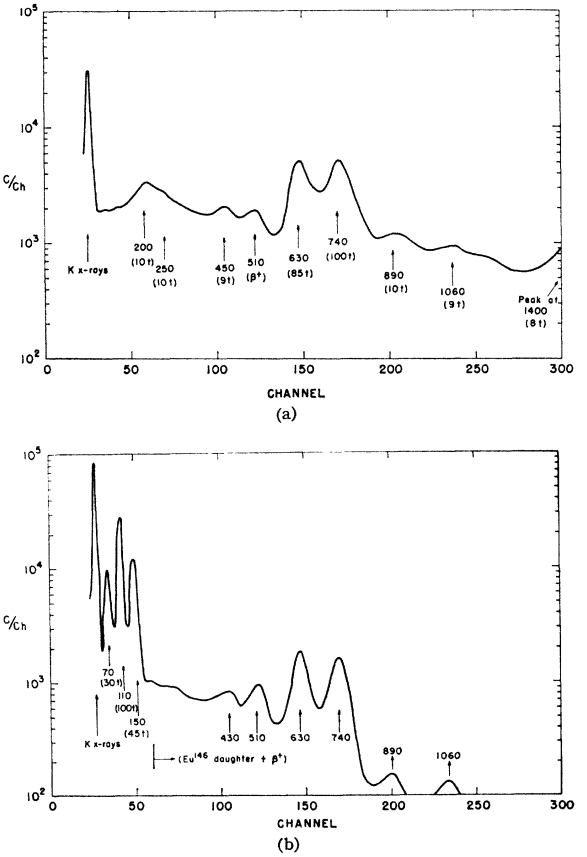

FIG. 2. (a) γ spectrum of Eu^{146} and (b) γ spectrum of Gd^{146}.

† Based on work performed under the auspices of the U. S. Atomic Energy Commission.

[1] R. W. Hoff, J. O. Rasmussen, and S. G. Thompson, Phys. Rev. 83, 1068 (1951).

No evidence of Gd^{145} decay was seen, indicating a half-life of less than 20 min for its decay.

II. Gd^{146}, Eu^{146}. The half-lives obtained for these isotopes, 50±0.5 days for Gd^{146} and 4.8±0.1 days for Eu^{146}, are in good agreement with the values of Gorodinskii *et al.*[2] No evidence of the 38-h activity reported by Hoff *et al.*[1] was found. The decay curve of the Eu indicates that not more than a 4% contribution of a 38-h activity could have been present. There was no noticeable change in the gamma spectrum over the first half-life.

Figure 2(a) is the gamma spectrum of Gd^{146} and 2(b) is the spectrum of Eu^{146}. The relative intensities and energies are listed below each peak. The 110-keV peak in Gd^{146} is a superposition of two gamma rays of that energy in coincidence with each other as reported by Gorodinskii.[2] The β^+/K x-ray ratio for Eu^{146} was found to be 0.10 and for Gd^{146} was 0.01.

III. Eu^{147}, Gd^{147}. The half-life obtained for Eu^{147} was 21.5±0.5 days as compared to 24 days found in reference 1. The half-life of Gd^{147} was found to be 1300±150 min (21.7±2.5 h). The larger error on this half-life was due to the fact that it had to be obtained by resolving the composite parent-daughter decay curve. Even so, it disagrees with the literature values[3,4] of 35 h and 29 h by more than the experimental error.

The gamma spectra and relative intensities are shown in Figs. 3(a) and 3(b). The β^+/K x-ray ratio for Eu^{147} was 0.01.

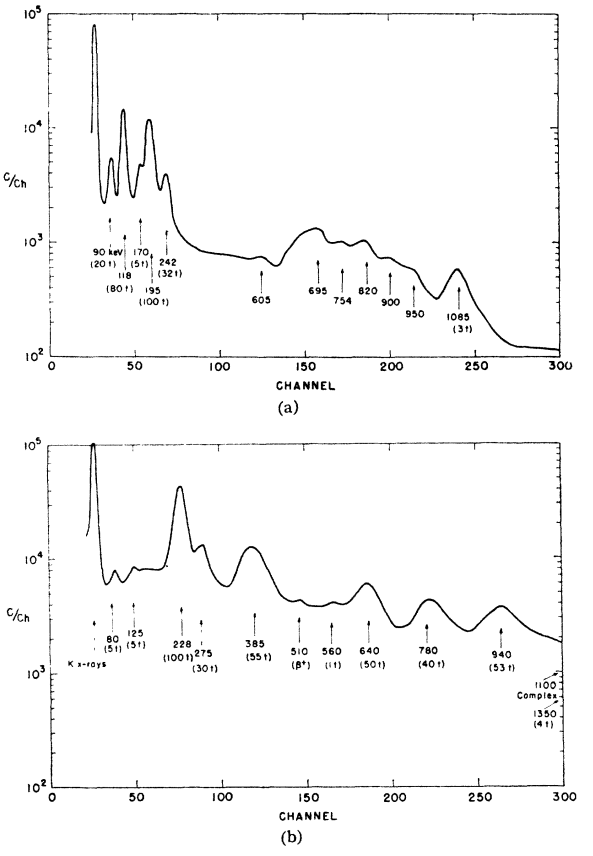

FIG. 3. (a) γ spectrum of Eu^{147} and (b) γ spectrum of Gd^{147}.

The authors would like to express their appreciation to the staff of the 60-in. cyclotron for their aid in performing the bombardment.

[2] G. M. Gorodinskii, A. N. Murin, and V. N. Pokrovskii, Izvest. Akad. Nauk. S.S.S.R. **22**, 811 (1958).

[3] N. M. Antaneva, A. A. Bashilov, B. S. Dzhelepov, and B. K. Preobrahzhenskii, Izvest. Akad. Nauk. S.S.S.R. **22**, 906 (1958).

[4] V. S. Shirley, W. G. Smith, and J. O. Rasmussen, Nucl. Phys. **4**, 395 (1957).