Radioactivity of Scandium 43

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The positron and photoelectron spectra of radioactive Sc^{43} have been investigated. A gamma-ray of 0.375±0.002 Mev and positron groups of 1.18±0.02 Mev and 0.77±0.04 Mev are assigned to the decay of Sc^{43}.

I. INTRODUCTION

PREVIOUS investigators have reported Sc^{43} to have a positron spectrum of 1.13 Mev[1] and a high energy gamma-ray.[1,2] Hibdon *et al.*[1] gives the energy of this gamma-ray as 1.65 Mev, whereas Walke[2] gives the energy as 1.0 Mev. Peacock and Deutsch[3] agree with this latter value.

For this investigation enriched $Ca^{43}CO_3$ (72.13 percent Ca^{43}, 5.17 percent Ca^{44}), obtained from Oak Ridge National Laboratory, was bombarded with ~7-Mev protons, and common $CaCO_3$ (97 percent Ca^{40}), of 99.97 percent purity, obtained from the Hach Chemical Company, was bombarded with ~20-Mev alpha particles in the Ohio State University cyclotron. Both the positron and photoelectron spectra have been investigated.

II. POSITRON SPECTRUM

Carrier-free samples of scandium produced by both the proton and alpha-bombardments were prepared in the following manner:

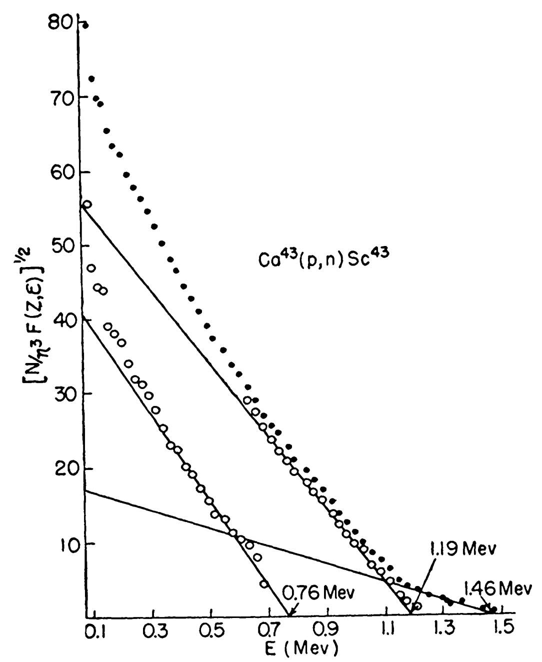

FIG. 1. Fermi plot of Sc^{43}.

The target material was covered with distilled water in a small beaker and was dissolved by the addition of a minimum amount of $3N$ hydrochloric acid. The solution was evaporated to dryness. This procedure was repeated twice more to insure the removal of radioactive fluorine. The residue was dissolved in 30 ml of $0.001N$ hydrochloric acid, titrated to pH 8.5 with $0.1N$ ammonium hydroxide, and filtered twice through Schleicher and Schuell Blue Ribbon filter papers. The filter papers, to which most of the scandium adhered, were washed thoroughly with a dilute solution of ammonium chloride, the pH of which was 8.5. The scandium was removed from the filter papers with boiling $3N$ hydrochloric acid, and the resulting solution was evaporated to a few drops. These were evaporated to dryness on a thin film of rubber hydrochloride, supported on an aluminum holder. The sample thickness was less than 0.7 mg/cm^2.

The positron spectrum of the active scandium produced by bombarding Ca^{43} with protons was studied in a solenoidal spectrometer. The Fermi plot for this spectrum, the data having been corrected for 3.9-hr half-life, is shown in Fig. 1.

Three components, obtained when the Fermi plot was analyzed, are shown. The highest energy component, having an end point of 1.46 Mev and relative abundance of 11 percent, is identified as belonging to 4-hr Sc^{44}.[4] The main component has an end point of 1.19 Mev, in fair agreement with the value of Hibdon *et al.*,[1] and a relative abundance of 71.5 percent. A third component, with a relative abundance of about 16 percent, has an end point energy of 0.76 Mev.

The positron spectrum of the scandium produced by bombarding Ca^{40} with alpha-particles was studied in a thick-lens spectrometer. The Fermi plot for this spectrum is shown in Fig. 2. The 1.46-Mev component is not observed in this case, showing that it does not belong to Sc^{43}. The first component has an end point of 1.18 Mev with a relative abundance of 76 percent, and the second component has an end point of 0.77 Mev with a relative abundance of 24 percent, in good agreement with the previous case.

In both cases the decay followed a 3.9-hr half-life in all regions of the spectrum for more than 20 hr after the start of measurements.

[1] Hibdon, Pool, and Kurbatov, Phys. Rev. **67**, 289 (1945).
[2] H. Walke, Phys. Rev. **57**, 163 (1940).
[3] W. C. Peacock and M. Deutsch, Phys. Rev. **69**, 306 (1946).
[4] J. A. Bruner and L. M. Langer, Phys. Rev. **79**, 606 (1950).

III. PHOTOELECTRON SPECTRUM

For the investigation of the photoelectron spectrum, the Ca^{43} was bombarded with $\sim$7-Mev protons. The sample was removed from the cyclotron target holder and placed in an aluminum source holder with sufficient thickness to cut out all positrons.

Figure 3 shows the photoelectron spectrum obtained with a thin lens spectrometer. It has been corrected for 3.9-hr half-life. A 21-mg/cm² uranium convertor was used for energies below 600 kev and a 40-mg/cm² uranium convertor was used for higher energies. In addition to the K and L annihilation peaks, a lower energy peak was observed, which decayed with a 3.9-hr half-life. This peak was also observed with a 17 mg/cm² lead convertor. From the positions of the peak with the lead and uranium convertors it is identified as the K-peak for a 375-kev gamma-ray. The only high energy gamma-ray which was observed was one with energy of 1.15 Mev. It is probably the 1.16-Mev gamma-ray reported by Bruner and Langer,[4] for Sc^{44}.

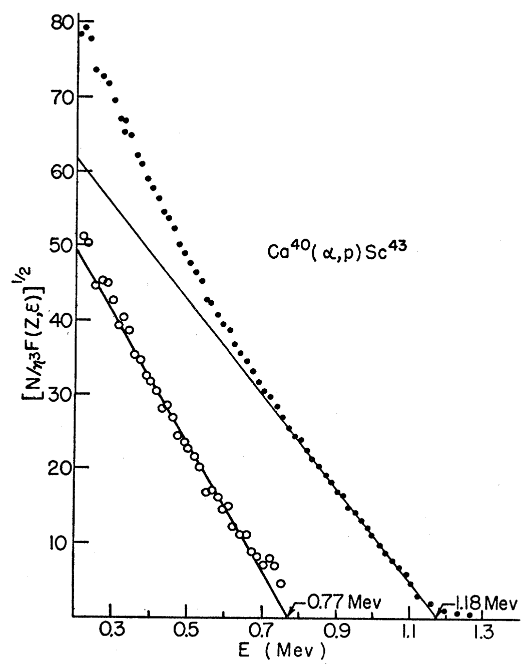

FIG. 2. Fermi plot of Sc^{43}.

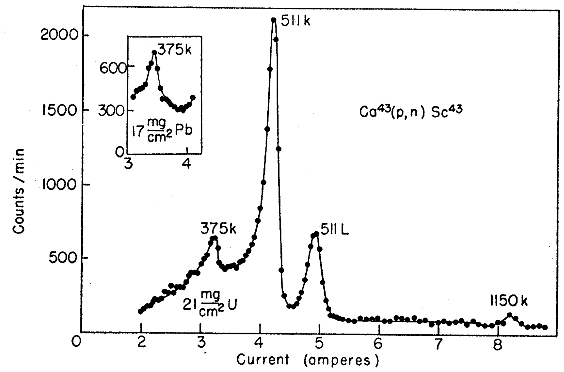

FIG. 3. Photoelectron spectrum of Sc^{43}.

IV. SUMMARY

The positron spectrum of Sc^{43} is complex with the main component having an end-point energy of 1.18 $\pm$0.02 Mev and the second component having an end-point energy of 0.77$\pm$0.04 Mev. The branching ratio of the decay of Sc^{43} is estimated, with the aid of the curves of Feenberg and Trigg[5] to correct for K-capture, to be 72 percent of the 1.18-Mev β_1^+K branch and 28 percent of the 0.77-Mev β_1^+K branch. The log(ft) values of the two β^+ components are 5.1 and 4.8, respectively.

A gamma-ray of 0.375$\pm$0.002 Mev is ascribed to the decay of Sc^{43}. No higher energy gamma-ray was found for Sc^{43}, and it is believed that if such a ray were present, it would have less than 15 percent relative abundance.

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[5] E. Feenberg and G. Trigg, Revs. Modern Phys. **22**, 399 (1950).