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Beta Decay of F^{17} and C^{11}†

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The beta decay of F^{17} and C^{11} has been investigated with a magnetic lens spectrometer. The positron spectrum of F^{17} consists of one component of maximum energy 1.748±0.006 Mev. The ground-state transition, comparative half-life $ft=2420$ sec, has the allowed shape down to 570 kev. Beta-ray branching to the first excited state of O^{17} at 874 kev, if present, has a relative intensity of less than one percent, corresponding to a comparative half-life $ft \gtrsim 2\times10^4$ sec. The positron spectrum of C^{11} consists of one component of maximum energy 968±8 kev. The ground-state transition, comparative half-life $ft=4170$ seconds, has the allowed shape down to 255 kev.

INTRODUCTION

IN the preceding paper (hereafter referred to as I) some results on the beta decay of F^{20} are reported. In this paper, a brief account will be given of the results obtained in investigating two mirror ("superallowed") transitions in the light elements. The beta decay of F^{17} has been investigated most recently by Perez-Mendez and Lindenfeld,[1] who report that the beta spectrum, end-point energy 1.72±0.03 Mev, deviates from linearity around 775 kev. This deviation from linearity is not due to beta-ray branching to the known 874-kev level in O^{17} since Perez-Mendez and Lindenfeld[2] report the absence of gamma radiation in the beta decay of F^{17}. In addition, Meyerhof[3] reports that in the beta decay of F^{17} less than one percent of the beta transitions result in gamma radiation. In the interest of establishing the linearity of the Fermi plot below 800 kev, and of determining more accurately the end point, it was felt that the beta spectrum of F^{17} should be remeasured. The beta spectrum of C^{11} has been measured by Townsend[4] and Siegbahn and Bohr.[5] They find a simple allowed spectrum with end point 0.981±0.005 and 0.993±0.010 Mev, respectively. It was felt that the C^{11} spectrum should be remeasured since the above-reported beta-ray end points are considerably higher than that expected from the $B^{11}(p,n)C^{11}$ threshold measurement. The threshold measurement reported by Richards and Smith[6] indicates a beta-ray end point of 0.958±0.003 Mev; the discrepancies thus lie outside the combined probable errors.

EXPERIMENTAL METHOD

Radioactive F^{17} ($\tau_{\frac{1}{2}}=66$ sec) was produced by the (d,n) reaction on O^{16}. PbO targets, evaporated on 0.15-mil aluminum foils, were bombarded with 2.1-Mev deuterons from the 3-Mev electrostatic generator. Radioactive C^{11} ($\tau_{\frac{1}{2}}=20.4$ min) was produced by the $B^{10}(d,n)C^{11}$ reaction. Thin B_2O_3 targets, having 0.15-mil aluminum backings, were bombarded with 1.77-Mev deuterons. The bombarding energy is below the $O^{16}(d,n)F^{17}$ threshold at 1.836 Mev[7] since F^{17} positrons would interfere with the measurement of the C^{11} spectrum. The spectra were normalized by directly comparing the counts at each point of the spectrum with that observed at a selected reference point. The targets were bombarded for a time comparable with the half-life, at the end of which the accelerator was shut down before the counting interval commenced. During the measurements, the half-life was carefully checked to insure that the positrons counted were from the F^{17} or the C^{11}. For a description of the beta-ray spectrometer and the scintillation counter detector, the reader is referred to I.

EXPERIMENTAL RESULTS

The observed positron spectrum from F^{17} is shown in Fig. 1, while the corresponding Fermi plot is shown in Fig. 2. An average of three independent determinations gave an end-point energy of 1.748±0.006 Mev. The C^{11} positron spectrum is displayed in Fig. 3, while the

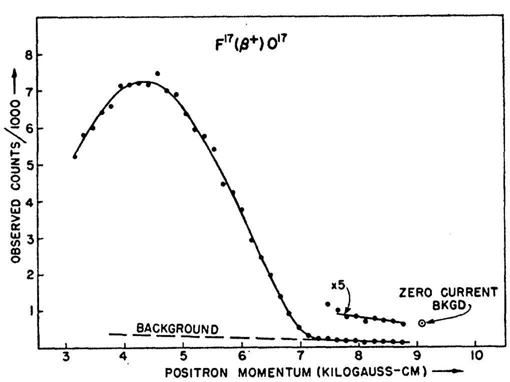

FIG. 1. Positron spectrum from the beta decay of F^{17}. The spectrum has not been corrected for background, i.e., the zero-current background has not been subtracted.

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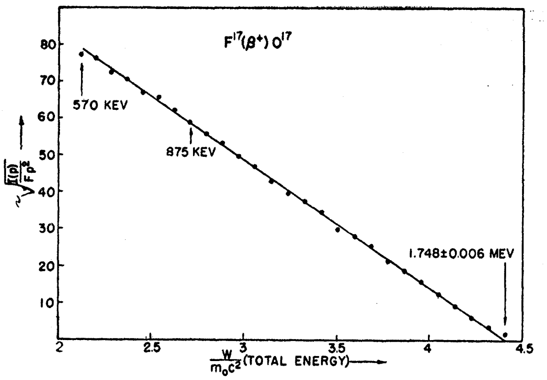

FIG. 2. Fermi-Kurie plot of the F^{17} positron spectrum.

corresponding Fermi plot is shown in Fig. 4. An average of three independent determinations gave an end-point energy of 968±8 kev. For both spectra, the least-squares solutions agree with the graphical ones to within 2 kev. It is of interest to note that the high-energy background tail of Figs. 1 and 3 is very similar to that which is observed with the F^{20} electron spectrum. This suggests, as is shown in I, that the slightly field-sensitive background is instrumental in origin, i.e., is attributed to the small degree of scattering present. However, the major part of the background correction is attributed to the constant zero-current background which has not been subtracted in Figs. 1 and 3. The method of background subtraction and analysis is similar to that described in I.

DISCUSSION

The Fermi plot of Fig. 2 is linear from the end point down to an energy of 570 kev. If the beta spectrum were complex, a deviation from linearity should occur around 875 kev. Since this is not observed experimentally, it is concluded that the spectrum is simple, and that the deviation from linearity observed in reference 1 is presumably due to scattered positrons caused perhaps by excessive source thickness. From an examination of the Fermi plot, an upper limit can be put on the transition to the known 874-kev level in O^{17}. If the excited-state transition does occur, its intensity is less than 1 percent (assuming an allowed shape for the excited-state component). The experimentally determined half-life of 66.0±1.8 sec coupled with the end-point determination gives an *ft* value of 2420 sec for the ground-state transition. The low *ft* value and the straight-line Fermi plot show that the transition is "superallowed." From the upper limit for the branching ratio, the minimum *ft* value for the excited-state transition is approximately 2×10^4 sec. This minimum estimate is reasonable since the assignment of spins and parities[8] predicts a second forbidden transition, *ft* of the order of 10^{13} sec.[9] The 1.748±0.006 Mev end point is in agreement with the 1.745±0.006 Mev expected from the *Q* values for the $O^{16}(d,n)F^{17}$ and $O^{16}(d,p)O^{17}$ reactions.[10]

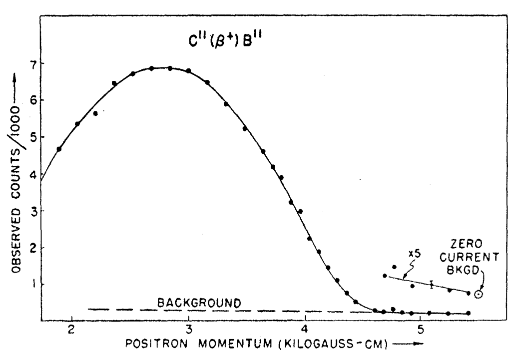

FIG. 3. Positron spectrum from the beta decay of C^{11}. The spectrum has not been corrected for the zero-current background.

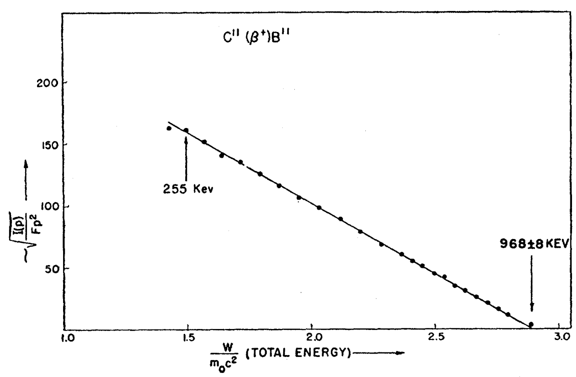

FIG. 4. Fermi-Kurie plot of the C^{11} positron spectrum.

The C^{11} Fermi plot, Fig. 4, is linear from the end-point down to 255 kev. The end-point energy of 968 kev coupled with a half-life of 20.4 min gives an *ft* value of 4170 sec for the ground-state transition. Hence the *ft* value and the allowed shape of the spectrum confirm the "superallowed" nature of the transition (C^{11} and B^{11} are mirror nuclei). The *ft* value lies within the accepted range for mirror transitions: *ft* between 1000–5000 sec. The 968±8 kev end point agrees with that expected from the $B^{11}(p,n)C^{11}$ threshold measurement within the combined probable errors.

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