K Capture to Positron Ratio for Na^{22}

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The ratio of electron capture to positron emission from Na^{22} to the 1.28-Mev excited state of Ne^{22} has been measured by determining the relative number of 1.28-Mev and 0.511-Mev gamma rays from this decay. The gamma-ray intensities were measured with a 4-in. by 4-in. NaI(Tl) scintillation spectrometer and a collimated geometry. Photopeak areas were determined for the two gamma-ray energies, and using photopeak to total areas previously determined and NaI absorption coefficients, the ratio of gamma-ray intensities was calculated. The results showed that 11.0±0.9 percent of the disintegrations to the excited state of Ne^{22} are not accompanied by the emission of two 0.511-Mev quanta, and therefore decay by orbital electron capture.

THE decay of Na^{22} provides a very convenient source of monoenergetic gamma rays in the one-Mev region. Decay schemes previous to the recent papers by Sherr and Miller[1] and by Maeder, Müller, and Wintersteiger[2] indicated a positron decay without orbital electron capture to an excited state of Ne^{22}, which then decayed to the ground state with the emission of a 1.28-Mev gamma ray. There would thus be two 0.511-Mev quanta for each 1.28-Mev gamma ray.

In our experiment, the relative number of 0.511-Mev and 1.28-Mev quanta was measured with a scintillation spectrometer. By this means, it was possible to determine how many of the decays from the excited state to the ground state with the emission of 1.28-Mev gamma rays were not accompanied by the emission of two 0.511-Mev gamma rays. This would indicate the number of disintegrations to the excited state of Ne^{22} which went by K capture rather than positron emission.

A 4-in. diameter by 4-in. long NaI crystal with a lead shield and collimating hole was used as the gamma detector. The crystal was optically coupled to a 2-in. Dumont 6292 photomultiplier tube. The collimator was six inches of lead with a hole having a $1\frac{1}{4}$-in. diameter at the crystal end and a 1-in. diameter at the source end. The pulse spectrum was analyzed by an automatic recording single-channel pulse-height analyzer.

The source used was $Na^{22}Cl$ deposited on a quarter-centimeter diameter thin disk of aluminum. This source was surrounded with 0.9 mm of Al which served to stop all the positrons. The source was placed at the apex of the cone formed by the collimator walls. The pulse spectrum taken with the Na^{22} source and the detector described is shown in Fig. 1. In order to determine relative strengths of the two monoenergetic gamma rays emitted, the photopeak areas were measured.

In the crystal of this size, the photoelectric peak response is considerably enhanced by the addition of pulses occurring when an incident gamma-ray Compton scatters and then has its scattered gamma-photon photoelectrically absorbed within the crystal. While the absolute detection efficiency in the whole pulse spectrum for such a crystal and geometry can be calculated from the NaI absorption coefficients, it is necessary to determine the photopeak efficiency at a

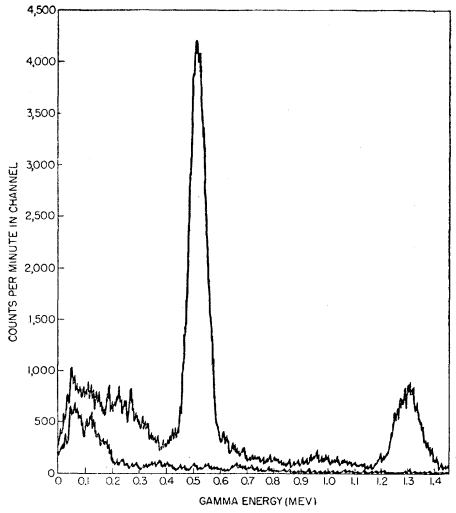

FIG. 1. Scintillation spectrometer pulse spectrum for gamma rays from Na^{22} decay. Detector: 4-in. diameter×4-in. NaI crystal; collimated geometry; single-channel analyzer; and automatic recording.

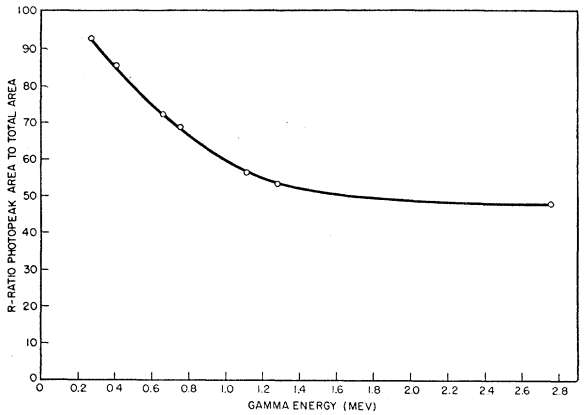

FIG. 2. Ratio of photopeak area to total area for a NaI scintillation spectrometer 4 in. in diameter and 4 in. long with collimated geometry. The source is on the axis of the crystal.

[1] R. Sherr and R. H. Miller, Phys. Rev. **93**, 1076 (1954).
[2] Maeder, Müller, and Wintersteiger, Helv. Phys. Acta **27**, 3 (1954).

given energy, either experimentally or by a rather involved calculation.

We have measured the relative photopeak efficiencies for the geometrical spectrometer arrangement discussed above for six monoenergetic gamma rays. This photopeak efficiency is shown in Fig. 2. From the results of this experiment, it was possible to calculate relative strengths of the two gamma rays present from the decay of Na^{22}. With the source solid angle the same for both gammas, the ratio of strengths of the two gammas is given by

$$\frac{\gamma_1}{\gamma_2}=\frac{\{1-\exp[-\mu(E_1)x]\}\{F(E_1)\}\{A(E_1)\}}{\{1-\exp[-\mu(E_2)x]\}\{F(E_2)\}\{A(E_2)\}},$$

where F is the photopeak efficiency and A is the photopeak area. A correction to source strengths for the difference in absorption in 0.9 mm of Al was calculated. The calculation of relative source strengths for the two gamma rays showed that (11.0±0.9) percent of the disintegrations to the excited state of Ne^{22} are not accompanied by the emission of two 0.511-Mev quanta, and therefore decay by orbital electron capture. This result agrees with the values (9.9±0.6) percent obtained by Sherr and Miller[1] and (11.5±5) percent obtained by Maeder *et al.*[2]

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Decay of $_{32}Ge^{75m}$ (49 sec), $_{32}Ge^{77m}$ (52 sec), and $_{32}Ge^{77}$ (12 hr)

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The investigations herein described have been carried out by using a scintillation coincidence spectrometer and 180° focusing magnetic spectrographs. Sources are prepared by the activation of both normal germanium and the enriched isotopes thereof in the Argonne reactor (CP-3′). Three of the neutron-induced activities of germanium are studied.

$_{32}Ge^{75m}$ *(49 sec):* The half-life and isotopic assignment of the activity are confirmed. From internal-conversion measurements, the energy of the isomeric transition is found to be 138.5±1.0 kev, and the K/L ratio estimated to be ~3.

$_{32}Ge^{77m}$ *(52 sec):* The isotopic assignment of the activity is confirmed and the half-life measured to be 52±2 seconds. The isomeric state of Ge^{77} decays by three branches: an isomeric transition of 159±3 kev to the ground state of Ge^{77}, an ~2.7-Mev beta ray to a 215±3-kev excited state of As^{77}, and an ~2.9-Mev beta ray to the ground state.

$_{32}Ge^{77}$ *(12 hr):* From the scintillation spectrometer measurements, the presence of eighteen gamma rays is deduced. Though beta-gamma and gamma-gamma coincidence experiments these are incorporated into a decay scheme which includes the 52-second isomeric state of Ge^{77} and nine excited states of As^{77}.

APPARATUS AND METHODS

NORMAL germanium has been found to consist of five stable isotopes. Neutron capture in three of these results in the formation of Ge^{71} (11 day), Ge^{75m} (49 sec), Ge^{75} (80 min), Ge^{77m} (52 sec), and Ge^{77} (12 hr). Previous studies of these activities have not been exhaustive. We have undertaken to investigate the two metastable states, Ge^{75m} and Ge^{77m}, and the 12 hour activity of the ground state of Ge^{77}.

The scintillation coincidence spectrometer[1] employed in this study is composed of two independent spectrometers, one incorporating a ten-channel pulse-height analyzer, and the other a single-channel analyzer. The ten-channel analyzer is used independently to examine the "normal" pulse-height distribution associated with the source, while both analyzers are employed to search for various coincidence combinations of the peaks found in the normal spectrum. In examining a normal gamma-ray spectrum, the sources are placed approximately six inches from the detecting crystal, and a collimator is interposed. (The collimator consists of a 2-in. lead block through which a $\frac{3}{4}$-in.-diameter hole is bored.) These arrangements serve two purposes: to increase the amplitude of the "photopeak" relative to the Compton distribution and to eliminate the possibility of "sum" peaks caused by the simultaneous detection of two coincident radiations. Many operational details of this instrument have been previously discussed.[2]

The efficiency and resolution of the scintillation coincidence spectrometer have been improved by the installation of larger NaI(Tl) crystals than those previously used and by replacing the R.C.A. type 5819 photomultipliers with Dumont type 6292 tubes. (The resolution is now about 8 percent for the 662-kev gamma ray of Cs^{137}.) The new crystals are nearly cubic,

[1] S. Burson and W. Jordon, Phys. Rev. **91**, 498 (1953).

[2] Burson, Jordon, and LeBlanc, Phys. Rev. **94**, 103 (1954).