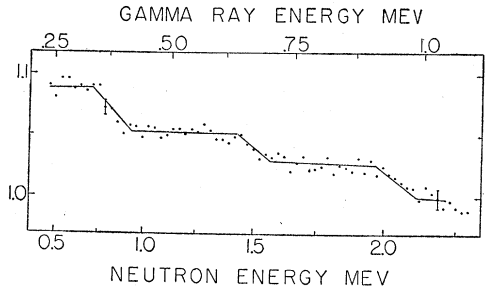


FIG. 8. Ratio plot for $Bi^{209}$.

### Bismuth-209

Gamma rays from the de-excitation of $Bi^{209}$ were observed at 1.66±0.05 and 0.899±0.022 Mev. The neutron ratio plot shown in Fig. 8 has steps at neutron energies of 1.49±0.06 and 0.80±0.07 Mev. These neutron energies correspond to levels at 0.99±0.06 and 1.68±0.07 Mev. Also present in the ratio plot is a step corresponding to the Compton edge of a 0.92±0.03 Mev gamma ray. No coincidence measurements were made.

The foregoing data suggest levels at 0.90±0.03 and 1.66±0.05 Mev; these levels have been observed by various other workers.[1,3–6,32]

A rather careful search was made in the region from 0.4 to 0.6 Mev in the gamma-ray spectra but no transition corresponding to the 0.46-Mev transition reported by Scherrer, Allison and Faust[1] or the 0.50-Mev isomeric state seen by Vegors and Axel[33] could be seen. Of course, detection in this region is made difficult by the 0.44-Mev photopeak in $Na^{23}$ and the Compton edge due to the 0.63-Mev gamma ray in $I^{127}$.

#### ACKNOWLEDGMENTS

We are grateful to Mr. Douglas McNutt who did much work in building the neutron source and to Mr. Naren Bali, Mr. Russell Snyder, and Mr. Ronald Callen who performed earlier $(n,n'\gamma)$ experiments at this laboratory. The authors also wish to extend their thanks to Mr. John Chambers who prepared the figures and performed much of the data reduction.

[32] M. A. Rothman and C. E. Mandeville, Phys. Rev. **93**, 796 (1954); R. M. Kiehn and C. Goodman, Phys. Rev. **93**, 177 (1954).
[33] S. H. Vegors and P. Axel, Phys. Rev. **101**, 1067 (1956).

PHYSICAL REVIEW VOLUME 110, NUMBER 4 MAY 15, 1958

# Decay of Tellurium-132†

G. D. CHEEVER,* W. S. KOSKI,* D. R. TILLEY,‡ AND LEON MADANSKY‡
*The Johns Hopkins University, Baltimore, Maryland*
(Received January 31, 1958)

The decay of $Te^{132}$ produced by fission of uranium has been investigated by using a scintillation spectrometer. In addition to the previously reported 0.23-Mev gamma ray and the iodine $K$ x-ray, a 0.053-Mev gamma ray has been observed. Coincidence measurements permitted the determination of $K$-shell conversion coefficients for the two transitions. Probable decay schemes compatible with the observations are discussed.

THE seventy-five hour[1] beta decay of $Te^{132}$ to $I^{132}$ was first observed by Abelson.[2] In more recent experiments[3–5] the beta end-point energy has been found to be 0.22 Mev and a gamma ray of 0.23 Mev has been observed. Work in this laboratory has revealed, in addition, the presence of a 0.053-Mev gamma ray. The results obtained on the gamma spectra and various coincidence measurements are reported briefly in this paper.

$Te^{132}$ was produced by bombarding an aqueous solution of uranyl acetate with neutrons obtained from the

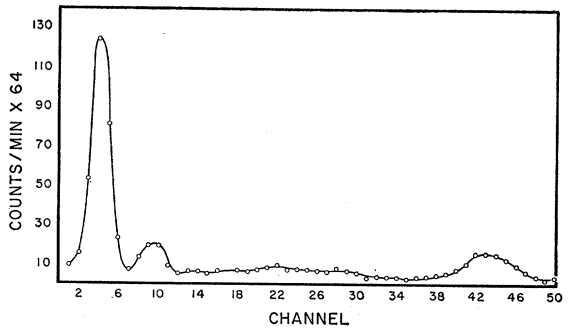


FIG. 1. Gamma-ray spectrum from $Te^{132}$, showing the 0.028-Mev iodine $K$ x-ray and the 0.053-Mev and 0.23-Mev gamma rays.

† Work done under the auspices of the U. S. Atomic Energy Commission.
* Department of Chemistry.
‡ Department of Physics.
[1] W. H. Fleming and H. G. Thode, Can. J. Chem. **34**, 408 (1956).
[2] P. H. Abelson, Phys. Rev. **56**, 1 (1939).
[3] H. J. Born and W. Seelman-Eggebert, Naturwissenschaften **31**, 201 (1943).
[4] Novey, Sullivan, Coryell, Newton, Sleight, and Johnson, *Radiochemical Studies: The Fission Products* (McGraw-Hill Book Company, Inc., New York, 1950), Paper No. 135, National Nuclear Energy Series, Plutonium Project Record, Vol. 9, Div. IV, Book 2.
[5] L. M. Langer and G. Ford (private communication), reported in Hollander, Perlman, and Seaborg, Revs. Modern Phys. **25**, 469 (1953).

irradiation of beryllium with 3-Mev deuterons. The tellurium was separated from the rest of the fission products by the method previously described by Glendenin.[6] In this procedure the tellurium is reduced to the elementary form by passing $SO_2$ into the hot acidic solution of irradiated uranyl acetate. Treatment with concentrated HBr assured the removal of selenium. The tellurium so processed was dissolved in nitric acid and then reduced again with $SO_2$. After several such oxidation-reduction cycles the tellurium was free of complicating impurities.

The gamma rays from $Te^{132}$ were examined with a packaged NaI(Tl) scintillation counter which was calibrated with the 0.123-Mev $Co^{57}$ gamma ray, the 0.087-Mev $Cd^{109}$ gamma ray, and the 0.032-Mev x-ray from $Cs^{137}$.

For the gamma-ray coincidence measurements a 2×1×1-centimeter NaI(Tl) crystal covered by 2 millimeters of Lucite to eliminate the electrons was used in conjunction with a 20-channel analyzer to detect the x-ray and 0.053-Mev gamma ray. The analyzer was gated with a resolving time of 1 microsecond by a pulse from another scintillation counter set on the photopeak of the 0.23-Mev gamma ray. Coincidence spectra were also obtained by gating with the 0.053-Mev gamma ray and the x-ray.

For the beta-ray measurements the source was mounted directly on a terphenyl plastic scintillator, and the beta spectra in coincidence with the 0.23-Mev gamma ray, the 0.053-Mev gamma ray, and the iodine $K$ x-ray were obtained in three successive measurements.

The singles spectrum of the gamma rays from $Te^{132}$ is shown in Fig. 1. In addition to the 0.23-Mev gamma ray previously reported[3–5] and the 0.028-Mev iodine $K$ x-ray, there appears a third peak representing a gamma ray of energy 0.053±0.005 Mev. All three peaks were found to decay with a half-life of 77±5 hours.

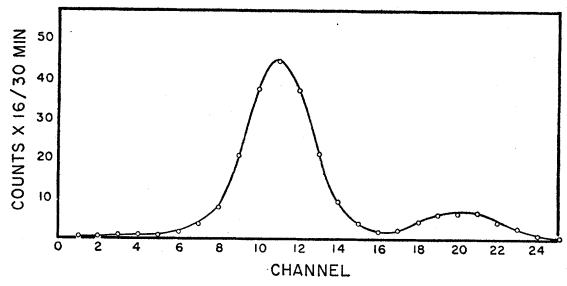


FIG. 2. Spectrum of the iodine $K$ x-ray and the 0.053-Mev gamma ray as it appears in coincidence with the 0.23-Mev gamma ray.

[6] L. E. Glendenin, *Radiochemical Studies: The Fission Products*, (McGraw-Hill Book Company, Inc., New York, 1951), National Nuclear Energy Series, Plutonium Project Record, Vol. 9, Div. IV, Book 3.

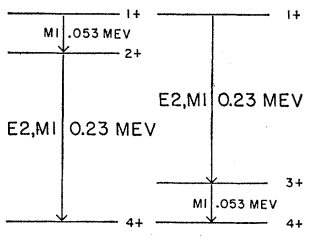


FIG. 3. Probable energy-level schemes in $I^{132}$.

Figure 2 shows the spectrum of the 0.053-Mev gamma ray and the x-ray as it appears in coincidence with the 0.23-Mev gamma ray.

The beta spectra that were observed in coincidence with the gamma rays and x-ray were distorted because of the thickness of the source and backscattering from the crystal face and the source backing. However, each of the spectra has an end point consistent with the reported beta energy of 0.22 Mev.[2–5] There is no indication of any beta branching, although the data are too crude to rule out a branch differing in energy by 0.053 Mev from the predominant branch.

If no branching of the beta transition is assumed, a simple decay scheme with the 0.23-Mev and 0.053-Mev transitions in cascade is indicated. On the basis of this scheme and the gamma-gamma coincidence data, it is possible to compute the $K$-shell conversion coefficients for the two transitions. It was necessary to correct the data for the relative detection efficiencies of the NaI(Tl) crystals for the 0.23-, 0.053-, and 0.028-Mev radiations, and the $K$-shell fluorescence yield in iodine.[7]

For the 0.053-Mev transition the $K$-shell conversion coefficient computed from the coincidence data is $\alpha_K=5.35\pm0.22$ which agrees well with the value of 5.13 for $M1$ radiation from Rose's tables.[8] The value measured for the 0.23-Mev transition is $\alpha_K=0.05\pm0.04$. This is consistent with Rose's values of 0.078, 0.082, and 0.019 for $M1$, $E2$, and $E1$ radiation, respectively.

From the decay of $I^{132}$ the most likely assignment for the ground state is 4+.[9,10] If no beta branching is assumed the $M1$ assignment for the 0.053-Mev transition together with the classification of the beta transition as allowed ($\log_{10}ft=4.6$) indicate for the most likely level sequence either 4+, 2+, 1+, or 4+, 3+, 1+, depending on which transition comes first in the decay. Both schemes are shown in Fig. 3. An experiment including lifetime measurements, angular correlations, and a search for additional beta branches is in progress.

[7] C. E. Roos, Phys. Rev. **93**, 401 (1954).
[8] Rose, Goertzel, and Perry, Oak Ridge National Laboratory Report, ORNL-1023, 1951 (unpublished).
[9] H. L. Finston and W. Bernstein, Phys. Rev. **96**, 71 (1954).
[10] G. Scharff-Goldhaber (private communication).