Title
BETA DECAY OF Np238

Authors
Rasmussen, John O.
Passell, Thomas O.
Stephens, Frank

Publication Date
1954-05-12

UCRL-2585
UNCLASSIFIED

UNIVERSITY OF CALIFORNIA

Radiation Laboratory

BERKELEY, CALIFORNIA

UCRL-2585

UNIVERSITY OF CALIFORNIA

Radiation Laboratory

Contract No. W-7405-eng-48

BETA DECAY OF Np^{238}

John O. Rasmussen, Jr., Thomas O. Passell and Frank Stephens, Jr.

May 12, 1954

Berkeley, California

Beta Decay of Np^{238}

John O. Rasmussen, Jr., Thomas O. Passell and Frank Stephens, Jr.
Radiation Laboratory and Department of Chemistry
University of California, Berkeley, California

May 12, 1954

This note is to report certain recent results obtained here regarding the high energy conversion line spectrum and beta-gamma and gamma-gamma coincidences in the beta decay of Np^{238}. The beta spectroscopic work of Freedman, Jaffey, and Wagner[1] as reinterpreted by Mihelich[2] found conversion lines of gamma rays of 43, 103, 983, and 1030 kev energy and a two component beta spectrum of 1272 and 258 kev. The recent work of Slätis, Rasmussen, and Atterling[3] confirmed these transitions with energies remeasured as 44.1, 102.1, 986, and 1029 kev. In addition they found weaker K conversion lines corresponding to transitions of 939 and 925 kev, the latter being somewhat doubtful because of its low intensity.

In the present study we obtained an intense source of Np^{238} by irradiation of Np^{237} with neutrons in the MTR reactor, Arco, Idaho. The irradiated neptunium was carefully purified by a chemical procedure involving an oxidation-reduction cycle.[4]

The region of the high energy conversion lines was examined repeatedly, using the $\pi\sqrt{2}$ double-focusing spectrometer[5] at 1.2 percent resolution. No new conversion lines were found in the momentum region most carefully examined (3530-5000 gauss cm) but the four transitions reported in the Stockholm work[3] were definitely confirmed. Table 1 gives the differences in $H\rho$ between the four high energy K lines on several runs. The Berkeley spectrometer is not set up to measure the absolute energies as well as the Stockholm instrument. Thus, we take the K line energy of γ_{986} as a standard but feel that the energy differences determined in the Berkeley work should be superior by virtue of the much stronger Np^{238} source used.

Table 1

Energy Difference Measurements of High Energy K Lines

E_K Stockholm[3] measured energy (kev)	$\Delta H\rho$ (gauss cm) Run 1	Run 2	Run 3	Run 4	$\Delta H\rho$ Average	ΔE Average	E_K Revised	E_γ[a]
907.2							907.6	1029.3
	156	156	154	152	154.8	43.2		
864.4							864.4	986.1
	158	159	161	164	160.5	44.6		
817.2							819.8	941.5
	b	58	51	48	52.3	14.5		
802.8							805.3	927.0

[a] Assuming K binding energy of plutonium to be 121.7 kev.

[b] Run 1 did not extend to low enough energy for this difference.

It is seen that only one energy difference is significantly different from the Stockholm work, namely that between the second and third (in energy) gamma rays, which is lower by 2.6 kev. With the new energy differences it seems more likely that γ_{986} and γ_{942} rather than γ_{1029} and γ_{986} proceed from a common level to ground and first excited states, respectively.

Beta-gamma coincidence studies of the beta spectrum (scintillation counter) in coincidence with electromagnetic radiation around 100 kev show predominantly the soft beta continuum and are consistent with no hard beta continuum coincidences at all. This is at variance with the report of Freedman et al.[1] that 100 kev radiation is in coincidence with hard beta particles. However, a sensitive coincidence measurement should detect coincidences between K x-rays and energetic conversion electrons. Our results suggest that the 146.2 kev level, which gives rise to the 102.1 kev gamma ray, is mainly populated by a high energy gamma transition. When measurements of the gamma spectrum in coincidence with electromagnetic radiation in the 100 kev region were made (using sodium iodide phosphors), they showed a high energy gamma peak definitely shifted to the low side of the unresolved peak in the 1 Mev region seen without coincidence. From these coincidence spectra we estimate the energy of the coincident gamma ray as 920 ± 25 kev. It seems likely that γ_{927} is this gamma ray. Energetically, $\gamma_{1029.3}$ fits well as the transition between the postulated 1073.4 kev level and the 44.1 kev level. (See Fig. 1.)

A coincidence determination of the fraction of hard beta particles in the continuum which are in coincidence with L x-rays was made.

L x-ray-alpha particle coincidence measurements were also made with Cm^{242} in order to eliminate fluorescence yield and absorption corrections from the calculations. Using the L/(M+N+O) ratio of 3.27[3] for conversion electrons of the 44.1 kev transition, these coincidence measurements indicate that 72 ± 7 percent of the hard beta particles cascade through the first excited state and 28 ± 7 percent go directly to ground.

We are led by these results to postulate the following decay scheme for Np^{238}:

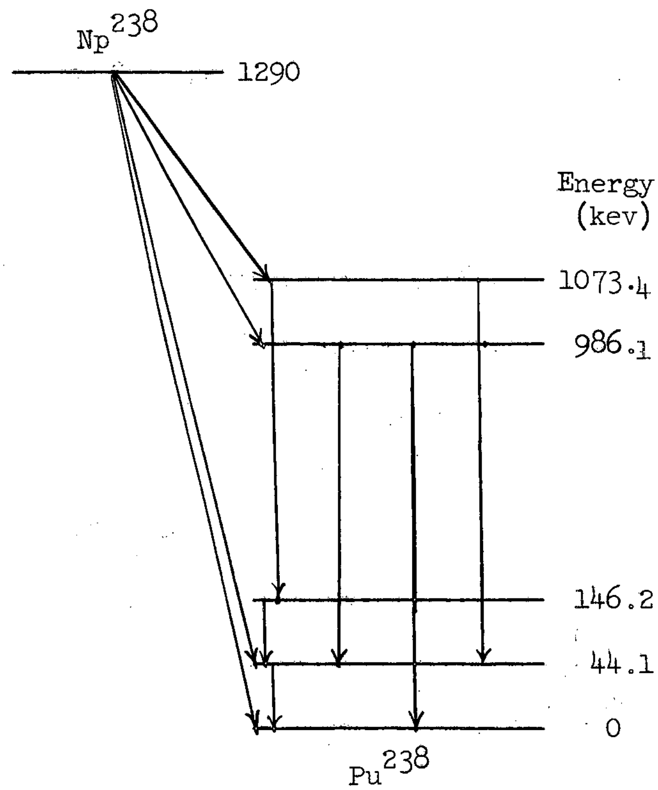

Fig. 1. Beta Decay Scheme of Np^{238}

We wish to thank Drs. Richard Smith, W. B. Lewis, and others of the MTR reactor group for facilitating the irradiation of neptunium. We are grateful to Donald Strominger and Peter Gray for their help with the chemical separations and the counting.

This work was performed under the auspices of the U.S. Atomic Energy Commission.

---

[1] Freedman, Jaffey, and Wagner, Phys. Rev. 79, 410 (1950).

[2] J. W. Mihelich, Phys. Rev. 87, 646 (1952).

[3] Slätis, Rasmussen, and Atterling, Phys. Rev. 93, 646 (1954).

[4] Magnusson, Thompson, and Seaborg, Phys. Rev. 78, 363 (1950).

[5] G. D. O'Kelley, Ph.D. Thesis, University of California Radiation Laboratory Unclassified Report UCRL-1243 (May 1951)(unpublished).