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COUNTING EFFICIENCY OF Np239

Author
Neumann, H.M.

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COUNTING EFFICIENCY OF Np^{239}

H. M. Neumann

August 1, 1950

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Carbide & Carbon Chemicals Division (Y-12 Plant)	19
General Electric Company, Richland	20-25
Hanford Operations Office	26
Iowa State College	27
Kellex Corporation	28
Knolls Atomic Power Laboratory	29-32
Los Alamos	33-35
Mound Laboratory	36-38
Naval Radiological Defense Laboratory	39
NEPA Project	40
New York Operations Office	41-42
Oak Ridge National Laboratory	43-48
Patent Branch, Washington	49
Technical Information Division, ORE	50-64
UCLA Medical Research Laboratory (Warren)	65
University of California Radiation Laboratory	66-68
University of Rochester	69-70
Total	70

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COUNTING EFFICIENCY OF Np^{239}

H. M. Neumann
Radiation Laboratory and Department of Chemistry
University of California, Berkeley, California

Aug. 1, 1950

The counting efficiency of the radiations from Np^{239} has been determined using the various beta-counters commonly used in this laboratory. The determinations were performed by comparing the counting rate of an aliquot of purified Np^{239} with the alpha-disintegration rate of the Pu^{239} resulting from its decay.

Four independent experiments were performed. In three, the Np^{239} was produced by neutron-irradiation of uranium, and $\sim 4 \times 10^8$ disintegrations/min. of Np^{239}, resulting in ~100 disintegrations/min. of Pu^{239}, were involved. In the fourth, a less reliable experiment, uranium was irradiated with deuterons, the neptunium formed in bombardment quickly removed, and Np^{239} allowed to form from the decay of U^{239}. The amounts of Np^{239} and Pu^{239} involved in this experiment were about one-fourth of the amounts present in the other experiments.

The purification of neptunium was accomplished by various combinations of LaF_3 precipitation under oxidizing and reducing conditions, passage through anion exchange resin and extraction with thenoyltrifluoroacetone. After purification, aliquots were mounted in several different ways, and the counting rates of these samples measured. Samples with what was assumed to be negligible backing were mounted on 1.9 mg/cm^2 mica and 2.5 mg/cm^2 cellophane. Samples were also mounted on a number of the commonly used backings; platinum (103 mg/cm^2), stainless steel (218 mg/cm^2), and glass (39.2 mg/cm^2). Generally, 10λ of solution was mounted, and the resulting sample was a circle of about 5 mm diameter.

Two types of end-window Geiger tubes were used. One type, hereafter referred to as Argon type, was filled with an argon-ethanol mixture (9 cm argon-1 cm ethanol), and had a window diameter of 3.05 cm and a window thickness of 2.7 mg/cm^2. The other type, hereafter referred to as Amperex type, was filled with an argon-chlorine mixture, and had a window diameter of 2.75 cm and a window thickness of 3.5 mg/cm^2. Two Amperex type tubes and three Argon type tubes were used and the results given are averaged values. The counts were taken inside the customary lead chamber at five standard shelf positions. The samples were supported on the shelves by 1 mm thick cardboard. In the case of the mica and cellophane backings, a 4.4 cm diameter hole was cut in the cardboard support so that no cardboard was under the sample. The distance from sample to window, and the total absorber (air plus window) for each of the five positions is given in Table II. Counts were also taken in a windowless counter commercially known as the Nucleometer.

The consistency of the four experiments is shown by the data of Table I.

Table I

Activity of Np^{239} at time of purification (counts/minute on shelf 2, Amperex tube, Pt backing)	Amount of Pu^{239} resulting from complete decay (disintegrations/minute)	Activity of Np^{239} at time of purification (disintegrations/minute)	Disintegrations per count (under stated conditions)
3.12×10^7	110	4.16×10^8	13.3
2.56×10^7	94	3.55×10^8	13.9
4.17×10^7	147	5.55×10^8	13.3
7.73×10^6	27	1.02×10^8	13.2

The first two experiments listed are considered to be superior, and a weighted average of all four results gives a value of 13.5 disintegrations per count.

The complete results are shown in Table II.

Table II

Amperex tubes (3.5 mg/cm^2 window)

Shelf	Distance from window to sample (cm)	Distance from window to sample: Total abs. (mg/cm^2)	No. of disintegrations per observed count: Platinum backing	No. of disintegrations per observed count: Negligible backing (2 mg/cm^2)	Assumed geometry	Absorption correction	Electrons per disintegration	
1	0.38	4.0	3.58	6.26	15%	1.37	1.46	
2	1.97	5.9	13.5	23.6	5.5%	1.60	1.23	
3	3.56	7.8	34.7	60.7	2.4%	1.86	1.28	1.25 Average
4	5.15	9.7	71.9	126	1.4%	2.16	1.22	
5	6.74	11.6	125	219	0.9%	2.49	1.26	
			Argon tubes (2.7 mg/cm^2 window)					
1	0.35	3.1	1.90	3.33	31%	1.28	1.24	
2	1.94	5.0	6.11	10.7	11.4%	1.49	1.22	
3	3.53	6.9	15.3	26.8	5.0%	1.74	1.30	1.34 Average
4	5.12	8.8	30.2	52.9	2.8%	2.02	1.36	
5	6.71	10.8	53.9	94.4	1.7%	2.36	1.47	

Nucleometer: 1.00 counts/disintegration (off Pt backing)

The values listed under "assumed geometry" are averaged values of geometry measurements made by a number of workers in this laboratory. These measurements were ordinarily made with weighed uranium standards. The area covered by these standards was ~1 sq cm, an appreciably larger area than the 0.2 sq cm area covered by the Np^{239} samples. The geometry for the Np^{239} samples might then be expected to be somewhat greater for a given shelf. This effect probably accounts for the higher counting rate observed with the amperex tube with the sample on shelf 1.

The electrons per disintegration value is calculated from the assumed geometry, absorption correction, and disintegration per count ratio for sample with negligible backing. The absorption correction was obtained from the lower curve of Fig. 1. The backing material and geometry apparently have little effect on the shape of the absorption curve at small absorber thicknesses, as evidenced by the three curves of Fig. 1.

The back-scattering factors for the various mountings used are shown in Table III. The back-scatter factor is here defined as the ratio of the count of a sample mounted on the stated backing to the count of a similar sample mounted on a 1.93 mg/cm^2 mica backing.

Table III

Backing material	Back-scatter factor
Mica (1.93 mg/cm^2)	1.00
Mica (1.93 mg/cm^2) on 1 mm cardboard	1.15
Glass (39.2 mg/cm^2) on 1 mm cardboard	1.22
Stainless steel (218 mg/cm^2) on 1 mm cardboard	1.46
Platinum (103 mg/cm^2) on 1 mm cardboard	1.75

If one assumes the geometry of the nucleometer to be 100% for the Np^{239} radiations, the 1.00 counts disintegration ratio would indicate that as far as this counter is concerned, all conversion electrons are in coincidence with the beta-particles preceding them. Using a platinum backing, one would expect the apparent geometry to be at least 87% (50% physical geometry increased by a factor of 1.75 for back-scattering) if only betas are emitted. Since conversion

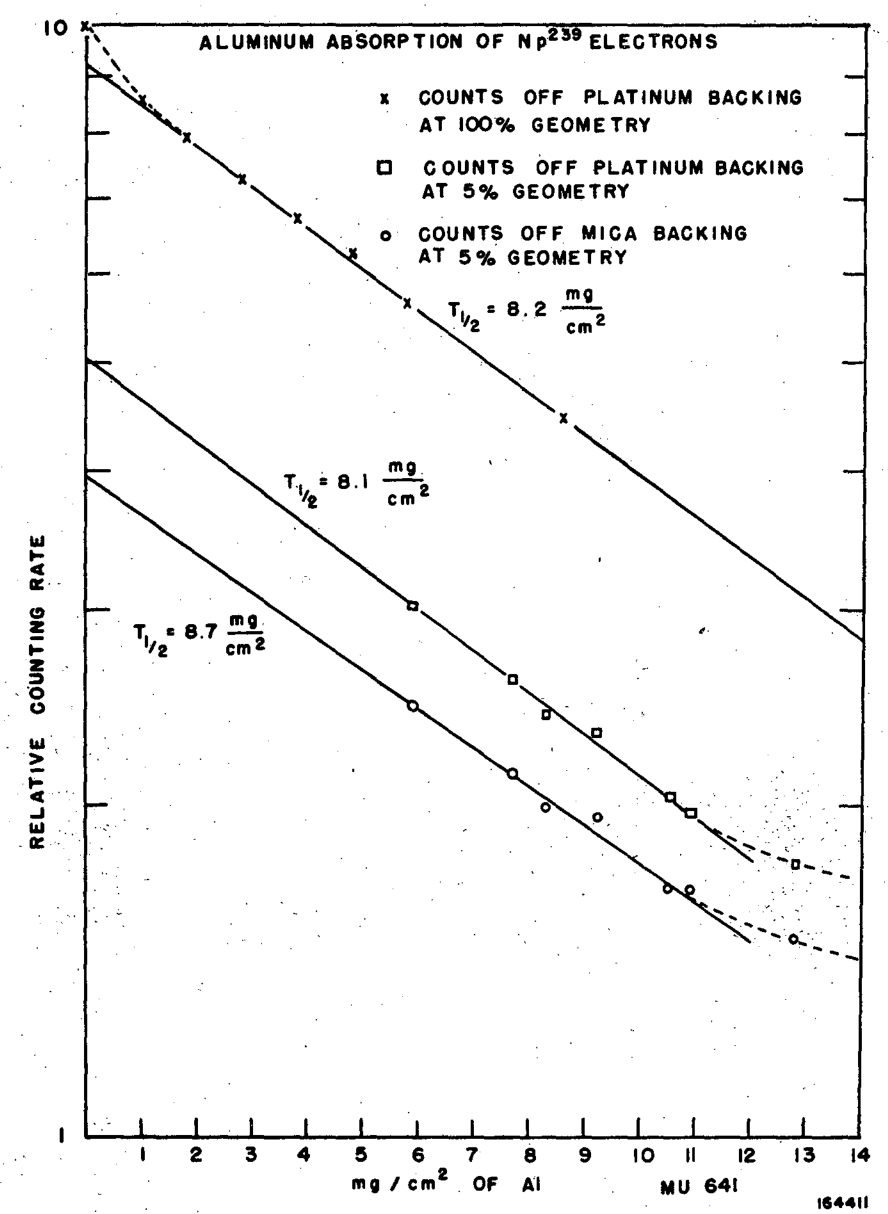
ALUMINUM ABSORPTION OF Np239 ELECTRONS
x COUNTS OFF PLATINUM BACKING AT 100% GEOMETRY
□ COUNTS OFF PLATINUM BACKING AT 5% GEOMETRY
o COUNTS OFF MICA BACKING AT 5% GEOMETRY
T1/2 = 8.2 mg/cm2
T1/2 = 8.1 mg/cm2
T1/2 = 8.7 mg/cm2
RELATIVE COUNTING RATE
10
1
1 2 3 4 5 6 7 8 9 10 11 12 13 14
mg / cm2 OF Al
MU 641
164411

Fig. 1

electrons are also present, the assumption of a 100% geometry is probably not a bad one.

The average value for the number of electrons per disintegration is given in Table II. The value obtained from shelf 1 data was not included in the average because the assumed geometry, due to its dependence on the area of the sample, is less reliable. The Argon shelf 1 data is further complicated by a decrease in the count due to increased coincidences resulting from higher geometry. Since the error in the electrons per disintegration ratio may be as large as 15%, the differences shown by the two types of counters may not be significant.

The value of ~1.3 electrons/disintegration is appreciably smaller than the value of ~2 obtained by Wahl and Seaborg.[1] Slatis[2] has examined the electron spectrum of Np^{239} and reports 2.1 electrons (β^- and e^-) per beta-disintegration. However, the end-window counters used would not detect electrons of less than 40-Kev energy, and the extrapolation of the absorption curve might not properly account for electrons of less than 65-Kev energy. From the data of Slatis there are 1.4 electrons of energy greater than 40 Kev per disintegration, and 1.2 electrons of energy greater than 65 Kev per disintegration. There would then seem to be no disagreement between the present result and that of Slatis.

[1] A. C. Wahl and G. T. Seaborg, Manhattan Project Metallurgical Laboratory Report CN-266 (September, 1942).

[2] Slatis, Arkiv. Mat. Astron. Fysik., 35A, No. 3 (1948).

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