^{17}N β^- decay

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	C. G. Sheu, J. H. Kelley, J. Purcell	ENSDF	5-Aug-2021

Parent: ^{17}N: E=0; J$^\pi$=1/2$^-$; $T_{1/2}$=4.173 s *4*; Q(β^-)=8679 *15*; %β^- decay=100.0

^{17}N-Q(β^-): from (2021Wa16).

^{17}N-$T_{1/2}$: weighted average of: 4174 ms *4* (1976Oh05) and 4169 ms *8* (1972Al42). Also see 4.14 s *4* (1948Kn24), 4.20 s *8* (1961Hi01), 4.16 s *1* (1965Do13), 4.17 s *2* (1970Me31), 4.15 s *10* (1976Fi03), 4.4 s *2* (1984In01), 4.23 s *49* (1991Re02) and (2008RiZX: 4.19 s *2*, 4.12 s *3*).

Foreword:

The measurements of β-delayed neutrons from ^{17}N decay are relatively consistent in both the energies and relative intensities of neutron groups. Most efforts did not determine the absolute feeding intensities to neutron groups, but rather the relative intensities of neutron groups are reported. The determination of "absolute" intensities relies on a renormalization using an assumption of %β-n=100−(4.66 *75*))=(95.34 *75*)%, where 4.66 *75* is the feeding to neutron-bound states (1964Si06).

1964Si06: ^{17}N activity was produced in thin-walled cells comprised of either aluminium or stainless steel using the ^{15}N(t,p) reaction. A NaI detector observed the γ-ray spectrum obtained in measurements on the stainless steel cell; transitions at E_γ= 870 and 2190 keV were observed with a relative ratio=(6.8 *9*):1.0. Since the 2190 transition corresponds to a cascade from ^{17}O*(3055) to ^{17}O*(870), the relative feeding of the first and second excited states is (5.8 *9*):1.0 . Care was taken to minimize contributions from n+p capture that could interfere with the E_γ=2190 keV analysis. No other γ-rays were observed; in particular transitions from ^{17}O*(3843:J$^\pi$=5/2$^-$) and transitions in ^{16}O were not observed.

The measurements on the aluminium cell were analyzed to obtain the singles β-ray spectrum and the β-ray plus γ-ray coincidence spectrum. The part of the singles spectrum that extended above the coincidence spectrum was analyzed to obtain the ratio of feeding to ^{17}O*(870) relative to feeding to the $^{17}O_{g.s.}$=(1.7 *4*):1.0.

Lastly, the beta spectrum was analyzed to determine the feeding β-ray intensity to ^{17}O*(0,870,3055) relative to the total β-ray intensity. These decay branches correspond to (4.66 *75*)% of all decays.

Hence the calculated branching fractions are (1.55 *47*)% to $^{17}O_{g.s.}$, (2.64 *47*)% to ^{17}O*(870), (0.460 *11*)% to ^{17}O*(3055). Furthermore, the lack of feeding to ^{17}O*(3843:J$^\pi$=5/2$^-$) is evidence for assigning J$^\pi$=1/2$^-$ to $^{17}N_{g.s.}$.

1973De32: ^{17}N ions were produced by bombarding 88% enriched ^{14}C target which was on a thick tungsten backing with 27-MeV α-particles. The neutrons were detected with a ^{3}He filled proportional counter. Three neutron groups at E_n=390 *16*, 1190 *30* and 1710 *40* keV emitted from ^{17}O*(4.55,5.09,5.94 MeV) to $^{16}O_{g.s.}$ with branching ratios of 27% *3*, 57% *4* and 11% *2*, respectively. Relative neutron branching ratios are measured, which are normalized to the accepted %β-n rate of 95%. From the neutron counts in the 1.9-2.6 MeV region an upper limit, <0.4%, is set for the branches emitted from ^{17}O*(6.1-6.8 MeV) to $^{16}O_{g.s.}$.

1973Po11: ^{17}N β^--decay activity was produced by bombarding enriched $^{15}N_2$ gas (95-99% ^{15}N) using a 2.9-MeV triton beam. The beam was chopped and had 4 second activation and counting periods. The β activity was detected by a NE102 detector, the γ-decay activity was detected via a 15.2 cm by 12.7 cm NaI detector. The neutron activity was initially measured using a NE102 disk, though issues with high backgrounds at low-energies led to additional measurements using a ^{3}He proportional counter. The β-n and β-γ coincidences were measured; there is no mention of n-γ coincidences, therefore neutron decays are assumed to populate $^{16}O_{g.s.}$.

Neutron peaks at 385 *4*, 1163 *14* and 1675 *24* keV were observed corresponding to decays from ^{17}O*(4.55,5.38,5.94 MeV) to $^{16}O_{g.s.}$, respectively. The relative ratios for decay branches were determined, and then the absolute branching ratios were determined by a self-consistent renormalization. The feeding to the $^{17}O_{g.s.}$ relative to ^{17}O*(870) was taken from (1964Si06) (=(1.7 *4*):1.0); other ratios, relative to the E_n=1.16 MeV group intensity, were determined. The absolute branching ratios were determined as Branching=(1.7 *5*)% to $^{17}O_{g.s.}$, (2.9 *5*)% to ^{17}O*(870), (0.54 *8*)% to ^{17}O*(3060), (37.9% *18*) to ^{17}O*(4550), (51.1% *15*) to ^{17}O*(5380), and (5.8% *6*) to ^{17}O*(5940). The total feeding to bound ^{17}O levels was found to be (5.14 *72*)%.

1976Al02: ^{17}N ions were produced in the ^{15}N(t,p) reaction by bombarding a Ti^{15}N target with 3.0-MeV tritons. The target was irradiated for 4 sec, followed by a 4 sec counting period.

The γ-ray activity was measured using a Ge(Li) detector. Energies for the ^{17}O first and second excited states were determined as 870.8 keV *2* and 3055.2 keV *3*, and the ratio of the γ ray intensities was measured as 1:(9.6 *4*). This ratio is significanly different from prior results and is attributed to the ability to resolve the E_γ=2190 keV transition from the E_γ=2223 keV peak from thermal neutron capture on hydrogen. No attempt to measure the ground-state branch was made, and hence the values for branching to $^{17}O_{g.s.}$ and ^{17}O bound levels was taken from (1964Si06). The branching ratios were found as (1.6 *5*)% to $^{17}O_{g.s.}$, (3.0 *5*)% to ^{17}O*(870), (0.34 *6*)% to ^{17}O*(3055).

Delayed neutrons were measured using a ^{3}He neutron detector; peaks at E_n=390, 1160 and 1690 keV were observed. Taking the

$^{17}N\ \beta^-$ decay (continued)

sum of β branches to neutron-stable level in ^{17}O as (4.9 *7*)%, the branching ratios from ^{17}O*(4.55,5.38,5.94 MeV) to $^{16}O_{g.s.}$ are found as 39.2% *20*, 48.0% *15* and 7.9% *7*, respectively.

1976Oh05: ^{17}N β-decay activity was produced via the $^6Li(n,\alpha)^3H$ and $^{18}O(^3H,\alpha)^{17}N$ reactions by placing an enriched $^6Li_2C^{18}O_3$ target ($\geq$ 95% ^6Li, 93.4% ^{18}O) in a reactor and utilizing a fast pneumatic tube system to transfer the sample between activation and counting stations. The ^{17}N neutron decay curve was measured with eight ^3He proportional counters surrounded by paraffin. Four peaks at E_n=382.8 *9*, 884 *21* (new identified), 1170.9 *8* and 1700.3 *17* keV were measured with Γ=54.8 *4*, 113 *55*, 63.2 *11* and 60.5 *32* keV, respectively. Normalization of the neutron emission probabilities to P_n=95% *1* from (1964Si06), yields the β^-n branching ratios from ^{17}O*(4549.3 *13*,5081 *21*, 5387.1 12, 5949.9 *19* keV) to $^{16}O_{g.s.}$ as, 34.8% *26*, 0.6% *4*, 52.7% *35* and 7.0% *5*, respectively.

In addition, $T_{1/2}$=4.174 s *4* was measured.

1984In01: The neutron spectrum of activated cooling water from the SLAC beam dump was analyzed using a ^3He spectrometer. The activity is presumably from the $^{18}O(\gamma,p)^{17}N$ reaction. In addition to strong neutron lines at E_n=383, 1170 and 1700 keV a significantly weaker group at E_n=2070 keV is suggested. This group has not been reported in other work.

1991Re02: Spallation products from 800 MeV proton bombardment of a ^{232}Th target were captured by a transport line with a mass-to-charge filter and transferred to the TOFI spectrometer at LAMPF. The beamline was separately tuned to transport a number of different nuclides. The neutrons were detected in a polyethylene moderate ^3He counter, and standard techniques were implemented. The β-delayed neutron probabilities were deduced from analysis of the number of implanted ions (per beam pulse) and the rate of β-delayed neutrons detected in the zero-threshold counter. The β-delayed neutron probability P_n=(102.4 *60*)% was deduced.

1996Ra02,2003Mi01: In these experiments, authors observed $^{17}N(\beta^-n)$ decay to calibrate the neutron energy and the neutron counters. Neutron peaks at 380, 1170 and 1700 keV were observed. The branching ratios of corresponding emissions from ^{17}O*(4.55,5.38,5.94 MeV) to $^{16}O_{g.s.}$ normalized to 95% *1* are 39.5% *46*, 49.1% *46* and 6.4% *10*, respectively (1996Ra02). A fourth known peak at E_n=880 keV was too weak to be observed.

2000Bu33,2001Gr06: A ^{17}N beam was produced by fragmenting a 77 MeV/A ^{18}O beam on a Be target; ^{17}N was selected by the LISE3 spectrometer. Neutron time-of-flight (tof) and energy spectra were obtained using the TONNERRE array which covered 45% of 4π. The intrinsic efficiency is rather high between 1 and 5 MeV. Neutron groups at E_n=380, 1170 and 1710 keV were observed. Intensities are not analyzed.

Comments:

For the population of bound ^{17}O states, the β-ray energy spectrum analysis of (1964Si06) [Branching(^{17}O*(0,870,3055))$_{total}$=(4.66 *75*) and R=1:(1.7 *4*) for β-decay to $^{17}O_{g.s.}$ vs decay to ^{17}O*(870)] are combined with R=(9.6 *4*):1 for the relative intensities of E_γ=870 and 2170 keV γ-rays from (1976Al02).

The data on decay feedings to bound states in ^{17}O is sparse; measurements are found in (1964Si06,1973Po11,1976Al02). The only complete measurement on the decay populating ^{17}O bound states is found in (1964Si06); along with studying the γ radiations with a NaI detector, they analyzed the β radiations. In (1964Si06) the ratio of the β-decay to $^{17}O_{g.s.}$ relative to feeding of ^{17}O*(870) is determined as 1:(1.7 *4*); there is no other comparible measurement. Further analysis of the β-ray spectrum determined that the bound ^{17}O*(0,870,3055) states are populated in (4.66 *75*)% of decays. In (1973Po11), use of the (1964Si06) ground state result, along with analysis of their NaI data results in finding the branching ratio to ^{17}O*(0,870,3055) as (5.14 *72*)%, but, as mentioned below, it is suggested that the E_γ=2170 keV intensity is enlarged by a systematic error associated with contributions from n+p capture. In (1973Po11) one finds the only reported connection between any neutron group intensity and a γ-ray transition intensity: $I(\gamma_{870\ keV})/I(E_n=1.16\ MeV)$=(0.0667 *95*). In (1976Al02) the value R=(9.6 *4*):1 for the relative intensities of E_γ=870 and 2170 keV γ-rays is found; they suggest the results of (1964Si06,1973Po11) are unreliable because neither group could resolve n+p capture γ rays from the 2170 keV decay transition; in spite of great caution described in those works this uncertainty discounts their E_γ=2170 keV intensities.

In all cases, the neutron group branching ratios are based on relative intensity measurements that are normalized to unity with inclusion of feedings to ^{17}O bound states.

There are discrepancies among the relative intensities reported in (1973De32,1973Po11,1976Al02,1976Oh05,1996Ra02). In the present analysis all measurements are considered; the results of (1973De32) appear to deviate significantly from other measurements and are excluded from analysis. The mean intensities from the remaining four measurements are determined after normalizing each measurement to the strongest decay transition. These intensities are then renormalized to yield %β-n=(100−(4.66 *75*))=(95.34 *75*)%.

^{17}O State: present (%) for major branches.

0: 1.61 *50*.

^{17}N β^- decay (continued)

871: 2.73 *56* (γ-ray intensity=(3.05 *56*)%).
3055: 0.32 *6*.
4554: 37.8 *11*.
5085: 0.57 *38*.
5379: 50.31 *99*.
5939: 6.69 *31*.
It is noted that the ratio I($\gamma_{870\ keV}$)/I(E_n=1.16 MeV)=(0.0667 *95*) from (1973Po11) is not well met in the present findings. This perhaps suggests new data on the feedings to bound states would be enlightening.

1948Kn24: ^{17}N(β^-n); measured decay products, E_n, I_n; deduced $T_{1/2}$.
1949Al04: ^{17}N(β^-n); The decay scheme of a 4.2-second neutron emitter has been investigated.
1949Ha55: ^{17}N(β^-n); measured decay products, E_n, I_n; deduced neutron energy distribution, an excited state width in ^{17}O.
1961Hi01: ^{17}N(β^-n); deduced nuclear properties.
1961Pe28: ^{17}N(β^-n); measured decay products, E_n, I_n; deduced energies of delayed neutrons, ^{17}N ground state J, π.
1963Gi04: ^{17}N(β^-n); deduced nuclear properties.
1965Do13: ^{17}N; measured $T_{1/2}$.
1970Me31: ^{17}N(β^-n); measured $T_{1/2}$.
1972Al42: ^{17}N; measured $T_{1/2}$.
1976Fi03: ^{17}N; measured $T_{1/2}$, delayed γ, delayed neutrons.
1977Fr19: ^{17}N; measured delayed neutron spectra.
1983Ra29: > transition rates. The asymmetry for the corresponding isovector E1 transitions in ^{17}O and ^{17}F is found to be, comparable in magnitude with the asymmetry for the analogous $\beta^{\mp}$ decays of ^{17}N and ^{17}Ne.
1993Bu21: ^{17}N(β^-); measured β-delayed E_α, I_α; deduced ^{12}C(α,α) reaction p-wave capture amplitude.
1994Do08: ^{17}N(β^-); measured β-delayed E_α, I_α, α(^{13}C)-coin; deduced log *ft*, total $\beta\alpha$-branching ratio. ^{17}O deduced levels contributing to α-decay.
1996Ue02,1996UeZZ: ^{17}N(β^-); measured NMR; deduced μ.
2008RiZX: ^{17}N(β^-); measured β-delayed neutron decay.
2013Ue01: ^{17}N(β),(β^-n); measured E_γ, I_γ, E_β, I_β, E(n) by tof, I(n), β-NMR, $\beta\gamma$-, $\beta\gamma\gamma$-, $\beta n\gamma$-coin.
See also (2002Mi17: theory).

Theory:
1970Be21: ^{17}N(β^-); calculated hindrance in nuclear matrix elements for unique first-forbidden transitions.
1970Hi15: ^{17}N(β^-); calculated log *ft*.
1971To08: ^{17}N; analayzed 1st-forbidden unique β-decay data; deduced f_1t, β-moments.
1972To03: ^{17}N(β^-); calculated nuclear matrix elements, shape factors, longitudinal polarisations for first-forbidden, non-unique β-transitions.
1992He12: ^{17}N(β^-); calculated square root of branching ratio for decay to final levels; deduced enhancements due to level mixing caused by T-odd forces.
1997Mi08: ^{17}N(β^-); analyzed β-decay rates via f values; deduced charge-dependent effects role. Shell model.

^{17}O Levels

E(level)†	J^π†	Γ†	E(level)†	J^π†	Γ†
0	5/2+		5732.07 *42*	(5/2−)	<1 keV
870.756 *20*	1/2+	179.6 ps *27*	5869.62 *40*	3/2+	6.6 keV *7*
3055.40 *6*	1/2−	110 fs *+24−21*	5931.6 *15*	1/2−	32 keV *3*
3842.8 *4*	5/2−	92×10^{-3} eV *6*	6361.5 *71*	1/2+	126 keV *14*
4551.8 *7*	3/2−	38.7 keV *28*	7543 *20*	3/2−	500 keV *50*
5086.8 *9*	3/2+	90 keV *3*	7992 *50*	1/2−	270 keV *27*
5387.1 *22*	3/2−	37.1 keV *24*	8200 *8*	3/2−	61 keV *10*

† From Adopted Levels.

^{17}N β^- decay (continued)

β^- radiations

E(decay)	E(level)	Iβ^- [@]	Log *ft*	Comments
(479 *17*)	8200	0.013[†] *3*	4.04 *12*	av Eβ=168.5 *68* Iβ^-: from (1994Do08). $\beta^-\alpha$ braching=(9.8×10^{-4} *20*)% (1994Do08). Γ_α/Γ=0.077 *8* (1973Fo11,1973Jo01).
(6.9×10^2 *5*)	7992	0.026[†] *6*	4.32 *17*	av Eβ=253 *22* Iβ^-: from (1994Do08). $\beta^-\alpha$ braching=(1.5×10^{-3} *3*)% (1994Do08). Γ_α/Γ=0.059 *7* (1973Fo11,1973Jo01).
(1136 *25*)	7543	<0.35[†]	>4.0	av Eβ=445 *11* Iβ^-: from (1994Do08). $\beta^-\alpha$ braching<6.9×10^{-5}% (1994Do08). Γ_α/Γ=0.0002 (1973Fo11,1973Jo01).
(2318 *17*)	6361.5	<0.08	>6.0	av Eβ=989.8 *79* Iβ^-: from (1976Oh05). See also (1973De32: Iβ^-≤0.4% for E$_x$=6.1-6.8 MeV).
(2747 *15*)	5931.6	6.69[#] *31*	4.380 *23*	av Eβ=1194.6 *73* Iβ^-: Literature values are (1973De32: 11% *2*), (1973Po11: 5.8% *6*), (1976Al02: 7.9% *7*), (1976Oh05: 7.0% *5*), (1996Ra02: 6.4% *10*).
(2809 *15*)	5869.62	<0.15	>6.1	av Eβ=1224.3 *72* Iβ^-: from (1976Oh05).
(2947 *15*)	5732.07	<0.23	>6.0	av Eβ=1290.3 *73* Iβ^-: from (1976Oh05).
(3292 *15*)	5387.1	50.31[#] *99*	3.851 *13*	av Eβ=1456.6 *74* Iβ^-: Literature values are (1973De32: 57% *4*), (1973Po11: 51.1% *15*), (1976Al02: 48.0% *15*), (1976Oh05: 52.7% *35*), (1996Ra02: 49.1% *46*).
(3592 *15*)	5086.8	0.57[#] *38*	6.0 *3*	av Eβ=1602.1 *73* Iβ^-: from normalized analysis of (1976Oh05: 0.6% *4*).
(4127 *15*)	4551.8	37.8[#] *11*	4.416 *15*	av Eβ=1862.5 *74* Iβ^-: Literature values are (1973De32: 27% *3*), (1973Po11: 37.9% *18*), (1976Al02: 39.2% *20*), (1976Oh05: 34.8% *26*), (1996Ra02: 39.5% *46*).
(4836 *15*)	3842.8	<7×10^{-3}	>8.5	av Eβ=2209.4 *74* Iβ^-: from (1976Al02). See also <0.1% (1964Si06).
(5624 *15*)	3055.40	0.32[‡] *6*	7.10 *9*	av Eβ=2597.1 *74* Iβ^-: See also (1964Si06: 0.460% *11*), (1973Po11: 0.54% *8*), (1976Al02: 0.34% *6*).
(7808 *15*)	870.756	2.73[‡] *56*	6.84 *9*	av Eβ=3674.9 *75* Iβ^-: See also (1964Si06: 2.64% *47*), (1973Po11: 2.9% *5*), (1976Al02: 3.0% *5*).
(8679 *15*)	0	1.61[‡] *50*	9.55[1u] *14*	av Eβ=4117.7 *75* Iβ^-: See alo (1964Si06: 1.55% *47*), (1973Po11: 1.7% *5*).

[†] Neutrons from these weakly populated states are not independtly observed (1994Do08).

[‡] Branching ratios decaying to ^{17}O*(g.s.,0.87,3.06) states are calculated using the ratio of Iβ^-(g.s.)/Iβ^-(0.87)=1:(1.7 *4*) (1964Si06) combined with the ratio of $I_{\gamma=870}/I_{\gamma=2170}$=(9.6 *4*):1 (1976Al02) then the bound state intensities are normalized to 4.66% *75* (1964Si06).

[#] Branching ratios for decay to ^{17}O*(4.55,5.08,5.38,5.94) states are deduced by considering values from (1973Po11, 1976Al02, 1976Oh05, 1996Ra02). Observations are normalized to the strongest decay branch, averaged, and then renormalizing to 95.34% *75*. For (1976Al02) we have used Iβ^-(5.94)=7.9% *7* from their Table II rather than 7.9% *3* from their abstract; this choice impacts the deduced branching intensities.

[@] Absolute intensity per 100 decays.

^{17}N β^- decay (continued)

$\gamma(^{17}O)$

E_γ †	I_γ ‡	E_i(level)	J^π_i	E_f	J^π_f	Mult.	Comments
870.732 *20*	3.05 *56*	870.756	1/2+	0	5/2+		I_γ: deduced from Iβ^-. See footnote above.
2184.49 *5*	0.32 *6*	3055.40	1/2−	870.756	1/2+	E1	I_γ: deduced from Iβ^-. Direct ground state decay is <1.5% (1976Al02).
3843.3 *4*	$<7\times10^{-3}$	3842.8	5/2−	0	5/2+		I_γ: from (1976Al02).

† From Adopted Levels.
‡ Absolute intensity per 100 decays.

^{17}N β^- decay

Decay Scheme

Intensities: $I_{(\gamma+ce)}$ per 100 parent decays