Energy Levels of Light Nuclei
$A = 17$

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Abstract: An evaluation of $A = 16$–17 was published in *Nuclear Physics A*281 (1977), p. 1. This version of $A = 17$ differs from the published version in that we have corrected some errors discovered after the article went to press. Figures and introductory tables have been omitted from this manuscript. Reference key numbers have been changed to the NNDC/TUNL format.

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^{17}Be

(Not illustrated)

This nucleus has not been observed. Its atomic mass excess is calculated to be 70.67 MeV. It is then unstable with respect to breakup into ^{16}Be + n and ^{15}Be + 2n by 3.37 and 3.34 MeV, respectively (1974TH01). See also (1976CA1R; theor.).

^{17}B

(Not illustrated)

^{17}B has been observed in the 4.8 GeV proton bombardment of uranium: it is particle stable and its ground state J^π is probably $\frac{3}{2}^-$ (1973BO30, 1974BO05). Its atomic mass excess is calculated to be 44.37 MeV (transverse form of the mass equation): it is then stable with respect to decay into ^{15}B + 2n by 0.53 MeV (1974TH01, 1975JE02). The E_{β^-}(max) for the decay to ^{17}C would then be 23.1 MeV. See also (1971AJ02) and (1972GA1F, 1972TH13, 1972WI1C, 1975BE31).

^{17}C

(Not illustrated)

^{17}C has been observed in the 5.5 GeV proton bombardment of uranium: it is particle stable (1968PO04). Its atomic mass excess is calculated to be 21.27 MeV (transverse form of the mass equation): it is then stable with respect to decay into ^{16}C + n by 0.50 MeV (1974TH01, 1975JE02). The E_{β^-}(ma$^{\mathrm{Q}}$) for the decay to ^{17}N would then be 13.4 MeV. See also (1971AJ02), (1971AR02, 1971BU1E), (1973TO16) and (1972TH13, 1973WI15, 1975BE31, 1975WI1E; theor.).

^{17}N

(Figs. 6 and 9)

GENERAL: (See also (1971AJ02).)

Theory and reviews: (1973PA1F, 1973RE17, 1973TO16, 1973WI15, 1974HA61, 1975BE31).

Experimental papers: (1971AR02, 1973KO1D, 1976DE1P).

1. (a) ^{17}N(β^-)^{17}O* → ^{16}O + n $\quad Q_{\mathrm{m}} = 4.536$

   (b) ^{17}N(β^-)^{17}O $\quad Q_{\mathrm{m}} = 8.682$

Table 17.1: Energy levels of ^{17}N [a]

E_x in ^{17}N (MeV $\pm$ keV)	$J^\pi; T$	τ or Γ	Decay	Reactions
0	$\frac{1}{2}^-; \frac{3}{2}$	$\tau_{1/2} = 4.169 \pm 0.008$ sec	β^- [b]	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
1.3739 ± 0.3	$\frac{3}{2}^-$	$\tau_m = 93 \pm 35$ fsec	γ	3, 11, 12
1.8496 ± 0.3	$\frac{1}{2}^+$	41^{+20}_{-9} psec	γ	3, 11, 12
1.9068 ± 0.3	$\frac{5}{2}^-$	11 ± 2 psec	γ	3, 11, 12
2.5260 ± 0.5	$\frac{5}{2}^+$	33 ± 3 psec	γ	3, 11, 12
3.1289 ± 0.5	$\frac{7}{2}^{(-)}$	275 ± 80 fsec	γ	3, 12
3.2042 ± 0.9	$\frac{3}{2}^-$	< 30 fsec	γ	3, 11, 12
3.6287 ± 0.7	$(\frac{7}{2}^-, \frac{9}{2}^-)$	12 ± 2 psec	γ	3, 11, 12
3.663 ± 4	$(\frac{1}{2}, \frac{3}{2})^-$	< 350 fsec	γ	3, 11, 12
3.9060 ± 2.0	$\leq \frac{7}{2}$	52 ± 22 fsec	γ	3
4.0064 ± 2.0	$(\frac{3}{2})$	< 15 fsec	γ	3, 11, 12
4.208 ± 3	$\leq \frac{5}{2}$	< 70 fsec	γ	3, 12
4.415 ± 3	$\leq \frac{7}{2}$	$(< 60$ fsec$)$	γ	3
5.170 ± 2	$(\frac{7}{2}^+, \frac{9}{2}^+)$	< 60 fsec	γ	3
5.195 ± 3	$(\frac{1}{2}, \frac{3}{2}, \frac{5}{2})^+$	< 95 fsec	γ	3
5.514 ± 3	$(\frac{3}{2})^-$	< 100 fsec	γ	3, 11
5.770 ± 3	$\leq \frac{7}{2}$	< 120 fsec	γ	3, 11
6.08 ± 30				3
6.24 ± 25				3
6.43 ± 30				3
6.61 ± 25				3
6.99 ± 20				3, 11
7.17 ± 40				3
7.37 ± 40				3
7.63 ± 40				3
7.73 ± 40				3
8.00 ± 25				3
8.14 ± 40				3
8.55 ± 40		broad		3
8.93 ± 40		broad		3
9.26 ± 40		broad		3
9.74 ± 40		broad		3

[a] See also Tables 17.4 and 17.5.

[b] See also Tables 17.2 and 17.3.

The half-life of ^{17}N is 4.169 ± 0.008 sec (1972AL42): the mean of earlier values (see (1971AJ02)) was 4.16 ± 0.01 sec. See also (1976FI03). The decay is principally [see Table 17.2] to the neutron unbound states ^{17}O*(4.55, 5.38, 5.94) [$J^\pi = \frac{3}{2}^-$, $\frac{3}{2}^-$ and $\frac{1}{2}^-$, respectively]. The nature of the decay is in agreement with $J^\pi = \frac{1}{2}^-$ for ^{17}N$_{\mathrm{g.s.}}$ (1973PO11, 1976AL02). For measurements of the neutron energies see (1973PO11). Excitation energies of ^{17}O states have been determined by (1973PO11) from E_{n} [e.g., 4.552 ± 0.004 MeV] and by (1976AL02). From E_γ to the first excited state whose E_{x} was taken to be 870.8 ± 0.2 keV, E_{x} for the second excited state of ^{17}O is 3055.2 ± 0.3 keV; the direct ground state decay of that state is $< 1.5\%$ (1976AL02). See also (1972SH1F) and (1972TO03; theor.). For a comparison of the ^{17}N and ^{17}Ne decays see Table 17.3 (1976AL02): the large values of δ show the importance of final state nuclear asymmetry in odd-A nuclei. See also (1972AL42).

2. ^{10}Be(^{11}B, α)^{17}N $\quad Q_{\mathrm{m}} = 10.980$

See (1976FI03).

3. ^{11}B(^{7}Li, p)^{17}N $\quad Q_{\mathrm{m}} = 8.416$

Proton groups and γ-rays have been studied by several groups: see Tables 17.4 and 17.5. Angular distributions of γ-rays, branching ratio and lifetime measurements lead to most of the J^π shown in these two tables; transition energies have also been very accurately determined (1974RO27, 1974RO28). See also (1971AJ02).

4. ^{12}C(^{7}Li, 2p)^{17}N $\quad Q_{\mathrm{m}} = -7.541$

See (1971HO26, 1976CE1E).

5. ^{14}C(α, p)^{17}N $\quad Q_{\mathrm{m}} = -9.715$

See (1961PE28).

6. ^{14}C(^{18}O, ^{15}N)^{17}N $\quad Q_{\mathrm{m}} = -5.735$

See (1972EY01).

7. ^{15}N(t, p)^{17}N $\quad Q_{\mathrm{m}} = -0.108$

See (1971AJ02).

Table 17.2: Beta decay of ^{17}N

Decay to ^{17}O* (MeV)	J^{π}	Branch (%) [a]		log ft [b]
		(1973PO11)	(1976AL02) [A]	
0	$\frac{5}{2}^+$	1.7 ± 0.5	1.6 ± 0.5 [c]	7.29 ± 0.11 [d]
0.87	$\frac{1}{2}^+$	2.9 ± 0.5	3.0 ± 0.5	6.80 ± 0.07
3.06	$\frac{1}{2}^-$	0.54 ± 0.08	0.34 ± 0.06	7.08 ± 0.08
3.84	$\frac{5}{2}^-$		$< 7 \times 10^{-3}$	> 8.5
4.55	$\frac{3}{2}^-$	37.9 ± 1.8	39.2 ± 2.0	4.40 ± 0.02
5.38	$\frac{3}{2}^-$	51.1 ± 1.5	48.0 ± 1.5	3.88 ± 0.02
5.94	$\frac{1}{2}^-$	5.8 ± 0.6	7.9 ± 0.7	4.31 ± 0.04

A = adopted.
[a] See also (1964SI06, 1973DE32).
[b] (1976AL02).
[c] (1964SI06).
[d] $\log f_1 t = 9.56 \pm 0.13$ (1971TO08).

Table 17.3: Comparison of ^{17}N and ^{17}Ne β-decay [a]

Final state in		J^{π}	Γ_n [b]	Γ_p [b]	$(ft)^-$ [c]	$(ft)^+$ [c]	δ [d]
^{17}O	^{17}F		(keV)	(keV)			
3.06	3.10	$\frac{1}{2}^-$	0	19	$(8.0 \pm 1.1) \times 10^6$ [e]	$(2.78 \pm 0.40) \times 10^6$	-0.65 ± 0.07
4.55	4.70	$\frac{3}{2}^-$	40	230	$(2.53 \pm 0.14) \times 10^4$ [f]	$(3.92 \pm 0.18) \times 10^4$	0.55 ± 0.11
5.38	5.52	$\frac{3}{2}^-$	28	69	$(7.59 \pm 0.28) \times 10^3$ [f]	$(7.22 \pm 0.15) \times 10^3$	-0.55 ± 0.04
5.94	6.04	$\frac{1}{2}^-$	23	28	$(2.04 \pm 0.19) \times 10^4$ [f]	$(2.61 \pm 0.07) \times 10^4$	0.28 ± 0.12

[a] (1976AL02).
[b] Γ_n and Γ_p are the neutron and proton widths of the ^{17}O and ^{17}F states, respectively.
[c] $(ft)^-$ and $(ft)^+$ are for the ^{17}N and ^{17}Ne decays, respectively.
[d] $\delta = [(ft)^+/(ft)^-] - 1$.
[e] From mean of branching values (see Table 17.2).
[f] From branching values of (1976AL02).

Table 17.4: Excited states of ^{17}N from ^{11}B(^{7}Li, p)^{17}N, ^{18}O(d, ^{3}He)^{17}N and ^{18}O(t, α)^{17}N [a]

E_x (keV)				l [c]	J^π [d]
(1974RO27) [b]	(1965HA05) [b]	(1966MC05) [b]	(1971HA48) [b]		
			0	1	$\frac{1}{2}^-$
1373.7 ± 0.5	1374.1 ± 0.4 [i]		1370 ± 20	1	$\frac{3}{2}^-$
1850.0 ± 0.5	1849.5 ± 0.3 [i]				$\frac{1}{2}^+$
			1870 ± 20	0	
1906.8 ± 0.4	1906.9 ± 0.5 [i]				$\frac{5}{2}^-$ [i]
2526.3 ± 1.0	2525.9 ± 0.6 [i]		2540 ± 20	2	$\frac{5}{2}^+$
3128.7 ± 0.6	3129.2 ± 0.6 [i]				$\frac{7}{2}^{(-)}$ [i]
			3180 ± 30	1	
3203 ± 2	3204.4 ± 0.9 [i]				$\frac{3}{2}^-$ [i]
3628.7 ± 0.7					$\geq \frac{3}{2}$ [g]
			3660 ± 30	1	
3663 ± 4					$(\frac{1}{2}, \frac{3}{2})^-$
3906.0 ± 2.0					$\leq \frac{7}{2}$
4006.4 ± 2.0			4020 ± 40		$\frac{3}{2}, \frac{5}{2}, \frac{7}{2}$
4208 ± 3					$\leq \frac{5}{2}$
4415 ± 3	4470 ± 10	4470 ± 40			$\leq \frac{7}{2}$
5170 ± 2					$\frac{3}{2} \leq J \leq \frac{9}{2}$ [h]
5195 ± 3	5210 ± 20	5230 ± 40			$(\frac{1}{2}, \frac{3}{2}, \frac{5}{2})^+$
5514 ± 3	5530 ± 20	5510 ± 40	$\equiv 5523$ [e]	1	$(\frac{1}{2}, \frac{3}{2})^-$
5770 ± 3	5830 ± 20	5830 ± 40	5820 ± 40		$\leq \frac{7}{2}$
	6070 ± 50	6090 ± 40			
	6250 ± 30	6230 ± 40			
	6450 ± 40	6410 ± 40			
	6600 ± 30	6620 ± 40			
	6990 ± 30	6990 ± 40	6990 ± 30	1	$(\frac{3}{2}, \frac{1}{2})^-$
		7170 ± 40			
	(7260 ± 50)				
		7370 ± 40			
	(7510 ± 70)				

Table 17.4: Excited states of ^{17}N from ^{11}B(^{7}Li, p)^{17}N, ^{18}O(d, ^{3}He)^{17}N and ^{18}O(t, α)^{17}N [a] (continued)

E_x (keV)				l [c]	J^π [d]
(1974RO27) [b]	(1965HA05) [b]	(1966MC05) [b]	(1971HA48) [b]		
		7630 ± 40			
	7790 ± 20	7730 ± 40			
	8000 ± 30	8000 ± 40			
	(8250 ± 30)	8140 ± 40			
		8550 ± 40 [f]			
		8930 ± 40			
		9260 ± 40			
		9740 ± 40			

[a] See also Table 17.3 in (1971AJ02) for the earlier work. The work reported in col. A in that table has not been published.
[b] ^{11}B(^{7}Li, p)^{17}N.
[c] ^{18}O(d, ^{3}He)^{17}N.
[d] (1971HA48, 1974RO27), except for values labeled [i].
[e] Used as calibration point.
[f] This state and the ones below are broad.
[g] Probably $(\frac{7}{2}, \frac{9}{2})^-$ (1974RO27).
[h] Probably $(\frac{7}{2}, \frac{9}{2})^+$ (1974RO27).
[i] ^{18}O(t, α)^{17}N (1976GU14).

8. ^{17}O(n, p)^{17}N $\qquad Q_m = -7.896$

See ^{18}O in (1978AJ03).

9. ^{18}O(γ, p)^{17}N $\qquad Q_m = -15.943$

See ^{18}O in (1978AJ03).

10. ^{18}O(n, d)^{17}N $\qquad Q_m = -13.718$

See ^{19}O in (1972AJ02).

Table 17.5: Radiative transitions and lifetimes of ^{17}N states

E_i (MeV)	J^{π}_{i}	E_f (MeV)	J^{π}_{f}	Branch (%)	$\Gamma_{\gamma}/\Gamma_{w}$ [e] (W.u.)	δ	τ_m	Refs.
1.37	$\frac{3}{2}^-$	0	$\frac{1}{2}^-$	100	$0.13^{+0.08}_{-0.04}$ (M1)		93 ± 35 fsec	(1974RO27)
				100	0.13 ± 0.05 (M1)	0.00 ± 0.03		(1976GU14)
1.85	$\frac{1}{2}^+$	0	$\frac{1}{2}^-$	90 ± 3	$(5.0 \pm 1.6) \times 10^{-6}$ (E1)		41^{+20}_{-9} psec	(1974RO27, 1974RO28)
				83 ± 3	$(5.0 \pm 2.0) \times 10^{-6}$ (E1)			(1976GU14)
		1.37	$\frac{3}{2}^-$	10 ± 3	$(3.2 \pm 1.5) \times 10^{-5}$ (E1)			(1974RO27, 1974RO28)
				17 ± 3	$(6 \pm 3) \times 10^{-5}$ (E1)	0.00 ± 0.02		(1976GU14)
1.91	$\frac{5}{2}^-$	0	$\frac{1}{2}^-$	78 ± 3	1.0 ± 0.2 (E2)		11 ± 2 psec	(1974RO27, 1974RO28)
				74 ± 4	0.8 ± 0.2 (E2)	0.00 ± 0.05		(1976GU14)
		1.37	$\frac{3}{2}^-$	22 ± 3	$(4.2 \pm 1.5) \times 10^{-3}$ (M1)			(1974RO27, 1974RO28)
				26 ± 4	$(5 \pm 1) \times 10^{-3}$ (M1) [g]	$-0.05^{+0.03}_{-0.14}$		(1976GU14)
2.53	$\frac{5}{2}^+$	0	$\frac{1}{2}^-$	14 ± 4	0.28 ± 0.11 (M2)		33 ± 3 psec	(1974RO27, 1974RO28)
				11 ± 1	0.22 ± 0.04 (M2)	-0.07 ± 0.18		(1976GU14)
		1.37	$\frac{3}{2}^-$	34 ± 4	$(1.0 \pm 0.2) \times 10^{-5}$ (E1)			(1974RO27, 1974RO28)
				34 ± 4	$(1.0 \pm 0.2) \times 10^{-5}$ (E1)	0.0 ± 0.1		(1976GU14)
		1.85	$\frac{1}{2}^+$	12 ± 2	9 ± 2 (E2)			(1974RO27, 1974RO28)
				12 ± 2	8.1 ± 1.6 (E2)	0.00 ± 0.06		(1976GU14)
		1.91	$\frac{5}{2}^-$	40 ± 3	$(8 \pm 1) \times 10^{-5}$ (E1)			(1974RO27, 1974RO28)
				43 ± 4	$(2.3 \pm 0.4) \times 10^{-5}$ (E1)	0.07 ± 0.07		(1976GU14)
3.13 [a]	$\frac{7}{2}^{(-)}$	1.91	$\frac{5}{2}^-$	100	$0.063^{+0.036}_{-0.016}$ (M1)		275 ± 80 fsec	(1974RO27)
				100	0.06 ± 0.02 (M1)	0.00 ± 0.04		(1976GU14)
3.20 [b]	$\frac{3}{2}^-$	0	$\frac{1}{2}^-$	88 ± 6	> 0.03 (M1)		< 30 fsec	(1974RO27)
				88 ± 4	> 0.025 (M1)	-0.06 ± 0.08 [f]		(1976GU14)
		1.91	$\frac{5}{2}^-$	12 ± 6	> 0.05 (M1)			(1974RO27)
				12 ± 4	> 0.05 (M1)			(1976GU14)
3.63 [c]	$(\frac{7}{2}^-, \frac{9}{2}^-)$	1.91	$\frac{5}{2}^-$	47 ± 10	0.8 ± 0.2 (E2)		12 ± 2 psec	(1974RO27, 1974RO28)
		3.13	$\frac{7}{2}^{(-)}$	53 ± 10	0.010 ± 0.03 (M1)			(1974RO27, 1974RO28)
3.66	$(\frac{1}{2}, \frac{3}{2})^-$	1.85	$\frac{1}{2}^+$	100	$> 7 \times 10^{-4}$ (E1)		< 350 fsec	(1974RO27)

Table 17.5: Radiative transitions and lifetimes of ^{17}N states (continued)

E_i (MeV)	J_i^π	E_f (MeV)	J_f^π	Branch (%)	Γ_γ/Γ_w [e] (W.u.)	δ	τ_m	Refs.
3.91	$\leq \frac{7}{2}$	1.91	$\frac{5}{2}^-$	100	$(8^{+5}_{-3}) \times 10^{-2}$ (M1) [h]		52 ± 22 fsec	(1974RO27)
4.01	$(\frac{3}{2})$	1.85	$\frac{1}{2}^+$	$\leq 15 \pm 5$ [d]			< 15 fsec	(1974RO27)
		2.53	$\frac{5}{2}^+$	85 ± 5	0.55 (M1)			(1974RO27)
4.21	$\leq \frac{5}{2}$	1.37	$\frac{3}{2}^-$	100			< 70 fsec	(1974RO27)
4.42	$\leq \frac{7}{2}$	1.91	$\frac{5}{2}^-$	100			(< 60) fsec	(1974RO27)
5.17	$(\frac{7}{2}^+, \frac{9}{2}^+)$	2.53	$\frac{5}{2}^+$	37 ± 7	> 15 (E2)		< 60 fsec	(1974RO27)
		3.13	$\frac{7}{2}^{(-)}$	63 ± 7				(1974RO27)
5.20	$(\frac{1}{2}, \frac{3}{2}, \frac{5}{2})^+$	1.85	$\frac{1}{2}^+$	≈ 42			< 95 fsec	(1974RO27)
		1.91	$\frac{5}{2}^-$	≈ 58				(1974RO27)
5.51	$(\frac{3}{2})^-$	0	$\frac{1}{2}^-$	≈ 50			< 100 fsec	(1974RO27)
		1.37	$\frac{3}{2}^-$	≈ 50				(1974RO27)
5.77	$\leq \frac{7}{2}$	1.37	$\frac{3}{2}^-$	≈ 25			< 120 fsec	(1974RO27)
		1.91	$\frac{5}{2}^-$	≈ 25				(1974RO27)
		4.01	$(\frac{3}{2})$	≈ 50 [d]				(1974RO27)

[a] Branches to ^{17}N*(0, 1.37, 1.85, 2.53) are, respectively, < 2, < 5, < 2 and $< 3\%$ (1976GU14).

[b] Branches to ^{17}N*(1.37, 1.85, 2.53) are, respectively, < 5, < 6 and $< 3\%$ (1976GU14).

[c] Branches to ^{17}N*(0, 1.37, 1.85, 2.53, 3.20) are, respectively, < 10, < 10, < 7, < 3, $< 2\%$ (1974RO28).

[d] This branch in uncertain.

[e] Assuming pure multipole transitions and J^π shown: see also Table 2 in the Introduction.

[f] Or $\delta = 2.1 \pm 0.4$ (1976GU14).

[g] $\Gamma_\gamma/\Gamma_w = 0.4^{-0.4}_{+1.3}$ (E2) (1976GU14).

[h] This number appears to be in error: see Table 2 in the Introduction.

11. ^{18}O(d, ^{3}He)^{17}N $\qquad Q_{\rm m} = -10.449$

Angular distributions of eight ^{3}He groups have been measured at $E_{\rm d} = 52$ MeV; see Table 17.4 (1971HA48).

12. ^{18}O(t, α)^{17}N $\qquad Q_{\rm m} = 3.872$

Alpha particle groups corresponding to ^{17}N states with $E_{\rm x} < 4.3$ MeV have been studied by (1960JA13): see Table 17.3 in (1971AJ02). (1976GU14: $E_{\rm t} = 3.5$ MeV) have studied α-γ angular correlations and γ-branching ratios for the first six excited states of ^{17}N: see Tables 17.4 and 17.5.

^{17}O

(Figs. 7 and 9)

GENERAL: (See also (1971AJ02).)

Shell model: (1968KA1C, 1969FE1A, 1970HA49, 1970IR01, 1971AR1R, 1971HS02, 1971JE02, 1971KA40, 1971LE30, 1971MU23, 1971WI01, 1971WI1F, 1972BA78, 1972BE22, 1972EL1C, 1972EN03, 1972HA1Q, 1972KA38, 1972LE1L, 1973DE13, 1973JU1A, 1973KU04, 1973LA1D, 1973RE17, 1973SM1C, 1974LO04, 1974RI09, 1976PO01).

Collective and cluster models: (1969FE1A, 1971AR1R, 1972LE1L, 1972NE1B).

Special levels: (1968KA1C, 1969FE1A, 1969WI1C, 1971AR1R, 1971BE59, 1971BE2D, 1971HS02, 1971KO12, 1971MU23, 1971SE1C, 1972BE22, 1972BE1E, 1972EN03, 1972HI17, 1972NI15, 1973JU1A, 1974RI09).

Electromagnetic transitions: (1969FE1A, 1970AL1D, 1970HA49, 1970SI1J, 1972EN03, 1972SE1G, 1973HA53, 1973RE17, 1973ZA1D, 1974KO1R, 1974LO04, 1974MC1F, 1976SH04).

Special reactions: (1971AR02, 1972PU1B, 1973WI15, 1974KU15, 1975TS01, 1975UD01, 1975VO09, 1976DA1T, 1976DE1P, 1976HI05, 1977PE08).

Astrophysical questions: (1972CL1A, 1973AR1E, 1973AU1B, 1973AU1D, 1973AU1C, 1973EN1A, 1973SM1A, 1973TA1D, 1973TR1B, 1974DE1M, 1975AR1E, 1975AU1D, 1975CO1J, 1975EN1A, 1975LA1E, 1975NO1D, 1975SC1H, 1975TR1A, 1976FI1E, 1976KO1K, 1976ME1H, 1976WA1M).

Pion capture and reactions (See also reactions 40 and 69.): (1973EI01, 1974DA23, 1974LI1D, 1975PA06, 1976EN02).

Other topics: (1968KA1C, 1969EL1A, 1970AL1E, 1970RY03, 1970SI1J, 1971AU08, 1971BA2Y, 1971BE59, 1971ER1C, 1971JE02, 1971KA40, 1971KO12, 1971LA1D, 1971PL1D, 1971SE1C, 1971NG01, 1972BA78, 1972CA37, 1972CH16, 1972DA21, 1972HA57, 1972KA38, 1972LE1L, 1972MA57, 1972NI15, 1972SH32, 1973AR1K, 1973BE1N, 1973DE13, 1973GO1H, 1973HY1A, 1973KO1J, 1973KU04, 1973MA48, 1973OS1A, 1973PA1F, 1973RA1E, 1973RE17, 1973RO1R, 1973RO1P, 1973SP1A, 1973YO1A, 1974AU03, 1974BR1E, 1974RE03, 1974SA05, 1974SL1C, 1975DR1D, 1975HE10, 1975MI02, 1975SH1H, 1976FE1B, 1976MA04, 1976MA05, 1976VA1C).

Ground state:

$$\mu = -1.89379 \pm 0.00009 \text{ nm (see (1974SHYR));}$$

$$Q = -25.6 \text{ mb (1968SC18);}$$

$$Q = -25.78 \text{ mb (1969SC34).}$$

See also (1973CO1P, 1974SHYR).

See also (1970AL1D, 1970RY03, 1970SI1J, 1971SH26, 1971TA1A, 1971WI01, 1972GL06, 1972LE1L, 1972VA36, 1972YO1B, 1973ARYL, 1973HI1A, 1973HO32, 1973LE07, 1973MI1C,

1973RE17, 1973RO1P, 1973SU1B, 1973SU1C, 1974DE1E, 1974HA27, 1974MC1F, 1974NE1B, 1974RE03, 1975BE31, 1975MI02, 1976CH1T, 1976PO01).

Table 17.6: Energy levels of ^{17}O

E_x in ^{17}O (MeV $\pm$ keV)	$J^\pi; T$	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
0	$\frac{5}{2}^+; \frac{1}{2}$		stable	1, 2, 5, 6, 7, 8, 13, 14, 15, 16, 18, 19, 20, 21, 22, 30, 31, 32, 40, 41, 42, 43, 44, 45, 46, 48, 49, 50, 52, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 70, 71, 72, 73, 74
0.87081 ± 0.22	$\frac{1}{2}^+$	$\tau_m = 258.6 \pm 2.6$ psec [b]	γ	1, 2, 5, 6, 7, 13, 14, 15, 16, 18, 19, 20, 21, 22, 30, 31, 32, 40, 41, 45, 46, 47, 48, 49, 50, 58, 61, 62, 63, 69, 70, 71, 72, 73, 74
3.0552 ± 0.3	$\frac{1}{2}^-$	$\tau_m = 120^{+80}_{-60}$ fsec [c]	γ	5, 6, 7, 13, 14, 18, 21, 22, 30, 32, 41, 45, 50, 52, 61, 71, 72, 74
3.841 ± 3	$\frac{5}{2}^-$	$\tau_m \leq 25$ fsec [c]	γ	5, 6, 7, 13, 14, 18, 21, 22, 30, 31, 40, 41, 45, 52, 61, 62, 71, 72
4.553 ± 2	$\frac{3}{2}^-$	$\Gamma = 40 \pm 5$	n	5, 6, 7, 13, 14, 21, 22, 30, 31, 34, 41, 45, 50, 52, 61, 62, 72
5.086 ± 2	$\frac{3}{2}^+$	95 ± 5	n	6, 7, 13, 14, 21, 22, 30, 34, 41, 61, 62
5.215 ± 5	$(\frac{9}{2}^-)$	< 0.1		6, 13, 14, 21, 22, 30, 31, 41, 52, 61, 72
5.380 ± 2	$\frac{3}{2}^-$	28 ± 7	n	21, 22, 30, 32, 34, 41, 50, 52, 61, 62, 72
5.698 ± 2	$\frac{7}{2}^-$	3.4 ± 0.3	n	6, 13, 14, 21, 22, 30, 31, 34, 41, 52

Table 17.6: Energy levels of ^{17}O (continued)

E_x in ^{17}O (MeV ± keV)	$J^\pi; T$	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
5.734 ± 2		< 1	n	5, 6, 13, 14, 21, 22, 34, 41, 72
5.870 ± 2	$\frac{3}{2}^+$	6.6 ± 0.7	n	6, 14, 21, 22, 30, 34, 41, 72
5.940 ± 4	$\frac{1}{2}^-$	32 ± 3	n	5, 6, 14, 21, 22, 30, 34, 41, 50, 52, 72
6.357 ± 8	$\frac{1}{2}^+$	124 ± 12	n	5, 21, 30, 34
6.863 ± 2	$(\frac{1}{2}^-)$	< 1	n	5, 6, 13, 14, 21, 22, 30, 34, 41, 52, 72
6.973 ± 2		< 1	n	6, 13, 14, 21, 22, 30, 34, 72
7.1687 ± 1.5	$\frac{5}{2}^-$	1.5 ± 0.2	n, α	5, 6, 9, 13, 14, 21, 30, 34, 39, 52
7.202 ± 10	$\frac{3}{2}^+$	280 ± 30	n, α	34, 39
7.3831 ± 1.5	$\frac{5}{2}^+$	0.6 ± 0.2	n, α	5, 6, 9, 13, 14, 21, 30, 31, 34, 39
7.3860 ± 1.5	$\frac{5}{2}^-$	0.9 ± 0.3	n, α	5, 9, 21, 30, 31, 34, 39, 52
7.560 ± 20	$\frac{3}{2}^-$	500 ± 50	n, α	34, 39, 41
7.577 ± 2	$\frac{7}{2}^-$	≤ 1	n, α	5, 6, 9, 13, 14, 21, 30, 34, 52
7.690 ± 4	$\frac{7}{2}^-$	18 ± 2	n, α	5, 6, 9, 14, 30, 34, 39
7.75 ± 20	$\frac{11}{2}^-$			13, 14, 23, 30, 31, 32, 52
7.956 ± 6	$\frac{1}{2}^+$	90 ± 9	n, α	9, 30, 34, 39
7.99 ± 50	$\frac{1}{2}^-$	270 ± 30	n, α	34, 39
8.070 ± 10	$\frac{3}{2}^+$	85 ± 9	n, α	9, 30, 34, 39
(8.18 ± 20)	$\frac{1}{2}^-$	69 ± 7	n, α	34, 39
8.200 ± 7	$\frac{3}{2}^-$	60	n, α	9, 30, 31, 34, 39
8.352 ± 4	$\frac{1}{2}^+$	9 ± 3	n, α	9, 30, 34, 39
8.410 ± 3	$\frac{5}{2}^+$	4 ± 3	n, α	6, 9, 13, 14, 30, 34, 39
8.474 ± 3	$\frac{7}{2}^+$	7 ± 3	n, α	5, 6, 9, 13, 14, 31, 39

Table 17.6: Energy levels of ^{17}O (continued)

E_x in ^{17}O (MeV ± keV)	$J^\pi; T$	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
8.508 ± 3	$\frac{5}{2}^-$	5 ± 3	n, α	6, 9, 13, 14, 30, 34, 39
8.700 ± 5	$\frac{3}{2}^-$	50 ± 3	n, α	9, 30, 34, 39
8.898 ± 8	$\frac{3}{2}^+$	101 ± 3	n, α	6, 9, 13, 14, 30, 31, 34, 39
8.972 ± 4	$\frac{7}{2}^-$	21 ± 3	n, α	6, 9, 14, 30, 34, 39
9.148 ± 4	$\frac{1}{2}^-$	4 ± 3	n, α	6, 9, 14, 34
9.15 ± 20	$\frac{9}{2}^-$			23, 30, 31, 32
9.187	$\frac{7}{2}^-$	3	n, α	9, 34
9.201 ± 4	$\frac{5}{2}^+$	5.5 ± 1	n, α	9, 34
9.422	$\frac{3}{2}^-$	120	n	34
9.493 ± 4	$\frac{5}{2}^-$	15 ± 1	n, α	5, 9, 14, 30
9.720 ± 5	$\frac{7}{2}^+$	16 ± 1	n, α	9, 14, 30, 34
9.775 ± 15	$\frac{3}{2}^+$	≈ 25	n, α	9, 34
9.865 ± 5		14	n, α	9, 14, 30, 34
9.878 ± 15		≈ 10	n, α	9, 34
9.977 ± 20	$\frac{5}{2}^+$	≈ 80	n, α	9
10.046 ± 20		≈ 100	n, α	9
10.178 ± 5	$\frac{7}{2}^-$	40	n, α	9, 34
10.337 ± 15	$\frac{5}{2}^+, \frac{7}{2}^-$	150	n, α	9, 30
10.429 ± 7		14 ± 3	n, α	9
10.49	$\frac{5}{2}^+, \frac{7}{2}^-$	75 ± 30	n, α	9
10.563 ± 10	$(\frac{7}{2}^-)$	47 ± 15	n, α	9, 30, 34, 35
10.773 ± 10	$\frac{1}{2}^+, \frac{7}{2}^-$	80 ± 20	n, α	9, 14, 30, 35
10.910 ± 7	$\frac{5}{2}$	57 ± 15	n, α	9, 30, 34, 35
11.030 ± 4	$T = \frac{1}{2}$	45 ± 10	n, α	9, 30
11.076 ± 4 [a]	$\frac{1}{2}^-; \frac{3}{2}$	5 ± 1	n, α	9, 30, 35, 63
11.229 ± 10		100 ± 30	n, α	5, 9
11.52	$(\frac{3}{2}, \frac{5}{2})$	190	n	34, 35
11.619 ± 10		120 ± 30	n, α	9
11.752 ± 10		40 ± 25	n, α	9

Table 17.6: Energy levels of ^{17}O (continued)

E_x in ^{17}O (MeV ± keV)	$J^\pi; T$	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
11.817 ± 15		12 ± 3	n, α	9, 14
12.006 ± 15	$\geq \frac{3}{2}$	270	n, α	9, 34, 35
12.11 ± 20		150 ± 50	n, α	9, 35
12.275 ± 15		100 ± 30	n, α	9
12.39 ± 20		130	n, α	9, 34
12.421 ± 15			n, α	9, 35
12.464 ± 5	$(\frac{3}{2})^-; \frac{3}{2}$	8 ± 2	n, α	9, 35, 63
12.596 ± 15		75 ± 30	n, α	9
(12.656)		95	n	34, 35
12.670 ± 15		≈ 5	n, α	9, 35
12.81 ± 25			n, α	9
12.93 ± 20		$\gtrsim 150$	n, α	9, 35
12.946 ± 5	$\frac{1}{2}^+; \frac{3}{2}$	6 ± 2	n, α	9, 63
12.993 ± 5	$T = \frac{3}{2}$	≤ 3	n, α	9, 63
13.077 ± 15		16 ± 4	n, α	9
13.485 ± 15		≈ 120	n, α	9
13.610 ± 15		250 ± 100	n, α	9
13.640 ± 5	$(\frac{5}{2})^+; \frac{3}{2}$			63
(13.672)		400	n	34
14.219 ± 8	$T = \frac{3}{2}$			63
14.282 ± 12	$T = \frac{3}{2}$			63
14.621		340	n	34
(14.98)	$\frac{5}{2}^+$	≈ 150	n, d, α	28, 34
15.101 ± 8	$T = \frac{3}{2}$			63
(15.15)	$(\frac{5}{2}, \frac{7}{2})^-$	≈ 200	p, d	26
(15.5)		broad	p, d α	26, 28
20.45			γ, t	20
21.7 ± 100	$\frac{5}{2}^+$	750	γ, d, ^{3}He, α	16, 17, 24
22.1 ± 100	$\frac{7}{2}^-$	750	γ, n, d, ^{3}He, α	16, 17, 24
22.5 ± 200	$\frac{3}{2}^-$	≈ 1000	γ, d, ^{3}He	16, 24, 51

Table 17.6: Energy levels of ^{17}O (continued)

E_x in ^{17}O (MeV ± keV)	$J^\pi; T$	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
23.0 ± 100	$\frac{1}{2}^+$	≈ 400	γ, d, ^{3}He	16, 17, 24
23.5 ± 100			γ, ^{3}He	16
24.4 ± 100			γ, ^{3}He	16

[a] See also Table 17.11.
[b] See Table 17.7 in (1971AJ02).
[c] See (1964AL11).

Mass of ^{17}O: the atomic mass excess of ^{17}O is -810.5 ± 0.8 keV (A.H. Wapstra, private communication).

1. ^{7}Li(^{14}N, α)^{17}O $\qquad Q_m = 16.158$

The angular distribution of the α_{0+1} group has been measured at $E(^{14}\text{N}) = 27.6$ MeV (1964WA1B).

2. ^{9}Be(^{16}O, ^{8}Be)^{17}O $\qquad Q_m = 2.480$

Angular distributions have been studied at $E(^{16}\text{O}) = 11$ MeV (^{17}O$_{g.s.}$) and 15 and 18 MeV (^{17}O*(0, 0.87)) (1970BA49, 1971BA68). The excitation curve for the one-neutron transfer to ^{17}O*(0.87) has been measured for $E(^{16}\text{O}) = 6$ to 22 MeV (1970BA55). See also (1971NI04) and (1971AL1D; theor.).

3. (a) ^{10}B(^{7}Li, p)^{16}N $\qquad Q_m = 13.990$ $\qquad E_b = 27.771$
(b) ^{10}B(^{7}Li, d)^{15}N $\qquad Q_m = 13.723$
(c) ^{10}B(^{7}Li, t)^{14}N $\qquad Q_m = 9.147$
(d) ^{10}B(^{7}Li, α)^{13}C $\qquad Q_m = 21.411$

Cross sections to various of the final states have been measured at $E(^7\text{Li}) = 5.20$ MeV (1966MC05).

4. (a) $^{11}B(^{6}Li, p)^{16}N$ $Q_m = 9.785$ $E_b = 23.566$
(b) $^{11}B(^{6}Li, d)^{15}N$ $Q_m = 9.517$
(c) $^{11}B(^{6}Li, t)^{14}N$ $Q_m = 4.9413$
(d) $^{11}B(^{6}Li, \alpha)^{13}C$ $Q_m = 17.205$

Cross sections to various of the final states have been measured at $E(^{6}Li) = 4.72$ MeV (1966MC05).

5. $^{12}C(^{6}Li, p)^{17}O$ $Q_m = 7.609$

Proton groups have been identified to various states of ^{17}O with $E_x \leq 15.8$ MeV and angular distributions of proton groups have been studied for $E(^{6}Li) = 3$ to 20 MeV: see (1971AJ02) for a complete listing. See also (1970JO1D) and ^{18}F in (1978AJ03).

6. $^{12}C(^{7}Li, d)^{17}O$ $Q_m = 2.583$

Angular distributions have been measured at $E(^{7}Li) = 3.24 - 3.64$ MeV (1967MO23: d_0, d_1) and at 21.1 MeV (1971SC21: see Table 17.7). The latter have been analyzed by a Hauser-Feshbach method. See also (1971AJ02) and ^{19}F in (1978AJ03).

7. $^{12}C(^{9}Be, \alpha)^{17}O$ $Q_m = 9.734$

Cross sections have been measured for the population of ^{17}O*(0, 0.87, 3.06, 3.84) for $E(^{12}C)_{c.m.} = 2.40$ to 6.34 MeV (1974HA25). At $E(^{9}Be) = 26.3$ MeV, α-groups are observed to the first six states of ^{17}O and to ^{17}O*(7.5, 8.4, 9.8, 11.0, 11.8, 13.6). Some of the higher states (unresolved) may be formed by some sort of direct mechanism (1975VE10).

8. $^{12}C(^{13}C, 2\alpha)^{17}O$ $Q_m = -0.914$

See (1976DA13).

9. (a) $^{13}C(\alpha, n)^{16}O$ $Q_m = 2.2152$ $E_b = 6.361$
(b) $^{13}C(\alpha, \alpha)^{13}C$

The yield of neutrons increases monotonically for $E_\alpha = 0.475$ to 0.700 MeV: $S(E) = [(5.48 \pm$

Table 17.7: States of ^{17}O from ^{12}C(^{7}Li, d)^{17}O, ^{13}C(^{6}Li, d)^{17}O and ^{13}C(^{7}Li, t)^{17}O [a]

^{17}O* (MeV)	σ [b] (mb)	σ [c] (mb)	dσ/dΩ (in μb/sr) [d]		J [e]
			(^{6}Li, d)	(^{7}Li, t)	
0	0.67	0.83	105	75	$\frac{5}{2}$
0.87	0.33	0.32	180	92	$\frac{1}{2}$
3.06	1.05	0.50	560	750	$\frac{1}{2}$
3.84	1.83	1.24	340	1400	$\frac{5}{2}$
4.55	2.02	0.76	285	1350	$\frac{3}{2}$
5.08	0.72		180	250	
5.22	1.87	2.40	245	230	$\frac{7}{2}$
5.70 5.73	2.69	1.93	230	530	
5.87 5.94	1.10	1.22			$\frac{5}{2}+\frac{1}{2}$
6.86	1.30	1.40	92	125	$\frac{7}{2}$
6.97	1.79	1.20	200	320	$\frac{5}{2}$
$7.17+7.20$	2.62	1.22	350	1050	$\frac{5}{2}$
$7.38+7.39$	4.52	1.96	720	2000	$\frac{9}{2}$
7.58	1.67	2.06	98	310	$\frac{9}{2}$
7.69	3.47	2.89	620	1100	$\frac{3}{2}+\frac{7}{2}+\frac{3}{2}$
7.76 ± 0.02			[f]	[f]	$(\frac{11}{2}^{-})$ [f]
8.41 8.47 8.51	7.52	4.39	940	2400	$\frac{5}{2}+\frac{9}{2}+\frac{5}{2}$
8.90 8.97	8.85	3.92			$\frac{3}{2}+\frac{7}{2}+\frac{7}{2}$
$9.15+9.19$	4.26	2.63			
9.49		1.65			
$9.72+9.78$		2.51			

Table 17.7: States of ^{17}O from ^{12}C(^{7}Li, d)^{17}O, ^{13}C(^{6}Li, d)^{17}O and ^{13}C(^{7}Li, t)^{17}O [a] (continued)

^{17}O* (MeV)	σ [b] (mb)	σ [c] (mb)	$d\sigma/d\Omega$ (in μb/sr) [d]		J [e]
			(^{6}Li, d)	(^{7}Li, t)	
9.87 } 9.88 }		3.03			
10.77		3.44			
11.91		4.72			

[a] See also Table 17.8 in (1971AJ02).

[b] From integration over angular distributions of deuteron groups from (^{7}Li, d) (1971SC21).

[c] From integration over angular distributions of triton groups (1971SC21).

[d] (1970BE31): $d\sigma/d\Omega$ taken at maximum of angular distribution. See also Table 17.8 in (1971AJ02) for $d\sigma/d\Omega$ at 30 for other states.

[e] (1971SC21).

[f] Angular distribution obtained by (1970BE31).

$1.77) + (12.05 \pm 3.91)E] \times 10^5$ MeV · b (1968DA05). Astrophysical considerations are discussed by (1968DA1D, 1973BA10, 1975FO19, 1976DE1G). Yield curves for reaction (a) have been measured for $E_\alpha = 1.0$ to 22.5 MeV: see (1971AJ02) for a listing of the earlier work and (1973BA10: total neutron yield; $E_\alpha = 1.0$ to 5.4 MeV), (1976MC11: n_0; $E_\alpha = 4.2$ to 8.7 MeV; $T = \frac{3}{2}$ states). Elastic scattering studies (reaction (b)) have been studied at $E_\alpha = 2.0$ to 26.6 MeV: see (1971AJ02) for the earlier results and (1973KU18, 1973LE28: 18 to 26.6 MeV). See also (1974WE1P). Observed resonances in the neutron yields and anomalies in the elastic scattering are displayed in Table 17.8. Some of the J^π values derived from the polarization studies of (1971BA06: n_0; $E_\alpha = 3.36$ to 4.80 MeV) and (1973BU14: n_0; $E_\alpha = 2.08, 2.25, 2.43$ MeV). See also (1970RO08, 1971SE1E, 1974LO1B) and (1972HA2A; theor.).

10. ^{13}C(α, p)^{16}N $\quad Q_m = -7.421 \quad E_b = 6.361$

See (1974SC1L; theor.).

11. ^{13}C(α, d)^{15}N $\quad Q_m = -7.6879 \quad E_b = 6.361$

Excitation functions for elastically scattered deuterons have been measured for $E_\alpha = 13$ to 25 MeV: strong fluctuations are observed (1973LE28). See also (1976LE1K).

Table 17.8: Resonances in $^{13}C(\alpha, n)^{16}O$ and $^{13}C(\alpha, \alpha)^{13}C$ [a]

E_{res} (MeV ± keV)	$\Gamma_{c.m.}$ (keV)	Γ_α/Γ	J^π	E_x (MeV)	Refs.
1.0563 ± 1.5	1.5 ± 0.2		$\frac{5}{2}$	7.1687	(1973BA10), A
1.3367 ± 1.5	$0.6^{+0.2}_{-0.1}$			7.3831	(1973BA10), A
1.3406 ± 1.5	$0.8^{+0.3}_{-0.2}$			7.3860	(1973BA10), A
1.590 ± 2	≤ 1		$\frac{7}{2}^-$	7.577	(1973BA10), A
1.745 ± 6	≤ 15		$\frac{5}{2}^+$	7.695	(1973BA10), A
2.083 ± 8	75	0.03	$\frac{1}{2}^-$	7.954	(1973BA10, 1973BU14), A
2.250 ± 8	110	0.05	$\frac{3}{2}^+$	8.081	(1973BA10, 1973BU14), A
2.407 ± 8	70	0.11	$\frac{3}{2}^-$	8.201	(1973BA10, 1973BU14), A
2.604 ± 4	9 ± 3	0.44	$\frac{1}{2}^+$	8.352	(1973BA10), A
2.680 ± 3	4 ± 3	0.08	$\frac{5}{2}^+$	8.410	(1973BA10), A
2.763 ± 3	7 ± 3	0.97	$\frac{7}{2}^+$	8.474	(1973BA10), A
2.808 ± 3	5 ± 3	0.26	$\frac{5}{2}^-$	8.508	(1973BA10), A
3.059 ± 5	50 ± 3	0.06	$\frac{3}{2}^-$	8.700	(1971BA06, 1973BA10), A
(3.1)	broad		$\frac{1}{2}^-$	(8.7)	(1971BA06)
3.318 ± 8	101 ± 3	0.50	$\frac{3}{2}^+$	8.898	(1971BA06, 1973BA10), A
3.415 ± 4	21 ± 3	0.04	$\frac{7}{2}^-$	8.972	(1971BA06, 1973BA10), A
3.645 ± 4	4 ± 3	0.45	$\frac{1}{2}^-$	9.148	(1971BA06, 1973BA10), A
(3.69)	3	1.00	$\frac{7}{2}^-$	(9.18)	(1968KE02)
3.714 ± 4	5.5 ± 1	0.20	$\frac{5}{2}^+$	9.201	(1971BA06, 1973BA10), A
4.096 ± 4	15 ± 1	0.85	$\frac{5}{2}^-$	9.493	(1973BA10), A
(4.3)			$\frac{3}{2}^-$	(9.6)	(1971BA06)
4.394 ± 5	16 ± 1	0.70	$\frac{7}{2}^+$	9.720	(1971BA06, 1973BA10), A
4.465 ± 15	≈ 25	0.90	$\frac{3}{2}^+$	9.775	(1971BA06, 1973BA10), A
4.583 ± 5	14			9.865	(1971BA06, 1973BA10), A
4.600 ± 15	≈ 10			9.878	(1971BA06, 1973BA10), A
4.730 ± 20	≈ 80	0.78	$\frac{5}{2}^+$	9.977	(1971BA06, 1973BA10), A
4.820 ± 20	≈ 100			10.046	(1973BA10)
(4.94)	138	0.85	$\frac{5}{2}^+$	(10.14)	(1968KE02)
4.993 ± 5	45	0.15	$\frac{7}{2}^-$	10.178	(1971BA06, 1973BA10), A
(5.08)	122	0.60	$\frac{7}{2}^+$	(10.2)	A

Table 17.8: Resonances in $^{13}C(\alpha, n)^{16}O$ and $^{13}C(\alpha, \alpha)^{13}C$ [a] (continued)

E_{res} (MeV ± keV)	$\Gamma_{c.m.}$ (keV)	Γ_α/Γ	J^π	E_x (MeV)	Refs.
5.200 ± 15	150		$\frac{5}{2}^+, \frac{7}{2}^-$	10.337	(1973BA10), A
5.321 ± 7	14 ± 3			10.429	(1973BA10), A
5.40	75 ± 30		$\frac{5}{2}^+, \frac{7}{2}^-$	10.49	A
5.496 ± 10	47 ± 15		$\frac{7}{2}^-, \frac{9}{2}^+$	10.563	A
(5.68)	≤ 25	1.00	$(\frac{7}{2}^+)$	(10.70)	(1968KE02)
5.771 ± 10	80 ± 20		$\frac{1}{2}^+, \frac{7}{2}^-$	10.773	A
5.945 ± 10	57 ± 15		$\frac{5}{2}$	10.906	A
6.107 ± 10	45 ± 10			11.030	A
6.167	5.0 ± 1.1		$\frac{1}{2}^-; T = \frac{3}{2}$	11.076 ± 0.005	(1976MC11)
6.367 ± 10	100 ± 30			11.229	A
6.878 ± 10	120 ± 30			11.619	A
7.051 ± 10	40 ± 25			11.752	A
7.136 ± 15	12 ± 3			11.817	A
7.384 ± 15				12.006	A
7.52 ± 20	150 ± 50			12.11	(1963SP02)
7.736 ± 15	100 ± 30			12.275	A
7.88 ± 20				12.39	(1963SP02)
7.927 ± 15				12.421	(1963SP02)
7.975	8 ± 2		$\frac{3}{2}^-; T = \frac{3}{2}$	12.458 ± 0.005	(1976MC11)
8.156 ± 15	75 ± 30			12.596	(1963SP02)
8.253 ± 15	≈ 5			12.670	(1963SP02)
8.44 ± 25				12.81	(1963SP02)
8.59 ± 20	$\gtrsim 150$			12.93	(1963SP02)
8.611	6 ± 2		$\frac{1}{2}^+; T = \frac{3}{2}$	12.944 ± 0.006	(1976MC11)
8.675	≤ 3		$\frac{5}{2}^-; T = \frac{3}{2}$	12.993 ± 0.006	(1976MC11)
8.72 ± 20				13.03	(1963SP02)
8.785 ± 15	16 ± 4			13.077	(1963SP02)
9.319 ± 15	≈ 120			13.485	(1963SP02)
9.483 ± 15	250 ± 100			13.610	(1963SP02)

A: see references listed for this state in Table 17.6 of (1971AJ02).

[a] See also Table 17.6 in (1971AJ02) and Table 17.12 here.

12. ^{13}C(α, t)^{14}N $Q_m = -12.2640$ $E_b = 6.361$

See (1974DM01). See also (1976LE1K).

13. ^{13}C(^{6}Li, d)^{17}O $Q_m = 4.887$

At $E(^{6}\text{Li}) = 18$ MeV angular distributions have been measured to many ^{17}O states: see Table 17.7 here and Table 17.8 in (1971AJ02) (1970BE31, 1971BE2D). Angular distributions are also reported at $E(^{6}\text{Li}) = 25.6$ MeV (1970GO29: $d_0 \rightarrow d_3$ and d to ^{17}O*(7.5, 8.9)). See also (1973OG1A).

14. ^{13}C(^{7}Li, t)^{17}O $Q_m = 3.894$

Angular distributions have been measured at $E(^{7}\text{Li}) = 17$ MeV (1970BE31), 20.5 MeV (1971BE2D, 1971SC21; DWBA analysis) and 30.1 MeV (1970GO29): see Table 17.7 here and Table 17.8 in (1971AJ02).

15. ^{13}C(^{16}O, ^{12}C)^{17}O $Q_m = -0.801$

Angular distributions have been studied at $E(^{16}\text{O}) = 14$ MeV ($^{17}\text{O}_{\text{g.s.}}$) and 17 and 20 MeV (^{17}O*(0, 0.87)) (1970BA49). The excitation curve for the one-neutron transfer to ^{17}O*(0.87) has been measured for $E(^{16}\text{O}) = 12$ to 25 MeV (1970BA55). See also (1971BA68) and (1973DE21).

16. ^{14}C(^{3}He, γ)^{17}O $Q_m = 18.762$

The capture cross sections at 90° for γ_0 and for γ_1 have been studied for $E(^{3}\text{He}) = 3.2$ to 7.5 MeV and angular distributions of the γ-rays have been studied at the six observed resonances: see Table 17.9 (1976CH04).

Table 17.9: States of ^{17}O from ^{14}C + ^{3}He

E_{res} (MeV)	Resonant for	$\Gamma_{c.m.}$ (MeV)	E_x	J^{π}	Refs.
3.6 ± 0.1	γ_0, (γ_1), α_0, α_1	0.75	21.7	$\frac{5}{2}^+$	(1972KE08, 1976CH04)
4.1 ± 0.1	γ_0, n_0, n_{3+4}, α_0, α_1	0.75	22.1	$\frac{7}{2}^-$	(1970HO08, 1972KE08, 1976CH04)
4.6 ± 0.2	γ_1	≈ 1	22.5	$\frac{3}{2}^{(-)}$	(1976CH04)
5.1 ± 0.1	γ_0, ^{3}He	≈ 0.4	23.0	$\frac{1}{2}^+$	(1972KE08, 1976CH04)
5.7 ± 0.1	γ_1		23.5		(1976CH04)
6.9 ± 0.1	γ_1		24.4		(1976CH04)

17. (a) ^{14}C(^{3}He, n)^{16}O $\quad Q_m = 14.6167 \quad E_b = 18.762$
(b) ^{14}C(^{3}He, p)^{16}N $\quad Q_m = 4.981$
(c) ^{14}C(^{3}He, d)^{15}N $\quad Q_m = 4.7136$
(d) ^{14}C(^{3}He, ^{3}He)^{14}C
(e) ^{14}C(^{3}He, α)^{13}C $\quad Q_m = 12.4015$

The excitation function for reaction (a) shows a resonance in the n_0 and n_{3+4} yields at $E(^{3}\text{He}) = 4.1$ MeV but not in the n_{1+2} yield: $J^{\pi} = \frac{1}{2}^-$ or $\frac{3}{2}^-$ is suggested [see, however, Table 17.9] (1970HO08).

Resonances are observed in the ^{3}He yield (reaction (d)) at $E(^{3}\text{He}) = 5.1$ MeV and in the α_0 and α_1 yield (reaction (e)) at 3.6 and 4.1 MeV. On the basis of a two-level analysis of the α-channel and an optical model plus resonance analysis of the elastic data, the corresponding ^{17}O states [21.7, 22.1, 23.0 MeV] are assigned $J^{\pi} = \frac{5}{2}^+$, $\frac{7}{2}^-$ and $\frac{1}{2}^+$, respectively (1971KE08, 1972KE08): see Table 17.9. (1972KE08) also report excitation functions in the range $E(^{3}\text{He}) = 2.2 - 7.0$ MeV ($\alpha_0 \rightarrow \alpha_3$), $3.2 - 4.4$ MeV ($p_0 \rightarrow p_3$), $3.2 - 5.5$ MeV (d) and 4.0 to 6.1 MeV (^{3}He): angular distributions for the α-groups have been measured at a number of energies. See also (1971AJ02).

18. ^{14}C(α, n)^{17}O $\quad Q_m = -1.816$

The upper limits to the decays $3.06 \rightarrow 0$ and $3.84 \rightarrow 0.87$ are, respectively, 2 and 5%. A study of n-γ correlations leads to $J^{\pi} = \frac{1}{2}^-$ and $(\frac{5}{2}^-)$ for ^{17}O*(3.06, 3.84) (1964AL11). See also (1973CL1E; astrophys. considerations).

19. ^{14}C(^{16}O, ^{13}C)^{17}O $\quad Q_m = -4.032$

Angular distributions have been measured at $E(^{16}O) = 20$, 25 and 30 MeV to $^{17}O_{g.s.}$ and at 30 MeV to ^{17}O*(0.87) (1975SC35, 1975SC42). See also (1973BR1C).

20. (a) $^{14}N(t, \gamma)^{17}O$ $\quad Q_m = 18.625$ $\quad E_b = 18.625$
(b) $^{14}N(t, p)^{16}N$ $\quad Q_m = 4.843$
(c) $^{14}N(t, d)^{15}N$ $\quad Q_m = 4.5761$
(d) $^{14}N(t, t)^{14}N$
(e) $^{14}N(t, \alpha)^{13}C$ $\quad Q_m = 12.2640$

The excitation functions for γ_0 and γ_1 have been measured at $90°$ for $E_t = 1.5$ to 3.6 MeV: a broad resonance is observed in the γ_0 yield corresponding to ^{17}O*(20.45). Some evidence is also reported for structures in the γ_1 yield (1973LI1G: prelim. results). Excitation functions have also been measured for the $p_0 \to p_3$, d_0, t_0 and α_0 and α_1 groups for $E_t = 1.0$ to 2.0 MeV: the reactions appear to proceed primarily via a direct interaction mechanism (1964SC09). See also (1974FA1A; theor.).

21. (a) $^{14}N(\alpha, p)^{17}O$ $\quad Q_m = -1.190$
(b) $^{14}N(\alpha, p\alpha)^{13}C$ $\quad Q_m = -7.551$

Angular distributions have been measured for ^{17}O states with $E_x < 7.6$ MeV in the range $E_p = 8.1 - 33.3$ MeV: see a listing of the references in (1971AJ02). The sequential decay (reaction (b)) appears to take place via ^{17}O states with $8.46 \leq E_x \leq 13.57$ MeV. Those involved are believed to have $J \geq \frac{5}{2}$, $\Gamma_\alpha/\Gamma \geq 0.6$ (1969BA17). See also ^{18}F in (1978AJ03) and (1971BU1K; theor.).

22. $^{14}N(^6Li, ^3He)^{17}O$ $\quad Q_m = 2.830$

At $E(^6Li) = 18$ MeV, the ^{3}He groups in this reaction and the triton groups in the mirror reaction (see ^{17}F, reaction 7) have been compared: ^{17}O*(3.84, 4.55, 5.22, $5.70 + 5.73$) are strongly excited. It is suggested that ^{17}O*(5.22) and ^{17}F*(5.21) are analogs with $J^\pi = \frac{9}{2}^-$. ^{17}O*(0, 0.87, 3.06, 5.08, 5.38, $5.87 + 5.94$, 6.86, 6.97) are also populated (1973BI01).

23. $^{14}N(^{10}B, ^7Be)^{17}O$ $\quad Q_m = -0.044$

At $E(^{10}B) = 100$ MeV ^{17}O*(7.75, 9.15) [$J^\pi = \frac{11}{2}^-$ and $\frac{9}{2}^-$, respectively] are populated (1976HAXX).

24. ^{15}N(d, γ)^{17}O $Q_m = 14.049$

Peaks in the excitation functions of both γ_0 and γ_1 have been observed corresponding to ^{17}O*(21.3, 21.9, 22.8) (1972CA1M; abstract).

25. ^{15}N(d, n)^{16}O $Q_m = 9.9031$ $E_b = 14.049$

The excitation function has been measured for $E_d = 0.5$ to 5.3 MeV. Above $E_d = 1$ MeV, pronounced peaks are observed, presumably to be ascribed to numerous overlapping resonances (1958WE31). The differential cross sections at $10°$ have been measured for $E_d = 2.2$ to 5.9 MeV for the neutrons to ^{16}O*(0, 6.13, 7.12, 8.87, 9.85, 10.95, 11.08) (1971MU09). Polarization measurements have been reported for $E_n = 1.6$ to 5.5 MeV (n_0: see (1971AJ02)) and at 4.83 MeV (1972FO17: n to ^{16}O*(0, 6.13, 7.12, 8.87, 9.85, $10.95+11.08$, $11.52+11.60$, 12.05, $12.44+12.53$, 12.80)) and 10.0 and 11.8 MeV (1971HI09; n_0). See also (1972BO49) and ^{16}O, and (1971HA1R).

26. ^{15}N(d, p)^{16}N $Q_m = 0.267$ $E_b = 14.049$

Excitation functions have been obtained for $E_d = 0.3$ to 2.7 MeV (1957BO04) and 4.25 to 6.25 MeV (1972BO49: $p_0 \rightarrow p_3$). Resonant structure at $E_d = 1.3$ and 1.9 MeV [^{17}O*(15.2, 15.7)] is reported by (1957BO04).

27. ^{15}N(d, d)^{15}N $E_b = 14.049$

The excitation function for the d_0 group has been measured for $E_d = 4.25$ to 6.25 MeV (1972BO49).

28. ^{15}N(d, α)^{13}C $Q_m = 7.6879$ $E_b = 14.049$

The α_0 yield curve for $E_d = 0.8$ to 1.8 MeV indicates two resonances at $E_d = 1.06$ and 1.25 MeV [$\Gamma \approx 100$ and 200 keV, respectively], attributed to an ^{17}O state at $E_x = 14.98$ MeV [$J^\pi = \frac{5}{2}^+$] and to one or more ^{17}O states at $E_x = 15.15$ MeV [$J^\pi = \frac{5}{2}^+$ or $\frac{7}{2}^-$] (1966TI03). In the range $E_d = 1.2$ to 2.5 MeV a broad maximum is observed in both the α_0 and α_1 yields at $E_d \approx 1.7$ MeV (1965MA59). The excitation function has also been studied for $E_d = 5$ to 10 MeV (1974WE1P).

29. ^{15}N(t, n)^{17}O $Q_m = 7.791$

Not reported.

30. ^{15}N(^{3}He, p)^{17}O $Q_m = 8.555$

At $E(^3\text{He}) = 18$ MeV angular distributions analyzed by DWBA, have been obtained for a number of ^{17}O states as displayed in Table 17.10: the wave functions of Zuker, Buck and McGrory appear to provide a good description of most of the states below $E_x = 9$ MeV (1972LE01). Angular distributions have also been reported at $E(^3\text{He}) = 2.4$ to 4.1 MeV (1973AB1D: $p_0 \to p_2$) and at 15 MeV (1975HA33: p_0, p_2). For the decay of the first $T = \frac{3}{2}$ state at $E_x = 11.08$ MeV, see Table 17.11 (1973AD02).

31. ^{15}N(α, d)^{17}O $Q_m = -9.799$

At $E_\alpha = 45.4$ MeV, the deuteron spectrum is dominated by the groups corresponding to states with $E_x = 7.742 \pm 0.020$ and 9.137 ± 0.030 MeV. These states are assigned $J^\pi = (\frac{11}{2}^-)$ and $(\frac{9}{2}^-)$ and arise from a dominant $(d_{5/2})^2_5 p^{-1}_{1/2}$ configuration. Angular distributions were measured as well for the deuterons corresponding to ^{17}O(0) and to states with $E_x = 0.87 \pm 0.05$, 5.208 ± 0.030, 5.690 ± 0.030, 7.367 ± 0.030, 8.459 ± 0.030, 8.890 ± 0.030 and 9.814 ± 0.030 MeV. In addition the excitation of states with $E_x = 3.85 \pm 0.05$, 4.57 ± 0.05 and 8.147 ± 0.030 MeV is also reported (1969LU07).

32. ^{15}N(^{11}B, ^{9}Be)^{17}O $Q_m = -1.768$

At $E(^{11}\text{B}) = 113.5$ MeV, ^{17}O states at 7.6 and 9.0 MeV are strongly populated. The excitation of ^{17}O*(0, 0.9, 3.0, 5.4) is also reported (1975PO10).

33. ^{16}O(n, γ)^{17}O $Q_m = 4.146$

$$\sigma_{\text{capt.}} = 178 \pm 25\ \mu\text{b [see (1973MU14)]},\ 202 \pm 27\ \mu\text{b (1976EA1B)}.$$

At the $E_n = 426 \pm 10$ keV resonance [see Table 17.12], $\Gamma_\gamma < 4.0$ eV, $\Gamma_n = 60 \pm 15$ keV (1971AL09). At thermal energies the branching via ^{17}O*(3.05) is $82 \pm 3\%$ (1976EA1B). For astrophysical considerations see (1968FOZY, 1970CL1C, 1971AL09, 1973CL1E).

Table 17.10: Levels of ^{17}O from ^{15}N(^{3}He, p)^{17}O [a]

E_x [b] (MeV)	L	E_x [b] (MeV)	L
0	(1 + 3)	8.192	0
0.874	1	8.322	
3.053	0	8.390	
3.845	2	8.492	(2)
4.549	0	8.682	
5.081	(1)	8.900	
5.215	(4)	8.955	
5.381	0	9.16	(4)
5.698	2	9.495	
5.873	(1)	9.712	
5.938	0	9.856	
6.37		(10.24)	
6.861	(0)	10.33	
6.973	(1 + 3)	10.57	
7.162	2	10.782	
7.382	2	10.913	
7.561		11.032 ± 0.004 [c]	
7.687		11.075 ± 0.004 [d]	
7.761	4		
7.938			
8.054	(1)		

[a] (1972LE01).

[b] ±10 keV, except where shown otherwise.

[c] See also (1970MC02): $T = \frac{1}{2}$.

[d] $J^\pi = \frac{1}{2}^-$; $T = \frac{3}{2}$: see Table 17.11 (1972LE01, 1973AD02).

Table 17.11: Decay properties of the lowest $T = \frac{3}{2}$ states in $A = 17$ [a]

		^{17}O*(11.076 ± 0.004)	^{17}F*(11.1931 ± 0.0023) [c]
J^π		$\frac{1}{2}^-$	$\frac{1}{2}^-$
$\Gamma_{c.m.}$ (keV)		5.0 ± 1.1 [b]	0.20 ± 0.04
Branching ratio (%) to ^{16}O* (MeV)	J^π		
0	0^+	91 ± 15	8.8 ± 1.6
6.05	0^+	} 5 ± 2	< 3
6.13	3^-		22 ± 2
6.92	2^+		24 ± 6
7.12	1^-		44 ± 4
^{13}C + α_0 or ^{13}N + α_0		6	< 7
Partial widths [Γ_p or Γ_n] to			
^{16}O(0)		4.5 ± 1.2 keV	19 ± 3 eV
^{16}O*(6.05)		} 0.25 ± 0.11 keV	< 17 eV
^{16}O*(6.13)			95^{+30}_{-50} eV [d]
^{16}O*(6.92)			100^{+40}_{-60} eV [d]
^{16}O*(7.12)			190^{+60}_{-100} eV [d]
Γ_{α_0}		0.3 keV	< 40 eV
Γ_{γ_1}			6.0 ± 2.5 eV
θ^2(g.s.)/θ^2(6.13)		0.31 ± 0.14	0.065 ± 0.019

[a] See also Table 2 in (1973AD02) and reaction 63.

[b] (1976MC11).

[c] (1971HA05, 1973AD02, 1974SK02, 1975HA06, 1976HI09).

[d] Note that the total width is 200 ± 40 eV.

34. ^{16}O(n, n)^{16}O $E_b = 4.146$

The scattering amplitude bound is $a = 5.80 \pm 0.05$ fm (1965DO14). The coherent scattering cross section is 4.23 ± 0.07 b (1964ST25). Earlier cross section, angular distribution and polarization measurements are listed in Table 17.10 of (1971AJ02). Recent measurements of σ_t are reported by (1972PEYR: $0.2 - 20$ MeV), (1974SC1C: $0.5 - 20.5$ MeV), (1973FO11: $0.6 - 0.9$, $1.12 - 1.16$, $1.39 - 4.33$ MeV), (1971FO1P, 1971FO24: $2.5 - 15.0$ MeV), (1972KI1D: elastic; $4.34 - 8.56$ MeV), (1971AN16: 14.7 MeV), (1972AU01: $24.63 - 58.90$ MeV) and (1974BA52, 1974BA62: $28 - 54$ GeV). See also (1976GAYV). (1973BU1D, 1974BU19) report $\sigma(\theta)$ at small angles for $E_n = 7.40$ to 9.50 MeV. Polarization studies are reported by (1973HI09, 1974HI1B: $E_n = 1 - 4$ MeV) and (1976DR08: 2.25 to 3.90 MeV).

Recent high resolution cross section measurements and analyses of the elastic scattering and of the (n, α) and ^{13}C(α, n) data have led to a much better understanding of the ^{17}O structure below $E_x = 9.5$ MeV: see Table 17.12 (1973FO11, 1973JO01). (1973JO01) has performed a multilevel two-channel R-matrix analysis. Five states contain nearly 100% of the 1d$_{3/2}$ strength and have their eigenenergy at $E_x \approx 5.7$ MeV [the dominant state is ^{17}O*(5.08)]. Spectroscopic factors are deduced for 26 states in ^{17}O for $4.5 < E_x < 9.5$ MeV [see Table 17.12]: the sum of these factors is 1% for $J^\pi = \frac{1}{2}^+$, 5% for $\frac{1}{2}^-$, 12% for $\frac{3}{2}^-$, 99% for $\frac{3}{2}^+$, 0.1% for $\frac{5}{2}^+$, 1% for $\frac{5}{2}^-$ and 14% for $\frac{7}{2}^-$ (1973JO01).

See also ^{16}O, (1971SE1D), (1971AJ02, 1972LA1F, 1973MU14, 1974SA1N) and (1970GN1A, 1970TI02, 1970VA1M, 1971DO15, 1971LE1B, 1971MA05, 1971MA62, 1971SC22, 1972HA2A, 1972LE1M, 1972PH06, 1972SC45, 1973LE1K, 1973SC1R, 1973ST05, 1973WE06, 1974GE03, 1974HI04, 1974MU1F, 1974PH03, 1975BE06, 1975CA05, 1975GE08, 1975PH01, 1975TH12; theor.).

35. ^{16}O(n, n$'$)^{16}O* $E_b = 4.146$

Earlier cross section measurements are listed in Table 17.10 of (1971AJ02). The cross sections for production of 6.13 and $(6.92 + 7.12)$ γ-rays in the range $E_n = 6.5$ to 10 MeV show a number of resonances: see Table 17.13 (1959HA13). See also the more recent studies of (1970LU16: $E_n = 6.74$ to 8.20 MeV; $\gamma_{6.13}$) and (1970OR1B: $E_n = 6.35$ to 16.52 MeV; $\gamma_{6.13}$, $\gamma_{6.92}$, $\gamma_{7.12}$). See also (1969RO1F, 1972KI1D, 1976NO1F).

36. ^{16}O(n, 2n)^{15}O $Q_m = -15.664$ $E_b = 4.146$

The cross section has been measured for $E_n = 17$ to 37 MeV (1961BR1A). See also (1974CA1J) and (1976GAYV).

37. ^{16}O(n, p)^{16}N $Q_m = -9.636$ $E_b = 4.146$

Table 17.12: Resonances [a] in ^{16}O(n, n)^{16}O and ^{16}O(n, α)^{13}C

E_n [b] (keV)	$\Gamma_{c.m.}$ [b] (keV)	$\Gamma_{\lambda n}$ [c] (keV)	$\Gamma_{\lambda\alpha}$ [c] (keV)	$\theta^2_{\lambda n}$ [c] (%)	J^π [b]	E_x (MeV)
433 ± 2 [j]	45	45		4.4	$\frac{3}{2}^-$	4.553
1000 ± 2 [j]	96	96		68.9 [i]	$\frac{3}{2}^+$	5.086
1140 [d]	< 0.1					5.218
1312 ± 2 [j]	42	41.5		0.91	$\frac{3}{2}^-$	5.380
1651 ± 2	3.4 ± 0.3	3.4		9.4	$\frac{7}{2}^-$	5.698
1689 ± 2	< 1				[e]	5.734
1833 ± 2	6.6 ± 0.7	6.6		0.95	$\frac{3}{2}^+$	5.870
1908 ± 4	32 ± 3	31.5		0.51	$\frac{1}{2}^-$	5.940
2351 ± 8 [h]	124 ± 12	124		0.81	$\frac{1}{2}^+$	6.357
2889 ± 2	< 1				[e]	6.863
3006 ± 2	< 1				[e]	6.973
3211 ± 3	1.3 ± 0.4	1.3	0.0033	0.44	$(\frac{5}{2}^-)$	7.166
3250 ± 10	280 ± 30	280	0.07	16.9	$\frac{3}{2}^+$	7.202
3438 ± 3	0.5 ± 0.2	0.5	0.01	0.01	$(\frac{5}{2}^+)$	7.379
3441 ± 3	1.1 ± 0.4	1.1	0.003	0.31	$\frac{5}{2}^-$	7.382
3630 ± 20	500 ± 50	500	0.08	5.1	$\frac{3}{2}^-$	7.560
3647 [d]	< 0.1					7.576
3766 ± 4	18 ± 2	18	0.01	2.9	$\frac{7}{2}^-$	7.688
4053 ± 8 [f]	90 ± 9	84	6.7	0.47	$\frac{1}{2}^+$	7.958
4090 ± 50 [f]	270 ± 30	250	16	3.4	$\frac{1}{2}^-$	7.99
4162 ± 8 [f]	85 ± 9	71	15	8.5	$\frac{3}{2}^+$	8.060
4290 ± 20 [f]	69 ± 7	68	0.8	0.68	$\frac{1}{2}^-$	(8.18)
4310 ± 10 [f]	52	48	4.0	0.43	$(\frac{3}{2}^-)$	8.199
4470	12	10	2.2	0.06	$\frac{1}{2}^+$	8.350
4532	5	4.8	0.54	0.8	$\frac{5}{2}^+$	8.408
4600	8		7.6	0.53	$\frac{7}{2}^+$	8.472
4610	≤ 11				$\geq \frac{3}{2}^+$	8.481
4637	5	3.4	1.9	0.40	$\frac{5}{2}^-$	8.507
4830 [f]	44	42	1.8	0.36	$\frac{3}{2}^-$	8.688
5050 [f]	78	68	9.5	4.2	$\frac{3}{2}^+$	8.895

Table 17.12: Resonances [a] in ^{16}O(n, n)^{16}O and ^{16}O(n, α)^{13}C (continued)

E_n [b] (keV)	$\Gamma_{c.m.}$ [b] (keV)	$\Gamma_{\lambda n}$ [c] (keV)	$\Gamma_{\lambda\alpha}$ [c] (keV)	$\theta^2_{\lambda n}$ [c] (%)	J^π [b]	E_x (MeV)
5131 [f]	25	23	2.3	1.5	$\frac{7}{2}^-$	8.971
5320	7				$\frac{1}{2}^-$	9.149
5360	3				$\frac{7}{2}^-$	9.187
5370	7				$\frac{5}{2}^+$	9.196
5610 [f]	120	120		0.91	$\frac{3}{2}^-$	9.422
5640 [f]	15				$\frac{5}{2}^-$	9.450
5640 [g]	140				$\geq \frac{3}{2}$	9.450
5914 ± 5	28				$\geq \frac{5}{2}$	9.708
6010	28				$\geq \frac{3}{2}$	9.798
6100	25				$\geq \frac{1}{2}$	9.88
6395 ± 7	38				$\geq \frac{3}{2}$	10.160
6807 ± 7	40				$\geq \frac{3}{2}$	10.547
7200 ± 8	70				$\geq \frac{3}{2}$	10.917
7830	190				$\geq \frac{3}{2}$	11.509
8320	270				$\geq \frac{3}{2}$	11.970
8740	130					12.365
9050	95					12.656
10130	400					13.672
11140	340				$(\geq \frac{3}{2})$	14.621
11540	180					14.997

[a] See also Table 17.8 here and Table 17.11 in (1971AJ02).

[b] See (1973FO11, 1973JO01). See (1971AJ02) for the earlier values.

[c] See (1973JO01).

[d] Not observed in σ_1: see (1973FO11).

[e] Not $\frac{1}{2}^+$ (1973FO11).

[f] See also (1974SC1C).

[g] For this resonance and all the follwoing ones see (1961FO07, 1969DA13, 1974SC1C).

[h] See also (1971WE08, 1973WE06).

[i] $S = 0.8 \pm 0.1$ (1974CO10).

[j] C.H. Johnson, private communication.

Table 17.13: Resonances in ^{16}O(n, n′γ)^{16}O (1959HA13, 1970LU16)

E_n (MeV)	E_x (MeV)
6.85 [a]	10.59
7.07	10.79
7.24	10.95
7.42	11.12
7.85 [b]	11.53
8.35	12.00
8.50	12.14
8.84	12.46
9.10	12.70
9.34	12.93

[a] Proposed $J^\pi = \frac{7}{2}^-$ (1970LU16).
[b] Proposed $J = \frac{3}{2}$ or $\frac{5}{2}$ (1970LU16).

Cross section measurements are listed in Table 17.10 of (1971AJ02) and in (1975SA1D; $E_n = 14.1$ MeV). See also (1971AJ02, 1971CU1B, 1971PR09, 1972ED01, 1974BO1E, 1974CA1J, 1976GAYV).

38. ^{16}O(n, d)^{15}N $\qquad Q_m = -9.9031 \qquad E_b = 4.146$

See ^{15}N in (1976AJ04).

39. ^{16}O(n, α)^{13}C $\qquad Q_m = -2.2152 \qquad E_b = 4.146$

The cross section has been measured from threshold to 20 MeV: see Table 17.10 in (1971AJ02) and (1970OR1B: $8-15.5$ MeV; $\gamma_{3.09}$, $\gamma_{3.68}$, $\gamma_{3.85}$) and (1973BO26: 14.1 MeV). See also (1968DA1E, 1971BR33, 1971NY03). Table 17.12 reflects the results from a multilevel two-channel R-matrix analysis of the data from this reaction and from the elastic scattering of neutrons (1973JO01). See also (1969RO1F, 1976NO1F), (1971AJ02, 1976GAYV) and (1972HA2A; theor.).

40. ^{16}O(p, π^+)^{17}O $\qquad Q_m = -136.205$

At $E_p = 185$ MeV angular distributions of pions to ^{17}O*(0, 0.88 ± 0.08, 3.85 ± 0.08) are reported by (1974DA23). See also (1976NO1D; theor.).

41. ^{16}O(d, p)^{17}O $\qquad Q_m = 1.921$

Observed proton groups are displayed in Table 17.14. Angular distributions have been measured at many energies in the range of $E_d = 0.3$ to 63.2 MeV: see Table 17.13 in (1971AJ02) for the earlier references and (1973CA30: $E_d = 1.0$ to 2.0 MeV; p_0, p_1), (DeForest, quoted in (1971KO21): 8 MeV; p_0, p_1), (1972CO15, 1973DA17: 9.3 and 13.3 MeV; p_0, p_1, p_3, p_4, p_5, p_8), (1972BR12: 12.3 MeV; p_0, p_1) and (1974CO04: 25.4, 36.0, 63.2 MeV: p_0, p_1, p_5).

The lifetime of ^{17}O*(0.87) is 258.6 ± 2.6 psec: see Table 17.7 in (1971AJ02). See also (1971DO13, 1973DO1D). $E_\gamma = 870.81 \pm 0.22$ keV (1966WI01). The width of ^{17}O*(5.08) observed in this reaction ($\Gamma = 70$ keV) is ≈ 0.7 that observed in ^{16}O(n, n): see (1974CO04, 1974FO17).

See also ^{18}F in (1978AJ03), (1970CA1C, 1971GR2B, 1972PR1D), (1976SC1G; applied work) and (1970DO10, 1970KI15, 1970KU1B, 1970OH1C, 1971BO50, 1971CO1B, 1971DO1A, 1972BU23, 1972DZ06, 1972FR1E, 1972GO04, 1972PH06, 1972SC45, 1972SC20, 1973BA74, 1973DO02, 1974BA19, 1974CO10, 1974GO02, 1974IM01, 1974OR1A, 1975CO12, 1976BO15, 1976SH13; theor.).

42. ^{16}O(t, d)^{17}O $\qquad Q_m = -2.112$

The angular distribution of the d_0 group has been studied at $E_t = 5.5$ MeV (1961BA10).

43. ^{16}O(α, ^{3}He)^{17}O $\qquad Q_m = -16.433$

See (1971AJ02, 1972PR1D, 1976HA27).

44. ^{16}O(^{6}Li, pα)^{17}O $\qquad Q_m = 0.447$

See (1974MI1F).

45. ^{16}O(^{7}Li, ^{6}Li)^{17}O $\qquad Q_m = -3.105$

Table 17.14: States of ^{17}O from ^{16}O(d, p)^{17}O and ^{19}F(d, α)^{17}O

E_x [a] (MeV $\pm$ keV)	$\Gamma_{c.m.}$ [a] (keV)	E_x [b] (MeV $\pm$ keV)	E_x [c] (MeV $\pm$ keV)	S [d]	J^π
0	< 8	0	0	≈ 0.9	$\frac{5}{2}^+$
0.871 ± 4 [e]	< 8	0.870 ± 20	0.883 ± 11	≈ 0.9	$\frac{1}{2}^+$
3.055 ± 4 [e]	< 8	3.060 ± 30	3.069 ± 10		$\frac{1}{2}^-$
3.846 ± 5 [e]	< 8	3.850 ± 30	3.856 ± 11		$\frac{5}{2}^-$ [g]
4.553 ± 6	40 ± 5	4.580 ± 20	4.567 ± 14	0.23	$\frac{3}{2}^-$
5.083 ± 10	95 ± 5	5.070 ± 20		1.25	$\frac{3}{2}^+$
5.215 ± 5	< 8		5.229 ± 13		$\frac{3}{2}$ [h]
5.378 ± 7	28 ± 7	5.310 ± 20	5.397 ± 14		$\frac{3}{2}^-$
5.695 ± 5 [f]	< 8			≈ 0.15	$\frac{7}{2}^-$
5.731 ± 5 [f]	< 8	5.760 ± 20	5.723 ± 14		
5.866 ± 5	< 8		5.875 ± 15		
5.940 ± 15	23 ± 10		5.957 ± 15		
		6.240 ± 20			
		6.890 ± 30	6.869 ± 14		
			(6.986 ± 15)		
			(7.371 ± 15)		
		7.510 ± 30			
		8.270 ± 40			
		(8.590 ± 40)			
		9.060 ± 40			

[a] ^{16}O(d, p)^{17}O (1957BR82).
[b] ^{16}O(d, p)^{17}O and ^{19}F(d, α)^{17}O (1951BU1A).
[c] ^{19}F(d, α)^{17}O (1952WA1A).
[d] (1973DA17, 1974CO04) [^{16}O(d, p)^{17}O].
[e] (1965GA1A) report $E_x = 873 \pm 5$, 3056 ± 4 and 3838 ± 4 keV.
[f] ΔE_x between ^{17}O*(5.73, 5.70) $= 34 \pm 2$ keV (1968BI09).
[g] (1965CO07, 1965CO09).
[h] (1968BI09).

The angular distribution involving $^{17}O_{g.s.}$ has been studied at $E(^{7}Li) = 36$ MeV. The population of ^{17}O*(0.87, 3.06, 3.84, 4.55, 5.38) is also reported (1973SC26).

46. $^{16}O(^{11}B, ^{10}B)^{17}O$ $\qquad Q_m = -7.311$

The excitation of ^{17}O*(0, 0.87) is reported at $E(^{11}B) = 113.1$ MeV (1967PO13).

47. $^{16}O(^{13}C, ^{12}C)^{17}O$ $\qquad Q_m = -0.801$

The product of the spectroscopic factors in the initial and final states [^{17}O*(0.87)] is 0.72 (1975SE03: from measurements of σ_t below Coulomb barrier). The angular distribution to ^{17}O*(0.87) has been measured at $E(^{13}C) = 36$ MeV (1976WE21). See also (1973BR1C) and (1974BE1J; theor.).

48. $^{16}O(^{14}N, ^{13}N)^{17}O$ $\qquad Q_m = -6.408$

At $E(^{14}N) = 79$ MeV angular distributions involving ^{17}O*(0, 0.87) have been studied: an anomaly is observed in the phase behavior of the distribution to the excited state. From this and other studies it is concluded that a multistep process via inelastic scattering is unlikely to occur in the excitation of $2s_{1/2}$ states (1976MO03). An angular distribution involving ^{17}O*$(0 + 0.87)$ has also been reported at $E(^{14}N) = 155$ MeV (1975NA15). See also (1976NA09).

49. $^{16}O(^{18}O, ^{17}O)^{17}O$ $\qquad Q_m = -3.898$

At $E(^{18}O) = 42$ and 52 MeV, the angular distributions involving ^{17}O*(0, 0.87) have been studied (1975RE15).

50. $^{17}N(\beta^-)^{17}O$ $\qquad Q_m = 8.682$

^{17}N decays principally to ^{17}O*(4.55, 5.38): see reaction 1 and Table 17.2 in ^{17}N.

51. (a) $^{17}O(\gamma, n)^{16}O$ $\qquad Q_m = -4.146$
(b) $^{17}O(\gamma, 2n)^{15}O$ $\qquad Q_m = -19.809$
(c) $^{17}O(\gamma, \alpha)^{13}C$ $\qquad Q_m = -6.361$

Table 17.15: B(E3) values from ^{17}O(e, e′) [a]

^{17}O* (MeV)	J^{π}	B(E3)↑ $(e^2 \cdot \mathrm{fm}^6)$
3.06	$\frac{1}{2}^-$	31 ± 6
3.84	$\frac{5}{2}^-$	153 ± 6
4.55	$\frac{3}{2}^-$	98 ± 8
5.22	$(\frac{9}{2}^-)$	360 ± 11
5.38	$\frac{3}{2}^-$	45 ± 12
5.70	$\frac{7}{2}^-$	270 ± 32
5.94	$\frac{1}{2}^-$	17 ± 10
6.86	$(\frac{1}{2}^-)$	(147 ± 34)
7.17	$\frac{5}{2}^-$	22 ± 25
7.39	$\frac{5}{2}^-$	47 ± 38
7.58	$\frac{7}{2}^-$	109 ± 26
7.75	$(\frac{11}{2}^-)$	369 ± 15

[a] (1975KI15).

The (γ, n$_0$) differential cross section at 98° has been measured for $E_{\mathrm{bs}} = 8$ to 33 MeV by (1976WO1D): both narrow and broad structures are observed throughout this energy range. The (γ, n) cross section has also been measured for $E_\gamma = 7.6$ to 30 MeV: it is dominated by a broad giant resonance centered at $E_{\mathrm{x}} \approx 23$ MeV (1976ME1K). The ^{17}O(γ, 2n) cross section is very small for these energies (1976ME1K). For reaction (c) see (1964GR08).

52. ^{17}O(e, e)^{17}O

The ^{17}O charge radius, $r_{\mathrm{rms}} = 2.662 \pm 0.026$ (using a distorted wave approximation), and 2.700 ± 0.026 fm (using a Born approximation) (1970SI02, 1970SI1K). Inelastic scattering in a range of momentum transfer $q = 0.6 - 1.1$ fm^{-1} has led to calculation of B(E3) values from the measured Coulomb form factors: see Table 17.15 (1975KI15). See also (1976AUZZ).

53. ^{17}O(n, n)^{17}O

See (1973IS07; theor.).

54. ^{17}O(p, p)^{17}O

Angular distributions of elastically scattered protons have been studied at $E_{\rm p} = 8.62$, 9.45 and 10.5 MeV (1975CR04; also p_1 and p_2), 11 MeV (1967AL06) and 65.8 MeV (1972LE27, 1972LE28, 1972LE1G). The matter rms radius of ^{17}O is 0.04 ± 0.03 fm greater than that for ^{16}O (1973LE07). See also ^{18}F in (1978AJ03) and (1970OH1C, 1971DO1A, 1975CO12, 1976CO01; theor.).

55. ^{17}O(d, d)^{17}O

The angular distribution of elastically scattered deuterons has been studied at $E_{\rm d} = 18$ MeV (1976LI01).

56. (a) ^{17}O(^{3}He, ^{3}He)^{17}O
(b) ^{17}O(α, α)^{17}O

Elastic angular distributions have been measured at $E(^3{\rm He}) = 11.0$ MeV (1970BO25) and 17.3 MeV (1968HA30). For reaction (b) see (1976CO27; theor.).

57. (a) ^{17}O(^{12}C, ^{12}C)^{17}O
(b) ^{17}O(^{13}C, ^{13}C)^{17}O

For reaction (a) see (1976EY01). For reaction (b) see (1974CH1Q).

58. ^{17}O(^{16}O, ^{16}O)^{17}O

Angular distributions involving ^{17}O*(0, 0.87) have been studied at $E(^{16}{\rm O}) = 22$, 24, 28 and 32 MeV (1973GE04, 1974GE01) and at $E(^{17}{\rm O}) = 25.7$, 27.7, 29.8 and 32.0 MeV (1975KA24): second-order transfer contributions are found to be important (1975KA24). See also (1973FI1C, 1974GO1L, 1975VO1B) and (1973BA2F, 1974BA46, 1974BE1J, 1974BO13, 1974YU01, 1975IM04, 1975WO1E; theor.).

59. ^{17}F(β^+)^{17}O $\qquad Q_{\rm m} = 2.762$

See ^{17}F.

60. ^{18}O(γ, n)^{17}O $\qquad Q_m = -8.044$

See (1975AL03) and ^{18}O in (1978AJ03).

61. ^{18}O(p, d)^{17}O $\qquad Q_m = -5.819$

Angular distributions have been measured at $E_p = 17.6$ MeV (1963LE03: $d_0 \rightarrow d_2$), 18.2 MeV (1967LU05: $d_0 \rightarrow d_3$), 20.0, 24.4, 29.8, 37.5 and 43.6 MeV (1974PI05: $d_0 \rightarrow d_4$) and 24.4 MeV (1973PI09: $d_0 \rightarrow d_7$; polarized protons). See also ^{19}F in (1978AJ03), (1976DA1K) and (1973IG02, 1973OR09, 1973YA1B; theor.).

62. ^{18}O(d, t)^{17}O $\qquad Q_m = -1.786$

Angular distributions of the tritons corresponding to ^{17}O*(0, 0.87, 3.84, 4.55, 5.08, 5.38) have been studied at $E_d = 15$ MeV (1961AR06). See also (1975HS01, 1976LA13; theor.).

63. ^{18}O(^{3}He, α)^{17}O $\qquad Q_m = 12.535$

Angular distributions of alpha particles are reported by (1965WA1D: α_0, α_1) at $E(^3\text{He}) = 2.68$ to 6.47 MeV and by (1969DE06: see Table 17.16) at $E(^3\text{He}) = 16$ MeV. The $T = \frac{3}{2}$ states reported by (1969DE06) are displayed in Table 17.16 [the isospin identification is based on the enhanced excitation and the narrow widths of these states]. The branching ratios for the various decays of ^{17}O*(11.08) [the lowest $T = \frac{3}{2}$ state in ^{17}O] and for the analog state in ^{17}F are displayed in Table 17.11: the decay width of the ^{17}O state is approximately 200 times greater than that of the ^{17}F state (1973AD02).

64. ^{18}O(^{9}Be, ^{10}Be)^{17}O $\qquad Q_m = -1.232$

Angular distributions have been studied at $E(^{18}\text{O}) = 16$ and 20 MeV (1971BA68, 1971KN05).

65. (a) ^{18}O(^{10}B, ^{11}B)^{17}O $\qquad Q_m = 3.412$
(b) ^{18}O(^{11}B, ^{12}B)^{17}O $\qquad Q_m = -4.674$

Table 17.16: $T = \frac{3}{2}$ states of ^{17}O from ^{18}O(^{3}He, α)^{17}O [a,b]

E_x (MeV ± keV)	l_n	J^π	C^2S [c]
11.082 ± 6	1	$(\frac{1}{2})^-$	0.49
12.471 ± 5	1	$(\frac{3}{2})^-$	0.27
12.950 ± 8	0	$\frac{1}{2}^+$	0.096
12.994 ± 8			
13.640 ± 5	2	$(\frac{5}{2})^+$	0.39
14.219 ± 8			
14.282 ± 12			
15.101 ± 8			

[a] See also Table 17.11.
[b] (1969DE06).
[c] Calculated assuming $C^2S = 4$ for ^{15}O*(6.18).

Angular distributions (reaction (a)) have been measured at $E(^{18}\text{O}) = 20$ and 24 MeV (1971BA68, 1971KN05). For S-factor measurements see (1974SW04). Cross sections for reaction (b) are several orders of magnitude less than those for reaction (a) for $E(^{18}\text{O})_{\text{c.m.}} = 3-7.7$ MeV (1974SW04).

66. (a) ^{18}O(^{12}C, ^{13}C)^{17}O $\quad Q_m = -3.097$
(b) ^{18}O(^{13}C, ^{14}C)^{17}O $\quad Q_m = 0.133$

See (1974CH1Q).

67. ^{18}O(^{14}N, ^{15}N)^{17}O $\quad Q_m = 2.790$

See (1974SW04).

68. ^{18}O(^{18}O, ^{19}O)^{17}O $\quad Q_m = -4.087$

See (1972EY01).

69. ^{19}F(π^-, 2n)^{17}O $\quad Q_m = 122.822$

The 0.87 MeV γ-ray is observed when ^{19}F captures π^- mesons (1976EN02).

70. ^{19}F(n, t)^{17}O $\qquad Q_m = -7.554$

Angular distributions of the t_0 and t_1 groups are reported at $E_n = 14.4$ MeV (1968RE07).

71. (a) ^{19}F(p, ^{3}He)^{17}O $\qquad Q_m = -8.318$
(b) ^{19}F(p, pd)^{17}O $\qquad Q_m = -13.812$

Angular distributions have been measured at $E_p = 30.5$ MeV (1967CO05: to ^{17}O*(0, 0.87)) and at 42.4 MeV (1974NE03: to ^{17}O*(0, 0.87, 3.06, 3.84)): comparisons have been made with the analog transitions in the mirror reaction ^{19}F(p, t)^{17}F. See also (1972HU1B, 1972PR1D), ^{20}Ne in (1978AJ03) and (1971AJ02). For reaction (b) see (1971DE1F).

72. ^{19}F(d, α)^{17}O $\qquad Q_m = 10.036$

Observed α-groups are displayed in Table 17.14. Angular distributions have been measured at many energies in the range $E_d = 0.3$ to 27.5 MeV: see Table 17.16 in (1971AJ02) for the earlier work and (1969ZA1A: $1.10 - 3.65$ (α_0, α_1) and 1.40 to 3.65 MeV (α_2, α_3)), (1971BE2F: $1.35 - 2.0$ MeV; $\alpha_0 \rightarrow \alpha_3$) and (1972LA18: 3 MeV; $\alpha_0 \rightarrow \alpha_3$). See also (1976BI03, 1976NE1D) and (1970SO12; applied).

73. ^{19}F(α, ^{6}Li)^{17}O $\qquad Q_m = -12.338$

Angular distributions are reported at $E_\alpha = 28$ MeV (1971KL1E: ^{17}O*(0, 0.87) + ^{6}Li$_{\rm g.s.}$; ^{17}O$_{\rm g.s.}$ + ^{6}Li*(3.56)) and 42 MeV (1968MI05: ^{17}O*(0, 0.87)).

74. ^{20}Ne(n, α)^{17}O $\qquad Q_m = -0.584$

At $E_n = 14.1$ MeV angular distributions are reported for α_0 and α_1 by (1966MC14) and (1971BA82: also α_2). (1971KA18) report the excitation of a number of states of ^{17}O with $E_x < 8$ MeV. See also (1972LI30) and (1973CL1E; astrophys. questions).

^{17}F
(Figs. 8 and 9)

GENERAL: (See also (1971AJ02).)

Shell and cluster models: (1970HA49, 1972EN03, 1972LE1L, 1973DE13, 1973KU04, 1973LA1D, 1973RE17, 1973SM1C, 1974LO04).

Special levels: (1969WI1C, 1971SE1C, 1972BE1E, 1972EN03, 1973LE06, 1974VA24).

Electromagnetic transitions: (1970AL1D, 1970HA49, 1970SI1J, 1972EN03, 1972SE1G, 1973HA53, 1973LE06, 1974HA1C, 1974LO04, 1974MC1F, 1976SH04).

Special reactions: (1971AR02, 1974LI1D, 1975WI07).

Other topics: (1970RY04, 1970SI1J, 1971AU02, 1971SE1C, 1971NG01, 1972BA25, 1972CA37, 1972CH16, 1972LE1L, 1972SH32, 1973DE13, 1973GO1H, 1973OS1A, 1973RE17, 1973RO1R, 1974BR1E, 1974RE03, 1974SL1C, 1974VA24, 1975SH20, 1975SH1H).

Ground state:

$$\mu = 4.7223 \pm 0.0012 \text{ nm (1974SHYR);}$$
$$Q = 0.10 \pm 0.02 \text{ b (1974MI21).}$$

See also (1970AL1D, 1970SI1J, 1971SH26, 1971TA1A, 1972LE1L, 1972VA36, 1972YO1B, 1973NO06, 1973RE17, 1974AN1F, 1974HA27, 1974MC1F, 1974RE03, 1974WI1N, 1975BE31, 1976CH1T).

1. ^{17}F(β^+)^{17}O $\qquad Q_{\rm m} = 2.762$

The half-life of ^{17}F is 65.2 ± 0.2 sec (1969WO09), 64.50 ± 0.25 sec (1972AL42). The mean of previous values [see Table 17.18 in (1971AJ02)] was 66.0 ± 0.2 sec which was the value reported by (1960JA12). We adopt $\tau_{1/2} = 64.50 \pm 0.25$ sec, $\log ft = 3.488 \pm 0.001$ (1972AL42) but suggest that another measurement of this half-life is in order. The upper limit for the β^+ decay to ^{17}O*(0.87) is $< 3.4 \times 10^{-4}$ per decay (1969GA05) [$\log ft > 5.6$]. See also (1970KO41, 1970MC23, 1971BH04, 1971LI1H, 1971WI18, 1972WI28, 1972WI1C, 1973LA03, 1973MU1D, 1973WI04, 1973WI11, 1974WI1M, 1975BA59, 1975BL1G, 1975KR14, 1975WI1E; theor.).

2. ^{12}C(^{12}C, ^{7}Li)^{17}F $\qquad Q_{\rm m} = -16.861$

See (1971AJ02).

Table 17.17: Energy levels of ^{17}F

E_x in ^{17}F (MeV ± keV)	$J^\pi; T$	τ or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
0	$\frac{5}{2}^+; \frac{1}{2}$	$\tau_{1/2} = 64.50 \pm 0.25$ sec	β^+	1, 2, 3, 4, 6, 7, 8, 9, 10, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 28, 29, 30
0.49533 ± 0.10	$\frac{1}{2}^+; \frac{1}{2}$	$\tau_m = 412 \pm 9$ psec	γ	4, 6, 7, 9, 10, 16, 17, 20, 21, 23, 25, 26, 29
3.104 ± 3	$\frac{1}{2}^-; \frac{1}{2}$	$\Gamma = 19 \pm 1$	γ, p	7, 9, 10, 11, 16, 17, 27, 29
3.857 ± 4	$\frac{5}{2}^-; \frac{1}{2}$	$\tau_m = 6 \pm 1$ fsec	γ, p	7, 9, 10, 11, 16, 17, 29
4.696 ± 10	$\frac{3}{2}^-; \frac{1}{2}$	$\Gamma = 225$	p	7, 9, 11, 16, 27
5.103 ± 10	$\frac{3}{2}^+; \frac{1}{2}$	1530	p	11, 20
5.212 ± 11	$(\frac{9}{2}); \frac{1}{2}$			7, 9
5.521 ± 10	$\frac{3}{2}^-; \frac{1}{2}$	68	p	7, 9, 11, 27
5.672 ± 10	$\frac{7}{2}^-; \frac{1}{2}$	40	p	7, 9, 11
5.682 ± 10	$\frac{1}{2}^+; \frac{1}{2}$	< 0.6	p	7, 9, 11
5.817 ± 10	$\frac{3}{2}^+; \frac{1}{2}$	180	p	7, 11
6.036 ± 10	$\frac{1}{2}^-; \frac{1}{2}$	30	p	7, 9, 11, 27
6.556 ± 10	$\frac{1}{2}^+; \frac{1}{2}$	200	p	11
6.699 ± 10	$\frac{3}{2}^-; \frac{1}{2}$	< 3	p	7, 9, 11
6.774 ± 10	$\frac{3}{2}^+; \frac{1}{2}$	4.5	p	11
7.027 ± 10	$\frac{5}{2}^-; \frac{1}{2}$	3.8	p	9, 11
7.356 ± 10	$\frac{3}{2}^+; \frac{1}{2}$	10 ± 2	p, α	9, 11, 15
7.448 ± 7		≤ 5	p	11
7.454 ± 7		7 ± 2	p, α	11, 15
7.471 ± 7		5 ± 2	p	11
7.479 ± 10	$\frac{3}{2}^+; \frac{1}{2}$	795	p	11
7.546 ± 10	$\frac{7}{2}^-; \frac{1}{2}$	30	p	11
7.75 ± 20	$\frac{1}{2}^+; \frac{1}{2}$	179 ± 3	p, α	11, 15, 27
7.95 ± 15		10 ± 3	p	11
8.01 ± 20		50 ± 20	p, α	11, 15
8.075 ± 10	$\frac{5}{2}^+; \frac{1}{2}$	100 ± 20	p, α	9, 11, 15, 27
8.2	$\frac{3}{2}^-; \frac{1}{2}$	700 ± 250	p, α	11, 15
8.383 ± 5	$\frac{5}{2}^-; \frac{1}{2}$	11 ± 5	p, α	11, 15

Table 17.17: Energy levels of ^{17}F (continued)

E_x in ^{17}F (MeV $\pm$ keV)	$J^\pi; T$	τ or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
8.416 ± 10	$\frac{7}{2}^+; \frac{1}{2}$	45 ± 10	p, α	11, 15, 27
8.75 ± 30	$\frac{5}{2}^+; \frac{1}{2}$	170 ± 30	p, α	11, 15
8.76	$\frac{3}{2}^+; \frac{1}{2}$	90 ± 20	p	11
8.97	$\frac{7}{2}^-; \frac{1}{2}$	165 ± 30	p, α	11, 15
9.27	$\frac{3}{2}^-; \frac{1}{2}$	140 ± 30	p, α	11, 15
9.91	$\frac{9}{2}^+; \frac{1}{2}$	90 ± 30	p, α	11, 15
10.04 ± 20	$\frac{7}{2}; \frac{1}{2}$	280 ± 100	p	11
10.22 ± 20		250 ± 80	p, α	15
10.40 ± 20	$(\frac{5}{2}^+); \frac{1}{2}$	160 ± 40	p	11
10.499 ± 15	$\frac{7}{2}^-; \frac{1}{2}$	165 ± 25	p, α	11, 15
10.79 ± 20		120 ± 40	p	11
10.91 ± 100	$\frac{1}{2}^-$	560 ± 100	p	11
10.95 ± 20		190 ± 50	p, α	11, 15
11.1931 ± 2.3	$\frac{1}{2}^-; \frac{3}{2}$	0.20 ± 0.04	γ, p, α	9, 10, 11, 15, 27
11.43 ± 20		240 ± 50	p, α	11, 15
11.58 ± 40		160 ± 30	p	11
12.00 ± 20		120 ± 40	p, α	11, 15
12.25 ± 20	$\frac{3}{2}^-$	300 ± 30	p	11
12.355 ± 10	$\frac{1}{2}^-$	190 ± 20	p	11
≈ 12.50	$\frac{7}{2}^-$	≈ 660	p	11
12.550 ± 1.4	$\frac{3}{2}^-; \frac{3}{2}$	2.83 ± 0.12	γ, p, α	9, 10, 11, 15
13.061 ± 4	$\frac{5}{2}^-; \frac{3}{2}$	2 ± 1	γ, p, α	9, 10, 11, 15
13.080 ± 4	$(\frac{1}{2}^+); \frac{3}{2}$	2 ± 1	p, α	11, 15
13.13	$\frac{5}{2}^-$	520 ± 50	p	11
13.781 ± 4	$\frac{5}{2}^+; \frac{3}{2}$	12 ± 5	p, α	11, 15
14.00 ± 50	$\frac{7}{2}^-$	260 ± 30	p	11
14.176 ± 6	$\frac{3}{2}^-; \frac{3}{2}$	30 ± 5	γ, p	10, 11
14.3040 ± 3.3	$\frac{7}{2}^-; \frac{3}{2}$	19.3 ± 1.6	γ, p, α	10, 11, 15
14.38 ± 50	$\frac{5}{2}^-$	610 ± 50	p	11
14.71 ± 100	$\frac{1}{2}^-$	470 ± 100	p	11

Table 17.17: Energy levels of ^{17}F (continued)

E_x in ^{17}F (MeV ± keV)	$J^\pi; T$	τ or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
14.809 ± 20	$\frac{1}{2}^+$	190 ± 25	p	11
15.6		≈ 550	p	11
(16.9)	$\frac{7}{2}^-$		γ, p	10
17.1	$\frac{5}{2}^-$	1500	p	11
(18.0)	$\frac{7}{2}^-$		γ, p	10
19.42 ± 50	$\frac{5}{2}^+$	≈ 300	γ, ^{3}He, α	4, 5
20.25 ± 50	$\frac{7}{2}^-$	≈ 350	γ, ^{3}He, α	4, 5
20.9	$\frac{9}{2}^+$	600	p	11
21.01 ± 50	$\frac{1}{2}^+$	≈ 280	γ, ^{3}He	4
21.8	$(\frac{9}{2}^+)$	400	p	11
22		≈ 5000	γ, p, α	10, 15
22.7	$\frac{7}{2}^+$	600	p	11
23.8	$\frac{7}{2}^+$	600	p	11
25.4	$\frac{7}{2}^-$	1500	p, α	11, 15
27.2	$\frac{5}{2}^-$	1500	p	11
28.9	$\frac{5}{2}^+$	2000	p	11

3. ^{12}C(^{14}N, ^{9}Be)^{17}F $\qquad Q_m = -10.436$

See (1975ZE1C).

4. ^{14}N(^{3}He, γ)^{17}F $\qquad Q_m = 15.8437$

The yield of γ_{0+1} at 90° shows resonant structures at $E(^3\text{He}) = 4.35 \pm 0.05, 5.36 \pm 0.05, 5.7$ and 6.28 ± 0.05 MeV, corresponding to ^{17}F*(19.42, 20.25, 20.5, 21.01), respectively. Angular distribution measurements are consistent with $J^\pi = \frac{5}{2}^+, \frac{7}{2}^-, (\frac{3}{2}^-)$ and $\frac{1}{2}^+$ for these states; the widths of the three highest ones are ≈ 350, 210 and 280 keV (1972MO39).

5. (a) ^{14}N(^{3}He, n)^{16}F $\quad Q_m = -0.969 \quad E_b = 15.8437$

(b) ^{14}N(^{3}He, p)^{16}O $\quad Q_m = 15.2430$

(c) ^{14}N(^{3}He, d)^{15}O $\quad Q_m = 1.8037$

(d) ^{14}N(^{3}He, np)^{15}O $\quad Q_m = -0.4210$

(e) ^{14}N(^{3}He, ^{3}He)^{14}N

(f) ^{14}N(^{3}He, α)^{13}N $\quad Q_m = 10.025$

(g) ^{14}N(^{3}He, 2α)^{11}C $\quad Q_m = 2.2955$

Excitation functions for p_0 have been measured for $E(^3\text{He}) = 2.5$ to 5.5 MeV (1963GO09), 3.5 to 18 MeV (1972BI01) and 5.5 to 10.5 MeV (1971GU22; also p_{1+2}, p_3, p_4): some large structures are observed. The elastic scattering of ^{3}He (reaction (e)) has been studied for $E(^3\text{He}) = 4$ to 7 MeV: there is some evidence in the excitation functions of the resonances reported in (^{3}He, γ) (reaction 4) (1972MO39). The yields of α_0, α_1 and α_{2+3} (reaction (f)) in the range $E(^3\text{He}) = 2.5$ to 8.5 MeV show broad un-correlated fluctuations, except for a structure at $E(^3\text{He}) = 4.5$ MeV (1970KN01). However, a study of α_0 [$E(^3\text{He}) = 3.5$ to 7 MeV] shows, at $\theta = 150°$, strong structures corresponding to the resonances at $E(^3\text{He}) = 4.35$ and 5.36 MeV reported in (^{3}He, γ): their analysis suggests $\Gamma = 300$ and 350 keV (1972MO39). For reaction (d) see (1973AD02). See also (1971ADZZ), (1971AJ02, 1974LO1B), (1974FA1A; theor.), ^{16}O, ^{16}F, and ^{13}N, ^{14}N and ^{15}O in (1976AJ04).

6. ^{14}N(α, n)^{17}F $\quad Q_m = -4.7347$

See ^{18}F in (1972AJ02). See also (1973DO1K).

7. ^{14}N(^{6}Li, t)^{17}F $\quad Q_m = 0.049$

At $E(^6\text{Li}) = 18$ MeV the triton groups in this reaction and the ^{3}He groups in the mirror reaction have been compared. ^{17}F*(3.86, 5.22, 5.67 + 5.68) are strongly excited. A state at $E_x = 5.220 \pm 0.010$ MeV is identified as the mirror state to ^{17}O*(5.22): its probable J^π is $\frac{9}{2}^-$. ^{17}F*(0, 0.50, 3.10, 4.70, 5.52, 5.82, 6.04, 6.70) are also populated (1973BI01). See also (1972BA1P).

8. ^{14}N(^{10}B, ^{7}Li)^{17}F $\quad Q_m = -1.944$

See (1976HAXX).

9. ^{15}N(^{3}He, n)^{17}F $\qquad Q_{\rm m} = 5.0101$

Angular distributions have been measured for the neutron groups to ^{17}F*(0, 0.50, 3.10, 3.86) at $E(^{3}{\rm He}) = 3.8$ and 4.8 MeV and to ^{17}F*(4.70, 5.52, 5.68) at the higher energy. The population of a state at $E_{\rm x} = 5.179 \pm 0.020$ MeV and of ^{17}F*(6.04, 6.70, 7.03, 7.36, 8.08) is also reported. ^{17}F*(5.18) probably has $J^{\pi} = \frac{3}{2}^{+}$ or $\frac{9}{2}^{+}$ (1972TH07, 1973ET01). Neutron groups have also been reported to ^{17}F states at $E_{\rm x} = 11.195 \pm 0.007$, 12.540 ± 0.010 and 13.059 MeV, with $\Gamma < 20$, < 25 and < 25 keV, respectively. Angular distributions at $E(^{3}{\rm He}) = 10.36$ and 11.88 MeV lead to $J^{\pi} = \frac{1}{2}^{-}$ for ^{17}F*(11.20) [$L = 0$], $\frac{3}{2}^{-}$ or $\frac{5}{2}^{-}$ for ^{17}F*(12.54) and ($\frac{3}{2}^{-}$, $\frac{5}{2}^{-}$) for ^{17}F*(13.06). These three states are probably the first three $T = \frac{3}{2}$ states in ^{17}F (1969AD02). The branching ratios for transitions to ^{16}O*(0, 6.05, 6.13) for ^{17}F*(11.20) and for the analog $T = \frac{3}{2}$ state in ^{17}O are displayed in Table 17.11: the ratios of the reduced widths are quite different in the two mirror nuclei (1970MC02, 1973AD02).

10. ^{16}O(p, γ)^{17}F $\qquad Q_{\rm m} = 0.6007$

$Q_0 = 600.35 \pm 0.28$ keV (1975RO05).

At low energies the direct capture to ^{17}F*(0, 0.50) has been observed: see (1971AJ02) for a summary of the earlier measurements and (1973RO34: $0.3 - 3.1$ MeV), (1975CH34: $0.85 - 2.55$ MeV). Extrapolation of cross section data leads to $S(0) = 9$ keV $\cdot$ b (1973RO34), 7.45 keV $\cdot$ b (1971BA1A). See also (1973CL1E, 1975CH34). An anomaly is observed at $E_{\rm p} = 2.66$ MeV [^{17}F*(3.10)] in the yield of the γ-ray transition to ^{17}F*(0.50): $\Gamma_{\gamma} = 12 \pm 2$ meV; $C^2S = 0.90$ and 1.00, respectively, for ^{17}F*(0, 0.50) (1973RO34). Another resonance is observed at $E_{\rm p} = 3.47$ MeV [^{17}F*(3.86)]: angular distributions of the γ-rays are characteristic of an almost pure dipole transition. The data lead to $J^{\pi} = \frac{5}{2}^{-}$, $\Gamma < 1.5$ keV, $\Gamma_{\gamma} = 0.11 \pm 0.02$ eV, $\tau_{\rm m} = 6 \pm 1$ fsec (1963SE14). For ^{17}F*(0.50), $\tau_{\rm m} = 445 \pm 22$ psec (1960KA10).

Five resonances corresponding to $T = \frac{3}{2}$ states are observed in the γ_1 and $\gamma_0 + \gamma_1$ yields: see Table 17.18 for the reported parameters (1975HA06). The lowest $T = \frac{3}{2}$ states of even parity at $E_{\rm x} = 13.27$ and 14.02 MeV [$J^{\pi} = (\frac{1}{2}^{+})$ and $\frac{5}{2}^{+}$] (see Table 17.19) are not observed here: $\Gamma_{\gamma} \leq 7$ and ≤ 11.8 eV, respectively (1975HA06). The (E1) values for the $T = \frac{3}{2}$ states are in good agreement with shell model 2p-1h calculations using realistic Kuo-Brown interaction matrix elements (1975HA06).

The ($\gamma_0 + \gamma_1$) yield at 90° has been studied for $E_{\rm p} = 15.75$ to 31.66 MeV: it shows the giant dipole resonance centered at $E_{\rm x} = 22$ MeV with a width of ≈ 5 MeV and a pigmy resonance centered at 17.5 MeV. The integrated strength of the, mainly $T = \frac{1}{2}$, giant resonance is 10 MeV $\cdot$ mb: the observed strength distribution is in good agreement with odd parity 2p-1h, 1p excitation calculations. The pigmy resonance is due to $f_{7/2} \rightarrow d_{5/2}$: the main $f_{7/2}$ strength lies in two states at $E_{\rm x} = 16.9$ and 18.0 MeV (1975HA07). See also (1971JO1D).

Table 17.18: Resonances in $^{16}O(p, \gamma)^{17}F$ [a]

E_p (MeV ± keV)	Resonant [b] in	Γ_γ (eV)	Γ (keV)	E_x (MeV)	$J^\pi; T$	Refs.
2.66	γ_1	$(12 \pm 2) \times 10^{-3}$		3.10	$\frac{1}{2}^-; \frac{1}{2}$	A, (1973RO34)
3.47	γ_0	0.11 ± 0.02	< 1.5	3.86	$\frac{5}{2}^-; \frac{1}{2}$	(1963SE14)
11.275 ± 6	γ_1	6.0 ± 2.5 [c]	≤ 1.6	11.204	$\frac{1}{2}^-; \frac{3}{2}$	(1975HA06)
12.707 ± 1	$\gamma_0 + \gamma_1$	11.3 ± 3.4 [c]	1.8 ± 0.5	12.550	$\frac{3}{2}^-; \frac{3}{2}$	(1975HA06) [e]
13.255 ± 6	$\gamma_0 + \gamma_1$	2.8 ± 1.8 [c]	5.0 ± 1.5	13.065	$\frac{5}{2}^-; \frac{3}{2}$	(1975HA06)
14.435 ± 10	$\gamma_0 + \gamma_1$	81 ± 54 [c,f]	41 ± 10	14.174	$\frac{3}{2}^-; \frac{3}{2}$	(1975HA06)
14.583 ± 6	$\gamma_0 + \gamma_1$	13.4 ± 7.0 [c]	28 ± 5	14.313	$\frac{7}{2}^-; \frac{3}{2}$	(1975HA06)
[d]						

A: See (1971AJ02).

[a] See also Table 17.19.

[b] γ_0 and γ_1 correspond to transitions to ^{17}F*(0, 0.50), respectively.

[c] These Γ_γ are based on J^π and Γ_{p_0}/Γ determinations by (1974SK02) and R.G. Van Bree (unpublished) [quoted by (1975HA06)]. The B(E1) values for these five states are 4.7 ± 2.0, 5.4 ± 1.6, 1.2 ± 0.8, 27 ± 18 and 4.4 ± 2.3 $[\times 10^{-3}]$ $e^2 \cdot$ fm^2.

[d] See the text of reaction 10 for discussion of the observed pigmy and giant resonances (1975HA07).

[e] J. Lowe, private communication.

[f] $\Gamma(\gamma_1)/\Gamma(\gamma_0) \leq 0.14$ (J. Lowe, private communication).

11. (a) $^{16}O(p, p)^{16}O$ $\qquad E_b = 0.6007$

(b) $^{16}O(p, p\alpha)^{12}C$ $\qquad Q_m = -7.1616$

(c) $^{16}O(p, pn)^{15}O$ $\qquad Q_m = -15.6640$

Yield curves for elastic protons, protons scattered to ^{16}O*(6.05, 6.13, 6.92, 7.12, 8.87) and for γ-rays from ^{16}O*(6.13, 6.92) have been studied at many energies up to $E_p = 46$ MeV: see Table 17.19 in (1971AJ02) for a listing of the earlier measurements and (1975CH34: p_0, $171.5_{c.m.}$, $E_p = 0.39$ to 1.99 MeV), (1971AU04: p_{1+2}, p_5; σ_t; $E_p = 17.0$ to 46.1 MeV) and (1969BU1B, 1971BU05: p_0, p_{1+2}, p_5; $E_p = 21.3$ to 38.5 MeV). The observed resonances are displayed in Table 17.19. Phase-shift analyses of elastic scattering polarization and cross section data have led to an increased understanding of the $T = \frac{1}{2}$ states of ^{17}F (1971PR05, 1975HI02) and the work of (1974SK02, 1976HI09) has fixed the characteristics of the first seven $T = \frac{3}{2}$ states of ^{17}F. (1974SK02) has studied the isospin multiplet mass equation by comparing analog $T = \frac{3}{2}$ states in $A = 17$. See also (1976IK01).

Table 17.19: Resonances in ^{16}O(p, p)^{16}O and ^{16}O(p, α)^{13}N

E_p (MeV $\pm$ keV)	$\Gamma_{c.m.}$ (keV)	Particles out	Γ_{p_0}/Γ	^{17}F* (MeV)	$J^\pi; T$	Refs.
2.663 ± 7	19 ± 1	p_0		3.106	$\frac{1}{2}^-$	A
3.47	1.53 ± 0.2	p_0		3.86	$\frac{5}{2}^-$	A, (1974DA04)
4.354 ± 10	225	p_0		4.696	$\frac{3}{2}^-$	A
4.787 ± 10	1530	p_0		5.103	$\frac{3}{2}^+$	A
5.231 ± 10	68	p_0		5.521	$\frac{3}{2}^-$	A
5.392 ± 10	40	p_0		5.672	$\frac{7}{2}^-$	A
5.402 ± 10	< 0.6	p_0		5.682	$\frac{1}{2}^+$	A
5.546 ± 10	180	p_0		5.817	$\frac{3}{2}^+$	A
5.779 ± 10	30	p_0		6.036	$\frac{1}{2}^-$	A
6.332 ± 10	200	p_0		6.556	$\frac{1}{2}^+$	A
6.484 ± 10	< 3	p_0		6.699	$\frac{3}{2}^-$	A
6.564 ± 10	4.5	p_0		6.774	$\frac{3}{2}^+$	A
6.833 ± 10	3.8	p_0, $\gamma_{6.13}$		7.027	$\frac{5}{2}^-$	A, (1974DA04)
7.183 ± 10	10 ± 2	p_0, p_2, α_0		7.356	$\frac{3}{2}^+$	A
7.280 ± 7	≤ 5	p_0		7.448		A
7.287 ± 7	7 ± 2	p_0, p_1, p_2, α		7.454		A
7.305 ± 7	5 ± 2	p_0, p_2		7.471		A
7.313 ± 10	795	p_0		7.479	$\frac{3}{2}^+$	A
7.385 ± 10	30	p_0, p_2, $\gamma_{6.13}$		7.546	$\frac{7}{2}^-$	A
7.60 ± 20	179 ± 3	p_0, p_1, α_0		7.75	$\frac{1}{2}^+$	A
7.81 ± 15	10 ± 3	p_2		7.95		A
7.88 ± 20	50 ± 20	p_0, $\gamma_{6.13}$, $\gamma_{6.92}$, α_0		8.01		A

Table 17.19: Resonances in ^{16}O(p, p)^{16}O and ^{16}O(p, α)^{13}N (continued)

E_p (MeV $\pm$ keV)	$\Gamma_{c.m.}$ (keV)	Particles out	Γ_{p_0}/Γ	^{17}F* (MeV)	$J^\pi; T$	Refs.
7.94 ± 15	100 ± 20	p_0, p_1, α_0		8.07	$\frac{5}{2}^+$	A
8.1	700 ± 250	(p_0), p_1, α_0		8.2	$\frac{3}{2}^-$	A
8.275 ± 5	11 ± 5	$p_0 \rightarrow p_3$, α_0		8.383	$\frac{5}{2}^-$	A
8.310 ± 10	45 ± 10	$p_0 \rightarrow p_3$, $\gamma_{6.13}$, $\gamma_{6.92}$, α_0		8.416	$\frac{7}{2}^+$	A
8.66 ± 30	170 ± 30	p_2, p_3, p_4, α_0		8.75	$\frac{5}{2}^+$	A
8.68	90 ± 20	p_0	0.2	8.76	$\frac{3}{2}^+$	(1971PR05)
8.90	165 ± 30	$p_0 \rightarrow p_4$, $\gamma_{6.13}$, $\gamma_{6.92}$, α_0	0.3	8.97	$\frac{7}{2}^-$	A, (1971PR05)
9.22	140 ± 30	$p_0 \rightarrow p_4$, $\gamma_{6.13}$, $\gamma_{6.92}$, α_0	$0.5 - 0.6$	9.27	$\frac{3}{2}^-$	A, (1971PR05)
(9.59 ± 20)	310 ± 70	p_0, p_1, p_4		(9.62)		(1964DA02)
9.90	90 ± 30	p_0, p_2, α_0	0.05	9.91	$\frac{9}{2}^+$	A, (1971PR05)
10.04 ± 20	280 ± 100	p_0, p_1		10.04	$\frac{7}{2}$	A
10.23 ± 20	250 ± 80	α_0		10.22		(1964DA02)
10.42 ± 20	160 ± 40	p_0, p_1, p_3		10.40	$(\frac{5}{2}^+)$	(1964DA02, 1975HI02)
10.525 ± 15	165 ± 25	p_0, p_2, α_0	0.28 ± 0.03	10.499	$\frac{7}{2}^-$	A, (1971PR05, 1975HI02)
(10.75 ± 50)		p_0, p_1, α_0		(10.71)	$(\frac{7}{2}^-)$	(1964DA02, 1975HI02)
10.83 ± 20	120 ± 40	p_0, p_2, (p_3), (α_0)		10.79		A
10.96 ± 100	560 ± 100	p_0	0.25 ± 0.07	10.91	$\frac{1}{2}^-$	(1975HI02)
11.00 ± 20	190 ± 50	(p_2), p_3, (α_0)		10.95		A
11.2636 ± 2.0 [a]	0.20 ± 0.04	p_0, p_2, p_4, α_0		11.1931 ± 2.3	$\frac{1}{2}^-; \frac{3}{2}$	A, (1974SK02, 1976HI09)
11.52 ± 20	240 ± 50	p_2, α_0		11.43		A
11.67 ± 40	160 ± 30	p_0, p_3		11.58		A
12.12 ± 20	120 ± 40	p_2, α_0		12.00		A

Table 17.19: Resonances in ^{16}O(p, p)^{16}O and ^{16}O(p, α)^{13}N (continued)

E_p (MeV ± keV)	$\Gamma_{c.m.}$ (keV)	Particles out	Γ_{p_0}/Γ	^{17}F* (MeV)	J^π; T	Refs.
12.39 ± 20	300 ± 30	p_0, p_2	0.26 ± 0.03	12.25	$\frac{3}{2}^-$	A, (1971PR05, 1975HI02)
12.500 ± 10	190 ± 20	p_0, p_1, p_4	0.31 ± 0.03	12.355	$\frac{1}{2}^-$	A, (1975HI02)
≈ 12.65	≈ 600	p_0	≈ 0.09	≈ 12.50	$\frac{7}{2}^-$	(1975HI02)
12.7077 ± 2.0 [b]	2.83 ± 0.12	p_0, p_2, p_4, p_5, α_0, α_1	0.26 ± 0.04	12.5507 ± 2.3	$\frac{3}{2}^-$; $\frac{3}{2}$	A, (1974SK02, 1976HI09)
(13.06 ± 100)		p_0		(12.88)	$(\frac{7}{2}^-)$	(1975HI02)
(13.06 ± 50)		p_0		(12.88)	$(\frac{1}{2}^+)$	(1975HI02)
13.250 ± 4	2 ± 1	p_0, p_{1+2}, p_{3+4}, p_5, α_0	0.15 ± 0.04	13.060	$\frac{5}{2}^-$; $\frac{3}{2}$	A, (1974SK02)
13.271 ± 4	2 ± 1	$p_0 \to p_4$, α_0	0.04 ± 0.02	13.080	$(\frac{1}{2}^+)$; $\frac{3}{2}$	A, (1974SK02)
13.32 ± 100	520 ± 50	p_0	0.163 ± 0.016	13.13	$\frac{5}{2}^-$	A, (1975HI02)
14.017 ± 4	12 ± 5	p_0, p_{1+2}, p_{3+4}, α_0	0.02 ± 0.01	13.781	$\frac{5}{2}^+$; $\frac{3}{2}$	A, (1974SK02)
(14.20 ± 50)		p_0		(13.95)	$(\frac{1}{2}^+)$	(1975HI02)
14.25 ± 50	260 ± 30	p_0	0.08 ± 0.01	14.00	$\frac{7}{2}^-$	(1975HI02)
14.438 ± 6	27 ± 5	p_0, p_{3+4}	0.04 ± 0.02	14.177	$\frac{3}{2}^-$; $\frac{3}{2}$	(1974SK02)
14.5730 ± 3.0 [c]	19.3 ± 1.6	p_0, p_{1+2}, p_{3+4}, p_5, α_0	0.11 ± 0.03	14.3040 ± 3.3	$\frac{7}{2}^-$; $\frac{3}{2}$	A, (1974SK02, 1976HI09)
14.65 ± 50	610 ± 50	p_0	0.10 ± 0.01	14.38	$\frac{5}{2}^-$	(1975HI02)
(14.94 ± 100)		p_0			$(\frac{3}{2}^-)$	(1975HI02)
15.00 ± 100	470 ± 100	p_0	0.25 ± 0.03	14.71	$\frac{1}{2}^-$	(1975HI02)
15.110 ± 20	190 ± 25	p_0	0.150 ± 0.015	14.809	$\frac{1}{2}^+$	(1975HI02)
(15.245 ± 100)		p_0		(14.94)	$(\frac{5}{2}^+)$	(1975HI02)
(15.30 ± 50)		p_0		(14.98)	$(\frac{3}{2}^+)$	(1975HI02)
(15.37 ± 100)		p_0		(15.05)	$(\frac{3}{2}^-)$	(1975HI02)
(15.545 ± 100)		p_0		(15.22)	$(\frac{7}{2}^-)$	(1975HI02)

Table 17.19: Resonances in ^{16}O(p, p)^{16}O and ^{16}O(p, α)^{13}N (continued)

E_p (MeV ± keV)	$\Gamma_{c.m.}$ (keV)	Particles out	Γ_{p_0}/Γ	^{17}F* (MeV)	$J^{\pi}; T$	Refs.
15.9 [d]	≈ 550	p_0, p_{1+2}		15.6		A
17.6	1500	p_0, p_{3+4}		17.1	$\frac{5}{2}^-$	A, (1971BU05)
20.4	600	p_0		19.8	$\frac{3}{2}^+$	A, (1971BU05)
21.6	600	p_0, (α)		20.9	$\frac{9}{2}^+$	A, (1971BU05)
22.6	400	p_0, (α)		21.8	$(\frac{9}{2}^+)$	(1971BU05)
23.5	600	p_0, p_5		22.7	$\frac{7}{2}^+$	A, (1971BU05)
24.7	600	p_0, (α)		23.8	$\frac{7}{2}^+$	(1971BU05)
26.4	1500	p_0, (α)		25.4	$\frac{7}{2}^-$	A, (1971BU05)
28.3	1500	p_0		27.2	$\frac{5}{2}^-$	A, (1971BU05)
30.1	2000	p_0		28.9	$\frac{5}{2}^+$	(1971BU05)

A: See references listed for this state in Table 17.20 (1971AJ02).

[a] $\Gamma_{p_0} = 19 \pm 3$ eV (1976HI09).

[b] $\Gamma_{p_0} = 0.94 \pm 0.06$ keV, $\Gamma_{\alpha_0} = 62 \pm 16$ eV, $\Gamma_{\alpha_1} = 53 \pm 22$ eV (1976HI09); J. Lowe, private communication.

[c] $\Gamma_{p_0} = 1.65 \pm 0.12$ keV, $\Gamma_{\alpha_0} = 2.6 \pm 0.7$ keV (1976HI09).

[d] See also Table 17.20 of (1971AJ02), for possible other resonances.

Other polarization measurements are reported at $E_p = 3.47$ and 6.83 MeV (1974DA04; p_0), 20 MeV (1974PL05, 1976PL1C; p_3, p_4, p_6, p_7), 30.3 MeV (1976DE12; p_0, p_2, p_3, p_5), 30.4 MeV (1972GR02; p_0, p_5), 30.4 to 39.9 MeV (1976LE16; p_5) and 49.4 MeV (1970CL10; p_0). See also (1971KL03). Total reaction cross section measurements are reported at $E_p = 18.8$ to 47.7 MeV (1975CA26), 21 to 43 MeV (1975SL02), and 231, 345, 464 and 552 MeV (1972RE06). See also (1971BE1D, 1971CR1A, 1973GO27, 1976WUZZ).

For reaction (b) see (1971EP03: 46.8 MeV). For reaction (c) see (1965VA23). For spallation measurements see (1973BE36, 1974LA18). See also (1970SH1J, 1971EP1D, 1971ST30, 1972AM04, 1973BA81).

See also ^{16}O, (1971AJ02, 1971PA1H), (1975ME1E; astrophys. considerations) and (1972GE07, 1972PH06, 1973CL01, 1973MO1E, 1973RU07, 1973TH02, 1974SI13, 1975BA05, 1975CA05, 1975GE08, 1975SM01, 1975TA1A, 1975TH03, 1975TH12, 1976COZV; theor.).

12. ^{16}O(p, n)^{16}F $\qquad Q_m = -16.212 \qquad E_b = 0.6007$

See ^{16}F and (1974MO06; theor.).

13. ^{16}O(p, d)^{15}O $\qquad Q_m = -13.4393 \qquad E_b = 0.6007$

The excitation function for d_0 at $\theta = 70°$ has been measured for $E_p = 21$ to 38.5 MeV: a strong resonance is observed at $E_p \approx 24$ MeV (1969BU1B, 1971BU05): see Table 17.19. For polarization measurements see (1967CH15; 30.3 MeV; d_0, d_3). See also ^{15}O in (1976AJ04) and (1970DE38, 1971SA1D; theor.).

14. (a) ^{16}O(p, t)^{14}O $\qquad Q_m = -20.4064 \qquad E_b = 0.6007$

(b) ^{16}O(p, ^{3}He)^{14}N $\qquad Q_m = -15.2430$

The excitation function at $\theta = 70°$ for tritons (reaction (a)) has been measured for $E_p = 32$ to 39.5 MeV: no structure is observed (1969BU1B, 1971BU05). Differential cross sections and analyzing powers have been studied at $E_p = 43.8$ MeV for the transitions to ^{14}O*(0, 5.17, 6.29, 6.59, 7.78, 9.72) and ^{14}N*(0, 2.31, 3.95, 5.11, 7.03, 9.17): attempts to fit the analyzing powers with zero-range DWBA were only successful for the first pair of analog states [$^{14}O_{g.s.}$, ^{14}N*(2.31)] (1974MA12). For other polarization measurements see (1970NE17: $E_p = 49.5$ MeV; t_0, ^{3}He to ^{14}N*(0, 2.31)). See also (1975MI01, 1976PL1C), (1971AJ02, 1972HA1X, 1976DA1K) and ^{14}N and ^{14}O in (1976AJ04).

15. ^{16}O(p, α)^{13}N $\qquad Q_m = -5.218 \qquad E_b = 0.6007$

Excitation functions of various α-groups and activation functions have been measured from threshold to $E_p = 44$ MeV: see Table 17.19 in (1971AJ02) for the earlier work and (1973MC12, 1973MC1H: 5.6 to 7.7 MeV; σ_t), (1973NE12: 5.7 to 10.5 MeV; σ_t for α_0). (1971GU23: 19 to 44 MeV; σ_t for α_0, α_1, α_{2+3}, α_4) and (1969BU1B, 1971BU05: 21.5 to 38.5 MeV). In addition, the work of (1974SK02, 1976HI09) has established the parameters of the first seven $T = \frac{3}{2}$ states of ^{17}F: see Table 17.19. No other resonances corresponding to $T = \frac{3}{2}$ states have been observed below $E_x = 16.21$ MeV (1974SK02). Resonances corresponding to $T = \frac{1}{2}$ states are also reported in Table 17.19. Some broad structures have been reported above $E_p \approx 15$ MeV: see (1971AJ02) and (1971BU05, 1971GU23): particularly strong peaks appear at $E_p \approx 22$ and 25.5 MeV (1971BU05).

This reaction is involved in explosive oxygen burning in stars: cross sections, and reaction rates determined as a function of the temperature of the star are discussed in (1973NE12, 1973MC12, 1973WO1C). See also (1973AR1E).

16. ^{16}O(d, n)^{17}F $\qquad Q_m = -1.6239$

$E_{thresh.}$ for ^{2}H(^{16}O, n)^{17}F $= 14530 \pm 3.2$ keV (1973MA1V).

Slow neutron thresholds have been observed corresponding to the ground and first excited states of ^{17}F: see (1971AJ02). The E_x of ^{17}F*(0.50) is 495.33 ± 0.10 keV (1966AL10; from γ-measurement); $\tau_m = 407 \pm 9$ psec (1964BE15). Neutron groups have been observed corresponding to ^{17}F*(0, 0.50, 3.10, 3.86, 4.70). Angular measurements have been obtained for the n_0 and n_1 groups ($l_p = 2$ and 0; $J^\pi = \frac{5}{2}^+$ and $\frac{1}{2}^+$, respectively) for $E_d \leq 12$ MeV: see Table 17.21 in (1971AJ02). For polarization measurements see (1972AN1G; n_0, n_1; $E_d = 3 - 4$ MeV). See also (1971TH1E, 1976FR13), (1976LO1B; applied) and (1971DZ07, 1976SH13; theor.).

17. (a) ^{16}O(^{3}He, d)^{17}F $\qquad Q_m = -4.8930$

(b) ^{16}O(^{3}He, dp)^{16}O $\qquad Q_m = -5.4938$

At $E(^{3}\text{He}) = 18$ MeV, angular distributions of the deuterons to ^{17}F*(0, 0.50, 3.104 ± 0.003, 3.857 ± 0.004) have been measured. The spectroscopic factors for ^{17}F*(0, 0.50) are 0.94 and 0.83. Two step processes appear to be involved in the excitation of ^{17}F*(3.10, 3.86) (1975FO16). See also (1972PR1D). For reaction (b) see (1967HO14). See also (1971AJ02).

18. ^{16}O(α, t)^{17}F $\qquad Q_m = -19.2139$

See (1972PR1D). See also (1971AJ02).

19. ^{16}O(^{7}Li, ^{6}He)^{17}F $\qquad Q_m = -9.377$

The angular distribution involving $^{17}F_{g.s.}$ has been measured at $E(^{7}Li) = 36$ MeV (1973SC26).

20. $^{16}O(^{10}B, ^{9}Be)^{17}F$ $Q_m = -5.985$

Angular distributions have been measured at $E(^{10}B) = 100$ MeV for the transitions to $^{17}F^*(0 + 0.50$, 5.1, 8.1) (1975NA15).

21. $^{16}O(^{11}B, ^{10}Be)^{17}F$ $Q_m = -10.629$

$^{17}F^*(0 + 0.50)$ are populated at $E(^{11}B) = 113$ MeV (1967PO13). See also (1971AL1D; theor.).

22. $^{16}O(^{12}C, ^{11}B)^{17}F$ $Q_m = -15.357$

See (1972SC21). See also (1971SC1F).

23. $^{16}O(^{14}N, ^{13}C)^{17}F$ $Q_m = -6.950$

Angular distributions involving $^{17}F^*(0, 0.50)$ have been measured at $E(^{14}N) = 79$ MeV (1976MO03) and 155 MeV (1975NA15, 1976NA09).

24. $^{16}O(^{16}O, ^{15}N)^{17}F$ $Q_m = -11.527$

See (1974RO04).

25. $^{17}O(p, n)^{17}F$ $Q_m = -3.542$

$E_{thresh.} = 3743 \pm 6$ keV (1973BA31).

Angular distributions of the n_0 and n_1 groups have been obtained for $E_p = 6.95$ to 13.50 MeV (n_0) and 6.95 to 12.45 MeV (n_1). There appears to be collective enhancement in the $L = 2$ transition to $^{17}F^*(0.5)$. A large spin-flip term in the effective two-body force is necessary to account for the strength of the ground state transition (1969AN06). See also ^{18}F in (1978AJ03).

26. ^{17}O(^{3}He, t)^{17}F $Q_{\rm m} = -2.778$

At $E(^{3}{\rm He}) = 17.3$ MeV, angular distributions have been obtained for the tritons corresponding to ^{17}F*(0, 0.50). The data have been analyzed using DWBA and a two-body interaction between the incident and target nucleons. An exact coupled-channel-equation calculation was also made for the ground state transition (1968HA30). See also (1971AJ02).

27. ^{17}Ne(β^{+})^{17}F $Q_{\rm m} = 14.53$

See ^{17}Ne.

28. ^{19}F(γ, 2n)^{17}F $Q_{\rm m} = -19.581$

See (1959OC07, 1976AN06) and ^{19}F in (1978AJ03).

29. ^{19}F(p, t)^{17}F $Q_{\rm m} = -11.099$

Angular distributions have been measured for the t_0, t_1, t_2 and t_3 groups at $E_{\rm p} = 22.8$ MeV (1963HO24), 42.4 MeV (1974NE03) and 45 MeV (1972HU1B). See also (1968AN1A, 1972PR1D), (1971AJ02) and ^{20}Ne in (1978AJ03).

30. ^{20}Ne(p, α)^{17}F $Q_{\rm m} = -4.1293$

See (1971AJ02). See also (1973CL1E; astrophys. considerations).

^{17}Ne
(Figs. 8 and 9)

GENERAL: (See also (1971AJ02).)

Theory and reviews: (1971HA1Y, 1973HA77, 1973RE17, 1975BE31).

Mass of ^{17}Ne: The mass excess of ^{17}Ne, determined from a measurement of the Q-value of ^{20}Ne(^{3}He, ^{6}He)^{17}Ne is 16.48 ± 0.05 MeV (1970ME11, 1972CE1A). Then ^{17}Ne $-$ ^{17}F $= 14.53$ MeV and E_b for p, ^{3}He and α are, respectively, 1.50, 6.46 and 9.05 MeV. See also (1971AJ02).

1. (a) ^{17}Ne(β^+)^{17}F* $\rightarrow$ ^{16}O + p $\quad Q_m = 13.93$
   (b) ^{17}Ne(β^+)^{17}F $\quad Q_m = 14.53$

The half-life of ^{17}Ne is 109.0 ± 1.0 msec (1971HA05). Earlier values (see (1971AJ02)) gave a mean value of 108.0 ± 2.7 msec. The decay is primarily to the proton unstable states of ^{17}F at 4.70, 5.52 and 6.04 MeV with $J^\pi = \frac{3}{2}^-, \frac{3}{2}^-$ and $\frac{1}{2}^-$, respectively: see Table 17.21. The super-allowed decay to the analog state [^{17}F*(11.20)] has $\log ft = 3.29^{+0.04}_{-0.07}$. The character of the decay leads to $J^\pi = \frac{1}{2}^-$ for ^{17}Ne$_{\rm g.s.}$ (1971HA05). See Table 17.3 for a comparison of the mirror ^{17}N and ^{17}Ne decays (1976AL02) and Table 17.11 for the decay of ^{17}F*(11.20). See also (1971HO1D, 1972TO03; theor.).

Table 17.20: Energy levels of ^{17}Ne

E_x in ^{17}Ne (MeV)	$J^\pi; T$	$\tau_{1/2}$ (msec)	Decay	Reactions
0	$\frac{1}{2}^-; \frac{3}{2}$	109.0 ± 1.0	β^+ [a]	1, 2
1.35 [b]				2
(1.84)				2
(2.77)				2
(3.70)				2
(5.28)				2

[a] See Tables 17.3 and 17.21.

[b] The evidence for the excited states of ^{17}Ne is preliminary.

2. ^{20}Ne(^{3}He, ^{6}He)^{17}Ne $\quad Q_m = -26.19$

Table 17.21: β^+ decay of ^{17}Ne [a]

Decay to ^{17}F* (MeV $\pm$ keV)	J^π	Branching (%)	$\log ft$ [b]	Decay to ^{16}O* (MeV)	Decay (%)
0	$\frac{5}{2}^+$	0.5 ± 0.2 [c]	6.95 ± 0.13		
0.50	$\frac{1}{2}^+$	1.1 ± 0.5 [c]	6.55 ± 0.21		
3.084 ± 30	$\frac{1}{2}^-$	0.48 ± 0.07	6.44 ± 0.06	0	100
4.609 ± 15	$\frac{3}{2}^-$	16.2 ± 0.7	4.59 ± 0.02	0	100
5.480 ± 10	$\frac{3}{2}^-$	54.0 ± 0.7	3.86 ± 0.01	0	100
6.037 ± 10	$\frac{1}{2}^-$	10.6 ± 0.2	4.42 ± 0.01	0	100
6.406 ± 30		0.35 ± 0.10	5.80 ± 0.13	0	100
7.708 ± 30	$\frac{1}{2}^+$	0.18 ± 0.05	5.67 ± 0.12	0	> 95
				6.05	< 5
8.075 ± 10	$\frac{5}{2}^+$	6.83 ± 0.11	3.96 ± 0.01	0	99.5
				6.05	0.49 ± 0.02
8.436 ± 10		6.51 ± 0.26	3.85 ± 0.02	0	94.3
				6.05	5.7 ± 0.5
8.825 ± 25		1.90 ± 0.06	4.23 ± 0.02	0	92.4
				6.05	7.6 ± 1.1
11.20 [e]	$\frac{1}{2}^-; T = \frac{3}{2}$	$0.71^{+0.10}_{-0.05}$	$3.29^{+0.04}_{-0.07}$	0	10 ± 2
				6.13	22 ± 2
				6.92	24 ± 6
				7.12	44 ± 4
[d]			0.54 ± 0.05		

[a] (1971HA05). See also Table 17.23 in (1971AJ02).

[b] $\log ft$ values calculated by (1971HA05) using an atomic mass excess of 16.517 ± 0.026 MeV [and $\tau_{1/2} = 109.0 \pm 1.0$ msec] rather than the presently adopted 16.48 ± 0.05 MeV. Since this energy difference leads to quite small changes, the original calculations are quoted here. However, Table 17.3 (which compares the analog decays) shows corrected ft values.

[c] Calculated branchings, based on the mirror ^{17}N decay.

[d] A proton group with $E_{\rm c.m.} = 2.83$ MeV has been observed: the level in ^{17}F to which it corresponds is not known.

[e] See also Table 17.11.

At $E(^6\text{He}) = 62.6$ MeV, ^{6}He groups are observed to ^{17}Ne*(0, 1.35, 1.84, 2.77, 3.70, 5.28) [from Fig. 3 in (1972CE1A)]. See also (1970WO1D).

^{17}Na

(Not illustrated)

^{17}Na has not been observed: its mass excess is predicted to be 35.61 MeV by (1966KE16). It is then unbound with respect to breakup into ^{16}Ne + p by 3.2 MeV and with respect to breakup into ^{14}O + 3p by 5.8 MeV. See also (1976CA1R; theor.).

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(Closed 01 November 1976)

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