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Energy Levels of Light Nuclei
$A = 17$

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Abstract: An evaluation of $A = 16$–17 was published in *Nuclear Physics A*375 (1982), 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. Also, Reference key numbers have been changed to the NNDC/TUNL format.

(References closed July 1, 1981)

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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).

^{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 $\frac{3}{2}^-$ (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 0.73 MeV (1974TH01, 1975JE02). The E_{β^-}(max) for the decay to ^{17}C would then be 23.3 MeV. See also (1977WA08) and (1981SE06; theor.).

^{17}C

(Fig. 9)

The Q-value of the ^{48}Ca(^{18}O, ^{17}C)^{49}Ti reaction, studied at $E(^{18}\text{O}) = 102$ MeV, $\theta \approx 8°$, leads to an atomic mass excess of 21.023 ± 35 keV. A group is also observed corresponding to an excited state of ^{17}C with $E_x = 292 \pm 20$ keV. Three closely spaced states with $J^\pi = \frac{1}{2}^+, \frac{3}{2}^+, \frac{5}{2}^+$ are predicted, based on systematics. The cross sections for formation of ^{17}C*(0, 0.29) are 3 and 9 μb/sr, respectively, at $\theta_{cm} = 10.5°$ (1977NO08). On the basis of the atomic mass excess given above, E_{β^-}(max) to $^{17}\text{N}_{g.s.} = 13.15$ MeV. ^{17}C is stable with respect to ^{16}C + n by 0.74 MeV. The Q-value of the ^{207}Pb(^{18}O, ^{17}C)^{208}Po reaction is -26.87 ± 0.22 MeV, leading to a mass excess of 21.10 ± 0.22 MeV for the ground state (doublet) of ^{17}C (1979BA31). See also (1977AJ02) and (1977AR06, 1980AL1F).

^{17}N

(Figs. 6 and 9)

GENERAL: See also (1977AJ02).

Theoretical papers and reviews: (1978KR19, 1979AL22, 1979BE1H, 1979BO22, 1980MI1G, 1981OS04).

Experimental papers: (1977AR06, 1977BA44, 1978GE1C, 1978KO01, 1980OL1C, 1981FR1D).

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

E_x in ^{17}N (MeV $\pm$ keV)	$J^\pi; T$	τ	Decay	Reactions
0	$\frac{1}{2}^-; \frac{3}{2}$	$\tau_{1/2} = 4.173 \pm 0.004$ sec	β^- [b]	1, 2, 3, 4, 5, 6, 7, 8, 9, 10
1.3739 ± 0.3	$\frac{3}{2}^-$	$\tau_m = 93 \pm 35$ fsec	γ	2, 3, 4, 6, 9, 10
1.8496 ± 0.3	$\frac{1}{2}^+$	41^{+20}_{-9} psec	γ	3, 4, 9, 10
1.9068 ± 0.3	$\frac{5}{2}^-$	11 ± 2 psec	γ	3, 4, 6, 10
2.5260 ± 0.5	$\frac{5}{2}^+$	33 ± 3 psec	γ	2, 3, 4, 9, 10
3.1289 ± 0.5	$\frac{7}{2}^-$	275 ± 80 fsec	γ	3, 4, 5, 6, 10
3.2042 ± 0.9	$\frac{3}{2}^-$	< 30 fsec	γ	3, 4, 9, 10
3.6287 ± 0.7	$(\frac{7}{2}, \frac{9}{2})^-$	12 ± 2 psec	γ	3, 4, 5, 6
3.663 ± 4	$\frac{1}{2}^-$	< 350 fsec	γ	3, 4
3.9060 ± 2.0	$(\frac{3}{2}, \frac{5}{2})^-$	52 ± 22 fsec	γ	3, 4
4.0064 ± 2.0	$\frac{3}{2}^{(-)}$	< 15 fsec	γ	3, 4, 9
4.209 ± 3	$\frac{5}{2}^+$	< 70 fsec	γ	3, 4
4.415 ± 3	$(\frac{3}{2}, \frac{5}{2})^-$	(< 60 fsec)	γ	3, 4
5.170 ± 2	$(\frac{9}{2}^+)$	< 60 fsec	γ	3, 4, 9
5.195 ± 3	$(\frac{1}{2}, \frac{3}{2})^+$	< 95 fsec	γ	3, 4
5.515 ± 3	$\frac{3}{2}^-$	< 100 fsec	γ	3, 4, 9
5.772 ± 3	$\leq \frac{7}{2}$	< 120 fsec	γ	3, 4
(6.08 ± 30)				3
E_x in ^{17}N (MeV $\pm$ keV)	$J^\pi; T$	Γ	Decay	Reactions
6.233 ± 8				3, 4
6.449 ± 3				3, 4
6.615 ± 19				3, 4
6.938 ± 15				4
6.981 ± 20	$(\frac{3}{2})^-$			3, 4, 9
7.013 ± 22				3, 4, 9
7.17 ± 40				3
7.37 ± 40				3
7.63 ± 40				3

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

E_x in ^{17}N (MeV ± keV)	$J^\pi; T$	Γ	Decay	Reactions
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
10.14	$(\frac{1}{2}, \frac{3}{2})^-$			9

[a] See also Table 17.5.

[b] See also Tables 17.2 and 17.3.

1. (a) ^{17}N(β^-)^{17}O* $\rightarrow$ ^{16}O + n $\quad Q_m = 4.536$

   (b) ^{17}N(β^-)^{17}O $\quad Q_m = 8.680$

The half-life of ^{17}N is 4.173 ± 0.004 sec (1976OH05, 1972AL42). See also (1971AJ02). The decay is principally [see Table 17.2] to the neutron unbound states ^{17}O*(4.55, 5.38, 5.94) [$J^\pi = \frac{3}{2}^-, \frac{3}{2}^-, \frac{1}{2}^-$]. The nature of the decay is in agreement with $J^\pi = \frac{1}{2}^-$ for $^{17}\mathrm{N}_{\mathrm{g.s.}}$ (1973PO11, 1976AL02). For a comparison of the ^{17}N and ^{17}Ne decays see Table 17.23 (1976AL02, 1976OH05).

2. ^{9}Be(^{9}Be, p)^{17}N. $\quad Q_m = 7.537$

Angular distributions are reported at $E(^9\mathrm{Be}) = 5.0$ MeV to ^{17}N*(0, 1.37, 2.53) (1977YO02).[†]

3. ^{11}B(^{7}Li, p)^{17}N $\quad Q_m = 8.417$

Observed proton groups and γ-rays are displayed in Table 17.4. Table 17.5 shows branching ratio and lifetime measurements (1974RO27, 1974RO28).

[†] See (1977AJ02) for several other reactions leading to ^{17}N.

Table 17.2: Beta decay of ^{17}N

Decay to ^{17}O* (keV)	J^{π}	Branch (%)	$\log ft$
0	$\frac{5}{2}^{+}$	1.6 ± 0.5 [c]	7.29 ± 0.11 [c,f]
871	$\frac{1}{2}^{+}$	3.0 ± 0.5 [c]	6.80 ± 0.07 [c]
3055.2 ± 0.3 [a]	$\frac{1}{2}^{-}$	0.34 ± 0.06 [c]	7.08 ± 0.08 [c]
3841	$\frac{5}{2}^{-}$	$< 7 \times 10^{-3}$ [c]	> 8.5 [c]
4551.2 ± 1.3 [b]	$\frac{3}{2}^{-}$	38.0 ± 1.3 [d]	4.41 ± 0.02 [g]
5083 ± 21 [b]	$\frac{3}{2}^{+}$	0.6 ± 0.4 [e]	5.9 ± 0.5 [e]
5389.0 ± 1.2 [b,h]	$\frac{3}{2}^{-}$	50.1 ± 1.3 [d]	3.86 ± 0.02 [g]
5738	$(\frac{1}{2}^{+})$	< 0.23 [e]	> 6.0 [e]
5868	$\frac{3}{2}^{+}$	< 0.15 [e]	> 6.0 [e]
5951.8 ± 1.9 [b,h]	$\frac{1}{2}^{-}$	6.9 ± 0.5 [d]	4.35 ± 0.03 [g]
6356	$\frac{1}{2}^{+}$	< 0.08 [e]	> 6.0 [e]

[a] (1976AL02): direct ground state decay < 1.5%.

[b] (1976OH05): from neutron groups. [The $E_{\rm x}$ have been recalculated here on the basis of 4144.3 ± 0.8 keV for $E_{\rm b}$ for a neutron in ^{17}O.] $\Gamma_{\rm n}$ for ^{17}O*(4.55, 5.08, 5.38, 5.94) are , respectively, 54.8 ± 0.4, 113 ± 55, 63.2 ± 1.1 and 60.5 ± 3.2 keV (1976OH05). See also Table 17.12.

[c] (1976AL02). See also (1977AJ02).

[d] Calculated from the mean of the values from (1973PO11, 1976AL02, 1976OH05), renormalized here, together with the new branch to ^{17}O*(5.08), to lead to a total neutron emission probability of 95 ± 1% [100% less the branches to ^{17}O*(0, 0.87, 3.06)].

[e] (1976OH05).

[f] $\log f_1 t = 9.56 \pm 0.13$ (1971TO08).

[g] Calculated using the tables of (1971GO40).

[h] See, however, Tables 17.7 and 17.12.

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

Final state in ^{17}O	Final state in ^{17}F	J^{π}	Γ_n [b,c] (keV)	Γ_p [b] (keV)	$(ft)^{-}$ [d,e]	$(ft)^{+}$ [d]	δ [f]
3.06	3.10	$\frac{1}{2}^-$	0	19	$(1.2 \pm 0.2) \times 10^7$	$(2.78 \pm 0.40) \times 10^6$	-0.77 ± 0.08
4.55	4.70	$\frac{3}{2}^-$	55	230	$(2.57 \pm 0.13) \times 10^4$	$(3.92 \pm 0.18) \times 10^4$	0.53 ± 0.11
5.38	5.52	$\frac{3}{2}^-$	63	69	$(7.2 \pm 0.3) \times 10^3$	$(7.22 \pm 0.15) \times 10^3$	0.00 ± 0.04
5.94	6.04	$\frac{1}{2}^-$	61	28	$(2.24 \pm 0.16) \times 10^4$	$(2.61 \pm 0.07) \times 10^4$	0.17 ± 0.09

[a] (1976AL02, 1976OH05). I am indebted to Dr. D.E. Alburger for his comments.
[b] Γ_n and Γ_p are the neutron and proton widths of the ^{17}O and ^{17}F states, respectively.
[c] Γ_n for ^{17}O*(4.55, 5.08, 5.38, 5.94) are reported to be, respectively 54.8 ± 0.4, 113 ± 55, 63.2 ± 1.1 and 60.5 ± 3.2 keV (1976OH05).
[d] $(ft)^{-}$ and $(ft)^{+}$ are for the ^{17}N and ^{17}Ne decays, respectively.
[e] See Table 17.2.
[f] $\delta \equiv [(ft)^{+}/(ft)^{-}] - 1$.

4. ^{15}N(t, p)^{17}N $\qquad Q_m = -0.108$

Observed proton groups are displayed in Table 17.6. See also (1971AJ02).

5. ^{15}N(α, 2p)^{17}N $\qquad Q_m = -19.922$

At $E_\alpha = 65$ MeV ^{17}N*(3.13, 3.63) are the only states of ^{17}N which are strongly populated (1978JA10).

6. ^{15}N(^{13}C, ^{11}C)^{17}N $\qquad Q_m = -15.293$

At $E(^{13}\text{C}) = 105$ MeV ^{17}N*(3.13, 3.63) are strongly populated (1979RA10).

7. ^{17}O(n, p)^{17}N $\qquad Q_m = -7.898$

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

8. ^{18}O(γ, p)^{17}N $\qquad Q_m = -15.942$

See (1976BA41) and ^{18}O in (1983AJ01).

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

E_x (keV)		l [f]	J^π [g]	C^2S [f]
A	B			
	0	1	$\frac{1}{2}^-$	2.02
1373.7 ± 0.5	1374.1 ± 0.4 [e]	1	$\frac{3}{2}^-$	0.38
1850.0 ± 0.5	1849.5 ± 0.3 [e]	0 [h]	$\frac{1}{2}^+$	0.41 ± 0.14
1906.8 ± 0.4	1906.9 ± 0.5 [e]		$\frac{5}{2}^-$	
2526.3 ± 1.0	2525.9 ± 0.6 [e]	2	$\frac{5}{2}^+$	0.53 ± 0.17
3128.7 ± 0.6	3129.2 ± 0.6 [e]		$\frac{7}{2}^{(-)}$	
3203 ± 2	3204.4 ± 0.9 [e]	1	$\frac{3}{2}^-$	0.05
3628.7 ± 0.7			$> \frac{3}{2}$ [i]	
3663 ± 4			$(\frac{1}{2}, \frac{3}{2})^-$	
3906.0 ± 2.0			$\leq \frac{7}{2}$	
4006.4 ± 2.0	4000 [f]	(1)	$\frac{3}{2}^{(-)}$	0.04
4208 ± 3			$\leq \frac{5}{2}$	
4415 ± 3			$\leq \frac{7}{2}$	
5170 ± 2	5170 [f]	(2)	$\frac{3}{2} \leq J \leq \frac{9}{2}$ [j]	0.08
5195 ± 3			$(\frac{1}{2}, \frac{3}{2}, \frac{5}{2})^+$	
5514 ± 3	$\equiv 5523$ [f]	1	$\frac{3}{2}^-$ [k]	1.83
5770 ± 3			$\leq \frac{7}{2}$	
6080 ± 30 [b,c]				
6240 ± 25 [b,c]				
6430 ± 30 [b,c]				
6610 ± 25 [b,c]				
6990 ± 20 [b,c]	6990 [f,h]	1	$(\frac{3}{2})^-$ [k]	0.32
7170 ± 40 [c]				
7370 ± 40 [c]				
	7510 [f]	(1)	$(\frac{1}{2}, \frac{3}{2})^-$	0.09
7630 ± 40 [c]				
7730 ± 40 [c]				
8000 ± 25 [b,c]				
8140 ± 40 [c]				

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

E_x (keV)		l [f]	J^{π} [g]	C^2S [f]
A	B			
8550 ± 40 [c,d]				
8930 ± 40 [c]				
9260 ± 40 [c]				
9740 ± 40 [c]				
	10140 [f]	(1)	$(\frac{1}{2}, \frac{3}{2})^-$	0.5

A: ^{11}B(^{7}Li, p)^{17}N: (1974RO27), except for states labelled [b] and [c].
B: ^{18}O(t, α)^{17}N (1976GU14) and ^{18}O(d, ^{3}He)^{17}N (1977MA10).
[a] See also Table 17.4 in (1977AJ02).
[b] (1965HA05).
[c] (1966MC05).
[d] This state and the ones below are broad.
[e] (1976GU14).
[f] ^{18}O(d, ^{3}He)^{17}N (1977MA10); $E_d = 52$ MeV; DWBA analysis.
[g] (1974RO27, 1976GU14, 1977MA10).
[h] Unresolved.
[i] Probably $(\frac{7}{2}, \frac{9}{2})^-$ (1974RO27).
[j] Probably $(\frac{7}{2}, \frac{9}{2})^+$ (1974RO27); see, however, (1977MA10).
[k] ^{18}O(d, ^{3}He)^{17}N (1981MA14); $E_{\vec{d}} = 52$ MeV.

9. ^{18}O(d, ^{3}He)^{17}N $\qquad Q_m = -10.449$

Observed groups of ^{3}He ions are displayed in Table 17.4: the $\frac{1}{2}^-$ ground state contains the full $1p_{1/2}$ strength. The strength of all other observed $l = 1$ transitions is assumed to originate from pickup from the $1p_{3/2}$ shell (1977MA10). Analyzing powers have been obtained at $E_{\vec{d}} = 52$ MeV to ^{17}N*(0, 1.37, 1.85, 2.53, 5.51, 6.99) (1981MA14).

10. ^{18}O(t, α)^{17}N $\qquad Q_m = 3.872$

At $E_t = 3.5$ MeV (1976GU14) have studied $\alpha - \gamma$ angular correlations and γ-ray branching ratios for the first six excited states of ^{17}N: see Tables 17.4 and 17.5. See also (1971AJ02).

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

E_i (MeV)	E_f (MeV)	Mult.	Branch (%)	$\Gamma_\gamma/\Gamma_\mathrm{W}$ [b] (W.u.)	τ_m
1.37	0	M1	100	0.13 ± 0.05	93 ± 35 fsec
1.85	0	E1	86.5 ± 2.5		41^{+20}_{-9} psec
	1.37	E1	13.5 ± 2.5	$(3.2 \pm 1.5) \times 10^{-5}$	
1.91	0	E2	77.0 ± 2.5	0.9 ± 0.2	11 ± 2 psec
	1.37	M1	23.0 ± 2.5	$(5 \pm 1) \times 10^{-3}$ [c]	
2.53	0	M2	11 ± 1	0.22 ± 0.04	33 ± 3 psec
	1.37	E1	34 ± 3	$(1.0 \pm 0.2) \times 10^{-5}$	
	1.85	E2	12.0 ± 1.5	8.1 ± 1.6	
	1.91	E1	41.0 ± 2.5		
3.13 [d]	1.91	M1	100	0.06 ± 0.02	275 ± 80 fsec
3.20 [e]	0	M1	88 ± 4	> 0.025 [f]	< 30 fsec
	1.91	M1	12 ± 4	> 0.05	
3.63 [g]	1.91	E2	47 ± 10	0.8 ± 0.2	12 ± 2 psec
	3.13	M1	53 ± 10	0.010 ± 0.03	
3.66	1.85	E1	100	$> 7 \times 10^{-4}$	< 350 fsec
3.91	1.91	M1	100	$(8^{+5}_{-3}) \times 10^{-2}$ [h]	52 ± 22 fsec
4.01	1.85		$\leq 15 \pm 5$ [i]		
	2.53	(M1)	85 ± 5	0.55	< 15 fsec
4.21	1.37		100		< 70 fsec
4.42	1.91		100		(< 60 fsec)
5.17	2.53	E2	37 ± 7	> 15	< 60 fsec
	3.13		63 ± 7		
5.20	1.85		≈ 42		< 95 fsec
	1.91		≈ 58		
5.52	0		≈ 50		< 100 fsec
	1.37		≈ 50		
5.77	1.37		≈ 25		< 120 fsec
	1.91		≈ 25		
	4.01		≈ 50 [i]		

[a] See Table 17.5 in (1977AJ02) for references and additional detail.

[b] Assuming pure multipole transitions and J^π from Table 17.1: see also Table 2 in the Introduction here.

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

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

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

[f] $\delta = -0.06 \pm 0.08$ or 2.1 ± 0.4 (1976GU14). All other δ reported by (1976GU14) are consistent with 0.

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

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

[i] This branch in uncertain.

Table 17.6: States of ^{17}N from ^{15}N(t, p) [a]

E_x (keV)	L	J^π	E_x (keV)	L	J^π
0 [b]	0	$\frac{1}{2}^-$	4420 ± 7 [b]	2	$(\frac{3}{2}, \frac{5}{2})^-$
1372 ± 6 [b]	2	$(\frac{3}{2}, \frac{5}{2})^-$	5179 ± 4 [c] }	5	$(\frac{9}{2}^+)$
1851 ± 4	1	$(\frac{1}{2}, \frac{3}{2})^+$		1	$((\frac{1}{2}, \frac{3}{2})^+)$
1909 ± 3 [b]	2	$(\frac{3}{2}, \frac{5}{2})^-$	5517 ± 6	(2)	
2524 ± 4	3	$(\frac{5}{2}, \frac{7}{2})^+$	5780 ± 6	(1)	
3127 ± 6 [b]	4	$(\frac{7}{2}, \frac{9}{2})^-$	6233 ± 8 [d]	(2)	
3201 ± 5 [b]	2	$(\frac{3}{2}, \frac{5}{2})^-$	6449 ± 3	(4, 5)	
3625 ± 6 [b]	4	$(\frac{7}{2}, \frac{9}{2})^-$	6627 ± 30	weak	
			6938 ± 15 }		
3664 ± 6 [b]	0	$\frac{1}{2}^-$	6981 ± 20 }	$(3, 4)$	
			7013 ± 22 }		
3906 ± 5 [b]	2	$(\frac{3}{2}, \frac{5}{2})^-$			
4011 ± 6	(1)				
4213 ± 6	3	$\frac{5}{2}^+$ [e]			

[a] (1979FO14): $E_t = 15.0$ MeV; DWBA analysis. See also (1978MO18).

[b] Predominantly 2p-1h states.

[c] Unresolved states.

[d] ^{17}N*(6.08) is not observed.

[e] The $\frac{7}{2}^+$ possibility can be eliminated because the $4.21 \to 1.37$ MeV transition would then have too large an M2 strength (> 500 W.u.) [P.M. Endt, private communication].

^{17}O

(Figs. 7 and 9)

GENERAL: See also (1977AJ02).

Shell model: (1976BA55, 1977DU04, 1977HA1Z, 1977PO16, 1978CH26, 1978KR02, 1979KA06, 1980BR13, 1980VA05).

Collective and cluster models: (1978CH26, 1978TA1A, 1978TH1A, 1980FU1G).

Special states: (1977HE18, 1977SH18, 1978AL1T, 1978EN1D, 1978TA1A, 1979MA2P, 1979ZA07, 1980CH35, 1980FU1G, 1980HI1C, 1980VA05, 1981TA09).

Electromagnetic transitions: (1976MC1G, 1977AL18, 1977AN1L, 1977BR03, 1977HA1Z, 1977HO04, 1978ZA1E, 1979SU1G, 1980CH35).

Complex reactions involving ^{17}O: (1976DU04, 1976LE1F, 1977AR06, 1977PE1G† , 1977RE1C, 1978KO01, 1978SE1H, 1979SA27, 1980LA1P, 1980OL1C, 1981SH1G).

Astrophysical questions: (1976BO1M, 1976NO1C, 1977AU1E, 1977CA1K, 1977CO1U, 1977CO1W, 1977DE1N, 1977DI1C, 1977EN1B, 1977NO1E, 1977PR1E, 1977RA1C, 1977TR1D, 1977WA1P, 1978BU1B, 1978CL1F, 1978LE1W, 1978PO1B, 1978ST1C, 1978TR1C, 1978WO1E, 1979CH1T, 1979JA1M, 1979LA1H, 1979LE1F, 1979PE1E, 1979RO1A, 1979SW1B, 1980AU1D, 1980CL1B, 1980PE1F, 1980WA1M, 1981GU1D, 1981WI1D, 1981WI1G).

Applications: (1978AM1D).

Pion and other meson capture and reactions (See also reactions 38 and 68): (1977HO1B, 1977SI01, 1978GA1C, 1979JO08, 1980DO1E, 1981OS04).

Other topics: (1976BA55, 1976BI1A, 1976OF1A, 1976SA1H, 1977BA3P, 1977GR16, 1977SH18, 1977SU1H, 1978EN1D, 1978GA1C, 1978KR02, 1978MC04, 1978SH1B, 1979BE1H, 1979BR30, 1979CO10, 1979HE1F, 1979KA06, 1979MA2P, 1979PI10, 1979VA06, 1979ZO1A, 1980HI1C, 1980ZO1A, 1981TA09).

Ground state of ^{17}O: (1976DU04, 1976FU06, 1976JO1B, 1976MC1G, 1976SA1H, 1977AN21, 1977BR03, 1977DU04, 1977HA1Z, 1977KO28, 1977NO07, 1977PO16, 1977SH13, 1978AN07, 1978AR1R, 1978AR04, 1978CH26, 1978FO22, 1978HE1D, 1978SL1B, 1978ZA1D, 1979BR17, 1979BR30, 1979SA27, 1979SU1G, 1979VA06, 1980BO04, 1980BR13, 1980CH35, 1980HI1C, 1981AV02, 1981SI1B, 1981TA09, 1981VA1F).

$$\mu = -1.89379 \pm 0.00009 \text{ nm (1978LEZA).}$$

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

† See also for spectroscopic factors.

Table 17.7: 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, 9, 12, 13, 15, 16, 18, 19, 20, 21, 22, 23, 24, 29, 30, 31, 32, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73
0.87081 ± 0.12	$\frac{1}{2}^+$	$\tau_m = 258.6 \pm 2.6$ psec	γ	1, 2, 5, 6, 7, 12, 13, 15, 16, 18, 19, 20, 21, 22, 29, 30, 31, 32, 38, 39, 42, 43, 44, 46, 47, 48, 50, 52, 54, 56, 57, 61, 62, 63, 68, 69, 70, 71, 72, 73
3.0552 ± 0.3	$\frac{1}{2}^-$	$\tau_m = 120^{+80}_{-60}$ fsec	γ	5, 6, 7, 12, 13, 18, 21, 22, 29, 31, 32, 38, 39, 42, 48, 50, 52, 61, 62, 70, 71
3.841 ± 3	$\frac{5}{2}^-$	$\tau_m \leq 25$ fsec	γ	5, 6, 7, 12, 13, 14, 18, 21, 22, 29, 30, 39, 42, 50, 61, 62, 70, 71
4.552 ± 2	$\frac{3}{2}^-$	$\Gamma = 40 \pm 5$	γ, n	5, 7, 12, 13, 21, 22, 29, 30, 33, 39, 42, 48, 49, 50, 61, 62, 71
5.085 ± 2	$\frac{3}{2}^+$	96 ± 5	γ, n	2, 6, 7, 12, 13, 21, 22, 29, 33, 39, 48, 49, 50, 61, 62

Table 17.7: Energy levels of ^{17}O (continued)

E_x in ^{17}O (MeV $\pm$ keV)	$J^\pi; T$	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
5.218	$(\frac{9}{2}^-)$	< 0.1	γ, n	6, 7, 12, 13, 14, 21, 22, 29, 30, 33, 39, 50, 61, 71
5.378 ± 2	$\frac{3}{2}^-$	28 ± 7	γ, n	7, 21, 22, 29, 33, 39, 42, 48, 49, 50, 61, 62, 71
5.697 ± 2	$\frac{7}{2}^-$	3.4 ± 0.3	γ, n	2, 6, 12, 13, 21, 22, 29, 30, 33, 39, 49, 50, 62
5.733 ± 2		< 1	n	2, 5, 6, 12, 13, 21, 22, 33, 39, 71
5.868 ± 2	$\frac{3}{2}^+$	6.6 ± 0.7	n	6, 7, 12, 13, 21, 22, 29, 33, 39, 71
5.939 ± 4	$\frac{1}{2}^-$	32 ± 3	γ, n	5, 6, 12, 13, 21, 22, 29, 33, 39, 48, 50, 62, 71
6.356 ± 8	$\frac{1}{2}^+$	124 ± 12	γ, n	5, 7, 21, 29, 33, 50
6.862 ± 2	$(\frac{1}{2}^-)$	< 1	γ, n	5, 6, 7, 12, 13, 21, 22, 29, 33, 39, 50, 62, 71
6.972 ± 2	$(\frac{5}{2}^+)$	< 1	γ, n	6, 7, 12, 13, 21, 22, 29, 33, 50, 71
7.1657 ± 0.8	$\frac{5}{2}^-$	1.38 ± 0.05	n, α	5, 6, 7, 10, 12, 13, 21, 29, 33, 37
7.202 ± 10	$\frac{3}{2}^+$	280 ± 30	n, α	12, 13, 21, 33, 37
7.3792 ± 1.0	$\frac{5}{2}^+$	0.64 ± 0.23	(γ), n, α	5, 6, 7, 10, 12, 13, 29, 30, 33, 37, 50, 62, 71
7.3822 ± 1.0	$\frac{5}{2}^-$	0.96 ± 0.20	γ, n, α	5, 7, 10, 12, 13, 21, 30, 33, 49, 50, 62, 71
7.559 ± 20	$\frac{3}{2}^-$	500 ± 50	n, α	33, 37, 39
7.576 ± 2	$\frac{7}{2}^-$	< 0.1	γ, n, α	5, 6, 10, 12, 13, 21, 29, 33, 50

Table 17.7: 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
7.6882 ± 0.9	$\frac{7}{2}^-$	14.4 ± 0.3	γ, n, α	5, 6, 10, 12, 13, 29, 33, 37, 49
7.757 ± 9	$\frac{11}{2}^-$		γ	29, 30, 50
7.956 ± 6	$\frac{1}{2}^+$	90 ± 9	n, α	10, 29, 33, 37
7.99 ± 50	$\frac{1}{2}^-$	270 ± 30	n, α	33, 37
8.070 ± 10	$\frac{3}{2}^+$	85 ± 9	n, α	10, 29, 33, 37
8.200 ± 7	$\frac{3}{2}^-$	60	γ, n, α	10, 29, 33, 37, 49, 62
8.3424 ± 0.9	$\frac{1}{2}^+$	11.4 ± 0.5	n, α	10, 29, 33, 37, 50
8.4023 ± 0.8	$\frac{5}{2}^+$	6.17 ± 0.13	n, α	6, 10, 12, 13, 29, 33, 37, 50
8.4660 ± 0.8	$\frac{7}{2}^+$	2.13 ± 0.11	n, α	5, 6, 10, 12, 13, 29, 33, 37, 50, 62
8.5007 ± 0.8	$\frac{5}{2}^-$	6.89 ± 0.22	γ, n, α	6, 10, 12, 13, 29, 33, 37, 49, 50
8.6870 ± 1.0	$\frac{3}{2}^-$	55.3 ± 0.6	γ, n, α	10, 29, 33, 37, 49, 62
8.897 ± 8	$\frac{3}{2}^+$	101 ± 3	n, α	6, 10, 12, 13, 29, 30, 33, 37
8.9672 ± 1.7	$\frac{7}{2}^-$	26 ± 2	γ, n, α	6, 10, 12, 13, 29, 33, 37, 49
9.147 ± 4	$\frac{1}{2}^-$	4 ± 3	n, α	6, 10, 12, 13, 62
9.15 ± 20	$\frac{9}{2}^-$			29, 30
9.18	$\frac{7}{2}^-$	3	α	10, 12, 13
9.1939 ± 0.8	$\frac{5}{2}^+$	3.53 ± 0.13	n, α	10, 12, 13, 33
9.42	$\frac{3}{2}^-$	120	n	33
9.492 ± 4	$\frac{5}{2}^-$	15 ± 1	n, α	5, 10, 13, 29, 33, 62
9.7119 ± 0.9	$\frac{7}{2}^+$	23.1 ± 0.3	n, α	10, 13, 29, 33
9.7833 ± 0.9	$\frac{3}{2}^+$	11.7 ± 0.3	n, α	10, 13, 33
9.8589 ± 0.9	$(\frac{5}{2}^-)$	4.01 ± 0.23	n, α	10, 13, 29, 33
9.8765 ± 1.3	$(\frac{1}{2}^-)$	16.7 ± 1.7	n, α	10, 13, 29, 33

Table 17.7: 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
9.976 ± 20	$\frac{5}{2}^+$	≈ 80	n, α	10
10.045 ± 20		≈ 100	n, α	10
10.1678 ± 1.0	$\frac{7}{2}^-$	49.1 ± 0.8	n, α	10, 33
10.336 ± 15	$\frac{5}{2}^+, \frac{7}{2}^-$	150	n, α	10, 29
10.423 ± 3		14 ± 3	n, α	10
10.49	$\frac{5}{2}^+, \frac{7}{2}^-$	75 ± 30	n, α	10
10.5591 ± 1.0	$(\frac{7}{2}^-)$	42.5 ± 1.1	n, α	10, 14, 29, 33, 34
10.777 ± 3	$\frac{1}{2}^+, \frac{7}{2}^-$	74 ± 3	n, α	10, 13, 29, 34
10.9129 ± 2.8	$(\frac{5}{2}^+)$	41.7 ± 1.4	n, α	10, 29, 33, 34
11.036 ± 3	$T = \frac{1}{2}$	31 ± 3	n, α	10, 29
11.0787 ± 0.9 [a]	$\frac{1}{2}^-; \frac{3}{2}$	2.4 ± 0.3	n, α	10, 29, 33, 62, 63
11.238		80 ± 3	n, α	5, 10
11.51	$\geq \frac{3}{2}$	190	n	33, 34
11.622		65 ± 2	n, α	10
11.750 ± 10		40 ± 25	γ, n, α	10, 50
11.815 ± 15		12 ± 3	n, α	10
12.005 ± 15	$\geq \frac{3}{2}$	270	n, α	10, 33, 34, 50
12.11 ± 20		150 ± 50	n, α	10, 14, 34
12.274 ± 15		100 ± 30	n, α	10
12.38 ± 20			n, α	10, 33
12.420 ± 15			n, α	10
12.4660 ± 1.0	$\frac{3}{2}^-; \frac{3}{2}$	6.9 ± 1.1	n, α	10, 33, 34, 62, 63
12.595 ± 15		75 ± 30	n, α	10
12.669 ± 15		≈ 5	n, α	10, 33, 34
12.81 ± 25			n, α	10
12.93 ± 20		≥ 150	n, α	10
12.944 ± 5	$\frac{1}{2}^+; \frac{3}{2}$	6 ± 2	n, α	10, 33, 34, 62, 63
12.9982 ± 1.0	$\frac{5}{2}^-; \frac{3}{2}$	2.5 ± 1.0	n, α	10, 33, 63
13.076 ± 15		16 ± 4	n, α	10
13.484 ± 15		≈ 120	n, α	10

Table 17.7: Energy levels of ^{17}O (continued)

E_x in ^{17}O (MeV $\pm$ keV)	$J^\pi; T$	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
13.58 ± 20	$(\frac{11}{2}^-, \frac{13}{2}^-)$			12, 13
13.609 ± 15		250 ± 100	n, α	10
13.6353 ± 2.5	$(\frac{5}{2})^+; \frac{3}{2}$	9 ± 5	n, α	33, 62, 63
(13.67)		400	n	33
14.15 ± 100	$(\frac{9}{2}^+, \frac{11}{2}^+)$	≈ 100		12
14.2303 ± 1.7	$(\frac{7}{2}^-); \frac{3}{2}$	20.5 ± 1.6	n, α	33, 63
14.286 ± 3	$T = \frac{3}{2}$	7.5 ± 4	n, α	33, 63
14.451 ± 3		40 ± 6	n, α	33
14.76 ± 100	$(\geq \frac{3}{2})$	340	γ, n	33, 50
14.791 ± 3	$(\frac{1}{2}^-, \frac{3}{2})$	36 ± 13	n, α	33
15.00		180	n, d, α	28, 33
15.1 ± 100	$(\frac{9}{2}^+, \frac{11}{2}^+)$	≈ 500		12
15.199 ± 3	$(\frac{3}{2}; \frac{3}{2})$	52 ± 14	γ, n, d, α	28, 33, 50
15.368 ± 3	$(\frac{5}{2}^+; \frac{3}{2})$	40 ± 6	n, d, α	27, 33
(15.6)		≈ 300	p, d, α	26, 27, 28
15.95 ± 150	$(\frac{9}{2}^+, \frac{11}{2}^+)$	≈ 700		12
16.243 ± 4	$(\frac{9}{2}^+; \frac{3}{2})$	21 ± 10	n, p, d, α	26, 33
16.58 ± 10	$(\frac{1}{2}, \frac{3}{2})^-; \frac{3}{2}$			62
16.6 ± 150	$(\frac{11}{2}^-, \frac{13}{2}^-)$			12
17.1 ± 150	$(\frac{11}{2}^-, \frac{13}{2}^-)$			12
17.436 ± 11	$(T = \frac{3}{2})$	66 ± 20	n, α	33
18.110 ± 4	$\frac{3}{2}^-; \frac{3}{2}$	46 ± 12	n, α	33, 62
19.6 ± 150	$(\frac{13}{2}^+, \frac{15}{2}^+)$	≈ 250		12
20.2 ± 150	$(\frac{13}{2}^+, \frac{15}{2}^+)$	≈ 250		12
21.2	$(\frac{13}{2}^+, \frac{15}{2}^+)$			12
21.7 ± 100	$\frac{5}{2}^+$	≈ 750	γ, ^{3}He, α	16, 17
22.1 ± 100	$\frac{7}{2}^-$	≈ 750	γ, n, ^{3}He, α	12, 16, 17
22.5 ± 200	$\frac{3}{2}^{(-)}$	≈ 1000	γ, ^{3}He	16
23		≈ 6000	γ, n	49, 50
23.0	$\frac{1}{2}^+$	≈ 400	γ, ^{3}He	16, 17

Table 17.7: 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
23.5			γ, ^{3}He	16
24.4			γ, ^{3}He	16

[a] See also Table 17.11, and see Table 17.6 in (1977AJ02).

1. ^{7}Li(^{14}N, α)^{17}O $Q_m = 16.157$

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

2. ^{9}Be(^{16}O, ^{8}Be)^{17}O $Q_m = 2.479$

Angular distributions have been studied at $E(^{16}\mathrm{O}) = 11$, 15 and 18 MeV, involving ^{17}O*(0, 0.87): see (1977AJ02). The cross section for the population of ^{17}O*(0.87) has been measured for $E(^{16}\mathrm{O}) = 5.5$ to 22 MeV: see (1970BA55, 1977SW05). See also (1979CH12). For astrophysical questions see (1977SW05, 1980CU1E). At $E(^9\mathrm{Be}) = 50$ MeV the population of ^{17}O*(5.09, 5.7, 7.6) is also reported (1977ST20).

3. (a) ^{10}B(^{7}Li, p)^{16}N $Q_m = 13.989$ $E_b = 27.770$
   (b) ^{10}B(^{7}Li, d)^{15}N $Q_m = 13.723$
   (c) ^{10}B(^{7}Li, t)^{14}N $Q_m = 9.147$
   (d) ^{10}B(^{7}Li, α)^{13}C $Q_m = 21.4099$

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

4. (a) ^{11}B(^{6}Li, p)^{16}N $Q_m = 9.785$ $E_b = 23.565$
   (b) ^{11}B(^{6}Li, d)^{15}N $Q_m = 9.5178$
   (c) ^{11}B(^{6}Li, t)^{14}N $Q_m = 4.9418$
   (d) ^{11}B(^{6}Li, α)^{13}C $Q_m = 17.205$

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

5. ^{12}C(^{6}Li, p)^{17}O $\qquad Q_m = 7.608$

Angular distributions have been studied for $E(^6\text{Li}) = 3$ to 20 MeV (see (1971AJ02)) and at 28 MeV (1980WA1H; p_0, p_1, p_2 and p to ^{17}O*(8.47, 11.8, 12.4)). See also ^{18}F in (1978AJ03, 1983AJ01).

6. ^{12}C(^{7}Li, d)^{17}O $\qquad Q_m = 2.582$

Angular distributions have been measured at $E(^7\text{Li}) = 3.24 \rightarrow 3.64$ MeV and at 21.1 MeV: see Table 17.7 in (1977AJ02). See also ^{19}F in (1978AJ03, 1983AJ01).

7. ^{12}C(^{9}Be, α)^{17}O $\qquad Q_m = 9.733$

Angular distributions of the α_0 and α_1 groups are reported at $E(^9\text{Be}) = 20$ MeV (1979JA22) and 16.1, 17.0 and 17.9 MeV (1981DE09; also α_2). The yield of α-particles has been studied for $E(^9\text{Be}) = 9.0$ to 20 MeV (1981DE09; α to ^{17}O* < 7.5 MeV), 10.5 to 26.3 MeV (1980HU1E; α_0) and 17.5 to 26.3 MeV (1978MA44; $\alpha_0 \rightarrow \alpha_3$). See also (1977AJ02), (1979BO1K) and (1980BR05; theor.).

8. ^{12}C(^{18}O, ^{13}C)^{17}O $\qquad Q_m = -3.098$

See (1978CH16).

9. ^{12}C(^{20}Ne, ^{15}O)^{17}O $\qquad Q_m = -9.089$

See (1979OR01).

10. (a) ^{13}C(α, n)^{16}O $\qquad Q_m = 2.2156 \qquad E_b = 6.3599$
(b) ^{13}C(α, α)^{13}C

Table 17.8: Resonances in ^{13}C(α, n) and ^{13}C(α, α) [a]

$E_{\rm res}$ (MeV $\pm$ keV)	$\Gamma_{\rm c.m.}$ (keV)	Γ_α/Γ	J^π	$E_{\rm x}$ (MeV)
1.0563 ± 1.5 [b]	1.5 ± 0.2		$\frac{5}{2}$	7.1676
1.3367 ± 1.5	$0.6^{+0.2}_{-0.1}$			7.3820
1.3406 ± 1.5	$0.8^{+0.3}_{-0.2}$			7.3849
1.590 ± 2	≤ 1		$\frac{7}{2}^-$	7.576
1.745 ± 6	≤ 15		$\frac{5}{2}^+$	7.694
2.083 ± 8	75	0.03	$\frac{1}{2}^-$	7.953
2.250 ± 8	110	0.05	$\frac{3}{2}^+$	8.080
2.407 ± 8	70	0.11	$\frac{3}{2}^-$	8.200
2.604 ± 4	9 ± 3	0.44	$\frac{1}{2}^+$	8.351
2.680 ± 3	4 ± 3	0.08	$\frac{5}{2}^+$	8.409
2.763 ± 3	7 ± 3	0.97	$\frac{7}{2}^+$	8.472
2.808 ± 3	5 ± 3	0.26	$\frac{5}{2}^-$	8.507
3.059 ± 5	50 ± 3	0.06	$\frac{3}{2}^-$	8.699
(3.1)	broad		$\frac{1}{2}^-$	(8.7)
3.318 ± 8	101 ± 3	0.50	$\frac{3}{2}^+$	8.897
3.415 ± 4	21 ± 3	0.04	$\frac{7}{2}^-$	8.971
3.645 ± 4	4 ± 3	0.45	$\frac{1}{2}^-$	9.147
(3.69)	3	1.00	$\frac{7}{2}^-$	(9.18)
3.714 ± 4	5.5 ± 1	0.20	$\frac{5}{2}^+$	9.200
4.096 ± 4	15 ± 1	0.85	$\frac{5}{2}^-$	9.492
(4.3)			$\frac{3}{2}^-$	(9.6)
4.394 ± 5	16 ± 1	0.70	$\frac{7}{2}^+$	9.719
4.465 ± 15	≈ 25	0.90	$\frac{3}{2}^+$	9.774
4.583 ± 5	14			9.864
4.600 ± 15	≈ 10			9.877
4.730 ± 20	≈ 80	0.78	$\frac{5}{2}^+$	9.976
4.820 ± 20	≈ 100			10.045
(4.94)	138	0.85	$\frac{5}{2}^+$	(10.14)
4.993 ± 5	45	0.15	$\frac{7}{2}^-$	10.177
(5.08)	122	0.60	$\frac{7}{2}^+$	(10.2)
5.200 ± 15	150		$\frac{5}{2}^+$, $\frac{7}{2}^-$	10.336

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

E_{res} (MeV $\pm$ keV)	$\Gamma_{c.m.}$ (keV)	Γ_α/Γ	J^π	E_x (MeV)
5.315 ± 3 [c]	14 ± 3			10.423
5.40	75 ± 30		$\frac{5}{2}^+, \frac{7}{2}^-$	10.49
5.492 ± 3 [c]	51 ± 2		$\frac{7}{2}^-, \frac{9}{2}^+$	10.559
(5.68)	≤ 25	1.00	$(\frac{7}{2}^+)$	(10.70)
5.778 ± 3 [c]	74 ± 3		$\frac{1}{2}^+, \frac{7}{2}^-$	10.777
5.945 ± 3 [c]	46 ± 2		$\frac{5}{2}$	10.905
6.117 ± 3 [c]	31 ± 3			11.036
6.167	5.0 ± 1.1		$\frac{1}{2}^-; T = \frac{3}{2}$	11.075 ± 0.005
6.380 ± 3 [c]	80 ± 3			11.238
6.883 ± 3 [c]	65 ± 2			11.622
7.051 ± 10	40 ± 25			11.750
7.136 ± 15	12 ± 3			11.815
7.384 ± 15				12.005
7.52 ± 20	150 ± 50			12.11
7.736 ± 15	100 ± 30			12.274
7.88 ± 20				12.38
7.927 ± 15				12.420
7.975	8 ± 2		$\frac{3}{2}^-; T = \frac{3}{2}$	12.457 ± 0.005
8.156 ± 15	75 ± 30			12.595
8.253 ± 15	≈ 5			12.669
8.44 ± 25				12.81
8.59 ± 20	≥ 150			12.93
8.611	6 ± 2		$\frac{1}{2}^+; T = \frac{3}{2}$	12.943 ± 0.006
8.675	≤ 3		$\frac{5}{2}^-; T = \frac{3}{2}$	12.992 ± 0.006
8.72 ± 20				13.03
8.785 ± 15	16 ± 4			13.076
9.319 ± 15	≈ 120			13.484
9.483 ± 15	250 ± 100			13.609

[a] See references listed in Tables 17.8 of (1977AJ02) and 17.6 of (1971AJ02). See also Table 17.12 here.
[b] See also (1976RA36).
[c] (1975BE44).

The yield of neutrons increases monotonically for $E_\alpha = 0.475$ to 1 MeV: $S(E) = [(5.48 \pm 1.77) + (12.05 \pm 3.91)E] \times 10^5$ MeV · b (1968DA05; $E_\alpha = 0.48$ to 0.70 MeV), $[(4.87 \pm 1.28) + (10.86 \pm 2.46)E] \times 10^5$ MeV · b (1976RA36, 1977RA1C; $E_\alpha = 0.60$ to 0.90 MeV). Astrophysical considerations are discussed by (1976RA36, 1977CO1U, 1977RA1C) and see (1977AJ02). Yield curves for reaction (a) have been measured for $E_\alpha = 1.0$ to 22.5 MeV: see (1971AJ02, 1977AJ02) and (1975BE44; $\alpha\gamma_{6.13}$; thresh. to 7.2 MeV). Elastic scattering studies [(reaction (b))] have been studied at $E_\alpha = 2.0$ to 26.6 MeV: see (1971AJ02, 1977AJ02). Observed resonances are displayed in Table 17.8.

11. (a) ^{13}C(α, p)^{16}N $\quad Q_m = -7.421 \quad E_b = 6.3599$
(b) ^{13}C(α, d)^{15}N $\quad Q_m = -7.6874$
(c) ^{13}C(α, t)^{14}N $\quad Q_m = -12.2634$

For reaction (b) see (1977AJ02). For all three reactions see ^{16}N here, and ^{14}N and ^{15}N in (1981AJ01).

12. ^{13}C(^{6}Li, d)^{17}O $\quad Q_m = 4.886$

Angular distributions of deuteron groups to many states of ^{17}O have been measured earlier at $E(^6\text{Li}) = 18$ and 25.6 MeV: see Table 17.7 in (1977AJ02). At $E(^6\text{Li}) = 35.5$ MeV angular distributions are reported to ^{17}O*(13.58 ± 0.02) which is strongly populated. Comparisons with ^{12}C(^{6}Li, d)^{16}O*(16.29) and with the results of reaction 13 here suggest that the peak corresponding to ^{17}O*(13.58) contains a state or states of spin $\frac{11}{2}^-$, $\frac{13}{2}^-$, or both, based on ^{16}O*(16.29) (1978CL08). (d, α) angular correlations [$E(^6\text{Li}) = 26$, 29 and 34 MeV] indicate the involvement of ^{17}O states at 13.6 ± 0.1 [$l = 6$], 14.15 ± 0.1 [5], 15.1 ± 0.1 [5], 15.95 ± 0.15 [5], 16.6 ± 0.15 [6], 17.1 ± 0.15 [6], 19.6 ± 0.15 [7], 20.2 ± 0.15 [7], 21.2 [7] and 22.1 MeV. $\Gamma \approx 0.1$, 0.5, 0.7, 0.25 and 0.25 MeV for ^{17}O*(14.2, 15.1, 16.0, 19.6, 20.2) (1978AR15). See also (1976ST22; theor.).

13. ^{13}C(^{7}Li, t)^{17}O $\quad Q_m = 3.893$

Angular distributions of triton groups to many states of ^{17}O have been measured earlier at $E(^7\text{Li}) = 17$, 20.5 and 30.1 MeV: see Table 17.7 in (1977AJ02). At $E(^7\text{Li}) = 35.7$ MeV angular

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

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

[a] For references see Table 17.9 in (1977AJ02).

distributions are reported to ^{17}O*(3.06) and to ^{17}O*(13.58) which is preferentially populated (see discusion in reaction 12). Narrow states at $E_x = 14.86$, 18.17 and 19.24 MeV are also strongly excited (1978CL08). See also (1978MA2G).

14. ^{13}C(^{13}C, ^{9}Be)^{17}O $\qquad Q_m = -4.288$

At $E(^{13}C) = 105$ MeV states of ^{17}O with $E_x = 3.9$, 5.2, 5.8 ± 0.1, 7.2, 7.6, 8.4 ± 0.06, 8.9, 9.8 ± 0.07, 10.55 ± 0.06, 12.1 ± 0.06, 13.3, 14.6 and 18.9 ± 0.14 MeV are reported (1979BR04).

15. (a) ^{13}C(^{16}O, ^{12}C)^{17}O $\qquad Q_m = -0.8021$
(b) ^{13}C(^{18}O, ^{14}C)^{17}O $\qquad Q_m = 0.132$

Angular distributions for reaction (a) have been studied at $E(^{16}O) = 12$ to 25 MeV [^{17}O*(0, 0.87): see (1977AJ02)] and at 13 and 14 MeV (1976DU04; see also for r_n). For reaction (b) see (1978CH16). See also (1980GO1L, 1980PA04; theor.).

16. ^{14}C(^{3}He, γ)^{17}O $\qquad Q_m = 18.7611$

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

17. (a) ^{14}C(^{3}He, n)^{16}O $Q_m = 14.6168$ $E_b = 18.7611$
(b) ^{14}C(^{3}He, p)^{16}N $Q_m = 4.981$
(c) ^{14}C(^{3}He, d)^{15}N $Q_m = 4.7139$
(d) ^{14}C(^{3}He, ^{3}He)^{14}C
(e) ^{14}C(^{3}He, α)^{13}C $Q_m = 12.4013$

See (1977AJ02) and Table 17.9. See also ^{16}N and ^{16}O here, and ^{13}C, ^{14}C and ^{15}N in (1981AJ01).

18. ^{14}C(α, n)^{17}O $Q_m = -1.8167$

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).

19. ^{14}C(^{16}O, ^{13}C)^{17}O $Q_m = -4.0322$

Angular distributions have been measured at $E(^{16}\text{O}) = 20$, 25 and 30 MeV (^{17}O*(0, 0.87)): see (1977AJ02). See also (1977WE1H; theor.).

20. (a) ^{14}N(t, γ)^{17}O $Q_m = 18.6233$
(b) ^{14}N(t, p)^{16}N $Q_m = 4.843$ $E_b = 18.6233$
(c) ^{14}N(t, d)^{15}N $Q_m = 4.5760$
(d) ^{14}N(t, t)^{14}N
(e) ^{14}N(t, α)^{13}C $Q_m = 12.2634$

The excitation functions for γ_0 and γ_1 have been measured for $E_t = 0.8$ to 3.3 MeV: broad resonances are observed at 2.2 and 2.8 MeV in the γ_0 cross section, and at 2.4 and 2.8 MeV in the γ_1 cross section. Both also exhibit a structure at 1.5 MeV. The data are consistent with states at $E_x = 19.76 \pm 0.06$ [$J^\pi = \frac{3}{2}$], 20.39 ± 0.05 [$\frac{5}{2}$, $\frac{7}{2}^-$], 20.58 ± 0.05 [$\frac{1}{2}$] and 21.05 ± 0.05 MeV [$\frac{3}{2}$] with $\Gamma = 0.55 \pm 0.05$, 0.66 ± 0.07, 0.57 ± 0.08 and 0.47 ± 0.06 MeV, and possibly with a state at ≈ 19.3 MeV. $\Gamma_{\gamma_0} > 1.0$, 4.3 and 5.8 eV for ^{17}O*(19.8, 20.4, 21.1) and $\Gamma_{\gamma_1} > 2.3$, 5.1 and 6.5 eV for ^{17}O*(19.8, 20.6, 21.1) (1980LO07). For reactions (b) $\rightarrow$ (e) see (1977AJ02). See also ^{16}N here, and ^{13}C, ^{14}N and ^{15}N in (1981AJ01).

21. (a) ^{14}N(α, p)^{17}O $Q_m = -1.1908$
(b) ^{14}N(α, αp)^{13}C $Q_m = -7.55063$

Angular distributions have been measured for ^{17}O states with $E_{\rm x} < 7.6$ MeV in the range $E_\alpha = 8.1 \rightarrow 33.3$ MeV: see a listing of the references in (1971AJ02). The sequential decay [reaction (b)] appears to take place via ^{17}O states with $8.46 \leq E_{\rm x} \leq 13.57$ MeV. Those involved are believed to have $J \geq \frac{5}{2}$, $\Gamma_\alpha/\Gamma \geq 0.6$ (1969BA17).

22. ^{14}N(^{6}Li, ^{3}He)^{17}O $\qquad Q_{\rm m} = 2.829$

At $E(^{6}{\rm Li}) = 18$ MeV, the groups in this reaction and the triton groups in the mirror reaction (see reaction 8 in ^{17}F) have been compared: ^{17}O*(3.84, 4.55, 5.22, $5.70+5.73$) are strongly excited. ^{17}O*(0, 0.87, 3.06, 5.09, 5.38, $5.87 + 5.94$, 6.86, 6.97) are also populated (1973BI01). See also (1977MA2G, 1978MA2G).

23. ^{14}N(^{10}B, ^{7}Be)^{17}O $\qquad Q_{\rm m} = -0.045$

See (1977MO1A).

24. ^{15}N(d, γ)^{17}O $\qquad Q_{\rm m} = 14.0473$

See (1977AJ02) [paper quoted there has not been published].

25. ^{15}N(d, n)^{16}O $\qquad Q_{\rm m} = 9.9029 \qquad E_{\rm b} = 14.0473$

Excitation functions have been measured for a number of neutron groups for $E_{\rm d} = 0.5$ to 5.9 MeV: a great deal of unresolved structure is apparent. Polarization measurements are reported for $E_{\rm d} = 1.6$ to 5.5 MeV and at 10.0 and 11.8 MeV. See (1977AJ02) for a listing of the work. See also ^{16}O.

26. ^{15}N(d, p)^{16}N $\qquad Q_{\rm m} = 0.267 \qquad E_{\rm b} = 14.0473$

Excitation functions have been obtained for $E_{\rm d} = 0.3$ to 6.3 MeV: [see (1977AJ02)] and at $E_{\rm d} = 1.4$ to 2.7 MeV (1977CA03; $p_0 \rightarrow p_3$). Structures are reported at $E_{\rm d} = 1.8$ [p_0, p_1, p_3] and 2.4 MeV [p_2] [^{17}O*(15.6, 16.2)] (1977CA03).

27. ^{15}N(d, d)^{15}N $\qquad E_{\rm b} = 14.0473$

Excitation functions for d_0 have been measured for $E_d = 4.25$ to 6.25 MeV [see (1977AJ02)] and 1.4 to 2.7 MeV (1977CA03). The latter report structures at ≈ 1.4 and 1.8 MeV.

28. ^{15}N(d, α)^{13}C $\qquad Q_m = 7.6874 \qquad E_b = 14.0473$

Yield curves have been measured for $E_d = 0.8$ to 2.5 MeV [see (1977AJ02)] and 1.2 to 2.7 MeV (1976CA28; $\alpha_0 \to \alpha_3$): structures have been reported at $E_d = 1.06$ and 1.25 MeV, and at ≈ 1.8 MeV. The latter has $\Gamma \approx 300$ keV (1976CA28).

29. ^{15}N(^{3}He, p)^{17}O $\qquad Q_m = 8.5537$

Observed proton groups are displayed in Table 17.10. See also (1977AJ02). For the parameters of the first $T = \frac{3}{2}$ state see Table 17.11.

30. ^{15}N(α, d)^{17}O $\qquad Q_m = -9.7995$

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 $^{17}O_{g.s.}$ and to states with $E_x = 0.87 \pm 0.05$, 5.22, 5.70, 7.38, 8.46, 8.89 and 9.81 [± 0.03] MeV. In addition the population of ^{17}O*(3.84, 4.55, 8.15 ± 0.03) is also reported (1969LU07).

31. ^{15}N(^{11}B, ^{9}Be)^{17}O $\qquad Q_m = -1.769$

At $E(^{11}B) = 115$ MeV angular distributions have been studied to ^{17}O*(5.23, 7.75, 9.18) [$J^\pi = \frac{9}{2}^-, \frac{11}{2}^-, \frac{9}{2}^-$] (1979RA10, 1980PR09). See also (1977AJ02).

32. ^{16}O(n, γ)^{17}O $\qquad Q_m = 4.1443$

$$\sigma_{capt.} = 202 \pm 28\ \mu b \text{ (1977MC05).}$$

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). $E(^{3}\text{He}) = 18$ MeV.

[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*(11.0787 ± 0.0008) [b]	^{17}F*(11.1928 ± 0.0021) [c]
J^π	$\frac{1}{2}^-$	$\frac{1}{2}^-$
$\Gamma_{\rm c.m.}$ (keV)	2.4 ± 0.3 [b]	0.20 ± 0.04
Branching ratio (%) to		
^{16}O*(MeV) J^π		
0 0^+	81 ± 6 [e]	9.3 ± 1.3
6.05 0^+ }		< 3
6.13 3^- }	5 ± 2	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 [$\Gamma_{\rm p}$ or $\Gamma_{\rm n}$] to		
^{16}O(0)	1.88 ± 0.12 keV	19 ± 3 eV
^{16}O*(6.05) }		< 8 eV
^{16}O*(6.13) }	0.12 ± 0.05 keV	45 ± 14 eV [d]
^{16}O*(6.92)		49 ± 19 eV [d]
^{16}O*(7.12)		90 ± 27 eV [d]
Γ_{α_0}	0.14 keV	< 19 eV [d]
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. See also (1978MC04).

[b] (1981HI01): $\Gamma_{\rm n_0} = 1.88 \pm 0.12$ keV. See also for IMME parameters for six $T = \frac{3}{2}$ states.

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

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

[e] Weighted mean of 91 ± 15 (1973AD02) and 79 ± 7% (1981HI01, and F. Hintenberger, private communication).

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

E_n (keV)	$\Gamma_{c.m.}$ (keV)	$\Gamma_{\lambda n}$ (keV)	$\Gamma_{\lambda\alpha}$ (keV)	J^π	E_x (keV)
433 ± 2 [b]	45	45 [j]		$\frac{3}{2}^-$	4552
1000 ± 2	96	96 [j]		$\frac{3}{2}^+$	5085
1140 [c]	< 0.1				5218
1312 ± 2	42	41.5 [j]		$\frac{3}{2}^-$	5378
1651 ± 2	3.4 ± 0.3	3.4		$\frac{7}{2}^-$	5697
1689 ± 2	< 1			[d]	5733
1833 ± 2	6.6 ± 0.7	6.6		$\frac{3}{2}^+$	5868
1908 ± 4	32 ± 3	31.5 [j]		$\frac{1}{2}^-$	5939
2351 ± 8	124 ± 12	124		$\frac{1}{2}^+$	6356
2889 ± 2	< 1			[d]	6862
3006 ± 2	< 1			[d]	6972
3211.70 ± 0.17	1.38 ± 0.05	1.38 ± 0.05 [e]	0.0033	$\frac{5}{2}^-$	7165.2
3250 ± 10	280 ± 30	280	0.07	$\frac{3}{2}^+$	7202
3438.38 ± 0.19	0.64 ± 0.23	0.64 ± 0.23 [e]	0.01	$\frac{5}{2}^+$	7378.4
3441.73 ± 0.14	0.96 ± 0.20	0.96 ± 0.20 [e]	0.003	$\frac{5}{2}^-$	7381.5
3630 ± 20	500 ± 50	500	0.08	$\frac{3}{2}^-$	7559
3647 [c]	< 0.1				7576
3767.76 ± 0.22	14.4 ± 0.3	13.0 ± 0.6 [e]	0.01	$\frac{7}{2}^-$	7688.2
4053 ± 8	90 ± 9	84	6.7	$\frac{1}{2}^+$	7958
4090 ± 50	270 ± 30	250	16	$\frac{1}{2}^-$	7990
4162 ± 8	85 ± 9	71	15	$\frac{3}{2}^+$	8059
4290 ± 20	69 ± 7	68	0.8	$\frac{1}{2}^-$	(8180)
4310 ± 10	52	48	4.0	$(\frac{3}{2}^-)$	8199
4463.41 ± 0.26	11.4 ± 0.5	8.1 ± 0.3	2.2	$\frac{1}{2}^+$	8342.4
4527.12 ± 0.07	6.17 ± 0.13	4.75 ± 0.11	0.54	$\frac{5}{2}^+$	8402.3
4594.83 ± 0.09	2.13 ± 0.11	1.18 ± 0.04	(7.6)	$\frac{7}{2}^+$	8466.0
4631.78 ± 0.12	6.89 ± 0.22	2.86 ± 0.08	1.9	$\frac{5}{2}^-$	8500.7
4829.9 ± 0.4	55.3 ± 0.6	48.9 ± 1.1	1.8	$\frac{3}{2}^-$	8687.0
5050	78	68	9.5	$\frac{3}{2}^+$	8895
5127.0 ± 1.6	26.3 ± 1.9	23.5 ± 1.9		$\frac{7}{2}^-$	8966.4

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

E_n (keV)	$\Gamma_{c.m.}$ (keV)	$\Gamma_{\lambda n}$ (keV)	$\Gamma_{\lambda\alpha}$ (keV)	J^π	E_x (keV)
5368.90 ± 0.09	3.53 ± 0.13	2.37 ± 0.08		$\frac{5}{2}^+$	9193.9
5610	120	120		$\frac{3}{2}^-$	9420
5640	140			$\geq \frac{3}{2}$	9450
5919.67 ± 0.14	23.1 ± 0.3	18.0 ± 0.6		$\frac{7}{2}^+$	9711.9
5995.68 ± 0.15	11.7 ± 0.3	10.3 ± 0.3		$\frac{3}{2}^+$	9783.3
6076.08 ± 0.15	4.01 ± 0.23	3.37 ± 0.23		$(\frac{5}{2}^-)$	9858.9
6094.8 ± 1.0	16.7 ± 1.7	10.9 ± 1.2		$(\frac{1}{2}^-)$	9876.5
6404.6 ± 0.5	49.1 ± 0.8	22.3 ± 0.6		$(\frac{7}{2}^-)$	10167.8
6820.7 ± 0.6	42.5 ± 1.1	17.2 ± 0.7 [e]		$(\frac{7}{2}^-)$	10559.1
7199.3 ± 1.3	41.7 ± 1.4	26.4 ± 0.9 [e]		$(\frac{5}{2}^+)$	10915.1
7373.31 ± 0.18	2.4 ± 0.3	1.88 ± 0.12 [e]		$\frac{1}{2}^-$ [g]	11078.7
7830	190			$\geq \frac{3}{2}$	11509
8320	270			$\geq \frac{3}{2}$	11970
8740	130				12365
8848.8 ± 0.6	6.9 ± 1.1	1.27 ± 0.14 [e]		$\frac{3}{2}^-$ [g]	12446.0
9050	95				12656
9353 ± 6	6 ± 2 [f]	0.21 ± 0.14 [e]		$\frac{1}{2}^+$ [g]	12940 ± 6
9414.9 ± 0.6	2.5 ± 1.0	0.40 ± 0.06 [e]		$\frac{5}{2}^-$ [g]	12998.2
10092.5 ± 2.4	9 ± 5	0.24 ± 0.09 [e]		$(\frac{5}{2}^+)$ [g]	13635.3
10130	400				13672
10725.5 ± 1.5	20.5 ± 1.6	2.07 ± 0.16 [e]		$(\frac{7}{2}^-)$ [g]	14230.3
10785 ± 3	7.5 ± 4	0.80 ± 0.16 [h]		[g]	14286
10960 ± 3	40 ± 6	13 ± 6 [h]			14451
11140	340			$(\geq \frac{3}{2})$	14621
11322 ± 3	36 ± 13	3.2 ± 1.0 [h]		$(\frac{1}{2}^-)$ [i]	14791
11540	180				14997
11756 ± 3	52 ± 14	11 ± 3 [h]		$(\frac{3}{2})$ [i]	15199
11936 ± 3	40 ± 6	7 ± 1 [h]		$(\frac{5}{2}^+)$ [i]	15368
12867 ± 4	21 ± 10	2 ± 0.5 [h]		$(\frac{9}{2}^+)$ [i]	16243
14136 ± 11	66 ± 20	8.0 ± 2.4 [h]		[g]	17436

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

E_n (keV)	$\Gamma_{c.m.}$ (keV)	$\Gamma_{\lambda n}$ (keV)	$\Gamma_{\lambda\alpha}$ (keV)	J^π	E_x (keV)
14853 ± 4	43 ± 12	1.0 ± 0.3 [e]		$\frac{3}{2}^-$	18110

[a] (1973FO11, 1973JO01, 1980CI03, 1981HI01). See also Table 17.12 in (1977AJ02).
[b] $\Gamma_\gamma < 4.0$ eV, $\Gamma_n = 60 \pm 15$ keV (1971AL09).
[c] Not observed in σ_t: see (1973FO11).
[d] Not $\frac{1}{2}^+$ (1973FO11).
[e] Γ_{n_0} (1980CI03, 1981HI01, and F. Hintenberger, private communication).
[f] (1976MC11).
[g] $T = \frac{3}{2}$.
[h] $(J \pm \frac{1}{2})\Gamma_{n_0}$ (1981HI01).
[i] J^π assignment by comparison with ^{17}N states presumed to be analogs; then $T = \frac{3}{2}$ (1981HI01).
[j] See also Table 17.2.

At thermal energies the branchings via ^{17}O*(0.87, 3.05) are (18 ± 3) and (82 ± 3)%; $E_\gamma = 870.89 \pm 0.22$ keV. The cross section for two-photon emission $\sigma_{2\gamma} < 3 \pm 19$ μb for $1200 < E_\gamma < 2843$ keV. The two-photon branching ratio is $(1.6 \pm 10) \times 10^{-2}$ (1977MC05). See also (1976LE27; theor.).

33. ^{16}O(n, n)^{16}O $\qquad E_b = 4.1443$

The scattering amplitude (bound) $a = 5.805 \pm 0.005$ fm, $\sigma_{free} = 3.761 \pm 0.007$ b (1979KO26). 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 $E_x = 18.2$ MeV: see Table 17.12 (1973FO11, 1973JO01, 1980CI03, 1981HI01). (1973JO01) has performed a multi-level 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 in (1977AJ02)]: 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 $\frac{3}{2}^+$m 0.1% for $\frac{5}{2}^+$, 1% for $\frac{5}{2}^-$ and 14% for $\frac{7}{2}^-$ (1973JO01). $T = \frac{3}{2}$ resonances are discussed by (1981HI01): see Tables 17.11 and 17.12.

Cross-section measurements are listed in Table 17.10 of (1971AJ02) and in (1977AJ02). At $E_n = 23.5$ keV, $\sigma_t = 3.736 \pm 0.007$ b (1975BI14; elemental O), σ_t has also been measured with high resolution for $E_n = 4.5$ to 8 MeV (1980CI03). At $E_n = 40.3$ and 50.4 MeV, σ_{non} is reported for elemntal O (1981ZA03). See also ^{16}O, (1975FI1B, 1978SU1E, 1979LA1J, 1980FR1K, 1980LA1D, 1980PA10), (1976CI1A, 1976KI1F), (1977LI1N, 1979JO1H; applications) and (1976LE26,

1977BA1N, 1977HO1P, 1977TH09, 1978FE06, 1978LE1H, 1979BA29; theor.).

34. ^{16}O(n, n′)^{16}O* $E_b = 4.1443$

A number of resonances have been observed in the cross sections for production of 6.13 and $(6.92 + 7.12)$ γ-rays: see Table 17.13 in (1977AJ02) and (1978NO04). For cross-section measurements see Table 17.10 in (1971AJ02), (1977AJ02) and (1978NO04: $E_n = 6.95$ to 10.25; $\gamma_{6.13}$, $\gamma_{6.92+7.12}$). See also (1978YA15).

35. ^{16}O(n, 2n)^{15}O $Q_m = -15.6639$ $E_b = 4.1443$

See (1977AJ02).

36. (a) ^{16}O(n, p)^{16}N $Q_m = -9.636$ $E_b = 4.1443$
(b) ^{16}O(n, d)^{15}N $Q_m = -9.9029$
(c) ^{16}O(n, t)^{14}N $Q_m = -14.4790$

For cross sections of reaction (a) see (1977AJ02). See also (1976SL2A). For reaction (b) see ^{15}N in (1981AJ01) and (1976SL2A). For triton emission see (1978QA01).

37. ^{16}O(n, α)^{13}C $Q_m = -2.2156$ $E_b = 4.1443$

Table 17.12 displays the results from a multi-level two-channel R-matrix analysis of the data from this reaction and from the elastic scattering of neutrons (1973JO01). For cross-section measurements see Table 17.10 in (1971AJ02), (1977AJ02) and (1978NO04; $E_n = 8.06$ to 10.25 MeV; $\gamma_{3.09}$, $\gamma_{3.68+3.85}$). See also (1978SU1D, 1978YA15, 1979RO1F) and (1976SL2A).

38. ^{16}O(p, π^+)^{17}O $Q_m = -136.205$

At $E_p = 185$ MeV (1974DA23) and 800 MeV (1979HO1L) angular distributions of pions to ^{17}O*(0, 0.87, 3.05) are reported. The cross section for π^+ production near threshold has been studied by (1979MA38, 1979MA39). For polarization measurements see (1981SJ1C; to ^{17}O*(0, 0.87)). See also (1979SO1C, 1980SJ1A), (1979JO1C, 1981AU1C) and (1977BR01; theor.).

39. ^{16}O(d, p)^{17}O $\quad Q_m = 1.9197$

Observed proton groups are displayed in Table 17.14 of (1977AJ02). 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) and (1977AJ02), and at $E_d = 698$ MeV (1981BO03; p_0, p_1). At $E_d = 12$ MeV angular distributions are reported for the proton groups to ^{17}O*(0, 0.87, 5.09): Γ_n for ^{17}O*(5.09) = 97 ± 5 keV (1979AN15). Reported parameters for ^{17}O*(0.87) are $\tau_m = 258.6 \pm 2.6$ psec [see Table 17.7 in (1971AJ02)] and $E_\gamma = 870.81 \pm 0.22$ keV [see (1977AJ02)], $E_\gamma = 870.725 \pm 0.020$ keV (1980WA24) [$E_x = 870.749 \pm 0.020$ keV (E.K. Warburton, private communication)].

See also ^{18}F in (1983AJ01), (1978RO1M, 1979SO01, 1980FL1B), (1978AM1D, 1978BO1L, 1978HI1E, 1978NI1B; applications), (1977TE1A) and (1976CO29, 1977GR20, 1977KA2D, 1977KO2J, 1977MU04, 1978KA1X, 1979GR11, 1980AM02, 1980AY01, 1980KR18, 1981SH1G; theor.).

40. ^{16}O(t, d)^{17}O $\quad Q_m = -2.1130$

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

41. ^{16}O(α, ^{3}He)^{17}O $\quad Q_m = -16.434$

See (1977AJ02) and (1979GR11; theor.).

42. ^{16}O(^{7}Li, ^{6}Li)^{17}O $\quad Q_m = -3.106$

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

43. ^{16}O(^{11}B, ^{10}B)^{17}O $\quad Q_m = -7.311$

Angular distributions are reported at $E(^{11}{\rm B}) = 115$ MeV to ^{17}O$_{\rm g.s.}$ (1979RA10). See also (1977AJ02).

44. (a) ^{16}O(^{12}C, ^{11}C)^{17}O $\quad Q_m = -14.577$
(b) ^{16}O(^{13}C, ^{12}C)^{17}O $\quad Q_m = -0.802$

Angular distributions have been measured at $E(^{13}\text{C}) = 36$ MeV [(1976WE21); to ^{17}O*(0.87)] and 105 MeV [(1979RA10); to ^{17}O*(0, 0.87)]. See also (1977AJ02) and (1977DU04, 1980SI12; theor.). For reaction (b) see (1977ZE1A; theor.).

45. ^{16}O(^{14}C, ^{13}C)^{17}O $\qquad Q_\text{m} = -4.032$

See (1981KO07).

46. ^{16}O(^{14}N, ^{13}N)^{17}O $\qquad Q_\text{m} = -6.409$

At $E(^{14}\text{N}) = 79$ 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 ^{16}O*$(0 + 0.87)$ has also been reported at $E(^{14}\text{N}) = 155$ MeV (1976NA09). See also (1980IZ1B; theor.).

47. ^{16}O(^{18}O, ^{17}O)^{17}O $\qquad Q_\text{m} = -3.900$

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

48. ^{17}N(β^-)^{17}O $\qquad Q_\text{m} = 8.680$

The decay is principally to ^{17}O*(4.55, 5.38, 5.94): see Table 17.2.

49. (a) ^{17}O(γ, n)^{16}O $\qquad Q_\text{m} = -4.1443$
(b) ^{17}O(γ, 2n)^{15}O $\qquad Q_\text{m} = -19.808$
(c) ^{17}O(γ, α)^{13}C $\qquad Q_\text{m} = -6.3599$

Forty-five resonances are reported for E_x up to 26.9 MeV in the differential cross section for (γ, n_0). $T = \frac{1}{2}$ components of the giant resonance are observed at $E_\text{x} = 19.8$, 21.5 and ≈ 26 MeV (1979JO05; brems.). Monoenergetic photons with $E_\gamma = 8.5$ to 39.7 MeV have been used to measure the (γ, n) and the (γ, 2n) [above 10 MeV] cross sections. The giant dipole resonance, 6 MeV broad, is centered at 23 MeV; a pigmy resonance is also observed at 13 MeV. Most of the GDR strength decays to $T = 1$ states in ^{16}O: this implies a $T = \frac{3}{2}$ assignment for the main part of the GDR. A broad structure, of $T = \frac{1}{2}$ nature, with $28 < E_\text{x} < 36$ MeV is also reported (1980JU01). For radiative widths see Table 17.13. See also (1977AJ02).

Table 17.13: Radiative widths from resonances in ^{17}O(γ, n)

E_x [a] (MeV)	J^π [a]	Γ_{γ_0} [b] (eV)	Γ_{γ_0} [c] (eV)
4.55	$\frac{3}{2}^-$	0.42	
5.09	$\frac{3}{2}^+$	1.0	
5.38	$\frac{3}{2}^-$	0.06	0.7 ± 0.4
5.70	$\frac{7}{2}^-$	0.4	1.1 ± 0.4
6.36	$\frac{1}{2}^+$	< 0.07	
7.38	$\frac{5}{2}^-$		0.8 ± 0.4
7.69	$\frac{7}{2}^-$		1.5 ± 0.5
8.20	$\frac{3}{2}^-$		1.4 ± 0.5
8.50	$\frac{5}{2}^-$		6.6 ± 1.8
8.69	$\frac{3}{2}^-$		1.2 ± 0.6
8.97	$\frac{7}{2}^-$		4.1 ± 0.8

[a] Values from Table 17.7.
[b] (1978HO16).
[c] (1979JO05; bremsstrahlung radiation): thirty-seven additional resonances are reported with E_x to 26.9 MeV.

50. ^{17}O(e, e)^{17}O

The ^{17}O charge radius, $\langle r^2\rangle^{1/2} = 2.710 \pm 0.015$ fm, based on $\langle r_{17}^2\rangle^{1/2}/\langle r_{16}^2\rangle^{1/2} = 1.0015 \pm 0.0025$ (1978KI01). (1979MI09) report $\langle r_{17}^2\rangle^{1/2} - \langle r_{16}^2\rangle^{1/2} = -0.008 \pm 0.007$ fm. Considerable deviation from single-particle predictions is observed in the elastic scattering for an effective momentum transfer range of 0.55 to 2.8 fm^{-1} (1979HY01). Inelastic scattering is reported to a number of ^{17}O states: see Tables 17.14 and 17.15. The data of (1977NO06) show a broad dipole resonance centered at 22–23 MeV with strength extending down to 10–12 MeV. A smaller resonance, with a form factor consistent with C2, is found between $E_x = 17.5$ and 19.6 MeV (1977NO06). The transitions to ^{17}O*(0.87, 5.08) can be described as single-particle transitions (1978KI01). See also (1980HY1A) and (1978AR04, 1979AR1F, 1979ZA1C, 1980BO04, 1981LI1N; theor.).

51. ^{17}O(n, n)^{17}O

See (1977NO07; theor.).

Table 17.14: Transition probabilites and ground state radiative widths from ^{17}O(e, e) [a]

E_x (MeV)	J^π [a]	Mult.	$\Gamma_{\gamma_0}(\mathrm{C}\lambda)$ (eV)	$B(\mathrm{C}\lambda\uparrow)$ $(e^2 \cdot \mathrm{fm}^{2\lambda})$	Mult.	$\Gamma_{\gamma_0}(\mathrm{M}\lambda)$ (eV)	$B(\mathrm{M}\lambda\uparrow)$ $(e^2 \cdot \mathrm{fm}^{2\lambda})$
0.87	$\frac{1}{2}^+$	C2					
3.06	$\frac{1}{2}^-$	C3	$(8.7 \pm 1.7) \times 10^{-8}$	31 ± 6			
3.84	$\frac{5}{2}^-$	C3	$(7.1 \pm 0.3) \times 10^{-7}$	153 ± 6	M2	$(4.6 \pm 1.8) \times 10^{-3}$	$(5 \pm 2) \times 10^{-2}$
4.55	$\frac{3}{2}^-$	C3	$(2.2 \pm 0.2) \times 10^{-6}$	98 ± 8	M2	$(1.8 \pm 0.7) \times 10^{-2}$	$(5.4 \pm 2.1) \times 10^{-2}$
5.09	$\frac{3}{2}^+$	C2	$(1.0 \pm 0.3) \times 10^{-2}$	2.5 ± 0.7			
5.22	$(\frac{9}{2}^-)$	C3	$(8.5 \pm 0.3) \times 10^{-6}$	360 ± 11	M2	$< 1 \times 10^{-2}$	$< 4 \times 10^{-2}$
5.38	$\frac{3}{2}^-$	C3	$(3.3 \pm 0.9) \times 10^{-6}$	45 ± 12	M2	$(4.5 \pm 2.2) \times 10^{-2}$	$(6 \pm 3) \times 10^{-2}$
5.70	$\frac{7}{2}^-$	C3	$(1.5 \pm 0.2) \times 10^{-5}$	270 ± 32	M2	0.15 ± 0.10	0.3 ± 0.2
5.94	$\frac{1}{2}^-$	C3	$(5.0 \pm 2.9) \times 10^{-6}$	17 ± 10			
6.36	$\frac{1}{2}^+$	C2	$(5.3 \pm 3.3) \times 10^{-2}$	2.1 ± 1.3			
6.86 [c]	$(\frac{1}{2}^-)$	C3	$(1.2 \pm 0.3) \times 10^{-4}$	147 ± 34			
6.97 [c]	$(\frac{5}{2}^+)$	C2	$(2.5 \pm 1.3) \times 10^{-2}$	1.9 ± 1.0			
				5.5 ± 1.0			
7.38 [c]	$\frac{5}{2}^+$	CO, or C2	$(6.3 \pm 1.8) \times 10^{-2}$	3.6 ± 1.0			
7.38 [c]	$\frac{5}{2}^-$	C3	$(2.1 \pm 1.7) \times 10^{-5}$	47 ± 38			
7.58	$\frac{7}{2}^-$	C1	$(7.8 \pm 2.0) \times 10^{-2}$	26 ± 7			
		C3	$(4.3 \pm 1.0) \times 10^{-5}$	109 ± 26			
7.76	$(\frac{11}{2}^-)$	C3	$(1.16 \pm 0.05) \times 10^{-4}$	369 ± 15			
				7.6 ± 1.4			
8.35 [c]	$\frac{1}{2}^+$			8.3 ± 2.6			
8.40 [c]	$\frac{5}{2}^+$						
8.47 [c]	$\frac{7}{2}^+$	CO, or C2					
8.50 [c]	$\frac{5}{2}^-$						

[a] (1978KI01). See also Table 17.15 in (1977AJ02).

[b] Used to evaluate the widths.

[c] These levels were unresolved and were analyzed as a group.

Table 17.15: Inelastic groups observed in ^{17}O(e, e′) [a]

E_x (MeV)	Γ (keV)	E_x (MeV)	Γ (keV)
11.71 ± 0.05	narrow	15.24 ± 0.10	≈ 200
11.95 ± 0.05	≈ 250	16.52 ± 0.05	≈ 300
12.66 ± 0.05	≈ 90	17.09 ± 0.05	narrow
12.96 ± 0.05	≈ 200	17.5 – 19.6 [b]	87 ± 33
13.56 ± 0.05	≈ 150	20.5	
14.14 ± 0.10	≈ 100	22.0 [c]	
14.76 ± 0.10	> 300	23.0 [c]	

[a] (1977NO06). Other inelastic groups are displayed in Table 17.14.
[b] C2.
[c] C1.

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

Angular distributions of elastically scattered protons have been measured at a number of energies in the range $E_p = 8.6$ to 65.8 MeV [see (1977AJ02)] and at $E_p = 35.2$ MeV (1980FA07). See also ^{18}F in (1983AJ01), (1978NO1G, 1978SE08, 1980KE1C, 1981PU1A) and (1976CO29, 1977TO1E, 1978AM05, 1978KA1X, 1979GR11, 1980AM02; theor.).

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

The angular distribution of elastically scattered deuterons has been studied at $E_d = 18$ MeV (1976LI01).

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

Elastic angular distributions have been measured at $E(^3\text{He}) = 11.0$ and 17.3 MeV [see (1977AJ02)] and at $E(^3\vec{\text{He}}) = 33.3$ MeV (1981LE1H; also polarization; to both ^{17}O*(0, 0.87)). In a study of the (^{3}He, p) reaction, (1978FO22) find 3–4% core excitation [3p-2h configuration] in the ground state of ^{17}O. For reaction (b) see (1977KN1E, 1979KN1F). See also (1977MA2E).

55. (a) ^{17}O(^{9}Be, ^{9}Be)^{17}O
(b) ^{17}O(^{10}B, ^{10}B)^{17}O

For reaction (a) see (1979PA1B; theor.). For fusion cross sections in reaction (b) see (1980WI09, 1981CH1V).

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

Elastic angular distributions are reported at $E(^{17}\text{O}) = 30.5$ and 33.8 MeV for reaction (a) and 29.8 and 32.3 for reaction (b) [also ^{17}O*(0.87)] (1977CH22, 1978CH03). For fusion cross section measurements see (1978HE18; reaction (a)) and (1980WI09; reactions (a) and (b)). See also (1978PA1B, 1978VA1A, 1979PA1B; theor.).

57. (a) ^{17}O(^{16}O, ^{16}O)^{17}O
(b) ^{17}O(^{18}O, ^{18}O)^{17}O

Angular distributions involving ^{17}O*(0, 0.87) in reaction (a) have been studied at $E(^{16}\text{O}) = 22$ to 32 MeV and $E(^{17}\text{O}) = 25.7$ to 32.0 MeV: see (1977AJ02). The elastic scattering angular distribution in reaction (b) has been reported at $E(^{17}\text{O}) = 36$ MeV (1977KA1Y). For fusion cross sections see (1980WI09; reaction (a)). See also (1974FI1D, 1978HO1C) and (1977IM1B, 1979CR03, 1979LE1B, 1979SA27; theor.).

58. (a) ^{17}O(^{24}Mg, ^{24}Mg)^{17}O
(b) ^{17}O(^{27}Al, ^{27}Al)^{17}O
(c) ^{17}O(^{40}Ca, ^{40}Ca)^{17}O

For reaction (a) see (1980PA1H; theor.). For reaction (b) see (1977EI01) for fusion cross sections. See also (1980SA1L) and (1978VA1A; theor.). For reaction (c) see (1980LA05; elastic $\sigma(\theta)$; $E(^{17}\text{O}) = 61.1$ MeV).

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

See ^{17}F.

60. ^{18}O(γ, n)^{17}O $\qquad Q_{\rm m} = -8.0446$

See (1976BA41) and ^{18}O in (1978AJ03, 1983AJ01).

61. ^{18}O(p, d)^{17}O $\qquad Q_{\rm m} = -5.820$

Angular distributions have been measured at a number of energies for $E_{\rm p} = 17.6$ to 43.6 MeV [see (1977AJ02)], at $E_{\rm p} = 24.4$ MeV (1973PI09; $d_0 \rightarrow d_7$) and at $E_{\rm p} = 51.9$ MeV (1977OH02; $d_0 \rightarrow d_2$). See also ^{19}F in (1983AJ01).

62. ^{18}O(d, t)^{17}O $\qquad Q_{\rm m} = -1.787$

Angular distributions of tritons have been measured at $E_{\rm d} = 17$ MeV [see (1977AJ02)] and at $E_{\rm d} = 17$ and 52 MeV: see Table 17.16. Comparisons of the analog reactions (d, t) and (d, ^{3}He) have been made at $E_{\rm d} = 52$ MeV (1977MA10): see also reaction 9 in ^{17}N.

63. ^{18}O(^{3}He, α)^{17}O $\qquad Q_{\rm m} = 12.533$

The $T = \frac{3}{2}$ states reported by (1969DE06) are displayed in Table 17.17 [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 $\qquad Q_{\rm m} = -1.233$

Angular distributions have been studied at $E(^{18}{\rm O}) = 16$ and 20 MeV: see (1977AJ02).

65. (a) ^{18}O(^{10}B, ^{11}B)^{17}O $\qquad Q_{\rm m} = 3.411$
(b) ^{18}O(^{11}B, ^{12}B)^{17}O $\qquad Q_{\rm m} = -4.675$

Angular distributions (reaction (a)) have been measured at $E(^{18}{\rm O}) = 20$ and 24 MeV: see (1977AJ02). For S-factor measurements see (1974SW04). Cross sections for reaction (b) are several orders of magnitude less than those for reaction (a) for $E(^{18}{\rm O})_{\rm cm} = 3 \rightarrow 7.7$ MeV (1974SW04).

Table 17.16: States of ^{17}O from ^{18}O(d, t) [a]

E_x [b] (MeV)	$J^\pi; T$ [b]	l	C^2S
0	$\frac{5}{2}^+; \frac{1}{2}$	2	1.53 [d]
0.87	$\frac{1}{2}^+; \frac{1}{2}$	0	0.21 [d]
3.06	$\frac{1}{2}^-; \frac{1}{2}$	1	1.08
3.84	$\frac{5}{2}^-; \frac{1}{2}$	> 2	
4.55	$\frac{3}{2}^-; \frac{1}{2}$	1	0.12
5.09	$\frac{3}{2}^+; \frac{1}{2}$	2	0.10
5.38	$\frac{3}{2}^-; \frac{1}{2}$	1	0.53
5.70	$\frac{7}{2}^-; \frac{1}{2}$		
5.94	$\frac{1}{2}^-; \frac{1}{2}$	1	0.06
6.86		$\neq 1$	
7.38 [c]	$\frac{5}{2}^+ + \frac{5}{2}^-$	$\neq 2$	
8.20	$\frac{3}{2}^-; \frac{1}{2}$	1	0.15
8.47	$\frac{7}{2}^+; \frac{1}{2}$		
8.69	$\frac{3}{2}^-; \frac{1}{2}$	1	0.10
9.15	$\frac{1}{2}^-; \frac{1}{2}$	1	0.10
9.49	$\frac{5}{2}^-; \frac{1}{2}$		
11.08	$\frac{1}{2}^-; \frac{3}{2}$	1	0.96
11.41 ± 0.01 [a]	$T = \frac{1}{2}$ [a]	(1)	0.04
12.12 ± 0.01 [a]	$T = \frac{1}{2}$ [a]	(1)	0.24
12.47	$\frac{3}{2}^-; \frac{3}{2}$	1	0.24
12.76 ± 0.01 [a]	$T = \frac{1}{2}$ [a]	(1)	0.17
12.94	$\frac{1}{2}^+; T = \frac{3}{2}$	0	0.19 ± 0.05
13.64	$(\frac{5}{2})^+; \frac{3}{2}$	2	0.29 ± 0.12
16.58 ± 0.01 [a]	$(\frac{1}{2}, \frac{3}{2})^-; \frac{3}{2}$ [a]	1	0.93
18.14 ± 0.01 [a]	$(\frac{1}{2}, \frac{3}{2})^-; \frac{3}{2}$ [a]	1	0.17

[a] (1977MA10): $E_d = 52$ MeV; DWBA analysis.

[b] From Table 17.7, unless footnote is shown.

[c] Unresolved.

[d] (1978FO05; $E_d = 17$ MeV) report spectroscopic factors of 1.48 ± 0.27 and 0.29 ± 0.05 (DWBA), 1.30 and 0.31 (CCBA), respectively, for ^{17}O*(0, 0.87).

Table 17.17: $T = \frac{3}{2}$ 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) in ^{16}O(^{3}He, α)^{15}O.

66. (a) ^{18}O(^{12}C, ^{13}C)^{17}O $\quad Q_m = -3.098$
(b) ^{18}O(^{13}C, ^{14}C)^{17}O $\quad Q_m = 0.132$
(c) ^{18}O(^{14}N, ^{15}N)^{17}O $\quad Q_m = 2.789$

For reactions (a) and (b) see (1977AJ02). For reaction (c) see (1974SW04).

67. ^{18}O(^{18}O, ^{19}O)^{17}O $\quad Q_m = -4.088$

See (1977KA21). See also (1977AJ02).

68. ^{19}F(π^-, 2n)^{17}O $\quad Q_m = 122.747$

The 0.87 MeV γ- ray is observed (1976EN02).

69. ^{19}F(n, t)^{17}O $\quad Q_m = -7.5560$

Angular distributions of the t_0 and t_1 groups are reported at $E_n = 14.4$ MeV: see (1977AJ02).

70. ^{19}F(p, ^{3}He)^{17}O $Q_{\rm m} = -8.320$

Angular distributions have been reported at $E_{\rm p} = 30.5$ and 42.4 MeV: see (1977AJ02). See also ^{20}Ne in (1978AJ03).

71. ^{19}F(d, α)^{17}O $Q_{\rm m} = 10.033$

Observed α-groups are displayed in Table 17.14 of (1977AJ02). Angular distributions have been measured at many energies in the range $E_{\rm d} = 0.3$ to 27.5 MeV: see Table 17.16 in (1971AJ02) and (1977AJ02). See also (1979AN35).

72. ^{19}F(α, ^{6}Li)^{17}O $Q_{\rm m} = -12.340$

Angular distributions are reported at $E_{\alpha} = 28$ and 42 MeV, involving ^{17}O*(0, 0.87): see (1977AJ02).

73. ^{20}Ne(n, α)^{17}O $Q_{\rm m} = -0.587$

At $E_{\rm n} = 14.1$ MeV angular distributions of α_0 and α_1 are reported: see (1977AJ02).

74. ^{29}Si(^{16}O, ^{28}Si)^{17}O $Q_{\rm m} = -4.330$

See (1980SI12; theor.).

^{17}F

(Figs. 8 and 9)

GENERAL: See also (1977AJ02).

Shell and cluster models: (1977DU04, 1977HA1Z, 1977PO16, 1978TH1A).

Special states: (1977HE18, 1978EN1D, 1980CH35, 1981TA09).

Electromagnetic transitions: (1976MC1G, 1977BR03, 1977HA1Z, 1977HO04, 1980CH35).

Complex reactions involving ^{17}F: (1977AR06).

Astrophysical questions: (1977SI1D, 1978WO1E).

Reactions involving pions: (1981OS04, 1981PU1A).

Other topics: (1976SA1H, 1977BA3P, 1978EN1D, 1978SH1B, 1978SL1B, 1979BE1H, 1981TA09).

Ground state of ^{17}F: (1976JO1B, 1976MC1G, 1976SA1H, 1977AN12, 1977BR03, 1977DU04, 1977HA1Z, 1977KO28, 1977PO16, 1977SH13, 1978AR1R, 1978SL1B, 1980CH35, 1981TA09).

$$\mu = 4.7223 \pm 0.0012 \text{ nm (1978LEZA)}.$$

$$Q = 0.10 \pm 0.02 \text{ b (1974MI21)}.$$

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

Two recent measurements of the half-life of ^{17}F are 64.31 ± 0.09 sec (1977AZ01) and 64.80 ± 0.12 sec (1977AL20): the weighted mean of these is 64.49 ± 0.16 sec; $\log ft = 3.36$. Earlier values are listed in (1971AJ02, 1977AJ02). 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 (1978RA2A) and (1977AZ02, 1978BR1R, 1979BA08, 1979OS1E, 1979TO1B; theor.).

2. ^{12}C(^{12}C, ^{7}Li)^{17}F $\qquad Q_m = -16.860$

See (1971AJ02).

3. ^{12}C(^{14}N, ^{9}Be)^{17}F $\qquad Q_m = -10.4362$

Angular distributions are reported to ^{17}F*(0, 0.50) at $E(^{14}\text{N}) = 53$ MeV (1976ZE04) and 78.8 MeV (1977MO1A; unresolved).

Table 17.18: Energy levels of ^{17}F

E_x in ^{17}F (MeV ± keV)	$J^\pi; T$	τ or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
0	$\frac{5}{2}^+; \frac{1}{2}$	$\tau_{1/2} = 64.49 \pm 0.16$ sec	β^+	1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32
0.49533 ± 0.10	$\frac{1}{2}^+$	$\tau_m = 412 \pm 9$ psec	γ	3, 5, 8, 10, 12, 18, 19, 22, 23, 24, 25, 26, 27, 28, 30, 32
3.104 ± 3	$\frac{1}{2}^-$	$\Gamma = 19 \pm 1$	γ, p	5, 8, 10, 12, 13, 18, 19, 28, 30
3.857 ± 4	$\frac{5}{2}^-$	1.5 ± 0.2	γ, p	5, 8, 10, 12, 13, 18, 19, 30
4.696 ± 10	$\frac{3}{2}^-$	225	p	8, 10, 13, 18, 28
5.103 ± 10	$\frac{3}{2}^+$	1530	p	12
5.22 ± 10	$(\frac{9}{2}^-)$			8, 10, 11
5.521 ± 10	$\frac{3}{2}^-$	68	p	8, 10, 13, 28
5.672 ± 10	$\frac{7}{2}^-$	40	p	8, 10, 13
5.682 ± 10	$\frac{1}{2}^+$	< 0.6	p	8, 10, 13
5.817 ± 10	$\frac{3}{2}^+$	180	p	8, 13
6.036 ± 10	$\frac{1}{2}^-$	30	p	8, 10, 13, 28
6.556 ± 10	$\frac{1}{2}^+$	200	p	13
6.7087 ± 0.3	$(\frac{3}{2}, \frac{5}{2})^+$	< 3	p	8, 10, 13
6.774 ± 10	$\frac{3}{2}^+$	4.5	p	13
7.027 ± 10	$\frac{5}{2}^-$	3.8	p	10, 13
7.356 ± 10	$\frac{3}{2}^+$	10 ± 2	p, α	10, 13, 17
7.448 ± 7		≤ 5	p	13
7.454 ± 7		7 ± 2	p, α	13, 17
7.471 ± 7		5 ± 2	p	13
7.479 ± 10	$\frac{3}{2}^+$	795	p	13
7.546 ± 10	$\frac{7}{2}^-$	30	p	13
7.75 ± 20	$(\frac{1}{2}^+)$	179 ± 3	p, α	13, 17, 28
7.95 ± 15		10 ± 3	p	13
8.01 ± 20		50 ± 20	p, α	13, 17

Table 17.18: Energy levels of ^{17}F (continued)

E_x in ^{17}F (MeV ± keV)	$J^\pi; T$	τ or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
8.075 ± 10	$\frac{5}{2}^+$	100 ± 20	p, α	10, 13, 17, 28
8.2	$\frac{3}{2}^-$	700 ± 250	p, α	13, 17
8.383 ± 5	$\frac{5}{2}^-$	11 ± 5	p, α	13, 17
8.416 ± 10	$\frac{7}{2}^+$	45 ± 10	p, α	13, 17, 28
8.75 ± 30	$\frac{5}{2}^+$	170 ± 30	p, α	13, 17
8.76	$\frac{3}{2}^+$	90 ± 20	p	13
8.98 ± 20	$\frac{7}{2}^-$	165 ± 30	p, α	13, 17
9.17 ± 60	$\frac{3}{2}^-$	140 ± 30	p, α	13, 17
9.92	$\frac{9}{2}^+$	90 ± 30	p, α	13, 17
10.04 ± 20	$\frac{7}{2}$	280 ± 100	p	13
10.22 ± 20		250 ± 80	α	17
10.40 ± 20	$(\frac{5}{2}^+)$	160 ± 40	p	13
10.499 ± 15	$\frac{7}{2}^-$	165 ± 25	p, α	13, 17
10.79 ± 20		120 ± 40	p, (α)	13, 17
10.91 ± 100	$\frac{1}{2}^-$	560 ± 100	p	13
10.95 ± 20		190 ± 50	p, (α)	13, 17
11.1928 ± 2.3	$\frac{1}{2}^-; \frac{3}{2}$	0.20 ± 0.04	γ, p, α	10, 12, 13, 17, 28
11.43 ± 20		240 ± 50	p, α	13, 17
11.58 ± 40		160 ± 30	p	13
12.00 ± 20		120 ± 40	p, α	13, 17
12.25 ± 20	$\frac{3}{2}^-$	300 ± 30	p	13
12.355 ± 10	$\frac{1}{2}^-$	190 ± 20	p	13
≈ 12.50	$\frac{7}{2}^-$	≈ 600	p	13
12.5501 ± 0.9	$\frac{3}{2}^-; \frac{3}{2}$	2.83 ± 0.12	γ, p, α	10, 12, 13, 17
13.061 ± 4	$\frac{5}{2}^-; \frac{3}{2}$	2 ± 1	γ, p, α	10, 12, 13, 17
13.080 ± 4	$(\frac{1}{2}^+); \frac{3}{2}$	2 ± 1	p, α	13, 17
13.13 ± 100	$\frac{5}{2}^-$	520 ± 50	p	13
13.781 ± 4	$\frac{5}{2}^+; \frac{3}{2}$	12 ± 5	p, α	13, 17
14.00 ± 50	$\frac{7}{2}^-$	260 ± 30	p	13
14.176 ± 6	$\frac{3}{2}^-; \frac{3}{2}$	30 ± 5	γ, p	12, 13
14.3037 ± 3.1	$\frac{7}{2}^-; \frac{3}{2}$	19.3 ± 1.6	γ, p, α	12, 13, 17

Table 17.18: Energy levels of ^{17}F (continued)

E_x in ^{17}F (MeV ± keV)	$J^\pi; T$	τ or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
14.38 ± 50	$\frac{5}{2}^-$	610 ± 50	p	13
14.71 ± 100	$\frac{1}{2}^-$	470 ± 100	p	13
14.809 ± 20	$\frac{1}{2}^+$	190 ± 25	p	13
15.6		≈ 550	p	13
17.1	$\frac{5}{2}^-$	1500	p	13
20.1 ± 200		1070 ± 160	γ, ^{3}He	5
20.4 ± 100		700 ± 100	γ, ^{3}He	5
20.9	$\frac{9}{2}^+$	600	p	13
21.3 ± 100		900 ± 100	γ, ^{3}He	5
21.8	$(\frac{9}{2}^+)$	400	p	13
22.7	$\frac{7}{2}^+$	600	p	13
23.8	$\frac{7}{2}^+$	600	p	13
25.4	$\frac{7}{2}^-$	1500	p	13
27.2	$\frac{5}{2}^-$	1500	p	13
28.9	$\frac{5}{2}^+$	2000	p	13

4. ^{12}C(^{20}Ne, ^{15}N)^{17}F $\qquad Q_m = -9.0962$

See (1979OR01).

5. ^{14}N(^{3}He, γ)^{17}F $\qquad Q_m = 15.8431$

Excitation functions for γ_0, γ_1, γ_2 and γ_3 have been studied for $E(^3\text{He}) = 3$ to 19 MeV: observed resonances are displayed in Table 17.19 (1981WA1R). [The earlier work by (1973MO1C), who studied the γ_{0+1} yield at $90°$, indicated several sharp resonances].

6. (a) ^{14}N(^{3}He, n)^{16}F $\qquad Q_m = -0.969 \qquad E_b = 15.8431$
(b) ^{14}N(^{3}He, p)^{16}O $\qquad Q_m = 15.2428$
(c) ^{14}N(^{3}He, d)^{15}O $\qquad Q_m = 1.8035$
(d) ^{14}N(^{3}He, ^{3}He)^{14}N
(e) ^{14}N(^{3}He, α)^{13}N $\qquad Q_m = 10.024$

Table 17.19: States of ^{17}F from ^{14}N(^{3}He, γ) [a]

$E(^3\text{He})$ (MeV)	$\Gamma_{\text{c.m.}}$ (MeV)	Res. in	$(2J+1)\Gamma_{^3\text{He}}\Gamma_\gamma$ (keV^2)	E_x (MeV)
(4.5) [b]	1.0 ± 0.3	γ_1, α [c]	32 ± 20	(19.5 ± 0.2)
5.2	1.07 ± 0.16	γ_2	63 ± 26	20.1 ± 0.2
(5.4) [b]	1.2 ± 0.4	γ_0	46 ± 32	(20.2 ± 0.3)
5.6	0.7 ± 0.1	γ_1	33 ± 11	20.4 ± 0.1
6.6	0.9 ± 0.1	γ_1	74 ± 18	21.3 ± 0.1
(7.8) [b]	2.0 ± 0.5	γ_0	260 ± 140	(22.2 ± 0.3)

[a] (1981WA1R). See also (1979CH2B, 1980CH1T). See, however, (1973MO1C).

[b] Uncertain: J. Lowe, private communication.

[c] See reaction 6.

Excitation functions for protons have been measured for $E(^3\text{He}) = 2.5$ to 18 MeV [see (1977AJ02)]: some large structures are observed. The polarization of the p_0 group has been studied at $E(^3\text{He}) = 9.8$ MeV. The elastic scattering of ^{3}He (reaction (d)) and the yield of α-particles (reaction (e)), studied in the ranges $E(^3\text{He}) = 4$ to 7 MeV and 2.5 to 8.5 MeV, respectively, show some evidence of structures (1970KN01, 1973MO1C): see the disucssion in (1977AJ02). See also ^{16}O and ^{16}F here, and ^{13}N, ^{14}N and ^{15}O in (1981AJ01).

7. ^{14}N(α, n)^{17}F $\qquad Q_m = -4.7347$

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

8. ^{14}N(^{6}Li, t)^{17}F $\qquad Q_m = 0.049$

At $E(^6\text{Li}) = 18$ MeV ^{17}F*(3.86, 5.22 ± 0.01, $5.67 + 5.68$) are strongly excited. $J^\pi = \frac{9}{2}^-$ is suggested for ^{17}F*(5.22) (1973BI01). See also (1977MA2G).

9. ^{14}N(^{10}B, ^{7}Li)^{17}F $\qquad Q_m = -1.945$

See (1977AJ02).

Table 17.20: Resonances in ^{16}O(p, γ)^{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	$(12 \pm 2) \times 10^{-3}$		3.11	$\frac{1}{2}^-; \frac{1}{2}$	A, (1973RO34) [g]
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, 1979KH03)
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	γ_0	72 ± 37 [e,f]	41 ± 10	14.174	$\frac{3}{2}^-; \frac{3}{2}$	(1975HA06, 1979KH03)
14.583 ± 6 [d]	$\gamma_0 + \gamma_1$	13.4 ± 7.0 [c]	28 ± 5	14.313	$\frac{7}{2}^-; \frac{3}{2}$	(1975HA06)

A: See (1971AJ02).

[a] See also Table 17.21.

[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 four states are 4.7 ± 2.0, 5.4 ± 1.6, 1.2 ± 0.8 and 4.4 ± 2.3 $[\times 10^{-3}]$ $e^2 \cdot$ fm^2.

[d] See the text of reaction 12 for discussion of the observed pigmy and giant resonances (1975HA07).

[e] See also Table 17.18 in (1977AJ02).

[f] $\Gamma_{\gamma_1}/\Gamma_{\gamma_0} \leq 0.14$, $(2J+1)\Gamma_p\Gamma_\gamma/\Gamma = 11.4 \pm 2.6$ eV.

[g] $C^2S = 0.90$ and 1.00, respectively, for ^{17}F*(0, 0.50).

10. ^{15}N(^{3}He, n)^{17}F $\qquad Q_m = 5.0097$

Angular distributions have been reported to most of the states of ^{17}F with $E_x < 8.1$ MeV at $E(^3\text{He}) = 3.8$ and 4.8 MeV: see (1977AJ02). Neutron groups have also been reported to ^{17}F states at $E_x = 11.195 \pm 0.007$, 12.540 ± 0.010 and 13.059 MeV, with $\Gamma < 20$, < 25 and < 25 keV, respectively. Angular distributions at $E(^3\text{He}) = 10.36$ 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).

11. ^{15}N(^{11}B, ^{9}Li)^{17}F $\qquad Q_m = -18.138$

At $E(^{11}\text{B}) = 115$ MeV ^{17}F*(0, 5.22) are strongly populated (1979RA10).

Table 17.21: Resonances in ^{16}O(p, p)^{16}O and ^{16}O(p, α)^{13}N [a]

E_p (MeV ± keV)	$\Gamma_{c.m.}$ (keV)	Particles out	Γ_{p_0}/Γ	^{17}F* (MeV)	$J^\pi; T$
2.663 ± 7	19 ± 1	p_0		3.105	$\frac{1}{2}^-$
3.47	1.53 ± 0.2	p_0		3.86	$\frac{5}{2}^-$
4.354 ± 10	225	p_0		4.696	$\frac{3}{2}^-$
4.787 ± 10	1530	p_0		5.103	$\frac{3}{2}^+$
5.231 ± 10	68	p_0		5.521	$\frac{3}{2}^-$
5.392 ± 10	40	p_0		5.672	$\frac{7}{2}^-$
5.402 ± 10	< 0.6	p_0		5.682	$\frac{1}{2}^+$
5.546 ± 10	180	p_0		5.817	$\frac{3}{2}^+$
5.779 ± 10	30	p_0		6.036	$\frac{1}{2}^-$
6.332 ± 10	200	p_0		6.556	$\frac{1}{2}^+$
6.4944 ± 0.1 [b]	< 3	p_0		6.7087	[j]
6.564 ± 10	4.5	p_0		6.774	$\frac{3}{2}^+$
6.833 ± 10	3.8	p_0, $\gamma_{6.13}$		7.027	$\frac{5}{2}^-$
7.183 ± 10	10 ± 2	p_0, p_2, α_0		7.356	$\frac{3}{2}^+$
7.280 ± 7	≤ 5	p_0		7.448	
7.287 ± 7	7 ± 2	p_0, p_1, p_2, α		7.454	
7.305 ± 7	5 ± 2	p_0, p_2		7.471	
7.313 ± 10	795	p_0		7.479	$\frac{3}{2}^+$
7.385 ± 10	30	p_0, p_2, $\gamma_{6.13}$		7.546	$\frac{7}{2}^-$
7.60 ± 20	179 ± 3	p_0, p_1, α_0		7.75	$\frac{1}{2}^+$
7.81 ± 15	10 ± 3	p_2		7.95	
7.88 ± 20	50 ± 20	p_0, $\gamma_{6.13}$, $\gamma_{6.92}$, α_0		8.01	
7.94 ± 15	100 ± 20	p_0, p_1, α_0		8.07	$\frac{5}{2}^+$
8.1	700 ± 250	(p_0), p_1, α_0		8.2	$\frac{3}{2}^-$
8.275 ± 4	11 ± 5	$p_0 \rightarrow p_3$, α_0		8.383	$\frac{5}{2}^-$
8.310 ± 10	45 ± 10	$p_0 \rightarrow p_3$, $\gamma_{6.13}$, $\gamma_{6.92}$, α_0		8.416	$\frac{7}{2}^+$
8.66 ± 30	170 ± 30	p_2, p_3, p_4, α_0		8.75	$\frac{5}{2}^+$
8.68	90 ± 20	p_0	0.2	8.76	$\frac{3}{2}^+$
8.91 [c]	165 ± 30	$p_0 \rightarrow p_4$, $\gamma_{6.13}$, $\gamma_{6.92}$, α_0	0.34 ± 0.05	8.98 ± 0.02	$\frac{7}{2}^-$
9.11 [c]	140 ± 30	$p_0 \rightarrow p_4$, $\gamma_{6.13}$, $\gamma_{6.92}$, α_0	0.55 ± 0.05	9.17 ± 0.06 [d]	$\frac{3}{2}^-$
9.91 [c]	90 ± 30	p_0, p_2, α_0	0.095 ± 0.005	9.92	$\frac{9}{2}^+$
10.04 ± 20	280 ± 100	p_0, p_1		10.04	$\frac{7}{2}$
10.23 ± 20	250 ± 80	α_0		10.22	
10.42 ± 20	160 ± 40	p_0, p_1, p_3		10.40	$(\frac{5}{2}^+)$
10.525 ± 15	165 ± 25	p_0, p_2, α_0	0.28 ± 0.03	10.499	$\frac{7}{2}^-$
(10.75 ± 50)		p_0, p_1, α_0		(10.71)	$(\frac{7}{2}^-)$
10.83 ± 20	120 ± 40	p_0, p_2, (p_3), (α_0)		10.79	

Table 17.21: Resonances in ^{16}O(p, p)^{16}O and ^{16}O(p, α)^{13}N [a] (continued)

E_p (MeV ± keV)	$\Gamma_{c.m.}$ (keV)	Particles out	Γ_{p_0}/Γ	^{17}F* (MeV)	$J^\pi; T$
10.96 ± 100	560 ± 100	p_0	0.25 ± 0.07	10.91	$\frac{1}{2}^-$
11.00 ± 20	190 ± 50	(p_2), p_3, (α_0)		10.95	
11.2636 ± 2.0 [e]	0.20 ± 0.04	p_0, p_2, p_4, α_0	0.093 ± 0.013	11.1928 ± 2.1	$\frac{1}{2}^-; \frac{3}{2}$
11.52 ± 20	240 ± 50	p_2, α_0		11.43	
11.67 ± 40	160 ± 30	p_0, p_3		11.58	
12.12 ± 20	120 ± 40	p_2, α_0		12.00	
12.39 ± 20	300 ± 30	p_0, p_2	0.26 ± 0.03	12.25	$\frac{3}{2}^-$
12.500 ± 10	190 ± 20	p_0, p_1, p_4	0.31 ± 0.03	12.355	$\frac{1}{2}^-$
≈ 12.65	≈ 600	p_0	≈ 0.09	≈ 12.50	$\frac{7}{2}^-$
12.7077 ± 2.0 [f]	2.83 ± 0.12	p_0, p_2, p_4, p_5, α_0, α_1	0.332 ± 0.018	12.5504 ± 2.3	$\frac{3}{2}^-; \frac{3}{2}$
(13.06 ± 100)		p_0		(12.88)	$(\frac{7}{2}^-)$
(13.06 ± 50)		p_0		(12.88)	$(\frac{1}{2}^+)$
13.250 ± 4	2 ± 1	p_0, p_{1+2}, p_{3+4}, p_5, α_0	0.15 ± 0.04	13.060	$\frac{5}{2}^-; \frac{3}{2}$
13.271 ± 4	2 ± 1	$p_0 \rightarrow p_4$, α_0	0.04 ± 0.02	13.080	$(\frac{1}{2}^+); \frac{3}{2}$
13.32 ± 100	520 ± 50	p_0	0.163 ± 0.016	13.13	$\frac{5}{2}^-$
14.017 ± 4	12 ± 5	p_0, p_{1+2}, p_{3+4}, α_0	0.02 ± 0.01	13.781	$\frac{5}{2}^+; \frac{3}{2}$
(14.20 ± 50)		p_0		(13.95)	$(\frac{1}{2}^+)$
14.25 ± 50	260 ± 30	p_0	0.08 ± 0.01	14.00	$\frac{7}{2}^-$
14.438 ± 6	27 ± 5	p_0, p_{3+4}	0.04 ± 0.02	14.177	$\frac{3}{2}^-; \frac{3}{2}$ [i]
14.5730 ± 3.0 [g]	19.3 ± 1.6	p_0, p_{1+2}, p_{3+4}, p_5, α_0	0.085 ± 0.008	14.3037 ± 3.1	$\frac{7}{2}^-; \frac{3}{2}$
14.65 ± 50	610 ± 50	p_0	0.10 ± 0.01	14.38	$\frac{5}{2}^-$
(14.94 ± 100)		p_0			$(\frac{3}{2}^-)$
15.00 ± 100	470 ± 100	p_0	0.25 ± 0.03	14.71	$\frac{1}{2}^-$
15.110 ± 20	190 ± 25	p_0	0.150 ± 0.015	14.809	$\frac{1}{2}^+$
(15.245 ± 100)		p_0		(14.94)	$(\frac{5}{2}^+)$
(15.30 ± 50)		p_0		(14.98)	$(\frac{3}{2}^+)$
(15.37 ± 100)		p_0		(15.05)	$(\frac{3}{2}^-)$
(15.545 ± 100)		p_0		(15.22)	$(\frac{7}{2}^-)$
15.9 [h]	≈ 550	p_0, p_{1+2}		15.6	
17.6	1500	p_0, p_{3+4}		17.1	$\frac{5}{2}^-$
20.4	600	p_0		19.8	$\frac{3}{2}^+$
21.6	600	p_0, (α)		20.9	$\frac{9}{2}^+$
22.6	400	p_0, (α)		21.8	$(\frac{9}{2}^+)$
23.5	600	p_0, p_5		22.7	$\frac{7}{2}^+$
24.7	600	p_0, (α)		23.8	$\frac{7}{2}^+$
26.4	1500	p_0, (α)		25.4	$\frac{7}{2}^-$
28.3	1500	p_0		27.2	$\frac{5}{2}^-$

Table 17.21: Resonances in ^{16}O(p, p)^{16}O and ^{16}O(p, α)^{13}N [a] (continued)

E_p (MeV ± keV)	$\Gamma_{c.m.}$ (keV)	Particles out	Γ_{p_0}/Γ	^{17}F* (MeV)	$J^\pi; T$
30.1	2000	p_0		28.9	$\frac{5}{2}^+$

[a] See earlier references in Tables 17.20 in (1971AJ02) and 17.19 in (1977AJ02). See also Table 17.20 here.
[b] Preliminary value (1980BA1M). See also (1981ST04).
[c] (1981KR1B): polarized protons; preliminary results. $\Gamma_p = 51 \pm 8$, 143 ± 30 and 11.4 ± 2 keV for ^{17}F*(8.98, 9.17, 9.92).
[d] (1981KR1B) report that there are indications of two very sharp resonances corresponding to ^{17}F*(9.10, 9.13) with $J^\pi = \frac{1}{2}^-$ and $\frac{3}{2}^-$.
[e] $\Gamma_{p_0} = 19 \pm 3$ eV (1976HI09).
[f] $\Gamma_{p_0} = 0.94 \pm 0.06$ keV, $\Gamma_{\alpha_0} = 62 \pm 16$ eV, $\Gamma_{\alpha_1} = 53 \pm 22$ eV (1976HI09); J. Lowe, private communication.
[g] $\Gamma_{p_0} = 1.65 \pm 0.12$ keV, $\Gamma_{\alpha_0} = 2.6 \pm 0.7$ keV (1976HI09).
[h] See also Table 17.20 of (1971AJ02), for possible other resonances.
[i] (1979DA11) have confirmed $J^\pi = \frac{3}{2}^-$.
[j] $J^\pi = (\frac{3}{2}, \frac{5}{2})^+$ (G. Bauer and H.T. Richards, private communication).

12. ^{16}O(p, γ)^{17}F $\qquad Q_m = 0.6004$

$Q_0 = 600.35 \pm 0.28$ keV (1976RO1T).

At low energies the direct capture to ^{17}F*(0, 0.50) is observed: see (1971AJ02, 1977AJ02). Extrapolation of cross-section data leads to $S(0) \approx 8$ keV · b: see (1977AJ02). In addition to two $T = \frac{1}{2}$ resonances, five resonances corresponding to $T = \frac{3}{2}$ states are observed in the γ_1 and $\gamma_0 + \gamma_1$ yields: see Table 17.20 for the reported parameters. The lowest $T = \frac{3}{2}$ states of even parity at $E_x = 13.27$ and 14.02 MeV [$J^\pi = (\frac{1}{2}^+)$ and $\frac{5}{2}^+$] (see Table 17.21) 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 $E_p = 15.75$ to 31.66 MeV: it shows the giant dipole resonance centered at $E_x = 22$ 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 · mb: the observed strength distribution is on 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 $E_x = 16.9$ and 18.0 MeV (1975HA07). See also (1979BL1F), (1981CA1D), (1975ZI1A; astrophys.) and (1977AL18; theor.).

13. (a) ^{16}O(p, p)^{16}O $\qquad E_b = 0.6004$

(b) ^{16}O(p, 2p)^{15}N $\qquad Q_m = -12.1276$

(c) ^{16}O(p, pn)^{15}O $Q_{\rm m} = -15.6639$

(d) ^{16}O(p, pα)^{12}C $Q_{\rm m} = -7.1620$

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 $E_{\rm p} = 46$ MeV: see Table 17.19 in (1971AJ02) and (1977AJ02) for the earlier work and (1981KR1B; $E_{\overline{\rm p}} = 8.5$ to 10.6 MeV; p_0), (1979DA11; $E_{\overline{\rm p}} \approx 14.4$ MeV; p_0). The observed resonances are displayed in Table 17.21.

Polarization results have been reported at $E_{\rm p} = 3.47$ to 49.4 MeV [see (1977AJ02)] and at $E_{\rm p} = 40$ MeV (1978MO14; p_5), 42.5, 44.0 and 49.3 MeV (1977PE09; p_5), 65 MeV (1979SA38, 1981SA1F; p_0), 135 MeV (1980KE14; p_2, p_4), 800 MeV (1979AD03, 1979GL1C; p_0, p_{1+2}, p_3, p_4, p_5) and 1 GeV (1978AL1G, 1978AL1X, 1980AL09). For total reaction cross sections see (1979DE31, 1981DY03). See also (1977AJ02).

Polarization in quasi-elastic scattering (reaction (b)) has been studied at $E_{\rm p} = 200$ MeV by (1976KI10, 1980KI06) and 635 MeV (1977NA29, 1978NA18). For reactions (c) and (d) see (1977AJ02). For reaction (d) see (1981DY03). For spallation measurements see (1976IN04, 1977MO1C) and (1979VD02). For antiproton scattering see (1981AU01; theor.).

See also ^{16}O and (1978GO05, 1978SA33, 1979WI1N, 1979WI1P, 1980LE28), (1979RA1C; astrophys.), (1977PL1A, 1979DE1P, 1979VO08, 1980MC1C, 1980WH1A, 1981RA1B) and (1976JE1A, 1976LE26, 1977KO2G, 1977PH02, 1978AB08, 1978AL07, 1978BI1L, 1978BR28, 1978GR1D, 1978PH01, 1978RE1G, 1978SC14, 1978WU03, 1979BI1C, 1979CH2C, 1979ER02, 1979KO01, 1979MA48, 1979PH05, 1979RA27, 1980AU09, 1980AY01, 1980DE2F, 1980DM1A, 1980MA28, 1980MA06, 1980RA1B, 1981DE2J; theor.).

14. ^{16}O(p, n)^{16}F $Q_{\rm m} = -16.211$ $E_{\rm b} = 0.6004$

For analyzing power measurements see (1981MA1F, 1981MA1J; $E_{\vec{\rm p}} = 135$ MeV). See also ^{16}F.

15. ^{16}O(p, d)^{15}O $Q_{\rm m} = -13.4392$ $E_{\rm b} = 0.6004$

The excitation function for d_0 ($\theta = 70°$) has been measured for $E_{\rm p} = 21$ to 38.5 MeV. A strong resonance is observed at $E_{\rm p} = 24$ MeV: see Table 17.21. Polarization measurements are reported at $E_{\rm p} = 65$ MeV (1981HO1L; d_0), 30.3 MeV [see (1977AJ02)] and $E_{\vec{\rm p}} = 200$ MeV (1981LI1B). See also ^{15}O in (1981AJ01) and (1979CA1A).

16. (a) ^{16}O(p, t)^{14}O $Q_{\rm m} = -20.4062$ $E_{\rm b} = 0.6004$

(b) ^{16}O(p, ^{3}He)^{14}N $Q_{\rm m} = -15.2428$

The excitation function ($\theta = 70°$) for tritons has been measured for $E_p = 32$ to 39.5 MeV: no structure is observed [see (1977AJ02)]. 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): attemts 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 (1977AJ02). See also ^{14}N and ^{14}O in (1981AJ01) and (1977HA1P).

17. ^{16}O(p, α)^{13}N $\qquad Q_m = -5.2185 \qquad E_b = 0.6004$

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) and (1977AJ02) for the earlier work and (1977GR17; 6.6 to 10.4 MeV; σ_t). Observed resonances are displayed in Table 17.21. Some broad structures have been reported above $E_p \approx 15$ MeV; particularly strong peaks appear at $E_p \approx 22$ and 25.5 MeV: see (1977AJ02).

This reaction is involved in explosive burning in stars: see (1977AJ02) for earlier work and (1977GR17; $S_0 = 4 \pm 3$ b at E_p(cm) $= 6.5$ MeV). See also (1977CL1F).

18. ^{16}O(d, n)^{17}F $\qquad Q_m = -1.6243$

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, respectively: $J^\pi = \frac{5}{2}^+$ and $\frac{1}{2}^+$) for $E_d \leq 12$ MeV: see Table 17.21 in (1971AJ02) and (1972AN21; $E_d = 3.10$, 3.40 and 3.66 MeV). For polarization measurements see ^{18}F in (1983AJ01). See also (1980HU1J) and (1977AJ02).

19. ^{16}O(^{3}He, d)^{17}F $\qquad Q_m = -4.8932$

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). Angular distributions have also been measured at $E(^3\text{He}) = 30$ MeV (1977KO2H; to ^{17}F*(5.1, 5.7) and at $E(^3\vec{\text{He}}) = 33$ MeV (1980LU03, 1981RO1H; d_0, d_1). See also ^{19}Ne in (1983AJ01) and (1977CO1Z; theor.).

20. ^{16}O(α, t)^{17}F $\qquad Q_m = -19.2137$

See (1971AJ02, 1977AJ02).

21. ^{16}O(^{7}Li, ^{6}He)^{17}F $Q_m = -9.374$

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

22. (a) ^{16}O(^{10}B, ^{9}Be)^{17}F $Q_m = -5.985$
(b) ^{16}O(^{11}B, ^{10}Be)^{17}F $Q_m = -10.628$

Angular distributions have been measured at $E(^{10}\text{B}) = 100$ MeV for the transitions to ^{17}F*($0+0.50$, 5.1, 8.1), (1975NA15), and at $E(^{11}\text{B}) = 115$ MeV for the transition to ^{17}F$_{g.s.}$ (1979RA10).

23. (a) ^{16}O(^{12}C, ^{11}B)^{17}F $Q_m = -15.3566$
(b) ^{16}O(^{13}C, ^{12}B)^{17}F $Q_m = -16.933$

Angular distributions have been measured at $E(^{12}\text{C}) = 76.8$ MeV (1977MO1A, 1979MO14; ^{17}F*(0, 0.5)) and at $E(^{13}\text{C}) = 105$ MeV (1979RA10; ^{17}F$_{g.s.}$).

24. ^{16}O(^{14}N, ^{13}C)^{17}F $Q_m = -6.9503$

Angular distributions involving ^{17}F*(0, 0.5) have been measured at $E(^{14}\text{N}) = 76.2$ MeV (1977MO1A, 1979MO14) and 155 MeV (1975NA15, 1976NA09).

25. ^{16}O(^{16}O, ^{15}N)^{17}F $Q_m = -11.5272$

Angular distributions involving ^{17}F*($0 + 0.5$) have been measured at $E(^{16}\text{O}) = 95.2$ MeV (1977MO1A, 1979MO14).

26. ^{17}O(p, n)^{17}F $Q_m = -3.544$

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 (1983AJ01).

27. ^{17}O(^{3}He, t)^{17}F $\qquad Q_m = -2.780$

Angular distributions have been studied for t_0 and t_1 at $E(^3\text{He}) = 17.3$ MeV [see (1977AJ02)] and for t_0 at $E(^3\vec{\text{He}}) = 33$ MeV (1981BA1G).

28. ^{17}Ne(β^+)^{17}F $\qquad Q_m = 14.53$

See ^{17}Ne.

29. ^{19}F(γ, 2n)^{17}F $\qquad Q_m = -19.582$

See ^{19}F in (1983AJ01).

30. ^{19}F(p, t)^{17}F $\qquad Q_m = -11.100$

Angular distributions have been measured for the $t_0 \rightarrow t_3$ groups at $E_p = 22.8$, 42.4 and 45 MeV: see (1977AJ02).

31. ^{20}Ne(p, α)^{17}F $\qquad Q_m = -4.1306$

See (1977GR17, 1980KO1Q) and (1977AJ02).

32. (a) ^{20}Ne(^{3}He, ^{6}Li)^{17}F $\qquad Q_m = -8.151$
(b) ^{22}Ne(^{3}He, ^{8}Li)^{17}F $\qquad Q_m = -15.993$

At $E(^3\text{He}) = 75$ and 88 MeV ^{17}F*(0, 0.5) have been populated in both reactions (1978KE06).

^{17}Ne

(Figs. 8 and 9)

GENERAL: See also (1977AJ02).

Theory and reviews: (1975BE56, 1977CE05, 1978GU10, 1978WO1E, 1979BE1H).

Other topics: (1981GR08).

Mass of ^{17}Ne: The mass excess adopted by (1977WA08) is 16.478 ± 0.026 MeV, based on unpublished data. We retain the mass excess 16.48 ± 0.05 MeV based on the evidence reviewed in (1977AJ02).

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

   (b) ^{17}Ne(β^+)^{17}F $\qquad Q_m = 14.53$

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 $J^\pi = \frac{3}{2}^-, \frac{3}{2}^-$ and $\frac{1}{2}^-$: see Table 17.23. 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$_{\text{g.s.}}$ (1971HA05). See Table 17.3 for a comparison of the mirror ^{17}N and ^{17}Ne decays and Table 17.11 for the decay of ^{17}F*(11.20). See also (1978RA2A).

Table 17.22: Energy levels of ^{17}Ne [a]

E_x in ^{17}Ne (MeV)	$J^\pi; T$	$\tau_{1/2}$ (msec)	Decay	Reaction
0	$\frac{1}{2}^-; \frac{3}{2}$	109.0 ± 1.0	β^+ [b]	1

[a] The evidence for excited states of ^{17}Ne has not been published: see (1977AJ02).

[b] See also Tables 17.3 and 17.23.

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

See (1977AJ02).

Table 17.23: β^+ decay of ^{17}Ne [a]

Decay to ^{17}F* (MeV ± 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
11.19 [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]					

[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 $E_{\rm cm} = 2.83$ MeV has been observed: the level in ^{17}F to which it corresponds is not known.

[e] See also Table 17.11.

^{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 4.3 MeV and with respect to breakup into ^{14}O + 3p by 5.7 MeV.

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(Closed 01 July 1981)

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