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Energy Levels of Light Nuclei
$A = 19$

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Abstract: An evaluation of $A = 18$–20 was published in *Nuclear Physics A*475 (1987), p. 1. This version of $A = 19$ 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.

(References closed June 1, 1987)

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Table of Contents for $A = 19$

Below is a list of links for items found within the PDF document. Figures from this evaluation have been scanned in and are available on this website or via the link below. The introductory Table 2 is also available via the link.

^{19}He, ^{19}Li, ^{19}Be

(Not observed)

See (1983ANZQ; theor.).

^{19}B

(Not illustrated)

^{19}B has been observed in the bombardment of Be by 12 MeV/A ^{56}Fe ions (1984MU27). It is suggested that the atomic mass excess of ^{19}B is 60.1 MeV [see (1978AJ03)]. ^{19}B is then stable with respect to breakup into ^{18}B+n by 1.8 MeV ^{17}B+2n by 0.1 MeV. ^{19}B is calculated to have $J^{\pi} = \frac{3}{2}^{-}$ and to have excited states at 1.88, 3.63 and 3.77 MeV with $J^{\pi} = \frac{1}{2}^{-}$, $\frac{5}{2}^{-}$ and $\frac{7}{2}^{-}$ (1985PO10). See also (1986GU1D, 1986PO13) and (1983ANZQ, 1985PO10; theor.).

^{19}C

(Fig. 8)

^{19}C has been observed in the 0.8 GeV proton bombardment of thorium (1986VI09) and in the fragmentation of 60 MeV/A argon ions (1987GI1E). The mass excess is 32.30 ± 0.24 MeV (1986VI09), 32.95 ± 0.42 MeV (1987GI1E): the weighted mean is 32.46 ± 0.21 MeV. ^{19}C is then stable with respect to decay into ^{18}C + n by 0.53 MeV and into ^{17}C + 2n by 4.72 MeV. The calculated half-life of ^{19}C is 1.2×10^{-2} sec (1984KL06). See also (1978AJ03, 1985WA02, 1986AN07, 1986GU1D) and (1983ANZQ, 1987SA15; theor.).

^{19}N

(Figs. 5 and 8)

A study of the ^{48}Ca(^{18}O, ^{19}N)^{47}Sc reaction leads to a mass excess of 15.872 ± 0.020 MeV for ^{19}N (1983HO08). This and earlier results [see (1983AJ01)] lead to an adopted (1985WA02) value of 15.873 ± 0.019 MeV. ^{19}N is then stable with respect to decay into ^{18}N + n by 5.32 MeV. The half-life of ^{19}N is reported to be 0.32 ± 0.10 sec (1986DU07), $0.21^{+0.2}_{-0.1}$ sec (1987MU1J). See also (1984KL06) and reaction 8 in ^{19}O. $P_{\mathrm{n}} \approx 33\%$ (1987MU1J; prelim.). In addition to the ground-state transition (1982NA08) report the population of states of ^{19}N at $E_{\mathrm{x}} = 1.12 \pm 0.04$ and 1.59 ± 0.04 MeV. See also (1984HI1A, 1986HU1A, 1986PI09), (1983DE2E, 1983WI1A, 1986AN07, 1986GU1D) and (1982CUZZ, 1983ANZQ, 1983FR1A; theor.).

^{19}O

(Fig. 5 and 8)

GENERAL: (See also (1983AJ01).)

Nuclear models: (1978WI1B, 1983BR29, 1983PO02, 1983SH44, 1984BA24, 1984CH1V, 1984RA13, 1986WA1R).

Special states: (1978WI1B, 1983BR29, 1983HU1J, 1983PO02, 1983SH44, 1984BA24, 1984CH1V, 1984RA13, 1984WI17, 1985LE1L, 1986AN07).

Electromagnetic transitions: (1983BR29, 1985LE1L).

Complex reactions involving ^{19}O: (1983FR1A, 1983WI1A, 1984GR08, 1984HI1A, 1984HO23, 1985PO11, 1986HA1B, 1986PO06, 1987LI04, 1987RI03).

Hypernuclei: (1984AS1D).

Other topics: (1978WI1B, 1983BR29, 1983EN04, 1983HU1J, 1984PO11, 1984WI17, 1985AN28, 1985TA26).

Ground state of ^{19}O: (1978WI1B, 1983ANZQ, 1983BU07, 1984FR13, 1985AN28, 1987SA15).

1. ^{19}O(β^-)^{19}F $\qquad$ $Q_{\rm m} = 4.820$

The weighted mean of several half-lives is 26.91 ± 0.08 sec: see (1972AJ02). A recent value is 27.03 ± 0.07 sec (1986AL11). The decay is complex: see ^{19}F, reaction 30 and Table 19.19. See also (1985XI1A) and (1985BR29; theor.).

2. ^{9}Be(^{18}O, ^{8}Be)^{19}O $\qquad$ $Q_{\rm m} = 2.292$

See (1983AJ01).

3. ^{13}C(^{7}Li, p)^{19}O $\qquad$ $Q_{\rm m} = 7.411$

States of ^{19}O reported in this reaction are displayed in Table 19.3.

4. ^{17}O(t, p)^{19}O $\qquad$ $Q_{\rm m} = 3.520$

Proton groups corresponding to ^{19}O states with $E_{\rm x} < 5.6$ MeV and E_γ measurements are displayed in Table 19.4.

Table 19.1: Energy levels of ^{19}O [a]

E_x (MeV $\pm$ keV)	$J^\pi; T$	τ [b] or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
0	$\frac{5}{2}^+; \frac{3}{2}$	$\tau_{1/2} = 26.91 \pm 0.08$ sec	β^-	1, 2, 3, 4, 5, 7, 8, 9
0.0960 ± 0.5	$\frac{3}{2}^+$	$\tau_m = 2.00 \pm 0.07$ nsec $g = -0.48 \pm 0.06$	γ	3, 4, 7, 8, 9
1.4717 ± 0.4	$\frac{1}{2}^+$	$\tau_m = 1.27 \pm 0.17$ psec	γ	3, 4, 7
2.3715 ± 1.0	$\frac{9}{2}^+$	> 3.5 psec	γ	3, 4, 7
2.7790 ± 0.9	$\frac{7}{2}^+$	93 ± 19 fsec	γ	3, 4, 7
3.0674 ± 1.6	$\frac{3}{2}^+$	≥ 1 psec	γ	3, 4, 7
3.1535 ± 1.7	$\frac{5}{2}^+$	(≥ 1 psec)	γ	3, 4, 7
3.2316 ± 2.3	$\frac{3}{2}^+$			3, 4, 7
3.9449 ± 1.4 [c]	$\frac{3}{2}^-$		γ	3, 4, 7
4.1093 ± 1.9	$\frac{3}{2}^+$	$\Gamma < 15$ keV		3, 4, 7
4.3281 ± 2.4	$\frac{3}{2}, \frac{5}{2}$	< 15		3, 4, 7
4.4025 ± 2.7	$\frac{3}{2} \rightarrow \frac{7}{2}$	< 15		3, 4, 7
4.5820 ± 4.6	$\frac{3}{2}^-$	52 ± 3	n	3, 4, 5, 7
4.7026 ± 2.7	$\frac{5}{2}^+$	< 15		3, 4, 7
4.9683 ± 5.5	$\frac{5}{2}, \frac{7}{2}$			3
5.0070 ± 4.5	$\frac{3}{2}, \frac{5}{2}$	< 15		3, 4, 7
5.0820 ± 5.4	$\frac{1}{2}^-$	49 ± 5	n	3, 5
5.1484 ± 3.2	$\geq \frac{5}{2}^+$	3.4 ± 1.0	n	3, 4, 5, 7
5.3840 ± 2.8	$(\frac{9}{2} \rightarrow \frac{13}{2})$			3
5.5035 ± 3.1 [c]		< 15		3, 4, 7
5.54	$\frac{3}{2}^+$	≈ 490	n	5
5.7046 ± 4.3 [c]	$\frac{7}{2}^-, \frac{5}{2}$	7.8 ± 1.4	n	3, 4, 5, 7
6.1196 ± 3.2 [c]	$\frac{3}{2}^+$	≈ 110	n	3, 5
6.1916 ± 5.5				3
6.2693 ± 2.6	$\frac{7}{2}^-$	19.2 ± 2.4	n	3, 4, 5, 7
6.4058 ± 3.1 [c]				3
6.4662 ± 4.8	$(\frac{7}{2} \rightarrow \frac{11}{2})$		(n)	3, 5, 7
6.583 ± 6 [c]				3, 7
6.903 ± 8				3, 7

Table 19.1: Energy levels of ^{19}O [a] (continued)

E_x (MeV $\pm$ keV)	$J^\pi; T$	τ [b] or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
6.988 ± 9				3, 7
7.118 ± 10				3, 7
7.242 ± 8				3, 7
7.508 ± 10				3
8.048 ± 20				3
8.132 ± 20				3
8.247 ± 20				3
8.450 ± 20				3
8.561 ± 20				3
8.591 ± 20				3
8.916 ± 20				3
8.923 ± 20				3
9.022 ± 20				3
9.064 ± 20				3
9.253 ± 20				3
9.324 ± 20				3
9.43				3
9.56				3
9.6	$\frac{7}{2}^-$		n	3, 5
9.9	$\frac{7}{2}^-$		n	3, 5
9.93				3
9.98				3
10.21	$\frac{7}{2}^-$		n	5
10.66	$\frac{7}{2}^-$		n	5
11.25 ± 50		240	n, α	6
11.58 ± 50		330	n, α	6

[a] See also Tables 19.2 and 19.5.

[b] See also reaction 1, and Table 19.2 in (1978AJ03).

[c] See footnotes to Table 19.3.

Table 19.2: Radiative decays in ^{19}O [a]

E_i (MeV)	J^π_i	E_f (MeV)	Branch (%) [a]	δ
0.096	$\frac{3}{2}^+$	0	100	
1.47	$\frac{1}{2}^+$	0	2.0 ± 0.2	
		0.096	98.0 ± 0.2	
2.37	$\frac{9}{2}^+$	0	100	0.002 ± 0.05
2.78	$\frac{7}{2}^+$	0	100	0.8 ± 0.5
3.07	$\frac{3}{2}^+$	1.47	100	
3.16	$\frac{5}{2}^+$	0	8 ± 4	
		0.096	92 ± 4	$0.03 < \delta < 2.3$
3.94	$\frac{3}{2}^-$	0	33 ± 8	
		0.096	39 ± 8	
		1.47	28 ± 4	

[a] For other values and for references see Table 19.5 in (1978AJ03).

5. (a) ^{18}O(n, γ)^{19}O $Q_m = 3.957$
   (b) ^{18}O(n, n)^{18}O $E_b = 3.957$

The thermal capture cross section is 0.16 ± 0.01 mb (1981MUZQ). The scattering amplitude (bound) $a = 5.84 \pm 0.07$ fm, $\sigma_{\text{free}} = 3.86 \pm 0.10$ b (1979KO26). The total cross section has been measured for $E_n = 0.14$ to 2.47 MeV [see (1978AJ03)] and at $E_n = 5$ to 7.5 MeV [G. Auchampaugh, quoted in (1986KO10)]. A multi-level R-matrix analysis of this and additional $\sigma(\theta)$ data leads to the states shown in Table 19.5 and to some additional structures. The five $\frac{7}{2}^-$ states [^{19}O*(6.27, 9.64, 9.84, 10.21, 10.66)] (see, however, footnote (a) to Table 19.5) contain about $20 - 30$% of the allowed $f_{7/2}$ single-particle strength. Isobaric analog assignments are presented (1986KO10). See also (1982RA1A).

6. ^{18}O(n, α)^{15}C $Q_m = -5.009$ $E_b = 3.957$

The total cross sections for the α_0 and α_1 groups have been measured for $E_n = 7.5$ to 8.6 MeV: resonance structure is reported at $E_n = 7.70 \pm 0.05$ and 8.05 ± 0.05 MeV with $\Gamma_{\text{lab}} = 0.25$ and 0.35 MeV, respectively [^{19}O*(11.25, 11.58)]: see (1978AJ03).

7. ^{18}O(d, p)^{19}O $Q_m = 1.732$

Table 19.3: States in ^{19}O from ^{13}C(^{7}Li, p) [a]

E_x (MeV ± keV)	J [b]	E_x (MeV ± keV)
0	$\frac{5}{2}$	6.4662 ± 4.8 [i]
0.0944 ± 1.1	$\frac{3}{2}$	6.5827 ± 6.0 [j]
1.4716 ± 1.8	$\frac{1}{2}$	6.903 ± 8
2.3711 ± 1.9	$\frac{9}{2}$	6.988 ± 9
2.7776 ± 1.9	$\frac{7}{2}$	7.118 ± 10
3.0674 ± 1.6	$\frac{3}{2}$	7.242 ± 8
3.1536 ± 2.8	$\frac{5}{2}$	7.508 ± 10
3.2316 ± 2.3	$\frac{3}{2}$	8.048 ± 20
3.9449 ± 1.4 [c]		8.132 ± 20
4.1093 ± 1.9	$\frac{3}{2}$	8.247 ± 20
4.3281 ± 2.4	$\frac{3}{2}, \frac{5}{2}$	8.450 ± 20
4.4025 ± 2.7	$\frac{3}{2}, \frac{5}{2}, \frac{7}{2}$	8.561 ± 20
4.5820 ± 4.6	$\frac{3}{2}$	8.591 ± 20
4.7026 ± 2.7 [d]		8.916 ± 20
4.9683 ± 5.5	$\frac{5}{2}, \frac{7}{2}$	8.923 ± 20
5.0070 ± 4.5	$\frac{3}{2}, \frac{5}{2}$	9.022 ± 20
5.0820 ± 5.4	$\frac{1}{2}$	9.064 ± 20
5.1484 ± 3.2	$\frac{5}{2}$	9.253 ± 20
5.3840 ± 2.8	$\frac{9}{2}, \frac{11}{2}, \frac{13}{2}$ [e]	9.324 ± 20
5.5035 ± 3.1 [f]		9.43
5.7046 ± 4.3 [g]		9.56
6.1196 ± 3.2 [h]		9.77
6.1916 ± 5.5	$\frac{1}{2}$	9.88
6.2693 ± 2.6	$\frac{7}{2}$	9.93
6.4058 ± 3.1 [h]		9.98

[a] (1977FO10); $E(^7\mathrm{Li}) = 16.0$ MeV. Angular distributions have been reported to all states with $E_x < 6.8$ MeV. See also (1978AJ03).
[b] Derived from total cross section and $2J + 1$ analysis.
[c] Corresponds to unresolved states. Assuming one of these to be a $\frac{3}{2}^-$ state (see Table 19.4), the other should have $J = \frac{7}{2} \rightarrow \frac{13}{2}$.
[d] May correspond to unresolved states.
[e] If this group corresponds to a single state.
[f] Narrow unresolved states: see discussion in (1977FO10).
[g] Cross section is too large for the known state at this energy with $J^\pi = \frac{3}{2}^+$. If this group corresponds to a doublet, the other member should have $J = \frac{1}{2} \rightarrow \frac{5}{2}$.
[h] Sharp group; if due to a single state $J = \frac{11}{2} \rightarrow \frac{17}{2}$.
[i] $J = (\frac{7}{2}, \frac{9}{2}, \frac{11}{2})$.
[j] The total cross section to this state is very high implying unresolved states: if there are two states one must have $J > \frac{13}{2}$.

Angular distributions have been measured at $E_d = 0.8$ to 15 MeV: see 1978AJ03, 1983AJ01). The l_n values and spectroscopic factors derived from these measurements are displayed in Table 19.4. Branching ratios are shown in Table 19.2. ^{19}O*(0.096) has g $= -0.48 \pm 0.06$; its configuration appears to be mainly $\mathrm{d}^3_{5/2}$ and $B(\mathrm{M1}) = 0.040 \pm 0.015\ \mu_N^2$. The ΔE value for the $1.47 \rightarrow 0.096$ transition is 1375.3 ± 0.5 keV. Assuming $E_x = 96.0 \pm 0.5$ keV (Table 19.1) $E_x = 1471.4 \pm 0.7$ keV. Angular correlations are consistent with $J^\pi = \frac{5}{2}^+$ for ground state and unambiguously fix $J^\pi = \frac{3}{2}^+$ and $\frac{1}{2}^+$, respectively, for ^{19}O*(0.096, 1.47): see (1978AJ03) for references. See also (1986SE1B).

8. $^{19}\mathrm{N}(\beta^-)^{19}\mathrm{O}$ $\qquad Q_m = 12.54$

The beta decay of ^{19}N is reported to involve γ-rays with $E_\gamma = 96.0 \pm 1.0$, 709.2 ± 0.8 and 3137.8 ± 1.0 keV, with relative intensities 100 ± 10, 63 ± 21 and 76 ± 21 (1986DU07).

9. $^{19}\mathrm{F}(\pi^-, \gamma)^{19}\mathrm{O}$ $\qquad Q_m = 134.749$

Transitions to ^{19}O*(0[u], 4.9, 6.3) have been observed in the radiative capture of stopped negative pions (1983MA16).

10. $^{19}\mathrm{F}(\mathrm{n, p})^{19}\mathrm{O}$ $\qquad Q_m = -4.037$

See (1986HEZW; $E_n = 200$ MeV).

Table 19.4: Levels of ^{19}O from ^{17}O(t, p) and ^{18}O(d, p)

E_x (MeV ± keV) [a]	$\Gamma_{c.m.}$ (keV) [a]	l_n [b]	L [c]	S [d]	J^π
0		2	0	0.57	$\frac{5}{2}^+$
0.0960 ± 0.5		2	2		$\frac{3}{2}^+$
1.4719 ± 0.5		0	2	1.00	$\frac{1}{2}^+$
2.3715 ± 1.0		2	$(2+4)$		$\frac{9}{2}^+$
2.7790 ± 0.9		(2)	2		$\frac{7}{2}^+$
3.0671 ± 2.6			$(2+4)$		$\frac{3}{2}^+$
3.1535 ± 2.4		2	$(0+2)$	(0.06)	$\frac{5}{2}^+$
3.237 ± 5		[a]			$\frac{3}{2}^+$
3.944 ± 3		1		0.11	$\frac{3}{2}^-$
4.118 ± 5	< 15	2	(2)	0.03	$\frac{3}{2}^+$
4.333 ± 12	< 15				
4.402 ± 12	< 15				
4.584 ± 12	75 ± 5	1		0.15	$\frac{3}{2}^-$
4.707 ± 12	< 15	2	[a]	0.02	$\frac{5}{2}^+$
4.998 ± 12	< 15				
5.150 ± 10	< 15	2	[a]	0.08	$\frac{5}{2}^+$
5.455 ± 10	320 ± 25	2	$(2+4)$	0.85	$\frac{3}{2}^+$
5.502 ± 12	< 15				
5.714 ± 12	< 15	2		0.17	$(\frac{3}{2}^+)$
6.280 ± 12	< 15	3		0.13	$\frac{7}{2}^-$
6.480 ± 15					
6.560 ± 15					
6.899 ± 15					
6.997 ± 15					
7.117 ± 15					
7.248 ± 15					

[a] For references see Table 19.3 in (1978AJ03). However there are a number of errors in that table which have been corrected here. I am grateful to Prof. F.C. Barker for pointing them out.
[b] ^{18}O(d, p)^{19}O.
[c] ^{17}O(t, p)^{19}O.
[d] $E_{\vec{d}} = 14.8$ MeV: polarization and differential cross section measurements. The spectroscopic factors for the states with $E_x > 4.1$ MeV have been calculated in the weakly bound approximation: see (1978AJ03).

Table 19.5: Resonances in ^{18}O(n, n)^{18}O [a]

$E_{\rm res}$ (MeV ± keV)	Γ (keV)	^{19}O* (MeV)	J^π
0.67	52 ± 3 [b]	4.59	$\frac{3}{2}^-$
1.18	49 ± 5 [b]	5.07	$\frac{1}{2}^-$
1.256 ± 10 [b]	3.4 ± 1.0 [b]	5.146	$\geq \frac{5}{2}^{(+)}$
1.42 [c]		5.30	$\frac{3}{2}^-$
1.67	490	5.54	$\frac{3}{2}^+$
1.840 ± 10 [b]	7.8 ± 1.4 [b]	5.699	$\frac{7}{2}^-, \frac{5}{2}$
2.22	110	6.06	$\frac{3}{2}^+$
2.45	19.2 ± 2.4 [b]	6.28	$\frac{7}{2}^-$
6.00		9.64	$\frac{7}{2}^-$
6.21		9.84	$\frac{7}{2}^-$
6.60		10.21	$\frac{7}{2}^-$
7.08 [d]		10.66	$\frac{7}{2}^-$

[a] These data are from a multi-level R-matrix re-analysis by (1986KO10) of the work displayed in Table 19.4 of (1978AJ03), together with unpublished $\sigma_{\rm t}$ data by G.F. Auchampaugh, and $\sigma(\theta)$ for n_0 and n_1 for $5.0 < E_{\rm n} < 7.5$ MeV. Uncertainties in $E_{\rm x}$ and Γ cannot be estimated. See also (1986KO10) for other states. I am indebted to Dr. Paul E. Koehler for additional comments.

[b] See Table 19.4 of (1978AJ03): $\Gamma_{\rm c.m.}$.

[c] See discussion in (1986KO10).

[d] May be a doublet, but at least one of the states has $J^\pi = \frac{7}{2}^-$ (1986KO10).

^{19}F

(Fig. 6 and 8)

GENERAL: (See also (1983AJ01).)

Shell model: (1978WI1B, 1979GO13, 1982RA1N, 1983BR29, 1983PO02, 1984MI1H, 1984RA13, 1985BR15, 1986WA1R, 1987KA09).

Cluster, collective and rotational models: (1979GO13, 1982RA1N, 1984ME02, 1985DI16, 1985MO20, 1985OH01, 1987DE05, 1987KA09).

Special states: (1978WI1B, 1982RA1N, 1983BI1C, 1983BR29, 1983CS01, 1983PO02, 1984AD1E, 1984HO1H, 1984ME02, 1984MI1H, 1984RA13, 1984WI17, 1985AD1A, 1985BR15, 1985DI16, 1985MI10, 1985MO20, 1986AN07, 1986CA27, 1986HA1Q, 1986KA1D, 1986WI1P, 1987DE05).

Electromagnetic transitions and giant resonances: (1982BR24, 1983BR29, 1983IS1F, 1983KA28, 1984CA02, 1984MI1H, 1985AD1A, 1985AL21, 1985DI16, 1986CA27, 1986ER1A, 1987DE05).

Astrophysical questions: (1981WA1Q, 1982CA1A, 1982NO1D, 1982WI1B, 1982WO1A, 1983AL23, 1983SI1B, 1984CO1H, 1985DW1A).

Applications: (1982CO1K, 1982MA1Q, 1983AM1A, 1983BI1M, 1983DE2J, 1983DU1D, 1983TO1F, 1984CA1D, 1985TO1J, 1986KL1B, 1986PI1E, 1987KH1D, 1987KH1A, 1987KN01).

Complex reactions involving ^{19}F: (1982HO10, 1983DE26, 1983JA05, 1983LE1F, 1983SO08, 1983WI1A, 1984BE22, 1984FI17, 1984GR08, 1984HI1A, 1984HO23, 1984NA12, 1984RA10, 1984SI15, 1985AG1A, 1985BE40, 1985GR1J, 1985HO05, 1985MC03, 1985MO08, 1985OS05, 1985PO11, 1985WA22, 1986AI1A, 1986FE03, 1986GR1A, 1986GR1B, 1986HA1B, 1986PL02, 1986PO06, 1986SA30, 1986SC28, 1986SC29, 1986SH2B, 1986SH1F, 1986SO10, 1986VA23, 1986WE1C, 1987KO15, 1987PA01, 1987RI03).

Muon and neutrino capture and reactions: (1984GR03, 1987SU06).

Pion capture and reactions: (1982BI08, 1982LI15, 1983GE12, 1983GM1A, 1983MA16, 1985BI01, 1986NA1K, 1986RO03, 1987KA09).

Anti-nucleon interactions: (1984GI11, 1986RO23, 1986SP01, 1987PO05).

Hypernuclei: (1984AS1D).

Other topics: (1978WI1B, 1981CL05, 1982HA43, 1983AD1B, 1983AR1J, 1983BI1C, 1983BR29, 1983SH32, 1984HO1H, 1984MI1H, 1984WI17, 1985AD1A, 1985AL21, 1985AN28, 1985MI10, 1986LA29, 1986NA1K).

Ground state of ^{19}F: (1978WI1B, 1982HA43, 1982LO13, 1983ANZQ, 1983AR1J, 1983BR27, 1983BU07, 1983RO1E, 1984AN1B, 1984AR1D, 1984WE04, 1985AN28, 1985HA18, 1985NA1A, 1986CA27, 1986RO03, 1987BR1F).

Table 19.6: Energy levels of ^{19}F [a]

E_x (MeV $\pm$ keV)	$J^\pi; T$	K^π	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
0	$\frac{1}{2}^+; \frac{1}{2}$	$\frac{1}{2}^+$	stable		7, 9, 10, 13, 14, 15, 16, 18, 19, 20, 21, 22, 23, 28, 29, 30, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53
0.109894 ± 0.005	$\frac{1}{2}^-$	$\frac{1}{2}^-$	$\tau_m = 0.853 \pm 0.010$ nsec	γ	7, 9, 13, 15, 16, 21, 23, 29, 30, 33, 34, 35, 37, 40, 49, 51, 53
0.197143 ± 0.004	$\frac{5}{2}^+$	$\frac{1}{2}^+$	128.8 ± 1.5 nsec $\lvert g\rvert = 1.441 \pm 0.003$	γ	6, 7, 10, 13, 14, 15, 16, 21, 22, 23, 29, 30, 34, 35, 36, 37, 40, 42, 44, 49, 51
1.34567 ± 0.13	$\frac{5}{2}^-$	$\frac{1}{2}^-$	4.13 ± 0.06 psec $\lvert g\rvert = 0.27 \pm 0.04$	γ	7, 9, 10, 14, 15, 16, 21, 23, 29, 30, 34, 35, 36, 37, 40
1.4587 ± 0.3	$\frac{3}{2}^-$	$\frac{1}{2}^-$	90 ± 20 fsec	γ	9, 10, 15, 16, 21, 29, 33, 34, 35, 36, 37, 40, 44, 51
1.554038 ± 0.009	$\frac{3}{2}^+$	$\frac{1}{2}^+$	5 ± 3 fsec	γ	7, 14, 15, 16, 21, 22, 23, 28, 29, 30, 34, 35, 36, 37, 40, 42, 44, 49, 51
2.779849 ± 0.034	$\frac{9}{2}^+$	$\frac{1}{2}^+$	280 ± 30 fsec	γ	2, 3, 5, 7, 10, 12, 14, 15, 16, 19, 21, 22, 28, 29, 34, 35, 36, 40, 42, 44, 50, 51
3.90817 ± 0.20	$\frac{3}{2}^+$	$\frac{3}{2}^+$	9 ± 5 fsec	γ	7, 15, 16, 21, 23, 29, 30, 33, 34, 36, 40, 51
3.9987 ± 0.7	$\frac{7}{2}^-$	$\frac{1}{2}^-$	19 ± 7 fsec	γ	7, 15, 16, 21, 28, 29, 34, 36, 40, 51

Table 19.6: Energy levels of ^{19}F [a] (continued)

E_x (MeV ± keV)	$J^\pi; T$	K^π	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
4.0325 ± 1.2	$\frac{9}{2}^-$	$\frac{1}{2}^-$	67 ± 15 fsec	γ	7, 10, 14, 15, 16, 21, 28, 34, 36, 40, 51
4.377700 ± 0.042	$\frac{7}{2}^+$	$\frac{3}{2}^+$	< 11 fsec	γ	7, 14, 15, 16, 21, 22, 23, 28, 29, 30, 34, 36, 40, 51
4.5499 ± 0.8	$\frac{5}{2}^+$	$\frac{3}{2}^+$	< 50 fsec	γ	7, 15, 16, 21, 23, 34, 36, 40, 51
4.5561 ± 0.5	$\frac{3}{2}^-$		17^{+10}_{-8} fsec	γ	7, 15, 16, 23, 28, 29, 34, 36, 40, 51
4.648 ± 1	$\frac{13}{2}^+$	$\frac{1}{2}^+$	3.7 ± 0.4 psec	γ	14, 15, 16, 21, 22, 23, 34, 40, 51
4.6825 ± 0.7	$\frac{5}{2}^-$		15.4 ± 3.0 fsec	γ, α	7, 15, 19, 21, 23, 28, 29, 34, 36, 40, 51
5.1066 ± 0.9	$\frac{5}{2}^+$		< 30 fsec	γ, α	7, 15, 16, 21, 23, 28, 29, 34, 36, 40, 51
5.337 ± 2	$\frac{1}{2}^{(+)}$		≤ 0.1 fsec	γ, α	7, 15, 16, 21, 23, 29, 34, 36, 40, 51
5.418 ± 1	$\frac{7}{2}^-$		$\Gamma = (2.6 \pm 0.7) \times 10^{-3}$	γ, α	3, 7, 15, 21, 23, 29, 34, 36, 40
5.4635 ± 1.5	$\frac{7}{2}^+$	$\frac{1}{2}^+$	$\tau_m \leq 0.26$ fsec	γ, α	7, 10, 14, 15, 16, 21, 22, 23, 34, 36, 40
5.5007 ± 1.7	$\frac{3}{2}^+$		$\Gamma = 4 \pm 1$ keV	γ, α	7, 8, 16, 21, 23, 34, 36, 40
5.535 ± 2	$\frac{5}{2}^+$			γ, α	7, 21, 23, 34, 36, 40, 51
5.621 ± 1	$\frac{5}{2}^-$		$\tau_m < 1.3$ fsec	γ, α	7, 21, 23, 28, 29, 34, 36, 40, 50, 51
5.938 ± 1	$\frac{1}{2}^+$			γ, α	7, 23, 28, 29, 34, 36, 51
6.070 ± 1	$\frac{7}{2}^+$		$\Gamma = 1.2$	γ, α	7, 21, 34, 36

Table 19.6: Energy levels of ^{19}F [a] (continued)

E_x (MeV ± keV)	$J^\pi; T$	K^π	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
6.088 ± 1	$\frac{3}{2}^-$		4	γ, α	7, 10, 15, 16, 21, 23, 34, 36, 51
6.100 ± 2	$\frac{9}{2}^-$			γ	23, 34
6.1606 ± 0.9	$\frac{7}{2}^-$		$(3.7 \pm 1.0) \times 10^{-3}$	γ, α	3, 7, 23, 34, 36, 51
6.255 ± 1	$\frac{1}{2}^+$		8	α	8, 21, 23, 28, 29, 34, 36, 51
6.282 ± 2	$\frac{5}{2}^+$		2.4	γ, α	7, 8, 14, 21, 23, 28, 34, 36
6.330 ± 2	$\frac{7}{2}^+$		2.4	γ, α	7, 8, 10, 21, 34, 36
6.429 ± 8	$\frac{1}{2}^-$		280	α	8, 34
6.4967 ± 1.4	$\frac{3}{2}^+$			γ, α	7, 16, 21, 23, 29, 34
6.5000 ± 0.9	$\frac{11}{2}^+$	$\frac{3}{2}^+$		γ, α	7, 16, 22, 23, 34
6.5275 ± 1.4	$\frac{3}{2}^+$		4	γ, α	7, 14, 16, 21, 23, 34
6.554 ± 2	$\frac{7}{2}^{(+)}$		1.6	γ, α	7, 21, 34
6.592 ± 2	$\frac{9}{2}^+$	$\frac{3}{2}^+$	$(7.6 \pm 1.8) \times 10^{-3}$	γ, α	3, 7, 14, 21, 23, 29, 34
6.787 ± 2	$\frac{3}{2}^-$		$(6.9 \pm 1.1) \times 10^{-3}$	γ, α	7, 8, 21, 23, 29, 34
6.8384 ± 0.9	$\frac{5}{2}^+$		1.2	γ, α	7, 8, 21, 23, 34
6.891 ± 4	$\frac{3}{2}^-$		28	γ, α	7, 8, 21, 34
6.9265 ± 1.7	$\frac{7}{2}^-$		2.4	γ, α	7, 8, 10, 14, 15, 21, 23, 29, 34
6.989 ± 3	$\frac{1}{2}^-$		51	α	8, 23, 34
7.114 ± 6	$\frac{7}{2}^+$		32	α	8, 29, 34
7.1662 ± 0.7	$\frac{11}{2}^-$		$(6.9 \pm 1.1) \times 10^{-3}$	γ, α	3, 7, 23, 34
7.262 ± 2	$\frac{3}{2}^+$		< 6	α	8, 14, 15, 16, 23, 28, 29, 34, 42
7.364 ± 4	$\frac{1}{2}^+$			α	16, 23, 28, 29, 34
7.5396 ± 0.9	$\frac{5}{2}^+; \frac{3}{2}$		(c)	γ, α	7, 8, 10, 14, 23, 29, 34
7.56 ± 10	$\frac{7}{2}^+$		< 90	α	8
7.587	$(\frac{5}{2}^-)$			γ	34

Table 19.6: Energy levels of ^{19}F [a] (continued)

E_x (MeV $\pm$ keV)	$J^\pi; T$	K^π	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
7.6606 ± 0.9	$\frac{3}{2}^+; \frac{3}{2}$			γ, α	7, 23, 29, 33, 34, 52
7.702 ± 5	$\frac{1}{2}^-$		< 30	α	8, 14, 23, 29, 34
7.74 ± 40	$(\frac{5}{2}, \frac{7}{2})^-$		< 6		34, 42
(7.90)			< 200	α	8
7.929 ± 3	$\frac{7}{2}^+; \frac{9}{2}$			γ, α	7, 14, 16
7.937 ± 3	$\frac{11}{2}^+$			γ, α	7, 22
8.0140 ± 1.0	$\frac{5}{2}^+$			p	29
8.084 ± 3			≤ 3	p, α	8, 27, 29
8.1377 ± 1.2	$\frac{1}{2}^+$		≤ 0.3	γ, p, α	8, 23, 27, 28, 29
(8.16)			< 50	α	8
8.1990 ± 1.0	$(\frac{5}{2}^+)$		≤ 1	γ, p, α	8, 23, 27, 29
8.2543 ± 2.6	$(\frac{5}{2}, \frac{7}{2})^-$		≤ 1.5	γ, p	23, 29, 42
8.288 ± 2	$\frac{13}{2}^-$	$(\frac{1}{2}^-)$	< 1 [c]	γ, α	3, 7, 8, 9, 10, 11, 12, 14, 15
8.3100 ± 1.2	$\frac{5}{2}^+$		0.047 ± 0.019	γ, p, α	7, 23, 27, 29
8.370 ± 4	$\frac{7}{2}, \frac{5}{2}^+$		7.5 ± 1.5	γ, α	7
8.5835 ± 1.6	$\frac{5}{2}^+$		≤ 0.5	γ, p, α	7, 23
8.5919 ± 1.0	$\frac{3}{2}^-$		2.0 ± 0.1	γ, p, α	7, 14, 23, 25, 27, 29
8.629 ± 4	$\frac{7}{2}^-$		< 1 [c]	γ, α	7, 8, 42
8.65	$\frac{1}{2}^+$		≈ 300	γ, p, α	23, 25, 27
8.7932 ± 1.5	$\frac{1}{2}^+; \frac{3}{2}$		46 ± 2	γ, p	23, 25, 27, 29
8.864 ± 4	$< \frac{9}{2}$		≈ 1	γ, α	7
8.9267 ± 2.8	$\frac{3}{2}^-$		3.6 ± 0.2	γ, p, α	14, 15, 23, 25, 27
8.953 ± 3	$\frac{11}{2}^-$		≈ 1 [c]	γ, α	3, 7, 8, 9, 10, 11, 12
9.030 ± 5	$\frac{5}{2}, \frac{7}{2}$		4.2 ± 1	γ, α	7
9.0997 ± 0.7	$\frac{7}{2}^-$		0.57 ± 0.03	γ, p, α	7, 23, 25, 27
9.101 ± 4	$\frac{7}{2}^+, \frac{9}{2}^+$		≈ 1	γ, α	7, 29
9.167 ± 1.4	$\frac{1}{2}^+$		6.2 ± 0.5	γ, p, α	7, 25, 27, 29
9.204 ± 7	$\frac{3}{2}$		10.2 ± 1.5	γ, α	7

Table 19.6: Energy levels of ^{19}F [a] (continued)

E_x (MeV $\pm$ keV)	$J^\pi; T$	K^π	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
9.267 ± 4	$\frac{11}{2}^+, \frac{9}{2}^+$		2 ± 1	γ, α	7
9.280 ± 5	$(\frac{7}{2}, \frac{9}{2})^+$		< 1.5	γ, α	7, 42
9.318 ± 2	$\frac{3}{2}^+$		3.4 ± 0.7	γ, p, α	7, 14, 23
9.321 ± 1.1	$\frac{1}{2}^+$		5.0 ± 0.2	p, α	25, 27
9.329 ± 4	$< \frac{5}{2}$		≈ 6	γ, α	7
9.509 ± 4	$\frac{5}{2}^+, \frac{7}{2}^+$ [c]		< 1 [c]	γ, α	7, 8
9.527 ± 6	$(\frac{5}{2})$		28	p, α	25, 27
9.5364 ± 2.0	$\frac{5}{2}^+$		6.3 ± 1.5	γ, p, α	7, 23
9.566 ± 3	$\frac{3}{2}^-$		26 ± 3	γ, p	23
9.575 ± 4	$\frac{3}{2}^-$		67 ± 3	γ, p, α	23, 25, 27
9.586 ± 3	$\frac{7}{2}$		8.9 ± 1.2	γ, p, α	7, 23, 29
9.642 ± 6	$\frac{3}{2}, \frac{5}{2}$		≈ 8	γ, α	7
9.654 ± 6	$\frac{3}{2}, \frac{5}{2}$		≈ 6	γ, α	7
9.6675 ± 1.5	$\frac{3}{2}^+$		3.6 ± 0.4	γ, p, α	7, 23, 25, 27, 29
9.710 ± 4	$\frac{9}{2}^+, \frac{11}{2}^-$ [c]		< 1 [c]	γ, α	3, 7, 8, 14
9.820 ± 1.0	$\frac{5}{2}^-$		0.3 ± 0.05	γ, p, α	7, 23, 25, 27
9.834 ± 3	$\frac{11}{2} \rightarrow \frac{15}{2}$		< 1 [c]	γ, α	7, 8
9.8740 ± 1.8	$\frac{11}{2}^-$		$(2.6 \pm 0.6) \times 10^{-3}$	γ, p, α	3, 7, 8, 14, 15, 23
9.887 ± 3	$\frac{1}{2}^+$		25 ± 2	γ, p, α	23, 25, 27
9.926 ± 3	$\frac{9}{2}^+$ [c]		≈ 1 [c]	γ, α	3, 7, 8
10.088 ± 5	$\frac{5}{2}^-, \frac{7}{2}^-$ [c]		< 1.5 [c]	γ, α	7, 8, 10
10.137 ± 0.8	$\frac{3}{2}^-$		4.3 ± 0.6	γ, p, α	7, 23, 27
10.162 ± 3	$\frac{1}{2}^+$		31	p, α	25, 27
10.232 ± 3	$\frac{1}{2}^+$		< 1	p, α	8, 25, 27
10.254 ± 3	$\frac{1}{2}^+$		22	p, α	25, 27
10.308 ± 4	$\frac{3}{2}^+$		9.2	p, α	8, 16, 25, 27
10.365 ± 4	$\frac{7}{2} \rightarrow \frac{11}{2}$		3 ± 1.5	γ, α	7, 29
10.411 ± 3	$\frac{13}{2}^+$	$\frac{3}{2}^+$	< 1.5 [c]	γ, α	3, 7, 8, 10, 14, 15, 16, 23, 50
10.469 ± 4			11.0 ± 1.2	p, α	8
10.488 ± 4			4.8 ± 0.8	p, α	8

Table 19.6: Energy levels of ^{19}F [a] (continued)

E_x (MeV $\pm$ keV)	$J^\pi; T$	K^π	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
10.4963 ± 1.3	$\frac{3}{2}^+$		5.7 ± 0.6	n, p, α	8, 24, 25, 27
10.521 ± 4			14 ± 2	p, α	8, 29
10.5423 ± 1.1			2.5 ± 0.2	n, p, α	8, 24
10.555 ± 3	$\frac{3}{2}^+; (\frac{3}{2})$		4.0 ± 1.2	p, α	8, 25, 27
10.5647 ± 2.0			4.6 ± 0.7	n, p, α	8, 24
10.581 ± 4	$(\frac{5}{2}^+)$		22 ± 3	p, α	25, 27
10.6143 ± 1.6	$\frac{5}{2}^+; \frac{3}{2}$		4.7 ± 0.5	n, p, α	24, 25, 27
10.7633 ± 2.5	$\frac{1}{2}^-$		6 ± 3	n, p, α	14, 24, 25, 27
10.8597 ± 1.9	$\frac{5}{2}^+$		24.0 ± 1.5	n, p, α	24, 25, 27
10.927 ± 8				γ	3
10.9750 ± 2.5	$(\frac{3}{2}, \frac{5}{2})^+$		14 ± 2	n, p, α	24, 25, 27
10.989 ± 2.5			7 ± 2	n, p	24
11.072 ± 2.7	$\frac{1}{2}^+$		35 ± 4	n, p, α	24, 25, 27
11.188 ± 4	$(\frac{1}{2}^-)$		17 ± 4	n, p, α	24, 25, 27
11.273 ± 3			7 ± 2	n, p	24
11.286 ± 7	$\frac{5}{2}^+$		22 ± 5	n, p, α	24, 25, 27
11.35 ± 25	$\frac{1}{2}^+$		272 ± 31	p	25
11.450 ± 3.5	$\frac{1}{2}^-$		38 ± 7	n, p, (α)	14, 24, 25, 27
11.478 ± 5			7 ± 3	n, p	24
11.502 ± 5	$(\frac{3}{2}^-)$		4 ± 2	n, p, α	24, 25, 27
11.540 ± 7	$\frac{5}{2}^+$		22 ± 5	n, p, α	24, 25, 27
11.569 ± 7	$(T = \frac{3}{2})$		15 ± 10	n, p	24
11.603 ± 12	$\frac{3}{2}^-$		63 ± 7	n, p	24, 25
11.653 ± 4	$\frac{3}{2}^+; (\frac{3}{2})$		33 ± 6	n, p, (α)	10, 14, 24, 25, 27
11.84 ± 10			< 50	n, p	24
11.93 ± 10			90	n, p	24
12.04 ± 20	$\frac{1}{2}^-$		71 ± 24	p, α	10, 25, 27
12.136 ± 8	$\frac{3}{2}^-; \frac{3}{2}$		105 ± 14	n, p, (α)	24, 25, 27
12.222 ± 12	$\frac{3}{2}^+$		74 ± 1	n, p, α	24, 25, 27
12.522 ± 7	$\frac{1}{2}^-$		15 ± 4	p	25
12.577 ± 10	$\frac{5}{2}^+$		48 ± 10	p, α	25, 27

Table 19.6: Energy levels of ^{19}F [a] (continued)

E_x (MeV ± keV)	$J^\pi; T$	K^π	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
12.58 ± 25	$\frac{1}{2}^-; \frac{3}{2}$		285 ± 48	p	25
12.78 ± 10	$\frac{5}{2}^+; \frac{3}{2}$		95 ± 38	n, p, (α)	14, 24, 25, 27
12.86 ± 30	$\frac{3}{2}^+; \frac{3}{2}$		276 ± 38	p	25
12.94 ± 25	$\frac{5}{2}^+$		71 ± 24	p, α	25, 27
12.98 ± 50	$\frac{1}{2}^-$		124 ± 38	p	25
13.068 ± 4	$\frac{1}{2}^+$		≤ 10	n, p, t	13, 24
13.09 ± 75	$\frac{3}{2}^-$		285 ± 71	p	25
13.17 ± 15			70	n, p	24
13.245 ± 10	$\frac{1}{2}^-$		7	t	13
13.270 ± 10	$\frac{1}{2}^+$		4.5	t	13
13.317 ± 8	$\frac{7}{2}^-; (\frac{3}{2})$		28 ± 6	n, p, α	24, 25, 27
13.36 ± 25	$\frac{3}{2}^-$		38 ± 19	p	25
13.532 ± 10	$\frac{1}{2}^+$		22	t	13
13.732 ± 11	$\frac{7}{2}^-; \frac{3}{2}$		52 ± 10	n, p, (α)	15, 24, 25, 27
13.878 ± 15	$\frac{1}{2}^+$		101	t	13
14.04 ± 20	$\frac{5}{2}^+$		141 ± 28	p	25
14.10 ± 21	$\frac{3}{2}^-$		84 ± 28	p	10, 15, 25
14.147 ± 20	$\frac{1}{2}^+$		21	t	13
14.24 ± 15			350	n, p	24
14.255 ± 15	$\frac{3}{2}^+$		51	t	13
14.33 ± 20	$\frac{3}{2}^-$		76 ± 28	p	25
14.352 ± 10	$\frac{1}{2}^+$		154	t	13
14.46 ± 25	$\frac{3}{2}^+$		179	t	13
14.46 ± 25	$\frac{5}{2}^+$		46	t	13
14.70 ± 20	$\frac{3}{2}^-$		124 ± 38	p	25
14.72 ± 70	$\frac{1}{2}^-$		257 ± 67	α	27
14.74 ± 50	$\frac{1}{2}^+$		361 ± 67	p, α	25, 27
14.78 ± 20	$\frac{5}{2}^+$			n, p	24, 25
14.92 ± 30	$\frac{7}{2}^-$			p	10, 15, 25
15.00 ± 20				n, p	24
15.36 ± 20	$\frac{1}{2}^-$			p	25

Table 19.6: Energy levels of ^{19}F [a] (continued)

E_x (MeV ± keV)	$J^\pi; T$	K^π	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
15.40 ± 30	$\frac{5}{2}^+$			p	25
15.56 ± 30					15
15.77 ± 21	$\frac{3}{2}^-$		150	n, p	24
16.09 ± 50					10
16.20 ± 40	$\frac{3}{2}^+$			p	25
16.23 ± 30	$\frac{7}{2}^-$			p	25
16.28 ± 20	$\frac{3}{2}^-$		200	n, p	24, 25
16.45 ± 50					10
16.80 ± 30				n, p	24
17.05 ± 40	$\frac{3}{2}^-$		331 ± 67	p	25
17.16 ± 40	$\frac{7}{2}^-$		323 ± 67	p	25
17.45 ± 30	$\frac{3}{2}^-$		32 ± 19	p	10, 25
17.65 ± 60	$\frac{7}{2}^-$		95 ± 57	p	25
17.93 ± 40	$\frac{3}{2}^-$		255 ± 57	p	25
18.03 ± 60	$\frac{7}{2}^-$		365 ± 57	p	10, 25
18.92 ± 30					10
19.07 ± 60	$\frac{3}{2}^-$		555 ± 143	p	25
19.83 ± 150	$\frac{5}{2}^-$		369 ± 57	p	25
19.89 ± 30	$\frac{3}{2}^-$		473 ± 57	p	10, 25
20.81 ± 50	$\frac{1}{2}^-$		412 ± 57	p	25
20.93 ± 50	$\frac{3}{2}^-$		317 ± 48	p	25
21.05 ± 40 [b]	$\frac{7}{2}^-$		448 ± 29	p	25

[a] See also Tables 19.7 and 19.8.

[b] For evidence of additional states see reaction 32.

[c] See Table 19.11.

$$\langle r^2 \rangle^{1/2} = 2.885\ (15)\ \text{fm [see (1978AJ03)]}$$

$$\mu_{g.s.} = +2.628866\ (8)\ \text{nm (1978LEZA)}$$

$$\mu_{0.197} = +3.607\ (8)\ \text{nm (1978LEZA)}$$

$$Q_{0.197} = -0.12 \pm 0.02\ \text{b (1978LEZA).}$$

1. ^{12}C(^{7}Li, ^{7}Li)^{12}C $E_b = 16.3942$

Vector analyzing power measurements for the elastic scattering have been reported at $E(^{7}\vec{\rm Li}) = 21.1$ MeV (1984MO06). Fusion cross sections have been measured by (1982DE30). For other channels in the interaction of ^{12}C+^{7}Li see (1978AJ03, 1983AJ01). See also (1986KA1C, 1986MO1E) and (1985SA13, 1986YO1A; theor.).

2. ^{12}C(^{9}Be, d)^{19}F $Q_m = -0.3007$

For excitation curves and angular distributions involving unresolved states and ^{19}F*(2.78) see (1983AJ01) and (1982HU06, 1983JA09). See also (1986BE19; theor.).

3. (a) ^{12}C(^{11}B, α)^{19}F $Q_m = 7.7305$
(b) ^{12}C(^{12}C, αp)^{19}F $Q_m = -8.2266$
(c) ^{12}C(^{14}N, ^{7}Be)^{19}F $Q_m = 11.4179$

States in ^{19}F with $5.4 < E_x < 11.0$ MeV observed in reaction (a) are displayed in Table 19.9. For reaction (b) see (1982SA27). See also (1983AJ01).

4. (a) ^{13}C(^{6}Li, t)^{16}O $Q_m = 6.9977$ $E_b = 18.6980$
(b) ^{13}C(^{6}Li, α)^{15}N $Q_m = 14.6842$
(c) ^{13}C(^{6}Li, ^{6}Li)^{13}C

Uncorrelated structures have been observed in the excitation functions for reactions (a) and (b). Fusion cross sections have also been measured: see (1983AJ01). See also (1981GL02) for reaction (a), ^{13}C and ^{15}N in (1986AJ01) and ^{16}O in (1986AJ04).

5. ^{13}C(^{9}Be, t)^{19}F $Q_m = 1.0102$

See (1983AJ01).

Table 19.7: Radiative transitions in ^{19}F [a]

E_i (MeV)	J^π_i	E_f (MeV)	Branching ratios (%)	δ
0.110	$\frac{1}{2}^-$	0	100	
0.197	$\frac{5}{2}^+$	0	100	
		0.110	< 0.06	
1.35	$\frac{5}{2}^-$	0.110	96.8 ± 1	0.0 ± 0.7 [b]
		0.197	3.2 ± 1	
1.46	$\frac{3}{2}^-$	0	20.5 ± 0.7	0.01 ± 0.03
		0.110	68.8 ± 0.9	0.248 ± 0.020
		0.197	10.7 ± 0.5	
		1.35	< 0.2 [h]	
1.55	$\frac{3}{2}^+$	0	2.55 ± 0.10	
		0.110	4.85 ± 0.12	
		0.197	92.6 ± 0.2	
		1.35	< 0.011 [h]	
		1.46	< 0.14 [h]	
2.78	$\frac{9}{2}^+$	0.197	100	
3.91	$\frac{3}{2}^+$	0	48 ± 2	
		0.110	17 ± 2	
		0.197	14 ± 2	
		1.55	21 ± 3	
4.00	$\frac{7}{2}^-$	0.197	18 ± 4	
		1.35	70 ± 4	
		1.46	12 ± 6	
4.03	$\frac{9}{2}^-$	1.35	100	
4.38 [c]	$\frac{7}{2}^+$	0	< 5	
		0.110	< 2	
		0.197	80.5 ± 2.0	0.155 ± 0.022
		2.78	19.5 ± 1.0	-0.16 ± 0.07
4.55 [d]	$\frac{5}{2}^+$	0.197	69 ± 7	
		1.35	5 ± 3	
		1.46	8 ± 3	
		1.55	18 ± 4	

Table 19.7: Radiative transitions in ^{19}F [a] (continued)

E_{i} (MeV)	J^{π}_{i}	E_{f} (MeV)	Branching ratios (%)	δ
4.56	$\frac{3}{2}^{-}$	0	36 ± 4	
		0.110	45 ± 5	
		0.197	9 ± 3	
		1.35	4 ± 3	
		1.46	< 4	
		1.55	6 ± 3	
4.65	$\frac{13}{2}^{+}$	2.78	100	$\|M\|^2 = 3.1 \pm 0.3$ W.u.
4.68	$\frac{5}{2}^{-}$	0.197	5.6 ± 0.9	$0 < \delta < 2.0$
		1.35	63.1 ± 3.8	$-0.22^{+0.14}_{-0.24}$
		1.46	31.3 ± 2.2	0.0 ± 0.24 or $2.0^{+1.5}_{-0.6}$
5.11 [i]	$\frac{5}{2}^{+}$	[j]	79.7 ± 3.7	$\Gamma_{\gamma}/\Gamma = 0.83 \pm 0.10$
		1.35	< 1.6	
		1.46	10.4 ± 2.7	$\|\delta\| < 1.4$
		1.55	1.8 ± 1.8	
		2.78	0.7 ± 0.6	
		3.91	5.4 ± 0.9	$\delta = 0.0 \pm 0.3$
		4.38	2.0 ± 0.5	
5.34	$\frac{1}{2}^{(+)}$	0	37 ± 4	
		0.110	42 ± 4	
		1.46	20 ± 2	
5.42	$\frac{7}{2}^{-}$	1.35	70	
		1.46	13	
		4.00	10	
		4.03	6	
5.46	$\frac{7}{2}^{+}$	0.197	4	
		1.35	32	
		1.55	5	
		2.78	59	
5.50	$\frac{3}{2}^{+}$	0.110	25	
		0.197	49	
		1.35	16	

Table 19.7: Radiative transitions in ^{19}F [a] (continued)

$E_{\rm i}$ (MeV)	$J^{\pi}_{\rm i}$	$E_{\rm f}$ (MeV)	Branching ratios (%)	δ
		1.55	11	
5.54	$\frac{5}{2}^+$	0	7	
		0.197	47	
		1.46	45	
5.62	$\frac{3}{2}^-$	0.197	39 ± 4	
		1.35	61 ± 4	
5.94	$\frac{1}{2}^+$	0	7 ± 4	
		0.110	20 ± 6	
		0.197	2 ± 1	
		1.46	63 ± 6	0.25 ± 0.02
		1.55	< 2	
		3.91	8 ± 3	0.28 ± 0.09
6.07	$\frac{7}{2}^+$	0.197	54 ± 5	-0.26 ± 0.02
		1.35	19 ± 2	
		1.55	$1^{+1}_{-0.5}$	0.035 ± 0.023
		2.78	23 ± 3	0.06 ± 0.08
		4.38	4 ± 1	
6.09	$\frac{3}{2}^-$	0	25 ± 4	-0.021 ± 0.014
		0.110	61 ± 5	0.045 ± 0.021
		0.197	14 ± 3	0.014 ± 0.043
6.16	$\frac{7}{2}^-$	0.197	31 ± 3	-0.045 ± 0.025
		1.35	65 ± 4	0.077 ± 0.007
		1.46	1.3 ± 0.6	
		4.00	1.6 ± 0.6	
		4.03	2.3 ± 0.3	
6.28	$\frac{5}{2}^+$	0	14 ± 2	-0.05 ± 0.07
		0.197	4.2 ± 1.0	
		1.35	36 ± 2	-0.01 ± 0.09
		1.46	26 ± 2	-0.02 ± 0.04
		1.55	20 ± 2	0.11 ± 0.06
6.33	$\frac{7}{2}^+$	0.197	56 ± 3	-0.27 ± 0.24

Table 19.7: Radiative transitions in ^{19}F [a] (continued)

E_i (MeV)	J_i^π	E_f (MeV)	Branching ratios (%)	δ
		1.35	17 ± 2	-0.02 ± 0.03
		1.55	8.5 ± 1.5	0.00 ± 0.14
		4.38	18 ± 2	0.04 ± 0.20
6.497	$\frac{3}{2}^+$	0	38 ± 2	-0.06 ± 0.04 or 2.00 ± 0.17
		0.110	14 ± 2	0.00 ± 0.03
		0.197	9 ± 2	$0.3 \rightarrow 1.8$
		1.35	14 ± 2	-0.11 ± 0.09
		1.46	25 ± 2	0.00 ± 0.07
6.500	$\frac{11}{2}^+$	2.78	55	
		4.65	45	
6.53	$\frac{3}{2}^+$	0	29 ± 2	0.32 ± 0.04 or 0.90 ± 0.06
		0.110	59 ± 3	0.00 ± 0.02
		4.55	12 ± 2	-0.23 ± 0.13
6.55	$\frac{7}{2}^{(+)}$	0.197	19 ± 2	0.03 ± 0.05
		1.35	55 ± 4	0.01 ± 0.03
		2.78	26 ± 3	0.05 ± 0.07
6.59	$\frac{9}{2}^+$	0.197	13 ± 2	-0.13 ± 0.13
		2.78	63 ± 3	-0.20 ± 0.20
		4.38	24 ± 2	0.02 ± 0.07
6.79	$\frac{3}{2}^-$	0	15 ± 2	-0.08 ± 0.03
		0.110	39 ± 2	0.11 ± 0.02
		0.197	13 ± 2	0.05 ± 0.06
		1.35	5.3 ± 0.8	
		1.46	25 ± 2	-0.13 ± 0.08
		3.91	2.6 ± 1.0	
6.84	$\frac{5}{2}^+$	0	9 ± 5	
		0.110	9 ± 5	
		0.197	27 ± 6	-0.5 ± 0.5
		1.35	10 ± 7	
		1.46	45 ± 8	-0.02 ± 0.11
6.89	$\frac{3}{2}^-$	0	9 ± 2	

Table 19.7: Radiative transitions in ^{19}F [a] (continued)

$E_{\rm i}$ (MeV)	$J^{\pi}_{\rm i}$	$E_{\rm f}$ (MeV)	Branching ratios (%)	δ
		1.35	61 ± 5	$0.22 \to 2.2$
		1.46	30 ± 5	0.15 ± 0.12
6.93	$\frac{7}{2}^-$	0.197	73 ± 3	-0.01 ± 0.03
		1.35	22 ± 2	0.01 ± 0.02
		2.78	2.4 ± 0.5	0.00 ± 0.16
		4.00	1.3 ± 0.5	
		4.03	1.3 ± 0.5	
7.17 [e]	$\frac{11}{2}^-$	4.00	5.6 ± 0.7	$\Gamma_\gamma/\Gamma = 0.025 \pm 0.003$
		4.03	90.9 ± 0.8	
		4.65	3.5 ± 0.5	
7.54	$\frac{5}{2}^+; T = \frac{3}{2}$	0.197	29 ± 3	0.09 ± 0.04
		1.35	1.2 ± 0.4	
		1.55	41 ± 3	0.017 ± 0.015
		4.38	27 ± 3	0.042 ± 0.030
		5.11	1.7 ± 0.4	
7.66 [f]	$\frac{3}{2}^+; T = \frac{3}{2}$	0	38 ± 4	0.06 ± 0.02
		0.197	13 ± 2	0.06 ± 0.07 or 3.5 ± 1.1
		1.55	36 ± 2	0.06 ± 0.04
		3.91	(3^{+3}_{-2})	
		4.55	5.1 ± 0.3	-0.11 ± 0.13
		5.11	5.9 ± 0.5	-0.04 ± 0.16
7.93	$\frac{7}{2}^+, \frac{9}{2}$	0.197	4	
		2.78	96	
7.94	$\frac{11}{2}^+$	2.78	10	
		4.65	90	
8.14	$\frac{1}{2}^+$	0	8 ± 1	
		0.11	24 ± 2	
		0.197	8 ± 1	
		1.55	2 ± 1	
		3.91	54 ± 2	Γ_γ (tot) $= 1.3$ eV
		5.94	1.0 ± 0.5	

Table 19.7: Radiative transitions in ^{19}F [a] (continued)

E_i (MeV)	J^{π}_{i}	E_f (MeV)	Branching ratios (%)	δ
		6.26	3 ± 1	
8.25	$(\frac{5}{2}, \frac{7}{2})^-$	0.197	18 ± 7	
		1.35	33 ± 10	
		1.46	24 ± 8	
		3.91	25 ± 8	
8.29 [g]	$\frac{13}{2}^-$	4.03	93 ± 4	Γ_γ (tot) $= 72 \pm 8$ meV
		4.65	7 ± 4	
8.31	$\frac{5}{2}^+$	0	12 ± 1	Γ_γ (tot) $= 0.71 \pm 0.17$ eV
		1.55	48 ± 2	$\delta = 0.02 \pm 0.05$ or 2.2 ± 0.6
		4.38	40 ± 2	$\delta = -0.14 \pm 0.07$
8.37 [g]	$\frac{7}{2}, \frac{5}{2}^+$	0.197	13 ± 2	
		1.35	39 ± 3	
		2.78	30 ± 3	
		4.00	18 ± 3	
8.58	$\frac{5}{2}^+$	0	4 ± 1	
		0.197	38 ± 5	
		1.35	23 ± 3	
		1.55	20 ± 3	
		4.00	(4 ± 1) [g]	
		4.55	2.0 ± 0.7	
		5.42	4 ± 1	
		5.46	2.0 ± 0.5	
		5.62	2.2 ± 0.5	
		5.94	1.8 ± 0.5	
		6.16	2.5 ± 0.5	
		6.93	0.5 ± 0.3	
8.59	$\frac{3}{2}^-$	0	5 ± 2	
		0.11	3 ± 1	
		0.197	42 ± 2	Γ_γ (tot) $= 0.85 \pm 0.17$ eV
		1.35	7 ± 1	
		1.55	28 ± 3	

Table 19.7: Radiative transitions in ^{19}F [a] (continued)

$E_{\rm i}$ (MeV)	$J^{\pi}_{\rm i}$	$E_{\rm f}$ (MeV)	Branching ratios (%)	δ
		3.91	8 ± 1	
		4.55	3.6 ± 0.6	
		5.11	1.0 ± 0.5	
		5.50	1.5 ± 0.5	
		6.28	0.6 ± 0.2	
		6.79	0.3 ± 0.1	
8.63 [g]	$\frac{7}{2}^-$	0.197	34 ± 2	
		1.35	6 ± 1	
		1.46	6 ± 1	
		2.78	38 ± 2	
		4.00	13 ± 1	
		4.03	3 ± 1	
8.65	$\frac{1}{2}^+$	0.11	53 ± 6	
		1.46	23 ± 6	
		3.91	24 ± 6	
8.79	$\frac{1}{2}^+; T = \frac{3}{2}$	0	1.2 ± 0.4	
		0.11	30 ± 1	
		0.197	0.3 ± 0.2	
		1.46	22 ± 1	
		1.55	8 ± 1	
		3.91	22 ± 1	
		5.34	0.5 ± 0.1	
		5.94	1.8 ± 0.2	
		6.09	1.7 ± 0.2	
		6.26	0.2 ± 0.1	
		6.49	6 ± 1	
		6.53	2.1 ± 0.2	
		6.79	1.2 ± 0.3	
		6.99	0.5 ± 0.1	
		7.26	1.7 ± 0.2	
		7.36	0.6 ± 0.1	

Table 19.7: Radiative transitions in ^{19}F [a] (continued)

E_i (MeV)	J_i^π	E_f (MeV)	Branching ratios (%)	δ
		7.66	0.2 ± 0.1	
8.86 [g]	$< \frac{9}{2}$	1.35	100	
8.92	$\frac{3}{2}^-$	0	5 ± 2	0.1 ± 0.3 or 1.7 ± 0.9
		0.11	10 ± 2	0.20 ± 0.04 or 2.9 ± 0.4
		0.197	24 ± 7	1.0 ± 0.8
		1.46	25 ± 7	3.0 ± 2.5
		1.55	23 ± 7	0.30 ± 0.06 or ∞
		3.91	13 ± 7	
8.95 [g]	$\frac{11}{2}^-$	2.78	50 ± 2	Γ_γ (tot) $= 230 \pm 30$ meV
		4.00	26 ± 2	
		4.03	9 ± 1	
		4.65	10 ± 2	
		5.42	5 ± 1	
9.03 [g]	$\frac{5}{2}, \frac{7}{2}$	0.197	44 ± 5	
		4.38	30 ± 5	
		6.07	26 ± 4	
9.100	$\frac{7}{2}^-$	0.197	2.0 ± 0.3	$\delta = 0.0 \pm 0.2$ or 2.5 ± 0.6
		1.35	2.7 ± 0.3	-0.1 ± 0.3 or ∞
		2.78	47 ± 2	-0.09 ± 0.10
		4.00	2.5 ± 0.3	0.3 ± 0.3 or -2.2 ± 0.9
		4.03	7.0 ± 0.5	-0.08 ± 0.01 or ∞
		4.68	2.0 ± 0.3	-0.09 ± 0.34 or ∞
		5.11	1.2 ± 0.2	0.0 ± 0.2 or 3.0 ± 1.6
		5.42	19 ± 2	0.25 ± 0.10 or -6.0 ± 5.5
		5.54	1.3 ± 0.7	0.1 ± 0.3
		5.62	3.3 ± 0.3	0.17 ± 0.10
		6.10	12 ± 1	0.0 ± 0.3
9.101 [g]	$\frac{7}{2}^+, \frac{9}{2}^+$	2.78	11 ± 2	
		4.00	24 ± 2	
		4.38	24 ± 2	
		6.07	15 ± 2	

Table 19.7: Radiative transitions in ^{19}F [a] (continued)

E_i (MeV)	J_i^π	E_f (MeV)	Branching ratios (%)	δ
		6.33	10 ± 2	
9.17 [g]	$\frac{1}{2}^+$	0.197	51 ± 2	
		1.55	30 ± 2	
		4.56	19 ± 2	
9.20 [g]	$\frac{3}{2}$	0	18 ± 2	
		0.110	46 ± 3	
		0.197	10 ± 4	
		1.35	26 ± 3	
9.27 [g]	$\frac{11}{2}^+, \frac{9}{2}^+$	2.78	27 ± 2	
		4.38	18 ± 2	
		4.65	55 ± 3	
9.28 [g]	$(\frac{7}{2}, \frac{9}{2})^+$	4.00	58 ± 3	
		4.03	42 ± 3	
9.32	$\frac{1}{2}^+$	0	30 ± 1	0.10 ± 0.08 or 1.4 ± 0.3
		0.197	12 ± 1	0.1 ± 0.4 or ≥ 0.6
		1.46	28 ± 1	0.1 ± 0.2
		1.55	17 ± 1	-0.2 ± 0.3 or ≤ 0.9
		3.91	3.0 ± 0.3	0.40 ± 0.05 or ≥ 2.3
		4.56	3.2 ± 0.3	0.2 ± 0.3
		4.68	6.8 ± 0.5	0.1 ± 0.2
9.33 [g]	$< \frac{5}{2}$	1.55	100	
9.51 [g]	$\frac{5}{2}^+, \frac{7}{2}^+$	1.35	14 ± 2	
		1.55	14 ± 2	
		2.78	72 ± 3	
9.54	$\frac{5}{2}^+$	1.35	26 ± 2	0.3 ± 1.1
		4.56	15 ± 1	0.7 ± 0.4
		4.68	12 ± 1	0.3 ± 0.3
		5.11	29 ± 2	0.3 ± 0.2
		7.54	10 ± 1	0.7 ± 0.3
		7.66	6 ± 1	0.4 ± 0.3 or $1.0 \rightarrow 0.4$
		8.02	2 ± 1	

Table 19.7: Radiative transitions in ^{19}F [a] (continued)

E_i (MeV)	J_i^π	E_f (MeV)	Branching ratios (%)	δ
9.566	$\frac{3}{2}^-$	0.197	77 ± 10	
		6.26	23 ± 6	
9.575	$\frac{3}{2}^-$	1.46	26 ± 2	-0.1 ± 0.2
		3.91	4 ± 1	-6 ± 7
		4.55	17 ± 2	
		6.09	38 ± 2	1.8 ± 1.0
		7.54	11 ± 2	-0.3 ± 0.8
		7.66	4 ± 1	-0.1 ± 1.3
9.59	$\frac{7}{2}$	1.35	32 ± 4	0.0 ± 0.5 or 3.7 ± 2.5
		2.78	30 ± 2	0.1 ± 0.2 or 11 ± 5
		4.00	17 ± 2	-0.7 ± 1.1
		4.55	21 ± 2	
9.64 [g]	$\frac{3}{2}, \frac{5}{2}$	0.197	13 ± 3	
		1.35	61 ± 7	
		4.55	26 ± 6	
9.65 [g]	$\frac{3}{2}, \frac{5}{2}$	1.35	41 ± 9	
		1.55	59 ± 9	
9.67	$\frac{3}{2}^+$	0	22 ± 2	-0.72 ± 0.04 or -10 ± 4
		0.11	20 ± 2	0.00 ± 0.05
		0.197	9 ± 1	0.30 ± 0.03 or 1.7 ± 0.3
		1.35	9 ± 1	0.00 ± 0.03
		1.46	5 ± 1	0.00 ± 0.07
		1.55	10 ± 1	0.00 ± 0.06 or -4.2 ± 1.3
		3.91	5.5 ± 0.5	0.12 ± 0.03 or -7.5 ± 2.0
		4.38	0.5 ± 0.2	
		4.55	8 ± 1	0.00 ± 0.03 or 4.7 ± 0.5
		5.11	1.5 ± 0.3	0.00 ± 0.05
		5.34	1.0 ± 0.2	-0.22 ± 0.03 or 3.3 ± 0.2
		6.84	1.0 ± 0.3	0.05 ± 0.02 or 3.3 ± 0.2
		7.54	4.0 ± 0.3	0.02 ± 0.03
		7.66	3.5 ± 0.3	0.14 ± 0.04

Table 19.7: Radiative transitions in ^{19}F [a] (continued)

E_i (MeV)	J^π_i	E_f (MeV)	Branching ratios (%)	δ
9.71 [g]	$\frac{9}{2}^+, \frac{11}{2}^-$	2.78	19 ± 3	
		4.03	80 ± 4	
		4.65	1 ± 1	
9.82	$\frac{5}{2}^-$	0.11	0.7 ± 0.2	
		0.197	41 ± 2	0.00 ± 0.05
		1.35	2.4 ± 0.5	-0.6 ± 0.2
		1.46	8 ± 1	-0.07 ± 0.05 or 2.7 ± 0.7
		1.55	30 ± 2	0.01 ± 0.04
		4.00	1.0 ± 0.2	0.0 ± 0.2 or ∞
		4.55	0.5 ± 0.1	0.30 ± 0.15
		4.68	4.8 ± 0.3	0.0 ± 0.1 or -1.7 ± 0.4
		5.11	0.3 ± 0.2	0.4 ± 0.5 or ∞
		5.42	10 ± 1	-0.04 ± 0.05 or ∞
		5.54	0.6 ± 0.2	0.0 ± 0.2
		5.62	0.7 ± 0.2	0.33 ± 0.15 or -3.4 ± 1.2
9.83 [g]	$\frac{11}{2} \rightarrow \frac{15}{2}$	4.65	100	
9.87	$\frac{11}{2}^-$	2.78	63 ± 3	0.0 ± 0.2
		4.00	4.2 ± 1.0	
		4.03	24 ± 2	-0.43 ± 0.05 or 2.2 ± 0.2
		4.65	2.1 ± 0.8	
		6.10	3.8 ± 0.8	0.2 ± 0.1 or 2.7 ± 1.0
		6.50	1.9 ± 0.7	-0.4 ± 0.7
		8.29	1.0 ± 0.3	
9.89	$\frac{1}{2}^+$	0.197	15 ± 8	
		1.46	15 ± 5	
		3.91	32 ± 2	
		5.94	4 ± 1	
		6.09	13 ± 3	
		6.53	16 ± 2	
		7.66	5 ± 1	
9.93 [g]	$\frac{9}{2}^+$	0.197	1 ± 1	

Table 19.7: Radiative transitions in ^{19}F [a] (continued)

E_i (MeV)	J^π_i	E_f (MeV)	Branching ratios (%)	δ
		2.78	19 ± 1	
		5.46	10 ± 1	
		6.07	7 ± 1	
		6.33	8 ± 1	
		6.50	54 ± 2	
10.09 [g]	$\frac{5}{2}^-, \frac{7}{2}^-$	0.197	10 ± 1	
		1.35	35 ± 2	
		4.00	19 ± 2	
		5.42	26 ± 2	
		6.07	10 ± 1	
10.14 [g]	$\frac{3}{2}^-$	1.35	29 ± 4	
		1.46	71 ± 4	
10.37 [g]	$\frac{7}{2} \rightarrow \frac{11}{2}$	4.03	100	
10.41 [g]	$\frac{13}{2}^+$	2.78	3 ± 1	
		4.68	88 ± 1	
		6.50	9 ± 1	

[a] For references and other information see Tables 19.7 in (1978AJ03, 1983AJ01) and (1982OL02). See also Tables 19.8, 19.9 and 19.14 here. See also Table 2 in the Introduction, and (1987FO03) for B(E2).
[b] $|M|^2 = 21.4 \pm 0.3$ W.u.
[c] $\Gamma_\gamma/\Gamma = 0.91 \pm 0.05$.
[d] $\Gamma_\gamma/\Gamma = 0.76 \pm 0.15$ for $4.55 \rightarrow 0.20$ transition.
[e] (1985DI16).
[f] $\Gamma_\gamma = 4.7$ eV, $\Gamma_\gamma/\Gamma = 0.65 \pm 0.10$.
[g] Branching ratios are the relative intensities at $\theta = 55°$.
[h] (1982VE05).
[i] W.J. Vermeer, M.Sc. thesis, Auckland University (1980) and private communication (1986).
[j] g.s. $+ 0.110 + 0.197$.

6. (a) ^{14}N(^{7}Li, d)^{19}F $\quad Q_m = 6.1218$
   (b) ^{14}N(^{12}C, ^{7}Be)^{19}F $\quad Q_m = -11.4179$
   (c) ^{14}N(^{14}N, 2αp)^{19}F $\quad Q_m = -4.9246$

Table 19.8: Lifetimes of some ^{19}F states

^{19}F* (MeV)	J^π	τ_m	Refs.
0.110	$\frac{1}{2}^-$	0.853 ± 0.010 nsec	mean: see (1972AJ02)
0.197	$\frac{5}{2}^+$	128.8 ± 1.5 nsec	mean: see (1978AJ03)
1.35	$\frac{5}{2}^-$	4.17 ± 0.06 psec [a]	(1983BI03)
1.46	$\frac{3}{2}^-$	90 ± 20 fsec	[c]
1.55	$\frac{3}{2}^+$	5 ± 3 fsec	[c]
2.78	$\frac{9}{2}^+$	280 ± 30 fsec	[c]
3.91	$\frac{3}{2}^+$	9 ± 5 fsec	[c]
4.00	$\frac{7}{2}^-$	19 ± 7 fsec	[c]
4.03	$\frac{9}{2}^-$	67 ± 5 fsec	[c]
4.38	$\frac{7}{2}^+$	< 11 fsec	[c]
4.55	$\frac{5}{2}^+$	< 50 fsec	[c]
4.56	$\frac{3}{2}^-$	17^{+10}_{-8} fsec [b]	[c]
4.65	$\frac{13}{2}^+$	3.68 ± 0.38 psec [b]	(1983BI03)
4.68	$\frac{5}{2}^-$	15.4 ± 3.0 fsec	[c]
5.11	$\frac{5}{2}^+$	< 30 fsec	[c]
5.34	$\frac{1}{2}^{(+)}$	≤ 0.1 fsec	[c]
5.42	$\frac{7}{2}^-$	≤ 0.9 fsec	[c]
5.46	$\frac{7}{2}^+$	≤ 0.26 fsec	[c]
5.62	$\frac{5}{2}^-$	< 1.3 fsec	[c]

[a] $|M|^2 = 21.4 \pm 0.3$ W.u. (1983BI03) for the E2 transition [$1.35 \rightarrow 0.11$]. See also (1985KE1C) and Table 19.8 in (1983AJ01).

[b] $|M|^2 = 3.1 \pm 0.3$ W.u. (1983BI03). See also (1983AJ01).

[c] See Table 19.8 in (1983AJ01) and Table 19.9 here.

See (1986NE1A) for reaction (a), (1986GO1B) for (b) and (1982DE39) for reaction (c).

7. ^{15}N(α, γ)^{19}F $\qquad Q_{\rm m} = 4.0138$

Resonances in yield of γ-rays are observed below $E_\alpha = 10.4$ MeV: the parameters for these are displayed in Table 19.10. Branching ratios are shown in Table 19.7 and $\tau_{\rm m}$ measurements in Table 19.8. The J^π values shown in Table 19.10 are based on correlation and angular distribution measurements and on branching ratio determinations. See also (1985DI16).

The $E_{\rm x}$ of states involved in cascade decays are 3999.6 ± 1.2, 4031.9 ± 0.4, 4377 ± 1 and 4548 ± 2 keV. The $K^\pi = \frac{1}{2}^-$ band involves ^{19}F*(0.110[$\frac{1}{2}^-$], 1.46[$\frac{3}{2}^-$], 1.35[$\frac{5}{2}^-$], 4.00[$\frac{7}{2}^-$], 4.03[$\frac{9}{2}^-$], 7.16[$\frac{11}{2}^-$]) and possibly ^{19}F*(8.29)[$\frac{13}{2}^-$] [J^π in brackets]. See, however, reaction 9. See (1972AJ02) for a discussion of the evidence for other assignments of J^π and K^π. ^{19}F*(10.41) is likely to be the second $\frac{13}{2}^+$ (2s, 1d)^3 state in ^{19}F. For references see (1983AJ01).

8. (a) ^{15}N(α, p)^{18}O $\qquad Q_{\rm m} = -3.9804 \qquad E_{\rm b} = 4.0138$
(b) ^{15}N(α, α)^{15}N

Resonances observed in the (α, $\alpha'\gamma$) and (α, pγ) reactions and in the elastic scattering are displayed in Table 19.11. See also (1985OH04; theor.).

9. ^{15}N(^{6}Li, d)^{19}F $\qquad Q_{\rm m} = 2.5387$

At $E(^6{\rm Li}) = 22$ MeV angular distributions are reported to ^{19}F*(0.11, 1.35[u], 1.46, 4.0[u], 8.29[u], 8.96[u]). Comparisons are made with the results from the ^{16}O(^{6}Li, d)^{20}Ne reaction, in an attempt to determine whether ^{19}F*(8.95) is the $\frac{11}{2}^-$ member of the $K^\pi = \frac{1}{2}^-$ band, of which ^{19}F*(8.29) is the $\frac{13}{2}^-$ member (1984MO08, 1985MO20) [but see (1985DI16)]. Configuration mixing in the $\frac{11}{2}^-$ states [^{19}F*(7.17, 8.95, 9.87)] and in the $\frac{7}{2}^-$ states [^{19}F*(4.00, 5.42)] to which they decay appears to be involved (1987FO03).

10. ^{15}N(^{7}Li, t)^{19}F $\qquad Q_{\rm m} = 1.5458$

This reaction has been studied at $E(^7{\rm Li}) = 40$ MeV: see Table 19.11 in (1983AJ01).

11. ^{15}N(^{11}B, ^{7}Li)^{19}F $\qquad Q_{\rm m} = -4.6499$

Table 19.9: States in ^{19}F from ^{12}C(^{11}B, α) [a]

E_x (MeV ± keV)	J^π	Γ_γ/Γ	Γ_α (eV) [b]	$\Gamma_{c.m.}$ (eV) [b]
5.42	$\frac{7}{2}^-$	0.040 ± 0.007	2.6 ± 0.7	2.7 ± 0.7
6.16	$\frac{7}{2}^-$	0.206 ± 0.017	2.9 ± 0.8	3.7 ± 1.0
6.59	$\frac{9}{2}^+$	0.044 ± 0.006	7.3 ± 1.7	7.6 ± 1.8
7.17	$\frac{11}{2}^-$	0.025 ± 0.003	6.7 ± 1.1	6.9 ± 1.1
8.95	$\frac{11}{2}^-$	< 0.004	> 29	> 29
9.71	$\frac{11}{2}^-$	< 0.007	> 79	> 79
9.83	$\frac{11}{2} \rightarrow \frac{15}{2}$	0.045 ± 0.009	1.6 ± 0.6	$\geq 1.6 \pm 0.6$
9.87	$\frac{11}{2}^-$	0.43 ± 0.04	1.4 ± 0.3	2.6 ± 0.6
10.41	$\frac{13}{2}^+$	0.010 ± 0.002	223 ± 66	$\geq 225 \pm 67$
10.927 ± 8		0.051 ± 0.004		

[a] (1986VEZT) and W.J. Vermeer, private communication; $E(^{11}$B$) = 33$, 35, 38 and 48 MeV.

[b] Derived.

See (1983AJ01).

12. ^{15}N(^{13}C, ^{9}Be)^{19}F $\qquad Q_m = -6.6338$

At $E(^{13}$C$) = 105$ MeV groups are reported to states which are generally unresolved; J^π assignments are suggested: see (1983AJ01).

13. (a) ^{16}O(t, γ)^{19}F $\qquad Q_m = 11.7003$

(b) ^{16}O(t, n)^{18}F $\qquad Q_m = 1.2683$ $\qquad E_b = 11.7003$

(c) ^{16}O(t, p)^{18}O $\qquad Q_m = 3.7061$

(d) ^{16}O(t, t)^{16}O

(e) ^{16}O(t, α)^{15}N $\qquad Q_m = 7.6865$

For reaction (a) see (1978AJ03). The excitation function for reaction (b) has been measured for $E_t = 0.3$ to 3.7 MeV: there is evidence for a maximum at $E_t = 2.5$ MeV. For resonances in the yields of p_0, p_1, α_0, α_{1+2} see (1978AJ03). The elastic yield [reaction (d)] shows a large number of resonances: their parameters are displayed in Table 19.12. See also (1982AO06, 1983AO03; theor.).

Table 19.10: Resonances in $^{15}N(\alpha, \gamma)^{19}F$ [a]

E_α (MeV ± keV)	$\Gamma_{c.m.}$ (keV)	$\omega\gamma$ (eV)	J^π	E_x (MeV ± keV)
0.85	$(42.8 \pm 8.5) \times 10^{-6}$ [b]	$(6.0 \pm 1.0) \times 10^{-3}$	$\frac{5}{2}^-$	4.681 ± 1
1.385 ± 3		$(13 \pm 8) \times 10^{-3}$ [c]	$\frac{5}{2}^+$	5.105 ± 2
1.678 ± 3	[i]	1.64 ± 0.16	$\frac{1}{2}^{(+)}$	5.337 ± 2
1.790		0.42 ± 0.09 [c]	$\frac{7}{2}^-$	5.427
1.839 ± 2	< 1	2.5 ± 0.4 [c]	$\frac{7}{2}^+$	5.465
1.883 ± 3	4 ± 1	4.2 ± 1.1 [c]	$\frac{3}{2}^+$	5.500
1.930		0.48 ± 0.11 [c]	$\frac{5}{2}^+$	5.54
2.035 ± 4		0.37 ± 0.09	$\frac{3}{2}^-$	5.620
2.441 ± 4		0.53 ± 0.13	$\frac{1}{2}^+$	5.938 ± 3
2.608 ± 2		2.70 ± 0.54	$\frac{7}{2}^+$	6.070 ± 1
2.631 ± 4		4.50 ± 0.90	$\frac{3}{2}^-$	6.088 ± 3
2.722 ± 2		2.40 ± 0.60	$\frac{7}{2}^-$	6.160 ± 1
2.873 ± 3		1.0 ± 0.2	$\frac{5}{2}^+$	6.282 ± 2
2.935 ± 3		0.76 ± 0.15	$\frac{7}{2}^+$	6.330 ± 2
3.1468 ± 1.5		1.7 ± 0.3	$\frac{3}{2}^+$	6.4976 ± 1.5
3.1498 ± 1.5		2.3 ± 0.4	$\frac{11}{2}^+$	6.5000 ± 1.5
3.183 ± 2		2.4 ± 0.4	$\frac{3}{2}^+$	6.526 ± 2
3.218 ± 2		0.63 ± 0.13	$\frac{7}{2}$	6.554 ± 2
3.267 ± 2		1.6 ± 0.3	$\frac{9}{2}^+$	6.592 ± 2
3.511 ± 3		10.9 ± 1.5	$\frac{3}{2}^-$	6.785 ± 2
3.576 ± 3		1.0 ± 0.2	$\frac{5}{2}$	6.836 ± 2
3.645 ± 5		6.1 ± 1.3	$\frac{3}{2}^-$	6.891 ± 4
3.688 ± 3		9.7 ± 1.4	$\frac{7}{2}$	6.925 ± 2
3.993 ± 2		1.00 ± 0.12 [j]	$\frac{11}{2}^-$	7.1662 ± 0.7
4.465		17.0 ± 2.7	$\frac{5}{2}^+; T = \frac{3}{2}$	7.538 ± 2
4.618		3.7 ± 0.9	$\frac{3}{2}^+; T = \frac{3}{2}$	7.659 ± 2
4.96 ± 3		2.3 ± 0.4	$\frac{7}{2}^+, \frac{9}{2}$	7.929
4.97 ± 3		3.1 ± 0.5	$\frac{11}{2}^+$	7.937
5.413 ± 5	< 1	0.53 ± 0.08	$\frac{13}{2}^-$	8.288 ± 2
5.438 [e]	< 1	2.1 ± 0.5 [d]	$\frac{5}{2}^+$	8.306 ± 4
5.519 [e]	7.5 ± 1.5	0.54 ± 0.2	$\frac{7}{2}, \frac{5}{2}^+$	8.370 ± 4

Table 19.10: Resonances in $^{15}N(\alpha, \gamma)^{19}F$ [a] (continued)

E_α (MeV ± keV)	$\Gamma_{c.m.}$ (keV)	$\omega\gamma$ (eV)	J^π	E_x (MeV ± keV)
5.784	≈ 1	5.1 ± 1.3	$\frac{5}{2}$	8.579 ± 4
5.794		1.6 ± 0.35 [f]	$\frac{3}{2}$	8.587 ± 3
5.847 [e]	< 1	2.5 ± 0.4	$\frac{7}{2}^-$	8.629 ± 4
6.145	< 1	0.2 ± 0.05	$< \frac{9}{2}$	8.864 ± 4
6.259 [e]	≈ 1	0.85 ± 0.2	$\frac{11}{2}^-, (\frac{9}{2}^+)$	8.953 ± 3
6.356	4.2 ± 1	0.53 ± 0.26	$\frac{5}{2}, \frac{7}{2}$	9.030 ± 5
6.442		0.48 ± 0.15 [g]	$\frac{7}{2}^+$	9.098 ± 4
6.445	≈ 1	0.40 ± 0.1	$\frac{7}{2}, \frac{9}{2}$	9.101 ± 4
6.526	9.9 ± 1.5	1.4 ± 1	$\frac{1}{2}, \frac{3}{2}$	9.165 ± 5
6.576	10.2 ± 1.5	1.5	$\frac{3}{2}$	9.204 ± 7
6.656	2 ± 1	0.15 ± 0.04	$\frac{11}{2}^+, \frac{9}{2}^+$	9.267 ± 4
6.672	< 1.5	0.38 ± 0.09	$\frac{7}{2}, \frac{9}{2}$	9.280 ± 5
6.723 [e]	3.4 ± 1	3.4 ± 1.7	$\frac{1}{2}^+$	9.320 ± 4
6.735	≈ 6		$< \frac{5}{2}$	9.329 ± 4
6.963	< 1	0.7 ± 0.2	$\frac{5}{2}^+, \frac{7}{2}^+$	9.509 ± 4
6.993	6.3 ± 1.5	0.5	$\frac{3}{2} \rightarrow \frac{7}{2}$	9.533 ± 6
7.057	9.6 ± 1.5	5.2 ± 3	$\frac{7}{2}$	9.584 ± 4
7.131	≈ 8	≈ 1	$\frac{3}{2}, \frac{5}{2}$	9.642 ± 6
7.146	≈ 6	≈ 2	$\frac{3}{2}, \frac{5}{2}$	9.654 ± 6
7.179	≈ 4	≈ 1	$\frac{1}{2}, \frac{3}{2}$	9.680 ± 6
7.217	< 1	4 ± 0.7	$\frac{9}{2}^+, \frac{11}{2}$	9.710 ± 4
7.349	< 1.5	3.5 ± 0.8 [h]	$\frac{5}{2}^+$	9.814 ± 4
7.375 [e]	< 1	0.51 ± 0.1	$\frac{11}{2} \rightarrow \frac{15}{2}$	9.834 ± 3
7.422	≈ 1.5	3.6 ± 0.6	$\frac{9}{2}^+, \frac{11}{2}^-$	9.872 ± 3
7.491	≈ 1	19.3 ± 3.0	$\frac{9}{2}^+$	9.926 ± 3
7.696	< 1.5	2.37 ± 0.5	$\frac{5}{2}, \frac{7}{2}$	10.088 ± 5
7.749	3.2 ± 1	1.3 ± 0.4	$\frac{3}{2}, \frac{5}{2}$	10.130 ± 6
8.047	3 ± 1.5	0.9 ± 0.4	$\frac{7}{2} \rightarrow \frac{11}{2}$	10.365 ± 4
8.105	< 1.5	15.0 ± 3.0	$\frac{11}{2}^+, \frac{13}{2}^+$	10.411 ± 3

[a] For references see Tables 19.8 in (1978AJ03) and 19.9 in (1983AJ01). For branching ratios see Table 19.7 here. $\omega\gamma \equiv (\Gamma_\alpha \Gamma_\gamma/\Gamma)\frac{1}{2}(2J+1)$. Preliminary results by (1987MAZV) for ^{19}F*(4.550, 4.556 [$J^\pi = \frac{5}{2}^+$, $\frac{3}{2}^-$] are $\omega\gamma = (9.7 \pm 2.0) \times 10^{-5}$ eV [$\Gamma_\alpha = (3.2 \pm 0.7) \times 10^{-5}$ eV] and $\omega\gamma < 1 \times 10^{-5}$ eV [$\Gamma_\alpha < 5 \times 10^{-6}$ eV], respectively.

[b] $\Gamma_\alpha = 2.1 \pm 0.7$ meV, $\Gamma_\gamma = 40.7 \pm 8.1$ meV.

[c] See also Table 19.7 in (1972AJ02).

[d] $\omega\gamma$ $(55°)$ for this value and all values below.

[e] Value recalculated by reveiwer from E_x.

[f] $\Gamma_\alpha/\Gamma_p = 0.026 \pm 0.008$.

[g] $\Gamma_\alpha/\Gamma_p = 0.1 \pm 0.04$. Using $\Gamma = 0.57 \pm 0.03$ keV (Table 19.18), $\Gamma_\alpha = 0.052 \pm 0.03$, $\Gamma_p = 0.52 \pm 0.03$ keV.

[h] $\Gamma_\alpha/\Gamma_p = 0.55 \pm 0.16$.

[i] See (1982KR05).

[j] See also (1985DI16).

14. ^{16}O(α, p)^{19}F $Q_m = -8.1137$

Angular distributions have been measured at $E_\alpha = 20.1$ to 40 MeV: see (1978AJ03, 1983AJ01). States observed in this reaction are displayed in Table 19.2 of (1978AJ03). See also (1986LE1Q; theor.).

15. ^{16}O(^{6}Li, ^{3}He)^{19}F $Q_m = -4.0953$

This reaction (and its mirror reaction ^{16}O(^{6}Li, t)^{19}Ne [see ^{19}Ne]) have been studied at $E(^6\text{Li}) = 24$ and 46 MeV: see (1978AJ03, 1983AJ01). Members of the $K^\pi = \frac{1}{2}^+$ and $\frac{1}{2}^-$ rotational bands have been identified: see Table 19.13. Other groups, mainly to unresolved states, have also been observed.

16. ^{16}O(^{7}Li, α)^{19}F $Q_m = 9.2323$

Many states have been populated in this reaction: see Table 19.14 in (1978AJ03) and (1984MO28; $E(^7\text{Li}) = 20$ MeV). Angular distributions in the latter work have been analyzed via Hauser-Feshbach compund nucleus calculations and FRDWBA, The $K^\pi = \frac{1}{2}^+$ and $\frac{1}{2}^-$ states [see Table 19.13] are discussed (1984MO28).

17. ^{16}O(^{10}B, ^{7}Be)^{19}F $Q_m = -6.9676$

Table 19.11: Levels of ^{19}F from ^{15}N(α, p) and ^{15}N(α, α) [a]

E_α (MeV $\pm$ keV)	$\Gamma_{\rm lab}$ (keV)	J^π	$E_{\rm x}$ (MeV $\pm$ keV)
1.878 ± 10	4	$\frac{3}{2}^+$	5.496
2.614 ± 10	1.5	$\frac{5}{2}^+$	6.077
2.635 ± 10	5	$\frac{5}{2}^-$	6.094
2.833 ± 10	10	$\frac{1}{2}^+$	6.250
2.883 ± 10	3	$\frac{5}{2}^+$	6.289
2.944 ± 10	3	$\frac{7}{2}^+$	6.338
3.060 ± 10	360	$\frac{1}{2}^-$	6.429 ± 8
3.194 ± 10	5	$\frac{1}{2}^+$	6.535
3.229 ± 10	2	$\frac{5}{2}^+$	6.563
3.525 ± 10	3	$\frac{3}{2}^-$	6.796
3.587 ± 10	1.5	$(\frac{5}{2}, \frac{3}{2})^+$	6.845
3.648 ± 10	35	$\frac{5}{2}^-$	6.893
3.705 ± 10	3	$(\frac{9}{2}, \frac{7}{2})^-$	6.938
3.770 ± 10	64	$\frac{1}{2}^-$	6.989 ± 8
3.930 ± 10	40	$\frac{7}{2}^+$	7.116 ± 8
4.127	< 8		7.271
4.23	< 82	$\frac{7}{2}^+$	7.35
4.465 [c]	0.16 ± 0.05	$\frac{5}{2}^+; T = \frac{3}{2}$	7.538
4.49	< 110	$\frac{7}{2}^+$	7.56
4.53	< 50	$\frac{5}{2}^+$	7.59
4.710	< 40	$\frac{1}{2}^-$	7.731
4.780	< 8		7.787
4.93	< 260		7.90 [e]
(5.005)	(< 8)		(7.964)
(5.018)	(< 5)		(7.974)
5.116	< 8		8.052
5.203	< 8		8.120
5.232	< 6		8.143
5.25	< 65		8.16
5.284	< 10		8.184
5.415 [c]	0.90 ± 0.10	$\frac{13}{2}^-$	8.288

Table 19.11: Levels of ^{19}F from ^{15}N(α, p) and ^{15}N(α, α) [a] (continued)

E_α (MeV $\pm$ keV)	Γ_{lab} (keV)	J^π	E_x (MeV $\pm$ keV)
5.481	< 10		8.340
5.847 [c]	0.066 ± 0.024	$\frac{7}{2}^{(-)}$	8.629
6.259 [c]	3.57 ± 0.05	$\frac{11}{2}^-$	8.954
6.963 [c]	0.46 ± 0.05	$\frac{7}{2}^+$	9.509
7.216 [c]	0.12 ± 0.03	$\frac{11}{2}^-$	9.709
7.373 [c]	< 0.2	$(\frac{11}{2} - \frac{15}{2})$	9.833
7.430 [c]	< 0.5	$\frac{11}{2}^-$	9.878
7.491 [c]	0.61 ± 0.09	$\frac{9}{2}^+; (\frac{3}{2})$	9.926
7.695 [c]	1.15 ± 0.14	$\frac{5}{2}^-$	10.087
7.877 [d]	< 1	$\frac{1}{2}^+$	10.231 ± 4
7.977 [d]		$\frac{3}{2}^+$	10.308 ± 4
8.104 [c]	0.31 ± 0.11	$\frac{13}{2}^+$	10.410
8.179 [d]	13.8 ± 1.5		10.469 ± 4
8.205 [d]	6.0 ± 1.0		10.488 ± 4
8.220	5.4 ± 1.0	$\frac{3}{2}^+$	10.501 ± 4
8.245	18 ± 2		10.521 ± 4
8.277	2.5 ± 1		10.546 ± 4
8.287 [d]	5.0 ± 1.5	$\frac{3}{2}^+$	10.554 ± 4
8.307 [d]	3.7 ± 1		10.560 ± 4

[a] For references see Tables 19.9 in (1978AJ03) and 19.10 in (1983AJ01). See also footnote (c).

[b] Resonances below $E_\alpha = 5.5$ MeV are observed in (α, α_0); resonances above that energy are observed in (α, pγ) and (α, $\alpha'\gamma$), except those labelled (c).

[c] ^{15}N(α, α_0): S.K.B. Hesmondhalgh, private communication. The total width shown is in the c.m. system and assumes $\Gamma_{tot} = \Gamma_{\alpha_0}$. I am indebted to Dr. Serena Hesmondhalgh for permission to quote this work and for a number of other useful comments.

[d] Value recalculated by reviewer from E_x.

[e] See, however, reaction 29.

See reaction 6 in ^{19}Ne. See also (1983AJ01).

18. ^{16}O(^{11}B, ^{8}Be)^{19}F $\qquad Q_m = 0.4766$

Table 19.12: Resonances in ^{16}O(t, t) [a]

$E_{\rm c.m.}$ (MeV)	$E_{\rm x}$ (MeV ± keV)	J^π	$\Gamma_{\rm c.m.}$ (keV)
1.368	13.068 ± 4	$\frac{1}{2}^+$	< 10
1.545	13.245 ± 10	$\frac{1}{2}^-$	7
1.570	13.270 ± 10	$\frac{1}{2}^+$	4.5
1.832	13.532 ± 10	$\frac{1}{2}^+$	22
2.018	13.718 ± 20	$\frac{3}{2}^-$	128
2.178	13.878 ± 15	$\frac{1}{2}^+$	101
2.447	14.147 ± 20	$\frac{1}{2}^+$	21
2.555	14.255 ± 15	$\frac{3}{2}^+$	51
2.652	14.352 ± 10	$\frac{1}{2}^+$	154
2.759	14.459 ± 25	$\frac{3}{2}^+$	179
2.763	14.463 ± 25	$\frac{5}{2}^+$	46

[a] For references see (1978AJ03).

See (1978AJ03).

19. (a) ^{16}O(^{12}C, ^{9}B)^{19}F $\qquad Q_{\rm m} = -15.665$

(b) ^{16}O(^{13}C, ^{10}B)^{19}F $\qquad Q_{\rm m} = -12.1754$

See (1982LE1N, 1983AJ01, 1986IK03).

20. ^{17}O(d, t)^{16}O $\qquad Q_{\rm m} = 2.1136 \qquad E_{\rm b} = 13.8139$

For polarization measurements see (1983AJ01). For other channels see (1978AJ03).

21. ^{17}O(^{3}He, p)^{19}F $\qquad Q_{\rm m} = 8.3204$

States studied in this reaction at $E(^3{\rm He}) = 18$ MeV are displayed in Table 19.14 of (1983AJ01). A recent study involving states with $E_{\rm x} \lesssim 7$ MeV is reported by (1986SE08).

Table 19.13: Levels of ^{19}F and ^{19}Ne from ^{16}O(^{6}Li, ^{3}He) and ^{16}O(^{6}Li, t) [a]

J^{π} [b]	E_x in ^{19}F (MeV)			E_x in ^{19}Ne (MeV)		
	$K^{\pi} = \frac{1}{2}^{+}$	$K^{\pi} = \frac{1}{2}^{-}$	other	$K^{\pi} = \frac{1}{2}^{+}$	$K^{\pi} = \frac{1}{2}^{-}$	other
$\frac{1}{2}^{+}$	0			0.0		
$\frac{3}{2}^{+}$	1.56			1.54 [d]		
$\frac{5}{2}^{+}$	0.20			0.24		
$\frac{7}{2}^{+}$	5.47			5.42		
$\frac{9}{2}^{+}$	2.78			2.79 [d]		
$\frac{11}{2}^{+}$	(6.50) [c]					
$\frac{13}{2}^{+}$	4.65			4.64		
$\frac{1}{2}^{-}$		0.11			0.28	
$\frac{3}{2}^{-}$		1.46			1.62 [d]	
$\frac{5}{2}^{-}$		1.35			1.51 [d]	
$\frac{7}{2}^{-}$		4.00			4.20 [f]	
$\frac{9}{2}^{-}$		4.03			4.14 [f]	
$\frac{3}{2}^{+}$			3.91			4.03
$\frac{7}{2}^{+}$			4.38			4.38
$\frac{5}{2}^{(+)}$			4.55			4.55 [d]
$\frac{3}{2}^{-}(\frac{1}{2}^{-})$			4.56			4.593 ± 0.006
$\frac{5}{2}^{-}$			4.68			4.71
$\frac{5}{2}^{(-)}$			5.11			5.09 [e]
$\frac{5}{2}^{+}$			5.34			
$\frac{7}{2}^{-}$			5.43			

[a] For references see Table 19.13 in (1983AJ01). E_x values shown are nominal.

[b] J^{π} assignments based on similarities in angular distributions, and on known spin of one of the analog states.

[c] Not strongly populated at $E(^{6}\text{Li}) = 24$ MeV.

[d] J^{π} assignments based on similarities in $\sigma_{\max}$ in both reactions, and on known spin of analog state.

[e] $J^{\pi} = (\frac{5}{2}^{-}, \frac{7}{2}^{-})$; a state at 4.78 MeV is also reported.

[f] See, however, reaction 5 in ^{19}Ne.

Table 19.14: Some bound states of ^{19}F involved in the capture γ-rays from ^{18}O + p [a]

E_x (keV)	E_x (keV)	E_x (keV)
4648 ± 1	6088 ± 1	6839 ± 1
5107 ± 1	6100 ± 2 [c]	6930 ± 3
5338 ± 4	6163 ± 2	6989 ± 3
5418 ± 1	6255 ± 1	7262 ± 2 [d]
5462 ± 2	6283 ± 3	7364 ± 4 [e]
5501 ± 2	6493 ± 3	7540 ± 1
5535 ± 2	6500 ± 1	7661 ± 1
5621 ± 1 [b]	6529 ± 2	
5938 ± 1	6789 ± 2	

[a] (1980WI17). See also Tables 19.7 and 19.15.
[b] $J^\pi = \frac{5}{2}^-$.
[c] $J^\pi = \frac{9}{2}^-$.
[d] $J^\pi = \frac{1}{2}^-, \frac{3}{2}$.
[e] $J^\pi = \frac{1}{2}^+$.

22. ^{17}O(α, d)^{19}F $\qquad Q_m = -10.0328$

At $E_\alpha = 47.5$ MeV angular distributions have been studied to the $\frac{1}{2}^+ \to \frac{9}{2}^+$ and the $\frac{13}{2}^+$ members of the $K = \frac{1}{2}^+$ band [^{19}F*(0, 0.197, 1.55, 2.78, 4.65, 5.47)], to two $\frac{11}{2}^+$ states ^{19}F*(6.49, 7.94) [both of which are strongly populated] and to the $\frac{7}{2}^+$ state at 4.38 MeV. The reaction populates strongly only those positive-parity states that are predominantly (sd)^3: see (1983AJ01).

23. ^{18}O(p, γ)^{19}F $\qquad Q_m = 7.9942$

This reaction has recently been studied for $E_p = 80$ to 2200 keV by (1980WI17). A large number of resonances have been investigated and E_{res}, total and partial widths, branching and mixing ratios and $\omega\gamma$ values are reported. Transition strength arguments as well as analyses of γ-ray angular distribution data lead to J^π assignments: see Tables 19.7, 19.14 and 19.15 for a display of the results (1980WI17).

In addition absolute cross sections measured for direct capture lead to C^2S values for a number of states of ^{19}F. Reduced widths and J^π determinations lead (1980WI17) to postulate ^{19}F*(3.91, 4.55, 4.38, 6.59, 6.50, 10.43) as the $J^\pi = \frac{3}{2}^+, \frac{5}{2}^+, \frac{7}{2}^+, \frac{9}{2}^+, \frac{11}{2}^+, \frac{13}{2}^+$ states of $K^\pi = \frac{3}{2}^+$ rotational

Table 19.15: Resonances in ^{18}O(p, γ)^{19}F [a]

E_p (keV)	Γ_{lab} (keV)	$\omega\gamma$ (eV)	J^π	E_x (MeV)
151 ± 2	< 0.3	$(1.1 \pm 0.1) \times 10^{-3}$ [j]	$\frac{1}{2}^+$	8.137 [e]
216 ± 1	< 1	$> 0.8 \times 10^{-5}$		8.199
274 ± 3	< 1.5	$(3.7 \pm 0.5) \times 10^{-5}$	$< \frac{7}{2}$	8.254
334 ± 2	< 1	$(0.95 \pm 0.08) \times 10^{-3}$	$\frac{5}{2}^+$	8.310 [f]
622 ± 2	< 0.5	$(10 \pm 2) \times 10^{-3}$	$\frac{5}{2}^+$	8.583
629.6 ± 0.3	2.0 ± 0.3	0.10 ± 0.02	$\frac{3}{2}^-$	8.5904 [g]
≈ 680	300		$\frac{3}{2}$	8.638
841 ± 2	48 ± 2	1.4 ± 0.2	$\frac{1}{2}^+$ [b] $T = \frac{3}{2}$	8.791 [h]
977 ± 2	10 ± 2	$(1.5 \pm 0.2) \times 10^{-2}$	$\frac{3}{2}$	8.919
1166.5 ± 0.4		0.29 ± 0.03 [j]	$\frac{7}{2}^-$	9.0988 [i]
1398 ± 2	3.6 ± 0.8	0.08 ± 0.01	$\frac{3}{2}^+$	9.318
1630 ± 2 [c]	7 ± 2	0.025 ± 0.005	$\frac{5}{2}^+$	9.538
1660 ± 3	27 ± 3	0.041 ± 0.010	$\frac{3}{2}^-$	9.566
1670 ± 4	70 ± 3	0.06 ± 0.01	$\frac{3}{2}^-$	9.576
1684 ± 4	8 ± 2	0.025 ± 0.004	$\frac{7}{2}$	9.589
1768 ± 1.4	3.8 ± 0.4	1.2 ± 0.2	$\frac{3}{2}^+$	9.668
1928.4 ± 0.6 [d]	0.3 ± 0.05	2.8 ± 0.7	$\frac{5}{2}$	9.820
1986 ± 2	< 1.5	0.13 ± 0.04	$\frac{11}{2}^-$	9.875
1996 ± 4	26 ± 2	0.14 ± 0.05	$\frac{1}{2}^+$	9.884
2263.0 ± 0.7	5.0 ± 1.0		$\frac{3}{2}^-$	10.137
> 2300 [d]				

[a] For references see Tables 19.15 in (1978AJ03) and 19.16 in (1983AJ01). See also Tables 19.7 and 19.14.

[b] Supported by direct capture into this state with a $\sin^2\ \theta$ distribution of the d.c. γ-rays and by interference patterns near the resonance.

[c] Decays partly (see Table 19.7) via a state at 8015 ± 2 keV with $J^\pi = \frac{5}{2}^+$.

[d] See Table 19.15 in (1978AJ03).

[e] $\Gamma_p = 0.17$ eV, $\Gamma_\alpha = 220$ eV, $\Gamma_\gamma = 1.3$ eV.

[f] $\Gamma_\gamma = 0.71 \pm 0.17$ eV, $\Gamma_p = 0.019 \pm 0.009$ eV, $\Gamma_\alpha = 46 \pm 19$ eV, $\Gamma_{total} = 47 \pm 19$ eV.

[g] $\Gamma_\gamma = 0.85 \pm 0.17$ eV, $\Gamma_p = 224 \pm 43$ eV, $\Gamma_\alpha = 3410 \pm 1220$ eV.

[h] The strength of the transition to ^{19}F*(7.262) [see Table 19.7] limits J to $\frac{1}{2}$ or $\frac{3}{2}$ for that state.

[i] The angular distribution of the γ-ray from this state to ^{19}F*(5.62) and branching ratio arguments lead to $J = \frac{5}{2}$ for that state.

[j] (1982BE29).

band; ^{19}F*(7.70 or 7.26, 6.09, 9.82, 6.93, 9.87) as the $J^\pi = \frac{1}{2}^-, \frac{3}{2}^-, \frac{5}{2}^-, \frac{7}{2}^-$ and $\frac{11}{2}^-$ members of the excited $K^\pi = \frac{1}{2}^-$ rotational band; and ^{19}F*(4.56, 4.68, 5.42, 6.10, 7.17) as the $J^\pi = \frac{3}{2}^-, \frac{5}{2}^-, \frac{7}{2}^-, \frac{9}{2}^-$ and $\frac{11}{2}^-$ members of the $K^\pi = \frac{3}{2}^-$ rotational band. The direct capture transition to ^{19}F*(7.54) indicates some isospin mixing in this $\frac{5}{2}^+$, first $T = \frac{3}{2}$ state in ^{19}F (1980WI17). See also Table 19.6.

Table 19.16: Resonances in ^{18}O(p, n)^{18}F [a]

E_p (MeV ± keV)	$\Gamma_{c.m.}$ (keV)	Res. in yield of [b]	J^π	E_x in ^{19}F (MeV)
2.643 ± 1.0	6.2 ± 0.5	n	$(\frac{3}{2})$	10.497
2.691 ± 1.0	2.5 ± 0.2	n		10.542
2.717 ± 1.0	5.2 ± 0.5	n		10.567
2.767 ± 1.5	4.7 ± 0.5	n	$\frac{5}{2}^{(+)}$	10.614
2.923 ± 4	6 ± 3	n		10.762
3.025 ± 2.0	24.0 ± 1.5	n	$\frac{3}{2}$	10.859
(3.08 ± 20)	≈ 60	n		(10.91)
3.148 ± 3	14 ± 2	n		10.975
3.164 ± 2.5	7 ± 2	n		10.990
3.250 ± 2.5	35 ± 4	n	$\frac{3}{2}$	11.072
3.370 ± 4	17 ± 4	n		11.185
3.463 ± 3	7 ± 2	n		11.273
3.470 ± 15	70 ± 20	n		11.280
3.653 ± 4	40 ± 10	n, n_1		11.453
3.680 ± 5	7 ± 3	n		11.479
3.705 ± 5	4 ± 2	n, n_1		11.502
3.748 ± 15	50 ± 15	n		11.543
3.775 ± 7	15 ± 10	n, n_2	$(T = \frac{3}{2})$	11.569
(3.79 ± 20)	60 ± 20	n		(11.58)
3.863 ± 4	45 ± 10	n, n_1		11.652
4.00		n_1, n_3		(11.78)
4.06 ± 10 [c]	< 50	n, n_1		11.84
4.11		n_1		(11.89)
4.16 ± 10	90	n, n_1		11.93
4.33		n_1, n_3		(12.09)
4.37 ± 10	100	n, n_1, n_2		12.13

Table 19.16: Resonances in ^{18}O(p, n)^{18}F [a] (continued)

E_p (MeV ± keV)	$\Gamma_{c.m.}$ (keV)	Res. in yield of [b]	J^π	E_x in ^{19}F (MeV)
4.47	50	n, n_1, n_2, n_3		12.23
4.58 ± 10 [d]		n_1		(12.33)
4.70		n_3		(12.44)
4.83		n_1, n_2, n_3		(12.57)
4.90		n_2		(12.63)
5.05 ± 10	200	n, n_1, n_2		12.78
5.10		n_1, n_2		(12.82)
5.20		n_2, n_3		(12.92)
5.35		n, n_1, n_2, n_3		13.06
5.47 ± 15	70	n, n_1		13.17
5.622 ± 15	30	n, n_1, n_2	$(T = \frac{3}{2})$	13.317
5.76		n_1, n_3		(13.45)
6.061 ± 15	50	n, n_1, n_2	$(T = \frac{3}{2})$	13.73
6.60 ± 15	350	n		14.24
(6.70 ± 15)		n		(14.34)
7.17 ± 20	300	n		14.78
7.40 ± 20		n		15.00
(7.8)		n		(15.4)
(7.98)		n		(15.55)
8.19 ± 25	150	n		15.75
8.74 ± 25	200	n		16.27
9.30 ± 30		n		16.80

[a] See Table 19.16 in (1978AJ03) for the references.

[b] n means total yield.

[c] Errors here and below are estimated from published data of (1964BA16) by H.B. Willard, private communication.

[d] See also (1982DI11).

Stellar reaction rates have also been calculated: the data cover $T_9 = 0.01 - 5.0$. The consequences for the final termination of the CNO tri-cycle are discussed by (1980WI17). See also (1982KR05), (1982RO1A, 1982WI1B; astrophysics) and (1982MA1Q, 1983AM1D; applications).

Table 19.17: Energy levels of ^{19}F from ^{18}O(p, p)^{18}O and ^{18}O(p, α)^{15}N [a]

$E_{\rm p}$ (MeV $\pm$ keV)	$\Gamma_{\rm lab}$ (keV)	Particles out	$\Gamma_{\rm p}$ [b] (keV)	Γ_α [b] (keV)	J^π	$E_{\rm x}$ (MeV)
0.095 ± 3	≤ 3	α_0	$\omega\gamma = (1.6 \pm 0.5) \times 10^{-7}$ eV			8.084
0.152 ± 1	≤ 0.5	α_0	0.17 ± 0.02 eV			8.138
0.216 ± 1	≤ 1	α_0	$(2.3 \pm 0.6) \times 10^{-3}$ eV			8.199
0.334 ± 1	≤ 1	α_0	0.057 ± 0.010 eV			8.310
0.6326 ± 0.4 [c]	2.1 ± 0.1	p_0, α_0	0.065 ± 0.006	2.0 ± 0.2	$\frac{3}{2}^-$	8.5933
≈ 0.695	≈ 340	p_0, α_0	5 [d]	95 [d]	$\frac{1}{2}^+$	8.65
0.846 ± 1.5 [g]	47 ± 1	p_0, α_0	26 ± 1.5	21 ± 1	$\frac{1}{2}^+; T = \frac{3}{2}$	8.795
0.9870 ± 0.7	3.8 ± 0.2	p_0, α_0	0.080 ± 0.007	3.7 ± 0.3	$\frac{3}{2}^-$	8.929
(1.135)	140					(9.069)
1.1685 ± 0.5	0.60 ± 0.03	p_0, α_0	0.005 ± 0.0006	0.595 ± 0.08	$\frac{7}{2}^+$	9.1007
1.2390 ± 1	6.1 ± 0.3	$p_0, (\alpha_0)$	0.40 ± 0.03	5.7 ± 0.4	$\frac{1}{2}^+$	9.167
1.4025 ± 1	5.2 ± 0.2	p_0, α_0	0.23 ± 0.02	5.0 ± 0.4	$\frac{1}{2}^+$	9.322
1.620 ± 6	30	p_0, α_0			$(\frac{5}{2})$	9.528
1.668 ± 6	27	p_0, α_0			$\frac{3}{2}$	9.574
1.766 ± 3	3.6	p_0, α_0	2.1	1.5	$\frac{3}{2}^+$	9.666
1.928 ± 3	0.16	p_0, α_0	0.09	0.07	$(\frac{5}{2}, \frac{7}{2})^-$	9.820
2.001 ± 4	31	p_0, α_0	12	19	$\frac{1}{2}^+$	9.889
2.2630 ± 0.7	5.0 ± 1.0	$\alpha_0, \alpha_1, \alpha_2$	≈ 5	0.004 [c]	$\frac{3}{2}^-$	10.137
2.289 ± 3	33	p_0, α_0	2.3	(1.0)	$\frac{1}{2}^+$	10.162
2.363 ± 3	4.5	p_0, α_0	2.8	1.7	$\frac{1}{2}^+$	10.232
2.387 ± 3	24	p_0, α_0	11	13	$\frac{3}{2}^+$	10.254
2.443 ± 4	9.7	p_0, α_0	5.2	4.5	$\frac{3}{2}^+$	10.308

Table 19.17: Energy levels of ^{19}F from ^{18}O(p, p)^{18}O and ^{18}O(p, α)^{15}N [a] (continued)

E_p (MeV ± keV)	Γ_{lab} (keV)	Particles out	Γ_p [b] (keV)	Γ_α [b] (keV)	J^π	E_x (MeV)
2.644 ± 3	4.6	$p_0, p_1, \alpha_0, \alpha_{1+2}$	2.4	(1.0)	$\frac{3}{2}^+$	10.498
2.705 ± 3	8 ± 2	p_1, α_0			$\frac{3}{2}^{(+)}; (T = \frac{3}{2})$	10.556
2.732 ± 4	23 ± 3	p_1, α_0			$(\frac{5}{2}^+)$	10.581
2.768 ± 3	4.0	$p_0, p_1, \alpha_0, \alpha_{1+2}$	0.7	(1.0)	$\frac{5}{2}^+; T = \frac{3}{2}$ [a]	10.615
2.925 ± 3	5.7	$p_0, p_1, \alpha_0, \alpha_{1+2}$	4.5	1.2	$\frac{1}{2}^-$	10.764
3.029 ± 4	19.5	$p_0, p_1, \alpha_0, \alpha_{1+2}$	13.0		$\frac{5}{2}^+$	10.862
(3.06)		α_0				(10.89)
3.148 ± 4	(14)	$p_0, p_1, \alpha_0, \alpha_{1+2}$	(4.5)	(4.5)	$(\frac{3}{2}, \frac{5}{2})^+$	10.975
3.266 ± 9	35	$p_0, p_1, \alpha_0, \alpha_{1+2}$			$\frac{1}{2}^+$	11.087
3.386 ± 9	20	$p_0, p_1, \alpha_0, \alpha_{1+2}$			$(\frac{1}{2}^-)$	11.200
3.479 ± 8	23 ± 5	$p_0, p_1, \alpha_0, \alpha_{1+2}$	4.3 ± 1		$\frac{5}{2}^+$	11.288
3.547 ± 25	286 ± 33	p_0	241 ± 2		$\frac{1}{2}^+$	11.35
3.643 ± 9	40 ± 7	$p_0, (\alpha_{1+2})$	17 ± 3		$\frac{1}{2}^-$	11.444
3.694 ± 9	29 ± 6	$p_0, p_1, \alpha_0, (\alpha_{1+2})$	12 ± 2		$\frac{3}{2}^-$	11.492
3.744 ± 8	23 ± 5	p_0, p_1, α_0	3.7 ± 1		$\frac{5}{2}^+$	11.539
3.811 ± 12	66 ± 7	p_0	30 ± 12		$\frac{3}{2}^-$	11.603
3.869 ± 8	28 ± 7	$p_0, p_1, (\alpha_{1+2})$	12 ± 2		$\frac{3}{2}^+; (T = \frac{3}{2})$	11.658
4.290 ± 30	75 ± 25	$p_0, \alpha_0, \alpha_{1+2}$	10 ± 3		$\frac{1}{2}^-$	12.06
4.390 ± 15	110 ± 15	$p_0, p_1, (\alpha_0, \alpha_{1+2})$	60 ± 10		$\frac{3}{2}^-; T = \frac{3}{2}$	12.151
4.465 ± 12 [e]	78 ± 1	$p_0, p_1, \alpha_0, \alpha_{1+2}$	48 ± 6		$\frac{3}{2}^+$	12.222
4.782 ± 7 [e]	16 ± 4	p_0, p_1	2.4 ± 1		$\frac{1}{2}^-$	12.522

Table 19.17: Energy levels of ^{19}F from ^{18}O(p, p)^{18}O and ^{18}O(p, α)^{15}N [a] (continued)

E_p (MeV ± keV)	Γ_{lab} (keV)	Particles out	Γ_p [b] (keV)	Γ_α [b] (keV)	J^π	E_x (MeV)
4.840 ± 10	50 ± 10	p_0, p_1, α_{1+2}	6.4 ± 2		$\frac{5}{2}^+$	12.577
4.848 ± 25	300 ± 50	p_0	80 ± 25		$\frac{1}{2}^-; T = \frac{3}{2}$	12.58
5.074 ± 30	100 ± 40	p_0, p_1, (α_0)	13 ± 5		$\frac{5}{2}^+; T = \frac{3}{2}$	12.80
5.135 ± 30	290 ± 40	p_0, p_1	114 ± 17		$\frac{3}{2}^+; T = \frac{3}{2}$	12.86
5.225 ± 25	75 ± 25	p_0, p_1, α_{1+2}	3 ± 1.5		$\frac{5}{2}^+$	12.94
5.27 ± 50	130 ± 40	p_0	20 ± 8		$\frac{1}{2}^-$	12.98
5.38 ± 75	300 ± 75	p_0	75 ± 25		$\frac{3}{2}^-$	13.09
5.622 ± 8 [e]	30 ± 6	p_0, p_1, α_0, α_{1+2}	10 ± 3		$\frac{7}{2}^-$	13.317
5.670 ± 25	40 ± 20	p_0	2 ± 2		$\frac{3}{2}^-$	13.36
6.060 ± 11	55 ± 10	p_0, p_1, (α_{1+2})	13 ± 3		$\frac{7}{2}^-; T = \frac{3}{2}$	13.732
6.390 ± 20 [f]	148 ± 30	p_0	12 ± 3		$\frac{5}{2}^+$	14.04
6.428 ± 30	88 ± 30	p_0	8 ± 3		$\frac{3}{2}^-$	14.08
6.687 ± 20	80 ± 30	p_0	9 ± 3		$\frac{3}{2}^-$	14.33
7.080 ± 20	130 ± 40	p_0	21 ± 5		$\frac{3}{2}^-$	14.70
7.10 ± 70	270 ± 70	α_0			$\frac{1}{2}^-$	14.72
7.125 ± 50	380 ± 70	p_0, α_0	100 ± 25		$\frac{1}{2}^+$	14.74
7.167 ± 40	210 ± 50	p_0	21 ± 6		$\frac{5}{2}^+$	14.78
7.337 ± 40	208 ± 30	p_0	20 ± 4		$\frac{7}{2}^-$	14.94
7.775 ± 20	70 ± 10	p_0	6 ± 2		$\frac{1}{2}^-$	15.36
7.820 ± 30	84 ± 25	p_0	7 ± 2		$\frac{5}{2}^+$	15.40
8.282 ± 40	102 ± 25	p_0	8 ± 3		$\frac{3}{2}^-$	15.83

Table 19.17: Energy levels of ^{19}F from ^{18}O(p, p)^{18}O and ^{18}O(p, α)^{15}N [a] (continued)

E_p (MeV ± keV)	Γ_{lab} (keV)	Particles out	Γ_p [b] (keV)	Γ_α [b] (keV)	J^π	E_x (MeV)
8.670 ± 40	180 ± 30	p_0	16 ± 4		$\frac{3}{2}^+$	16.20
8.695 ± 30	234 ± 40	p_0	13 ± 4		$\frac{7}{2}^-$	16.23
8.747 ± 30	176 ± 30	p_0	13 ± 4		$\frac{3}{2}^-$	16.28
9.563 ± 40	348 ± 70	p_0	39 ± 8		$\frac{3}{2}^-$	17.05
9.679 ± 40	340 ± 70	p_0	30 ± 8		$\frac{7}{2}^-$	17.16
9.986 ± 30	34 ± 20	p_0	3 ± 2		$\frac{3}{2}^-$	17.45
10.200 ± 60	100 ± 60	p_0	5 ± 3		$\frac{7}{2}^-$	17.65
10.496 ± 40	268 ± 60	p_0	23 ± 5		$\frac{3}{2}^-$	17.93
10.596 ± 60	384 ± 60	p_0	32 ± 7		$\frac{7}{2}^-$	18.03
11.698 ± 60	584 ± 150	p_0	22 ± 7		$\frac{3}{2}^-$	19.07
12.499 ± 150	388 ± 60	p_0	13 ± 6		$\frac{5}{2}^-$	19.83
12.547 ± 40	498 ± 60	p_0	39 ± 8		$\frac{3}{2}^-$	19.87
13.542 ± 50	434 ± 60	p_0	32 ± 5		$\frac{1}{2}^-$	20.81
13.662 ± 50	334 ± 50	p_0	12 ± 4		$\frac{3}{2}^-$	20.93
13.791 ± 40	472 ± 30	p_0	25 ± 5		$\frac{7}{2}^-$	21.05

[a] See also Tables 19.14 in (1972AJ02) and 19.17 in (1978AJ03) for the earlier work and references.

[b] See also Table 19.15.

[c] $\omega\gamma = 420 \pm 80$ eV (1979LO01).

[d] Widths not in accord with Γ measured by (1979LO01) who calculate also $\omega\gamma \approx 1.2 \times 10^5$ eV.

[e] See (1982DI11). A resonance at $E_{\rm p} = 4.58$ MeV in the p channel is also reported. It is suggested that the states corresponding to $E_{\rm x} = 12.33$, 12.52 and 13.32 MeV have $T = \frac{3}{2}$ and $J^\pi = (\frac{3}{2}^+)$, $\frac{5}{2}^{(+)}$ and $\frac{3}{2}^-$, respectively.

[f] The parameters of this resonance and most of the ones below are from a phase-shift analysis by (1979MU05) of the elastic scattering for $E_{\rm p} = 6.1$ to 16.6 MeV. Other structures have also been observed but parameters for those have not been obtained.

[g] See also (1986CO1F; prelim.).

24. ^{18}O(p, n)^{18}F $Q_{\rm m} = -2.4387$ $E_{\rm b} = 7.9942$

Yield measurements are reported from $E_{\rm p} = 2.5$ to 13.5 MeV [see (1978AJ03) for the references]. The observed resoannces are displayed in Table 19.16.

25. ^{18}O(p, p)^{18}O $E_{\rm b} = 7.9942$

Scattering studies have been carried out for $E_{\rm p} = 0.6$ to 16.3 MeV and for $E_{\vec{\rm p}} = 6.1$ to 16.6 MeV: see (1978AJ03, 1983AJ01). Pronounced resonant structure is evident up to 14 MeV. Observed resonances are shown in Table 19.17. For polarization measurements see (1982GL08; $E_{\vec{\rm p}} = 800$ MeV). See also (1982NA13, 1984PH02, 1986DE1G; theor.).

26. ^{18}O(p, t)^{16}O $Q_{\rm m} = -3.7061$ $E_{\rm b} = 7.9942$

For polarization measurements at $E_{\vec{\rm p}} = 90$ MeV see (1985VOZZ; prelim.). See also (1978AJ03).

27. ^{18}O(p, α)^{15}N $Q_{\rm m} = 3.9804$ $E_{\rm b} = 7.9942$

Yield measurements have been studied for $E_{\rm p} = 72$ keV to 14 MeV: see (1972AJ02, 1983AJ01): observed resonances are displayed in Table 19.17. See also (1982RO1A, 1982WI1B, 1984HA1R, 1984HA1Z, 1986BA89, 1987RO25; astrophys.) and (1982MA1Q, 1986CO2B; applied).

28. ^{18}O(d, n)^{19}F $Q_{\rm m} = 5.7697$

Angular distributions of neutron groups corresponding to ^{19}F states with $E_{\rm x} < 8.2$ MeV have been measured at $E_{\rm d} = 3$ and 4 MeV: see Table 19.18 in (1978AJ03) and Table 19.18 here.

29. ^{18}O(^{3}He, d)^{19}F $Q_{\rm m} = 2.5007$

Angular distributions of the deuterons corresponding to many states of ^{19}F have been analyzed by DWBA: the results are shown in Table 19.18. The spectroscopic factors obtained for ^{19}F*(7.54, 8.80), the $T = \frac{3}{2}$, $J^{\pi} = \frac{5}{2}^{+}$ and $\frac{1}{2}^{+}$ analogs of ^{19}O*(0, 1.47) are in good agreement with those obtained for the ^{19}O states in the ^{18}O(d, p)^{19}O reaction: see (1978AJ03). A search for a state at $E_{\rm x} = 7.90$ MeV [just below the ^{18}O + p threshold, and of astrophysical interest] has been unsuccessful: $\theta^2_{\rm p} < 5 \times 10^{-5}$ (1986CH29). See also (1983MU13, 1984BL21; theor.).

30. ^{19}O(β^{-})^{19}F $Q_{\rm m} = 4.820$

Table 19.18: Energy levels of ^{19}F from ^{18}O(d, n)^{19}F and ^{18}O(^{3}He, d)^{19}F [a]

E_x [b] (MeV ± keV)	l [b]	$C^2S(2J_f+1)$ [b]	J^π [b]
0	0	0.42 [a]	$\frac{1}{2}^+$
0.112 ± 3	1	0.224	$\frac{1}{2}^-$
0.199 ± 3	2	2.45 [a]	$\frac{5}{2}^+$
1.347 ± 5			
1.460 ± 5	1	0.098	$\frac{3}{2}^-$
1.5544 ± 0.6 [c]	2	1.01	$\frac{3}{2}^+$
2.784 ± 5	4	0.027	$\frac{9}{2}^+$
3.912 ± 5			
3.999 ± 1 [c]	(3)	(0.019)	$(\frac{7}{2}^-)$
4.036 ± 10			
4.3761 ± 0.8 [c]	(4)	(0.048)	$(\frac{7}{2}^+)$
4.5557 ± 0.5 [c]	2	0.31	[a]
4.684 ± 1 [c]			
5.113 ± 5 [a]	(2, 3)		$\frac{5}{2}^-, \frac{7}{2}^-$ [a]
5.34 ± 5	(2, 3)	0.0065	$\frac{5}{2}^+$
5.428 ± 8	(2, 3)	(0.042)	$(\frac{3}{2}^+)$
5.492 ± 5 [d]			
5.54 ± 5	3	0.14	$\frac{7}{2}^-$
5.625 ± 4			
5.943 ± 5	0	0.014	$\frac{1}{2}^+$
6.095 ± 5	1	0.12	$\frac{1}{2}^-$
6.167 ± 5			
6.255 ± 8	(0)	0.19 [a]	$\frac{1}{2}^+$ [a]
6.503 ± 5	2	0.133	$\frac{3}{2}^+$
6.595 ± 10			
6.792 ± 5	1	0.29 [a]	$\frac{3}{2}^-$
6.93 ± 5	(2, 3)		$(\frac{5}{2}^+, \frac{7}{2}^-)$
7.112 ± 8	2	0.087	$\frac{5}{2}^+$
7.26 ± 5			
7.364 ± 5	0	0.091	$\frac{1}{2}^+$
7.540 ± 3	2	0.665	$\frac{5}{2}^+; T = \frac{3}{2}$

Table 19.18: Energy levels of ^{19}F from ^{18}O(d, n)^{19}F and ^{18}O(^{3}He, d)^{19}F [a] (continued)

E_x [b] (MeV $\pm$ keV)	l [b]	$C^2S(2J_f+1)$ [b]	J^π [b]
7.665 ± 5	(2)	0.035 [a]	$(\frac{3}{2}^+)$
7.702 ± 5	(0, 1)	(0.052)	$(\frac{3}{2}^-)$
8.0140 ± 1.0 [e]	2	0.26	$\frac{5}{2}^+$
8.086 ± 5	(2, 3)	0.097	$(\frac{5}{2}^+)$
8.135 ± 5	(0, 1)	0.156	$\frac{1}{2}^+$ [a]
8.198 ± 5	(2, 3)	0.035	$(\frac{5}{2}^+)$
8.255 ± 5	(2)	0.035	$(\frac{5}{2}^+)$
8.31 ± 5 [e]	2		$\frac{5}{2}^+$
8.592 ± 10	(2, 3)		
8.795 ± 15	0	(0.13)	$\frac{1}{2}^+; T = \frac{3}{2}$
9.113 ± 10			
9.18 ± 15			
9.596 ± 10			
9.682 ± 15			
10.275 ± 15			
10.33 ± 15			
10.525 ± 15			

[a] See also Table 19.18 in (1978AJ03). Column 3 should refer to footnote (c).
[b] ^{18}O(^{3}He, d): $E(^3\text{He}) = 16$ MeV, except where footnote is shown.
[c] ^{18}O(d, nγ).
[d] Many of the states with $E_x \geq 4.5$ MeV are unresolved: compare with Table 19.6.
[e] ^{18}O(^{3}He, d): $E(^3\text{He}) = 26.4$ MeV (1986CH29) (and A.E. Champagne, private communication). $\theta_p^2 = 1.3 \times 10^{-2}$ and 7.4 ± 10^{-4}, respectively for ^{19}F*(8.01, 8.31).

The decay is primarily by allowed transitions to ^{19}F*(0.197, 1.55), $J^\pi = \frac{5}{2}^+, \frac{3}{2}^+$. Very weak branches are also observed to ^{19}F*(0.11, 1.35, 3.91, 4.39), $J^\pi = \frac{1}{2}^-, \frac{5}{2}^-, \frac{3}{2}^+, \frac{7}{2}^+$: see Table 19.19. The half-life is 26.91 ± 0.08 sec: see reaction 1 in ^{19}O. The character of the allowed decay to the $\frac{5}{2}^+$ and $\frac{3}{2}^+$ states, and the forbiddenness of the decay to the ground state of ^{19}F are consistent with $J^\pi = \frac{5}{2}^+$ for the ground state of ^{19}O, and then with $(\frac{7}{2}^+)$ for ^{19}F*(4.39). Gamma-ray branching ratios are displayed in Table 19.7. See also (1983AJ01, 1985BR29).

31. ^{19}F(γ, n)^{18}F $\qquad Q_m = -10.4320$

The cross section for (γ, Tn) has been measured for $E_\gamma = 10.5$ to 28 MeV: it shows a clear resonance at $E_\gamma \approx 12$ MeV and unresolved structures at higher energies: see (1978AJ03). See also (1982COZV), (1972AJ02), (1982VI07; applications) and (1983KA28; theor.).

Table 19.19: Branching in ^{19}O(β^-)^{19}F [a]

Decay to ^{19}F* (keV)	J^π	Branch (%)	$\log ft$
0	$\frac{1}{2}^+$	≤ 4	≥ 6.5
110	$\frac{1}{2}^-$	$0.055^{+0.013}_{-0.038}$	$8.34^{+0.30}_{-0.10}$
197.143 ± 0.004	$\frac{5}{2}^+$	45.4 ± 1.5	5.384 ± 0.014
1346	$\frac{5}{2}^-$	0.017 ± 0.002	8.25 ± 0.05
1459	$\frac{3}{2}^-$	< 0.010	> 8.4
1554.038 ± 0.009	$\frac{3}{2}^+$	54.4 ± 1.2	4.625 ± 0.010
2779.849 ± 0.034	$\frac{9}{2}^+$	< 0.002	> 8.2
3908.17 ± 0.20	$\frac{3}{2}^+$	0.0081 ± 0.0005	6.133 ± 0.027
3999	$\frac{7}{2}^-$	< 0.001	> 6.9
4033	$\frac{9}{2}^-$	< 0.001	> 6.8
4377.700 ± 0.042	$\frac{7}{2}^+$	0.0984 ± 0.0030	3.859 ± 0.017
4550	$\frac{5}{2}^+$	< 0.001	> 5.1

[a] (1982OL02). See Table 19.19 in (1978AJ03) for the earlier work.

[b] E_x shown with uncertainties were determined by (1982OL02).

32. (a) ^{19}F(γ, p)^{18}O $\qquad Q_m = -7.9942$

(b) ^{19}F(γ, t)^{16}O $\qquad Q_m = -11.7003$

(1984KE04) have measured absolute differential cross sections for the p_0 and p_1 channels at 7 angles for $E_\gamma = 13.4$ to 25.8 MeV. Angle integrated cross sections for (γ, p_0) show pronounced structures at $E_\gamma = 15.45$, 16.70, 17.35 and 18.55 MeV as well as a broad bump at ≈ 20.5 MeV. Additional minor structures may exist at $E_\gamma = 13.65$, 14.35, 15.85, 17.90, 19.5, 21.3, 22.2 and 23.5 MeV. In the (γ, p_1) reaction broad bumps appear at $\approx (17.0)$ and 21.5 MeV. The E2 cross section [from (γ, p_0) angular distribution coefficients] is estimated to be ≈ 0.37 of the E2 EWSR (1984KE04). The (γ, p_{tot}) cross section to 26 MeV has been derived by (1985KE03). See also (1978AJ03).

In reaction (b) the (γ, t_0) reaction has been studied for $E_\gamma = 18$ to 23 MeV: two peaks are observed at $E_\gamma = 18.8$ and 20.1 MeV. It is suggested that $J^\pi = \frac{1}{2}^-$ or $\frac{3}{2}^-$, $T = \frac{1}{2}$. The (γ, t_0) process contributes ≈ 1% to the total GDR: see (1978AJ03).

33. ^{19}F(γ, γ)^{19}F

The energy of the first excited state is 109.894 ± 0.005 keV; its width is $(5.1 \pm 0.7) \times 10^{-7}$ eV. ^{19}F*(1.46, 3.91, 7.66) are also excited. The scattering cross section is relatively small and structureless for $E_\gamma = 14$ to 30 MeV: see (1978AJ03).

34. ^{19}F(e, e)^{19}F

With $E_e = 78$ to 340 MeV, and with an energy resolution of 25–50 keV, most states of ^{19}F with $E_x < 7.7$ MeV have been observed and the longitudinal and transverse form factors have been derived and compared with shell-model calculations. The spectrum of positive-parity longitudinal excitations is dominated at higher momentum transfer by the $\frac{1}{2}^+ \rightarrow \frac{9}{2}^+$ members of the ground state $K^\pi = \frac{1}{2}^+$ band. The C2 strength is concentrated at $E_x < 1.5$ MeV with a small secondary concentration for $5.5 < E_x < 6.5$ MeV. The C4 strength is spread from 3 to 6 MeV, dominantly in ^{19}F*(2.78) [$J^\pi = \frac{9}{2}^+$]. The spectra of longitudinal excitations of negative parity states are dominated by ^{19}F*(1.35) [$J^\pi = \frac{5}{2}^-$] and ^{19}F*(5.5) [$\frac{5}{2}^- + \frac{7}{2}^-$]. In the transverse mode ^{19}F*(0.11, 6.79) [$J^\pi = \frac{1}{2}^-, \frac{3}{2}^-$, respectively] are prominent. Agreement with theory is good for $\frac{5}{2}^-$ and $\frac{7}{2}^-$ but poorer for $\frac{1}{2}^-$ and $\frac{3}{2}^-$ states. The parity of ^{19}F*(5.34) is uncertain while that of ^{19}F*(6.55) is probably positive. States are reported at 7.587 and 7.753 MeV with $J^\pi = (\frac{5}{2}^-)$ and $(\frac{7}{2}^-)$, respectively (1985BR15). The form factors for ^{19}F*(0, 0.11, 2.78) have also been studied by (1986DO10) for $q = 0.4 - 2.8$ fm^{-1}. For electromagnetic transition rates see Table 19.20. For the earlier work see (1978AJ03, 1983AJ01). See also (1985TU1B, 1987DE43) and (1983BR27, 1986BO29, 1986BR1X; theor.).

35. ^{19}F(n, n)^{19}F

Angular distributions of neutron groups have been reported at $E_n = 2.6$, 14.1 and 14.2 MeV: see (1972AJ02).

36. ^{19}F(p, p)^{19}F

Table 19.21 in (1978AJ03) displays energy levels of ^{19}F derived from this reaction. Angular distributions of various proton groups have been measured from $E_p = 4.3$ to 35.2 MeV [see (1978AJ03, 1983AJ01)] and at $E_p = 2.76$ and 2.97 MeV (1986OU01). The ground-state rotational band is characterized by $\beta_2 = 0.44 \pm 0.04$, $\beta_4 = 0.14 \pm 0.04$. The *g* of ^{19}F*(0.197) is 1.442 ± 0.003 (1969BL18), 1.438 ± 0.005 (1984AS03). The mixing ratio for the $1.46 \rightarrow 0.11$ transition ($\frac{3}{2}^- \rightarrow$

Table 19.20: Electromagnetic transition rates from ^{19}F(e, e) [a]

E_x in ^{19}F (MeV)	J^π	Mult.	$\lvert M\rvert^2$ [b]
0.110	$\frac{1}{2}^-$	C1	$(5.5 \pm 0.6) \times 10^{-4}$
0.197	$\frac{5}{2}^+$	C2	62.8 ± 0.7
1.46	$\frac{3}{2}^-$	C1	$(9 \pm 2) \times 10^{-4}$
1.55	$\frac{3}{2}^+$	M1	0.15 ± 0.09
3.91	$\frac{3}{2}^+$	M1	0.43 ± 0.25
4.56	$\frac{3}{2}^-$	C1	$(2.8 \pm 2.3) \times 10^{-4}$
5.34	$\frac{1}{2}^+$	M1	0.34 ± 0.05
	$\frac{1}{2}^-$	C1	$(3.8 \pm 0.5) \times 10^{-3}$
5.50	$\frac{3}{2}^+$	M1	0.025
6.09	$\frac{3}{2}^-$	C1	$(4.7 \pm 1.3) \times 10^{-3}$
6.28	$\frac{5}{2}^+$	C2	17 ± 6
6.79	$\frac{3}{2}^-$	C1	$(5.0 \pm 1.3) \times 10^{-3}$
		M2	87 ± 42
7.66	$\frac{3}{2}^+; T = \frac{3}{2}$	M1	0.26 ± 0.08

[a] (1985BR15). See Table 19.20 in (1978AJ03) for the earlier work. P.M. Endt (private communication) adopts $\lvert M\rvert^2 = 8.9 \pm 0.5$ (C3), 6.9 ± 0.5 (C2) and 6.1 ± 2.4 W.u. (M5) for the ground state transitions of ^{19}F*(1.35, 1.55, 2.78).

[b] B(C1) in units of $e^2 \cdot \mathrm{fm}^2$, B(M1) in units of μ_N^2, B(C2) in units of $e^2 \cdot \mathrm{fm}^4$ and B(M2) in units of $\mu_N^2 \cdot \mathrm{fm}^2$. These are for transitions *from* the ground state.

$\frac{1}{2}^-; K = \frac{1}{2}^-$ band) δ(E2/M1) $= 0.248 \pm 0.020$. The E2 strength is 18.7 ± 1.9 W.u. The $1.46 \rightarrow 0$ transition is pure E1 ($\delta = 0.01 \pm 0.03$). For references see (1983AJ01). See also ^{20}Ne, (1985OU01, 1986HA1T) and (1983IK1B).

37. ^{19}F(d, d)^{19}F

Angular distributions have been measured for $E_d = 2.0$ to 15 MeV: see (1972AJ02, 1978AJ03).

38. ^{19}F(t, t)^{19}F

Elastic angular distributions have been studied for $E_t = 2$ and 7.2 MeV: see (1972AJ02).

39. ^{19}F(^{3}He, ^{3}He)^{19}F

Elastic angular distributions have been measured for $E(^3\text{He}) = 4.0$ to 29 MeV [see (1972AJ02, 1978AJ03)] and at 25 MeV (1982VE13). $\langle r^2 \rangle^{1/2}_{\text{matter}} = 2.72 \pm 0.12$ fm (1982VE13).

40. ^{19}F(α, α)^{19}F

Elastic angular distributions have been studied at $E_\alpha = 19.9$ to 23.3 MeV and at 38 MeV: see (1972AJ02). Many inelastic groups have also been studied: see Table 19.22 in (1978AJ03).

The energy of the γ-ray from the $1.35 \rightarrow 0.11$ transition is 1235.8 ± 0.2 keV; E_x is then 1345.7 ± 0.2 keV. $|\text{g}| = 0.269 \pm 0.043$ (1983BI03). See also Table 19.7. For τ_m see Table 19.8. ^{19}F*(4.65) decays to the $\frac{9}{2}^+$ state ^{19}F*(2.78): the angular distribution of the cascade γ-rays and the τ_m of ^{19}F*(4.65) set $J^\pi = \frac{13}{2}^+$. See also (1980ZO04, 1984CS01, 1984SA28, 1986NO1F) and (1983AJ01).

41. (a) ^{19}F(^{6}Li, ^{6}Li)^{19}F
(b) ^{19}F(^{7}Li, ^{7}Li)^{19}F

See (1978AJ03).

42. (a) ^{19}F(^{12}C, ^{12}C)^{19}F
(b) ^{19}F(^{12}C, ^{12}C)^{19}F* $\rightarrow \alpha + {}^{15}$N $Q_m = -4.0138$

Angular distributions (reaction (a)) have been studied at $E(^{12}\text{C}) = 40.6$ MeV [see (1983AJ01)] and at 30.0 to 60.1 MeV [as well as at $E(^{19}\text{F}) = 63.8$ MeV] (1984TA08, 1986TAZO; to ^{19}F*(0, 0.197, 1.55, 2.78)) and at $E(^{19}\text{F}) = 46.5$ to 57.1 MeV (1984MA32; to ^{19}F*(0, 0.197)) [see it and (1986VO12) for yield measurements].

Angular correlations involving the α-decay to ^{15}N$_{\text{g.s.}}$ of twenty ^{19}F states have been measured at $E(^{19}\text{F}) = 78.5$, 82 and 144 MeV and analyzed with DWBA and strong absorption model calculations. Two new states with $J^\pi = \frac{5}{2}^-$ or $\frac{7}{2}^-$ are reported at 7.740 and 8.277 MeV [estimated ± 0.04 MeV]. It is suggested that ^{19}F*(7.26, 9.287) are $\frac{3}{2}^+$ and $\frac{7}{2}^+$, $\frac{9}{2}^+$, respectively (1985SM04). See also (1986GA13, 1986IKZZ, 1986MA1Z), (1983AJ01, 1983BI13, 1984FR1A, 1984HA53, 1985HU04) and (1982GI1C, 1982LO13, 1983CI08, 1986HA13, 1986HE1A, 1987CO01; theor.).

43. (a) ^{19}F(^{14}N, ^{14}N)^{19}F
(b) ^{19}F(^{15}N, ^{15}N)^{19}F

Elastic scattering angular distributions have been studied at $E(^{14}\text{N}) = 19.5$ MeV and at $E(^{15}\text{N}) = 23$, 26 and 29 MeV: see (1983AJ01).

44. (a) ^{19}F(^{16}O, ^{16}O)^{19}F
(b) ^{19}F(^{18}O, ^{18}O)^{19}F

Elastic angular distributions have been studied at $E(^{16}\text{O}) = 21.4$ and 25.8 MeV and at $E(^{19}\text{F}) = 27$, 30, 33 and 36 MeV (reaction (a)) [also to ^{19}F*(1.46) at the two higher energies], and $E(^{16}\text{O}) = 60$ and 80 MeV (1986FUZV; also to ^{19}F*(0.20, 1.55, 2.78)), and at 27, 30 and 33 MeV [reaction (b)]: see (1978AJ03). See also (1986FU1C, 1986GA13), (1983DU13, 1986BA69) and (1982OH05; theor.).

45. ^{19}F(^{23}Na, ^{23}Na)^{19}F

See (1983AJ01, 1984FR1A) and (1985HU04; theor.).

46. ^{19}F(^{24}Mg, ^{24}Mg)^{19}F

See (1983AJ01). See also (1984PE19, 1986BR1W, 1986PE1G).

47. (a) ^{19}F(^{27}Al, ^{27}Al)^{19}F
(b) ^{19}F(^{28}Si, ^{28}Si)^{19}F
(c) ^{19}F(^{30}Si, ^{30}Si)^{19}F

See (1983AJ01) and (1984FR1A, 1984HA53, 1985ST1B, 1986BL08, 1986PE1G) and (1985OH01, 1986HA13; theor.).

48. ^{19}F(^{40}Ca, ^{40}Ca)^{19}F

For fusion cross sections see (1985RO01). See also (1983HE1B, 1984FR1A).

49. ^{19}Ne(β^+)^{19}F $\qquad Q_m = 3.2384$

See ^{19}Ne.

50. ^{20}Ne(d, ^{3}He)^{19}F $\qquad Q_m = -7.354$

See (1978AJ03).

51. ^{20}Ne(t, α)^{19}F $\qquad Q_m = 6.966$

See Table 19.23 in (1978AJ03).

52. ^{21}Ne(p, ^{3}He)^{19}F $\qquad Q_m = -11.890$

At $E_p = 45$ MeV ^{3}He groups are observed to some $T = \frac{1}{2}$ states in ^{19}F and to ^{19}F*(7.66), the $\frac{3}{2}^+$ $T = \frac{3}{2}$ analog of ^{19}O*(0.095): see reaction 12 in ^{19}Ne and (1978AJ03).

53. ^{22}Ne(p, α)^{19}F $\qquad Q_m = -1.675$

The parity violating asymmetry of the 110 keV γ-rays emitted by polarized ^{19}F* nuclei is $A_\gamma = -(6.8 \pm 2.1) \times 10^{-5}$ (1987EL03, 1982EL08). See also (1978AJ03).

54. ^{23}Na(d, ^{6}Li)^{19}F $\qquad Q_m = -8.994$

See (1984NE1A).

^{19}Ne
(Figs. 7 and 8)

GENERAL: (See also (1983AJ01).)

Nuclear models: (1983BR29, 1983PO02).

Special states: (1983BI1C, 1983BR29, 1983PO02, 1986AN07).

Electromagnetic transitions: (1982BR24, 1983BR29, 1985AL21).

Astrophysical questions: (1981WA1Q, 1982WI1B, 1986LA07).

Applications: (1982BO1N).

Complex reactions involving ^{19}Ne: (1981DE1P, 1983JA05, 1984GR08, 1985BE40, 1986GR1A, 1986HA1B, 1987RI03).

Pion capture and reactions (See also reaction 8.): (1983ME1H, 1984DA1P, 1984HU1C).

Hypernuclei: (1984AS1D).

Other topics: (1983AR1J, 1983BI1C, 1983BR29, 1985AL21, 1985AN28).

Ground state of ^{19}Ne: (1983BU07, 1983ANZQ, 1983AR1J, 1985AN28, 1985HA18, 1987BR1F).

$$\mu_{\text{g.s.}} = -1.88542\ (8)\ \text{nm (1982MA39)}$$
$$\mu_{0.239} = -0.740\ (8)\ \text{nm (1978LEZA)}$$

1. ^{19}Ne(β^+)^{19}F $\qquad Q_{\text{m}} = 3.2384$

We adopt the half-life of ^{19}Ne suggested by (1983AD03): 17.34 ± 0.09 sec. See also (1978AJ03). The decay is principally to ^{19}F$_{\text{g.s.}}$: see Table 19.23. The ^{19}Ne decay to ^{19}F*(0.11) [$J^\pi = \frac{1}{2}^+ \rightarrow \frac{1}{2}^-$] proceeds by vector and axial vector weak currents, with the former making a negligible contribution. The measured decay rates are roughly an order of magnitude smaller than predicted using the $0\hbar\omega + 1\hbar\omega$ shell model (1981AD05, 1983AD03). The decay of polarized ^{19}Ne is consistent with time-reversal invariance: see (1983SC32, 1984HA01). See also (1983AD1C, 1983AD1B, 1983AD1D, 1983VA01, 1984AD1E, 1984SI1G, 1985AD1A, 1985CA1P, 1985GR1A, 1986WI1P) and (1983CA03 [see for discussion of weak magnetism form factor and for search for heavy neutrinos], 1983GI1B, 1983VO05, 1984BO03, 1984HO1L, 1985GI09, 1986BR1X; theor.).

2. ^{15}O(α, γ)^{19}Ne $\qquad Q_{\text{m}} = 3.5294$

Table 19.21: Energy levels of ^{19}Ne [a]

E_x (MeV ± keV)	$J^\pi; T$	K^π	τ or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
0	$\frac{1}{2}^+; \frac{1}{2}$	$\frac{1}{2}^+$	$\tau_{1/2} = 17.22 \pm 0.02$ sec	β^+	1, 3, 4, 5, 8, 9, 10, 11, 12
0.23827 ± 0.11	$\frac{5}{2}^+$	$\frac{1}{2}^+$	$\tau_m = 26.0 \pm 0.8$ nsec $g = -0.296 \pm 0.003$	γ	4, 5, 9, 10, 11, 12
0.27509 ± 0.13	$\frac{1}{2}^-$	$\frac{1}{2}^-$	$\tau_m = 61.4 \pm 3.0$ psec	γ	4, 5, 9, 11
1.50756 ± 0.3	$\frac{5}{2}^-$	$\frac{1}{2}^-$	$1.4^{+0.5}_{-0.6}$ psec	γ	4, 5, 9, 11
1.5360 ± 0.4	$\frac{3}{2}^+$	$\frac{1}{2}^+$	28 ± 11 fsec	γ	4, 5, 9, 10, 11
1.6156 ± 0.5	$\frac{3}{2}^-$	$\frac{1}{2}^-$	143 ± 31 fsec	γ	4, 5, 9, 11
2.7947 ± 0.6	$\frac{9}{2}^+$	$\frac{1}{2}^+$	140 ± 35 fsec	γ	4, 5, 6, 8, 9, 10, 11, 12
4.0329 ± 2.4	$\frac{3}{2}^+$		< 50 fsec	γ	5, 7, 11, 12
4.140 ± 4	$(\frac{9}{2})^-$	$(\frac{1}{2}^-)$	< 0.3 psec	γ	5, 7, 11
4.1971 ± 2.4	$(\frac{7}{2})^-$	$(\frac{1}{2}^-)$	< 0.35 psec	γ	4, 5, 7, 11
4.3791 ± 2.2	$\frac{7}{2}^+$	$(\frac{1}{2}^+)$	< 0.12 psec	γ	5, 7, 11
4.549 ± 4	$(\frac{1}{2}, \frac{3}{2})^-$		< 80 fsec	γ	5, 7, 11
4.600 ± 4	$(\frac{5}{2}^+)$		< 0.16 psec	γ	5, 7
4.635 ± 4	$\frac{13}{2}^+$	$\frac{1}{2}^+$	> 1 psec	γ	4, 5, 6, 7, 8, 11
4.712 ± 10	$(\frac{5}{2}^-)$				5
4.783 ± 20					11
5.092 ± 6	$\frac{5}{2}^+$			γ	5, 7, 11, 12
5.351 ± 10	$\frac{1}{2}^+$				11
5.424 ± 7	$(\frac{7}{2}^+)$	$(\frac{1}{2}^+)$			4, 5, 11
5.463 ± 20					11
5.539 ± 9					11
5.832 ± 9					11
6.013 ± 7	$(\frac{3}{2}, \frac{1}{2})^-$				11
6.092 ± 8					5, 11
6.149 ± 20					12
6.288 ± 7					5, 11
6.437 ± 9					11
6.742 ± 7	$(\frac{3}{2}, \frac{1}{2})^-$				11

Table 19.21: Energy levels of ^{19}Ne [a] (continued)

E_x (MeV ± keV)	$J^\pi; T$	K^π	τ or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
6.861 ± 7					5, 11
7.067 ± 9					11
7.21 ± 20					5, 11
7.253 ± 10					11
(7.326 ± 15)					11
(7.531 ± 15)					11
7.616 ± 16	$\frac{3}{2}^+; \frac{3}{2}$				4, 11, 12
7.700 ± 10					11
(7.788 ± 10)					11
7.994 ± 15					11
8.069 ± 12					5, 11
8.236 ± 10					11
8.442 ± 9					4, 5, 11
8.523 ± 10					11
(8.810 ± 25)					11
8.920 ± 9					4, 5, 6, 11
9.013 ± 10					11
9.100 ± 20					11
9.240 ± 20					4, 11
9.489 ± 25					11
9.81 ± 20					4, 5, 6, 7, 11
10.01 ± 20					5
			$\Gamma_{c.m.}$ = (keV)		
10.407 ± 30	$\frac{3}{2}^+$		45	p, ^{3}He, α	3, 4, 11
10.46	$\frac{1}{2}^+$		355	p, ^{3}He, α	3
10.613 ± 20					11
11.08 ± 20					4, 5, 6
11.24 ± 20					5
1 1.40 ± 20					5
11.51 ± 50	$\frac{3}{2}^-, (\frac{1}{2}^-)$		25	^{3}He, α	4
12.23 ± 50	$\frac{5}{2}^+$		200 ± 25	^{3}He, α	4, 6

Table 19.21: Energy levels of ^{19}Ne [a] (continued)

E_x (MeV ± keV)	$J^\pi; T$	K^π	τ or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
12.40 ± 50	$\frac{7}{2}^+$		180 ± 25	^{3}He, α	3
12.56 ± 20					5
12.69 ± 50	$\frac{1}{2}^+$		180 ± 40	p, ^{3}He	3
13.1 ± 30					5
13.22 ± 30					5
13.8 ± 250			670 ± 250	γ, ^{3}He	3
14.18 ± 30					5, 6
14.44 ± 30					5
14.78 ± 30			620 ± 130	γ, ^{3}He	3, 5
16.23 ± 130			400 ± 130	γ, n, ^{3}He	3
18.4 ± 500			4400 ± 500	γ, ^{3}He	3

[a] See also Table 19.22.

(1986LA07) have recalculated the ^{15}O(α, γ) direct capture rate at stellar energies. See also (1987MAZV) and (1987DE05; theor.).

3. (a) ^{16}O(^{3}He, γ)^{19}Ne $\quad Q_m = 8.4433$
(b) ^{16}O(^{3}He, n)^{18}Ne $\quad Q_m = -3.196$ $\quad E_b = 8.4433$
(c) ^{16}O(^{3}He, p)^{18}F $\quad Q_m = 2.0321$
(d) ^{16}O(^{3}He, d)^{17}F $\quad Q_m = -4.8931$
(e) ^{16}O(^{3}He, ^{3}He)^{16}O
(f) ^{16}O(^{3}He, α)^{15}O $\quad Q_m = 4.9139$
(g) ^{16}O(^{3}He, ^{7}Be)^{12}C $\quad Q_m = -5.5744$

Excitation functions at 90° for γ_{0-2}, γ_{3-5} and γ_6 [reaction (a)] have been measured for $E(^3\text{He}) =$ 3 to 19 MeV (1983WA05): see Table 19.24 for a listing of the resonances reported in this and in other channels. See also (1983AJ01) and (1981LE01, 1985HA11, 1986BA89, 1987CO07; theor.).

4. ^{16}O(α, n)^{19}Ne $\quad Q_m = -12.1345$

Table 19.22: Radiative decay of ^{19}Ne levels [a]

E_i (MeV) [b]	J^{π}_i	E_f (MeV)	J^{π}_f	Branch (%)	τ_m
0.24	$\frac{5}{2}^+$	0	$\frac{1}{2}^+$	100	26.0 ± 0.8 nsec
0.28	$\frac{1}{2}^-$	0	$\frac{1}{2}^+$	(100) [c]	61.4 ± 3.0 psec
1.51	$\frac{5}{2}^-$	0.24	$\frac{5}{2}^+$	12 ± 3	
		0.28	$\frac{1}{2}^-$	88 ± 3 [d]	$1.4^{+0.5}_{-0.6}$ psec
1.54	$\frac{3}{2}^+$	0.24	$\frac{5}{2}^+$	95 ± 3 [d]	28 ± 11 fsec
		0.28	$\frac{1}{2}^-$	5 ± 3	
1.62	$\frac{3}{2}^-$	0	$\frac{1}{2}^+$	20 ± 3 [d]	
		0.24	$\frac{5}{2}^+$	10 ± 3	
		0.28	$\frac{1}{2}^-$	70 ± 4	143 ± 31 fsec
2.79	$\frac{9}{2}^+$	0.24	$\frac{5}{2}^+$	100 [d]	140 ± 35 fsec
4.03	$\frac{3}{2}^+$	0	$\frac{1}{2}^+$	80 ± 15	< 50 fsec
		0.28	$\frac{1}{2}^-$	5 ± 5	
		1.54	$\frac{3}{2}^+$	15 ± 5	
4.14	$(\frac{9}{2})^-$	1.51	$\frac{5}{2}^-$	100	< 0.3 psec
4.20	$(\frac{7}{2})^-$	0.24	$\frac{5}{2}^+$	20 ± 5	
		1.51	$\frac{5}{2}^-$	80 ± 5	< 0.35 psec
4.38	$\frac{7}{2}^+$	0.24	$\frac{5}{2}^+$	85 ± 4	< 0.12 psec
		2.79	$\frac{9}{2}^+$	15 ± 4	
4.55	$(\frac{1}{2}, \frac{3}{2})^-$	0	$\frac{1}{2}^+$	35 ± 25	
		0.28	$\frac{1}{2}^-$	65 ± 25	< 80 fsec
4.60	$(\frac{5}{2}^+)$	0.24	$\frac{5}{2}^+$	90 ± 5	< 0.16 psec
		1.54	$\frac{3}{2}^+$	10 ± 5	
4.64	$\frac{13}{2}^+$	2.79	$\frac{9}{2}^+$	100	> 1 psec

[a] See Table 19.26 in (1978AJ03) for additional data and for references.

[b] $E_x = 238.27 \pm 0.11$, 275.09 ± 0.13, 1507.56 ± 0.3, 1536.0 ± 0.4, 1615.6 ± 0.5 and 2794.7 ± 0.6 keV from E_γ measurements: see Table 19.25 in (1978AJ03).

[c] $B(\mathrm{E1}) = (1.06 \pm 0.05) \times 10^{-3}$ W.u.

[d] $\Gamma_\gamma = 0.17 \pm 0.08$, 24^{+27}_{-8}, $3.7^{+1.8}_{-0.9}$ and $2.0^{+1.3}_{-0.6}$ meV: see Table 19.26 in (1978AJ03).

Gamma transitions have been observed from the first six excited states of ^{19}Ne: see Table 19.25 in (1978AJ03) and Table 19.21 here. Angular distributions of many neutron groups have been studied at $E_\alpha = 41$ MeV: see (1983AJ01).

5. ^{16}O(^{6}Li, t)^{19}Ne $\qquad Q_{\rm m} = -7.351$

This reaction and the mirror reaction ^{16}O(^{6}Li, ^{3}He)^{19}F have been studied at $E(^6{\rm Li}) = 24$, 35, 36 and 46 MeV: see (1978AJ03, 1983AJ01). Table 19.13 displays the analog states observed in the two reactions. In addition triton groups are reported to states with $E_{\rm x} = 6.08$, 6.28, 6.85, 7.21, 8.08, 8.45, 8.94, 9.81, 10.01, 11.08, 11.24, 11.40, 12.56 [all ± 0.02], 13.1, 13.22, 14.18, 14.44, 14.78 [remaining, ± 0.03] MeV. See also (1983CU02).

6. ^{16}O(^{10}B, ^{7}Li)^{19}Ne $\qquad Q_{\rm m} = -9.344$

This as well as the analog reaction [^{16}O(^{10}B, ^{7}Be)^{19}F] have been studied at $E(^{10}{\rm B}) = 100$ MeV. On the basis of similar yields and $E_{\rm x}$, and in addition to the low-lying analogs, it is suggested that the following pairs of states are analogs in ^{19}F–(^{19}Ne): 8.98 (8.94), 11.33 (11.09), 12.79 (12.48), 14.15 (14.17), 14.99 (14.61) and 15.54 (15.40) [± 100 keV]; however, problems of energy resolution are evident. See (1983AJ01) for references on this and on other heavy-ion induced reactions.

7. ^{17}O(^{3}He, n)^{19}Ne $\qquad Q_{\rm m} = 4.2997$

Neutron-γ coincidence measurements lead to the determination of excitation energies [$E_{\rm x} = 4032.9 \pm 2.4, 4140 \pm 4, 4197.1 \pm 2.4, 4379.1 \pm 2.2, 4549 \pm 4, 4605 \pm 5, 4635 \pm 4$ and (5097 ± 10) keV], $\tau_{\rm m}$ and branching ratios (see Table 19.21). On the basis of these it is suggested that ^{19}Ne*(4.14, 4.20) are the analogs of ^{19}F*(4.03, 4.00) [$J^\pi = \frac{9}{2}^-, \frac{7}{2}^-$] and that ^{19}Ne*(4.55, 4.60) are the analogs of ^{19}F*(4.556, 4.550) [$J^\pi = \frac{5}{2}^+, \frac{3}{2}^-$]. There is no evidence for a reported state at $E_{\rm x} = 4.78$ MeV: see (1978AJ03).

8. ^{18}O(p, π^-)^{19}Ne $\qquad Q_{\rm m} = -134.813$

This reaction (at $E_{\vec{\rm p}} = 201$ MeV) selectively populates stretched 2p–1h states, in particular ^{19}Ne*(4.64) [$J^\pi = \frac{13}{2}^+$] and a structure near 10 MeV. Angular distributions and $A_{\rm y}$ are reported for ^{19}Ne*(0, 2.80, 4.6) (1986KE04). See also (1982VI05), (1986JA1H) and (1984BEZZ; theor.).

Table 19.23: Branchings in ^{19}Ne(β^+)^{19}F [a]

Decay to ^{19}F* (MeV)	J^π	Branch (%)	$\log ft$ [b]
0	$\frac{1}{2}^+$	99.99	3.237 ± 0.002
0.11	$\frac{1}{2}^-$	$(1.2 \pm 0.2) \times 10^{-2}$	7.061 ± 0.072
1.55 [c]	$\frac{3}{2}^+$	$(2.22 \pm 0.21) \times 10^{-3}$ [d]	5.700 ± 0.041

[a] (1983AD03). See also (1981AD05).
[b] See also (1985BR29).
[c] E_γ for ^{19}F*$(1.55 \rightarrow 0.20) = 1356.92 \pm 0.15$ keV (1976AL07), 1356.84 ± 0.13 keV (1983AD03).
[d] From (1976AL07, 1983AD03).

Table 19.24: Resonances reported in ^{16}O + ^{3}He [a]

$E(^3$He) (MeV)	Resonance in	$\Gamma_{\text{c.m.}}$ (MeV)	E_x (MeV)	J^π
2.400	$p_{1\rightarrow4}$, $p_{5,6,7}$, α_0	0.355	10.46	$\frac{1}{2}^+$
2.425	$p_{1\rightarrow4}$, $p_{5,6,7}$, α_0	0.045	10.48	$\frac{3}{2}^+$
3.65	pγ, ^{3}He, α_0	0.025	11.51 ± 0.05	$\frac{3}{2}^-$, $(\frac{1}{2}^-)$
4.50	^{3}He, α_0	0.200 ± 0.025	12.23 ± 0.05	$\frac{5}{2}^+$
4.70	^{3}He, α_0	0.180 ± 0.025	12.40 ± 0.05	$\frac{7}{2}^+$
5.05	p_0, p_1, p_5, ^{3}He	0.18 ± 0.04	12.69 ± 0.05	$\frac{1}{2}^+$
6.37 [b]	γ_0, γ_{1+2}	0.67 ± 0.25	13.8 ± 0.25	
7.65 [b]	γ_{1+2}	0.62 ± 0.13	14.88 ± 0.13	
9.26 [b]	γ_{1+2}, n	0.40 ± 0.13	16.23 ± 0.13	
11.8 [b]	$\gamma_{0\rightarrow2}$	4.4 ± 0.5	18.4 ± 0.5	

[a] See reaction 2, ^{19}Ne, in (1978AJ03) for references.
[b] $(2J+1)\Gamma_{^3\text{He}}\Gamma_\gamma = 30 \pm 17$, 89 ± 44, 18 ± 4 and 17000 ± 5300 keV^2 for ^{19}Ne*(13.8, 14.9, 16.2, 18.4) (1983WA05).

9. ^{19}F(p, n)^{19}Ne $Q_m = -4.0207$

Neutron measurements are shown in Table 19.24 of (1972AJ02). Excited states of ^{19}Ne determined from γ-spectra are displayed in Table 19.25 of (1978AJ03). Branching ratio and τ_m measurements are summarized in Table 19.22 here. For the *g*-factor of ^{19}Ne*(0.24) see Table 19.21. Recently angular distributions have been measured at $E_p = 160$ MeV to ^{19}Ne*(0[0], 1.54[$(0+2)$], 5.4[0], 6.2[$(0+1)$], 7.1[$(0+1)$], 7.7[$(0+1)$], 8.60[(0)], 10.2[(1)], 11.0[0], 12.1) (1984RA22; [L in brackets] also forward $\sigma(\theta)$ at $E_p = 120$ MeV). See (1984RA22, 1985WA24) for discussions of the GT strengths. See also ^{20}Ne, (1983RA1C, 1984TAZS) and (1985BA66; applications).

10. ^{19}F(^{3}He, t)^{19}Ne $Q_m = -3.2570$

Angular distributions have been obtained for the triton groups to ^{19}Ne*(0.24, 1.54, 2.79) at $E(^3\text{He}) = 26$ MeV: see (1978AJ03).

11. ^{20}Ne(^{3}He, α)^{19}Ne $Q_m = 3.7092$

Alpha groups have been observed to ^{19}Ne states with $E_x < 10.6$ MeV: see Tables 19.21 and 19.25. Angular distributions have been measured for $E(^3\text{He}) = 10$ to 35 MeV: see (1972AJ02). DWBA analysis of the strongest transitions leads to the l and J^π values shown in Table 19.25. ^{19}Ne*(0, 0.24, 1.54, 2.79) are identified as members of the $K = \frac{1}{2}^+$ rotational band [with ^{19}Ne*(4.38) as the $\frac{7}{2}^+$ member] and ^{19}Ne*(0.28, 1.51, 1.62) with the $K^\pi = \frac{1}{2}^-$ band. Candidates for the $\frac{7}{2}^-$ and $\frac{9}{2}^-$ members of the $K = \frac{1}{2}^-$ band are thought to be ^{19}Ne*(4.15, 4.20). Possible matching of other ^{19}Ne states with those in ^{19}F is also discussed: see (1972AJ02). For lifetime and radiative decay measurements see Table 19.21. See also (1981CL05; theor.).

12. ^{21}Ne(p, t)^{19}Ne $Q_m = 15.147$

At $E_p = 40$ MeV the angular distributions to ^{19}Ne*(0.24, 4.03, 5.09) are well described by $L = 2$, 0 and 4, respectively. ^{19}Ne*(4.03), $J^\pi = \frac{3}{2}^+$, has a dominant 5p–2h configuration. ^{19}Ne*(5.09) has $\pi = +$ and its J is consistent with $\frac{5}{2}$. At $E_p = 45$ MeV the triton group to a state with $E_x = 7.620 \pm 0.025$ MeV has an angular distribution [$L = 0$] which is similar to that for ^{19}F*(7.66): both are thought to be the analogs of the $(J^\pi; T) = (\frac{3}{2}^+; \frac{3}{2})$ 0.096 MeV first excited state of ^{19}O. The ground state of ^{19}O has $J^\pi = \frac{5}{2}^+$; L for the anaolg state should be 2. ^{19}Ne*(0, 2.79) are also populated: see (1978AJ03, 1983AJ01).

Table 19.25: ^{19}Ne levels from ^{20}Ne(^{3}He, α) [a]

E_x (MeV ± keV)	l_n	J^π	E_x (MeV ± keV)
0	0	$\frac{1}{2}^+$	6.862 ± 7
0.23834 ± 0.15	2	$\frac{5}{2}^+$	7.067 ± 9
0.27530 ± 0.2	1	$\frac{1}{2}^-$	(7.178 ± 15)
1.5040 ± 3		$(\frac{5}{2}^-)$	7.253 ± 10
1.5324 ± 3		$(\frac{3}{2})^+$	(7.326 ± 15)
1.6115 ± 3	1	$(\frac{3}{2})^-$	(7.531 ± 15)
2.7917 ± 3	4, 5	$(\frac{9}{2}^+)$	7.614 ± 20
4.036 ± 10	2	$(\frac{3}{2}, \frac{5}{2})^+$	7.700 ± 10
4.142 ± 10			(7.788 ± 10)
4.200 ± 10			7.994 ± 15
4.379 ± 10			8.063 ± 15
4.551 ± 10	1	$(\frac{1}{2}, \frac{3}{2})^-$	8.236 ± 10 [b]
4.625 ± 10			8.440 ± 10
4.712 ± 10			8.523 ± 10
4.783 ± 20			(8.810 ± 25)
5.089 ± 7			8.915 ± 10
5.351 ± 10	0	$\frac{1}{2}^+$	9.013 ± 10
5.424 ± 7			9.100 ± 20
5.463 ± 20			9.240 ± 20
5.539 ± 9			9.489 ± 25
5.832 ± 9			9.886 ± 50 [b]
6.013 ± 7	1	$(\frac{3}{2}, \frac{1}{2})^-$	10.407 ± 30 [b]
6.094 ± 8			10.613 ± 20
6.149 ± 20			
6.289 ± 7			
6.437 ± 9			
6.742 ± 7	1	$(\frac{3}{2}, \frac{1}{2})^-$	

[a] See Table 19.27 of (1978AJ03) for additional results and for a listing of the references.
[b] Unresolved states.

^{19}Na

(Fig. 8)

A study of this nucleus via the ^{24}Mg(^{3}He, ^{8}Li)^{19}Na reaction at $E(^{3}\text{He}) = 76.3$ MeV leads to an atomic mass excess of 12.929 ± 0.012 MeV for ^{19}Na; it is then unstable with respect to breakup into ^{18}Ne + p by 321 ± 13 keV. An excited state at $E_{\text{x}} = 120 \pm 10$ keV is also reported (1975BE38, 1985WA02). See also (1985AN28, 1986AN07) and (1983ANZQ, 1983AU1B; theor.).

^{19}Mg, etc.

(Not observed)

See (1977CE05), (1986AN07) and (1983ANZQ; theor.).

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