Energy Levels of Light Nuclei
$A = 19$

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Abstract: An evaluation of $A = 18$–20 was published in *Nuclear Physics A*392 (1983), 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.

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^{19}B

(Not illustrated)

Assuming the atomic mass excess to be 60.1 MeV [see (1978AJ03)], ^{19}B is stable with respect to breakup into ^{18}B + n by 1.8 MeV and into ^{17}B + 2n by 0.4 MeV.

^{19}C

(Not illustrated)

^{19}C has been observed in the 4.8 GeV proton bombardment of uranium: it is particle stable (1974BO05). The calculated mass excess of ^{19}C is 32.45 MeV using the modified form of the IMME (1975JE02): ^{19}C would then be stable with respect to decay into ^{18}C + n by 0.53 MeV and into ^{17}C + 2n by 4.72 MeV [see (1982AJ01) for the mass of ^{17}C. See also (1978AJ03).

^{19}N

(Fig. 8)

Studies of the ^{18}O(^{18}O, ^{17}F)^{19}N and ^{208}Pb(^{18}O, ^{207}Bi)^{19}N reactions at $E(^{18}\text{O}) = 91$ and 93 MeV, respectively, lead to values of the atomic mass excess of ^{19}N of 15.856 ± 0.050 (1982NA08) and 15.96 ± 0.15 MeV (1979BA31). The adopted value is 15.866 ± 0.048 MeV. ^{19}N is then stable with respect to decay into ^{18}N + n by 5.45 MeV. Differential cross sections for the two reactions in which ^{19}N has been observed are ≈ 500 nb/sr $(6°)$ (1982NA08) and ≈ 120 nb/sr $(85°)$ (1979BA31). In addition to the ground-state transition, (1982NA08) report the population of states at $E_{\text{x}} = 1.12 \pm 0.04$ and 1.59 ± 0.04 MeV. See also (1980AL1F, 1980NA12) and (1978AJ03).

^{19}O

(Figs. 5 and 8)

GENERAL: (See also (1978AJ03).)

Shell model: (1977GR16, 1979DA15, 1980KU05, 1982KI02).

Electromagnetic transitions: (1976MC1G, 1978KR19, 1980KU05).

Special states: (1977GR16, 1977SH18, 1979DA15, 1982KI02).

Astrophysical questions: (1979WO07).

Complex reactions involving ^{19}*O:* (1978KO01, 1979AL22, 1981GR08).

Other topics: (1977GR16, 1977SH18, 1979BE1H, 1979CO09, 1980SH1H, 1982KI02).

Ground-state properties of ^{19}*O:* (1976MC1G).

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

E_x (MeV ± 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, 9, 10, 11, 12
0.0960 ± 0.5	$\frac{3}{2}^+$	$\tau_m = 2.00 \pm 0.07$ nsec g $= -0.48 \pm 0.06$	γ	3, 4, 9, 10, 12
1.4717 ± 0.4	$\frac{1}{2}^+$	$\tau_m = 1.27 \pm 0.17$ psec	γ	3, 4, 9
2.3715 ± 1.0	$\frac{9}{2}^+$	> 3.5 psec	γ	3, 4, 9
2.7790 ± 0.9	$\frac{7}{2}^+$	93 ± 19 fsec	γ	3, 4, 9
3.0674 ± 1.6	$\frac{3}{2}^+$	≥ 1 psec	γ	3, 4, 9
3.1535 ± 1.7	$\frac{5}{2}^+$	(≥ 1 psec)	γ	3, 4, 9
3.2316 ± 2.3	$\frac{3}{2}^+$			3, 4, 9
3.9449 ± 1.4 [c]	$\frac{3}{2}^-$		γ	3, 4, 9
4.1093 ± 1.9	$\frac{3}{2}^+$	$\Gamma < 15$ keV		3, 4, 9
4.3281 ± 2.4	$\frac{3}{2}, \frac{5}{2}$	< 15		3, 4, 9
4.4025 ± 2.7	$\frac{3}{2} \rightarrow \frac{7}{2}$	< 15		3, 4, 9
4.5820 ± 4.6	$\frac{3}{2}^-$	52 ± 3	n	3, 4, 6, 9
4.7026 ± 2.7	$\frac{5}{2}^+$	< 15		3, 4, 9
4.9683 ± 5.5	$\frac{5}{2}, \frac{7}{2}$			3
5.0070 ± 4.5	$\frac{3}{2}, \frac{5}{2}$	< 15		3, 4, 9
5.0820 ± 5.4	$\frac{1}{2}^-$	49 ± 5	n	3, 6
5.1484 ± 3.2	$\geq \frac{5}{2}^+$	3.4 ± 1.0	n	3, 4, 6, 9
5.33	$\frac{3}{2}^+$	330	n	6
5.3840 ± 2.8	$(\frac{9}{2} \rightarrow \frac{13}{2})$			3
5.455 ± 9	$\frac{5}{2}^+$	280	n	6
5.5035 ± 3.1 [c]		< 15		3, 4, 9
5.7046 ± 4.3 [c]		7.8 ± 1.4	n	3, 4, 6, 9
6.1196 ± 3.2 [c]				3
6.13	$\frac{3}{2}^+$	190	n	6
6.1916 ± 5.5	$\frac{1}{2}^-$	120	n	3, 6
6.2693 ± 2.6	$\frac{7}{2}^-$	19.2 ± 2.4	n	3, 4, 6, 9
6.4058 ± 3.1 [c]				3
6.4662 ± 4.8	$(\frac{7}{2} \rightarrow \frac{11}{2})$		(n)	3, 6, 9

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
6.583 ± 6 [c]				3, 9
6.903 ± 8				3, 9
6.988 ± 9				3, 9
7.118 ± 10				3, 9
7.242 ± 8				3, 9
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
9.77				3
9.88				3
9.93				3
9.98				3
11.25 ± 50		240	n, α	6
11.58 ± 50		330	n, α	6

[a] See also Table 19.2.

[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_i^π	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).

1. ^{19}O(β^-)^{19}F $\qquad Q_m = 4.819$

The weighted mean of several reported half-lives is 26.91 ± 0.08 sec: see (1972AJ02). The decay is complex: see ^{19}F, reaction 36 and Table 19.20. See also (1977OK1A; theor.).

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

Cross sections and S-factors are reported for $E_{cm} = 1.77$ to 6.71 MeV (1980RO13). See also (1978AJ03).

3. ^{13}C(^{7}Li, p)^{19}O $\qquad Q_m = 7.413$

States of ^{19}O reported in this reaction are displayed in Table 19.3 (1977FO10).

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

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

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); $E(^7\text{Li}) = 16.0$ 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 19.5), 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 $J \geq \frac{13}{2}$.

5. ^{18}O(n, γ)^{19}O $\qquad$ $Q_m = 3.957$

The thermal capture cross section is 0.16 ± 0.01 mb (1981MUZQ). See also (1978AJ03).

6. ^{18}O(n, n)^{18}O $\qquad$ $E_b = 3.957$

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 measured for $E_n = 0.14$ to 2.47 MeV shows five resonances at $E_n = 0.66$, 1.19, 1.26, 1.84 and 2.45 MeV [see Table 19.5] in addition to a broad maximum at $E_n = 1.6$ MeV and resonance structure near 2.3 MeV (1965VA03). A phase-shift analysis by (1964DO08, 1973DO05) is consistent with the (1965VA03) results and suggests that the two broad structures can each be accounted for in terms of two levels whose parameters are displayed in Table 19.5. At higher energies [$E_n = 2.45$ to 8.50 MeV and 10.6 to 19.0 MeV] the total cross section shows additional structures. See also (1978AJ03, 1981MUZQ).

7. (a) ^{18}O(n, p)^{18}N $\qquad$ $Q_m = -13.25$ $\qquad$ $E_b = 3.957$
(b) ^{18}O(n, d)^{17}N $\qquad$ $Q_m = -13.717$

See (1978AJ03).

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	$(0+2)$	(0.06)	$\frac{5}{2}^+$
3.1535 ± 2.4		[a]			$\frac{3}{2}^+$
3.237 ± 5		1		0.11	$\frac{3}{2}^-$
3.944 ± 3	< 15	2	(2)	0.03	$\frac{3}{2}^+$
4.118 ± 5	< 15				
4.333 ± 12					
4.402 ± 12	75 ± 5	1		0.15	$\frac{3}{2}^-$
4.584 ± 12	< 15	2	[a]	0.02	$\frac{5}{2}^+$
4.707 ± 12	< 15				
4.998 ± 12	< 15	2	[a]	0.08	$\frac{5}{2}^+$
5.150 ± 10	320 ± 25	2	$(2+4)$	0.85	$\frac{3}{2}^+$
5.455 ± 10	45				
5.502 ± 12	< 15	2		0.17	$(\frac{3}{2})^+$
5.714 ± 12	< 15	3		0.13	$(\frac{7}{2}^-)$
6.280 ± 12					
6.480 ± 15					
6.560 ± 15					
6.899 ± 15					
6.997 ± 15					
7.117 ± 15					
7.248 ± 15					

[a] For references and other values see Table 19.3 in (1978AJ03).
[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.

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

E_{res} (MeV ± keV)	Γ_{cm} (keV)	^{19}O* (MeV)	J^π
0.661 ± 10	52 ± 3	4.583	$\frac{3}{2}^-$
1.192 ± 10	49 ± 5	5.086	$\frac{1}{2}^-$
1.256 ± 10	3.4 ± 1.0	5.146	$\frac{3}{2}$
1.45	330	5.33	$\frac{3}{2}^+$
1.60	280	5.47	$\frac{5}{2}^+$
1.840 ± 10	7.8 ± 1.4	5.699	$\frac{3}{2}$
2.30	190	6.13	$\frac{3}{2}^+$
2.37	120	6.20	$\frac{1}{2}^-$
2.445 ± 10	19.2 ± 2.4	6.272	$\frac{7}{2}^-$
≈ 2.58		(6.40)	
(2.63)		(6.45)	

[a] See Table 19.4 in (1978AJ03) for references.

8. ^{18}O(n, α)^{15}C $\quad Q_m = -5.0097 \quad E_b = 3.957$

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 $\Gamma_{lab} = 0.25$ and 0.35 MeV, respectively [^{19}O*(11.25, 11.58)] (1967ST28).

9. ^{18}O(d, p)^{19}O $\quad Q_m = 1.732$

Angular distributions have been measured at $E_d = 0.8$ to 15 MeV: see (1978AJ03) for the earlier work and (1979ST21; $E_{\vec{d}} = 8$ to 12 MeV). The l_n values and spectroscopic factors dereived from these measurements are displayed in Table 19.4.

Branching ratios are shown in Table 19.3. ^{19}O*(0.096) has $g = -0.48 \pm 0.06$; its configuration appears to be mainly $d^3_{5/2}$ and $B(M1) = (0.040 \pm 0.015)\ \mu_N^2$ (1976GO09). The ΔE value for the $1.47 \to 0.096$ 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 (1973WA10). Angular correlations are consistent with $J^\pi = \frac{5}{2}^+$ for the ground state and unambiguously fix $J^\pi = \frac{3}{2}^+$ and $\frac{1}{2}^+$, respectively, for ^{19}O*(0.096, 1.47) (1965AL13).

10. (a) ^{18}O(^{13}C, ^{12}C)^{19}O $\quad Q_m = -0.989$

(b) ^{18}O(^{14}C, ^{13}C)^{19}O $\quad Q_{\rm m} = -4.219$

(c) ^{18}O(^{17}O, ^{16}O)^{19}O $\quad Q_{\rm m} = -0.186$

(d) ^{18}O(^{18}O, ^{17}O)^{19}O $\quad Q_{\rm m} = -4.087$

An angular distribution is reported for reaction (a) at $E(^{18}{\rm O}) = 31$ MeV to $^{19}{\rm O}_{\rm g.s+0.096}$ (1978CH16). At $E(^{18}{\rm O}) = 36$ MeV angular distributions for reaction (c) to ^{19}O*($0 + 0.096$, 1.47) have been studied by (1977KA1Y). Differential cross sections are reported for $E(^{18}{\rm O}) = 30$ to 36 MeV for reaction (d) (1977KA21). See also (1978AJ03).

11. ^{19}N(β^-)^{19}O $\quad Q_{\rm m} = 12.54$

The β-decay of ^{19}N has not been observed.

12. ^{19}F(n, p)^{19}O $\quad Q_{\rm m} = -4.036$

Angular distributions have been reported at $E_{\rm n} = 14.1$ and 14.4 MeV for the $p_0 \rightarrow p_2$ groups: see (1972AJ02) and ^{20}F.

^{19}F
(Figs. 6 and 8)

GENERAL: (See also (1978AJ03).)

Shell model: (1978CH26, 1978DA1N, 1978MA2H, 1979DA15, 1980KU05, 1980MC1L, 1981ER03, 1981GR06, 1982KI02).

Cluster, collective and rotational models: (1977BU22, 1977FO1E, 1978BR21, 1978CH26, 1978PE09, 1978PI1E, 1978TA1A, 1978TH1A, 1978ZE07, 1979FO03, 1979MA27, 1979PE16, 1979SA41, 1979SA43, 1980FU1G).

Electromagnetic transitions: (1976MC1G, 1977BI1D, 1977CL03, 1977HE1L, 1977MA2P, 1978DE1K, 1978KR19, 1978PE09, 1978SC19, 1978ZE07, 1979MA27, 1979PE16, 1979SA41, 1979SA43, 1980BR09, 1980FU1G, 1980KU05, 1980MI1G).

Special states: (1977MA2P, 1978BR21, 1978MA2H, 1978PE09, 1978PI1E, 1978SC19, 1978TA1A, 1978ZE07, 1979DA15, 1979FO03, 1979LA10, 1979SA41, 1979SA43, 1980BR21, 1980FU1G, 1981ER03, 1982KI02).

Astrophysical questions: (1977TR1D, 1978DI1D, 1978ME1D, 1978OR1A, 1979CH1T, 1979LA1H, 1979RA1C, 1979WO07, 1980CO1R, 1980GO1D).

Applied topics: (1979FO1F, 1979GR1E, 1980DE1U, 1980DI03, 1980KR1C, 1980MC1H).

Complex reactions involving ^{19}F: (1978CA1N, 1978GO1N, 1978OB01, 1978VO1D, 1978YO01, 1979BE31, 1979GA04, 1979GO11, 1979MO17, 1979SA26, 1979NA1F, 1980GR10, 1981CI03, 1981GR08, 1981NA1E, 1982SH1E).

Muon and neutrino capture and reactions: (1978LE04, 1978SC13, 1981MU1E).

Pion capture and reactions: (1977BE2P, 1977MA35, 1977ST27, 1978OL04, 1978SI1D, 1979BE31, 1979BO1N, 1979KI1G, 1979NA1F, 1980LI1J, 1980ST25, 1981BE63, 1981FR17, 1981LIZR, 1981NI03, 1982BI1H).

Kaon capture: (1978AT01).

Other topics: (1977GR16, 1978AN15, 1978BR21, 1978DE1K, 1978MA2H, 1979BE1H, 1979BE2L, 1979CO09, 1979DE10, 1979DE18, 1979HE1F, 1979LA10, 1979MA27, 1979PE16, 1979SA41, 1979SA43, 1980BR21, 1980DE1F, 1980KO1U, 1980TA1L, 1981AD1E, 1981AR1D, 1981CA1H, 1981DU1D, 1981ER03, 1982KI02).

Ground state of ^{19}F: (1976MC1G, 1977MA35, 1977MA2P, 1977NO07, 1978AN07, 1978BR21, 1978CH26, 1978HE1D, 1978MA54, 1978ZA1D, 1978ZE07, 1979MA27, 1979SA41, 1979SA43, 1980BR09, 1980BR13, 1980HA41, 1981AR1D).

$$\mu_{\text{g.s.}} = +2.628866 \pm 0.000008 \text{ nm (1978LEZA)};$$

$\mu_{0.197} = +3.607 \pm 0.008$ nm (1978LEZA);

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

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		2, 3, 6, 8, 12, 13, 15, 19, 20, 21, 23, 24, 26, 27, 28, 29, 34, 35, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66
0.109894 ± 0.0005	$\frac{1}{2}^-$	$\frac{1}{2}^-$	$\tau_m = 0.853 \pm 0.010$ nsec	γ	13, 20, 21, 26, 29, 35, 36, 41, 43, 44, 48, 58, 62, 64, 65
0.197143 ± 0.004	$\frac{5}{2}^+$	$\frac{1}{2}^+$	128.8 ± 1.5 nsec	γ	13, 15, 19, 20, 21, 26, 27, 29, 35, 36, 42, 43, 44, 45, 48, 50, 62, 64
1.34567 ± 0.13	$\frac{5}{2}^-$	$\frac{1}{2}^-$	4.4 ± 0.6 psec	γ	13, 15, 19, 20, 21, 26, 29, 35, 36, 43, 44, 45, 48
1.4587 ± 0.3	$\frac{3}{2}^-$	$\frac{1}{2}^-$	90 ± 20 fsec	γ	13, 15, 20, 21, 26, 29, 35, 41, 43, 44, 45, 48, 52, 62
1.554038 ± 0.009	$\frac{3}{2}^+$	$\frac{1}{2}^+$	5 ± 3 fsec	γ	13, 19, 20, 21, 26, 27, 29, 34, 35, 36, 42, 43, 44, 45, 48, 50, 58, 62
2.779849 ± 0.034	$\frac{9}{2}^+$	$\frac{1}{2}^+$	280 ± 30 fsec	γ	4, 5, 7, 10, 11, 13, 15, 17, 19, 20, 21, 24, 26, 27, 29, 34, 35, 42, 43, 44, 45, 48, 61, 62

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
3.90817 ± 0.20	$\frac{3}{2}^+$	$\frac{3}{2}^+$	9 ± 5 fsec	γ	20, 21, 26, 29, 35, 36, 41, 44, 48, 62
3.9987 ± 0.7	$\frac{7}{2}^-$	$\frac{1}{2}^-$	19 ± 7 fsec	γ	13, 20, 21, 26, 29, 34, 35, 44, 48, 62
4.0325 ± 1.2	$\frac{9}{2}^-$	$\frac{1}{2}^-$	67 ± 15 fsec	γ	13, 15, 17, 19, 20, 21, 26, 29, 34, 36, 44, 48, 62
4.377700 ± 0.042	$\frac{7}{2}^+$	$\frac{3}{2}^+$	< 11 fsec	γ	13, 19, 20, 21, 26, 27, 29, 34, 35, 36, 42, 44, 48, 62
4.5499 ± 0.8	$\frac{5}{2}^+$	$\frac{3}{2}^+$	< 50 fsec	γ	13, 20, 21, 26, 29, 44, 48, 62
4.5561 ± 0.5	$\frac{3}{2}^-$		17^{+10}_{-8} fsec	γ	20, 21, 34, 35, 44, 48, 62
4.648 ± 1	$\frac{13}{2}^+$	$\frac{1}{2}^+$	2.2 ± 0.3 psec	γ	13, 19, 20, 21, 24, 26, 27, 29, 42, 48, 62
4.6825 ± 0.7	$\frac{5}{2}^-$		15.4 ± 3.0 fsec	γ, α	13, 20, 29, 34, 35, 44, 48, 62
5.1066 ± 0.9	$\frac{5}{2}^+$		< 30 fsec	γ, α	13, 20, 21, 26, 29, 34, 35, 44, 48, 62
5.337 ± 2	$\frac{1}{2}^{(+)}$		≤ 0.1 fsec	γ, α	13, 20, 21, 26, 29, 35, 44, 48, 62
5.418 ± 1	$\frac{7}{2}^-$		≤ 0.9 fsec	γ, α	13, 20, 26, 29, 35, 44, 48
5.4635 ± 1.5	$\frac{7}{2}^+$	$\frac{1}{2}^+$	≤ 0.26 fsec	γ, α	13, 15, 19, 20, 21, 26, 27, 29, 42, 44, 48
5.5007 ± 1.7	$\frac{3}{2}^+$		$\Gamma = 4 \pm 1$ keV	γ, α	13, 14, 21, 29, 44, 48
5.535 ± 2	$\frac{5}{2}^+$			γ, α	13, 26, 29, 44, 48, 62
5.621 ± 1	$\frac{5}{2}^-$		$\tau_m < 1.3$ fsec	γ, α	13, 26, 29, 34, 35, 44, 48, 61, 62

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
5.938 ± 1	$\frac{1}{2}^+$			γ, α	13, 29, 34, 35, 44, 62
6.070 ± 1	$\frac{7}{2}^+$		$\Gamma = 1.2$	γ, α	13, 14
6.088 ± 1	$\frac{3}{2}^-$		4	γ, α	13, 14, 15, 20, 21, 29
6.100 ± 2	$\frac{9}{2}^-$			γ	29
6.1606 ± 0.9	$\frac{7}{2}^-$			γ, α	13, 29, 44, 62
6.255 ± 1	$\frac{1}{2}^+$		8	γ, α	14, 29, 34, 35, 44
6.282 ± 2	$\frac{5}{2}^+$		2.4	γ, α	13, 14, 19, 29, 34, 44
6.330 ± 2	$\frac{7}{2}^+$		2.4	γ, α	13, 14, 15, 44
6.429 ± 8	$\frac{1}{2}^-$		280	α	14
6.4967 ± 1.4	$\frac{3}{2}^+$			γ, α	13, 21, 29, 35
6.5000 ± 0.9	$\frac{11}{2}^+$	$\frac{3}{2}^+$		γ, α	13, 21, 27, 29
6.5275 ± 1.4	$\frac{3}{2}^+$		4	γ, α	13, 14, 19, 21, 29
6.554 ± 2	$\frac{7}{2}$		1.6	γ, α	13, 14
6.592 ± 2	$\frac{9}{2}^+$	$\frac{3}{2}^+$		γ, α	13, 19, 29, 35
6.787 ± 2	$\frac{3}{2}^-$		2.4	γ, α	13, 14, 29, 35, 62
6.8384 ± 0.9	$\frac{5}{2}^+$		1.2	γ, α	13, 14, 29
6.891 ± 4	$\frac{3}{2}^-$		28	γ, α	13, 14, 21
6.9265 ± 1.7	$\frac{7}{2}^-$		2.4	γ, α	13, 14, 15, 19, 20, 29, 35
6.989 ± 3	$\frac{1}{2}^-$		51	α	14, 29
7.114 ± 6	$\frac{7}{2}^+$ [b]		32	α	14, 35
7.1662 ± 0.7	$\frac{11}{2}^-$			γ, α	13
7.262 ± 2	$\frac{1}{2}^-, \frac{3}{2}$		$\lesssim 6$	α	14, 19, 20, 21, 29, 34, 35
7.364 ± 4	$\frac{1}{2}^+$			α	14, 21, 34, 35
7.5396 ± 0.9	$\frac{5}{2}^+; \frac{3}{2}$			γ, α	13, 15, 19, 29, 35
7.56 ± 10	$\frac{7}{2}^+$		$\lesssim 90$	α	14
7.6606 ± 0.9	$\frac{3}{2}^+; \frac{3}{2}$			γ, α	13, 29, 35, 41, 63
7.702 ± 5	$\frac{1}{2}^-$		$\lesssim 30$	α	14, 19, 35

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
7.79			$\lesssim 6$	α	14
7.90			$\lesssim 200$	α	14
7.929 ± 3	$\frac{7}{2}^+, \frac{9}{2}$			γ, α	13, 14, 19, 21
7.937 ± 3	$\frac{11}{2}^+$			γ, α	13, 27
8.015 ± 2	$\frac{5}{2}^+$				29, 35
8.0838 ± 2.6			≤ 3	p, α	33, 35
8.1368 ± 1.0	$\frac{1}{2}^+$		≤ 0.3	γ, p, α	14, 29, 33, 34, 35
(8.16)			$\lesssim 50$	α	14
8.1980 ± 0.8	$(\frac{5}{2}^+)$		≤ 1	γ, p, α	29, 33, 35
8.2535 ± 2.6	$(\frac{5}{2}^+)$		≤ 1.5	γ, p	29, 35
8.288 ± 2	$\frac{13}{2}^-$	$(\frac{1}{2}^-)$	< 1	γ, α	13, 15, 16, 17, 19, 20, 29
8.310 ± 1	$\frac{5}{2}^+$		0.047 ± 0.019	γ, p, α	13, 29, 33, 35
8.370 ± 4	$\frac{7}{2}, \frac{5}{2}^+$		7.5 ± 1.5	γ, α	13
8.581 ± 2	$\frac{5}{2}^+$		≤ 0.5	γ, p, α	13, 29
8.5891 ± 1.0	$\frac{3}{2}^-$		2.0 ± 0.1	γ, p, α	13, 19, 29, 31, 33, 35
8.629 ± 4	$\frac{7}{2}^-$		< 1	γ, α	13
8.65	$\frac{1}{2}^+$		≈ 300	γ, p, α	29, 31, 33
8.793 ± 2	$\frac{1}{2}^+; \frac{3}{2}$		46 ± 2	γ, p	29, 35
8.864 ± 4	$< \frac{9}{2}$		≈ 1	γ, α	13
8.919 ± 2	$\frac{3}{2}$		10 ± 2	γ, p	29
8.9280 ± 0.8	$\frac{3}{2}^-$		3.6 ± 0.2	p, α	31, 33
8.953 ± 3	$\frac{11}{2}^-$		4.2 ± 1	γ, α	13, 15, 16, 17, 19, 20, 31, 33
9.030 ± 5	$\frac{5}{2}, \frac{7}{2}$			γ, α	13
9.0988 ± 0.6	$\frac{7}{2}^-$		0.57 ± 0.03	γ, p, α	13, 29, 31, 33
9.101 ± 4	$\frac{7}{2}^+, \frac{9}{2}^+$		≈ 1	γ, α	13, 35
9.167 ± 1.1	$\frac{1}{2}^+$		6.2 ± 0.5	γ, p, α	13, 31, 33, 35
9.204 ± 7	$\frac{3}{2}$		10.2 ± 1.5	γ, α	13
9.267 ± 4	$\frac{11}{2}^+, \frac{9}{2}^+$		2 ± 1	γ, α	13
9.280 ± 5	$\frac{7}{2}, \frac{9}{2}$		< 1.5	γ, α	13

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
9.318 ± 2	$\frac{3}{2}^+$		3.4 ± 0.7	γ, p, α	13, 19, 29
9.321 ± 1.1	$\frac{1}{2}^+$		5.0 ± 0.2	p, α	31, 33
9.329 ± 4	$< \frac{5}{2}$		≈ 6	γ, α	13
9.509 ± 4	$\frac{5}{2}^+, \frac{7}{2}^+$		< 1	γ, α	13
9.527 ± 6	$(\frac{5}{2})$		28	p, α	31, 33
9.537 ± 2	$\frac{5}{2}^+$		6.3 ± 1.5	γ, α	13, 21, 29, 31, 33
9.565 ± 3	$\frac{3}{2}^-$		26 ± 3	γ, p	29
9.574 ± 4	$\frac{3}{2}^-$		67 ± 3	γ, p, α	29, 31, 33
9.586 ± 3	$\frac{7}{2}$		8.9 ± 1.2	γ, p, α	13, 29, 35
9.642 ± 6	$\frac{3}{2}, \frac{5}{2}$		≈ 8	γ, α	13
9.654 ± 6	$\frac{3}{2}, \frac{5}{2}$		≈ 6	γ, α	13
9.6676 ± 1.3	$\frac{3}{2}^+$		3.6 ± 0.4	γ, p, α	13, 29, 31, 32, 35
9.710 ± 4	$\frac{9}{2}^+, \frac{11}{2}^-$		< 1	γ, α	13, 19
9.819 ± 0.8	$\frac{5}{2}^-$		0.3 ± 0.05	γ, p, α	13, 29, 31, 33
9.834 ± 3	$\frac{11}{2} \rightarrow \frac{15}{2}$		< 1	γ, α	13
9.8734 ± 1.7	$\frac{11}{2}^-$		$\lesssim 1.5$	γ, p, α	13, 19, 20, 29
9.886 ± 3	$\frac{1}{2}^+$		25 ± 2	γ, p, α	29, 31, 33
9.926 ± 3	$\frac{9}{2}^+$		≈ 1	γ, α	13, 15
10.088 ± 5	$\frac{5}{2}^-, \frac{7}{2}^-$		< 1.5	γ, α	13
10.136 ± 0.8	$\frac{3}{2}^-$		4.3 ± 0.6	γ, p, α	13, 29, 33
10.161 ± 3	$\frac{1}{2}^+$		31	p, α	31, 33
10.231 ± 3	$\frac{1}{2}^+$		< 1	p, α	14, 31, 33
10.253 ± 3	$\frac{1}{2}^+$		22	p, α	31, 33
10.308 ± 3	$\frac{3}{2}^+$		9.2	p, α	14, 21, 31, 33
10.365 ± 4	$\frac{7}{2} \rightarrow \frac{11}{2}$		3 ± 1.5	γ, α	13, 35
10.411 ± 3	$\frac{13}{2}^+$	$\frac{3}{2}^+$	< 1.5	γ, α	13, 15, 19, 21, 29, 61
10.469 ± 4			11.0 ± 1.2	p, α	14
10.488 ± 4			4.8 ± 0.8	p, α	14
10.4964 ± 1.0	$\frac{3}{2}^+$		5.7 ± 0.6	n, p, α	14, 30, 31, 33
10.521 ± 4			14 ± 2	p, α	14, 35

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
10.5423 ± 1.1			2.5 ± 0.2	n, p, α	14, 30
10.555 ± 3	$\frac{3}{2}^+; (\frac{3}{2})$		4.0 ± 1.2	p, α	14, 31, 33
10.5656 ± 1.1			4.6 ± 0.7	n, p, α	14, 30
10.580 ± 4	$(\frac{5}{2}^+)$		22 ± 3	p, α	31, 33
10.613 ± 1.6	$\frac{5}{2}^+; \frac{3}{2}$		4.7 ± 0.5	n, p, α	30, 31, 33
10.762 ± 3	$\frac{1}{2}^-$		6 ± 3	n, p, α	19, 30, 31, 33
10.8588 ± 1.8	$\frac{5}{2}^+$		24.0 ± 1.5	n, p, α	30, 31, 33
10.974 ± 3	$(\frac{3}{2}, \frac{5}{2})^+$		14 ± 2	n, p, α	30, 31, 33
10.989 ± 2.5			7 ± 2	n, p	30
11.071 ± 2.5	$\frac{1}{2}^+$		35 ± 4	n, p, α	30, 31, 33
11.187 ± 4	$(\frac{1}{2}^-)$		17 ± 4	n, p, α	30, 31, 33
11.272 ± 3			7 ± 2	n, p	30
11.285 ± 8	$\frac{5}{2}^+$		22 ± 5	n, p, α	30, 31, 33
11.35 ± 25	$\frac{1}{2}^+$		272 ± 31	p	31
11.451 ± 4	$\frac{1}{2}^-$		38 ± 7	n, p, (α)	19, 30, 31, 33
11.478 ± 5			7 ± 3	n, p	30
11.502 ± 5	$(\frac{3}{2}^-)$		4 ± 2	n, p, α	30, 31, 33
11.540 ± 8	$\frac{5}{2}^+$		22 ± 5	n, p, α	30, 31, 33
11.568 ± 7	$(T = \frac{3}{2})$		15 ± 10	n, p	30
11.602 ± 12	$\frac{3}{2}^-$		63 ± 7	n, p	30, 31
11.652 ± 4	$\frac{3}{2}^+; (\frac{3}{2})$		33 ± 6	n, p, (α)	15, 19, 30, 31, 33
11.84 ± 10			< 50	n, p	30
11.93 ± 10			90	n, p	30
12.04 ± 21	$\frac{1}{2}^-$		71 ± 24	p, α	15, 31, 33
12.14 ± 10	$\frac{3}{2}^-; \frac{3}{2}$		105 ± 14	n, p, (α)	30, 31, 33
12.221 ± 12	$\frac{3}{2}^+$		74 ± 1	n, p, α	16, 17, 30, 31, 33
12.521 ± 7	$\frac{1}{2}^-$		15 ± 4	p	31
12.576 ± 10	$\frac{5}{2}^+$		48 ± 10	p, α	31, 33
12.58 ± 25	$\frac{1}{2}^-; \frac{3}{2}$		285 ± 48	p	31
12.78 ± 10	$\frac{5}{2}^+; \frac{3}{2}$		95 ± 38	n, p, (α)	19, 30, 31, 33
12.86 ± 30	$\frac{3}{2}^+; \frac{3}{2}$		276 ± 38	p	31

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
12.94 ± 25	$\frac{5}{2}^+$		71 ± 24	p, α	31, 33
12.98 ± 50	$\frac{1}{2}^-$		124 ± 38	p	31
13.068 ± 4	$\frac{1}{2}^+$		≤ 10	n, p, t	18, 20
13.09 ± 75	$\frac{3}{2}^-$		285 ± 71	p	31
13.17 ± 15			70	n, p	30
13.245 ± 10	$\frac{1}{2}^-$		7	t	18
13.270 ± 10	$\frac{1}{2}^+$		4.5	t	18
13.317 ± 8	$\frac{7}{2}^-; (\frac{3}{2})$		28 ± 6	n, p, α	30, 31, 33
13.36 ± 25	$\frac{3}{2}^-$		38 ± 19	p	21, 31
13.532 ± 10	$\frac{1}{2}^+$		22	t	18
13.731 ± 11	$\frac{7}{2}^-; \frac{3}{2}$		52 ± 10	n, p, (α)	15, 20, 30, 31, 33
13.878 ± 15	$\frac{1}{2}^+$		101	t	18
14.04 ± 20	$\frac{5}{2}^+$		141 ± 28	p	31
14.10 ± 21	$\frac{3}{2}^-$		84 ± 28	p	15, 20, 31
14.147 ± 20	$\frac{1}{2}^+$		21	t	18
14.24 ± 15			350	n, p	30
14.255 ± 15	$\frac{3}{2}^+$		51	t	18
14.32 ± 20	$\frac{3}{2}^-$		76 ± 28	p	21, 31
14.352 ± 10	$\frac{1}{2}^+$		154	t	18
14.46 ± 25	$\frac{3}{2}^+$		179	t	18
14.46 ± 25	$\frac{5}{2}^+$		46	t	18
14.70 ± 20	$\frac{3}{2}^-$		124 ± 38	p	31
14.72 ± 70	$\frac{1}{2}^-$		257 ± 67	α	33
14.74 ± 50	$\frac{1}{2}^+$		361 ± 67	p, α	31, 33
14.78 ± 20	$\frac{5}{2}^+$			n, p	30, 31
14.92 ± 30	$\frac{7}{2}^-$			p	15, 16, 20, 31
15.00 ± 20				n, p	30
15.35 ± 20	$\frac{1}{2}^-$			p	31
15.40 ± 30	$\frac{5}{2}^+$			p	31
15.56 ± 30					20
15.77 ± 21	$\frac{3}{2}^-$		150	n, p	30, 31

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
16.09 ± 50					15
16.20 ± 40	$\frac{3}{2}^+$			p	30
16.23 ± 30	$\frac{7}{2}^-$			p	31
16.27 ± 20	$\frac{3}{2}^-$		200	n, p	31
16.45 ± 50					15
16.80 ± 30				n, p	30
17.05 ± 40	$\frac{3}{2}^-$		331 ± 67	p	31
17.16 ± 40	$\frac{7}{2}^-$		323 ± 67	p	31
17.45 ± 30	$\frac{3}{2}^-$		32 ± 19	p	15, 16, 31
17.65 ± 60	$\frac{7}{2}^-$		95 ± 57	p	31
17.93 ± 40	$\frac{3}{2}^-$		255 ± 57	p	31
18.02 ± 60	$\frac{7}{2}^-$		365 ± 57	p	31
18.2 ± 50					15
18.92 ± 30					15, 20
19.07 ± 60	$\frac{3}{2}^-$		555 ± 143	p	31
19.83 ± 150	$\frac{5}{2}^-$		369 ± 57	p	31
19.87 ± 40	$\frac{3}{2}^-$		473 ± 57	p	31
19.93 ± 50					15
20.81 ± 50	$\frac{1}{2}^-$		412 ± 57	p	31
20.93 ± 50	$\frac{3}{2}^-$		317 ± 48	p	31
21.05 ± 40	$\frac{7}{2}^-$		448 ± 29	p	31

[a] See also Tables 19.7 and 19.8.

[b] See also (1979FO03).

1. (a) ^{9}Be(^{10}B, 2α)^{11}B $Q_m = 9.882$
   (b) ^{9}Be(^{10}B, αn)^{14}N $Q_m = 10.040$

The total reaction cross section has been measured for $E(^{10}\text{B}) = 2.20$ to 10.43 MeV (1979CH22).

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

E_i (MeV)	J_i^π	E_f (MeV)	Branching ratio (%)	δ
0.110	$\frac{1}{2}^-$	0	100 [a]	
0.197	$\frac{5}{2}^+$	0	100 [a]	
		0.110	< 0.06	
1.35	$\frac{5}{2}^-$	0.110	96.8 ± 1	0.0 ± 0.7
		0.197	3.2 ± 1	
1.46 [b]	$\frac{3}{2}^-$	0	20.5 ± 0.7 [c]	0.01 ± 0.03 [d]
		0.110	68.8 ± 0.9 [c]	0.248 ± 0.020 [d]
		0.197	10.7 ± 0.5 [c]	
1.55 [b]	$\frac{3}{2}^+$	0	2.55 ± 0.10 [a]	
		0.110	4.85 ± 0.12 [a]	
		0.197	92.6 ± 0.2 [a]	
2.78 [b]	$\frac{9}{2}^+$	0.197	100 [a]	
3.91 [b,e]	$\frac{3}{2}^+$	0	48 ± 2 [a]	
		0.110	17 ± 2 [a]	
		0.197	14 ± 2 [a]	
		1.55	21 ± 3 [a]	
4.00 [b]	$\frac{7}{2}^-$	0.197	18 ± 4	
		1.35	70 ± 4	
		1.46	12 ± 6	
4.03 [b]	$\frac{9}{2}^-$	1.35	100	
4.38 [f,g]	$\frac{7}{2}^+$	0	< 5	
		0.110	< 2	
		0.197	80.5 ± 2.0 [a]	0.155 ± 0.022
		2.78	19.5 ± 1.0 [a]	-0.16 ± 0.07
4.55 [b,h,i]	$\frac{5}{2}^+$	0.197	69 ± 7	
		1.35	5 ± 3	
		1.46	8 ± 3	
		1.55	18 ± 4	
4.56 [b]	$\frac{3}{2}^-$	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	$\lvert M\rvert^2 = 5.5 \pm 1.8$ W.u.
4.68 [b,c,j]	$\frac{5}{2}^-$	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 $2.0^{+1.5}_{-0.6}$

Table 19.7: Radiative transitions in ^{19}F † (continued)

$E_{\rm i}$ (MeV)	$J^{\pi}_{\rm i}$	$E_{\rm f}$ (MeV)	Branching ratio (%)	δ
5.11	$\frac{5}{2}^{+}$	0.197	80	$\Gamma_{\gamma}/\Gamma = 0.83 \pm 0.10$
		1.46	20	
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	
		1.55	11	
5.54	$\frac{5}{2}^{+}$	0	7	
		0.197	47	
		1.46	45	
5.62 [l]	$\frac{3}{2}^{-}$	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 [m]	$\frac{7}{2}^{+}$	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 [n]	$\frac{3}{2}^{-}$	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 [o]	$\frac{7}{2}^{-}$	0.197	31 ± 3	-0.045 ± 0.025
		1.35	65 ± 4	0.077 ± 0.007

Table 19.7: Radiative transitions in ^{19}F † (continued)

E_i (MeV)	J_i^π	E_f (MeV)	Branching ratio (%)	δ
		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
		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 [p]	$\frac{11}{2}^+$	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 [q]	$\frac{9}{2}^+$	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	

Table 19.7: Radiative transitions in ^{19}F † (continued)

$E_{\rm i}$ (MeV)	$J^{\pi}_{\rm i}$	$E_{\rm f}$ (MeV)	Branching ratio (%)	δ
		1.46	45 ± 8	-0.02 ± 0.11
6.89 [r]	$\frac{3}{2}^-$	0	9 ± 2	
		1.35	61 ± 5	$0.22 \rightarrow 2.2$
		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	$\frac{11}{2}^-$	4.00	5 ± 1	
		4.03	91 ± 1	
		4.65	4 ± 1	
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 [b,t]	$\frac{3}{2}^+; T = \frac{3}{2}$	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 [u]	$\frac{11}{2}^+$	2.78	10	
		4.65	90	
8.14 [v]	$\frac{1}{2}^+$	0	8 ± 1	
		0.11	24 ± 2	
		0.197	8 ± 1	
		1.55	2 ± 1	
		3.91	54 ± 2	$\Gamma_{\gamma} = 1.3$ eV
		5.94	1.0 ± 0.5	
		6.26	3 ± 1	
8.25 [v]	$(\frac{5}{2}^+)$	0.197	18 ± 7	
		1.35	33 ± 10	
		1.46	24 ± 8	
		3.91	25 ± 8	

Table 19.7: Radiative transitions in ^{19}F † (continued)

E_i (MeV)	J_i^π	E_f (MeV)	Branching ratio (%)	δ
8.29 [w]	$\frac{13}{2}^-$	4.03	93 ± 4	$\Gamma_\gamma = 72 \pm 8$ meV
		4.65	7 ± 4	
8.31 [x]	$\frac{5}{2}^+$	0	9 ± 3	
			12 ± 1 [A]	$\Gamma_\gamma = 0.71 \pm 0.17$ eV
		1.55	48 ± 6	
			48 ± 2 [A]	$\delta = 0.02 \pm 0.05$ or 2.2 ± 0.6
		4.38	43 ± 6	
			40 ± 2 [A]	$\delta = -0.14 \pm 0.07$
8.37 [w]	$\frac{7}{2}, \frac{5}{2}^+$	0.197	13 ± 2	
		1.35	39 ± 3	
		2.78	30 ± 3	
		4.00	18 ± 3	
8.58	$\frac{5}{2}^+$	0	4 ± 1 [A]	
		0.197	44 ± 2	
			38 ± 5 [A]	
		1.35	24 ± 2	
			23 ± 3 [A]	
		1.55	20 ± 2	
			20 ± 3 [A]	
		4.00	4 ± 1 [w]	
		4.55	2.0 ± 0.7 [A]	
		5.42	6 ± 1	
			4 ± 1 [A]	
		5.46	2.0 ± 0.5 [A]	
		5.62	2.2 ± 0.5 [A]	
		5.94	1.8 ± 0.5 [A]	
		6.16	2.5 ± 0.5 [A]	
		6.93	0.5 ± 0.3 [A]	
8.59 [b,x]	$\frac{3}{2}^-$	0	5 ± 2 [A]	
		0.11	3 ± 1 [A]	
		0.197	59 ± 2	
			42 ± 2 [A]	$\Gamma_\gamma = 0.85 \pm 0.17$ eV
		1.35	7 ± 1 [A]	
		1.55	34 ± 2	
			28 ± 3 [A]	
		3.91	7 ± 1	
			8 ± 1 [A]	
		4.55	3.6 ± 0.6 [A]	

Table 19.7: Radiative transitions in ^{19}F † (continued)

E_i (MeV)	J_i^π	E_f (MeV)	Branching ratio (%)	δ
		5.11	1.0 ± 0.5 [A]	
		5.50	1.5 ± 0.5 [A]	
		6.28	0.6 ± 0.2 [A]	
		6.79	0.3 ± 0.1 [A]	
8.63 [w]	$\frac{7}{2}^-$	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 [v]	$\frac{1}{2}^+$	0.11	53 ± 6	
		1.46	23 ± 6	
		3.91	24 ± 6	
8.79 [b,v]	$\frac{1}{2}^+; T = \frac{3}{2}$	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	
		7.66	0.2 ± 0.1	
8.86 [w]	$\frac{3}{2}$	1.35	100	
8.92 [v]	$\frac{3}{2}$	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 [w]	$\frac{11}{2}^-$	2.78	50 ± 2	Γ_γ(tot) $= 230 \pm 30$ meV

Table 19.7: Radiative transitions in ^{19}F † (continued)

E_i (MeV)	J_i^π	E_f (MeV)	Branching ratio (%)	δ
		4.00	26 ± 2	
		4.03	9 ± 1	
		4.65	10 ± 2	
		5.42	5 ± 1	
9.03 [w]	$\frac{5}{2}, \frac{7}{2}$	0.197	44 ± 5	
		4.38	30 ± 5	
		6.07	26 ± 4	
9.098 [x]	$\frac{7}{2}^-$	0.197	2.0 ± 0.3 [A]	$\delta = 0.0 \pm 0.2$ or 2.5 ± 0.6
		1.35	2.7 ± 0.3 [A]	-0.1 ± 0.3 or ∞
		2.78	71 ± 2	
			47 ± 2 [A]	-0.09 ± 0.10
		4.00	2.5 ± 0.3 [A]	0.3 ± 0.3 or -2.2 ± 0.9
		4.03	9 ± 1	
			7.0 ± 0.5 [A]	-0.08 ± 0.01 or ∞
		4.68	2.0 ± 0.3 [A]	-0.09 ± 0.34 or ∞
		5.11	1.2 ± 0.2 [A]	0.0 ± 0.2 or 3.0 ± 1.6
		5.42	20 ± 2	
			19 ± 2 [A]	0.25 ± 0.10 or -6.0 ± 5.5
		5.54	1.3 ± 0.7 [A]	0.1 ± 0.3
		5.62	3.3 ± 0.3 [A]	0.17 ± 0.10
		6.10	12 ± 1 [A]	0.0 ± 0.3
9.101 [w]	$\frac{7}{2}^+, \frac{9}{2}^+$	2.78	11 ± 2	
		4.00	24 ± 2	
		4.38	24 ± 2	
		6.07	15 ± 2	
		6.33	10 ± 2	
9.17 [w]	$\frac{1}{2}^+$	0.197	51 ± 2	
		1.55	30 ± 2	
		4.56	19 ± 2	
9.20 [w]	$\frac{3}{2}$	0	18 ± 2	
		0.110	46 ± 3	
		0.197	10 ± 4	
		1.35	26 ± 3	
9.27 [w]	$\frac{11}{2}^+, \frac{9}{2}^+$	2.78	27 ± 2	
		4.38	18 ± 2	
		4.65	55 ± 3	
9.28 [w]	$\frac{7}{2}, \frac{9}{2}$	4.00	58 ± 3	
		4.03	42 ± 3	

Table 19.7: Radiative transitions in ^{19}F † (continued)

E_i (MeV)	J_i^π	E_f (MeV)	Branching ratio (%)	δ
9.32 [b,x]	$\frac{1}{2}^+$	0	29 ± 2	
			30 ± 1 [A]	0.10 ± 0.08 or 1.4 ± 0.3
		0.197	9 ± 1	
			12 ± 1 [A]	0.1 ± 0.4 or ≥ 0.6
		1.46	41 ± 3	
			28 ± 1 [A]	0.1 ± 0.2
		1.55	21 ± 3	
			17 ± 1 [A]	-0.2 ± 0.3 or ≤ 0.9
		3.91	3.0 ± 0.3 [A]	0.40 ± 0.05 or ≥ 2.3
		4.56	3.2 ± 0.3 [A]	0.2 ± 0.3
		4.68	6.8 ± 0.5 [A]	0.1 ± 0.2
9.33 [w]	$< \frac{5}{2}$	1.55	100	
9.51 [w]	$\frac{5}{2}^+, \frac{7}{2}^+$	1.35	14 ± 2	
		1.55	14 ± 2	
		2.78	72 ± 3	
9.54 [v]	$\frac{5}{2}^+$	1.35	100 [w]	
			26 ± 2 [A]	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 ± 0.4
		8.02	2 ± 1	
9.565 [v]	$\frac{3}{2}^-$	0.197	77 ± 10	
		6.26	23 ± 6	
9.574 [v]	$\frac{3}{2}^-$	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 [x]	$\frac{7}{2}$	0.197	24 ± 2 [w]	
		1.35	17 ± 2	
			32 ± 4 [A]	0.0 ± 0.5 or 3.7 ± 2.5
		2.78	33 ± 3	
			30 ± 2 [A]	0.1 ± 0.2 or 11 ± 5
		4.00	15 ± 2	
			17 ± 2 [A]	-0.7 ± 1.1

Table 19.7: Radiative transitions in ^{19}F † (continued)

E_i (MeV)	J_i^π	E_f (MeV)	Branching ratio (%)	δ
		4.03	11 ± 1 [w]	
		4.55	21 ± 2 [A]	
9.64 [w]	$\frac{3}{2}, \frac{5}{2}$	0.197	13 ± 3	
		1.35	61 ± 7	
		4.55	26 ± 6	
9.65 [w]	$\frac{3}{2}, \frac{5}{2}$	1.35	41 ± 9	
		1.55	59 ± 9	
9.67 [b,x]	$\frac{3}{2}^+$	0	34 ± 5	
			22 ± 2 [A]	-0.72 ± 0.04 or -10 ± 4
		0.11	36 ± 5	
			20 ± 2 [A]	0.00 ± 0.05
		0.197	9 ± 1 [A]	0.30 ± 0.03 or 1.7 ± 0.3
		1.35	9 ± 1 [A]	0.00 ± 0.03
		1.46	5 ± 1 [A]	0.00 ± 0.07
		1.55	30 ± 6	
			10 ± 1 [A]	0.00 ± 0.06 or -4.2 ± 1.3
		3.91	5.5 ± 0.5 [A]	0.12 ± 0.03 or -7.5 ± 2.0
		4.38	0.5 ± 0.2 [A]	
		4.55	8 ± 1 [A]	0.00 ± 0.03 or 4.7 ± 0.5
		5.11	1.5 ± 0.3 [A]	0.00 ± 0.05
		5.34	1.0 ± 0.2 [A]	-0.22 ± 0.03 or 3.3 ± 0.2
		6.84	1.0 ± 0.3 [A]	0.05 ± 0.02 or 3.3 ± 0.2
		7.54	4.0 ± 0.3 [A]	0.02 ± 0.03
		7.66	3.5 ± 0.3 [A]	0.14 ± 0.04
9.71 [w]	$\frac{9}{2}^+, \frac{11}{2}^-$	2.78	19 ± 3	
		4.03	80 ± 4	
		4.65	1 ± 1	
9.82 [b,x]	$\frac{5}{2}^-$	0.11	0.7 ± 0.2 [A]	
		0.197	41 ± 2	
			41 ± 2 [A]	0.00 ± 0.05
		1.35	2.4 ± 0.5 [A]	-0.6 ± 0.2
		1.46	10 ± 1	
			8 ± 1 [A]	-0.07 ± 0.05 or 2.7 ± 0.7
		1.55	34 ± 2	
			30 ± 2 [A]	0.01 ± 0.04
		4.00	1.0 ± 0.2 [A]	0.0 ± 0.2 or ∞
		4.55	0.5 ± 0.1 [A]	0.30 ± 0.15
		4.68	4 ± 1	

Table 19.7: Radiative transitions in ^{19}F † (continued)

E_i (MeV)	J_i^π	E_f (MeV)	Branching ratio (%)	δ
			4.8 ± 0.3 A	0.0 ± 0.1 or -1.7 ± 0.4
		5.11	0.3 ± 0.2 A	0.4 ± 0.5 or ∞
		5.42	11 ± 1	
			10 ± 1 A	-0.04 ± 0.05 or ∞
		5.54	0.6 ± 0.2 A	0.0 ± 0.2
		5.62	0.7 ± 0.2 A	0.33 ± 0.15 or -3.4 ± 1.2
9.83 w	$\frac{11}{2} \to \frac{15}{2}$	4.65	100	
9.87 x	$\frac{11}{2}^-$	2.78	68 ± 4	
			63 ± 3 A	0.0 ± 0.2
		4.00	5 ± 1	
			4.2 ± 1.0 A	
		4.03	24 ± 3	
			24 ± 2 A	-0.43 ± 0.05 or 2.2 ± 0.2
		4.65	3 ± 1	
			2.1 ± 0.8 A	
		6.10	3.8 ± 0.8 A	0.2 ± 0.1 or 2.7 ± 1.0
		6.50	1.9 ± 0.7 A	-0.4 ± 0.7
		8.29	1.0 ± 0.3 A	
9.89 v	$\frac{1}{2}^+$	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 w	$\frac{9}{2}^+$	0.197	1 ± 1	
		2.78	19 ± 1	
		5.46	10 ± 1	
		6.07	7 ± 1	
		6.33	8 ± 1	
		6.50	54 ± 2	
10.09 w	$\frac{5}{2}^-, \frac{7}{2}^-$	0.197	10 ± 1	
		1.35	35 ± 2	
		4.00	19 ± 2	
		5.42	26 ± 2	
		6.07	10 ± 1	
10.14 w	$\frac{3}{2}^-$	1.35	29 ± 4	
		1.46	71 ± 4	

Table 19.7: Radiative transitions in ^{19}F † (continued)

E_i (MeV)	J_i^π	E_f (MeV)	Branching ratio (%)	δ
10.37 [w]	$\frac{7}{2} \rightarrow \frac{11}{2}$	4.03	100	
10.41 [w]	$\frac{13}{2}^+$	2.78	3 ± 1	
		4.68	88 ± 1	
		6.50	9 ± 1	

A = adopted.
† For references see Table 19.7 in (1978AJ03). See also Tables 19.9, 19.15 and 19.16.
[a] (1982OL02).
[b] See also (1978DI13).
[c] Revised to sum to 100%: see (1978AJ03).
[d] (1980DI12).
[e] Transitions to ^{19}F*(1.35, 1.46, 2.78) are < 4, < 4 and $< 2\%$.
[f] $\Gamma_\gamma/\Gamma = 0.91 \pm 0.05$ (1976RO07).
[g] Transitions to ^{19}F*($1.35 + 1.46$, 1.55) are each $< 0.8\%$.
[h] $\Gamma_\gamma/\Gamma = 0.76 + 0.15$ (1976RO07).
[i] Transitions to ^{19}F*(0, 0.11) are each $< 5\%$.
[j] Transitions to ^{19}F*(0, 0.11, 1.55, 2.78) are < 0.5, < 1.5, < 5 and $< 2\%$.
[k] Transitions to ^{19}F*(0.197, 1.35, 1.55) are < 1, < 1.5 and $< 2\%$.
[l] Transitions to ^{19}F*(0, 0.11, 1.46, 1.55) are < 5, < 2, < 25 and $< 25\%$.
[m] Transitions to ^{19}F*(4.00, 4.03) are < 2 and $< 1\%$.
[n] Transitions to ^{19}F*(1.35, 1.46, 1.55) are < 0.5, < 1.5 and $< 1\%$.
[o] Transitions to ^{19}F*(2.78, 4.38, 4.68) < 1, < 1 and $< 2\%$.
[p] Transitions to ^{19}F*(4.00, 4.03, 4.38, 5.47) are < 3, < 3, < 3 and $< 2\%$.
[q] Transitions to ^{19}F*(4.00, 4.03, 4.55, 4.65, 5.43, 5.47) are < 2 to $< 8\%$: see (1978AJ03).
[r] Transitions to ^{19}F*(0.11, 0.197) are < 8 and $< 5\%$.
[s] Transitions to other states are < 0.2 to $< 2\%$: see (1978AJ03).
[t] $\Gamma_\gamma = 4.7$ eV, $\Gamma_\gamma/\Gamma = 0.65 \pm 0.10$; see Table 19.9 in (1972AJ02). Transitions to ^{19}F*(0.11, 1.35, 1.46, 4.38) are < 0.4, < 1.3, < 1 and $< 1.3\%$.
[u] Transitions to other states are < 7 to $< 10\%$.
[v] (1980WI17).
[w] (1978SY01): branching rations are relative intensities at $\theta = 55°$.
[x] First branching ratio value shown for each transition is from (1978SY01); second is from (1980WI17). Where only one value is shown it is from (1980WI17), except when footnoted.

2. ^{9}Be(^{14}N, α)^{19}F $\qquad Q_m = 13.2739$

See (1972AJ02).

3. (a) ^{12}C(^{7}Li, γ)^{19}F $\qquad Q_m = 16.396$

(b) ^{12}C(^{7}Li, n)^{18}F $\qquad Q_m = 5.964$ $\qquad E_b = 16.396$

(c) ^{12}C(^{7}Li, p)^{18}O $\quad Q_\mathrm{m} = 8.402$

(d) ^{12}C(^{7}Li, d)^{17}O $\quad Q_\mathrm{m} = 2.582$

(e) ^{12}C(^{7}Li, t)^{16}O $\quad Q_\mathrm{m} = 4.695$

(f) ^{12}C(^{7}Li, α)^{15}N $\quad Q_\mathrm{m} = 12.3817$

(g) ^{12}C(^{7}Li, ^{7}Li)^{12}C

For reaction (a) see (1978AJ03). The yield of ^{18}F [reaction (b)] has been determined for $E(^7\mathrm{Li}) = 2.5$ to 3.5 MeV (1961NO05). The cross sections for reaction (c), (d), (e) and (f) vary strongly over the range $E(^7\mathrm{Li}) = 4$ to 14 MeV but with little, if any, cross correlation. Strong fluctuations continue to $E(^7\mathrm{Li}) = 25$ MeV and there is some evidence of structures at higher energies: for a listing of the earlier references see (1978AJ03). The excitation functions for several groups in ^{16}O have been studied for $E(^{12}\mathrm{C}) = 54$ to 62 MeV, as has the total cross section (for residues of $A > 8$) for $E(^7\mathrm{Li}) = 10$ to 38 MeV (1981DE15). See (1976PO02, 1978DR07) for reaction (g). See also (1981XE01; theor.), ^{18}O here, ^{16}O and ^{17}O in (1982AJ01), ^{15}N in (1981AJ01) and ^{12}C in (1980AJ01).

4. ^{12}C(^{9}Be, d)^{19}F $\quad Q_\mathrm{m} = -0.3005$

At $E(^9\mathrm{Be}) = 12 - 27$ MeV angular distributions are reported to ^{19}F*(2.78) and to several unresolved groups (1979JA22, 1981JA09). The excitation function for ^{19}F*(2.78) has been measured for $E(^9\mathrm{Be}) = 10.5$ to 25.9 MeV (1980HU1E).

5. ^{12}C(^{11}B, α)^{19}F $\quad Q_\mathrm{m} = 7.7303$

At $E(^{11}\mathrm{B}) = 18.0$ to 34.1 MeV excitation functions are reported for the transitions to ^{19}F*($0 + 0.11 + 0.20$, $1.35 + 1.46 + 1.56$, 2.78) (1979FR05).

6. ^{12}C(^{12}C, αp)^{19}F $\quad Q_\mathrm{m} = -8.2266$

For the yield of ^{19}F for $E(^{12}\mathrm{C}) = 24$ to 62 MeV see (1980KO02).

7. ^{12}C(^{14}N, ^{7}Be)^{19}F $\quad Q_\mathrm{m} = -11.419$

Angular distributions are reported at $E(^{14}\mathrm{N}) = 78.8$ MeV for the transitions to ^{19}F*($0 + 0.11 + 0.20$, $1.35 + 1.46 + 1.55$, 2.78) (1977MO1A, 1979MO14).

8. ^{12}C(^{20}Ne, ^{13}N)^{19}F 	$Q_m = -10.901$

See (1979OR01).

9. (a) ^{13}C(^{6}Li, t)^{16}O 	$Q_m = 6.9994$ 	$E_b = 18.6997$
(b) ^{13}C(^{6}Li, α)^{15}N 	$Q_m = 14.6859$
(c) ^{13}C(^{6}Li, ^{6}Li)^{13}C

Excitation functions for tritons to a number of states of ^{16}O have been measured for $E(^6\text{Li}) =$ 20 to 32 MeV [correlated structures are not observed (1980CU03)] and 24 to 26 MeV (1982AB02). Excitation functions for α_0 have been measured for $E(^6\text{Li}) = 7.7$ to 16.8 MeV: structures are observed but they are not correlated (1974CO13). For reaction (c) see (1976PO02, 1978DR07). For fusion cross sections see (1981DEZE, 1981DEZW). See also (1981ME1F; theor.).

10. ^{13}C(^{9}Be, t)^{19}F 	$Q_m = 1.0105$

Angular distributions have been studied at $E(^{13}\text{C}) = 27.9$ MeV to ^{19}F*($0 + 0.11 + 0.20, 2.78$) (1980BO21).

11. (a) ^{14}N(^{6}Li, p)^{19}F 	$Q_m = 11.1491$
(b) ^{14}N(^{7}Li, d)^{19}F 	$Q_m = 6.123$

See (1978AJ03).

12. ^{14}N(^{10}B, αp)^{19}F 	$Q_m = 6.6886$

Cross sections have been measured for $E(^{14}\text{N}) = 7$ to 18 MeV (1978WU1C).

13. ^{15}N(α, γ)^{19}F 	$Q_m = 4.0138$

Resonances in the yield of γ-rays are observed below $E_\alpha = 10.4$ MeV: the parameters for these are displayed in Table 19.9. Branching ratios are shown in Table 19.7 and τ_m measurements (1977DI18, 1980AN02) in Table 19.8. The J^π values are shown in Table 19.9 are based on correlation and angular distribution measurements and on branching ratio determinations.

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

^{19}F* (MeV)	τ_m	Refs.
0.110	0.853 ± 0.010 nsec	mean: see (1972AJ02)
0.197	128.8 ± 1.5 nsec	mean: see (1978AJ03)
1.35	3.7 ± 0.7 psec	(1980AN02)
	4.4 ± 0.6 psec [A]	see (1980AN02)
1.46	140 ± 15 fsec	(1980AN02)
	90 ± 20 fsec [A]	see [e]
1.55	5 ± 3 fsec	(1980AN02)
2.78	370 ± 25 fsec	(1980AN02)
	280 ± 30 fsec [A]	see [e]
3.91 [b]	9 ± 5 fsec	(1977DI18)
4.00 [b]	19 ± 7 fsec	(1980AN02)
4.03	63 ± 19 fsec	(1980AN02)
	67 ± 15 fsec [A]	see (1980AN02)
4.38 [c]	< 11 fsec	(1975LE16)
4.55 [d]	< 50 fsec	(1976RO07)
4.56	17^{+10}_{-8} fsec [A]	(1975LE16)
	< 30 fsec	(1976BH03)
4.65	2.2 ± 0.3 psec	mean: see (1978AJ03)
4.68 [d]	15.4 ± 3.0 fsec	(1972RO01)
5.11 [d]	< 30 fsec	(1976RO07)
5.34	≤ 0.1 fsec	see [f]
5.42	≤ 0.9 fsec	see [g]
5.46	≤ 0.26 fsec	see [f]
5.62	< 1.3 fsec	see [f]

A = adopted.
[a] See also Tables 19.10 in (1972AJ02) and in (1978AJ03). I am greatly indebted to Dr. D.W.O. Rogers for his comments and criticisms of the 1978 table.
[b] See also (1976BH03).
[c] See also (1976RO07).
[d] See also (1975LE16).
[e] P.M. Endt, private communication; based on reassessment of uncertainties in τ_m measurements.
[f] Using the rule $\Gamma > 4\Gamma_\alpha\Gamma_\gamma/\Gamma$ (P.M. Endt, private communication). See also (1980AN02, 1975LE16).
[g] From $\omega\gamma$ and Γ_γ/Γ (P.M. Endt, private communication). See also (1980AN02).

Table 19.9: 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		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	$\frac{11}{2}^-$	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 19.9: Resonances in $^{15}N(\alpha, \gamma)^{19}F$ [a] (continued)

E_α (MeV $\pm$ keV)	$\Gamma_{c.m.}$ (keV)	$\omega\gamma$ (eV)	J^π	E_x (MeV $\pm$ 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 Table 19.8 in (1978AJ03). For branching ratios see Table 19.7 here. Resonances with $E_\alpha > 5.4$ MeV are from (1978SY01). $\omega\gamma = \omega\Gamma_\gamma\Gamma_\alpha/\Gamma$.
[b] $\Gamma_\alpha = 2.1 \pm 0.7$ meV, $\Gamma_\gamma = 40.7 \pm 8.1$ meV (1972RO01).
[c] See also Table 19.7 in (1972AJ02).
[d] $\omega\gamma$ (55°) for this value and all values below (1978SY01).
[e] Value recalculated by reviewer from E_x.
[f] $\Gamma_\alpha/\Gamma_p = 0.026 \pm 0.008$ (1978SY01).
[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 (1978SY01).
[h] $\Gamma_\alpha/\Gamma_p = 0.55 \pm 0.16$ (1978SY01).

The E_x of states involved in cascade decays are 4377 ± 1 and 4548 ± 2 keV (1976RO07), 3999.6 ± 1.2 and 4031.9 ± 0.4 keV (1973RO09). 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 $[\frac{11}{2}^-]$) (1973RO09) and possibly ^{19}F*(8.29 $[\frac{13}{2}^-]$) (1974UN01) [J^π in brackets]. The situation concerning the other bands is not clear: 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 (1976SY01, 1978SY01). See also (1978TA1U; astrophys.).

14. (a) ^{15}N(α, p)^{18}O $\qquad Q_m = -3.9796 \qquad E_b = 4.0138$

(b) ^{15}N(α, α)^{15}N

Resonances observed in the (α, $\alpha'\gamma$) and (α, pγ) reactions (1978SY01) and in the elastic scattering (reaction (b)) [see (1978AJ03) for references] are displayed in Table 19.10. The elastic excitation function has been measured for $E_\alpha = 16$ to 23.7 MeV by (1977FE08). See also (1979LE18; theor.).

15. ^{15}N(^{7}Li, t)^{19}F $\qquad Q_m = 1.547$

This reaction has been studied at $E(^7\text{Li}) = 40$ MeV: see Table 19.11 (1979MA26). See also (1978AJ03).

16. ^{15}N(^{11}B, ^{7}Li)^{19}F $\qquad Q_m = -4.6514$

At $E(^{11}\text{B}) = 115$ MeV, ^{19}F*(8.29, 8.96) [$J^\pi = \frac{13}{2}^-, \frac{11}{2}^-$, respectively] are populated as are states at 10.4 ± 0.05, 12.26 ± 0.07, 12.67 ± 0.08, 14.9 ± 0.09, 15.4 ± 0.09, 17.4 ± 0.08, 18.6 ± 0.08 and 19.7 ± 0.08 MeV (1979BR04).

Table 19.10: Levels of ^{19}F from ^{15}N(α, p) and ^{15}N(α, α) [a]

E_α (MeV $\pm$ keV)	Γ_{lab} (keV)	J^π	E_{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 [c]	$\lesssim 8$		7.271
4.23	$\lesssim 82$	$\frac{7}{2}^+$	7.35
4.49	$\lesssim 110$	$\frac{7}{2}^+$	7.56
4.53	$\lesssim 50$	$\frac{5}{2}^+$	7.59
4.710	$\lesssim 40$	$\frac{1}{2}^-$	7.731
4.780	$\lesssim 8$		7.787
4.93	$\lesssim 260$		7.90
(5.005)	($\lesssim 8$)		(7.964)
(5.018)	($\lesssim 5$)		(7.974)
5.116	$\lesssim 8$		8.052
5.203	$\lesssim 8$		8.120
5.232	$\lesssim 6$		8.143
5.25	$\lesssim 65$		8.16
5.284	$\lesssim 10$		8.184
5.481	$\lesssim 10$		9.340
7.877 [d]	< 1	$\frac{1}{2}^+$	10.231 ± 4

Table 19.10: 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)
7.977 [d]		$\frac{3}{2}^+$	10.308 ± 4
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 Table 19.9 in (1978AJ03).
[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, $\alpha'\gamma$) (1978SY01).
[c] I am indebted to Prof. C. Rolfs for his comments on the resonances with $4 < E_\alpha < 5.5$ MeV.
[d] Value recalculated by reviewer from E_x.

17. ^{15}N(^{13}C, ^{9}Be)^{19}F $\quad Q_m = -6.6341$

At $E(^{13}\text{C}) = 105$ MeV, ^{19}F*(4.02, 8.29, 8.95, 12.26 ± 0.1, 12.65 ± 0.1, 14.8 ± 0.12) are strongly populated. ^{19}F*(2.78) is also observed. It is suggested that ^{19}F*(8.29, 8.95, 12.26, 12.65) have $J^\pi = \frac{13}{2}^-, \frac{11}{2}^-, (\frac{17}{2}^-), (\frac{15}{2}^-)$, respectively, and that ^{19}F*(12.26, 12.66) are members of the $2N + L = 8$ α-cluster band in ^{19}F (1979BR04). See also (1977FO1E).

18. (a) ^{16}O(t, γ)^{19}F $\quad Q_m = 11.7003$
(b) ^{16}O(t, n)^{18}F $\quad Q_m = 1.2690$ $\quad E_b = 11.7003$
(c) ^{16}O(t, p)^{18}O $\quad Q_m = 3.7069$
(d) ^{16}O(t, t)^{16}O
(e) ^{16}O(t, α)^{15}N $\quad Q_m = 7.6865$

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

Table 19.11: States in ^{19}F from ^{15}N(^{7}Li, t) [a]

E_x (MeV ± keV)	E_x (MeV ± keV)	E_x (MeV ± keV)
0.19 ± 15	7.54 ± 15	13.78 ± 30
1.34 ± 15	8.29 ± 15	14.12 ± 30
1.46 ± 15	8.95 ± 15 [b]	14.50 ± 30 [b]
2.78 ± 15	9.35 ± 30	14.92 ± 30 [b]
4.02 ± 15	9.92 ± 30 [b]	16.09 ± 50
4.56 ± 15	10.40 ± 30	16.45 ± 50
5.46 ± 15	11.5 ± 30	17.4 ± 50
6.10 ± 15	11.7 ± 30	18.2 ± 50
6.32 ± 15	12.01 ± 30	18.7 ± 50
6.94 ± 15	12.5 [c]	19.93 ± 50

[a] (1979MA26): $E(^{7}\text{Li}) = 40$ MeV.
[b] Relatively strongly populated at $\theta = 15°$.
[c] Unresolved.

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

$E_{\text{c.m.}}$ (MeV)	E_x (MeV ± keV)	J^π	$\Gamma_{\text{c.m.}}$ (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] (1973WE11): resonance parameters used to fit elastic scattering data. See also (1978AJ03).

of resonances: their parameters are displayed in Table 19.12. See also (1977CI1D), (1981AO01; theor.) and ^{18}O here.

19. ^{16}O(α, p)^{19}F $\qquad Q_{\rm m} = -8.1137$

Angular distributions have been measured at $E_\alpha = 20.1$ to 40 MeV [see (1978AJ03)] and at $E_\alpha = 40$ MeV (1979VA08: to ^{19}F*($0 + 0.20$, 2.78, 4.65): the 3p $\frac{13}{2}^+$ strength is split between ^{19}F*(4.65, 10.42). States observed in this reaction are displayed in Table 19.12 of (1978AJ03).

20. ^{16}O(^{6}Li, ^{3}He)^{19}F $\qquad Q_{\rm m} = -4.094$

This reaction (and its mirror reaction ^{16}O(^{6}Li, t)^{19}Ne [see reaction 7 in ^{19}Ne]) have been studied at $E(^6\text{Li}) = 24$ MeV [see (1978AJ03)] and at 46 MeV (1979MA26). Members of the $K^\pi = \frac{1}{2}^+$ and $\frac{1}{2}^-$ rotational bands have been identified: see Table 19.13. In addition ^{3}He groups are reported to states with $E_{\rm x} = 6.10$, 6.92, 7.25, 8.29, 8.96, 9.7, 9.88, 10.4 [all ± 0.015], to unresolved states near 11.5, 12.7 and to states at $E_{\rm x} = 13.76$, 14.10, 15.00, 15.56 and 18.92 [± 0.03] MeV (1979MA26). See also (1977FO1E).

21. ^{16}O(^{7}Li, α)^{19}F $\qquad Q_{\rm m} = 9.234$

Many states have been populated in this reaction: see Table 19.14 in (1978AJ03). See also (1977FO1E).

22. ^{16}O(^{10}B, ^{7}Be)^{19}F $\qquad Q_{\rm m} = -6.968$

This reaction, as well as the analog reaction [^{16}O(^{10}B, ^{7}Li)^{19}Ne] have been studied at $E(^{10}\text{B}) = 100$ MeV: an attempt is made to match analog states [see reaction 8 in ^{19}Ne] but problems of energy resolution are evident (1976HA06). See also (1977FO1E).

23. ^{16}O(^{11}B, ^{8}Be)^{19}F $\qquad Q_{\rm m} = 0.4765$

The angular distribution for the transition to $^8\text{Be}_{\rm g.s.} + {}^{19}\text{F}_{\rm g.s.}$ has been measured at $E(^{16}\text{O}) = 60$ MeV (1972SC17).

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

[a] (1972BI14, 1972GA08, 1973BI02, 1979MA26).

[b] Energies are nominal.

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

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

[e] J^{π} assignments based on similarities in σ_{max} in both reactions, and on known spin of anaolg state.

[f] $J^{\pi} = (\frac{5}{2}^{-}, \frac{7}{2}^{-})$ (1973BI02); a state at 4.78 MeV is also reported (1973BI02).

[g] See, however, reaction 10 in ^{19}Ne.

24. (a) ^{16}O(^{12}C, 2αp)^{19}F $Q_{\rm m} = -15.3886$

(b) ^{16}O(^{13}C, ^{10}B)^{19}F $Q_{\rm m} = -12.1763$

For reaction (a) see (1978CH15). At $E(^{13}\text{C}) = 105$ MeV ^{19}F*(2.78, 4.68) are preferentially populated (1979GO17, 1979RA10).

25. (a) ^{17}O(d, n)^{18}F $Q_{\rm m} = 3.382$ $E_{\rm b} = 13.813$

(b) ^{17}O(d, p)^{18}O $Q_{\rm m} = 5.8199$

(c) ^{17}O(d, t)^{16}O $Q_{\rm m} = 2.1130$

(d) ^{17}O(d, ^{3}He)^{16}N $Q_{\rm m} = -8.287$

(e) ^{17}O(d, α)^{15}N $Q_{\rm m} = 9.7995$

For reaction (a) see ^{18}F in (1972AJ02); for reaction (b) see ^{18}O; for reaction (e) see ^{15}N in (1970AJ04). At $E_{\overline{\rm d}} = 52$ MeV polarization measurements are reported involving the groups to ^{16}O*(6.13, 8.87, 19.19) and ^{16}N*(0, 0.297, 6.17 + 6.36) (1981MA1E). See also ^{16}N and ^{16}O in (1982AJ01).

26. ^{17}O(^{3}He, p)^{19}F $Q_{\rm m} = 8.320$

States studied in this reaction at $E(^{3}\text{He}) = 18$ MeV are displayed in Table 19.14.

27. ^{17}O(α, d)^{19}F $Q_{\rm m} = -10.033$

At $E_{\alpha} = 47.5$ MeV angular distributions have been studied to the $\frac{1}{2}^{+} \rightarrow \frac{9}{2}^{+}$ 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 predominantly (sd)^{3} (1978FO11, 1975FO07).

28. ^{17}O(^{13}C, ^{11}B)^{19}F $Q_{\rm m} = -4.865$

See (1977CH22).

Table 19.14: States of ^{19}F from ^{17}O(^{3}He, p) [a]

E_x (MeV ± keV)	L	E_x (MeV ± keV)	L
0.0 [b]	$2\ (+4)$	4.373 ± 4 [b]	$0 + 2$
0.106 ± 10	$(1 + 3)$	4.545 ± 6 [b]	2
0.188 ± 5 [b]	0	4.644 ± 6 [b]	4
1.346 ± 10	$3\ (+5)$	5.099 ± 4 [d]	$0 + 2$
1.460 ± 8	$1 + 3$	5.332 ± 10	
1.556 ± 3 [b]	0	5.414 ± 8	$3\ (+5)$
2.783 ± 3 [b]	2	5.465 ± 3 [b]	2
3.902 ± 9 [c]	$2 + 0$	5.533 ± 8	$2 + 4$
3.993 ± 5 }	$3\ (+5)$	5.621 ± 7	1 ± 3
4.026 ± 12 }			

[a] (1978FO22, 1979BI05, 1979FO06): $E(^3\text{He}) = 18$ MeV.
[b] Dominant (sd)^3 character.
[c] $\frac{3}{2}^+$; predominantly 5p–2h.
[d] Second (sd)^3 $\frac{5}{2}^+$ level.

29. ^{18}O(p, γ)^{19}F $\qquad Q_m = 7.9934$

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 distrubution data lead to J^π assignments: see Tables 19.7, 19.15 and 19.16 for a display of the results (1980WI17).

In addition absolute cross sections measured for direct capture leads to C^2S values for a number of states of ^{19}F. Reduced widths and J^π determinations lead to (1980WI17) to postulate ^{19}F*(3.91, 4.55, 4.38, 6.59, 6.50, 10.43) as the $J^\pi = \frac{3}{2}^+, \frac{5}{2}^+, \frac{7}{2}^+, \frac{9}{2}^+, \frac{11}{2}^+, \frac{13}{2}^+$ of the $K^\pi = \frac{3}{2}^+$ rotational band; ^{19}F*(7.73 or 7.26, 6.09, 9.81, 6.92, 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).

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 (1980WI17). See also (1975ZI1A; astrophys.). For the earlier work see (1978AJ03). See also (1978DI13).

30. ^{18}O(p, n)^{18}F $\qquad Q_m = -2.4379 \qquad E_b = 7.9934$

Table 19.15: 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 19.16.
[b] $J^\pi = \frac{5}{2}^-$.
[c] $J^\pi = \frac{9}{2}^-$.
[d] $J^\pi = \frac{1}{2}^-, \frac{3}{2}$.
[e] $J^\pi = \frac{1}{2}^+$.

Yield measurements are reported from $E_p = 2.5$ to 13.5 MeV [see (1978AJ03) for the references]. Table 19.17 displays the observed resonances. See also ^{18}F.

31. ^{18}O(p, p)^{18}O $\qquad E_b = 7.9934$

Scattering studies have been carried out for $E_p = 0.6$ to 16.3 MeV [see (1978AJ03)], and for $E_p = 3.05$ to 3.5 MeV (1978DI13; $p_1\gamma$) and $E_{\vec{p}} = 6.1$ to 16.6 MeV (1979MU05; p_0, p_1). Pronounced resonant structure is evident up to $E_{\vec{p}} = 14$ MeV (1979MU05). Observed resonances are displayed in Table 19.18. For other polarization measurements see (1981GL1B; $E_{\vec{p}} = 800$ MeV) and (1978AJ03). See also (1980FA06) and ^{18}O.

32. (a) ^{18}O(p, d)^{17}O $\qquad Q_m = -5.820 \qquad E_b = 7.9934$
(b) ^{18}O(p, t)^{16}O $\qquad Q_m = -3.7069$

See (1978AJ03) and ^{16}O, ^{17}O in (1982AJ01). See also (1979AM03; theor.).

Table 19.16: 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	$(1.0 \pm 0.1) \times 10^{-3}$	$\frac{1}{2}^+$	8.136 [e]
216 ± 1	≤ 1	$> 0.8 \times 10^{-5}$		8.198
274 ± 3	≤ 1.5	$(3.7 \pm 0.5) \times 10^{-5}$	$\leq \frac{7}{2}$	8.253
334 ± 2	≤ 1	$(0.95 \pm 0.08) \times 10^{-3}$	$\frac{5}{2}^+$	8.310 [f]
622 ± 2	≤ 0.5	$(10 \pm 2) \times 10^{-3}$	$\frac{5}{2}^+$	8.582
629.6 ± 0.3	2.0 ± 0.3	0.10 ± 0.02	$\frac{3}{2}^-$	8.5896 [g]
≈ 680	300		$\frac{3}{2}$	8.637
841 ± 2	48 ± 2	1.4 ± 0.2	$\frac{1}{2}^+$ [b] $T = \frac{3}{2}$	8.790 [h]
977 ± 2	10 ± 2	$(1.5 \pm 0.2) \times 10^{-2}$	$\frac{3}{2}$	8.919
1166.5 ± 0.4		0.31 ± 0.10	$\frac{7}{2}^-$	9.0980 [i]
1398 ± 2	3.6 ± 0.8	0.08 ± 0.01	$\frac{3}{2}^+$	9.317
1630 ± 2 [c]	7 ± 2	0.025 ± 0.005	$\frac{5}{2}^+$	9.537
1660 ± 3	27 ± 3	0.041 ± 0.010	$\frac{3}{2}^-$	9.565
1670 ± 4	70 ± 3	0.06 ± 0.01	$\frac{3}{2}^-$	9.575
1684 ± 4	8 ± 2	0.025 ± 0.004	$\frac{7}{2}$	9.588
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	$\frac{5}{2}$	9.819
1986 ± 2	< 1.5	0.13 ± 0.04	$\frac{11}{2}^-$	9.874
1996 ± 4	26 ± 2	0.14 ± 0.05	$\frac{1}{2}^+$	9.883
2263.0 ± 0.7	5.0 ± 1.0		$\frac{3}{2}^-$	10.136
> 2300 [d]				

[a] Mostly from (1980WI17). For earlier references see Table 19.15 in (1978AJ03). See also Tables 19.7 and 19.15 here.

[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 (1980WI17).

[c] Decays partly (see Table 19.7) via a state at 8015 ± 2 keV with $J^\pi = \frac{5}{2}^+$ (1980WI17).

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

[e] $\Gamma_p = 0.17$ eV, $\Gamma_\alpha = 220$ eV, $\Gamma_\gamma = 1.3$ eV: see (1980WI17) for this footnote and the ones below.

[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 arguements lead to $J = \frac{5}{2}$ for that state.

Table 19.17: 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	$(\frac{3}{2})$	10.496
2.691 ± 1.0	2.5 ± 0.2	n		10.542
2.717 ± 1.0	5.2 ± 0.5	n		10.566
2.767 ± 1.5	4.7 ± 0.5	n	$\frac{5}{2}^{(+)}$	10.613
2.923 ± 4	6 ± 3	n		10.761
3.025 ± 2.0	24.0 ± 1.5	n	$\frac{3}{2}$	10.858
(3.08 ± 20)	≈ 60	n		(10.91)
3.148 ± 3	14 ± 2	n		10.974
3.164 ± 2.5	7 ± 2	n		10.989
3.250 ± 2.5	35 ± 4	n	$\frac{3}{2}$	11.071
3.370 ± 4	17 ± 4	n		11.184
3.463 ± 3	7 ± 2	n		11.272
3.470 ± 15	70 ± 20	n		11.279
3.653 ± 4	40 ± 10	n, n_1		11.452
3.680 ± 5	7 ± 3	n		11.478
3.705 ± 5	4 ± 2	n, n_1		11.502
3.748 ± 15	50 ± 15	n		11.542
3.775 ± 7	15 ± 10	n, n_2	$(T = \frac{3}{2})$	11.568
(3.79 ± 20)	60 ± 20	n		(11.58)
3.863 ± 4	45 ± 10	n, n_1		11.651
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
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)

Table 19.17: 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)
5.05 ± 10	200	n, n_1, n_2		12.77
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.

33. ^{18}O(p, α)^{15}N $\qquad Q_m = 3.9796 \qquad E_b = 7.9934$

Yield measurements have been studied for $E_p = 0.50$ to 14 MeV [see (1972AJ02)] and at $E_p = 72$ to 935 keV (1979LO01; α_0), 235 to 698 keV (1978MA30; α_0) and 6.6 to 10.4 MeV (1979WI09; α_0): observed resonances are displayed in Table 19.18. The stellar reaction rates have been determined for $T_9 = 0.008$ to 2.5 (1978RO1D). See also (1975ZI1A, 1978MA30; astrophys.) and (1978AJ03).

Table 19.18: Energy levels of ^{19}F from ^{18}O(p, p)^{18}O and ^{18}O(p, α)^{15}N [a]

E_p (MeV ± keV)	Γ_{lab} (keV)	Particles out	Γ_p [b] (keV)	Γ_α [b] (keV)	J^π	E_x (MeV)
0.095 ± 3 [c]	≤ 3	α_0	$\omega\gamma = (1.6 \pm 0.5) \times 10^{-7}$ eV			8.083
0.152 ± 1 [c]	≤ 0.5	α_0	0.17 ± 0.02 eV			8.137
0.216 ± 1 [c]	≤ 1	α_0	$(2.3 \pm 0.6) \times 10^{-3}$ eV			8.198
0.334 ± 1 [c]	≤ 1	α_0	0.057 ± 0.010 eV			8.310
0.6326 ± 0.4 [d]	2.1 ± 0.1	p_0, α_0	0.065 ± 0.006	2.0 ± 0.2	$\frac{3}{2}^-$	8.5925
≈ 0.695 [c]	≈ 340	p_0, α_0	5 [e]	95 [e]	$\frac{1}{2}^+$	8.65
0.846 ± 1.5	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	$\frac{3}{2}^-$	8.928
(1.135)	140					(9.068)
1.1685 ± 0.5	0.60 ± 0.03	p_0, α_0	0.005 ± 0.0006	0.595 ± 0.08	$\frac{7}{2}^+$	9.0999
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	$\frac{1}{2}^+$	9.321
1.620 ± 6	30	p_0, α_0			$(\frac{5}{2})$	9.527
1.668 ± 6	27	p_0, α_0			$\frac{3}{2}$	9.573
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	$(\frac{5}{2}, \frac{7}{2})^-$	9.819
2.001 ± 4	31	p_0, α_0	12	19	$\frac{1}{2}^+$	9.888
2.2630 ± 0.7	5.0 ± 1.0	$\alpha_0, \alpha_1, \alpha_2$	≈ 5	0.004 [c]	$\frac{3}{2}^-$	10.136
2.289 ± 3	33	p_0, α_0	2.3	(1.0)	$\frac{1}{2}^+$	10.161
2.363 ± 3	4.5	p_0, α_0	2.8	1.7	$\frac{1}{2}^+$	10.231
2.387 ± 3	24	p_0, α_0	11	13	$\frac{3}{2}^+$	10.253
2.443 ± 4	9.7	p_0, α_0	5.2	4.5	$\frac{3}{2}^+$	10.307
2.644 ± 3	4.6	$p_0, p_1, \alpha_0, \alpha_{1+2}$	2.4	(1.0)	$\frac{3}{2}^+$	10.497
2.705 ± 3	8 ± 2	p_1, α_0			$\frac{3}{2}^{(+)}; (T = \frac{3}{2})$	10.555
2.732 ± 4	23 ± 3	p_1, α_0			$(\frac{5}{2}^+)$	10.580
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]	10.614
2.925 ± 3	5.7	$p_0, p_1, \alpha_0, \alpha_{1+2}$	4.5	1.2	$\frac{1}{2}^-$	10.763
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)	$(\frac{3}{2}, \frac{5}{2})^+$	10.974
3.266 ± 9	35	$p_0, p_1, \alpha_0, \alpha_{1+2}$			$\frac{1}{2}^+$	11.086
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		$\frac{1}{2}^-$	11.443
3.694 ± 9	29 ± 6	$p_0, p_1, \alpha_0, (\alpha_{1+2})$	12 ± 2		$\frac{3}{2}^-$	11.491
3.744 ± 8	23 ± 5	p_0, p_1, α_0	3.7 ± 1		$\frac{5}{2}^+$	11.539

Table 19.18: 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)
3.811 ± 12	66 ± 7	p_0	30 ± 12		$\frac{3}{2}^-$	11.602
3.869 ± 8	28 ± 7	$p_0, p_1, (\alpha_{1+2})$	12 ± 2		$\frac{3}{2}^+; (T = \frac{3}{2})$	11.657
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		$\frac{3}{2}^-; T = \frac{3}{2}$	12.150
4.465 ± 12	78 ± 1	$p_0, p_1, \alpha_0, \alpha_{1+2}$	48 ± 6		$\frac{3}{2}^+$	12.221
4.782 ± 7	16 ± 4	p_0, p_1	2.4 ± 1		$\frac{1}{2}^-$	12.521
4.840 ± 10	50 ± 10	p_0, p_1, α_{1+2}	6.4 ± 2		$\frac{5}{2}^+$	12.576
4.848 ± 25	300 ± 50	p_0	80 ± 25		$\frac{1}{2}^-; T = \frac{3}{2}$	12.58
5.074 ± 30	100 ± 40	$p_0, p_1, (\alpha_0)$	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	30 ± 6	$p_0, p_1, \alpha_0, \alpha_{1+2}$	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	$p_0, p_1, (\alpha_{1+2})$	13 ± 3		$\frac{7}{2}^-; T = \frac{3}{2}$	13.731
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		$\frac{3}{2}^-$	14.32
7.080 ± 20	130 ± 40	p_0	21 ± 5		$\frac{3}{2}^-$	14.70
7.10 ± 70 [g]	270 ± 70	α_0			$\frac{1}{2}^-$	14.72
7.125 ± 50 [f,g]	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		$\frac{1}{2}^-$	15.35
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
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		$\frac{3}{2}^-$	16.27
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		$\frac{7}{2}^-$	18.02
11.698 ± 60	584 ± 150	p_0	22 ± 7		$\frac{3}{2}^-$	19.07

Table 19.18: 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)
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 19.17 in (1978AJ03) and 19.14 in (1972AJ02) for the earlier work and references.
[b] See also Table 19.16.
[c] (1979LO01).
[d] $\omega\gamma = 420 \pm 80$ eV (1979LO01).
[e] Widths not in accord with Γ measured by (1979LO01) who calculate also $\omega\gamma \approx 1.2 \times 10^5$ eV.
[f] The parameters of this resonance and all the ones below [except for the two footnoted [g]] are from a phase-shift analysis by (1979MU05) of the elastic scattering for $E_{\vec{p}} = 6.1$ to 16.6 MeV. Other structures have also been observed but parameters for those have not been obtained.
[g] (1979WI09).

34. (a) ^{18}O(d, n)^{19}F $\qquad Q_m = 5.7685$
(b) ^{18}O(d, nα)^{15}N $\qquad Q_m = 1.7546$

Angular distributions of neutron groups corresponding to ^{19}F states with $E_x < 8.2$ MeV have been measured at $E_d = 3$ and 4 MeV: see Table 19.18 in (1978AJ03). Gamma-ray measurements are reported here in Table 19.19 and τ_m measurements in Table 19.8. For reaction (b) see (1972AJ02).

35. ^{18}O(^{3}He, d)^{19}F $\qquad Q_m = 2.4998$

Angular distributions of the deuterons corresponding to many states of ^{19}F have been analyzed by DWBA: the results are shown in Table 19.19. 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 (1971FO18). See also (1979HAYZ) and (1978AJ03).

36. ^{19}O(β^-)^{19}F $\qquad Q_m = 4.819$

Table 19.19: 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	(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			
5.54 ± 5	3	0.14	$\frac{7}{2}^-$
5.625 ± 4 [c]			
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 [e]	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 [e]	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 19.19: 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)	$(\frac{3}{2}^-)$
8.015 ± 5	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			
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): $E(^{3}$He$) = 16$ MeV (1970SC25), except where footnote is shown.
[c] ^{18}O(d, nγ) (1975LE16).
[d] 5.106 ± 3 (1975LE16).
[e] Unresolved.

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 19.20. 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): see (1966OL01). Gamma-ray branching ratios are displayed in Table 19.7.

Time differential $\beta-\gamma$ angular correlation measurements lead to a ratio $+0.030 \pm 0.015$ for the Fermi to Gamow-Teller matrix elements ($C_V M_F / C_A M_{GT}$) for the allowed β^- decay ($\frac{5}{2}^+ \to \frac{5}{2}^+$) from ^{19}O$_{g.s.}$ to ^{19}F$_{0.197}$. This leads to a value for M_F (isospin-forbidden fermi matrix element)

Table 19.20: Branching in ^{19}O(β^-)^{19}F [a]

Decay to ^{19}F* (keV) [b]	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).

of $(4.7 \pm 2.4) \times 10^{-3}$. The admixture of the analog of the ^{19}O$_{\rm g.s.}$ in the ^{19}F excited state $\alpha = (2.7 \pm 1.4) \times 10^{-3}$ and the effective charge-dependent matrix element $|H_{\rm CD}| = 20 \pm 10$ keV (1978PE14).

37. (a) ^{19}F(γ, n)^{18}F $\qquad Q_{\rm m} = -10.4313$
(b) ^{19}F(γ, 2n)^{17}F $\qquad Q_{\rm m} = -19.5819$
(c) ^{19}F(γ, 2np)^{16}O $\qquad Q_{\rm m} = -20.1823$

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. The integrated cross section to 29 MeV is 108 ± 7 MeV$\cdot$mb (1974VE06). For reports of other structures see (1972AJ02, 1978AJ03). See also (1979TH05) and ^{18}F. For reactions (b) and (c) see (1978AJ03).

38. ^{19}F(γ, p)^{18}O $\qquad Q_{\rm m} = -7.9934$

The integrated cross sections for the p_0 and p_1 processes at $90°$ for $E_\gamma = 13.3 \rightarrow 25.4$ and $15.2 \rightarrow 26.0$ MeV are, respectively, 1.80 ± 0.27 and 0.50 ± 0.45 MeV $\cdot$ mb/sr. The (γ, p_0) cross section at $90°$ shows broad structures at $E_\gamma = 15.0$, 17.0 and 23 MeV (1975TS03). For a report of other structures see (1978AJ03). See also (1979KE1B, 1979TH05) and ^{18}O.

39. ^{19}F(γ, t)^{16}O $\qquad Q_{\rm m} = -11.7003$

This reaction has been studied for the transition to $^{16}\text{O}_{\text{g.s.}}$ for $E_\gamma = 18$ to 23 MeV. Two peaks are observed at $E_\gamma = 18.8$ and 20.1 MeV: the angular distribution of t_0 indicates $J^\pi = \frac{1}{2}^-$ or $\frac{3}{2}^-$, $T = \frac{1}{2}$. The triton GDR contributes $\approx 1\%$ or the total GDR (1974SK04).

40. ^{19}F(γ, α)^{15}N $\qquad Q_{\rm m} = -4.0138$

See (1979TH05) and ^{15}N in (1981AJ01).

41. ^{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. $E_{\rm x} = 7663 \pm 4$ keV for the latter. The scattering cross section is relatively small and structureless for $E_\gamma = 14$ to 30 MeV. See (1978AJ03) for references.

42. (a) ^{19}F(e, e)^{19}F
(b) ^{19}F(e, en)^{18}F $\qquad Q_{\rm m} = -10.4313$
(c) ^{19}F(e, ep)^{18}O $\qquad Q_{\rm m} = -7.9934$

The rms radius of $^{19}\text{F} = 2.885 \pm 0.015$ fm (1973HA13). At $E_{\rm e} = 400$ MeV, $0.5 \leq q \leq 2.5$ fm^{-1}, the squared form factors have been determined for ^{19}F*(0, 1.55, 0.197, 5.46, 2.78, 4.65) [the $J^\pi = \frac{1}{2}^+, \frac{3}{2}^+, \frac{5}{2}^+, \frac{7}{2}^+, \frac{9}{2}^+, \frac{13}{2}^+$ members of the $K = \frac{1}{2}^+$ ground-state rotational band] as well as for ^{19}F*(4.38) [$J^\pi = \frac{7}{2}^+$]. The data are consistent for $q < 1.8$ fm^{-1} with transition strengths which were derived from a variation-after-projection, Hartree-Fock approximation (VPHF). However for the transitions to ^{19}F*(1.55, 0.197) ($q > 1.8$ fm^{-1}) the relative magnitudes of the transitions require a strong M3 component in the $\frac{5}{2}^+$ state and a weak component in the $\frac{3}{2}^+$ state, consistent with predominant $\mathbf{L} \cdot \mathbf{S}$ coupling. Including M5 and M7 strength improves the agreement with the data for ^{19}F*(2.78, 4.65) (1978WI01). The deformation parameters for the ground-state band are $\beta_2 = 0.43 \pm 0.02$, $\beta_4 = 0.12 \pm 0.02$ (1975OY01). Values of $|M|^2$ adotped by P.M. Endt (private communication) are 8.9 ± 0.5 (E3), 6.9 ± 0.5 (E2) and 6.1 ± 2.4 W.u. (M5) for the g.s. transitions of ^{19}F*(1.35, 1.55, 2.78): for other values see Table 19.20 in (1978AJ03). For reactions (b) and (c) see (1978AJ03).

43. ^{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). E_x for the first six excited states of ^{19}F, derived from γ-ray measurements, are 109.8 ± 0.2, 197.2 ± 0.2, 1345.4 ± 0.3, 1456.9 ± 1.1, 1554.0 ± 0.3 and 2775.1 ± 3.5 keV (1968SP01). See also (1978CO18, 1980CO1U), (1978AJ03), (1977NO07; theor.) and ^{20}F here.

44. (a) ^{19}F(p, p)^{19}F
(b) ^{19}F(p, 2p)^{18}O $\quad\quad Q_m = -7.9934$

Table 19.21 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 30 MeV [see (1978AJ03)] and at 35.2 MeV (1980FA07; p_0). The ground-state rotational band is characterized by $\beta_2 = 0.44 \pm 0.04$, $\beta_4 = 0.14 \pm 0.04$ (1973DE06, 1974DE46). The g of ^{19}F*(0.197) $= 1.47 \pm 0.03$ (1978KR05). The mixing ratio for the $1.46 \to 0.11$ transition ($\frac{3}{2}^- \to \frac{1}{2}^-$; $K = \frac{1}{2}^-$ band), δ(E2/M1) has been remeasured by (1980DI12) to be 0.224 ± 0.040. A re-analysis of earlier experiments leads to a "best" value of 0.248 ± 0.020 for the ratio and to an E2 strength of 18.7 ± 1.9 W.u. The $1.46 \to 0$ transition is pure E1 ($\delta = 0.01 \pm 0.03$) (1980DI12). See Table 2 in the Introduction in this publication, and Table 19.7. For reaction (b) see ^{18}O. See also (1981KE1E, 1982FI1C), (1978SH1U, 1980KR1C; applied), (1977PH02, 1979ZE04, 1980KO1V; theor.) and ^{20}Ne.

45. ^{19}F(d, d)^{19}F

Angular distributions of elastically scattered deuterons has been measured for $E_d = 2.0$ to 15 MeV [see (1972AJ02)] for the earlier references] and for 1.6 to 2.4 MeV (1978AS07). Angular distributions have also been measured for $d_1 \to d_5$ and $B(E\lambda)$ have been derived (1970DE06; $E_d = 15$ MeV). For polarization measurements see (1978AJ03). See also (1979AN35).

46. ^{19}F(t, t)^{19}F

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

Table 19.21: States of ^{19}F from ^{19}F(p, p′)^{19}F*

E_x (keV) [a]	L [b]	β_L [b]	J^π
197.6 ± 0.6	2	0.55	$\frac{5}{2}^+$
1345.8 ± 0.2	3	0.33	$\frac{5}{2}^-$
1458.8 ± 0.3			$\frac{3}{2}^-$
1554.0 ± 0.4	2	0.58	$\frac{3}{2}^+$
2779.8 ± 0.6	4	0.22	$\frac{9}{2}^+$
3907.1 ± 1.0			$\frac{3}{2}^+$
3998.5 ± 0.8			$\frac{7}{2}^-$
4032.5 ± 2			$\frac{9}{2}^-$
4377.7 ± 1.0			$\frac{7}{2}^+$
4548.8 ± 1.0	2	0.20	$\frac{5}{2}^+$
4557.5 ± 1.0			$\frac{3}{2}^-, (\frac{1}{2}^-)$
4682.5 ± 1.2	[c]		
5110 ± 10	2	0.15 [d]	$\frac{5}{2}^{(-)}$
5340 ± 10			
5420 ± 10	3	0.45	$\frac{7}{2}^-$
5470 ± 10			
5500 ± 10			
5540 ± 10			
5630 ± 10	[e]		
5940 ± 10			
(6080)			
6090 ± 10			
6170 ± 10			
6250 ± 10			
6290 ± 10			
6330 ± 10			

[a] For references see Table 19.21 in (1978AJ03).
[b] (1974DE46): $E_p = 30$ MeV.
[c] (1974DE46) report excitation of a state with $E_x = 4.69$ MeV, $J^\pi = \frac{3}{2}^-$, $L = 3$, $\beta_L = 0.17$.
[d] If $L = 2$.
[e] (1974DE46) report excitation of a state with $E_x = 5.63$ MeV, $J^\pi = \frac{5}{2}^-$, $L = 3$, $\beta_L = 0.33$.

47. (a) ^{19}F(^{3}He, ^{3}He)^{19}F

(b) ^{19}F(^{3}He, ^{6}He)^{16}F $\quad Q_m = -14.842$

Elastic angular distributions have been measured for $E(^{3}\text{He}) = 4.0$ to 29 MeV: see (1972AJ02, 1978AJ03). For reaction (b) see (1978AJ03) and ^{16}F in (1982AJ01). See also (1979GR11; theor.).

48. (a) ^{19}F(α, α)^{19}F

(b) ^{19}F(α, αp)^{18}O $\quad Q_m = -7.9934$

(c) ^{19}F(α, 2α)^{15}N $\quad Q_m = -4.0138$

(d) ^{19}F(α, αt)^{16}O $\quad Q_m = -11.7003$

Angular distributions of elastically scattered α-particles have been measured 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 $1.35 \rightarrow 0.11$ transition is 1235.8 ± 0.2 keV. Using $E_x = 109.894 \pm 0.005$ keV for the energy of the first excited state, E_x for ^{19}F* is then 1345.7 ± 0.2 keV (1967WA13). At $E_\alpha = 12.7$ MeV, a state at 4.648 MeV is populated which is then observed to γ-decay to the $\frac{9}{2}^+$ state at 2.78 MeV. The angular distribution of the cascade γ-rays and the lifetime of ^{19}F*(4.65), set $J^\pi = \frac{13}{2}^+$ for ^{19}F*(4.65) (1969JA09). For reaction (b) see ^{18}O (1979NA06). For reactions (c) and (d) see (1972CH18; $E_\alpha = 60.2$ MeV).

49. (a) ^{19}F(^{6}Li, ^{6}Li)^{19}F

(b) ^{19}F(^{7}Li, ^{7}Li)^{19}F

Elastic angular distributions have been reported in both reactions at $E(\text{Li}) = 20$ and 34 MeV: see (1978AJ03).

50. (a) ^{19}F(^{10}B, ^{10}B)^{19}F

(b) ^{19}F(^{12}C, ^{12}C)^{19}F

For reaction (a) see (1971KN05). Angular distributions [reaction (b)] involving ^{19}F*(0, 0.197, 1.55) have been studied at $E(^{12}\text{C}) = 40.6$ MeV (1980KA1T). See also (1978AJ03). Fusion cross section measurements are reported by (1976SP07, 1977KO38, 1979KO20). See also (1980CO08, 1981MAZJ) and (1978BI1G, 1978HO13, 1978VA1A, 1979NA03, 1980LO02; theor.).

51. (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 (1977KU06) and at $E(^{15}\text{N}) = 23$, 26 and 29 MeV (1973GA14).

52. (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 at 27, 30 and 33 MeV [reaction (b)]: see (1978AJ03). See also (1979GAZV) and (1980OH05; theor.).

53. ^{19}F(^{20}Ne, ^{20}Ne)^{19}F

See (1972AJ02) and (1979SI1K; theor.).

54. ^{19}F(^{23}Na, ^{23}Na)^{19}F

For fusion cross sections see (1978HO20). See also (1978HO13, 1980LE11; theor.).

55. ^{19}F(^{24}Mg, ^{24}Mg)^{19}F

For fusion cross sections see (1981LE04).

56. ^{19}F(^{27}Al, ^{27}Al)^{19}F

For fusion measurements see (1981CH32). See also (1980SA1L).

57. (a) ^{19}F(^{28}Si, ^{28}Si)^{19}F
(b) ^{19}F(^{30}Si, ^{30}Si)^{19}F

See (1980KU04) for the leastic scattering at E(Si) $= 60$ MeV. For fusion measurements see (1981CH32). See also (1979GO13; theor.).

58. ^{19}Ne(β^+)^{19}F $Q_m = 3.2383$

See ^{19}Ne.

59. ^{20}Ne(γ, p)^{19}F $Q_m = -12.8447$

See (1972AJ02).

60. ^{20}Ne(n, d)^{19}F $Q_m = -10.6200$

See (1978AJ03).

61. ^{20}Ne(d, ^{3}He)^{19}F $Q_m = -7.3515$

At $E_d = 52$ MeV ^{3}He angular distributions are reported corresponding to some unresolved states in ^{19}F and to ^{19}F*(2.78, 5.62, 10.41) [the first two involve $l = 4$ and $l = 1$]: see (1978AJ03).

62. ^{20}Ne(t, α)^{19}F $Q_m = 6.9694$

See Table 19.22.

63. ^{21}Ne(p, ^{3}He)^{19}F $Q_m = -11.888$

At $E_p = 45$ MeV, ^{3}He groups are observed to some $T = \frac{1}{2}$ states in ^{19}F and to $\frac{3}{2}^+$, $T = \frac{3}{2}$ analog of ^{19}O*(0.095): $E_x = 7.660 \pm 0.035$ MeV (1969HA38). At $E_p = 40$ MeV comparison of the ground-state angular distributions in this reaction and in the mirror (p, t) reaction [see reaction 18 in ^{19}Ne] shows a suppression of the $S = 1$, $T = 0$ component of the (p, ^{3}He) cross section: this is observed to occur for all $T_Z = \frac{1}{2}$ nuclei with $A < 40$ (1976NA18).

Table 19.22: States of ^{19}F and ^{19}Ne from ^{20}Ne(t, α) and ^{20}Ne(^{3}He, α)

E_x in ^{19}F (MeV $\pm$ keV) [a]	l_p [b]	J^π	C^2S [b,c]		E_x in ^{19}Ne (MeV)
			(t, α)	(^{3}He, α)	
0	0	$\frac{1}{2}^+$	0.12	0.20	0
0.11	1	$\frac{1}{2}^-$	1.7	1.8	0.28
0.20	2	$\frac{5}{2}^+$	1.6	0.95	0.24
1.46	1	$\frac{3}{2}^-$	0.30	0.21	1.62
1.55	2	$\frac{3}{2}^+$	0.31 [d]	0.70	1.54
2.794 ± 15					
3.917 ± 15		$\frac{3}{2}^+$	≤ 0.04	≤ 0.1	4.03
4.00					
4.032 ± 15					
4.385 ± 15					
$4.55 + 4.56$	1	$\frac{3}{2}^-$	0.69	0.57	4.55
$4.65 + 4.68$					
5.102 ± 15					
5.343 ± 15					
5.481 ± 15					
5.539 ± 15					
5.628 ± 15					
5.937 ± 20					
6.092 ± 15	1	$\frac{3}{2}^-$	1.0	1.4	6.01
6.169 ± 30					
6.247 ± 25					
6.501 ± 25					
6.79	1	$\frac{3}{2}^-$	0.96	1.5	6.74

[a] For references see Table 19.23 in (1978AJ03). E_x for which errors are not shown are nominal.

[b] (1974GA28): $E_t = 20$ MeV.

[c] Calculated using finite range and non-local corrections. The (^{3}He, α) results are from (1970GA18). The absolute DWBA normalization factors were 4.6 for (t, α) and 10.2 for (^{3}He, α).

[d] Poor DWBA fit.

64. ^{21}Ne(d, α)^{19}F $Q_{\rm m} = 6.465$

See (1978AJ03).

65. ^{22}Ne(p, α)^{19}F $Q_{\rm m} = -1.675$

The parity-non-conserving asymmetry of the 110 keV γ-rays emitted by polarized ^{19}F* nuclei is $\delta = -(1.8 \pm 0.9) \times 10^{-4}$ (1975AD01). See also (1978AJ03).

66. ^{23}Na(n, n$'\alpha$)^{19}F $Q_{\rm m} = -10.467$

See (1978AJ03).

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

GENERAL: (See also (1978AJ03).)

Nuclear models: (1978MA2H, 1978PE09, 1978PI06, 1979DA15, 1979MA27, 1979PE16, 1982KI02).

Electromagnetic transitions: (1978PE09, 1978SC19, 1979MA27, 1979PE16).

Special states: (1978MA2H, 1978PE09, 1978PI06, 1978SC19, 1979DA15, 1980OK01, 1982KI02).

Astrophysical questions: (1977SI1D, 1979RA1C, 1979WO07).

Applied topics: (1979AL1Q).

Complex reactions involving ^{19}*Ne:* (1978SH18, 1981GR08).

Other topics: (1978MA2H, 1979BE1H, 1979MA27, 1979PE16, 1982KI02).

Ground state of ^{19}*Ne:* (1978MA54, 1979MA27, 1979SA41, 1979SA43).

$\mu_{\text{g.s.}} = -1.88542 \pm 0.00006$ nm (1980MA1G, 1982MAZY; prelim. results).

$\mu_{0.239} = -0.740 \pm 0.008$ nm (1978LEZA).

1. ^{19}Ne(β^+)^{19}F $\qquad Q_{\text{m}} = 3.2383$

The half-life of ^{19}Ne is 17.22 ± 0.02 sec: see (1978AJ03). The decay is principally to ^{19}F$_{\text{g.s.}}$ [$\log ft = 3.237 \pm 0.001$ (1976AL07)]. The allowed nature of the decay to the ground state of ^{19}F sets $J^\pi = \frac{1}{2}^+$ for ^{19}Ne$_{\text{g.s.}}$. Very weak branches are also observed to ^{19}F*(0.110) [$J^\pi = \frac{1}{2}^-$], $(1.20\pm0.20)\times10^{-2}$%, $\log ft = 7.05\pm0.08$ (1981AD05) and to ^{19}F*(1.55) [$J^\pi = \frac{3}{2}^+$], $(2.1\pm0.3)\times 10^{-3}$%, $\log ft = 5.72 \pm 0.06$. The transition ^{19}F*(1.55 $\rightarrow$ 0.20) invloves $E_\gamma = 1356.92 \pm 0.15$ keV (1976AL07). See also (1982LOZZ) and (1978AJ03).

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 negligable contribution. The measured decay rate is roughly an order of magnitude smaller than predicted using standard wave functions (1981AD05). See also (1978KL1D, 1979SCZW, 1982SC1C, 1982SCZZ), (1977GA1E, 1977TE1B, 1978AJ03, 1978CA1H, 1978RA2A, 1978WE1J, 1979CA1K) and (1977KL09, 1980AN31, 1980OK01, 1981HA1Q; theor.).

2. ^{12}C(^{12}C, αn)^{19}Ne $\qquad Q_{\text{m}} = -12.2473$

See (1980KO02).

Table 19.23: 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, 2, 3, 5, 6, 7, 11, 12, 13, 14, 15, 16, 17, 18
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	6, 7, 9, 11, 12, 13, 17, 18
0.27509 ± 0.13	$\frac{1}{2}^-$	$\frac{1}{2}^-$	$\tau_m = 61.4 \pm 3.0$ psec	γ	6, 7, 11, 17
1.50756 ± 0.3	$\frac{5}{2}^-$	$\frac{1}{2}^-$	$1.4^{+0.5}_{-0.6}$ psec	γ	6, 7, 11, 17
1.5360 ± 0.4	$\frac{3}{2}^+$	$\frac{1}{2}^+$	28 ± 11 fsec	γ	6, 7, 9, 11, 12, 13, 17
1.6156 ± 0.5	$\frac{3}{2}^-$	$\frac{1}{2}^-$	143 ± 31 fsec	γ	6, 7, 11, 17
2.7947 ± 0.6	$\frac{9}{2}^+$	$\frac{1}{2}^+$	140 ± 35 fsec	γ	4, 6, 7, 8, 9, 11, 12, 13, 17, 18
4.0329 ± 2.4	$\frac{3}{2}^+$		< 50 fsec	γ	7, 10, 17, 18
4.140 ± 4	$(\frac{9}{2})^-$	$(\frac{1}{2}^-)$	< 0.3 psec	γ	7, 10, 17
4.1971 ± 2.4	$(\frac{7}{2})^-$	$(\frac{1}{2}^-)$	< 0.35 psec	γ	6, 7, 10, 17
4.3791 ± 2.2	$\frac{7}{2}^+$		< 0.12 psec	γ	7, 10, 13, 17
4.549 ± 4	$(\frac{1}{2}, \frac{3}{2})^-$		< 80 fsec	γ	7, 10, 17
4.600 ± 4	$(\frac{5}{2}^+)$		< 0.16 psec	γ	7, 10
4.635 ± 4	$\frac{13}{2}^+$	$\frac{1}{2}^+$	> 1 psec	γ	4, 6, 7, 8, 9, 10, 17
4.712 ± 10	$(\frac{5}{2}^-)$				7
4.783 ± 20					17
5.092 ± 6	$\frac{5}{2}^+$			γ	7, 10, 17, 18
5.351 ± 10	$\frac{1}{2}^+$				17
5.424 ± 7	$(\frac{7}{2}^+)$	$(\frac{1}{2}^+)$			6, 7, 17
5.463 ± 20					17
5.539 ± 9					17
5.832 ± 9					17
6.013 ± 7	$(\frac{3}{2}, \frac{1}{2})^-$				17
6.092 ± 8					7, 17
6.149 ± 20					17
6.288 ± 7					7, 17
6.437 ± 9					17
6.742 ± 7	$(\frac{3}{2}, \frac{1}{2})^-$				17
6.861 ± 7					7, 17
7.067 ± 9					17
7.21 ± 20					7, 17

Table 19.23: Energy levels of ^{19}Ne [a] (continued)

E_x (MeV ± keV)	$J^\pi; T$	K^π	τ or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
7.253 ± 10					17
(7.326 ± 15)					17
(7.531 ± 15)					17
7.616 ± 16	$\frac{3}{2}^+; \frac{3}{2}$				6, 17, 18
7.700 ± 10					17
(7.788 ± 10)					17
7.994 ± 15					17
8.069 ± 12					7, 17
8.236 ± 10 [b]					17
8.442 ± 9					6, 7, 17
8.523 ± 10					17
(8.810 ± 25)					17
8.920 ± 9					6, 7, 8, 17
9.013 ± 10					17
9.100 ± 20					17
9.240 ± 20					6, 17
9.489 ± 25					17
9.81 ± 20					6, 7, 8, 9, 17
10.01 ± 20					7
			$\Gamma_{c.m.} =$ (keV)		
10.407 ± 30 [b]	$\frac{3}{2}^+$		45	p, ^{3}He, α	5, 6, 17
10.46	$\frac{1}{2}^+$		355	p, ^{3}He, α	5
10.613 ± 20					17
11.08 ± 20					6, 7, 8
11.24 ± 20					7
$1\ 1.40 \pm 20$					7
11.51 ± 50	$\frac{3}{2}^-, (\frac{1}{2}^-)$		25	^{3}He, α	5
12.23 ± 50	$\frac{5}{2}^+$		200 ± 25	^{3}He, α	5, 8, 9
12.40 ± 50	$\frac{7}{2}^+$		180 ± 25	^{3}He, α	5
12.56 ± 20					7
12.69 ± 50	$\frac{1}{2}^+$		180 ± 40	p, ^{3}He	5
13.1 ± 30					7
13.22 ± 30					7

Table 19.23: Energy levels of ^{19}Ne [a] (continued)

E_x (MeV ± keV)	$J^\pi; T$	K^π	τ or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
13.8 ± 250			670 ± 250	γ, ^{3}He	5
14.18 ± 30					7, 8
14.44 ± 30					7
14.78 ± 30			620 ± 130	γ, ^{3}He	5, 7
16.23 ± 130			400 ± 130	γ, n, ^{3}He	5
18.4 ± 500			4400 ± 500	γ, ^{3}He	5

[a] See also Table 19.24.

[b] Broad or unresolved states.

3. ^{14}N(^{10}B, αn)^{19}Ne $\quad Q_m = 2.6679$

See (1978WU1C).

4. ^{15}N(^{12}C, ^{8}Li)^{19}Ne $\quad Q_m = -22.596$

At $E(^{12}\mathrm{C}) = 115$ MeV ^{19}Ne*(2.79, 4.64) are populated (1979PA06).

5. (a) ^{16}O(^{3}He, γ)^{19}Ne $\quad Q_m = 8.4434$
   (b) ^{16}O(^{3}He, n)^{18}Ne $\quad Q_m = -3.196$ $\quad E_b = 8.4434$
   (c) ^{16}O(^{3}He, p)^{18}F $\quad Q_m = 2.0328$
   (d) ^{16}O(^{3}He, d)^{17}F $\quad Q_m = -4.8932$
   (e) ^{16}O(^{3}He, ^{3}He)^{16}O
   (f) ^{16}O(^{3}He, α)^{15}O $\quad Q_m = 4.9140$
   (g) ^{16}O(^{3}He, ^{7}Be)^{12}C $\quad Q_m = -5.5758$

Excitation functions at $\theta = 40°$ and $90°$ have been measured for $\gamma_{0\to2}$, $\gamma_{3\to5}$ and γ_6 [reaction (a)] for $E(^3\mathrm{He}) = 3$ to 19 MeV: see Table 19.25 for a listing of the observed structures (1981WA1R). A resonance-like structure is reported at $E(^3\mathrm{He}) \approx 9.5$ MeV in the yield of neutron groups [reaction (b)] (1970AD02).

Table 19.24: 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] $E_x = 238.27 \pm 0.11, 275.09 \pm 0.13, 1507.56 \pm 0.3, 1536.0 \pm 0.4, 1615.6 \pm 0.5$ and 2794.7 ± 0.6 keV from E_γ measurements: see Table 19.25 in (1978AJ03).

[c] $B(E1) = (1.06 \pm 0.05) \times 10^{-3}$ W.u. (1970BH02)

[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).

Table 19.25: Resonances reported in $^{16}O + ^{3}He$ [a]

$E(^3He)$ (MeV)	Resonance in	$\Gamma_{c.m.}$ (MeV)	E_x (MeV)	J^π
2.400	$p_{1\to4}$, $p_{5,6,7}$, α_0	0.355	10.46	$\frac{1}{2}^+$
2.425	$p_{1\to4}$, $p_{5,6,7}$, α_0	0.045	10.48	$\frac{3}{2}^+$
3.65	$p\gamma$, ^3He, α_0	0.025	11.51 ± 0.05	$\frac{3}{2}^-$, $(\frac{1}{2}^-)$
4.50	^3He, α_0	0.200 ± 0.025	12.23 ± 0.05	$\frac{5}{2}^+$
4.70	^3He, α_0	0.180 ± 0.025	12.40 ± 0.05	$\frac{7}{2}^+$
5.05	p_0, p_1, p_5, ^3He	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]	$\gamma_{0\to2}$	4.4 ± 0.5	18.4 ± 0.5	

[a] See reaction 2, ^{19}Ne, in (1978AJ03) for references.

[b] $(2J+1)\Gamma_{^3He}\Gamma_\gamma = 30 \pm 16$, 89 ± 40, 18 ± 2 and 17000 ± 4000 keV^2 for ^{19}Ne*(13.8, 14.9, 16.2, 18.4) (1981WA1R).

Cross sections for production of 0.94, 1.04 and 1.08 MeV γ-rays [reaction (c)] have been measured for $E(^3He) = 2.6$ to 4.0 MeV (1980HE06). The earlier work on reactions (c), (e) and (f) is summarized in (1978AJ03): reported resonances are shown in Table 19.25.

Analyzing powers for reactions (d) [to ^{17}F*(0, 0.5)] and (f) [to ^{15}O*(0, 6.18)] have been measured at $E(^3\vec{He}) = 33$ MeV (1980LU02, 1980LU03, 1981KA1L). Polarization measurements in reaction (g) are reported by (1981LE1F; 41 MeV).

See also (1979KA1G, 1981RO1H) and ^{18}F, ^{18}Ne, ^{16}O and ^{17}F in (1982AJ01), ^{15}O in (1981AJ01) and ^{12}C in (1980AJ01).

6. $^{16}O(\alpha, n)^{19}Ne$ $\qquad Q_m = -12.1344$

Gamma transitions have been observed from the first six excited states of ^{19}Ne: see Table 19.25 in (1978AJ03) and Table 19.24 here. At $E_\alpha = 41$ MeV angular distributions are reported for the n_{0+1} group and for neutron groups to ^{19}Ne*(1.55, 2.78, 4.20, 4.63, 5.43, 6.2, 6.80, 7.61, 8.42, 8.95, 9.23, 9.88, 10.40, 11.09, 12.49), many of which correspond to unresolved states. The relative spectroscopic factors, from a DW analysis, are 0.83, 1.62, 1.0, 2.92, 1.63 for ^{19}Ne*(0, 0.24, 1.54, 2.79, 4.62, 5.4) (1981OV01).

7. $^{16}O(^6Li, t)^{19}Ne$ $\qquad Q_m = -7.351$

This reaction (and the mirror reaction ^{16}O(^{6}Li, ^{3}He)^{19}F) have been studied at $E(^{6}\text{Li}) = 24$, 35 and 36 MeV [see (1978AJ03)] and 46 MeV (1979MA26). Table 19.13 displays the analog states observed in the two reactions. In addition triton groups are reported to states with $E_x = 6.08$, 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 (1979MA26).

8. (a) ^{16}O(^{10}B, ^{7}Li)^{19}Ne $\qquad Q_m = -9.344$

(b) ^{16}O(^{11}B, ^{8}Li)^{19}Ne $\qquad Q_m = -18.767$

Reaction (a) as well as the analog reaction [^{16}O(^{10}B, ^{7}Be)^{19}F] have been studied at $E(^{10}\text{B}) = 100$ MeV. On the basis of similar yields and E_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 (1976HA06).

^{19}Ne*(4.63) is relatively strongly populated at $E(^{11}\text{B}) = 115$ MeV [reaction (b)]. ^{19}Ne*(2.79, 5.4, 9.8, 12.27) are also excited (1979RA10, 1981GO11) [see latter for S_{rel}].

9. ^{16}O(^{12}C, ^{9}Be)^{19}Ne $\qquad Q = -11.4297$

At $E(^{12}\text{C}) = 115$ MeV ^{19}Ne*(4.63) is strongly populated. ^{19}Ne*(0.24, 1.54, 2.79, 9.8, 12.27) are also observed (1979GO17, 1979RA10, 1981GO11) [see the latter for S_{rel}]. See also (1978CH15).

10. ^{17}O(^{3}He, n)^{19}Ne $\qquad Q_m = 4.299$

Neutron-γ coincidence measurements lead to the determination of excitation energies [$E_x = 4032.9 \pm 2.4$, 4140 ± 4, 4197.1 ± 2.4, 4379.1 ± 2.2, 4549 ± 4, 4605 ± 5, 4635 ± 4 and (5097 ± 10) keV], τ_m and branching ratios (see Table 19.24). 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) [$J^\pi = \frac{9}{2}^-, \frac{7}{2}^-$, respectively] and that ^{19}Ne*(4.55, 4.60) are the analogs of ^{19}F*(4.558, 4.555) [$J^\pi = \frac{5}{2}^+, \frac{3}{2}^-$, respectively]. There is no evidence for a reported state at $E_x = 4.78$ MeV (1973DA31).

11. ^{19}F(p, n)^{19}Ne $\qquad Q_m = -4.0207$

Excited states of ^{19}Ne determined from γ-spectra are displayed in Table 19.25 of (1978AJ03). Branching ratio and $\tau_{\rm m}$ measurements are summarized in Table 19.24 here. Neutron measurements are shown in Table 19.24 of (1972AJ02). For the g-factor of ^{19}Ne*(0.24) see Table 19.23. See also (1979WI1N, 1980HU1J) and ^{20}Ne.

12. ^{19}F(^{3}He, t)^{19}Ne $\quad Q_{\rm m} = -3.2570$

At $E(^{3}{\rm He}) = 26$ MeV angular distributions of the triton groups to ^{19}Ne*(0.24, 1.54, 2.79) have been obtained by (1970SC05); those to ^{19}Ne*(0, 0.24) appear to proceed primarily via $L = 0$ and $L = 2$, respectively.

13. ^{19}F(^{6}Li, ^{6}He)^{19}Ne $\quad Q_{\rm m} = -6.745$

At $E(^{6}{\rm Li}) = 34$ MeV the transitions to ^{19}Ne*(0, 0.24, 1.54, 2.79, 4.368 ± 0.010) have been studied (1974GA11).

14. ^{20}Ne(γ, n)^{19}Ne $\quad Q_{\rm m} = -16.8653$

See ^{20}Ne.

15. ^{20}Ne(p, d)^{19}Ne $\quad Q_{\rm m} = -14.6407$

See (1972AJ02).

16. ^{20}Ne(d, t)^{19}Ne $\quad Q_{\rm m} = -10.6080$

See (1978AJ03).

17. ^{20}Ne(^{3}He, α)^{19}Ne $\quad Q_{\rm m} = 3.7125$

Table 19.26: ^{19}Ne levels from ^{20}Ne(^{3}He, α) [a]

E_x (MeV ± keV)	l_n	J^π	C^2S	E_x (MeV ± keV)
0	0	$\frac{1}{2}^+$	0.12	6.862 ± 7
0.23834 ± 0.15	2	$\frac{5}{2}^+$	1.04	7.067 ± 9
0.27530 ± 0.2	1	$\frac{1}{2}^-$	1.96	(7.178 ± 15)
1.5040 ± 3		$(\frac{5}{2}^-)$		7.253 ± 10
1.5324 ± 3		$(\frac{3}{2})^+$	(0.73)	(7.326 ± 15)
1.6115 ± 3	1	$(\frac{3}{2})^-$	0.21	(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	$\frac{1}{2}^+$	0.01	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	$(\frac{3}{2}, \frac{1}{2})^-$	(3.62)	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.

Alpha groups have been observed to ^{19}Ne states with $E_x < 10.6$ MeV: see Tables 19.22 and 19.26. 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 19.26. Relative spectroscopic factors were also extracted. ^{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: see, however, Table 19.23] and ^{19}Ne*(0.28, 1.51, 1.62) with the $K = \frac{1}{2}^-$ 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 (1970GA18). For lifetime and radiative measurements see Table 19.24.

18. ^{21}Ne(p, t)^{19}Ne $\qquad Q_m = -15.145$

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 dominant 5p-2h configuration. ^{19}Ne*(5.09) has $\pi = +$ and its J is consistent with the previous value of $\frac{5}{2}$ (1978FO26, 1979FO06). At $E_p = 45$ MeV the triton group to a state with $E_x = 7.620 \pm 0.025$ has an angular distribution [$L = 0$] which is similar to that for ^{19}F*(7.66): both are thought to be 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 analog state should be 2 (1969HA38). ^{19}Ne*(0, 2.79) are also populated: see (1978AJ03).

^{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 12.928 ± 0.012 MeV for ^{19}Na; it is then unstable with respect to breakup into $^{18}\text{Ne} + \text{p}$ by 320 ± 13 keV. An excited state at $E_x = 120 \pm 10$ keV is also reported (1975BE38). See also (1978AJ03, 1978GU10, 1979BE1H).

^{19}Mg

(Not illustrated)

^{19}Mg has not been observed: see (1977CE05).

References

(Closed 01 May 1982)

References are arranged and designated by the year of publication followed by the first two letters of the first-mentioned author's name and then by two additional characters. Most of the references appear in the National Nuclear Data Center files (Nuclear Science References Database) and have NNDC key numbers. Otherwise, TUNL key numbers were assigned with the last two characters of the form 1A, 1B, etc. In response to many requests for more informative citations, we have, when possible, included up to ten authors per paper and added the authors' initials.

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