Revised Manuscript *02 October 2018*

Energy Levels of Light Nuclei
$A = 19$

F. Ajzenberg-Selove

University of Pennsylvania, Philadelphia, Pennsylvania 19104-6396

Abstract: An evaluation of $A = 18$–20 was published in *Nuclear Physics A*475 (1987), p. 1. This version of $A = 19$ differs from the published version in that we have corrected some errors discovered after the article went to press. Figures and introductory tables have been omitted from this manuscript. Reference key numbers have been changed to the NNDC/TUNL format.

(References closed June 1, 1987)

The original work of Fay Ajzenberg-Selove was supported by the US Department of Energy [DE-FG02-86ER40279]. Later modification by the TUNL Data Evaluation group was supported by the US Department of Energy, Office of High Energy and Nuclear Physics, under: Contract No. DEFG05-88-ER40441 (North Carolina State University); Contract No. DEFG05-91-ER40619 (Duke University).

Table of Contents for $A = 19$

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

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

(Not observed)

See (1983ANZQ; theor.).

^{19}B

(Not illustrated)

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

^{19}C

(Fig. 8)

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

^{19}N

(Figs. 5 and 8)

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

^{19}O
(Fig. 5 and 8)

GENERAL: (See also (1983AJ01).)

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

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

Electromagnetic transitions: (1983BR29, 1985LE1L).

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

Hypernuclei: (1984AS1D).

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

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

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

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

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

See (1983AJ01).

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

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

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

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

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

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

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

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

[a] See also Tables 19.2 and 19.5.

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

[c] See footnotes to Table 19.3.

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

E_i (MeV)	J_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).

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

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

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

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)]: see (1978AJ03).

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

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

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

[a] (1977FO10); $E(^7\text{Li}) = 16.0$ 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 19.4), the other should have $J = \frac{7}{2} \to \frac{13}{2}$.

[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 $J = \frac{1}{2} \to \frac{5}{2}$.

[h] Sharp group; if due to a single state $J = \frac{11}{2} \to \frac{17}{2}$.

[i] $J = (\frac{7}{2}, \frac{9}{2}, \frac{11}{2})$.

[j] The total cross section to this state is very high implying unresolved states: if there are two states one must have $J > \frac{13}{2}$.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

[c] See discussion in (1986KO10).

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

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

GENERAL: (See also (1983AJ01).)

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

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

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

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

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

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

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

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

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

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

Hypernuclei: (1984AS1D).

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

[a] See also Tables 19.7 and 19.8.
[b] For evidence of additional states see reaction 32.
[c] See Table 19.11.

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

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

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

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

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

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

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

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

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

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

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

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

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

See (1983AJ01).

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

See (1983AJ01).

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

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

13. (a) ^{16}O(t, γ)^{19}F $\qquad Q_m = 11.7003$
(b) ^{16}O(t, n)^{18}F $\qquad Q_m = 1.2683 \qquad E_b = 11.7003$
(c) ^{16}O(t, p)^{18}O $\qquad Q_m = 3.7061$
(d) ^{16}O(t, t)^{16}O
(e) ^{16}O(t, α)^{15}N $\qquad Q_m = 7.6865$

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

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

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

Table 19.10: Resonances in ^{15}N(α, γ)^{19}F [a] (continued)

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

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

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

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

[e] Value recalculated by reveiwer from $E_{\rm x}$.

[f] $\Gamma_\alpha/\Gamma_{\rm p} = 0.026 \pm 0.008$.

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

[h] $\Gamma_\alpha/\Gamma_{\rm p} = 0.55 \pm 0.16$.

[i] See (1982KR05).

[j] See also (1985DI16).

14. ^{16}O(α, p)^{19}F $Q_{\rm m} = -8.1137$

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

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

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

16. ^{16}O(^{7}Li, α)^{19}F $Q_{\rm m} = 9.2323$

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

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

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

E_α (MeV $\pm$ keV)	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	< 8		7.271
4.23	< 82	$\frac{7}{2}^+$	7.35
4.465 [c]	0.16 ± 0.05	$\frac{5}{2}^+; T = \frac{3}{2}$	7.538
4.49	< 110	$\frac{7}{2}^+$	7.56
4.53	< 50	$\frac{5}{2}^+$	7.59
4.710	< 40	$\frac{1}{2}^-$	7.731
4.780	< 8		7.787
4.93	< 260		7.90 [e]
(5.005)	(< 8)		(7.964)
(5.018)	(< 5)		(7.974)
5.116	< 8		8.052
5.203	< 8		8.120
5.232	< 6		8.143
5.25	< 65		8.16
5.284	< 10		8.184
5.415 [c]	0.90 ± 0.10	$\frac{13}{2}^-$	8.288

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

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

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

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

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

[d] Value recalculated by reviewer from $E_{\rm x}$.

[e] See, however, reaction 29.

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

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

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

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

[a] For references see (1978AJ03).

See (1978AJ03).

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

[j] (1982BE29).

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

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

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

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

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

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

[b] n means total yield.

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

[d] See also (1982DI11).

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

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

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

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

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

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

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

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

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

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

[b] See also Table 19.15.

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

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

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

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

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

24. ^{18}O(p, n)^{18}F $\quad Q_m = -2.4387 \quad E_b = 7.9942$

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

25. ^{18}O(p, p)^{18}O $\quad E_b = 7.9942$

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

26. ^{18}O(p, t)^{16}O $\quad Q_m = -3.7061 \quad E_b = 7.9942$

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

27. ^{18}O(p, α)^{15}N $\quad Q_m = 3.9804 \quad E_b = 7.9942$

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

28. ^{18}O(d, n)^{19}F $\quad Q_m = 5.7697$

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) and Table 19.18 here.

29. ^{18}O(^{3}He, d)^{19}F $\quad Q_m = 2.5007$

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

30. ^{19}O(β^-)^{19}F $\quad Q_m = 4.820$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

33. ^{19}F(γ, γ)^{19}F

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

40. ^{19}F(α, α)^{19}F

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

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

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

See (1978AJ03).

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

49. ^{19}Ne(β^+)^{19}F $\quad Q_\mathrm{m} = 3.2384$

See ^{19}Ne.

50. ^{20}Ne(d, ^{3}He)^{19}F $\quad Q_\mathrm{m} = -7.354$

See (1978AJ03).

51. ^{20}Ne(t, α)^{19}F $\quad Q_\mathrm{m} = 6.966$

See Table 19.23 in (1978AJ03).

52. ^{21}Ne(p, ^{3}He)^{19}F $\quad Q_\mathrm{m} = -11.890$

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

53. ^{22}Ne(p, α)^{19}F $\quad Q_\mathrm{m} = -1.675$

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

54. ^{23}Na(d, ^{6}Li)^{19}F $\quad Q_\mathrm{m} = -8.994$

See (1984NE1A).

^{19}Ne

(Figs. 7 and 8)

GENERAL: (See also (1983AJ01).)

Nuclear models: (1983BR29, 1983PO02).

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

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

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

Applications: (1982BO1N).

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

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

Hypernuclei: (1984AS1D).

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

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

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

$$\mu_{0.239} = -0.740\ (8)\ \text{nm (1978LEZA)}$$

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

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

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

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

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

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

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

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

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

[a] See also Table 19.22.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

This 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. See (1983AJ01) for references on this and on other heavy-ion induced reactions.

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

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 19.21). On the basis of these it is suggested that ^{19}Ne*(4.14, 4.20) are the analogs of ^{19}F*(4.03, 4.00) [$J^\pi = \frac{9}{2}^-, \frac{7}{2}^-$] and that ^{19}Ne*(4.55, 4.60) are the analogs of ^{19}F*(4.556, 4.550) [$J^\pi = \frac{5}{2}^+, \frac{3}{2}^-$]. There is no evidence for a reported state at $E_x = 4.78$ MeV: see (1978AJ03).

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

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

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

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

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

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

$E(^3He)$ (MeV)	Resonance in	$\Gamma_{c.m.}$ (MeV)	E_x (MeV)	J^π
2.400	$p_{1\rightarrow4}$, $p_{5,6,7}$, α_0	0.355	10.46	$\frac{1}{2}^+$
2.425	$p_{1\rightarrow4}$, $p_{5,6,7}$, α_0	0.045	10.48	$\frac{3}{2}^+$
3.65	$p\gamma$, ^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]	$\gamma_{0\rightarrow2}$	4.4 ± 0.5	18.4 ± 0.5	

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

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

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

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

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

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

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

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

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

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

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

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

^{19}Na

(Fig. 8)

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

^{19}Mg, etc.

(Not observed)

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

References

(Closed 01 June 1987)

1964BA16 J.K. Bair, C.M. Jones and H.B. Willard, Nucl. Phys. 53 (1964) 209

1969BL18 J. Bleck, D.W. Haag and W. Ribbe, Nucl. Instrum. Meth. Phys. Res. 67 (1969) 169

1972AJ02 F. Ajzenberg-Selove, Nucl. Phys. A190 (1972) 1

1975BE38 W. Benenson, A. Guichard, E. Kashy, D. Mueller, H. Nann and L.W. Robinson, Phys. Lett. B58 (1975) 46

1976AL07 D.E. Alburger, Phys. Rev. C13 (1976) 2593

1977CE05 J. Cerny and J.C. Hardy, Ann. Rev. Nucl. Sci. 27 (1977) 333

1977FO10 H.T. Fortune and H.G. Bingham, Nucl. Phys. A293 (1977) 197

1978AJ03 F. Ajzenberg-Selove, Nucl. Phys. A300 (1978) 1

1978LEZA C.M. Lederer, V.S. Shirley, E. Browne, J.M. Dairiki, R.E. Doebler, A.A. Shihab-Eldin, L.J. Jardine, J.K. Tuli and A.B. Buyrn, Table of Isotopes 7th Ed. (1978)

1978WI1B B.H. Wildenthal, Nukelonika 23 (1978) 459

1979GO13 M.B. Golin and S. Kubono, Phys. Rev. C20 (1979) 1347

1979KO26 L. Koester, K. Knopf and W. Waschkowski, Z. Phys. A292 (1979) 95

1979LO01 H. Lorenz-Wirzba, P. Schmalbrock, H.P. Trautvetter, M. Wiescher, C. Rolfs and W.S. Rodney, Nucl. Phys. A313 (1979) 346

1979MU05 G. Murillo, M. Fernandez, P. Perez, J. Ramirez, S.E. Darden, M.C. Cobian-Rozak and L. Montestruque, Nucl. Phys. A318 (1979) 352

1980WI17 M. Wiescher, H.W. Becker, J. Gorres, K.-U. Kettner, H.P. Trautvetter, W.E. Kieser, C. Rolfs, R.E. Azuma, K.P. Jackson and J.W. Hammer, Nucl. Phys. A349 (1980) 165

1980ZO04 L. Zolnai, E. Koltai, Z. Mathe, I. Chekh and E. Somorjai, Izv. Akad. Nauk SSSR Ser. Fiz. 44 (1980) 2281

1981AD05 E.G. Adelberger, M.M. Hindi, C.D. Hoyle, H.E. Swanson and R.D. von Lintig, Phys. Rev. C24 (1981) 313

1981CL05 C.F. Clement and S.M. Perez, J. Phys. (London) G7 (1981) L293

1981DE1P R.M. DeVries and N.J. Digiacomo, J. Phys. (London) G7 (1981) L51

1981GL02 C.W. Glover and K.W. Kemper, Nucl. Phys. A366 (1981) 469

1981LE01 P. Lezoch, H.J. Trost, Md.A. Rahman and U. Strohbusch, Phys. Lett. B98 (1981) 158

1981MUZQ S.F. Mughabghab, M. Divadeenam and N.E. Holden, Neutron Cross Sections Part A, Z=1-60 (1981)

1981WA1Q R.K. Wallace and S.E. Woosley, Astrophys. J. Suppl. 45 (1981) 389

1982AO06 K. Aoki and H. Horiuchi, Prog. Theor. Phys. 68 (1982) 2028

1982BE29 H.W. Becker, W.E. Kieser, C. Rolfs, H.P. Trautvetter and M. Wiescher, Z. Phys. A305 (1982) 319

1982BI08 B.L. Birbrair and Yu.A. Kalashnikov, J. Phys. (London) G8 (1982) 1531

1982BO1N Boyd, Bull. Amer. Phys. Soc. 27 (1982) 761

1982BR24 B.A. Brown, B.H. Wildenthal, W. Chung, S.E. Massen, M. Bernas, A.M. Bernstein, R. Miskimen, V.R. Brown and V. A.Madsen, Phys. Rev. C26 (1982) 2247

1982CA1A Cameron, Essays in Nucl. Astrophys. (1982) 23

1982CO1K Coote, Sparks and Blattner, Nucl. Instrum. Meth. Phys. Res. 197 (1982) 213

1982COZV B. Cottman, A.M. Bernstein, K.I. Blomqvist, S.A. Dytman and J. Nelson, Bull. Amer. Phys. Soc. 27 (1982) 709, BE7

1982CUZZ M.S. Curtin, B.H. Wildenthal and B.A. Brown, Bull. Amer. Phys. Soc. 27 (1982) 696, AC6

1982DE30 L.C. Dennis, K.M. Abdo, A.D. Frawley and K.W. Kemper, Phys. Rev. C26 (1982) 981

1982DE39 P.A. DeYoung, J.J. Kolata, L.J. Satkowiak and M.A. Xapsos, Phys. Rev. C26 (1982) 1482

1982DI11 G.U. Din, J.A. Cameron, V. Janzen and R. Schubank, Nucl. Phys. A385 (1982) 256

1982EL08 K. Elsener, W. Gruebler, V. Konig, C. Schweizer, P.A. Schmelzbach, J. Ulbricht, F. Sperisen and M. Merdzan, Phys. Lett. B117 (1982) 167

1982GI1C R. Giordano, F. Porto, S. Sambataro and A. Scalia, Proc. Int. Conf. on Nucleus-Nucleus Collisions, 26 Sept.-1 Oct. 1982, East Lansing, MI, USA (1982) 101

1982GL08 C. Glashausser, R. de Swiniarski, K. Jones, S. Nanda, F.T. Baker, M. Grimm, V. Penumetcha, A. Scott, G. Adams, G. Igo et al., Phys. Lett. B116 (1982) 215

1982HA43 J.A. Hall and I.P. Johnstone, Phys. Rev. C26 (1982) 1248

1982HO10 H. Homeyer, M. Burgel, M. Clover, Ch. Egelhaaf, H. Fuchs, A. Gamp, D. Kovar and W. Rauch, Phys. Rev. C26 (1982) 1335

1982HU06 M. Hugi, J. Lang, R. Muller, J. Sromicki, E. Ungricht, K. Bodek, L. Jarczyk, B. Kamys, A. Strzalkowski and H. Witala, Phys. Rev. C25 (1982) 2403

1982KR05 H. Krawinkel, H.W. Becker, L. Buchmann, J. Gorres, K.U. Kettner, W.E. Kieser, R. Santo, P. Schmalbrock, H.P. Trautvetter, A. Vlieks et al., Z. Phys. A304 (1982) 307

1982LE1N R. Legrain, Nucl. Phys. A387 (1982) 219

1982LI15 B.J. Lieb, H.S. Plendl, C.E. Stronach, H.O. Funsten and V.G. Lind, Phys. Rev. C26 (1982) 2084

1982LO13 M. Lozano, J.I. Escudero and G. Madurga, J. Phys. (London) G8 (1982) 1259

1982MA1Q B. Maurel, G. Amsel and J.P. Nadai, Nucl. Instrum. Meth. Phys. Res. 197 (1982) 1

1982MA39 D.W. MacArthur, F.P. Calaprice, A.L. Hallin, M.B. Schneider and D.F. Schreiber, Phys. Rev. C26 (1982) 1753

1982NA08 F. Naulin, C. Detraz, M. Roy-Stephan, M. Bernas, J. de Boer, D. Guillemaud, M. Langevin, F. Pougheon and P. Roussel, J. Phys. Lett. 43 (1982) L29

1982NA13 S. Nanda and C. Glashausser, Phys. Rev. C26 (1982) 758

1982NO1D Norman, Astrophys. J. 258 (1982) 41

1982OH05 S. Ohkubo, Phys. Rev. C25 (1982) 2498

1982OL02 J.W. Olness, E.K. Warburton and D.E. Alburger, Nucl. Phys. A378 (1982) 539

1982RA1A J. Rapaport, Phys. Rept. 87 (1982) 25

1982RA1N Ragnarsson and Aberg, Proc. Nucl. Phys. Workshop I.C.T.P. Trieste, Italy, 1981 (1982) 175

1982RO1A Rodney and Rolfs, Essay in Nucl. Astrophys. (1982) 171

1982SA27 L.J. Satkowiak, P.A. DeYoung, J.J. Kolata and M.A. Xapsos, Phys. Rev. C26 (1982) 2027

1982VE05 W.J. Vermeer and A.R. Poletti, J. Phys. (London) G8 (1985) 851

1982VE13 J. Vernotte, G. Berrier-Ronsin, J. Kalifa and R. Tamisier, Nucl. Phys. A390 (1982) 285

1982VI05 S.E. Vigdor, T.G. Throwe, M.C. Green, W.W. Jacobs, R.D. Bent, J.J. Kehayias, W.K. Pitts and T.E. Ward, Phys. Rev. Lett. 49 (1982) 1314

1982VI07 J. Visser, C.N.M. Bakker, G.A. Brinkman, B. Proot and E. Jacobs, Int. J. Appl. Radiat. Isot. 33 (1982) 1381

1982WI1B M. Wiescher and K.-U. Kettner, Astrophys. J. 263 (1982) 891

1982WO1A Woosley and Weaver, Essays in Nucl. Astrophys. (1982) 377

1983AD03 E.G. Adelberger, M.M. Hindi, C.D. Doyle, H.E. Swanson, R.D. von Lintig and W.C. Haxton, Phys. Rev. C27 (1983) 2833

1983AD1B E.G. Adelberger, Proc. NATO Advanced Study Institute on Symmetries in Nucl. Struct., 16-28 Aug. 1982, Dronten, Netherlands; Eds., Abrahams, Allaart and Dieperink (1983) 55

1983AD1C E.G. Adelberger, Comments Nucl. Part. Phys. 11 (1983) 189

1983AD1D Adelberger, Proc. Int. Conf. on Nucl. Phys., Aug.-Spet. 1983; Eds., P. Blasi and R.A. Ricci (1983) 499

1983AJ01 F. Ajzenberg-Selove, Nucl. Phys. A392 (1983) 1; Erratum Nucl. Phys. A413 (1984) 168

1983AL23 J. Almeida and F. Kappeler, Astrophys. J. 265 (1983) 417

1983AM1A G. Amsel and J.A. Davies, Nucl. Instrum. Meth. Phys. Res. 218 (1983) 177

1983AM1D G. Amsel and B. Maurel, Nucl. Instrum. Meth. Phys. Res. 218 (1983) 183

1983ANZQ Y. Ando, M. Uno and M. Yamada, JAERI-M-83-025 (1983)

1983AO03 K. Aoki and H. Horiuchi, Prog. Theor. Phys. (Kyoto) 69 (1983) 857

1983AR1J Arima et al., in Florence (1983) 207

1983AU1B N. Auerbach, Phys. Rept. 98 (1983) 273

1983BI03 J. Billowes, J. Asher, D.W. Bennett, J.A.G. de Raedt, M.A. Grace and B.J. Murphy, J. Phys. (London) G9 (1983) 293

1983BI13 J.R. Birkelund and J.R. Juizenga, Ann. Rev. Nucl. Part. Sci. 33 (1983) 265

1983BI1C P.G. Bizzeti, Riv. Nuovo Cim. 6 (1983) 1

1983BI1M Bird and Clayton, Nucl. Instrum. Meth. Phys. Res. 218 (1983) 525

1983BR27 B.A. Brown, R. Radhi and B.H. Wildenthal, Phys. Lett. B133 (1983) 5

1983BR29 B.A. Brown and B.H. Wildenthal, Phys. Rev. C28 (1983) 2397

1983BU07 B. Buckand S.M. Perez, Phys. Rev. Lett. 50 (1983) 1975; Erratum Phys. Rev. Lett. 51 (1983) 1395

1983CA03 F.P. Calaprice and D.J. Millener, Phys. Rev. C27 (1983) 1175

1983CI08 O. Civitarese, B.V. Carlson, M.S. Hussein and A. Szanto de Toledo, Phys. Lett. B125 (1983) 22

1983CS01 J. Cseh, J. Phys. (Londond) G9 (1983) 655

1983CU02 A. Cunsolo, A. Foti, G. Imme, G. Pappalardo, G. Raciti and N. Saunier, Phys. Lett. B124 (1983) 439

1983DE26 P.A. De Young, J.J. Kolata, L.J. Satkowiak and M.A. Xapsos, Phys. Rev. C28 (1983) 692

1983DE2E C. Detraz, Nucl. Phys. A409 (1983) 353

1983DE2J Deconnick and Vanoystaeyen, Nucl. Instrum. Meth. Phys. Res. 218 (1983) 165

1983DU13 G.G. Dussel, A.O. Gattone and E.E. Maqueda, Phys. Rev. Lett. 51 (1983) 2366

1983DU1D Dunham et al., Unpublished (1983)

1983EN04 Y.M. Engel and R.D. Levine, Phys. Rev. C28 (1983) 2321

1983FR1A W.A. Friedman and W.G. Lynch, Phys. Rev. C28 (1983) 950

1983GE12 P.M. Gensini, Lett. Nuovo Cim. 38 (1983) 469

1983GI1B Girard, Phys. Rev. C27 (1983) 2418

1983GM1A M. Gmitro, H.R. Kissener, P. Truol and R.A. Eramzhyan, Fiz. Elem. Chastits At. Yadra 14 (1983) 773; Sov. J. Part. Nucl. 14 (1983) 323

1983HE1B W. Henning, Nucl. Phys. A400 (1983) 295

1983HO08 M.A.C. Hotchkis, L.K. Fifield, J.R. Leigh, T.R. Ophel, G.D. Putt and D.C. Weisser, Nucl. Phys. A398 (1983) 130

1983HU1J Huang, Song. Wang and Kuo, Chin. Phys. 3 (1983) 403

1983IK1B Ikebata and Kudo, Proc. RCNP Int. Symp. on Light Ion Reaction Mechanism, Osaka (1983) 512

1983IS1F Ishkhanov and Kapitonov, in Florence (1983) 203

1983JA05 U. Jahnke, G. Ingold, H. Homeyer, M. Burgel, Ch. Egelhaaf, H. Fuchs and D. Hilscher, Phys. Rev. Lett. 50 (1983) 1246

1983JA09 L. Jarczyk, B. Kamys, Z. Rudy, A. Strzalkowski, H. Witala, M. Hugi, J. Lang, R. Muller, J. Sromicki and H.H. Wolter. Phys. Rev. C28 (1983) 700

1983KA28 I.M. Kapitonov, Yad. Fiz. 38 (1983) 612; Sov. J. Nucl. Phys. 38 (1983) 364

1983LE1F J.R. Letaw, Phys. Rev. C28 (1983) 2178

1983MA16 C.J. Martoff, J.A. Bistirlich, C.W. Clawson, K.M. Crowe, M. Koike, J.P. Miller, S.S. Rosenblum, W.A. Zajc, H.W. Baer, A.H. Wapstra et al., Phys. Rev. C27 (1983) 1621

1983ME1H Metsch, Klingenbeck and Huber, in Florence (1983) 378

1983MU13 A.M. Mukhamedzhanov, R. Yarmukhamedov and P.O. Dzhamalov, Yad. Fiz. 37 (1983) 1405; Sov. J. Nucl. Phys. 37 (1983) 838

1983PO02 A. Polls, H. Muther, A. Faessler, T.T.S. Kuo and E. Osnes, Nucl. Phys. A401 (1983) 124

1983RA1C Rapaport, AIP Conf. Proc. 97 (1983) 365

1983RO1E Romanov and Grechukhin, in Moscow (1983) 249

1983SC32 M.B. Schneider, F.P. Calaprice, A.L. Hallin, D.W. MacArthur and D.F. Schreiber, Phys. Rev. Lett. 51 (1983) 1239; Erratrum Phys. Rev. Lett. 52 (1984) 695

1983SH32 J. Shurpin, T.T.S. Kuo and D. Strottman, Nucl. Phys. A408 (1983) 310

1983SH44 R.K. Sheline, Aust. J. Phys. 36 (1983) 825

1983SI1B J.A. Simpson, Ann. Rev. Nucl. Part. Sci. 33 (1983) 323

1983SO08 L.G. Sobotka, M.L. Padgett, G.J. Wozniak, G. Guarino, A.J. Pacheco, L.G. Moretto, Y. Chan, R.G. Stokstad, I. Tserruya and S. Wald, Phys. Rev. Lett. 51 (1983) 2187

1983TO1F Tombrello, IEEE Trans. Nucl. Sci. 30 (1983) 1169

1983VA01 J. van Klinken, K. Stam, W.Z. Venema, V.A. Wichers and D. Atkinson, Phys. Rev. Lett. 50 (1983) 94

1983VO05 P. Vogel and B. Werner, Nucl. Phys. A404 (1983) 345

1983WA05 C.E. Waltham, S.H. Chew, J. Lowe, J.M. Nelson and A.R. Barnett, Nucl. Phys. A395 (1983) 119

1983WI1A Wilczynski, Proc. Int. Conf. on Nucl. Phys., Aug.-Sept. 1983, Florence; Eds., P. Blasi and R.A. Ricci; Vol. 2 (1983) 305

1984AD1E E.G. Adelberger, AIP Conf. Proc. 123 (1984) 300

1984AN1B Anagnostatos, in Panic (1984) I56

1984AR1D Arima, Prog. Part. Nucl. Phys. 11 (1984) 53

1984AS03 J. Asher, D.W. Bennett, H.A. Doubt, M.A. Grace, T.J. Moorhouse and B.J. Murphy, J. Phys. (London) G10 (1984) 1079

1984AS1D F. Asai, H. Bando and M. Sano, Phys. Lett. B145 (1984) 19

1984BA24 F.C. Barker, Aust. J. Phys. 37 (1984) 17

1984BE22 C. Beck, F. Haas, R.M. Freeman, B. Heusch, J.P. Coffin, G. Guillaume, F. Rami and P. Wagner, Phys. Rev. C29 (1984) 1942

1984BEZZ R. Bent, J. Conte and M. Dillig, Bull. Amer. Phys. Soc. 29 (1984) 627, AF9

1984BL21 L.D. Blokhintsev, A.M. Mukjamedzhanov and A.N. Safronov, Fiz. Elem. Chastits At. Yadra 15 (1984) 1296; Sov. J. Part. Nucl 15 (1984) 580

1984BO03 A.I. Boothroyd, J. Markey and P. Vogel, Phys. Rev. C29 (1984) 603

1984CA02 J.A. Cameron, Can. J. Phys. 62 (1984) 115

1984CA1D T.A. Cahill, Y. Matsuda, D. Shadoan, R.A. Eldred and B.H. Kusko, Nucl. Instrum. Meth. Phys. Res. B231 (1984) 263

1984CH1V W.H. Chung and J.H. Lee, New Phys. (Korea) 24 (1984) 267

1984CO1H Cook, Stone and Vogt, Astrophys. J. 279 (1984) 827

1984CS01 J. Cseh, E. Koltay, Z. Mate, E. Somorjai and L. Zolnai, Nucl. Phys. A413 (1984) 311

1984DA1P d'Achard van Enschut et al., in Panic (1984) L6

1984FI17 D.J. Fields, W.G. Lynch, C.B. Chitwood, C.K. Gelbke, M.B. Tsang, H. Utsunomiya and J. Aichelin, Phys. Rev. C30 (1984) 1912

1984FR13 H. Friedrich, Phys. Lett. B146 (1984) 135

1984FR1A P. Frobrich, Phys. Rept. 116 (1984) 337

1984GI11 W.R. Gibbs and W.B. Kaufmann, Phys. Lett. B145 (1984) 1

1984GR03 D.P. Grechukhin and S.V. Romanov, Yad. Fiz. 39 (1984) 48; Sov. J. Nucl. Phys. 39 (1984) 28

1984GR08 R.E.L. Green, R.G. Korteling and K.P. Jackson, Phys. Rev. C29 (1984) 1806

1984HA01 A.L. Hallin, F.P. Calaprice, D.W. MacArthur, L.E. Piilonen, M.B. Schneider and D.F. Schreiber, Phys. Rev. Lett. 52 (1984) 337; Erratum Phys. Rev. Lett 52 (1984) 1054

1984HA1R M.J. Harris and D.L. Lambert, Astrophys. J. 281 (1984) 739

1984HA1Z M.J. Harris and D.L. Lambert, Astrophys. J. 285 (1984) 674

1984HA53 Q. Haider and F.B. Malik, At. Data Nucl. Data Tables 31 (1984) 185

1984HI1A A.S. Hirsch, A. Bujak, J.E. Finn, L.J. Gutay, R.W. Minich, N.T. Porile, R.P. Scharenberg and B.C. Stringfellow, Phys. Rev. C29 (1984) 508

1984HO1H B.R. Holstein, AIP Conf. Proc. 123 (1984) 1110

1984HO1L Holstein, Phys. Rev. C29 (1984) 623

1984HO23 H. Homeyer, M. Burgel, Ch. Egelhaaf, H. Fuchs and G. Thoma, Z. Phys. A319 (1984) 143

1984HU1C Hupke et al., in Panic (1984) I50

1984KE04 E. Kerkhove, H. Ferdinande, R. van de Vyver, P. Berkvens, P. van Otten, E. van Camp and D. Ryckbosch, Phys. Rev. C29 (1984) 2047

1984KL06 H.V. Klapdor, J. Metzinger and T. Oda, At. Data Nucl. Data Tables 31 (1984) 81

1984MA32 C.F. Maguire, G.L. Bomar, L. Cleeman, J.H. Hamilton, R.B. Piercey, J.C. Peng, N. Stein and P.D. Bond, Phys. Rev. Lett. 53 (1984) 548

1984ME02 A.C. Merchant, Nucl. Phys. A417 (1984) 109

1984MI1H Millener, Drexel Univ. Symp., Unpublished (1984)

1984MO06 Z. Moroz, K. Rusek, P. Egelhof, S. Kossionides, K.-H. Mobius, G. Tungate, E. Steffens, G. Grawert, I. Koenig and D. Fick, Nucl. Phys. A417 (1984) 498

1984MO08 S. Mordechai and H.T. Fortune, Phys. Rev. C29 (1984) 1765

1984MO28 S. Mordechai and H.T. Fortune, Phys. Rev. C30 (1984) 1924

1984MU27 J.A. Musser and J.D. Stevenson, Phys. Rev. Lett. 53 (1984) 847

1984NA12 Y. Nagame, H. Nakahara, K. Sueki, H. Kudo, I. Kohno and M. Yanokura, Z. Phys. A317 (1984) 31

1984NE1A Nemets, Rudchik and Chuvilski, in Alma Ata (1984) 334

1984PE19 M. Petrascu, I. Berceanu, I. Brancus, A. Buta, C. Grama, I. Lazar, I. Mihai, M. Petrovici and V. Simion, Rev. Roum. Phys. 29 (1984) 689

1984PH02 D.L. Pham and R. de Swiniarski, Nuovo Cim. A83 (1984) 294

1984PO11 D.N. Poenaru and M. Ivascu, J. Phys. (Paris) 45 (1984) 1099

1984RA10 W.D.M. Rae, A.J. Cole, B.G. Harvey and R.G. Stokstad, Phys. Rev. C30 (1984) 158

1984RA13 P.K. Rath, H. Muther, A. Polls, A. Faessler, B. Metsch and D. Zwarts, Nucl. Phys. A427 (1984) 511

1984RA22 J. Rapaport, C. Gaarde, J. Larsen, C. Goulding, C.D. Goodman, C. Foster, D.J. Horen, T. Masterson, E. Sugarbaker and T.N. Taddeucci, Nucl. Phys. A431 (1984) 301

1984SA28 V.S. Sadkovsky, G.A. Feofilov, A.E. Denisov, R.P. Kolalis and L. Peres Tamaio, Izv. Akad. Nauk. SSSR Ser. Fiz. 48 (1984) 995; Bull. Acad. Sci. USSR Phys. Ser. 48 (1984) 158

1984SI15 S.H. Simon, P.L. Gonthier, R.K. Choudhury, M.N. Namboodiri, K. Hagel, S. Kniffen, R. Patton, L. Adler and J.B. Natowitz, Nucl. Phys. A430 (1984) 249

1984SI1G Simonius, AIP Conf. Proc. 123 (1984) 1115

1984TA08 T. Tachikawa, N. Kato, H. Fujita, K. Kimura, T. Sugimitsu, K. Morita, K. Anai, T. Inoue, H. Inoue, Y. Nakajima et al., Phys. Lett. B139 (1984) 267

1984TAZS T.N. Taddeucci, Bull. Amer. Phys. Soc. 29 (1984) 1032, BA4

1984WE04 E. Wesolowski, J. Phys. (London) G10 (1984) 321

1984WI17 B.H. Wildenthal, Prog. Part. Nucl. Phys. 11 (1984) 5

1985AD1A E.G. Adelberger and W.C. Haxton, Ann. Rev. Nucl. Part. Sci. 35 (1985) 501

1985AG1A M.M. Aggarwal and P.L. Jain, Phys. Rev. C31 (1985) 1233

1985AL21 T.K. Alexander, B. Castel and I.S. Towner, Nucl. Phys. A445 (1985) 189

1985AN28 M.S. Antony, J. Britz, J.B. Bueb and A. Pape, At. Data Nucl. Data Tables 33 (1985) 447

1985BA66 F.M. Baumann, B. Bruggemann, H. Freiesleben, Th. Grodotzki and H.Chr. Hilber, Nucl. Instrum. Meth. 238 (1985) 443

1985BE40 C. Beck, F. Haas, R.M. Freeman, B. Heusch, J.P. Coffin, G. Guillaume, F. Rami and P. Wagner, Nucl. Phys. A442 (1985) 320

1985BI01 B.L. Birbrair, V.N. Fomenko, A.B. Gridnev and Yu.A. Kalashnikov, J. Phys. (London) G11 (1985) 471

1985BR15 B.A. Brown, B.H. Wildenthal, C.F. Williamson, F.N. Rad, S. Kowalski, H. Crannell and J.T. O'Brien, Phys. Rev. C32 (1985) 1127

1985BR29 B.A. Brown and B.H. Wildenthal, At. Data Nucl. Data Tables 33 (1985) 347

1985CA1P F.P. Calaprice, Nucl. Phys. A434 (1985) 515

1985DI16 W.R. Dixon, D.W.O. Rogers, R.S. Storey and A.A. Pilt, Phys. Rev. C32 (1985) 2205

1985DW1A Dwyer and Meyer, Astrophys. J. 294 (1985) 441

1985GI09 T.A. Girard, Phys. Rev. C32 (1985) 2192

1985GR1A L. Grenacs, Ann. Rev. Nucl. Part. Sci. 35 (1985) 455

1985GR1J Gross and Zhang, Phys. Lett. B161 (1985) 47

1985HA11 J.S. Hanspal, R.J. Griffiths and N.M. Clarke, Phys. Rev. C31 (1985) 1138

1985HA18 S.S. Hanna and J.W. Hugg, Hyperfine Interactions 21 (1985) 59

1985HO05 J.J. Hogan, J. Asher and D.J. Parker, Phys. Rev. C31 (1985) 477

1985HU04 M.S. Hussein, B.V. Carlson, O. Civitarese and A. Szanto De Toledo, Phys. Rev. Lett. 54 (1985) 2659

1985KE03 E. Kerkhove, R. Van de Vyver, H. Ferdinande, D. Ryckbosch, P. Van Otten, P. Berkvens and E. Van Camp, Phys. Rev. C32 (1985) 368

1985KE1C J. Keinonen, AIP Conf. Proc. 125 (1985) 557

1985LE1L J.H. Lee and W.-H. Chang, New Phys. (Korea) 25 (1985) 381

1985MC03 M.A. McMahan, L.G. Moretto, M.L. Padgett, G.J. Wozniak, L.G. Sobotka and M.G. Mustafa, Phys. Rev. Lett. 54 (1985) 1995

1985MI10 R.E. Mischke, Nucl. Phys. A434 (1985) 505c

1985MO08 M. Morjean, J.L. Charvet, J.L. Uzureau, Y. Patin, A. Peghaire, Y. Pranal, L. Sinopoli, A. Billerey, A. Chevarier, N. Chevarier et al., Nucl. Phys. A438 (1985) 547

1985MO20 S. Mordechai and H.T. Fortune, Phys. Rev. C32 (1985) 2207

1985NA1A Nakai, Hyperfine Interactions 21 (1985) 1

1985OH01 S. Ohkubo and M. Kamimura, Phys. Lett. B150 (1985) 25

1985OH04 S. Ohkubo and Y. Ishikawa, Phys. Rev. C31 (1985) 1560

1985OS05 R. Ost, A. Gamp, S. Kox, C. Perrin, N. Longequeue and F. Merchez, Phys. Rev. C32 (1985) 1927

1985OU01 S. Ouichaoui, H. Beaumevieille, N. Bendjaballah, A.C. Chami, A. Dauchy, B. Chambon, D. Drain and C. Pastor, Nuovo Cim. A86 (1985) 170

1985PO10 N.A.F.M. Poppelier, L.D. Wood and P.W.M. Glaudemans, Phys. Lett. B157 (1985) 120.

1985PO11 D.N. Poenaru, M. Ivascu, A. Sandulescu and W. Greiner, Phys. Rev. C32 (1985) 572

1985RO01 G. Rosner, J. Pochodzalla, B. Heck, G. Hlawatsch, A. Miczaika, H.J. Rabe, R. Butsch, B. Kolb, B. Sedelmeyer, Phys. Lett. B150 (1985) 87

1985SA13 Y. Sakuragi, M. Kamimura, M. Yahiro and M. Tanifuji, Phys. Lett. B153 (1985) 372

1985SM04 A.E. Smith, S.C. Allcock, W.D.M. Rae, B.R. Fulton and D.W. Banes, Nucl. Phys. A441 (1985) 701

1985ST1B R.G. Stokstad, Treatise on Heavy-Ion Sci. 3 (1985) 83

1985TA26 X. Tang, L. Gao and Y. Tian, Chin. J. Nucl. Phys. 7 (1985) 263

1985TO1J Torrisi, Sheng, Rapisarda and Foti, Nuovo Cim. D5 (1985) 164

1985TU1B W. Turchinetz, Nucl. Phys. A446 (1985) 23

1985VOZZ K.F. Von Reden, W.W. Daehnick, S.A. Dytman, R.D. Rosa, J.D. Brown, C.C. Foster, W.W. Jacobs and J.R. Comfort, Bull. Amer. Phys. Soc. 30 (1985) 701, AE10

1985WA02 A.H. Wapstra and G. Audi, Nucl. Phys. A432 (1985) 1

1985WA22 S. Wald, S.B. Gazes, C.R. Albiston, Y. Chan, B.G. Harvey, M.J. Murphy, I. Tserruya, R.G. Stokstad, P.J. Countryman, K. Van Bibber et al., Phys. Rev. C32 (1985) 894

1985WA24 J.W. Watson, W. Pairsuwan, B.D. Anderson, A.R. Baldwin, B.S. Flanders, R. Madey, R.J. McCarthy, B.A. Brown, B.H. Wildenthal and C.C. Foster, Phys. Rev. Lett. 55 (1985) 1369

1985XI1A Xiao et al., Nucl. Tech. 3 (1985) 42

1986AI1A Aichelin and Stocker, Phys. Lett. B176 (1986) 14

1986AJ01 F. Ajzenberg-Selove, Nucl. Phys. A449 (1986) 1

1986AJ04 F. Ajzenberg-Selove, Nucl. Phys. A460 (1986) 1

1986AL11 J. Alstad, T. Bjornstad and G. Skarnemark, Nucl. Instrum. Meth. Phys. Res. A244 (1986) 490

1986AN07 M.S. Antony, J. Britz and A. Pape, At. Data Nucl. Data Tables 34 (1986) 279

1986BA69 D. Baye, Nucl. Phys. A460 (1986) 581

1986BA89 G. Baur, Phys. Lett. B178 (1986) 135

1986BE19 B. Bendyk, L. Jarczyk, B. Kamys, A. Strzalkowski and H. Witala, Phys. Rev. C34 (1986) 753

1986BL08 K. Blatt, K. Becker, B. Heck, H. Jansch, H. Leucker, D. Fick, R. Caplar, R. Butsch, D. Kramer, K.-H. Mobius et al., Phys. Rev. Lett. 57 (1986) 819

1986BO29 M. Bouten and M.C. Bouten, Nucl. Phys. A459 (1986) 253

1986BR1W Brancus et al., in Harrogate (1986) C232

1986BR1X Brown, in Harrogate (1986) 119

1986CA27 M. Carchidi, B.H. Wildenthal and B.A. Brown, Phys. Rev. C34 (1986) 2280

1986CH29 A.E. Champagne and M.L. Pitt, Nucl. Phys. A457 (1986) 367

1986CO1F D.D. Cohen, A. Katsaros and S. Frisken, 11th Ainse Nucl. Phys. Conf., Melbourne, Australia, 1986 (1986) 16

1986CO2B D.D. Cohen, A. Katsaros and D. Garton, Nucl. Instrum. Meth. Phys. Res. B15 (1986) 555

1986DE1G R. de Swiniarski and D.L. Pham, J. Phys. Soc. Jpn. Suppl. 55 (1986) 932

1986DO10 A.J.H. Donne, G. van Middelkoop, L. Lapikas, T. Suzuki, P.W.M. Glaudemans and D. Zwarts, Nucl. Phys. A455 (1986) 453

1986DU07 J.P. Dufour, R. Del Moral, A. Fleury, F. Hubert, D. Jean, M.S. Pravikoff, H. Delagrange, H. Geissel and K.-H. Schmidt, Z. Phys. A324 (1986) 487

1986ER1A R.A. Eramzhyan, B.S. Ishkhanov, I.M. Kapitonov and V.G. Neudatchin, Phys. Rept. 136 (1986) 229

1986FE03 M.A.G. Fernandes, B.l. Burks, D.J. Horen, G.R. Satchler, R.L. Auble, F.E. Bertrand, J.L. Blankenship, J.L.C. Ford, Jr., E.E. Gross, D.C. Hensley et al., Phys. Rev. C33 (1986) 1971

1986FU1C Fujita et al., Rep. Joint Seminar on Heavy-Ion Nucl. Phys. and Nucl. Chem. JAERI (1986) 63

1986FUZV H. Fujita, N. Kato, T. Tachikawa, T. Sugimitsu, K. Kimura, Y. Ikeda, H. Yamaguchi, Y. Nakajima, Y. Sugiyama, Y. Tomita et al., in Harrogate (1986) 317; C130

1986GA13 E.N. Gazis, C.T. Papadopoulos, R. Vlastou and A.C. Xenoulis, Phys. Rev. C34 (1986) 872

1986GO1B Gorionov et al., in Kharkov (1986) 373

1986GR1A C. Gregoire and B. Tamain, Ann. Phys. (France) 11 (1986) 323

1986GR1B Grashin et al., Izv. Akad. Nauk SSSR Ser. Fiz. 50 (1986) 944

1986GU1D D. Guerreau, J. Phys. (Paris) 47 (1986) C4-207

1986HA13 Q. Haider and F.B. Malik, J. Phys. (London) G12 (1986) 537

1986HA1B B.G. Harvey, J. Phys. (Paris) 47 (1986) C4-29

1986HA1Q Haxton, Proc. Int. Nucl. Phys. Conf., Harrogate, U.K., No. 68, Vol. 2 (1986) 415

1986HA1T Harmon and Knox, Bull. Amer. Phys. Soc. 31 (1986) 1285

1986HE1A He et al., in Harrogate (1986) C51

1986HEZW R. Helmer, W.P. Alford, A. Celler, O. Hausser, K. Hicks, K.P. Jackson, S. Yen, R. Henderson, C.A. Miller, A. Yavin et al., Bull. Amer. Phys. Soc. 31 (1986) 1214

1986HU1A Hubert et al., J. Phys. (France) 47 (1986) C4-229

1986IK03 H. Ikezoe, N. Shikazono, Y. Tomita, K. Ideno, Y. Sugiyama, E. Takekoshi, T. Tachikawa and T. Nomura, Nucl. Phys. A456 (1986) 298

1986IKZZ Y. Ikeda, N. Kato, H. Fujita, H. Yamaguchi, T. Sugimitsu, K. Kimura and Y. Nakajima, in Harrogate (1986) 316; C129

1986JA1H Jacobs, AIP Conf. Proc. 142 (1986) 181

1986KA1C M. Kamimura, Y. Sakuragi, M. Yahiro and M. Tanifuji, J. Phys. Soc. Jpn. Suppl. 55 (1986) 205

1986KA1D Karban, in Dubna (1986) 83

1986KE04 J.J. Kehayias, R.D. Bent, M.C. Green, M. Hugi, H. Nann and T.E. Ward, Phys. Rev. C33 (1986) 1388

1986KL1B Klein and Mutsgers, Bull. Amer. Phys. Soc. 31 (1986) 1308

1986KO10 P.E. Koehler, H.D. Knox, D.A. Resler, R.O. Lane and G.F. Auchampaugh, Nucl. Phys. A453 (1986) 429

1986LA07 K. Langanke, M. Wiescher, W.A. Fowler and J. Gorres, Astrophys. J. 301 (1986) 629

1986LA29 J. Lang, Th. Maier, R. Muller, F. Nessi-Tedaldi, Th. Roser, M. Simonius, J. Sromicki and W. Haeberli, Phys. Rev. C34 (1986) 1545

1986LE1Q Leitner, Muther and Taigel, in Harrogate (1986) C120

1986MA1Z Maguire and Hamilton, Port. Phys. 178 (1986) 1

1986MO1E Z. Moroz, J. Phys. Soc. Jpn. Suppl. 55 (1986) 221

1986NA1K G. Nardulli, J. Phys. Soc. Jpn. Suppl. 55 (1986) 1000

1986NE1A Nemets et al., in Kharkov (1986) 372

1986NO1F Norman et al., in Santa Fe 1985 (1986) 981

1986OU01 S. Ouichaoui, H. Beaumevielle, N. Bendjaballah and A. Genoux-Lubain, Nuovo Cim. A94 (1986) 133

1986PE1G Petrascu et al., Stud. and Cercet. Fiz. 38 (1986) 825

1986PI09 C. Pillai, L.W. Swenson, D.J. Vieira, G.W. Butler, J.M. Wouters, S.H. Rokni, K. Vaziri and L.P. Remsberg, Radiat. Eff. 96 (1986) 41

1986PI1E Pivovarov and Chirokov, in Kharkov (1986) 539

1986PL02 R. Planeta, P. Belery, J. Brzychczyk, P. Cohilis, Y. El Masri, Gh. Gregoire, K. Grotowski, Z. Majka, S. Micek, M. Szczodrak et al., Phys. Rev. C34 (1986) 512

1986PO06 D.N. Poenaru, W. Greiner, K. Depta, M. Ivascu, D. Mazilu and A. Sandulescu, At. Data Nucl. Data Tables 34 (1986) 423

1986PO13 F. Pougheon, D. Guillemaud-Mueller, E. Quiniou, M.G. Saint Laurent, R. Anne, D. Bazin, M. Bernas, D. Guerreau, J.C. Jacmart, S.D. Hoath et al., Europhys. Lett. 2 (1986) 505

1986RO03 R. Rockmore and B. Saghai, Phys. Rev. C33 (1986) 576

1986RO23 D. Rohmann, H. Barth, A.D. Hancock, H. Koch, Th. Kohler, A. Kreissl, H. Poth, U. Raich, A. Wolf, L. Tauscher et al., Z. Phys. A325 (1986) 261

1986SA30 H. Sato and Y. Okuhara, Phys. Rev. C34 (1986) 2171

1986SC28 C.J.S. Scholz, L. Ricken and E. Kuhlmann, Z. Phys. A325 (1986) 203

1986SC29 H.R. Schmidt, S.B. Gazes, Y. Chan, R. Kamermans and R.G. Stokstad, Phys. Lett. B180 (1986) 9

1986SE08 H.M. Sen Gupta, M.A. Zaman, F. Watt and M.J. Hurst, Nuovo Cim. A93 (1986) 217

1986SE1B N. Seichert, W. Assmann, H. Clement, G. Graw, C. Hategan, H. Kader, F. Merz and P. Schiemenz, J. Phys. Soc. Jpn. Suppl. 55 (1986) 646

1986SH1F W.Q. Shen, S.Z. Yin, Z.Y. Guo, W.L. Zhan, Y.T. Zhu, G.M. Jin, W.M. Qiao, E.C. Wu and C.L. Jiang, Chin. Phys. 6 (1986) 80

1986SH2B Shibata and Fujita, Phys. Lett. B172 (1986) 283

1986SO10 L.G. Sobotka, D.G. Sarantites, H. Puchta, F.A. Dilmanian, M. Jaaskelainen, M.L. Halbert, J.H. Barker, J.R. Beene, R.L. Ferguson, D.C. Hensley et al., Phys. Rev. C34 (1986) 917

1986SP01 D.A. Sparrow, Phys. Rev. C33 (1986) 287

1986TAZO T. Tachikawa, N. Kato, H. Fujita, K. Kimura, T. Sugimitsu, K. Anai, Y. Nakajima, K. Morita, M. Tanaka and S. Kubono, in Harrogate (1986) 313; C126

1986VA23 C.P.M. van Engelen, E.A. Bakkum, R.J. Meijer and R. Kamermans, Nucl. Phys. A457 (1986) 375.

1986VEZT W.J. Vermeer and D.M. Pringle, in Harrogate (1986) 184; B158

1986VI09 D.J. Vieira, J.M. Wouters, K. Vaziri, R.H. Kraus, Jr., H. Wollnik, G.W. Butler, F.K. Wohn and A.H. Wapstra, Phys. Rev. Lett. 57 (1986) 3253

1986VO12 G. Vourvopoulos, C.F. Maguire, Z. Kui, LC. Dennis, K.W. Kemper and D.P. Sanderson, Phys. Rev. C34 (1986) 2180

1986WA1R Wang et al., Bull. Amer. Phys. Soc. 31 (1986) 816

1986WE1C G.D. Westfall, Nucl. Phys. A447 (1986) 591c

1986WI1P D. Wilkinson, J. Phys. Soc. Jpn. Suppl. 55 (1986) 347

1986YO1A M.I. Yousef, J. Phys. Soc. Jpn. Suppl. 55 (1986) 766

1987BR1F Brown and Wildenthal, MSUCL-603 (1987)

1987CO01 A.J. Cole, Phys. Rev. C35 (1987) 117

1987CO07 J. Cook, Nucl. Phys. A465 (1987) 207

1987DE05 P. Descouvemont and D. Baye, Nucl. Phys. A463 (1987) 629

1987DE43 H. De Vries, C.W. De Jager and C. De Vries, At. Data Nucl. Data Tables 36 (1987) 495

1987EL03 K. Elsener, W. Gruebler, V. Konig, P.A. Schmelzbach, J. Ulbricht, B. Vuaridel, D. Singy, C. Forstner and W.Z. Zhang, Nucl. Phys. A461 (1987) 579

1987FO03 H.T. Fortune, Phys. Rev. C35 (1987) 1141

1987GI1E Gillibert et al., GANIL P.87-05 (1987)

1987KA09 T. Kajino, H. Toki and K.-I. Kubo, Phys. Rev. C35 (1987) 1370

1987KH1A Khubeis and Ziegler, Nucl. Instrum. Meth. Phys. Res. B24-25 (1987) 691

1987KH1D Khubeis and Ziegler, Nucl. Instrum. Meth. Phys. Res. B24-25 (1987) 682

1987KN01 M. Knopp, K.-H. Speidel, F. Hagelberg, H.-J. Simonis, P.N. Tandon and J. Gerber, Z. Phys. D4 (1987) 329

1987KO15 T. Kozik, J. Buschmann, K. Grotowski, H.J. Gils, N. Heide, J. Kiener, H. Klewe-Nebenius, H. Rebel, S. Zagromski, A.J. Cole et al., Z. Phys. A326 (1987) 421

1987LI04 J.S. Lilley, M.A. Nagarajan, D.W. Banes, B.R. Fulton and I.J. Thompson, Nucl. Phys. A463 (1987) 710

1987MAZV P.V. Magnus, P.D. Parker, M.S. Smith, R.E. Azuma, J.D. King, C. Campbell and J. Vise, Bull. Amer. Phys. Soc. 32 (1987) 1062, EG8

1987MU1J Mueller, GANIL P.87-06; XXV Int. Winter Meeting on Nucl. Phys., Bormio, Italy (1987)

1987PA01 D.J. Parker, J.J. Hogan and J. Asher, Phys. Rev. C35 (1987) 161

1987PO05 H. Poth, H. Barth, G. Buche, A.D. Hancock, H. Koch, Th. Kohler, A. Kreissl, U. Raich, D. Rohmann, A. Wolf et al., Nucl. Phys. A466 (1987) 667

1987RI03 J. Richert and P. Wagner, Nucl. Phys. A466 (1987) 132

1987RO25 C. Rolfs, H.P. Trautvetter and W.S. Rodney, Rept. Prog. Phys. 50 (1987) 233

1987SA15 H. Sagawa and H. Toki, J. Phys. (London) G13 (1987) 453

1987SU06 T. Suzuki, D.F. Measday and J.P. Roalsvig, Phys. Rev. C35 (1987) 2212