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Energy Levels of Light Nuclei
$A = 19$

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Abstract: An evaluation of $A = 18$–20 was published in *Nuclear Physics A*300 (1978), 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 November 1, 1977)

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^{19}B

(Not illustrated)

The mass of ^{19}B excess is predicted to be 59.92 MeV (1974TH01), 60.19 MeV (1976JA23, 1976WA18). Assuming the atomic mass excess to be 60.1 MeV, ^{19}B is stable with respect to breakup into ^{18}B + n by 1.8 MeV and into ^{17}B + 2n by 0.4 MeV [see ^{18}B]. See also (1972TH13, 1974BO05) and (1975BE31, 1976CA1R; theor.).

^{19}C

(Not illustrated)

^{19}C has been observed in the 4.8 GeV proton bombardment of uranium. It is particle stable (1974BO05). The calculated mass excess of ^{19}C is 32.45 MeV using the modified form of the IMME (1975JE02): ^{19}C would then be stable with respect to decay into ^{18}C + n by 1.0 MeV and into ^{17}C + 2n by 5.0 MeV. For other mass predictions see (1974TH01, 1976JA23, 1976WA18, 1977WA08). See also (1972AJ02), (1972CE1A, 1972GA1F, 1972TH13, 1973VO1D) and (1975BE31; theor.).

^{19}N

(Fig. 8)

A study of the ^{18}O(^{18}O, ^{17}F)^{19}N reaction with $E(^{18}\mathrm{O}) = 91$ MeV leads to a mass excess for ^{19}N of 15.81 ± 0.09 MeV: at $\theta = 10°$, $d\sigma/d\Omega_{\mathrm{cm}} = 100$ nb/sr (1977DE14). ^{19}N is then stable with respect to breakup into ^{18}N+n by 5.5 MeV. Another report of the mass excess of ^{19}N gives 15.96 ± 0.15 MeV (1977BA3V; abstract). A previous report by (1974GU19) of the formation of ^{19}N in ^{10}Be(^{11}B, 2p) and of its subsequent β-decay is incorrect: see (1976FI03). For mass calculations see (1974TH01, 1975JE02, 1976JA23, 1976WA18, 1977WA08). See also (1972AJ02), (1972TH13, 1972WA07, 1973TO16, 1977AR06, 1977BH1B) and (1973WI15, 1975BE31; theor.).

^{19}O

(Figs. 5 and 8)

GENERAL: (See also (1972AJ02).)

Shell model: (1970MI1K, 1971DE1W, 1972AL33, 1972LE13, 1973CO03, 1973JU1A, 1973LA1D, 1973MC06, 1974CO39, 1975BA81).

Cluster, collective or deformed models: (1973LA27).

Electromagnetic transitions: (1972AL33, 1973LA27, 1974LA1F).

Special states: (1972AL33, 1972LE13, 1973JU1A, 1973MC06, 1975BA81, 1975MI07).

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

E_x (MeV ± keV)	$J^\pi; T$	τ 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, 10, 12, 14
0.0960 ± 0.5	$\frac{3}{2}^+$	$\tau_m = 2.00 \pm 0.07$ nsec $g = -0.48 \pm 0.06$	γ	3, 4, 10, 14
1.4717 ± 0.4	$\frac{1}{2}^+$	$\tau_m = 1.27 \pm 0.17$ psec	γ	3, 4, 10, 12, 14
2.3715 ± 1.0	$\frac{9}{2}^+$	> 3.5 psec	γ	3, 4, 10
2.7790 ± 0.9	$\frac{7}{2}^+$	93 ± 19 fsec	γ	3, 4, 10
3.067 ± 3	$\frac{3}{2}^+$	≥ 1 psec	γ	3, 4, 10
3.1545 ± 2.5	$\frac{5}{2}^+$	(≥ 1 psec)	γ	3, 4, 10
3.237 ± 5	$\frac{3}{2}^+$			3, 4, 10
3.944 ± 3	$\frac{3}{2}^-$		γ	3, 10
3.9468 ± 2.5	$\frac{7}{2} \rightarrow \frac{13}{2}$			3
4.118 ± 5	$\frac{3}{2}^+$	$\Gamma < 15$ keV		4, 10
4.333 ± 12		< 15		4, 10
4.402 ± 12		< 15		4, 10
4.583 ± 8	$\frac{3}{2}^-$	52 ± 3	n	4, 6, 10
4.707 ± 12	$\frac{5}{2}^+$	< 15		4, 10
4.998 ± 12		< 15		4, 10
5.086 ± 10	$\frac{1}{2}^-$	49 ± 5	n	6
5.146 ± 8	$(\frac{3}{2}, \frac{5}{2}^+)$	3.4 ± 1.0	n	4, 6, 10
5.33	$\frac{3}{2}^+$	330	n	6
5.455 ± 9	$\frac{5}{2}^+$	280	n	6
5.502 ± 12		< 15		4, 10
5.706 ± 8	$\frac{3}{2}^+$	7.8 ± 1.4	n	4, 6, 10
6.13	$\frac{3}{2}^+$	190	n	6
6.20	$\frac{1}{2}^-$	120	n	6
6.276 ± 7	$\frac{7}{2}^-$	19.2 ± 2.4	n	4, 6, 10
6.480 ± 15				6, 10
6.560 ± 15				10
6.899 ± 15				10
6.997 ± 15				10
7.117 ± 15				10

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

E_x (MeV ± keV)	$J^\pi; T$	τ or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
7.248 ± 15				10
11.25 ± 50		240	n, α	8
11.58 ± 50		330	n, α	8

[a] See also Tables 19.2 and 19.5.

Complex reactions involving ^{19}O: (1973BA81, 1973WI15, 1975BA1Q, 1975FO09, 1977AR06).

Reactions involving muons: (1972KH1A, 1973HO1R).

Other topics: (1973CO03, 1973GR11, 1973LA27, 1973SP1A, 1974CO39, 1975BA81, 1977DA10, 1977SH13).

Ground state properties of ^{19}O: (1973LA27, 1973MC06, 1974CO39, 1975BE31, 1976DU04).

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

The weighted mean of several reported half-lives is 26.91 ± 0.08 sec: see (1972AJ02). The decay is complex: see ^{19}F and Table 19.19. See also (1972EY01) and (1973LA03, 1973WI11, 1975NA20, 1975NA21, 1977AZ02; theor.).

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

See (1971BA68). See also (1971NI04) and (1972AJ02).

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

Angular distributions have been measured at $E(^7\text{Li}) = 16$ MeV to the first eight states of ^{19}O (1973WI08) and to a state at $E_x = 3946.8 \pm 2.5$ keV (1974FO26). Using the $(2J_f + 1)$ relationship (1973WI08) suggest $J = \frac{3}{2}$ for ^{19}O*(3.24) and (1974FO26) set $J = \frac{7}{2} \rightarrow \frac{13}{2}$ for ^{19}O*(3.95). The high spin of this latter state suggests that it is not the same state as the one at the same E_x reported in the ^{18}O(d, p) reaction (1974FO26). See also (1974FO1J).

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

Table 19.2: Lifetime measurements of some ^{19}O states [a]

^{19}O* (MeV)	τ_m	Reaction	Refs.
0.096	2.00 ± 0.07 nsec	^{18}O(d, p)	(1965MC10)
1.472	1.27 ± 0.17 psec	^{18}O(d, p)	(1973WA10)
2.37	> 3.5 psec	^{17}O(t, p), ^{18}O(d, p)	(1971HI06)
2.78	70 ± 26 fsec	^{17}O(t, p), ^{18}O(d, p)	(1971BR02)
	117 ± 26 fsec	^{17}O(t, p) ^{18}O(d, p)	(1971HI06)
3.07	≥ 1 psec	^{17}O(t, p), ^{18}O(d, p)	(1971BR02)
3.15	≥ 1 psec [b]	^{17}O(t, p), ^{18}O(d, p)	(1971BR02)

[a] See also Table 19.2 in (1972AJ02).

[b] See, however, (1976SO08).

Proton groups corresponding to ^{19}O states with $E_x < 5.6$ MeV are displayed in Table 19.3 (1966WI05) as are J^π assignments based in part on DWBA analysis (1972CR06, 1975CR03). See also (1974FO1J). Excitation energies from E_γ and τ_m measurements are reported in Tables 19.3 and 19.2, respectively (1971BR02, 1971HI06).

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

At $E_n = 0.0253$ eV ($\nu_n = 2200$ m/sec), the capture cross section is 0.16 ± 0.01 mb (1974SH1E). (1976GAYV) shows unpublished cross section data for $0.2 < E_n < 1.0$ MeV. See also (1971BL05), (1973CL1E; astrophys. considerations) and (1972AJ02).

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

The coherent scattering amplitude (bound) is $a = 6.00 \pm 0.13$ fm (1973MU14). The total cross section measured for $E_n = 0.14$ to 2.47 MeV shows four resonances at $E_n = 0.66$, 1.19, 1.26, 1.84 and 2.45 MeV [see Table 19.4] in addition to a broad maximum at $E_n = 1.6$ MeV and resonance structure near 2.3 MeV (1965VA03). A phase shift analysis by (1964DO08, 1973DO05) is consistent with the (1965VA03) results and suggests that the two broad structures can each be accounted for in terms of two levels whose parameters are displayed in Table 19.4. At higher energies [$E_n = 2.82$ to 4.17 MeV (1959SC30), 2.45 to 8.50 MeV and 10.6 to 19.0 MeV (1965SA1A)] the total cross section shows additional structures. See also (1973MU14, 1976GAYV).

Table 19.3: Levels of ^{19}O from ^{17}O(t, p)^{19}O and ^{18}O(d, p)^{19}O [a]

E_x (MeV ± keV)					$\Gamma_{c.m.}$ [h] (keV)	l_n [b]	L [c]	S [i]	J^π
(1963YA03) [b]	(1966WI05) [b,c]	(1969FI07, 1970FI08) [b,e]	(1971BR02) [d,e]	(1971HI06) [d,e]					
0	0	0				2 [i]	0 [k]	0.57	$\frac{5}{2}^+$ [i]
[f]	0.096 ± 12	0.097 ± 2	0.096 ± 2	[g]		2 [k]	2 [k]		$\frac{3}{2}^+$ [j]
1.468 ± 15	1.467 ± 12	1.470 ± 3	1.470 ± 2	1.4719 ± 0.5 [g]		0 [i]	2 [k]	1.00	$\frac{1}{2}^+$ [i]
	2.373 ± 12	2.369 ± 4	2.367 ± 4	2.3715 ± 1.0		2 [k]	$(2+4)$ [k]		$\frac{9}{2}^+$ [j]
2.612 ± 5									
	2.779 ± 12	2.777 ± 3	2.774 ± 4	2.7790 ± 0.9		(2) [k]	2 [k]		$\frac{7}{2}^+$ [j]
			(2.794 ± 3)				$(2+4)$ [k]		$\frac{3}{2}^+$ [j]
	3.070 ± 12	3.070 ± 5	3.066 ± 3			2 [i]	$(0+2)$ [k]	(0.06)	$\frac{5}{2}^+$ [i]
3.171 ± 15	3.156 ± 12	3.157 ± 3	3.150 ± 3			[k]			$\frac{3}{2}^+$ [j]
	3.229 ± 12	3.237 ± 5				1 [i]		0.11	$\frac{3}{2}^-$ [i]
	3.945 ± 12	3.944 ± 3			< 15	2 [i]	(2) [k]	0.03	$\frac{3}{2}^+$ [i]
4.111 ± 15	4.111 ± 12	4.118 ± 5			< 15				
	4.333 ± 12				< 15				
	4.402 ± 12				75 ± 15	1 [i]		0.15	$\frac{3}{2}^-$ [i]
	4.584 ± 12				< 15	2 [i]	[k]	0.02	$\frac{5}{2}^+$ [i]
	4.707 ± 12				< 15				
	4.998 ± 12				< 15	2 [i]	[k]	0.08	$\frac{5}{2}^+$ [i]
5.153 ± 15	5.148 ± 12				320 ± 25	2 [i]	$(2+4)$ [k]	0.85 [l]	$\frac{3}{2}^+$ [i]
5.447 ± 15	5.460 ± 12				< 15				
	5.502 ± 12				< 15	2 [i]		0.17	$(\frac{3}{2})^+$ [i,j]
(5.708 ± 15)	5.714 ± 12				< 15	3 [i]		0.13	$\frac{7}{2}^-$ [i]
6.282 ± 15	6.280 ± 12								
6.480 ± 15									
6.560 ± 15									
6.899 ± 15									
6.997 ± 15									
7.117 ± 15									
7.248 ± 15									

[a] See also Table 19.3 in (1972AJ02) for the earlier work.

[b] ^{18}O(d, p)^{19}O: proton spectra measurements.

[c] ^{17}O(t, p)^{19}O: proton spectra measurements.

[d] ^{17}O(t, p)^{19}O: γ-ray measurements.

[e] ^{18}O(d, p)^{19}O: γ-ray measurements.

[f] Observed but group was weak.

[g] Other values for these two states are 96.0 ± 0.5 and 1472 ± 1 keV (1971MC11).

[h] (1966WI05, 1973WI05).

[i] $E_{\vec{d}} = 14.8$ 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 neutron approximation (1974SE01).

[j] See (1975CR03).

[k] (1966WI05, 1975CR03).

[l] 0.92 ± 0.14 (1973WI05).

Table 19.4: Resonances in ^{18}O(n, n)^{18}O [a]

E_{res} (MeV ± keV)	$\Gamma_{c.m.}$ (keV)	^{19}O* (MeV)	J^π	Refs.
0.661 ± 10	52 ± 3	4.583	$\frac{3}{2}^-$	(1965VA03, 1964DO08)
1.192 ± 10	49 ± 5	5.086	$\frac{1}{2}^-$	(1965VA03, 1964DO08)
1.256 ± 10	3.4 ± 1.0	5.146	$\frac{3}{2}$	(1965VA03)
1.45	330	5.33	$\frac{3}{2}^+$	(1965VA03, 1973DO05)
1.60	280	5.47	$\frac{5}{2}^+$	(1973DO05)
1.840 ± 10	7.8 ± 1.4	5.699	$\frac{3}{2}$	(1965VA03)
2.30	190	6.13	$\frac{3}{2}^+$	(1965VA03, 1964DO08, 1973DO05)
2.37	120	6.20	$\frac{1}{2}^-$	(1965VA03, 1964DO08, 1973DO05)
2.445 ± 10	19.2 ± 2.4	6.272	$\frac{7}{2}^-$	(1965VA03, 1964DO08)
≈ 2.58		(6.40)		(1965SA1A)
(2.63)		(6.45)		(1965SA1A)

[a] See also (1959SC30, 1965SA1A, 1976GAYV) for evidence of additional structures.

7. ^{18}O(n, p)^{18}N $\quad Q_m = -13.27 \quad E_b = 3.957$

See (1972ED01).

8. ^{18}O(n, d)^{17}N $\quad Q_m = -13.717 \quad E_b = 3.957$

See (1964AM02).

9. ^{18}O(n, α)^{15}C $\quad Q_m = -5.010 \quad E_b = 3.957$

The total cross sections for the α_0 and α_1 groups have been measured for $E_n = 7.5$ to 8.6 MeV: resonance structure is reported at $E_n = 7.70 \pm 0.05$ and 8.05 ± 0.05 MeV with $\Gamma_{lab} = 0.25$ and 0.35 MeV, respectively [^{19}O*(11.25, 11.58)] (1967ST28).

10. ^{18}O(d, p)^{19}O $\quad Q_m = 1.732$

Angular distributions of proton groups have been measured at $E_d = 0.8$ MeV to 15 MeV: see (1972AJ02) for the earlier work and (1972FA19; 3 MeV; p_0, p_1, p_2), (1974SE01; $E_{\vec{d}} = 14.8$ MeV; see Table 19.3). The l_n values and spectroscopic factors derived from these measurements are displayed in Table 19.3. See also (1973ST1B, 1975ST1P).

Branching ratios are shown in Table 19.5 and τ_m measurements in Table 19.2. ^{19}O*(0.096) has $g = -0.48 \pm 0.06$; its configuration appears to be mainly $d^3_{5/2}$ and $B(M1) = (0.040 \pm 0.015)\mu_n^2$ (1976GO09). The ΔE value for the $1.47 \rightarrow 0.096$ transition is 1375.3 ± 0.5 keV. Assuming $E_x = 96.0 \pm 0.5$ keV (Table 19.1), $E_x = 1471.4 \pm 0.7$ keV (1973WA10). Angular correlations are consistent with $J^\pi = \frac{5}{2}^+$ for the ground state and unambiguously fix $J^\pi = \frac{3}{2}^+$ and $\frac{1}{2}^+$, respectively, for ^{19}O*(0.096, 1.47) (1965AL13). They also suggest $J = \frac{9}{2}$ for ^{19}O*(2.37) and $\frac{7}{2}^+$ for ^{19}O*(2.78) (1971HI06). (1976SO08) find $J = \frac{5}{2}$, $\frac{7}{2}$ or $\frac{9}{2}$, $\frac{3}{2}$ or $\frac{7}{2}$; and $\frac{3}{2}$ or $\frac{5}{2}$ for ^{19}O*(2.37, 2.78, 3.15). See also (1974FO1J, 1976DA1K), (1973DO02; theor.) and ^{20}F.

11. (a) ^{18}O(t, d)^{19}O $\qquad Q_m = -2.300$
    (b) ^{18}O(α, ^{3}He)^{19}O $\qquad Q_m = -16.621$

Not reported.

12. (a) ^{18}O(^{13}C, ^{12}C)^{19}O $\qquad Q_m = -0.989$
    (b) ^{18}O(^{14}C, ^{13}C)^{19}O $\qquad Q_m = -4.219$
    (c) ^{18}O(^{17}O, ^{16}O)^{19}O $\qquad Q_m = -0.186$
    (d) ^{18}O(^{18}O, ^{17}O)^{19}O $\qquad Q_m = -4.087$

For reaction (a) see (1971BA68, 1974CH1Q, 1976DU04). For reactions (b) and (d) see (1972EY01). The angular distribution for reaction (c) has been measured at $E_{cm} = 18.52$ MeV (1977KA2E; to ^{19}O*(0, 1.47)): ^{10}O*(1.47) is populated predominantly by a 1n transfer. The rms radius of the neutron excess distributions is 3.30 ± 0.05 fm (1976DU04).

13. ^{19}N(β^-)^{19}O $\qquad Q_m = 12.48$

A report by (1974GU19) regarding delayed neutrons from ^{19}O following the presumed β-decay of ^{19}N is incorrect: see (1976FI03). See also ^{19}N.

14. ^{19}F(n, p)^{19}O $\qquad Q_m = -4.036$

Table 19.5: Radiative decays in ^{19}O

E_i (MeV)	J_i^{π}	E_f (MeV)	Branch (%) [a]	δ	Refs.
0.096	$\frac{3}{2}^+$	0	100		
1.47	$\frac{1}{2}^+$	0	1.5 ± 0.6		(1970FI08)
			1.4 ± 0.2		(1971MC11)
			2.0 ± 0.2		(1971BR02)
		0.096	98.5 ± 0.6		(1970FI08)
			98.6 ± 0.2		(1971MC11)
			98.0 ± 0.2		(1971BR02)
2.37	$\frac{9}{2}^+$	0	100	0.02 ± 0.05	(1970FI08, 1971HI06, 1976SO08)
		0.096	< 11		(1970FI08)
		1.47	< 12		(1970FI08)
2.78	$\frac{7}{2}^+$	0	100	0.8 ± 0.5	(1970FI08, 1971HI06, 1976SO08)
		0.096	< 10		(1970FI08)
		1.47	< 5		(1970FI08)
		2.37	< 7		(1970FI08)
3.07	$\frac{3}{2}^+$	1.47			(1971BR02)
3.16	$\frac{5}{2}^+$	0	8 ± 4		(1970FI08)
		0.096	92 ± 4	$0.03 < \delta < 2.3$	(1970FI08, 1976SO08)
		1.47	< 6		(1970FI08)
		2.37	< 9		(1970FI08)
		2.78	< 10		(1970FI08)
3.94	$\frac{3}{2}^-$	0	24 ± 8		(1970FI08)
			33 ± 8		(1971HI06)
		0.096	48 ± 8		(1970FI08)
			39 ± 8		(1971HI06)
		1.47	28 ± 4		(1970FI08)
			28 ± 4		(1971HI06)
		2.37	< 15		(1970FI08)
		2.78	< 15		(1970FI08)
		3.16	< 15		(1970FI08)

[a] The last value listed is believed to be the most reliable.

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

15. (a) ^{19}F(t, ^{3}He)^{19}O $\quad Q_m = -4.800$

(b) ^{21}Ne(n, ^{3}He)^{19}O $\quad Q_m = -15.924$

(c) ^{22}Ne(n, α)^{19}O $\quad Q_m = -5.711$

These reactions have not been reported.

^{19}F

(Figs. 6 and 8)

GENERAL: (See also (1972AJ02).)

Shell model: (1970FL1A, 1972EN03, 1972GU05, 1972LE13, 1972NE1B, 1973DE13, 1973JU1A, 1973LA1D, 1973MA1K, 1973MC06, 1973MC1E, 1973ME1D, 1973SM1C, 1974CO39, 1975BA81, 1975GA1L, 1975MA1U, 1975SUZR, 1977HA33, 1977SH11).

Cluster, collective and rotational models: (1972NE1B, 1973DE06, 1973MC1E, 1973NE1C, 1973RO19, 1976LE19, 1977BU05, 1977HO1F).

Electromagnetic transitions: (1971DU13, 1972EN03, 1972GU05, 1972NE1B, 1973CO1F, 1973GA1H, 1973HA53, 1973PE09, 1973RO19, 1973SU1C, 1974JO12, 1974MC1F, 1974MU1C, 1975BO12, 1975GA06, 1975GA1L, 1975HE1K, 1975NA21, 1975NA20, 1976BO38, 1977BU05).

Special states: (1972FO29, 1972GA14, 1972HI17, 1972EN03, 1972LE13, 1972NE1B, 1973JU1A, 1973MC06, 1973MU18, 1973RO19, 1974OL1B, 1975BA81, 1975BO12, 1975BO1T, 1975MA1U, 1975MC1H, 1975SUZR, 1976BO1T, 1976BO43, 1977BU05, 1977HA33, 1977SC08, 1977SH11).

Complex reactions involving ^{19}F: (1972PU1B, 1972OH01, 1973WI15, 1975AL1H, 1975AR14, 1975HO1K, 1975RE08, 1975VO09, 1976BA08, 1976BR1T, 1976BU16, 1976EG02, 1976HI05, 1976NA11, 1977AR06, 1977BU05, 1977CO14, 1977NA03, 1977PR05, 1977ST1J, 1977TA07, 1977VA02).

Applied topics: (1975BE1U, 1975GO1U, 1976EA1A, 1976EC1B, 1976GO1P, 1976RA1J, 1977CO1F).

Astrophysical questions: (1972CL1A, 1973AU1B, 1973AU1C, 1973CA1B, 1973TA1D, 1973TR1B, 1975BU1H, 1975GO1T, 1975MA1R, 1975TR1A, 1976BO1M, 1976GI1C, 1976RO1J, 1976SI1D, 1977ST1J).

Muon and neutrino captures and reactions: (1972BU29, 1972KH1A, 1973HO34, 1974DO1C, 1974EN10, 1975CA1H, 1977MU1A).

Pion capture and reactions † *:* (1972EC1A, 1972GO1D, 1972HU1A, 1972MI11, 1972PL04, 1973DA1G, 1973HO43, 1973KA19, 1974HU14, 1974LI1H, 1974ST1G, 1974TA18, 1975KA1G, 1975VA1D, 1975VO1D, 1976AS1B, 1976BA1R, 1976EN02, 1976JA04, 1976LI18, 1976SI1J, 1977BA2H, 1977SI01).

Kaon capture: (1972WI04).

Other topics: (1971RO1C, 1971SY1A, 1972BA25, 1972CA37, 1972GA14, 1973CO1F, 1973DE13, 1973GR11, 1973MA1K, 1973MA48, 1973YO1A, 1974CO39, 1974GA36, 1974RE03, 1975BA81,

† Gamma rays with $E_\gamma = 109.8 \pm 0.1$ and 197.0 ± 0.1 keV (1969PO07), 109.8 ± 0.2 and 197.98 ± 0.19 keV (1970BL07) and 198.10 ± 0.10 keV (1972EC1A) have been reported in pion-induced reactions.

1975BL1F, 1975HE10, 1975MC1H, 1976BL1C, 1976BO1T, 1976BO43, 1976MA04, 1977DA10, 1977SH11, 1977SH13).

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		1, 3, 4, 7, 8, 12, 13, 14, 15, 17, 18, 20, 22, 23, 28, 29, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 57, 58, 59, 60
0.109894 ± 0.005	$\frac{1}{2}^-$	$\frac{1}{2}^-$	$\tau_m = 0.853 \pm 0.010$ nsec	γ	8, 12, 13, 14, 15, 23, 29, 31, 32, 33, 39, 40, 42, 45, 55, 58
0.19724 ± 0.19	$\frac{5}{2}^+$	$\frac{1}{2}^+$	128.8 ± 1.5 nsec $\mu = +3.60$ n.m. $Q = 0.11$ b	γ	8, 12, 13, 14, 15, 23, 29, 32, 39, 40, 41, 42, 44, 45, 55, 58
1.34567 ± 0.13	$\frac{5}{2}^-$	$\frac{1}{2}^-$	4.8 ± 0.5 psec	γ	8, 13, 14, 15, 23, 29, 39, 40, 41, 43, 45
1.4587 ± 0.3	$\frac{3}{2}^-$	$\frac{1}{2}^-$	75 ± 13 fsec	γ	8, 13, 14, 15, 23, 29, 33, 40, 41, 43, 45, 49, 55
1.5540 ± 0.2	$\frac{3}{2}^+$	$\frac{3}{2}^+$	$4.4^{+2.4}_{-2.0}$ fsec	γ	8, 13, 14, 15, 23, 28, 29, 32, 39, 40, 41, 43, 45, 54, 55
2.7798 ± 0.6	$\frac{9}{2}^+$	$\frac{1}{2}^+$	259 ± 30 fsec	γ	6, 8, 11, 13, 14, 15, 23, 29, 39, 40, 41, 45, 54, 55
3.9057 ± 0.8	$\frac{3}{2}^+$		9 ± 5 fsec	γ	8, 14, 15, 23, 28, 33, 41, 45, 54, 55
3.9987 ± 0.7	$\frac{7}{2}^-$	$\frac{1}{2}^-$	< 40 fsec	γ	8, 14, 15, 23, 28, 29, 39, 41, 45, 54, 55
4.0325 ± 1.2	$\frac{9}{2}^-$	$\frac{1}{2}^-$	71 ± 10 fsec	γ	8, 11, 13, 14, 15, 29, 39, 41, 45, 54, 55
4.3767 ± 0.7	$\frac{7}{2}^+$		< 11 fsec	γ	8, 13, 14, 15, 21, 28, 29, 32, 41, 45, 54, 55
4.5499 ± 0.8	$\frac{5}{2}^+$		< 50 fsec	γ	14, 25, 28, 29, 39, 41, 45, 55
4.5561 ± 0.5	$\frac{3}{2}^-$		17^{+10}_{-8} fsec	γ	14, 15, 28, 41, 45, 54, 55
4.647 ± 20	$\frac{13}{2}^+$	$\frac{1}{2}^+$	2.2 ± 0.3 psec	γ	11, 13, 14, 15, 23, 45, 55
4.6825 ± 0.7	$\frac{5}{2}^-$		15.4 ± 3.0 fsec	γ, α	8, 14, 28, 29, 41, 45, 54, 55
5.1053 ± 1.7	$\frac{5}{2}^+$		< 30 fsec	γ, α	8, 14, 15, 28, 29, 41, 45, 54, 55
5.337 ± 2	$\frac{1}{2}^{(+)}$		≤ 15 fsec	γ, α	8, 14, 15, 29, 41, 45, 54
5.425 ± 7	$\frac{7}{2}^-$			γ, α	8, 13, 14, 23, 29, 39, 41, 45, 54
5.465 ± 2	$\frac{7}{2}^+$	$\frac{1}{2}^+$	$\Gamma < 1$ keV	γ, α	8, 13, 14, 15, 21, 41, 45, 54
5.500 ± 3	$\frac{3}{2}^+$		$\Gamma = 4 \pm 1$	γ, α	8, 9, 15, 29, 41, 45
5.54 ± 5	$\frac{5}{2}^+$			γ, α	8, 29, 41, 45, 54
5.623 ± 3	$\frac{3}{2}^-$		$\tau_m < 45$ fsec	γ, α	8, 28, 41, 45, 54, 55

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

E_x (MeV ± keV)	$J^\pi; T$	K^π	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
5.939 ± 3	$\frac{1}{2}^+$			γ, α	8, 29, 41, 55
6.070 ± 1	$\frac{7}{2}^+$		$\Gamma = 1.2$	γ, α	8, 9, 15, 41, 54
6.090 ± 3	$\frac{3}{2}^-$		4	γ, α	8, 9, 13, 15, 29, 41, 54, 55
6.160 ± 1	$\frac{7}{2}^-$			γ, α	8, 29, 41, 55
6.252 ± 6	$\frac{1}{2}^+$		8	α	9, 29, 41, 55
6.282 ± 2	$\frac{5}{2}^+$		2.4	γ, α	8, 9, 13, 41
6.330 ± 2	$\frac{7}{2}^+$		2.4	γ, α	8, 9, 41
6.429 ± 8	$\frac{1}{2}^-$		280	α	9
6.498 ± 1.5	$\frac{3}{2}^+$			γ, α	8, 15, 29, 55
6.500 ± 1.5	$\frac{11}{2}^+$			γ, α	8, 15, 21, 55
6.526 ± 2	$\frac{3}{2}^+$		4	γ, α	8, 9, 13, 15
6.554 ± 2	$\frac{7}{2}$		1.6	γ, α	8, 9
6.592 ± 2	$\frac{9}{2}^+$			γ, α	8, 13, 29
6.785 ± 2	$\frac{3}{2}^-$		2.4	γ, α	8, 9, 29, 54, 55
6.836 ± 2	$\frac{5}{2}^+$		1.2	γ, α	8, 9
6.891 ± 4	$\frac{3}{2}^-$		28	γ, α	8, 9, 15
6.925 ± 2	$\frac{7}{2}^-$		2.4	γ, α	8, 9, 13, 29
7.00 ± 10	$\frac{1}{2}^-$		51	α	9
7.11 ± 10	$\frac{7}{2}^+$		32	α	9, 29
7.1662 ± 0.7	$\frac{11}{2}^-$			γ, α	8, 29
7.265 ± 10			$\lesssim 6$	α	9, 13, 15, 29
7.364 ± 5	$(\frac{1}{2}^+)$			α	9, 29
7.538 ± 2	$\frac{5}{2}^+; T = \frac{3}{2}$			γ, α	8, 9, 13, 29
7.56 ± 10	$\frac{7}{2}^+$		$\lesssim 90$	α	9
7.660 ± 2	$\frac{3}{2}^+; T = \frac{3}{2}$			γ, α	8, 29, 33, 57
7.702 ± 5	$(\frac{3}{2}^-)$				29
7.73	$\frac{1}{2}^-$		$\lesssim 30$	α	9, 13, 15
7.79			$\lesssim 6$	α	9
7.90			$\lesssim 200$	α	9
7.929 ± 3	$\frac{7}{2}^+, \frac{9}{2}$			γ, α	8, 13, 15
7.937 ± 3	$\frac{11}{2}^+$			γ, α	8, 15, 21
8.015 ± 5 [b]	$\frac{5}{2}^+$		$(\lesssim 4)$	γ, α	8, 9, 29
8.086 ± 5					29
8.135 ± 5	$\frac{1}{2}^+$		$\lesssim 5$	α	9, 29
(8.16)			$\lesssim 50$	α	9
8.198 ± 5	$(\frac{5}{2}^+)$		$\lesssim 8$	α	9, 29
8.255 ± 5	$(\frac{5}{2}^+)$				29
8.288 ± 2	$\frac{13}{2}^-$			γ, α	8, 11, 13, 29

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
8.310 ± 5					29
(8.53 ± 20)					15
8.591 ± 1	$\frac{3}{2}$		2.0 ± 0.1	γ, p	13, 23, 25, 29
8.637	$\frac{1}{2}^+$		95	p	25
8.795 ± 1.5	$\frac{1}{2}^+; T = \frac{3}{2}$		45 ± 1	γ, p, α	23, 25, 27, 29
8.928 ± 0.8	$\frac{3}{2}^-$		3.6 ± 0.2	p, α	13, 15, 25, 27
8.957 ± 2	$\frac{11}{2}^+$			γ, α	8, 11, 15
9.099 ± 1	$\frac{7}{2}^+; T = \frac{3}{2}$		$(24 \pm 23) \times 10^{-3}$	γ, p, α	23, 25, 27, 29
9.167 ± 1	$\frac{1}{2}^+$		5.8 ± 0.3	p, (α)	25, 27, 29
9.27	$\frac{11}{2}^+$			γ, α	8
9.321 ± 1	$\frac{1}{2}^+$		4.9 ± 0.2	γ, p, α	9, 13, 23
9.527 ± 6	$(\frac{5}{2})$		29	p, α	15, 25, 27
9.573 ± 6	$\frac{3}{2}$		26	p, α	25, 27, 29
9.668 ± 2	$\frac{3}{2}^+$		3.8 ± 1.0	γ, p, α	23, 25, 27, 29
9.819 ± 0.8	$\frac{5}{2}^-$		0.29 ± 0.05	γ, p, α	15, 23, 25, 27
9.872	$\frac{11}{2}^-$			γ, α	8, 13
9.888 ± 4	$\frac{1}{2}^+$		29	p, α	25, 27
(9.898 ± 2)					13
10.136 ± 0.8	$\frac{3}{2}^-$		4.7 ± 1.0	γ, p	23, 27
10.161 ± 3	$\frac{1}{2}^+$		31	p, α	25, 27
10.231 ± 3	$\frac{1}{2}^+$		4.3	(γ), p, α	23, 25, 27
10.253 ± 3	$\frac{3}{2}^+$		22	(γ), p, α	23, 25, 27, 29
10.307 ± 4	$\frac{3}{2}^+$		9.2	(γ), p, α	15, 25, 27, 29
10.411 ± 3	$\frac{13}{2}^+$		< 1	γ, α	8, 13, 15
10.496 ± 1	$\frac{3}{2}^+$		4.3	(γ), n, p, α	23, 24, 25, 27, 29
10.542			2.5 ± 0.2	(γ), n, p	23, 24, 29
10.555 ± 3	$\frac{3}{2}^{(+)}; (\frac{3}{2})$		8 ± 2	(γ), p, α	23, 25, 27
10.566 ± 1				n, p	24
10.580 ± 4	$(\frac{5}{2}^+)$		22 ± 3	(γ), p, α	23, 25, 27
10.613 ± 1.6	$\frac{5}{2}^+; T = \frac{3}{2}$		4.7 ± 0.5	(γ), n, p, α	23, 24, 25, 27
10.763 ± 3	$\frac{1}{2}^-$		6 ± 3	n, p, α	13, 24, 25, 27
10.859 ± 2	$\frac{5}{2}^+$		24.0 ± 1.5	n, p, α	24, 25, 27
10.974 ± 3	$(\frac{3}{2}, \frac{5}{2})^+$		14 ± 2	n, p, α	24, 25, 27
10.989 ± 2.5			7 ± 2	n, p	24
11.071 ± 2.5	$\frac{1}{2}^+$		35 ± 4	n, p, α	24, 25, 27
11.187 ± 4	$(\frac{1}{2}^-)$		17 ± 4	n, p, α	24, 25, 27
11.217	$\frac{11}{2}^+$			γ, α	8
11.272 ± 3			7 ± 2	n, p	24

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
11.285 ± 8	$\frac{5}{2}^+$		22 ± 5	n, p, α	24, 25, 27
11.35 ± 25	$\frac{1}{2}^+$		270 ± 30	p	25
11.451 ± 4	$\frac{1}{2}^-$		38 ± 7	n, p, (α)	13, 24, 25, 27
11.478 ± 5			7 ± 3	n, p	24, 25
11.502 ± 5			4 ± 2	n, p	24, 25
11.540 ± 8	$\frac{5}{2}^+$		22 ± 5	n, p, α	24, 25, 27
11.568 ± 7	$(T = \frac{3}{2})$		15 ± 10	n, p	24
11.602 ± 12	$\frac{3}{2}^-$		63 ± 7	p	25
11.652 ± 4	$\frac{3}{2}^+; (\frac{3}{2})$		45 ± 10	n, p, (α)	13, 24, 25, 27
11.84 ± 10			< 50	n, p	24
11.93 ± 10			90	n, p	24
12.06 ± 30	$\frac{1}{2}^-$		70 ± 25	(n), p, α	24, 25, 27
12.14 ± 10	$\frac{3}{2}^-, T = \frac{3}{2}$		105 ± 15	γ, n, p, (α)	24, 25, 27, 34
12.221 ± 12	$\frac{3}{2}^+$		74 ± 1	n, p, α	24, 25, 27
12.521 ± 7	$\frac{1}{2}^-$		15 ± 4	p	25
12.576 ± 10	$\frac{5}{2}^+$		47 ± 10	(n), p, α	24, 25, 27
12.58 ± 25	$\frac{1}{2}^-; T = \frac{3}{2}$		285 ± 50	p	25
12.78 ± 10	$\frac{5}{2}^+; T = \frac{3}{2}$		95 ± 40	n, p, (α)	13, 24, 25, 27
12.86 ± 30	$\frac{3}{2}^+; T = \frac{3}{2}$		275 ± 40	p	25
12.94 ± 25	$\frac{5}{2}^+$		70 ± 25	p, α	25, 27
12.98 ± 50	$\frac{1}{2}^-$		125 ± 40	p	25
13.068 ± 4	$\frac{1}{2}^+$		≤ 10	n, p, t	12, 24
13.09 ± 75	$\frac{3}{2}^-$		285 ± 70	p	25
13.17 ± 15			70	n, p	24
13.245 ± 10	$\frac{1}{2}^-$		7	t	12
13.270 ± 10	$\frac{1}{2}^+$		4.5	t	12
13.317 ± 6	$\frac{7}{2}^-; (\frac{3}{2})$		28 ± 6	n, p, α	24, 25, 27
13.36 ± 25	$\frac{3}{2}^-$		40 ± 20	p	25
13.532 ± 10	$\frac{1}{2}^+$		22	t	12
13.731 ± 11	$\frac{7}{2}^-; T = \frac{3}{2}$		52 ± 10	n, p, (α)	24, 25, 27
13.878 ± 15	$\frac{1}{2}^+$		101	γ, n, t	12, 34
14.147 ± 20	$\frac{1}{2}^+$		21	t	12, 13
14.24 ± 15			350	n, p, α	24, 25, 27
14.255 ± 15	$\frac{3}{2}^+$		51	t	12
14.352 ± 10	$\frac{1}{2}^+$		154	t	12
14.46 ± 25	$\frac{3}{2}^+$		179	t	12
14.46 ± 25	$\frac{5}{2}^+$		46	t	12
14.78 ± 20			300	n, p	24

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
15.00 ± 20				n, p	13, 24
15.75 ± 25			150	n, p	24
16.27 ± 25			200	γ, n, p	24, 34
16.80 ± 30				n, p	24
17.9				p, α	25, 27

[a] See also Tables 19.7 and 19.10.

[b] I am particularly indebted for the comments by Prof. C. Rolfs on the states near the proton binding energy.

Ground state of ^{19}*F:* (1971SH26, 1971TA1A, 1972GU05, 1972VA36, 1973EN1B, 1973HO32, 1973MC06, 1973ME1E, 1973SU1B, 1973SU1C, 1974CO39, 1974DE1E, 1974EN10, 1974MC1F, 1974OL1B, 1974RE03, 1975GA06, 1976CH1T, 1977AN12, 1977BU05).

$$\mu_{g.s.} = +2.6288 \text{ nm (1976FU06);}$$

$$= +2.628866\ (8) \text{ nm (V. Shirley, private communication);}$$

$$\mu_{0.198} = +3.60 \text{ nm (1976FU06);}$$

$$Q_{0.198} = \pm 0.11 \text{ b (1976FU06). See also (1974MI21, 1974SHYR, 1976BR20).}$$

The mass of ^{19}F derived from the work of (1975SM02) is $18.99840317\ (6)$ a.m.u. Using the conversion factor $931.5016\ (26)$ MeV/a.m.u., the mass excess of ^{19}F would then be -1.4875 MeV. (1977WA08) adopts -1.48738 ± 0.00013, as we do also.

1. ^{9}Be(^{14}N, α)^{19}F $\qquad Q_m = 13.2739$

See (1972AJ02).

2. (a) ^{12}C(^{7}Li, γ)^{19}F $\qquad Q_m = 16.396$
   (b) ^{12}C(^{7}Li, n)^{18}F $\qquad Q_m = 5.964$ $\qquad E_b = 16.396$
   (c) ^{12}C(^{7}Li, p)^{18}O $\qquad Q_m = 8.402$
   (d) ^{12}C(^{7}Li, d)^{17}O $\qquad Q_m = 2.582$
   (e) ^{12}C(^{7}Li, t)^{16}O $\qquad Q_m = 4.695$
   (f) ^{12}C(^{7}Li, α)^{15}N $\qquad Q_m = 12.382$

For reaction (a) see (1977LO1M). The yield of ^{18}F [reaction (b)] has been determined for $E(^7\text{Li}) = 2.5$ to 3.5 MeV (1961NO05). The yields of α-particles have been measured by (1962HO06;

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

E_i (MeV)	J^π_i	E_f (MeV)	J^π_f	Branching ratio (%)	δ	Refs.
0.110	$\frac{1}{2}^-$	0	$\frac{1}{2}^+$	100		
0.197	$\frac{5}{2}^+$	0	$\frac{1}{2}^+$	100		
		0.110	$\frac{1}{2}^-$	< 0.06		(1970CO22)
1.35	$\frac{5}{2}^-$	0	$\frac{1}{2}^+$	< 3		(1976BH03)
		0.110	$\frac{1}{2}^-$	96.8 ± 1 [A]		(1969PO03)
				96 ± 3		(1976BH03)
					0.0 ± 0.7	(1972RO01)
		0.197	$\frac{5}{2}^+$	3.2 ± 1 [A]		(1969PO03)
				4 ± 1		(1976BH03)
1.46	$\frac{3}{2}^-$	0	$\frac{1}{2}^+$	22.5 ± 2		(1969PO03)
				21 ± 1		(1970LA02)
				20.0 ± 1	$\lvert\delta\rvert < 0.06$	(1971HA30)
				20 ± 2		(1976BH03)
				20.7 ± 0.7		mean
		0.110	$\frac{1}{2}^-$	66.3 ± 3		(1969PO03)
				68 ± 3		(1970LA02)
				69.7 ± 1	$0.30 < \delta < 0.38$	(1971HA30)
				70 ± 4		(1976BH03)
				69.3 ± 0.9		mean
					$\delta = 0.56 \pm 0.13$	(1972RO33)
		0.197	$\frac{5}{2}^+$	10.9 ± 2		(1969PO03)
				11 ± 0.5		(1970LA02)
				10.2 ± 1	$-0.1 < \delta < 0$	(1971HA30)
				10 ± 2		(1976BH03)
				10.8 ± 0.5		mean
1.55	$\frac{3}{2}^+$	0	$\frac{1}{2}^+$	2.4 ± 0.5		(1966OL01)
				2.0 ± 0.7		(1969PO03)
				4 ± 2		(1976BH03)
				2.3 ± 0.4		mean
		0.110	$\frac{1}{2}^-$	4.6 ± 0.5		(1959JO26)
				5.2 ± 0.7		(1966OL01)
				5.3 ± 1		(1969PO03)
				6 ± 2		(1976BH03)
				4.9 ± 0.4		mean
		0.197	$\frac{5}{2}^+$	92.4 ± 0.9		(1966OL01)
				92.7 ± 1		(1969PO03)
				90 ± 4		(1976BH03)
				92.5 ± 0.7		mean
2.78	$\frac{9}{2}^+$	0.197	$\frac{5}{2}^+$	100		[a]
3.91 [b]	$\frac{3}{2}^+$	0	$\frac{1}{2}^+$	48 ± 5		(1976BH03)
		0.110	$\frac{1}{2}^-$	18 ± 4		(1976BH03)
		0.197	$\frac{5}{2}^+$	16 ± 4		(1976BH03)
		1.35	$\frac{5}{2}^-$	< 4		(1976BH03)
		1.46	$\frac{3}{2}^-$	< 4		(1976BH03)
		1.55	$\frac{3}{2}^+$	18 ± 4		(1976BH03)
		2.78	$\frac{9}{2}^+$	< 2		(1965AL20)
4.00	$\frac{7}{2}^-$	0.197	$\frac{5}{2}^+$	18 ± 4		(1976BH03)
		1.35	$\frac{5}{2}^-$	70 ± 4		(1976BH03)
		1.46	$\frac{3}{2}^-$	12 ± 6		(1976BH03)

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

E_i (MeV)	J_i^π	E_f (MeV)	J_f^π	Branching ratio (%)	δ	Refs.
4.03	$\frac{9}{2}^-$	1.35	$\frac{5}{2}^-$	100		(1976BH03)
4.38 [c]	$\frac{7}{2}^+$	0	$\frac{1}{2}^+$	< 5		(1966OL01)
		0.110	$\frac{1}{2}^-$	< 2		(1966OL01)
		0.197	$\frac{5}{2}^+$	85 ± 5		(1966TH02)
				82 ± 7		(1966OL01)
				89 ± 2 [A]	0.155 ± 0.022	(1976RO07)
		$1.35 + 1.46$		< 0.8		(1976RO07)
		1.55	$\frac{3}{2}^+$	< 0.8		(1976RO07)
		2.78	$\frac{9}{2}^+$	15 ± 5		(1966TH02)
				18 ± 7		(1966OL01)
				11 ± 2	-0.16 ± 0.07	(1976RO07)
4.55 [d,e]	$\frac{5}{2}^+$	0	$\frac{1}{2}^+$	< 5		(1976BH03)
		0.110	$\frac{1}{2}^-$	< 5		(1976BH03)
		0.197	$\frac{5}{2}^+$	69 ± 7		(1976BH03)
		1.35	$\frac{5}{2}^-$	5 ± 3		(1976BH03)
		1.46	$\frac{3}{2}^-$	8 ± 3		(1976BH03)
		1.55	$\frac{3}{2}^+$	18 ± 4		(1976BH03)
4.56 [d]	$\frac{3}{2}^-$	0	$\frac{1}{2}^+$	36 ± 4		(1976BH03)
		0.110	$\frac{1}{2}^-$	45 ± 5		(1976BH03)
		0.197	$\frac{5}{2}^+$	9 ± 3		(1976BH03)
		1.35	$\frac{5}{2}^-$	4 ± 3		(1976BH03)
		1.46	$\frac{3}{2}^-$	< 4		(1976BH03)
		1.55	$\frac{3}{2}^+$	6 ± 3		(1976BH03)
4.65	$\frac{13}{2}^+$	2.78	$\frac{9}{2}^+$	100	$\lvert M\rvert^2 = 5.5 \pm 1.8$ W.u.	see (1972AJ02)
4.68	$\frac{5}{2}^-$	0	$\frac{1}{2}^+$	< 0.5		(1972RO01)
		0.110	$\frac{1}{2}^-$	< 1.5		(1972RO01)
		0.197	$\frac{5}{2}^+$	6 ± 1	$0 < \delta < 2.0$	(1972RO01)
				4 ± 2		(1976BH03)
		1.35	$\frac{5}{2}^-$	63 ± 6	$-0.22^{+0.14}_{-0.24}$	(1972RO01)
				64 ± 5		(1976BH03)
		1.46	$\frac{3}{2}^-$	31 ± 3	0.0 ± 0.24 or $2.0^{+1.5}_{-0.6}$	(1972RO01)
				32 ± 3		(1976BH03)
		1.55	$\frac{3}{2}^+$	< 5		(1972RO01)
		2.78	$\frac{9}{2}^+$	< 2		(1972RO01)
5.11	$\frac{5}{2}^+$	0.197	$\frac{5}{2}^+$	80	$\Gamma_\gamma/\Gamma = 0.83 \pm 0.10$	(1970AI01, 1976RO07)
		1.46	$\frac{3}{2}^-$	20		(1970AI01)
5.34	$\frac{1}{2}^{(+)}$	0	$\frac{1}{2}^+$	37 ± 4		(1972RO33)
		0.110	$\frac{1}{2}^-$	42 ± 4		(1972RO33)
		0.197	$\frac{5}{2}^+$	< 1		(1972RO33)
		1.35	$\frac{5}{2}^-$	< 1.5		(1972RO33)
		1.46	$\frac{3}{2}^-$	20 ± 2		(1972RO33)
		1.55	$\frac{3}{2}^+$	< 2		(1972RO33)
5.43	$\frac{7}{2}^-$	1.35	$\frac{5}{2}^-$	70		(1970AI01)
		1.46	$\frac{3}{2}^-$	13		(1970AI01)
		4.00	$\frac{7}{2}^-$	10		(1970AI01)
		4.03	$\frac{9}{2}^-$	6		(1970AI01)
5.47	$\frac{7}{2}^+$	0.197	$\frac{5}{2}^+$	4		(1971DI18)
		1.35	$\frac{5}{2}^-$	32		(1971DI18)

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

E_i (MeV)	J_i^π	E_f (MeV)	J_f^π	Branching ratio (%)	δ	Refs.
		1.55	$\frac{3}{2}^+$	5		(1971DI18)
		2.78	$\frac{9}{2}^+$	59		(1971DI18)
5.50	$\frac{3}{2}^+$	0.110	$\frac{1}{2}^-$	25		(1970AI01)
		0.197	$\frac{5}{2}^+$	49		(1970AI01)
		1.35	$\frac{5}{2}^-$	16		(1970AI01)
		1.55	$\frac{3}{2}^+$	11		(1970AI01)
5.54	$\frac{5}{2}^+$	0	$\frac{1}{2}^+$	7		(1970AI01)
		0.197	$\frac{5}{2}^+$	47		(1970AI01)
		1.46	$\frac{3}{2}^-$	45		(1970AI01)
5.62	$\frac{3}{2}^-$	0	$\frac{1}{2}^+$	< 5		(1972RO33)
		0.110	$\frac{1}{2}^-$	< 2		(1972RO33)
		0.197	$\frac{5}{2}^+$	39 ± 4		(1972RO33)
		1.35	$\frac{5}{2}^-$	61 ± 4		(1972RO33)
		1.46	$\frac{3}{2}^-$	< 25		(1972RO33)
		1.55	$\frac{3}{2}^+$	< 25		(1972RO33)
5.94	$\frac{1}{2}^+$	0	$\frac{1}{2}^+$	7 ± 4		(1972RO33)
		0.110	$\frac{1}{2}^-$	20 ± 6		(1972RO33)
		0.197	$\frac{5}{2}^+$	2 ± 1		(1972RO33)
		1.46	$\frac{3}{2}^-$	63 ± 6	0.25 ± 0.02	(1972RO33)
		1.55	$\frac{3}{2}^+$	< 2		(1972RO33)
		3.91	$\frac{3}{2}^{(+)}$	8 ± 3	0.28 ± 0.09	(1972RO33)
6.07	$\frac{7}{2}^+$	0.197	$\frac{5}{2}^+$	54 ± 5	-0.26 ± 0.02	(1972RO33)
		1.35	$\frac{5}{2}^-$	19 ± 2		(1972RO33)
		1.55	$\frac{3}{2}^+$	$1^{+1}_{-0.5}$	0.035 ± 0.023	(1972RO33)
		2.78	$\frac{9}{2}^+$	23 ± 3	0.06 ± 0.08	(1972RO33)
		4.00	$\frac{7}{2}^-$	< 2		(1972RO33)
		4.03	$\frac{9}{2}^-$	< 1		(1972RO33)
		4.38	$\frac{7}{2}^+$	4 ± 1		(1972RO33)
6.09	$\frac{3}{2}^-$	0	$\frac{1}{2}^+$	25 ± 4	-0.021 ± 0.014	(1972RO33)
		0.110	$\frac{1}{2}^-$	61 ± 5	0.045 ± 0.021	(1972RO33)
		0.197	$\frac{5}{2}^+$	14 ± 3	0.014 ± 0.043	(1972RO33)
		1.35	$\frac{5}{2}^-$	< 0.5		(1972RO33)
		1.46	$\frac{3}{2}^-$	< 1.5		(1972RO33)
		1.55	$\frac{3}{2}^+$	< 1		(1972RO33)
6.16	$\frac{7}{2}^-$	0.197	$\frac{5}{2}^+$	31 ± 3	-0.045 ± 0.025	(1972RO33)
		1.35	$\frac{5}{2}^-$	65 ± 4	0.077 ± 0.007	(1972RO33)
		1.46	$\frac{3}{2}^-$	1.3 ± 0.6		(1972RO33)
		2.78	$\frac{9}{2}^+$	< 1		(1972RO33)
		4.00	$\frac{7}{2}^-$	1.6 ± 0.6		(1972RO33)
		4.03	$\frac{9}{2}^-$	2.3 ± 0.3		(1972RO33)
		4.38	$\frac{7}{2}^+$	< 1		(1972RO33)
		4.68	$\frac{5}{2}^-$	< 2		(1972RO33)
6.28 [f]	$\frac{5}{2}^+$	0	$\frac{1}{2}^+$	14 ± 2	-0.05 ± 0.07	(1977DI08)
		0.197	$\frac{5}{2}^+$	4.2 ± 1.0		(1977DI08)
		1.35	$\frac{5}{2}^-$	36 ± 2	-0.01 ± 0.09	(1977DI08)
		1.46	$\frac{3}{2}^-$	26 ± 2	-0.02 ± 0.04	(1977DI08)
		1.55	$\frac{3}{2}^+$	20 ± 2	0.11 ± 0.06	(1977DI08)
6.33 [f]	$\frac{7}{2}^+$	0.197	$\frac{5}{2}^+$	56 ± 3	-0.27 ± 0.24	(1977DI08)

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

E_i (MeV)	J^π_i	E_f (MeV)	J^π_f	Branching ratio (%)	δ	Refs.
		1.35	$\frac{5}{2}^-$	17 ± 2	-0.02 ± 0.03	(1977DI08)
		1.55	$\frac{3}{2}^+$	8.5 ± 1.5	0.00 ± 0.14	(1977DI08)
		4.38	$\frac{7}{2}^+$	18 ± 2	0.04 ± 0.20	(1977DI08)
6.498 [f]	$\frac{3}{2}^+$	0	$\frac{1}{2}^+$	38 ± 2	-0.06 ± 0.04 or 2.00 ± 0.17	(1977DI08)
		0.110	$\frac{1}{2}^-$	14 ± 2	0.00 ± 0.03	(1977DI08)
		0.197	$\frac{5}{2}^+$	9 ± 2	$0.3 \to 1.8$	(1977DI08)
		1.35	$\frac{5}{2}^-$	14 ± 2	-0.11 ± 0.09	(1977DI08)
		1.46	$\frac{3}{2}^-$	25 ± 2	0.00 ± 0.07	(1977DI08)
6.500	$\frac{11}{2}^+$	2.78	$\frac{9}{2}^+$	55		(1969AI01, 1970AI01, 1977DI08)
		4.00	$\frac{7}{2}^-$	< 3		(1969AI01)
		4.03	$\frac{9}{2}^-$	< 3		(1969AI01)
		4.38	$\frac{7}{2}^+$	< 3		(1969AI01)
		4.65	$\frac{13}{2}^+$	45		(1969AI01, 1970AI01, 1977DI08)
		5.47	$\frac{7}{2}^+$	< 2		(1969AI01)
6.53	$\frac{3}{2}^+$	0	$\frac{1}{2}^+$	29 ± 2	0.32 ± 0.04 or 0.90 ± 0.06	(1977DI08)
		0.110	$\frac{1}{2}^-$	59 ± 3	0.00 ± 0.02	(1977DI08)
		4.55	$\frac{5}{2}^+$	12 ± 2	-0.23 ± 0.13	(1977DI08)
6.55	$\frac{7}{2}$	0.197	$\frac{5}{2}^+$	19 ± 2	0.03 ± 0.05	(1977DI08)
		1.35	$\frac{5}{2}^-$	55 ± 4	0.01 ± 0.03	(1977DI08)
		2.78	$\frac{9}{2}^+$	26 ± 3	0.05 ± 0.07	(1977DI08)
6.59	$\frac{9}{2}^+$	0.197	$\frac{5}{2}^+$	13 ± 2	-0.13 ± 0.13	(1971DI18, 1977DI08)
		2.78	$\frac{9}{2}^+$	63 ± 3	-0.20 ± 0.20	(1971DI18, 1977DI08)
		4.00	$\frac{7}{2}^-$	< 4		(1971DI18)
		4.03	$\frac{9}{2}^-$	< 2		(1971DI18)
		4.38	$\frac{7}{2}^+$	24 ± 2	0.02 ± 0.07	(1971DI18, 1977DI08)
		4.55	$\frac{5}{2}^+$	< 2		(1971DI18)
		4.65	$\frac{13}{2}^+$	< 2		(1971DI18)
		5.43	$\frac{7}{2}^-$	< 3		(1971DI18)
		5.47	$\frac{7}{2}^+$	< 8		(1971DI18)
6.79	$\frac{3}{2}^-$	0	$\frac{1}{2}^+$	15 ± 2	-0.08 ± 0.03	(1977DI08)
		0.110	$\frac{1}{2}^-$	39 ± 2	0.11 ± 0.02	(1977DI08)
		0.197	$\frac{5}{2}^+$	13 ± 2	0.05 ± 0.06	(1977DI08)
		1.35	$\frac{5}{2}^-$	5.3 ± 0.8		(1977DI08)
		1.46	$\frac{3}{2}^-$	25 ± 2	-0.13 ± 0.08	(1977DI08)
		3.91	$\frac{3}{2}^+$	2.6 ± 1.0		(1977DI08)
6.84	$\frac{5}{2}$	0	$\frac{1}{2}^+$	9 ± 5		(1977DI08)
		0.110	$\frac{1}{2}^-$	9 ± 5		(1977DI08)
		0.197	$\frac{5}{2}^+$	27 ± 6	-0.5 ± 0.5	(1977DI08)
		1.35	$\frac{5}{2}^-$	10 ± 7		(1977DI08)
		1.46	$\frac{3}{2}^-$	45 ± 8	-0.02 ± 0.11	(1977DI08)
6.89	$\frac{3}{2}^-$	0	$\frac{1}{2}^+$	9 ± 2		(1977DI08)
		0.110	$\frac{1}{2}^-$	< 8		(1977DI08)
		0.197	$\frac{5}{2}^+$	< 5		(1977DI08)
		1.35	$\frac{5}{2}^-$	61 ± 5	$0.22 \to 2.2$	(1977DI08)
		1.46	$\frac{3}{2}^-$	30 ± 5	0.15 ± 0.12	(1977DI08)
6.93	$\frac{7}{2}^-$	0.197	$\frac{5}{2}^+$	73 ± 3	-0.01 ± 0.03	(1977DI08)
		1.35	$\frac{5}{2}^-$	22 ± 2	0.01 ± 0.02	(1977DI08)
		2.78	$\frac{9}{2}^+$	2.4 ± 0.5	0.00 ± 0.16	(1977DI08)

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

E_i (MeV)	J_i^π	E_f (MeV)	J_f^π	Branching ratio (%)	δ	Refs.
		4.00	$\frac{7}{2}^-$	1.3 ± 0.5		(1977DI08)
		4.03	$\frac{9}{2}^-$	1.3 ± 0.5		(1977DI08)
7.17	$\frac{11}{2}^-$	1.35	$\frac{5}{2}^-$	< 0.75		(1973RO09)
		4.00	$\frac{7}{2}^-$	6 ± 2		(1973RO09, 1977DI08)
				5 ± 1 [A]		(1977FI06)
		4.03	$\frac{9}{2}^-$	94 ± 2		(1973RO09, 1977DI08)
				91 ± 1 [A]	$\Gamma_\gamma = 0.15 \pm 0.2$ eV [l]	(1977FI06)
		4.65	$\frac{13}{2}^+$	3.6 ± 0.9 [A]		(1977FI06)
7.54	$\frac{5}{2}^+; T = \frac{3}{2}$	0	$\frac{1}{2}^+$	< 0.3		(1976RO07)
		0.110	$\frac{1}{2}^-$	< 0.2		(1976RO07)
		0.197	$\frac{5}{2}^+$	29 ± 3	0.09 ± 0.04	(1976RO07)
		1.35	$\frac{5}{2}^-$	1.2 ± 0.4		(1976RO07)
		1.46	$\frac{3}{2}^-$	(< 0.4)		(1976RO07)
		1.55	$\frac{3}{2}^+$	41 ± 3	0.017 ± 0.015	(1976RO07)
		2.78	$\frac{9}{2}^+$	(< 2)		(1976RO07)
		3.91	$\frac{3}{2}^+$	< 0.2		(1976RO07)
		4.00	$\frac{7}{2}^-$	< 0.2		(1976RO07)
		4.38	$\frac{7}{2}^+$	27 ± 3	0.042 ± 0.030	(1976RO07)
		4.55	$\frac{5}{2}^+$	< 0.3		(1976RO07)
		4.56	$\frac{3}{2}^-$	< 1.2		(1976RO07)
		4.68	$\frac{5}{2}^-$	< 1.2		(1976RO07)
		5.11	$\frac{5}{2}^-$	1.7 ± 0.4		(1976RO07)
		5.47	$\frac{7}{2}^+$	< 0.4		(1976RO07)
		6.07	$\frac{7}{2}^+$	< 0.9		(1976RO07)
7.66 [g]	$\frac{3}{2}^+; T = \frac{3}{2}$	0	$\frac{1}{2}^+$	38 ± 4	0.06 ± 0.02 or 3.7 ± 1.0	(1976RO07)
		0.110	$\frac{1}{2}^-$	< 0.4		(1976RO07)
		0.197	$\frac{5}{2}^+$	13 ± 2	0.06 ± 0.07 or 3.5 ± 1.1	(1976RO07)
		1.35	$\frac{5}{2}^-$	< 1.3		(1976RO07)
		1.46	$\frac{3}{2}^-$	< 1		(1976RO07)
		1.55	$\frac{3}{2}^+$	36 ± 2	0.06 ± 0.04 or -4.7 ± 1.0	(1976RO07)
		3.91	$\frac{3}{2}^+$	(3^{+3}_{-2})		(1976RO07)
		4.38	$\frac{7}{2}^+$	< 1.3		(1976RO07)
		4.55	$\frac{5}{2}^+$	5.1 ± 0.3	-0.11 ± 0.13	(1976RO07)
		5.11	$\frac{5}{2}^-$	5.9 ± 0.5	-0.04 ± 0.16	(1976RO07)
7.93	$\frac{7}{2}^+, \frac{9}{2}$	0.197	$\frac{5}{2}^+$	4		(1971DI18)
		2.78	$\frac{9}{2}^+$	96		(1971DI18)
7.94	$\frac{11}{2}^+$	2.78	$\frac{9}{2}^+$	11		(1970RO1C)
				10		(1971DI18)
		4.00	$\frac{7}{2}^-$	< 7		(1971DI18)
		4.03	$\frac{9}{2}^-$	< 7		(1971DI18)
		4.38	$\frac{7}{2}^+$	< 7		(1971DI18)
		4.65	$\frac{13}{2}^+$	89		(1970RO1C)
				90		(1971DI18)
		5.43	$\frac{7}{2}^-$	< 9		(1971DI18)
		5.47	$\frac{7}{2}^+$	< 10		(1971DI18)
		6.50	$\frac{11}{2}^+$	< 7		(1971DI18)
		6.59	$\frac{9}{2}^+$	< 7		(1971DI18)
8.29	$\frac{13}{2}^-$	1.35	$\frac{5}{2}^-$	< 2		(1974UN01)

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

E_i (MeV)	J^{π}_i	E_f (MeV)	J^{π}_f	Branching ratio (%)	δ	Refs.
		4.00	$\frac{7}{2}^-$	< 5		(1974UN01)
		4.03	$\frac{9}{2}^-$	100	$\Gamma_\gamma = 76 \pm 11$ meV	(1974UN01)
				91 ± 1 [A]	$\Gamma_\gamma = 70 \pm 10$ meV	(1977FI06)
		4.65	$\frac{13}{2}^+$	< 7		(1974UN01)
				9 ± 1 [A]		(1977FI06)
8.59	$\frac{3}{2}$	0	$\frac{1}{2}^+$	51 ± 4		(1962NE03)
		0.110	$\frac{1}{2}^-$	9 ± 3		(1962NE03)
		0.197	$\frac{5}{2}^+$	40 ± 3		(1962NE03)
8.80	$\frac{1}{2}^+; T = \frac{3}{2}$	0	$\frac{1}{2}^+$	< 10		(1965AL20)
		0.110	$\frac{1}{2}^-$	42 ± 4		(1965AL20)
		0.197	$\frac{5}{2}^+$	< 5		(1965AL20)
		1.35	$\frac{5}{2}^-$	< 5		(1965AL20)
		1.46	$\frac{3}{2}^-$	21 ± 5		(1965AL20)
		1.55	$\frac{3}{2}^+$	19 ± 5		(1965AL20)
		2.78	$\frac{9}{2}^+$	< 1		(1965AL20)
		3.91	$\frac{3}{2}^+$	18 ± 2		(1965AL20)
8.96 [h]	$\frac{11}{2}^+$	2.78	$\frac{9}{2}^+$	51 ± 3	Γ_γ(total) $= 230 \pm 30$ meV	(1977FI06)
		4.00	$\frac{7}{2}^-$	26 ± 3		(1977FI06)
		4.03	$\frac{9}{2}^-$	8 ± 1		(1977FI06)
		4.65	$\frac{13}{2}^+$	13 ± 2		(1977FI06)
		5.43	$\frac{7}{2}^-$	3 ± 1		(1977FI06)
9.10	$\frac{7}{2}^+; T = \frac{3}{2}$	0.110	$\frac{1}{2}^-$	(< 0.5)		(1965AL20)
		0.197	$\frac{5}{2}^+$	11 ± 2		(1965AL20)
		1.35	$\frac{5}{2}^-$	4 ± 1		(1965AL20)
		2.78	$\frac{9}{2}^+$	64 ± 4 [k]		(1965AL20)
		4.00	$\frac{7}{2}^-$	8 ± 2		(1965AL20)
		5.43	$\frac{7}{2}^-$	(8 ± 2)		(1965AL20)
		6.07	$\frac{7}{2}^+$	(5 ± 2)		(1965AL20)
9.32	$\frac{1}{2}^+$	0	$\frac{1}{2}^+$	86 ± 4		(1962NE03)
		0.110	$\frac{1}{2}^-$	4 ± 2		(1962NE03)
		0.197	$\frac{5}{2}^+$	10 ± 2		(1962NE03)
9.87	$\frac{11}{2}^-$	2.78	$\frac{9}{2}^+$	68 ± 2	$\Gamma_\gamma = 0.58 \pm 0.08$ eV	(1977FI06)
		4.00	$\frac{7}{2}^-$	6 ± 1		(1977FI06)
		4.03	$\frac{9}{2}^-$	24 ± 2		(1977FI06)
		4.65	$\frac{13}{2}^+$	2.5 ± 0.6		(1977FI06)
10.136 [i]	$\frac{3}{2}^-$	0	$\frac{1}{2}^+$	84 ± 3		(1962NE03)
		0.110	$\frac{1}{2}^-$	4 ± 2		(1962NE03)
		0.197	$\frac{5}{2}^+$	12 ± 2		(1962NE03)
10.41	$\frac{13}{2}^+$		[j]			(1976SY01, 1977SY1A)
11.217	$\frac{11}{2}^+$	2.78	$\frac{9}{2}^+$	2.4		(1977SY1A)
		4.65	$\frac{13}{2}^+$	(98)	$\Gamma_\gamma = 1.1 \pm 0.1$ eV	(1977SY1A)

A = adopted.

[a] See also Table 19.9 in (1972AJ02) and Tables 19.8, 19.10, 19.15 and 19.20 here.

[b] See also (1965AL20).

[c] $\Gamma_\gamma/\Gamma = 0.91 \pm 0.05$ (1976RO07).

[d] See also (1972LE20).

[e] $\Gamma_\gamma/\Gamma = 0.76 \pm 0.15$ (1976RO07).

[f] See also (1970AI01).

[g] $\Gamma_\gamma = 4.7$ eV, $\Gamma_\gamma/\Gamma = 0.65 \pm 0.10$; see Table 19.9 in (1972AJ02).

[h] See also (1974UN01).

[i] See also (1971WO12, 1972WO15).

[j] Strong decay to ^{19}F*(4.65, 6.50) [$J^\pi = \frac{13}{2}^+, \frac{11}{2}^+$, respectively]. Weak decay to ^{19}F*(2.78) [$\frac{9}{2}^+$]; from (α, γ) measurement $\delta = 0.08 \pm 0.08$ if $J = \frac{13}{2}$, 0.47 ± 0.06 if $J = \frac{11}{2}$. If ^{19}F*(10.41), $J = \frac{11}{2}$, $|M|^2$(M1) $= 0.010 \pm 0.003$, 0.46 ± 0.10 and 0.18 ± 0.03 W.u. for the transitions to ^{19}F*(2.78, 4.65, 6.50) and $|M|^2$(E2) $= 25 \pm 7$ W.u. for transition to ^{19}F*(4.65) (1976SY01).

[k] $\Gamma_\gamma = 0.84 \pm 0.19$ eV. Total $\Gamma_\gamma(9.10) = 1.31 \pm 0.31$ eV.

[l] See also Table 19.8.

3.2 to 4.0 MeV; α_0, α_{1+2}, α_3), by (1970CA14; 4.4 to 14 MeV; α_0), by (1972CR1B, 1974FO1J (prelim. results); 12 to 25 MeV; α_0), by (1973TS02; 28 to 35 MeV; α to ^{15}N*(5.27, 5.30, 6.32, 8.57, 9.16, 9.83, 10.70, 12.56)). (1970CA14) report that the cross section for reactions (c), (d), (e), (f) vary strongly over the range $E(^7\text{Li}) = 4$ to 14 MeV but with little, if any, cross correlation. Strong fluctuations continue to $E(^7\text{Li}) = 25$ MeV (1974FO1J) and there is some evidence of structures at higher energies (1973TS02). For total reaction cross sections at several energies in the range $E(^7\text{Li}) = 4.5$ to 13.0 MeV see (1972PO07). See also ^{18}O here, ^{16}O and ^{17}O in (1977AJ02) and ^{15}N in (1976AJ04).

3. ^{12}C(^{9}Be, d)^{19}F $\qquad Q_m = -0.3005$

See (1975VE10).

4. ^{12}C(^{11}B, α)^{19}F $\qquad Q_m = 7.7303$

See (1976DA07, 1977HI01) and (1978EN06). See also (1973FO1A).

5. ^{13}C(^{6}Li, α)^{15}N $\qquad Q_m = 16.2748 \qquad E_b = 18.6997$

Excitation functions for α_0 have been measured for $E(^6\text{Li}) = 7.7$ to 16.8 MeV: structures are observed but they are not correlated (1974CO13).

Table 19.8: Resonances in ^{15}N(α, γ)^{19}F [a]

E_α (MeV $\pm$ keV)	$\Gamma_{\rm c.m.}$ (keV)	$\omega\Gamma_\gamma$ (eV)	J^π	$E_{\rm x}$ (MeV $\pm$ keV)	Refs.
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	(1972RO01)
1.385 ± 3		$(13 \pm 8) \times 10^{-3}$ [c]	$\frac{5}{2}^{(+)}$	5.105 ± 2	(1970AI01, 1976RO07)
1.678 ± 3		1.64 ± 0.16	$\frac{1}{2}^{(+)}$	5.337 ± 2	A, (1972RO33)
1.790		0.42 ± 0.09 [c]	$\frac{7}{2}^-$	5.427	(1970AI01)
1.839 ± 2	< 1	2.5 ± 0.4 [c]	$\frac{7}{2}^+$	5.465	A
1.883 ± 3	4 ± 1	4.2 ± 1.1 [c]	$\frac{3}{2}^+$	5.500	A
1.930		0.48 ± 0.11 [c]	$\frac{5}{2}^+$	5.54	(1970AI01)
2.035 ± 4		0.37 ± 0.09	$\frac{3}{2}^-$	5.620	(1972RO33)
2.441 ± 4		0.53 ± 0.13	$\frac{1}{2}^+$	5.938 ± 3	(1972RO33)
2.608 ± 2		2.70 ± 0.54	$\frac{7}{2}^+$	6.070 ± 1	(1972RO33)
2.631 ± 4		4.50 ± 0.90	$\frac{3}{2}^-$	6.088 ± 3	(1972RO33)
2.722 ± 2		2.40 ± 0.60	$\frac{7}{2}^-$	6.160 ± 1	(1972RO33)
2.873 ± 3		1.0 ± 0.2	$\frac{5}{2}^+$	6.282 ± 2	(1970AI01, 1977DI08)
2.935 ± 3		0.76 ± 0.15	$\frac{7}{2}^+$	6.330 ± 2	(1970AI01, 1977DI08)
3.1468 ± 1.5		1.7 ± 0.3	$\frac{3}{2}^+$	6.4976 ± 1.5	(1970AI01, 1977DI08)
3.1498 ± 1.5		2.3 ± 0.4	$\frac{11}{2}^+$	6.5000 ± 1.5	(1977DI08)
3.183 ± 2		2.4 ± 0.4	$\frac{3}{2}^+$	6.526 ± 2	(1977DI08)
3.218 ± 2		0.63 ± 0.13	$\frac{7}{2}$	6.554 ± 2	(1977DI08)
3.267 ± 2		1.6 ± 0.3	$\frac{9}{2}^+$	6.592 ± 2	(1977DI08)
3.511 ± 3		10.9 ± 1.5	$\frac{3}{2}^-$	6.785 ± 2	(1977DI08)
3.576 ± 3		1.0 ± 0.2	$\frac{5}{2}$	6.836 ± 2	(1977DI08)
3.645 ± 5		6.1 ± 1.3	$\frac{3}{2}^-$	6.891 ± 4	(1977DI08)
3.688 ± 3		9.7 ± 1.4	$\frac{7}{2}$	6.925 ± 2	(1977DI08)
3.993 ± 2		1.00 ± 0.12	$\frac{11}{2}^-$	7.1662 ± 0.7	(1973RO09, 1974UN01, 1977DI08, 1977FI06)
4.465		17.0 ± 2.7	$\frac{5}{2}^+; T = \frac{3}{2}$	7.538 ± 2	A, (1976RO07)
4.618		3.7 ± 0.9	$\frac{3}{2}^+; T = \frac{3}{2}$	7.659 ± 2	A, (1976RO07)
4.96 ± 3		2.3 ± 0.4	$\frac{7}{2}^+, \frac{9}{2}$	7.929	A
4.97 ± 3		3.1 ± 0.5	$\frac{11}{2}^+$	7.937	A
5.413 ± 5		0.53 ± 0.08	$\frac{13}{2}^-$	8.288 ± 2	(1974UN01, 1977FI06)
6.258 ± 5		0.91 ± 0.17	$\frac{11}{2}^+$	8.957 ± 2	(1974UN01, 1977FI06)
			$\frac{11}{2}^+$	9.27	(1977SY1A)
			$\frac{11}{2}^-$	9.88	(1977FI06)
7.75	< 3	[d]		(10.127 ± 2)	(1972WO15)
8.105	< 1	15.0 ± 3.0	$\frac{13}{2}^+$	10.411 ± 3	(1976SY01)
			$\frac{11}{2}^+$	11.217	(1977SY1A)

A: see references listed inn Table 19.7 of (1972AJ02).

[a] See also Table 19.7 here.

[b] $\Gamma_\alpha = 2.1 \pm 0.7$ meV, $\Gamma_\gamma = 40.7 \pm 8.1$ meV (1972RO01).

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

[d] See (1972WO15); see also for the possibility of a neighboring resonance.

6. ^{14}N(^{6}Li, p)^{19}F $\qquad Q_m = 11.1491$

Angular distributions have been reported at $E(^6\text{Li}) = 5.3$ to 6.0 MeV for the proton group to ^{19}F*(2.78) (1968RI13).

7. (a) ^{14}N(^{7}Li, d)^{19}F $\qquad Q_m = 6.123$

(b) ^{14}N(^{10}B, αp)^{19}F $\qquad Q_m = 6.6886$

See (1968MI09) for reaction (a) and (1977HI01) for reaction (b).

8. ^{15}N(α, γ)^{19}F $\qquad Q_m = 4.0138$

Resonances in the yield of γ-rays are observed below $E_\alpha = 8.2$ MeV: the parameters for these are displayed in Table 19.8 (1970AI01, 1972RO01, 1972RO33, 1972WO15, 1973RO09, 1974UN01, 1976RO07, 1976SY01, 1977DI08, 1977FI06, 1977SY1A). Branching ratios are shown in Table 19.7 and lifetime measurements in Table 19.10. The J^π values shown in Table 19.8 are based on correlation and angular distribution measurements and on branching ratio determinations. The E_x of states involved in cascade decays are 4377 ± 1 and 4548 ± 2 keV (1976RO07), 3999.6 ± 1.2 and 4031.9 ± 0.4 keV (1973RO09). The $K^\pi = \frac{1}{2}^-$ band involves ^{19}F*(0.110 [$\frac{1}{2}^-$], 1.46 [$\frac{3}{2}^-$], 1.35 [$\frac{5}{2}^-$], 4.00 [$\frac{7}{2}^-$], 4.03 [$\frac{9}{2}^-$], 7.16 [$\frac{11}{2}^-$]) (1973RO09) and possibly ^{19}F*(8.29) [($\frac{13}{2}^-$)] (1974UN01) [J^π in brackets]. The situation concerning the other bands is not as clear: see (1972AJ02) for a discussion of the evidence for other assignments of J^π and K^π. It is suggested that ^{19}F*(10.41) is likely to be the second $\frac{13}{2}^+$ (2s, 1d)^3 state in ^{19}F (1976SY01). See also (1971RO1C) and (1975SC1Y; astrophys. considerations).

9. (a) ^{15}N(α, α)^{15}N $\qquad E_b = 4.0138$

(b) ^{15}N(α, ^{8}Be)^{11}B $\qquad Q_m = -11.0832$

The elastic scattering has been studied for $E_\alpha = 1.75$ to 5.50 MeV (1959SM02, 1961SM02, 1972MO42) and for 5.2 to 12.0 MeV (1973WE1P; abstract): see Table 19.9 for the observed resonances. For reaction (b) see (1974JE1A).

Table 19.9: Levels of ^{19}F from ^{15}N(α, α_0)^{15}N [a]

E_α (MeV $\pm$ keV)	$\Gamma_{\rm lab}$ (keV)	J^π	$E_{\rm x}$ (MeV)
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 [b]	360	$\frac{1}{2}^-$	6.429 ± 0.008
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 [b]	64	$\frac{1}{2}^-$	6.989 ± 0.008
3.930 ± 10 [b]	40	$\frac{7}{2}^+$	7.116 ± 0.008
4.127 [c]	$\lesssim 8$		7.271
4.23	$\lesssim 82$	$\frac{7}{2}^+$	7.35
4.49	$\lesssim 110$	$\frac{7}{2}^+$	7.56
4.53	$\lesssim 50$	$\frac{5}{2}^+$	7.59
4.710	$\lesssim 40$	$\frac{1}{2}^-$	7.731
4.780	$\lesssim 8$		7.787
4.93	$\lesssim 260$		7.90
(5.005)	($\lesssim 8$)		(7.964)
(5.018)	($\lesssim 5$)		(7.974)
5.116	$\lesssim 8$		8.052
5.203	$\lesssim 8$		8.120
5.232	$\lesssim 6$		8.143
5.25	$\lesssim 65$		8.16
5.284	$\lesssim 10$		8.184
5.481	$\lesssim 10$		9.340

[a] (1959SM02, 1961SM02, 1972MO42).

[b] See also (1977DI08).

[c] I am indebted to Prof. C. Rolfs for his comments on the resonances above 4 MeV.

Table 19.10: Lifetimes of some ^{19}F states [a]

^{19}F* (MeV)	τ_m	Refs.
0.110	0.853 ± 0.010 nsec	mean: see (1972AJ02)
0.197	129.9 ± 2.3 nsec	(1967BE14)
	128 ± 2 nsec	(1968KL05)
	128.8 ± 1.5 nsec	mean
1.35	5.2 ± 0.9 psec	(1968PA11)
	4.7 ± 0.6 psec	(1969JO10)
	$5.3^{+1.5}_{-0.9}$ psec	(1969PO03)
	3.5 ± 1.3 psec	(1976BH03)
	4.8 ± 0.5 psec	mean
1.46	62 ± 20 fsec	(1964BO22)
	57 ± 24 fsec	(1969PO03)
	100 ± 20 fsec	(1976BH03)
	75 ± 13 fsec	mean
1.55 [b,c]	$4.4^{+2.4}_{-2.0}$ fsec	see (1969PO03)
2.78 [a]	246 ± 44 fsec	(1968TO11)
	270 ± 40 fsec	(1976BH03)
	259 ± 30 fsec	mean
3.91 [c]	9 ± 5 fsec	(1977DI18)
4.00 [c]	< 40 fsec	(1976BH03)
4.03	87 ± 16 fsec	(1973RO09)
	60 ± 25 fsec	(1974UN01)
	60 ± 15 fsec	(1976BH03)
	71 ± 10 fsec	mean
4.38 [d]	< 11 fsec	(1975LE16)
4.55 [b,c,d]	< 50 fsec	(1976RO07)
4.56 [b,c,d]	17^{+10}_{-8} fsec	(1975LE16)
4.65	2.3 ± 0.5 psec	(1969BH01)
	2.1 ± 0.4 psec	(1969JA09)
	2.2 ± 0.3 psec	mean
4.68 [c]	15.4 ± 3.0 fsec [A]	(1972RO01)
5.11 [d]	< 30 fsec	(1976RO07)

Table 19.10: Lifetimes of some ^{19}F states [a] (continued)

^{19}F* (MeV)	τ_m	Refs.
5.34	≤ 15 fsec	(1969PO03)
5.47	≤ 19 fsec	(1969PO03)
5.50	≤ 43 fsec	(1969PO03)
5.62	< 45 fsec	(1975LE16)

A = adopted.

[a] See also Table 19.10 in (1972AJ02).

[b] See also (1972LE20).

[c] See also (1976BH03).

[d] See also (1976RO07).

10. ^{15}N(^{7}Li, t)^{19}F $\quad Q_m = 1.547$

This reaction has been studied at $E(^7\text{Li}) = 15$ and 20 MeV (1970MI1E; prelim. results) and analyzed by (1972KU13, 1974KU07). See also (1971BA2V).

11. ^{15}N(^{13}C, ^{9}Be)^{19}F $\quad Q_m = -6.6341$

At $E(^{13}\text{C}) = 105$ MeV, ^{19}F*(4.04, 8.27, 8.97, 12.26, 12.67) are strongly populated. ^{19}F*(2.80, 4.64) are also observed. It is suggested that ^{19}F*(8.97, 12.26, 12.67) have $J^\pi = \frac{11}{2}^-$, $\frac{17}{2}^-$ and $\frac{15}{2}^-$, respectively, with ^{19}F*(12.26) belonging to the lowest $K^\pi = \frac{1}{2}^-$ band (1976PI16). See, however, Table 19.6.

12. (a) ^{16}O(t, γ)^{19}F $\quad Q_m = 11.7003 \quad E_b = 11.7003$

(b) ^{16}O(t, n)^{18}F $\quad Q_m = 1.2690$

(c) ^{16}O(t, p)^{18}O $\quad Q_m = 3.7069$

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

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

Table 19.11: Resonances in ^{16}O(t, t) [a]

$E_{\text{c.m.}}$ (MeV)	E_x (MeV $\pm$ keV)	J^π	$\Gamma_{\text{c.m.}}$ (keV)
1.368	13.068 ± 4	$\frac{1}{2}^+$	≤ 10
1.545	13.245 ± 10	$\frac{1}{2}^-$	7
1.570	13.270 ± 10	$\frac{1}{2}^+$	4.5
1.832	13.532 ± 10	$\frac{1}{2}^+$	22
2.018	13.718 ± 20	$\frac{3}{2}^-$	128
2.178 [b]	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 [b]	14.352 ± 10	$\frac{1}{2}^+$	154
2.759 [b]	14.459 ± 25	$\frac{3}{2}^+$	179
2.763	14.463 ± 25	$\frac{5}{2}^+$	46

[a] (1973WE11): resonance parameters used to fit elastic scattering data.
[b] Also reported by (1968ET1A).

Resonances in the yield of γ_{0+1+2} (reaction (a)) are reported at $E_t = 1.5$ and 2.4 MeV with $\Gamma = 0.10$ and 0.12 MeV (1973SC1G; abstract). The excitation function for reaction (b) has been measured for $E_t = 0.3$ to 2.1 MeV (see (1972AJ02)), 1.1 to 1.7 MeV (1976MA54; n_0) and at $E_t = 1.6$ to 3.7 MeV (1977RE01): there is evidence for a maximum at $E_t = 2.5$ MeV. At $E_t = 3.7$ MeV the cross section is ≈ 0.4 b (1977RE01).

Resonances in the yields of p_0, p_1, α_0 and α_{1+2} are reported by (1967KO11) corresponding to states with $E_x = 12.42$, 12.67, (12.75), 12.83, 12.91, 12.97, (13.06) and (13.14) MeV ($\pm \approx 25$ keV) [not all resonances observed in every channel]. See also (1974KA1N). An analysis by the Humblet-Rosenfeld theory of the elastic yield (reaction (d)) in the range $E_t = 1.4$ to 3.7 MeV suggests a large number of resonances: their parameters are displayed in Table 19.11 (1973WE11). See also (1972AJ02), (1976LE19; theor.), (1973BA1R, 1977RE01; applied), ^{18}O and ^{18}F here, and ^{15}N in (1976AJ04).

13. ^{16}O(α, p)^{19}F $\qquad Q_m = -8.1137$

Angular distributions have been measured at $E_\alpha = 20.1$ MeV (1975PO1F; $p_0 \to p_5$), 26.7 and 33.1 MeV (1961YA02; $p_{0\to2}$, $p_{3\to5}$) and at 40 MeV (1976VA26): see Table 19.12. At $E_\alpha = 40$ MeV ^{19}F*(9.872) is strongly excited: it is suggested that it is a $\frac{11}{2}^-$ state and that the $\frac{11}{2}^-$ cluster

Table 19.12: States of ^{19}F from ^{16}O(α, p)^{19}F [a]

E_x [b] (MeV ± keV)	J^π [c]	S_{rel} [e]	E_x [b] (MeV ± keV)	J^π [c]	S_{rel} [e]
0 [d]	$\frac{1}{2}^+$	1.38	8.280 ± 7 [d]	$(\frac{13}{2}^-)$	
0.199 ± 2 [d]	$\frac{5}{2}^+$	1.22	8.601 ± 5 [d]	$\frac{3}{2}$	
1.353 ± 3 [d]	$\frac{5}{2}^-$		8.932 ± 8 [d]	$\frac{3}{2}^-$	
1.556 ± 2 [d]	$\frac{3}{2}^+$	1.06	9.313 ± 10	$\frac{1}{2}^+$	
2.7797 ± 0.4 [d]	$\frac{9}{2}^+$	1.00	9.702 ± 7 [d]		
4.027 ± 2 [d]	$\frac{7}{2}^- + \frac{9}{2}^-$		9.898 ± 2 [d]	$\frac{11}{2}^+$	1.11
4.371 ± 5 [d]	$\frac{7}{2}^+$	≤ 0.12	10.420 ± 2 [d]		1.23
4.6448 ± 1.3 [d]	$\frac{13}{2}^+$	1.49	10.742 ± 9		
5.456 ± 2 [d]	$\frac{7}{2}^+$	0.85	11.245 ± 7 [d]		
6.107 ± 5 [d]	$(\frac{3}{2}^-)$		11.430 ± 13		
6.286 ± 6 [d]	$\frac{5}{2}^+$		11.667 ± 6		
6.529 ± 6	$\frac{3}{2}^+$		11.989 ± 15		
6.582 ± 14	$\frac{9}{2}^+$		12.335 ± 7		
6.918 ± 3 [d]	$\frac{7}{2}^{(-)}$		12.802 ± 8 [d]		
7.243 ± 3 [d]			13.474 ± 6		
7.543 ± 9	$\frac{5}{2}^+; T = \frac{3}{2}$		13.797 ± 4 [d]		
7.723 ± 12	$\frac{3}{2}^-$		14.120 ± 3 [d]		
7.926 ± 3 [d]	$(\frac{7}{2}^+, \frac{9}{2})$	0.33	15.039 ± 8 [d]		
			15.571 ± 8		

[a] (1976VA26): $E_\alpha = 40$ MeV; compare with Table 19.6.

[b] Obtained by autofit program using several low-lying states of ^{19}F for calibration purposes: the actual energy resolution was 80–150 keV (1976VA26).

[c] From Table 19.6.

[d] Angular distribution obtained for this state.

[e] All values normalized to 1.00 for ^{19}F*(2.78).

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

J^{π} [c]	E_x [b] in ^{19}F (MeV)			E_x [b] 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		
$\frac{3}{2}^{+}$	1.56			1.54 [e]		
$\frac{5}{2}^{+}$	0.20			0.24		
$\frac{7}{2}^{+}$	5.47			5.42		
$\frac{9}{2}^{+}$	2.78			2.79 [e]		
$\frac{11}{2}^{+}$	(6.50) [d]					
$\frac{13}{2}^{+}$	4.65			4.64		
$\frac{1}{2}^{-}$		0.11			0.28	
$\frac{3}{2}^{-}$		1.46			1.62 [e]	
$\frac{5}{2}^{-}$		1.35			1.51 [e]	
$\frac{7}{2}^{-}$		4.00			4.20 [g]	
$\frac{9}{2}^{-}$		4.03			4.14 [g]	
$\frac{3}{2}^{+}$			3.91 [e]			4.03 [e]
$\frac{7}{2}^{+}$			4.38			4.38 [e]
$\frac{5}{2}^{(+)}$			4.55			4.55 [e]
$\frac{3}{2}^{-}$ $(\frac{1}{2}^{-})$			4.56			4.593 ± 0.006
$\frac{5}{2}^{-}$			4.68			4.71
$\frac{5}{2}^{(-)}$			5.11			5.09 [f]
$\frac{5}{2}^{+}$			5.34			
$\frac{7}{2}^{-}$			5.43			
						(6.12)
$(\frac{5}{2}, \frac{7}{2})^{-}$						6.29
$(\frac{11}{2}, \frac{9}{2})^{-}$						6.86

[a] (1971BI06, 1972BI14, 1972GA08, 1973BI02). See also reaction 14 in ^{19}Ne.

[b] Energies are nominal.

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

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

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

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

[g] See, however, reaction 5 in ^{19}Ne (1973DA31).

strength is split between it and ^{19}F*(8.957) (1977KO2L; abstract). See also (1974FO1J) and (1975AR1J, 1975GE18; theor.).

14. ^{16}O(^{6}Li, ^{3}He)^{19}F $\quad Q_{\rm m} = -4.094$

This reaction (and its mirror reaction ^{16}O(^{6}Li, t)^{19}Ne: see reaction 4 in ^{19}Ne) have been studied at $E(^{6}\text{Li}) = 24$ MeV. Members of the $K^{\pi} = \frac{1}{2}^{+}$ and $\frac{1}{2}^{-}$ rotational bands have been identified: see Table 19.13 (1972BI14, 1972GA08). See also (1973FO1A, 1977MA2G).

15. ^{16}O(^{7}Li, α)^{19}F $\quad Q_{\rm m} = 9.234$

Many states of ^{19}F have been populated in this reaction: see Table 19.14 (1974TS03). See also (1969GL06, 1972BA1P, 1973WE11). It is suggested that ^{19}F*(8.89, 9.81), which are strongly populated at $E(^{7}\text{Li}) = 35$ MeV, are the third $\frac{11}{2}^{+}$ and the second $\frac{13}{2}^{+}$ states (1974TS03). See also (1975GO15).

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

This reaction, as well as the analog reaction [^{16}O(^{10}B, ^{7}Li)^{19}Ne] have been studied at $E(^{10}\text{B}) = 100$ MeV: an attempt is made to match analog states [see reaction 5 in ^{19}Ne] but problems of energy resolution are evident (1976HA06).

17. ^{16}O(^{11}B, ^{8}Be)^{19}F $\quad Q_{\rm m} = 0.4765$

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

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

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

(c) ^{17}O(d, α)^{15}N $\quad Q_{\rm m} = 9.799$

For reaction (a) see ^{18}F in (1972AJ02); for reaction (b) see ^{18}O; for reaction (c) see ^{15}N in (1970AJ04).

Table 19.14: States of ^{19}F from ^{16}O(^{7}Li, α)^{19}F [a]

E_x [b] (MeV ± keV)	$(d\sigma/d\Omega)_{max}$ (mb/sr)	E_x [b] (MeV ± keV)	$(d\sigma/d\Omega)_{max}$ (mb/sr)
0	0.34	5.50	0.96
0.11	0.05	6.08	1.5
0.20	$1-2$	6.48	} 0.21
1.35	0.15	6.50	
1.46	0.08	6.53	1.07
1.56	0.87	6.89 ± 20	4.2
2.78	1.3	7.21 ± 20	0.37
3.91	0.07	7.70 ± 20	2.7
4.00	} 0.48	7.94 ± 20	0.26
4.03		8.53 ± 20	3.1
4.38	0.12	8.89 ± 20	2.8
4.55	} 0.30	9.53 ± 20	4.7
4.56		9.81 ± 20	3.8
4.65	3.7	10.32 ± 20	1.4
5.11	0.36	10.44 ± 20	2.8
5.34	0.22	[c]	
5.47	1.3		

[a] (1974TS03): $E(^{7}\text{Li}) = 35$ MeV.

[b] Nominal energies except for the latest ten values.

[c] At $E(^{7}\text{Li}) = 30$ MeV the excitation of ^{19}F*(7.25, 10.2, 12.1, 13.4) and of ^{19}F*(12.90 ± 0.05, 13.46 ± 0.05, 13.94 ± 0.05, 14.30 ± 0.05) are reported by (1969GL06) and by (1972BA1P, 1973WE11), respectively.

19. ^{17}O(t, n)^{19}F $\qquad Q_m = 7.556$

Not reported.

20. ^{17}O(^{3}He, p)^{19}F $\qquad Q_m = 8.320$

This reaction has been studied at $E(^3\text{He}) = 18$ MeV (1974BI1C; abstract).

21. ^{17}O(α, d)^{19}F $\qquad Q_m = -10.033$

At $E_\alpha = 47.5$ MeV many states of ^{19}F have been populated: angular distributions to the two $\frac{7}{2}^+$ states ^{19}F*(4.38, 5.47) and to the two states $\frac{11}{2}^+$ states ^{19}F*(6.50, 7.94) are reported.

It is concluded that ^{19}F*(4.38) is mostly $(d_{5/2})^3_{J=\frac{7}{2}}$ and that the higher state is more deformed. In the case of the $\frac{11}{2}^+$ states both appear to be deformed to the same extent suggesting that there is no single $\frac{11}{2}^+$ member of the ground-state rotational band (1975FO07).

22. ^{17}O(^{13}C, ^{11}B)^{19}F $\qquad Q_m = -4.865$

See (1977CH22).

23. ^{18}O(p, γ)^{19}F $\qquad Q_m = 7.9934$

Resonances for capture radiation observed for $E_p = 0.3$ to 3.0 MeV are displayed in Table 19.15. At the $E_p = 0.85$ MeV resonance [^{19}F*(8.80)], the intensity of the transition $8.80 \rightarrow 3.91$ and the anisotropy of the $8.80 \rightarrow 3.91 \rightarrow 0$ γ-rays limit J of ^{19}F*(3.91) to $\frac{3}{2}$ or $\frac{5}{2}$. $J = \frac{5}{2}$ is ruled out by the angular distribution of the γ-rays. At the $E_p = 1.17$ MeV resonance [^{19}F*(9.10)], the angular distribution of the γ-rays to the $\frac{5}{2}^+$ state at 0.197 MeV indicate $J^\pi = \frac{7}{2}^+$ [$\frac{9}{2}^+$ not completely excluded] for ^{19}F*(9.10). $J = \frac{5}{2}$ or $\frac{9}{2}$ is suggested for ^{19}F*(2.78). The γ-decay of the resonances at $E_p = 1.77$ and 1.93 MeV is very complex (1965AL20). For branching ratios and Γ_γ see Table 19.7 (1962NE03, 1965AL20, 1971WO12, 1972WO15). See also (1973CL1E; astrophys. considerations).

24. ^{18}O(p, n)^{18}F $\qquad Q_m = -2.4379 \qquad E_b = 7.9934$

Yield measurements have been reported from $E_p = 2.5$ to 13.5 MeV: the measurements by (1969BE57; n; $2.6 \rightarrow 3.3$ MeV), (1973BA31; σ_t; $2.6 \rightarrow 3.9$ MeV), (1969DI07; n_1, γ, $n_2\gamma$, $n_3\gamma$) and n; $3.0 \rightarrow 7.0$ MeV), (1964BA16; σ_t; $3.5 \rightarrow 10$ MeV) and (1973FR10; $n_0 \rightarrow n_4$; $4.6 \rightarrow 6.6$ MeV) lead to the resonances shown in Table 19.16. See also ^{18}F.

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

E_p (keV)	Γ_{lab} (keV)	J^π	E_x (MeV)	Refs.
629.6 ± 0.3	2.0 ± 0.3	$\frac{3}{2}^+$	8.5896	A
848 ± 2	40 ± 5	$\frac{3}{2}$	8.796	A
1166.5 ± 0.4	$(25 \pm 24) \times 10^{-3}$	$\frac{7}{2}^+$ [b]	9.0980	A
1398 ± 3	4		9.317	A
1685 ± 5 [d]	< 15		(9.589)	(1959BU05)
1769 ± 2	4.0 ± 1.0	$\frac{3}{2}^+$	9.669	(1959BU05, 1962NE03)
1778			(9.677)	(1962NE03)
1790			(9.688)	(1962NE03)
1928.4 ± 0.6 [c]	0.3 ± 0.05	$\frac{5}{2}$ [f]	9.819	A
2263.0 ± 0.7	5.0 ± 1.0	$\frac{3}{2}^-$	10.136	(1962NE03, 1969DU1A, 1971WO12, 1972WO15)
2.36 [e]			(10.23)	(1962NE03)
2.39	47 ± 10		(10.26)	(1962NE03)
2.41	10 ± 5		(10.28)	(1962NE03)
2.44			(10.30)	(1962NE03)
(2.60)			(10.46)	(1962NE03)
(2.66)			(10.51)	(1962NE03)
(2.68)			(10.53)	(1962NE03)
(2.73)			(10.58)	(1962NE03)
(2.77)			(10.62)	(1962NE03)
(2.80)			(10.64)	(1962NE03)
(2.84)			(10.68)	(1962NE03)

A: See references for this state in Table 19.12 in (1972AJ02).

[a] See also Table 19.7.

[b] Most probable value, although $J^\pi = \frac{9}{2}^+$ is also possible: see text. $T = \frac{3}{2}$ (1965AL20).

[c] Γ_γ and Γ_p are $\lesssim$ few eV (1969DU1A).

[d] See, however, (1962NE03).

[e] See (1962NE03) for additional resonant structure between $E_p = 2.33$ and 2.78 MeV.

[f] From γ-ray angular distributions (I.E. Wright, private communication).

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

E_p (MeV ± keV)	$\Gamma_{c.m.}$ (keV)	Res. [b] in yield of	J^π	E_x in ^{19}F (MeV)	Refs.
2.643 ± 1.0	6.2 ± 0.5	n	$(\frac{3}{2})$	10.496	(1969BE57, 1973BA31)
2.691 ± 1.0	2.5 ± 0.2	n		10.542	(1969BE57, 1973BA31)
2.717 ± 1.0	5.2 ± 0.5	n		10.566	(1969BE57, 1973BA31)
2.767 ± 1.5	4.7 ± 0.5	n	$\frac{5}{2}^{(+)}$	10.613	(1969BE57, 1973BA31)
2.923 ± 4	6 ± 3	n		10.761	(1973BA31)
3.025 ± 2.0	24.0 ± 1.5	n	$\frac{3}{2}$	10.858	(1969BE57, 1973BA31)
(3.08 ± 20)	≈ 60	n		(10.91)	(1973BA31)
3.148 ± 3	14 ± 2	n		10.974	(1969BE57, 1973BA31)
3.164 ± 2.5	7 ± 2	n		10.989	(1969BE57, 1973BA31)
3.250 ± 2.5	35 ± 4	n	$\frac{3}{2}$	11.071	(1969BE57, 1973BA31)
3.370 ± 14	17 ± 4	n		11.184	(1973BA31)
3.463 ± 3	7 ± 2	n		11.272	(1973BA31)
3.470 ± 15	70 ± 20	n		11.279	(1973BA31)
3.653 ± 4	40 ± 10	n, n_1		11.452	(1973BA31)
3.680 ± 5	7 ± 3	n		11.478	(1973BA31)
3.705 ± 5	4 ± 2	n, n_1		11.502	(1973BA31)
3.748 ± 15	50 ± 15	n		11.542	(1973BA31)
3.775 ± 7	15 ± 10	n, n_2	$(T = \frac{3}{2})$ [c]	11.568	(1973BA31)
(3.79 ± 20)	60 ± 20	n		(11.58)	(1973BA31)
3.863 ± 4	45 ± 10	n, n_1		11.651	(1973BA31)
4.00		n_1, n_3		(11.78)	(1969DI07)
4.06 ± 10 [d]	< 50	n, n_1		11.84	(1964BA16, 1969DI07)
4.11		n_1		(11.89)	(1969DI07)
4.16 ± 10	90	n, n_1		11.93	(1964BA16, 1969DI07)
4.33		n_1, n_3		(12.09)	(1969DI07)
4.37 ± 10	100	n, n_1, n_2		12.13	(1964BA16, 1969DI07)
4.47	50	n, n_1, n_2, n_3		12.23	(1964BA16, 1969DI07)
4.58 ± 10		n_1		(12.33)	(1969DI07)
4.70		n_3		(12.44)	(1969DI07)
4.83		n_1, n_2, n_3		(12.57)	(1969DI07)

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

E_p (MeV $\pm$ keV)	$\Gamma_{c.m.}$ (keV)	Res. [b] in yield of	J^π	E_x in ^{19}F (MeV)	Refs.
4.90		n_2		(12.63)	(1969DI07)
5.05 ± 10	200	n, n_1, n_2		12.77	(1964BA16, 1969DI07, 1973FR10)
5.10		n_1, n_2		(12.82)	(1969DI07)
5.20		n_2, n_3		(12.92)	(1969DI07)
5.35		n, n_1, n_2, n_3		13.06	(1964BA16, 1969DI07)
5.47 ± 15	70	n, n_1		13.17	(1964BA16, 1969DI07)
5.622 ± 15	30	n, n_1, n_2	$(T = \frac{3}{2})$	13.317	(1969DI07, 1973FR10)
5.76		n_1, n_3		(13.45)	(1969DI07)
6.061 ± 15	50	n, n_1, n_2	$(T = \frac{3}{2})$	13.73	(1964BA16, 1969DI07, 1973FR10)
6.60 ± 15	350	n		14.24	(1964BA16)
(6.70 ± 15)		n		(14.34)	(1964BA16)
7.17 ± 20	300	n		14.78	(1964BA16)
7.40 ± 20		n		15.00	(1964BA16)
(7.8)		n		(15.4)	(1964BA16)
(7.98)		n		(15.55)	(1964BA16)
8.19 ± 25	150	n		15.75	(1964BA16)
8.74 ± 25	200	n		16.27	(1964BA16)
9.30 ± 30		n		16.80	(1964BA16)

[a] See also Table 19.13 in (1972AJ02).

[b] n means total yield.

[c] See (1968BE34).

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

25. ^{18}O(p, p)^{18}O $\qquad E_b = 7.9934$

Scattering studies have been carried out for $E_p = 0.6$ to 16.3 MeV [see (1972AJ02)] and at $E_p = 3.4$ to 6.2 MeV (1973OR01; p_0, R-matrix analysis) and with polarized protons for $E_p = 3.8$ to 6.1 MeV (1975AL20; p_0, p_1) and at 6.0 to 16.6 MeV (1976MU1C; p_0; prelim.). Observed resonances are displayed in Table 19.17. Pronounced resonance structure continues to $E_p = 12$ MeV (1976MU1C). Polarization measurements are also reported at $E_p = 24.5$ MeV (1974ES02). See also

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

E_{p} [a] (MeV ± keV)	Γ_{lab} (keV)	Particles out	Γ_{p} (keV)	Γ_{α} (keV)	J^{π}	E_{x} (MeV)	Refs.
0.6326 ± 0.4	2.1 ± 0.1	p_0	0.065 ± 0.006	2.0 ± 0.2	$\frac{3}{2}^-$	8.5925	A
0.680	100	p_0	5	95	$\frac{1}{2}^+$	8.637	A
0.846 ± 1.5	47 ± 1	p_0, α_0	26 ± 1.5	21 ± 1	$\frac{1}{2}^+; T = \frac{3}{2}$	8.795	A
0.9870 ± 0.7	3.8 ± 0.2	p_0, α_0	0.080 ± 0.007	3.7 ± 0.3	$\frac{3}{2}^-$	8.928	A
(1.135)	140					(9.068)	A
1.1685 ± 0.5	0.60 ± 0.03	p_0, α_0	0.005 ± 0.0006	0.595 ± 0.08	$\frac{7}{2}^+$	9.0999	A
1.2390 ± 1	6.1 ± 0.3	$p_0, (\alpha_0)$	0.40 ± 0.03	5.7 ± 0.4	$\frac{1}{2}^+$	9.167	A
1.4025 ± 1	5.2 ± 0.2	p_0, α_0	0.23 ± 0.02	5.0 ± 0.4	$\frac{1}{2}^+$	9.321	A
1.620 ± 6	30	p_0, α_0			$(\frac{5}{2})$	9.527	A
1.668 ± 6	27	p_0, α_0			$\frac{3}{2}$	9.573	A
1.766 ± 3	3.6	p_0, α_0	2.1	1.5	$\frac{3}{2}^+$	9.666	A
1.928 ± 3	0.16	p_0, α_0	0.09	0.07	$(\frac{5}{2}, \frac{7}{2})^-$	9.819	A
2.001 ± 4	31	p_0, α_0	12	19	$\frac{1}{2}^+$	9.888	A
2.2630 ± 0.7	5.0 ± 1.0	$\alpha_0, \alpha_1, \alpha_2$	≈ 5	0.004 [c]	$\frac{3}{2}^-$	10.136	B
2.289 ± 3	33	p_0, α_0	2.3	(1.0)	$\frac{1}{2}^+$	10.161	A
2.363 ± 3	4.5	p_0, α_0	2.8	1.7	$\frac{1}{2}^+$	10.231	A
2.387 ± 3	24	p_0, α_0	11	13	$\frac{3}{2}^+$	10.253	A
2.443 ± 4	9.7	p_0, α_0	5.2	4.5	$\frac{3}{2}^+$	10.307	A
2.644 ± 3	4.6	$p_0, p_1, \alpha_0, \alpha_{1+2}$	2.4	(1.0)	$\frac{3}{2}^+$	10.497	A
2.705 ± 3	8 ± 2	p_1, α_0			$\frac{3}{2}^+; (T = \frac{3}{2})$	10.555	A
2.732 ± 4	23 ± 3	p_1, α_0			$(\frac{5}{2}^+)$	10.580	A
2.768 ± 3	4.0	$p_0, p_1, \alpha_0, \alpha_{1+2}$	0.7	(1.0)	$\frac{5}{2}^+; T = \frac{3}{2}$ [b]	10.614	A
2.925 ± 3	5.7	$p_0, p_1, \alpha_0, \alpha_{1+2}$	4.5	1.2	$\frac{1}{2}^-$	10.763	A
3.029 ± 4	19.5	$p_0, p_1, \alpha_0, \alpha_{1+2}$	13.0		$\frac{5}{2}^+$	10.862	A
(3.06)		α_0				(10.89)	A
3.148 ± 4	(14)	$p_0, p_1, \alpha_0, \alpha_{1+2}$	(4.5)	(4.5)	$(\frac{3}{2}, \frac{5}{2})^+$	10.974	A
3.266 ± 9	35	$p_0, p_1, \alpha_0, \alpha_{1+2}$			$\frac{1}{2}^+$	11.086	A

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

E_p [a] (MeV ± keV)	Γ_{lab} (keV)	Particles out	Γ_p (keV)	Γ_α (keV)	J^π	E_x (MeV)	Refs.
3.386 ± 9	20	$p_0, p_1, \alpha_0, \alpha_{1+2}$			$(\frac{1}{2}^-)$	11.200	A
3.479 ± 8	23 ± 5	$p_0, p_1, \alpha_0, \alpha_{1+2}$	4.3 ± 1		$\frac{5}{2}^+$	11.288	A, (1973OR01)
3.547 ± 25	286 ± 33	p_0	241 ± 2		$\frac{1}{2}^+$	11.35	(1973OR01)
3.643 ± 9	40 ± 7	$p_0, (\alpha_{1+2})$	17 ± 3		$\frac{1}{2}^-$	11.443	A, (1973OR01)
3.694 ± 9	29 ± 6	$p_0, p_1, \alpha_0, (\alpha_{1+2})$	12 ± 2		$\frac{3}{2}^-$	11.491	A, (1973OR01)
3.744 ± 8	23 ± 5	p_0, p_1, α_0	3.7 ± 1		$\frac{5}{2}^+$	11.539	A, (1973OR01)
3.811 ± 12	66 ± 7	p_0	30 ± 12 [d]		$\frac{3}{2}^-$	11.602	(1973OR01, 1975AL20)
3.869 ± 8 [a]	28 ± 7	$p_0, p_1, (\alpha_{1+2})$	12 ± 2 [d]		$\frac{3}{2}^+; (T = \frac{3}{2})$	11.657	A, (1973OR01, 1975AL20)
4.290 ± 30	75 ± 25	$p_0, \alpha_0, \alpha_{1+2}$	10 ± 3		$\frac{1}{2}^-$	12.06	A, (1973OR01, 1975AL20)
4.390 ± 15	110 ± 15	$p_0, p_1, (\alpha_0, \alpha_{1+2})$	60 ± 10		$\frac{3}{2}^-; T = \frac{3}{2}$	12.150	A, (1973OR01, 1975AL20)
4.465 ± 12 [a]	78 ± 1	$p_0, p_1, \alpha_0, \alpha_{1+2}$	48 ± 6 [d]		$\frac{3}{2}^+$	12.221	A, (1973OR01, 1975AL20)
4.782 ± 7	16 ± 4	p_0, p_1	2.4 ± 1		$\frac{1}{2}^-$	12.521	(1969DI07, 1973OR01, 1975AL20)
4.840 ± 10	50 ± 10	p_0, p_1, α_{1+2}	6.4 ± 2 [d]		$\frac{5}{2}^+$	12.576	(1973OR01, 1975AL20)
4.848 ± 25 [a]	300 ± 50	p_0	80 ± 25		$\frac{1}{2}^-; T = \frac{3}{2}$	12.58	(1973OR01, 1975AL20)
5.074 ± 30	100 ± 40	$p_0, p_1, (\alpha_0)$	13 ± 5		$\frac{5}{2}^+; T = \frac{3}{2}$	12.80	A, (1975AL20)
5.135 ± 30	290 ± 40	p_0, p_1	114 ± 17		$\frac{3}{2}^+; T = \frac{3}{2}$	12.86	(1973OR01, 1975AL20)
5.225 ± 25	75 ± 25	p_0, p_1, α_{1+2}	3 ± 1.5		$\frac{5}{2}^+$	12.94	(1969DI07, 1973OR01, 1975AL20)
5.27 ± 50	130 ± 40	p_0	20 ± 8		$\frac{1}{2}^-$	12.98	(1975AL20)
5.38 ± 75	300 ± 75	p_0	75 ± 25		$\frac{3}{2}^-$	13.09	(1975AL20)
5.622 ± 8	30 ± 6	$p_0, p_1, \alpha_0, \alpha_{1+2}$	10 ± 3		$\frac{7}{2}^-$	13.317	(1969DI07, 1973OR01, 1975AL20)
5.670 ± 25 [a]	40 ± 20	p_0	2 ± 2		$\frac{3}{2}^-$	13.36	(1975AL20)
6.060 ± 11	55 ± 10	$p_0, p_1, (\alpha_{1+2})$	13 ± 3		$\frac{7}{2}^-; T = \frac{3}{2}$	13.731	(1969DI07, 1973OR01, 1975AL20)
6.65		p_1, α_{1+2}				14.29	(1969DI07)

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

$E_{\rm p}$ [a] (MeV $\pm$ keV)	$\Gamma_{\rm lab}$ (keV)	Particles out	$\Gamma_{\rm p}$ (keV)	Γ_{α} (keV)	J^{π}	$E_{\rm x}$ (MeV)	Refs.
10.5		p_0, p_1, α_0				17.9	(1966ST04)

A: See references listed for this state in Table 19.14 in (1972AJ02).

B: (1972WO15) and private communication.

[a] For other reported resonances see Table 19.14 in (1972AJ02).

[b] Probable analog of ^{19}O*(3.15): isospin impurities may be present (1969SE02, 1969SE03).

[c] $\alpha_0 + \alpha_2$ only.

[d] See also (1975AL20).

(1974PL05, 1974LO1B, 1976PL1C, 1977KU1L, 1977PL1A) and (1975BA05, 1976ES1B; theor.).

26. (a) ^{18}O(p, d)^{17}O $\quad Q_m = -5.820 \quad E_b = 7.9934$

(b) ^{18}O(p, t)^{16}O $\quad Q_m = -3.7069$

Polarized protons at $E_p = 24.4$ MeV have been used to study both reactions (a) and (b) (1973PI09): see ^{16}O and ^{17}O in (1977AJ02). Total cross sections for several deuteron and triton groups are reported at $E_p = 20.0$, 24.4, 29.8, 37.5 and 43.6 MeV by (1974PI05). See also (1976DA1K, 1976PL1C).

27. ^{18}O(p, α)^{15}N $\quad Q_m = 3.9796 \quad E_b = 7.9934$

Yield measurements have been studied for $E_p = 0.50$ to 14 MeV: see (1972AJ02). See also (1972WO15). Observed resonances are displayed in Table 19.17. The (astrophysical) hydrogen burning of ^{18}O proceeds predominantly ($\geq 99\%$) through the reaction ^{18}O(p, α)^{15}N (1974RO1N). See also (1975FO19, 1977CL1F). Total cross section measurements are reported by (1974PI05; 20.6, 26.1, 34.2, 42.2 MeV; α_0, α_{1+2}, α_3). See also (1974LO1B), (1973TU1B; applied) and (1974NI1A; theor).

28. (a) ^{18}O(d, n)^{19}F $\quad Q_m = 5.7685$

(b) ^{18}O(d, nα)^{15}N $\quad Q_m = 1.7546$

Angular distributions of neutron groups corresponding to ^{19}F states with $E_x < 8.2$ MeV have been measured at $E_d = 3$ and 4 MeV: see Table 19.18 (1968GU07, 1972TA26). Gamma-ray measurements are reported in Tables 19.18 (E_x), 19.7 (branching ratios) and 19.10 (τ_m) (1972LE20, 1975LE16). For slow neutron threshold measurements see Table 19.15 in (1972AJ02). At $E_d \approx 5.1$ MeV, reaction (b) appears to involve ^{19}F states at $E_x \approx 8$ to 10 MeV (1970BO08).

29. ^{18}O(^{3}He, d)^{19}F $\quad Q_m = 2.4998$

Angular distributions of the deuterons corresponding to many states of ^{19}F have been analyzed by DWBA: the results are shown in Table 19.18 (1970SC25; $E(^3\text{He}) = 16$ MeV). See also (1970GR04). The spectroscopic factors obtained by DWBA for ^{19}F*(7.54, 8.80), the $T = \frac{3}{2}$, $J^\pi = \frac{5}{2}^+$ and $\frac{1}{2}^+$ analogs of ^{19}O*(0, 1.47) are in good agreement with those obtained for the ^{19}O states in the ^{18}O(d, p)^{19}O reaction (1971FO18). See also (1970SC25) and (1972EN03, 1973VI01; theor).

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

E_x (MeV ± keV)		l_p [a]	l [b]	$C^2S(2J_f+1)$		J^π [b]
(1975LE16) [a]	(1970SC25) [b]			[d]	[b]	
	0	0	0	0.29	0.42	$\frac{1}{2}^+$
	0.112 ± 3		1		0.224	$\frac{1}{2}^-$
	0.199 ± 3	2	2	1.68	2.45	$\frac{5}{2}^+$
	1.347 ± 5					
	1.460 ± 5		1		0.098	$\frac{3}{2}^-$
1.5544 ± 0.6	1.556 ± 5		2		1.01	$\frac{3}{2}^+$
	2.784 ± 5	4	4 [f]		0.027 [f]	$\frac{9}{2}^+$
3.9048 ± 0.8	3.912 ± 5					
3.999 ± 1	4.002 ± 5		(3)		(0.019)	$(\frac{7}{2}^-)$
	4.036 ± 10					
4.3761 ± 0.8	4.385 ± 5		(4) [f]		(0.048) [f]	$(\frac{7}{2}^+)$
4.551 ± 1	4.555 ± 5		2		0.31	$\frac{3}{2}^+$ [g]
4.5557 ± 0.5						
4.684 ± 1	4.675 ± 10 [e]					
5.106 ± 3	5.113 ± 5	3	(2, 3) [f]			$\frac{5}{2}^-, \frac{7}{2}^-$ [h]
	5.34 ± 5		(2, 3)		0.0065	$\frac{5}{2}^+$
	5.428 ± 8		(2, 3)		(0.042)	$(\frac{3}{2}^+)$
	5.495 ± 5 [e]					
	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)	0.24	0.19	$\frac{1}{2}^+$ [d]
	6.503 ± 5 [e]		2 [f]		0.133 [f]	$\frac{3}{2}^+$
	6.595 ± 10					
	6.792 ± 5	1	1 [f]	0.27	0.29 [f]	$\frac{3}{2}^-$
	6.93 ± 5		(2, 3)			$(\frac{5}{2}^+, \frac{7}{2}^-)$
	7.112 ± 8 [e]		2		0.087	$\frac{5}{2}^+$
	7.26 ± 5					

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

E_x (MeV ± keV)		l_p [a]	l [b]	$C^2S(2J_f+1)$		J^{π} [b]
(1975LE16) [a]	(1970SC25) [b]			d	b	
	7.364 ± 5		0		0.091	$\frac{1}{2}^+$
	7.540 ± 3	1	2		0.665	$\frac{5}{2}^+; T=\frac{3}{2}$
	7.665 ± 5	0	(2)	0.14	0.035	$(\frac{3}{2}^+)$
	7.702 ± 5		(0, 1)		(0.052)	$(\frac{3}{2}^-)$
	8.015 ± 5		2		0.26	$\frac{5}{2}^+$
	8.086 ± 5		(2, 3)		0.097	$(\frac{5}{2}^+)$
	8.135 ± 5	0	(0, 1)		0.156	$\frac{1}{2}^+$ [d]
	8.198 ± 5		(2, 3)		0.035	$(\frac{5}{2}^+)$
	8.255 ± 5		(2)		0.035	$(\frac{5}{2}^+)$
	8.31 ± 5					
	8.592 ± 10		(2, 3)			
	8.795 ± 15		0		(0.13)	$\frac{1}{2}^+; T=\frac{3}{2}$
	9.113 ± 10					
	9.18 ± 15					
	9.596 ± 10					
	9.682 ± 15					
	10.275 ± 15					
	10.33 ± 15					
	10.525 ± 15					

[a] ^{18}O(d, nγ) (1975LE16). For τ_m, see Table 19.10.
[b] ^{18}O(^{3}He, d): $E(^3$He$) = 16$ MeV (1970SC25).
[c] ^{18}O(d, n): $E_d = 3$ MeV (1968GU07) and 4 MeV (1972TA26).
[d] Using DWUCK (1972TA26).
[e] Unresolved.
[f] See also (1970GR04).
[g] J probably $\frac{5}{2}$. This appears to be a different state from the one involved in the ^{20}Ne(d, ^{3}He)^{19}F reaction, with $J^{\pi} = \frac{3}{2}^-$; see (1970KA31).
[h] (1968GU07).

30. ^{18}O(α, t)^{19}F $\qquad Q_m = -11.8207$

Not reported.

31. ^{18}O(^{6}Li, αn)^{19}F $\qquad Q_m = 4.295$

For τ_m of ^{19}F*(0.110) see Table 19.10 (1969NI09).

32. ^{19}O(β^-)^{19}F $\qquad Q_m = 4.819$

The decay is primarily by allowed transitions to ^{19}F*(0.197, 1.55), $J^\pi = \frac{5}{2}^+$ and $\frac{3}{2}^+$, respectively. Very weak branches are also observed to ^{19}F*(0.11, 4.39), $J^\pi = \frac{1}{2}^-$ and $\frac{7}{2}^+$, respectively: 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 forbiddeness of the decay to the ground state of ^{19}F are consistent with $J^\pi = \frac{5}{2}^+$ for the ground state of ^{19}O, and then with $(\frac{7}{2}^+)$ for ^{19}F*(4.39): see (1966OL01). Gamma-ray branching ratios are displayed in Table 19.7 (1966OL01, 1970CO22). See also (1970CO1D). A preliminary study of the allowed decay to ^{19}F*(0.197) has been carried out to measure the F/GT mixing ratio (1976PE1D).

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 (1962BO1A, 1962SE12). ^{19}F*(1.46, 3.91, 7.66) are also excited: for τ_m of the first of these states see Table 19.10 (1964BO22); $E_x = 3906 \pm 6$ and 7663 ± 4 keV for the latter (1972SH07) [see also for Γ_γ]. The scattering cross section is relatively small and structureless for $E_\gamma = 14$ to 30 MeV (1967LO1B).

34. ^{19}F(γ, n)^{18}F $\qquad Q_m = -10.4313$

The (γ, n$_0$) and (γ, n$_1$) cross section, derived from bremsstrahlung show peaks at $E_\gamma = 12.10 \pm 0.04$ [0.20 ± 0.05], 12.38 ± 0.04 [0.17 ± 0.05], 13.82 ± 0.05 [0.25 ± 0.10] and 16.24 ± 0.05 [0.30 ± 0.15] MeV [Γ in brackets]. It is suggested that the two lower states have $J^\pi = \frac{1}{2}^-$ and the two upper states have $J^\pi = \frac{3}{2}^-$. The integrated cross section in the interval $E_\gamma = 11.9 \rightarrow 17.9$ is 14.4 ± 2.2 MeV$\cdot$mb (1976SH12). 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.

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

Decay to ^{19}F* (keV)	J^π	Branch (%)	log ft	Refs.
0	$\frac{1}{2}^+$	≤ 4	≥ 6.5	(1959AL06, 1959JO26)
0.110 [b]	$\frac{1}{2}^-$	$0.048^{+0.012}_{-0.033}$	$10.16^{+0.51}_{-0.10}$ [e]	(1970CO22)
0.197 [c]	$\frac{5}{2}^+$	41.5^{+2}_{-5}	$5.42^{+0.06}_{-0.03}$ [f]	(1959AL06)
1.35	$\frac{5}{2}^-$		≥ 7.1	(1959JO26)
1.46	$\frac{3}{2}^-$		≥ 6.7	(1959JO26)
1.55 [d]	$\frac{3}{2}^+$	58.5 ± 2	4.59 ± 0.03 [f]	(1959AL06)
2.78	$\frac{9}{2}^+$	≤ 0.15	> 7.4	(1959AL06, 1966OL01)
4.38	$\frac{7}{2}^+$	0.16 ± 0.012	3.60 [f]	(1966OL01)

[a] See also (1959AJ76).
[b] $E_\gamma = 111.5 \pm 1.5$ keV (1954JO21), 112 ± 2 keV (1959JO26).
[c] $E_\gamma = 199.6 \pm 1.5$ keV (1954JO21).
[d] $E_x = 1.5539 \pm 0.0013$ MeV (1966AL12).
[e] log $f_1 t$ (1970CO22). See also (1971TO08).
[f] Based on Q_m and $\tau_{1/2} = 26.91 \pm 0.08$ sec: see ^{19}O, reaction 1 (B.A. Zimmerman, private communication).

The integrated cross section to 29 MeV is 108 ± 7 MeV · mb (1974VE06). See also (1976BE1H). Additional structures have been reported in earlier work [see (1972AJ02)] and by (1971BA2W, 1972VA32, 1973CA19). See also (1972TH15, 1975NO10, 1975WO04), (1974BU1A, 1975AB1F, 1975BR1F, 1977DA1B) and ^{18}F.

35. (a) $^{19}F(\gamma, 2n)^{17}F$ $\qquad Q_m = -19.5819$
(b) $^{19}F(\gamma, 2np)^{16}O$ $\qquad Q_m = -20.1823$

The integrated (γ, 2n) cross section to 60 MeV is given as 9.1 ± 0.9 MeV · mb by (1976AN06) who also report a number of structures. The cross section for reactions (a) and (b) for $E_\gamma = 22$ to 28 MeV shows no structure (1974VE06). See also (1972VA32, 1973CA19, 1976MA62) and (1976BE1H).

36. $^{19}F(\gamma, p)^{18}O$ $\qquad Q_m = -7.9934$

The integrated cross sections for the p_0 and p_1 processes at 90° for $E_\gamma = 13.3 \rightarrow 25.4$ and $15.2 \rightarrow 26.0$ MeV are, respectively, 1.80 ± 0.27 and 0.50 ± 0.45 MeV · mb/sr. The (γ, p_0) cross section at 90° shows broad structures at $E_\gamma = 15.0$, 17.0 and 23 MeV (1975TS03). Peaks have also been reported corresponding to ^{19}F*(10.4, 11.4, 11.9, (12.8), 13.6, 15.4, 16.5, (18.1)) (1960FO10). See also (1972TH15, 1976TH1E) and ^{18}O.

37. ^{19}F(γ, t)^{16}O $\qquad Q_m = -11.7003$

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

38. ^{19}F(γ, α)^{15}N $\qquad Q_m = -4.0138$

See (1972TH15). See also (1972SP1B, 1976TH1E, 1977SP06) and ^{15}N in (1976AJ04).

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

The rms radius of $^{19}\mathrm{F} = 2.885 \pm 0.015$ fm (1973HA13). Elastic and inelastic form factors have been measured for a number of ^{19}F states: see (1973HA13, 1975OY01). Table 19.20 shows the extracted radiative ground-state transition strengths (1973HA13, 1975OY01, 1975WI1H). The deformation parameters for the ground state $K^\pi = \frac{1}{2}^+$ rotational band are $\beta_2 = 0.43 \pm 0.02$, $\beta_4 = 0.12 \pm 0.02$ (1975OY01).

For reaction (b) see (1975WO04); for reaction (c) see (1975TS03). See also (1975BE1T), (1972THZF, 1974DE1E, 1975BE1G) and (1972AJ02) for the earlier work.

40. ^{19}F(n, n′)^{19}F

Angular distributions of neutron groups have been reported for $E_n = 2.6$ and 14.1 and 14.2 MeV: see (1972AJ02). E_x for the first six excited states of ^{19}F, derived from γ-ray measurements, are 109.8 ± 0.2, 197.2 ± 0.2, 1345.4 ± 0.3, 1456.9 ± 1.1, 1554.0 ± 0.3 and 2775.1 ± 3.5 keV (1968SP01) [see (1972AJ02) for other, unpublished, measurements]. $E_\gamma = 110.1 \pm 0.2$ and 197.2 ± 0.3 keV (1972OP01), 1236.9 ± 0.6 and 1358.6 ± 0.7 keV (1976PR08). Gamma decay of states with $E_x < 5.4$ MeV is reported by (1972NI05). See also (1973LE1C, 1974RO03) and ^{20}F.

Table 19.20: Radiative widths from ^{19}F(e, e)

E_x in ^{19}F (MeV)	J^π	Mult.	$\|M\|^2$ (W.u.)	Refs.
0.110	$\frac{1}{2}^-$	E1	10^{-3}	(1975WI1H) [a]
0.197	$\frac{5}{2}^+$	E2	$5.7^{+3.3}_{-2.6}$	(1973HA13)
1.35	$\frac{5}{2}^-$	E3	11 ± 3	(1975OY01) [b]
1.55	$\frac{3}{2}^+$	E2	8.0 ± 1.0	(1975OY01) [b]
2.78	$\frac{9}{2}^+$	E4	5.8 ± 1.3	(1975OY01)
4.00	$\frac{7}{2}^-$	E3	< 0.4	(1975OY01)
4.03	$\frac{9}{2}^-$	E5	16 ± 7	(1975OY01)
4.55	$\frac{5}{2}^+$	E2	1.0 ± 0.2	(1975OY01)
5.43	$\frac{7}{2}^-$	E3	15 ± 4	(1975OY01)

[a] Abstract.
[b] See also (1973HA13).

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

Table 19.21 displays energy levels of ^{19}F derived from this reaction (1968GU07, 1969PO03, 1978BH01). Angular distributions of various proton groups have been measured from $E_p = 4.3$ to 17.5 MeV: see (1972AJ02) and at 30 MeV (1973DE06, 1974DE46; see Table 19.21). The ground state rotational band is characterized by $\beta_2 = 0.44 \pm 0.04$, $\beta_4 = 0.14 \pm 0.04$ (1973DE06, 1974DE46). See Tables 19.7 and 19.10 for branching ratio and τ_m measurements. See also (1972SO1A, 1973HE1E). For reaction (b) see (1972HI10). See also (1973LE1C), (1973RU1B; applied work), (1973PE09, 1977DE17; theor.) and (1972AJ02).

42. ^{19}F(d, d)^{19}F

Angular distributions of elastically scattered deuterons have been measured for $E_d = 2.0$ to 15 MeV: see (1972AJ02). In addition, angular distributions have been measured at $E_d = 15$ MeV for $d_1 \to d_5$ (1970DE06) and $B(E\lambda)$ have been derived. See also (1971BE2F). For polarization measurements see (1972BO1G, 1977AN24) and (1978EN06). See also (1972SC1F; theor.).

43. ^{19}F(t, t)^{19}F

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

E_x (keV)			L [c]	β_L [c]	J^π
(1968GU07)	(1969PO03)	(1976BH03) [b]			
	197.6 ± 0.6		2	0.55	$\frac{5}{2}^+$
	1345.8 ± 0.2	1345.4 ± 0.6	3	0.33	$\frac{5}{2}^-$
	1459.1 ± 0.5	1458.6 ± 0.4			$\frac{3}{2}^-$
	1554.2 ± 0.4	1553.5 ± 0.6	2	0.58	$\frac{3}{2}^+$
		2779.8 ± 0.6	4	0.22	$\frac{9}{2}^+$
3920 ± 10		3907.1 ± 1.0			$\frac{3}{2}^+$
4010 ± 10		3998.5 ± 0.8			$\frac{7}{2}^-$
4040 ± 10		4032.5 ± 1.2			$\frac{9}{2}^-$
4390 ± 10		4377.7 ± 1.0			$\frac{7}{2}^+$
		4548.8 ± 1.0 [g]	2	0.20	$\frac{5}{2}^+$
4560 ± 10					
		4557.5 ± 1.0 [h]			$\frac{3}{2}^-$
4690 ± 10		4682.5 ± 1.2	[d]		
5110 ± 10			2	0.15 [e]	$\frac{5}{2}^+$
5340 ± 10					
5420 ± 10			3	0.45	$\frac{7}{2}^-$
5470 ± 10					
5500 ± 10					
5540 ± 10					
5630 ± 10			[f]		
5940 ± 10					
(6080)					
6090 ± 10					
6170 ± 10					
6250 ± 10					
6290 ± 10					
6330 ± 10					

[a] See also Table 19.19 in (1972AJ02).
[b] Based on $E_x = 109.9$ and 197.1 keV.
[c] (1974DE46): $E_p = 30$ MeV.
[d] (1974DE46) report excitation of a state with $E_x = 4.69$ MeV, $J^\pi = \frac{3}{2}^-$, $L = 3$, $\beta_L = 0.17$.
[e] If $L = 2$.
[f] (1974DE46) report excitation of s state with $E_x = 5.63$ MeV, $J^\pi = \frac{5}{2}^-$, $L = 3$, $\beta_L = 0.33$.
[g] $J^\pi = \frac{5}{2}^+$.
[h] $J^\pi = \frac{3}{2}^-$ or $(\frac{1}{2}^-)$.

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

44. (a) ^{19}F(^{3}He, ^{3}He)^{19}F
(b) ^{19}F(^{3}He, ^{6}He)^{16}F $\qquad Q_m = -14.845$

Elastic angular distributions have been measured for $E(^3\text{He}) = 4.0$ to 29 MeV [see (1972AJ02)] and at 16 MeV (1974VE03; also to ^{19}F*(0.20)). The triton reduced width for ^{19}F, derived from a study of reaction (b) at $E(^3\text{He}) = 30.0$ and 40.7 MeV, is 0.021 (1972OH01). See also (1972YO02).

45. (a) ^{19}F(α, α)^{19}F
(b) ^{19}F(α, 2α)^{15}N $\qquad Q_m = -4.0138$
(c) ^{19}F(α, αt)^{16}O $\qquad Q_m = -11.7003$

Angular distributions of elastically scattered α-particles have been measured at $E_\alpha = 19.9$ to 23.3 MeV and at 38 MeV [see (1972AJ02)]. Many inelastic groups have also been studied: see Table 19.22 (1973KR20). The ground state $K^\pi = \frac{1}{2}^+$ rotational band is characterized by $\beta_2 = 0.35$ and $\beta_4 = 0.12$ (1973KR20).

The energy of the γ-ray from $1.35 \rightarrow 0.11$ transition is 1235.8 ± 0.2 keV. Using $E_x = 109.894 \pm 0.005$ keV for the energy of the first excited state, E_x for ^{19}F* is then 1345.7 ± 0.2 keV (1967WA13). At $E_\alpha = 12.7$ MeV, a state at 4.648 MeV is populated which is then observed to γ-decay to the $\frac{9}{2}^+$ state at 2.78 MeV. The angular distribution of the cascade γ-rays and the lifetime of ^{19}F*(4.65), set $J^\pi = \frac{13}{2}^+$ for ^{19}F*(4.65) (1969JA09). See also (1971BE60, 1972BA1R). For reactions (b) and (c) at $E_\alpha = 60.2$ MeV, see (1972CH18).

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

Elastic angular distributions have been reported for both reactions at $E(\text{Li}) = 20$ MeV (1969BE90) and 34 MeV (1975WI30). See also (1972WA31; theor.).

47. (a) ^{19}F(^{10}B, ^{10}B)^{19}F
(b) ^{19}F(^{12}C, ^{12}C)^{19}F

Table 19.22: States of ^{19}F from ^{19}F(α, α') [a]

E_x (MeV ± keV) [b]	L [c]	$\lvert\beta_L\rvert$	J^π [d]	$\lvert M\rvert^2\downarrow$ (W.u.)
0				
0.11	1			
0.20	2	(≈ 0.3)		(≈ 2.9)
1.35	3	0.242		1.93
1.46	1			
1.55	2	0.359		4.16
2.783 ± 20	4	0.175		1.07
3.91	2	0.081	$\frac{3}{2}^+$	0.21
4.00	(3)			
4.03	(5)			
4.398 ± 20	4	0.068		0.16
4.551 ± 20	2	0.149		0.71
4.56				
4.647 ± 20	(6)			
4.677 ± 20	(3)			
5.113 ± 20	3	0.126	$\frac{5}{2}^-$	0.52
5.349 ± 20				
5.431 ± 20	3	0.325		3.48
5.482 ± 20	4	0.122		0.052
5.494 ± 20	2	0.075		0.024
5.555 ± 20	2	0.072	$\frac{5}{2}^+$	0.017
5.630 ± 20	3	0.267	$\frac{5}{2}^-$	2.36

[a] (1973KR20): $E_\alpha = 25$ MeV.

[b] Energies are nominal unless uncertainty is indicated. Authors state accuracy of E_x is in range $\pm 8 \rightarrow 20$ keV.

[c] If L is in parentheses, fit DWBA was not possible: value of L shown is that implied by the selection rules for one-step excitation.

[d] Only those J^π determined by (1973KR20).

For reaction (a) see (1971KN05). For reaction (b) see (1969VO10, 1972SC03; $E(^{19}F) = 40$, 60 and 68.8 MeV). See also (1973BR1C, 1975GR41, 1975VO1B, 1977BA3E, 1977PE1J).

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

For reaction (a) see (1972AJ02). The elastic scattering has been studied at $E(^{15}N) = 23$, 26 and 29 MeV by (1973GA14). See also (1975VO1B).

49. (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 $E(^{16}O) = 21.4$ and 25.8 MeV (1975MO31) and at $E(^{19}F) = 27$, 30, 33 and 36 MeV (reaction (a)) [also to $^{19}F^*(1.46)$ at the two higher energies] and at 27, 30 and 33 MeV (reaction (b)) (1973GA14). See also (1973VO1E, 1975VO1B) and (1976OH03, 1977SC1K; theor.).

50. $^{19}F(^{20}Ne, ^{20}Ne)^{19}F$

See (1972AJ02).

51. $^{19}Ne(\beta^+)^{19}F$ $Q_m = 3.2383$

See ^{19}Ne.

52. $^{20}Ne(\gamma, p)^{19}F$ $Q_m = -12.8447$

See (1972AJ02) and ^{20}Ne here.

53. $^{20}Ne(n, d)^{19}F$ $Q_m = -10.6200$

See (1976KI1D).

54. ^{20}Ne(d, ^{3}He)^{19}F $\qquad Q_{\rm m} = -7.3515$

At $E_{\rm d} = 52$ MeV, ^{3}He groups are observed, and angular distributions are reported, corresponding to states at $E_{\rm x} = 0.15 \pm 0.04$, 1.51 ± 0.03, 2.83 ± 0.04 ($l = 4$), 3.99 ± 0.07, 4.56 ± 0.02 ($l = 1$), 5.44 ± 0.05, 5.69 ± 0.07 ($l = 1$), 6.10 ± 0.03, 6.78 ± 0.02 ($l = 1$) and 10.42 ± 0.15 MeV (1970KA31). See also (1971IN1C) and (1972EN03, 1973EL07, 1973SA1A; theor.).

55. ^{20}Ne(t, α)^{19}F $\qquad Q_{\rm m} = 6.9694$

Observed α-groups are displayed in Table 19.23 where spectroscopic factors are compared with those of analog states in n^{19}Ne (1961SI03, 1974GA28). For $\tau_{\rm m}$ of ^{19}F*(4.65) see Table 19.10 (1969BH01).

56. ^{21}Ne(n, t)^{19}F $\qquad Q_{\rm m} = -11.124$

Not reported.

57. ^{21}Ne(p, ^{3}He)^{19}F $\qquad Q_{\rm m} = -11.888$

At $E_{\rm p} = 45$ MeV, ^{3}He groups are observed to some $T = \frac{1}{2}$ states in ^{19}F and to the $\frac{3}{2}^{+}$, $T = \frac{3}{2}$ analog of ^{19}O*(0.095): $E_{\rm x} = 7.660 \pm 0.035$ MeV (1969HA38). At $E_{\rm p} = 40$ MeV comparison of the ground-state angular distributions in this reaction and in the mirror (p, t) reaction [see reaction 15 in ^{19}Ne] shows a suppression of the $S = 1, T = 0$ component of the (p, ^{3}He) cross section: this is observed to occur for all $T_{\rm Z} = \frac{1}{2}$ nuclei with $A < 40$ (1976NA18).

58. ^{21}Ne(d, α)^{19}F $\qquad Q_{\rm m} = 6.465$

The population of the first three states of ^{19}F has been observed (1952MI54).

59. ^{22}Ne(p, α)^{19}F $\qquad Q_{\rm m} = -1.675$

The parity-non-conserving asymmetry of the 110 keV γ-rays emitted by polarized ^{19}F* nuclei in $\delta = -(1.8 \pm 0.9) \times 10^{-4}$ (1975AD01). See also (1973BR1C, 1976AD1B, 1977AD1C) and (1975BO12, 1976BO38).

60. ^{23}Na(n, n$'\alpha$)^{19}F $\qquad Q_{\rm m} = -10.467$

See (1966WO03).

Table 19.23: States of ^{19}F and ^{19}Ne from ^{20}Ne(t, α) and ^{20}Ne(^{3}He, α)

E_x in ^{19}F (MeV $\pm$ keV)		l_p [a]	J^π	C^2S [a,b]		E_x in ^{19}Ne
(1961SI03)	(1974GA28) [a]			(t, α)	(^{3}He, α)	(MeV)
	0	0	$\frac{1}{2}^+$	0.12	0.20	0
	0.11	1	$\frac{1}{2}^-$	1.7	1.8	0.28
	0.20	2	$\frac{5}{2}^+$	1.6	0.95	0.24
	1.46	1	$\frac{3}{2}^-$	0.30	0.21	1.62
	1.55	2	$\frac{3}{2}^+$	0.31 [c]	0.70	1.54
2.794 ± 15	2.78					
3.917 ± 15	3.91		$\frac{3}{2}^+$	≤ 0.04	≤ 0.1	4.03
	4.00					
4.032 ± 15	4.03					
4.385 ± 15	4.38					
4.563 ± 15	$4.55 + 4.56$	1	$\frac{3}{2}^-$	0.69	0.57	4.55
(4.690 ± 40)	$4.65 + 4.68$					
5.102 ± 15	5.11					
5.343 ± 15						
5.481 ± 15						
5.539 ± 15						
5.628 ± 15						
5.937 ± 20						
6.092 ± 15	6.09	1	$\frac{3}{2}^-$	1.0	1.4	6.01
6.169 ± 30						
6.247 ± 25						
6.501 ± 25						
	6.79	1	$\frac{3}{2}^-$	0.96	1.5	6.74

[a] (1974GA28): $E_t = 20$ MeV. E_x are nominal.
[b] Calculated using finite range and non-local corrections. The (^{3}He, α) results are from (1970GA18). The absolute DWBA normalization factors were 4.6 for (t, α) and 10.2 for (^{3}He, α).
[c] Poor DWBA fit.

^{19}Ne

(Figs. 7 and 8)

GENERAL: (See also (1972AJ02).)

Nuclear models: (1972EN03, 1972NE1B, 1972WE01, 1973DE13, 1977BU05).

Electromagnetic transitions: (1972EN03, 1972LE06, 1973HA53, 1973PE09, 1977BU05).

Special states: (1972EN03, 1972GA14, 1972HI17, 1972NE1B, 1972WE01, 1977BU05, 1977SC08).

Complex reactions involving ^{19}Ne: (1976HI05, 1977BU05).

Astrophsyical questions: (1973CL1E).

Muon capture: (1972MI11).

Pion capture and reactions ‡ *:* (1972EC1A).

Other topics: (1972CA37, 1973DE13, 1973MA1K, 1974RE03, 1975BL1F, 1975SH20, 1977SH13).

Ground state of ^{19}Ne: (1971SH26, 1971TA1A, 1972LE06, 1972VA36, 1973EN1B, 1973ME1E, 1974RE03, 1974SHYR, 1977AN12, 1977BU05).

$\mu_{\text{g.s.}} = -1.887$ nm (1976FU06);

$\mu_{0.239} = -0.74$ nm (1976FU06).

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

The half-life of ^{19}Ne is 17.43 ± 0.06 sec (1962EA02), 17.36 ± 0.06 sec (1968GO10, 1974WI14), 17.219 ± 0.017 sec (1975AZ01). See Table 19.22 in (1972AJ02) for earlier measurements. We adopt $\tau_{1/2} = 17.22 \pm 0.02$ sec. See also (1977VI1D). The decay is principally to ^{19}F$_{\text{g.s.}}$ [$\log ft = 3.237 \pm 0.001$ (1976AL07)]. The allowed nature of the decay to the ground state of ^{19}F sets $J^\pi = \frac{1}{2}^+$ for ^{19}Ne$_{\text{g.s.}}$. A very weak branch is also observed to ^{19}F*(1.55): the branching ratio is $(2.1 \pm 0.3) \times 10^{-3}$% [$\log ft = 5.72 \pm 0.06$]; $E_\gamma = 1356.92 \pm 0.15$ keV for the transition ^{19}F*($1.55 \rightarrow 0.20$) (1976AL07). Other values for this branching ratio are $(8.2 \pm 2.0) \times 10^{-4}$% (1975FR15), $< 3 \times 10^{-3}$% (1974MA31, 1975MAXA). The ratio of $\epsilon_{\text{K}}/\beta^+$ is $(9.6 \pm 0.3) \times 10^{-4}$ (1972LE33).

‡ A γ-ray with $E_\gamma = 275.34 \pm 0.50$ keV is reported by Backenstoss et al. [quoted in (1972EC1A).]. The identification of the γ-ray is not certain (1972EC1A).

Table 19.24: 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, 8, 9, 10, 11, 14, 15
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	3, 4, 8, 9, 10, 14, 15
0.27509 ± 0.13	$\frac{1}{2}^-$	$\frac{1}{2}^-$	$\tau_m = 61.4 \pm 3.0$ psec	γ	3, 4, 8, 14
1.50756 ± 0.3	$\frac{5}{2}^-$	$\frac{1}{2}^-$	$1.4^{+0.5}_{-0.6}$ psec	γ	3, 4, 8, 14
1.5360 ± 0.4	$\frac{3}{2}^+$	$\frac{1}{2}^+$	28 ± 11 fsec	γ	3, 4, 5, 8, 9, 10, 14
1.6156 ± 0.5	$\frac{3}{2}^-$	$\frac{1}{2}^-$	143 ± 31 fsec	γ	3, 4, 8, 14
2.7947 ± 0.6	$\frac{9}{2}^+$	$\frac{1}{2}^+$	140 ± 35 fsec	γ	3, 4, 5, 8, 9, 10, 14, 15
4.0329 ± 2.4	$(\frac{3}{2}, \frac{5}{2})^+$		< 50 fsec	γ	4, 7, 14
4.140 ± 4	$(\frac{9}{2})^-$	$(\frac{1}{2}^-)$	< 0.3 psec	γ	4, 7, 14
4.1971 ± 2.4	$(\frac{7}{2})^-$	$(\frac{1}{2}^-)$	< 0.35 psec	γ	4, 5, 7, 14
4.3791 ± 2.2	$\frac{7}{2}^+$		< 0.12 psec	γ	4, 7, 10, 14
4.549 ± 4	$(\frac{1}{2}, \frac{3}{2})^-$		< 80 fsec	γ	4, 7, 14
4.600 ± 4	$(\frac{5}{2}^+)$		< 0.16 psec	γ	4, 7, 14
4.635 ± 4	$\frac{13}{2}^+$	$\frac{1}{2}^+$	> 1 psec	γ	4, 5, 6, 7, 14
4.712 ± 10	$(\frac{5}{2}^-)$				4, 14
4.783 ± 20					4, 14
5.092 ± 6	$(\frac{5}{2}, \frac{7}{2})^-$			γ	14
5.351 ± 10	$\frac{1}{2}^+$				14
5.424 ± 7	$(\frac{7}{2}^+)$	$\frac{1}{2}^+$			4, 14
5.463 ± 20					14
5.539 ± 9					14
5.832 ± 9					14
6.013 ± 7	$(\frac{3}{2}, \frac{1}{2})^-$				14
6.094 ± 8					14
6.149 ± 20					14
6.289 ± 7					4, 5, 14
6.437 ± 9					14
6.742 ± 7	$(\frac{3}{2}, \frac{1}{2})^-$				5, 14
6.862 ± 7					4, 14
7.067 ± 9					14
(7.178 ± 15)					14

Table 19.24: Energy levels of ^{19}Ne [a] (continued)

E_x (MeV $\pm$ keV)	$J^\pi; T$	K^π	τ or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
7.253 ± 10					14
(7.326 ± 15)					14
(7.531 ± 15)					4, 14
7.616 ± 16	$\frac{3}{2}^+; \frac{3}{2}$				5, 14, 15
7.700 ± 10					14
(7.788 ± 10)					14
7.994 ± 15					14
8.063 ± 15					14
8.236 ± 10 [b]					5, 14
8.440 ± 10					5, 14
8.523 ± 10					14
(8.810 ± 25)					14
8.915 ± 10					5, 14
9.013 ± 10					14
9.100 ± 20					14
9.240 ± 20					14
9.489 ± 25					14
9.886 ± 50 [b]					5, 14
10.407 ± 30 [b]	$\frac{3}{2}^+$		45	p, ^{3}He, α	2, 14
10.46	$\frac{1}{2}^+$		355	p, ^{3}He, α	2
10.613 ± 20					14
11.09 ± 100 [b]					5
11.51	$\frac{3}{2}^-(\frac{1}{2}^-)$		25	^{3}He, α	2
12.23 ± 50	$\frac{5}{2}^+$		200 ± 25	^{3}He, α	2
12.43 ± 50	$\frac{7}{2}^+$		180 ± 25	^{3}He, α	2, 5
12.69 ± 50	$\frac{1}{2}^+$		180 ± 40	p, ^{3}He, α	2
14.17 ± 100					5
14.61 ± 100					5
15.40 ± 100			620 ± 130	γ, ^{3}He	5

[a] See also Tables 19.13 and 19.26.

[b] Broad or unresolved states.

(1977BA08) have studied the triple angular correlation ^{19}F$^+\nu$, and find a preliminary result of $D = (-0.62 \pm 0.88) \times 10^{-3}$, which is consistent with T-invariance and which corresponds to a phase difference between the axial-vector and vector weak coupling constants of $\phi = 180.07 \pm 0.10°$. For an earlier experiment on the existence of second class currents see (1974VA1J, 1975CA28). See also (1972AJ02, 1975CA1F, 1976CA1E, 1976SI1H, 1977BA48) and (1972HO14, 1973LA03, 1973MU1D, 1973WI04, 1973WI11, 1974LE1G, 1974WI1M, 1975CA35, 1977AZ02, 1977HO16, 1977KL1F, 1977KU1E, 1977LE1R; theor.).

2. (a) ^{16}O(^{3}He, γ)^{19}Ne	$Q_m = 8.4434$	
(b) ^{16}O(^{3}He, n)^{18}Ne	$Q_m = -3.196$	$E_b = 8.4434$
(c) ^{16}O(^{3}He, p)^{18}F	$Q_m = 2.0328$	
(d) ^{16}O(^{3}He, ^{3}He)^{16}O		
(e) ^{16}O(^{3}He, α)^{15}O	$Q_m = 4.9140$	
(f) ^{16}O(^{3}He, 2n)^{17}Ne	$Q_m = -22.427$	
(g) ^{16}O(^{3}He, 2α)^{11}C	$Q_m = 5.306$	

The capture cross section at the 2.40 MeV resonance (reaction (a)) is $< 0.8\ \mu$b (1959BR79). Studies of the excitation functions for reactions (c) and (e) [α_0, $p_{1+2+3+4}$, p_5, p_6, p_7] for $E(^3\text{He}) = 2.0$ to 3.0 MeV are interpreted in terms of two resonances at $E(^3\text{He}) = 2.400$ and 2.425 MeV (^{19}Ne*(10.46, 10.48)) with $\Gamma = 355$ and 45 keV, $J^\pi = \frac{1}{2}^+$ and $\frac{3}{2}^+$, respectively (1959BR79, 1961SI09). Studies of the (p_0, p_1, p_5) yields, of the elastic yield (reaction (d)), and the analysis of angular distributions in the range $E(^3\text{He}) = 4.3$ to 5.6 MeV show the presence of a single resonance at $E(^3\text{He}) = 5.05 \pm 0.05$ MeV [^{19}Ne*(12.69)], $\Gamma = 180 \pm 40$ keV, $J^\pi = \frac{1}{2}^+$ (1967RO10). A resonance-like structure is also reported at $E(^3\text{He}) \approx 9.5$ MeV in the yields of neutron groups (reaction (b)) (1970AD02). See also (1976GA27).

The elastic scattering (reaction (d)) and the α_0 yield (reaction (e)) have been studied for $E(^3\text{He}) = 3.2$ to 7.0 MeV by (1972OT01). They report a state at $E_x = 11.51 \pm 0.05$ MeV [$E(^3\text{He}) = 3.65$ MeV] with $J^\pi = \frac{3}{2}^-$ or $(\frac{1}{2}^-)$, $\Gamma_{cm} = 25$ keV. In addition, two states at $E_x = 12.23$ and 12.40 MeV (± 0.05 MeV) [$E(^3\text{He}) = 4.50$ and 4.70 MeV], $J^\pi = \frac{5}{2}^+$ and $\frac{7}{2}^+$, $\Gamma_{cm} = 200$ and 180 keV (± 25 keV) respectively, are indicated by a two-level analysis. An R-matrix analysis seems to indicate additional structure as well (1972OT01). The polarization of elastically scattered ^{3}He has been studied at $E(^3\text{He}) = 18$ MeV (1972MC01). See also (1967LE1C; theor.). The α_0 yield for $E(^3\text{He}) = 4.0$ to 9.0 MeV shows fluctuations which are analyzed with a coherence width of 130 ± 20 keV (1969DA08). These fluctuations continue at least to 11.8 MeV (1969BR07).

For other work on these reactions see (1972AJ02). See also (1974LO1B).

3. ^{16}O(α, n)^{19}Ne	$Q_m = -12.1344$

Lifetime measurements and E_γ measurements are displayed in Tables 19.25 and 19.26 (1970GI09, 1971IT02). See also (1973DE1J, 1975SK1B).

Table 19.25: Excited states of ^{19}Ne from ^{16}O(α, n)^{19}Ne and ^{19}F(p, n)^{19}Ne [a]

E_x (keV)			J^{π} [c]
(1970GI09)	(1971IT02)	(1977LE03)	
238.2 ± 0.2	236.8 ± 0.7		
275.1 ± 0.2	273.9 ± 0.7		
1507.9 ± 0.4	1506.1 ± 0.8 [b]	1507.8 ± 0.6	$\frac{5}{2}^-$
1536.3 ± 0.5	1534.7 ± 0.7 [b]	1536.6 ± 0.6	$\frac{3}{2}^+$
1615.5 ± 0.7		1615.7 ± 0.6	$\frac{3}{2}^-$
2794.6 ± 1.5		2794.7 ± 0.6	$\frac{9}{2}^+$

[a] See also Table 19.24 in (1972AJ02).
[b] Observed via $E_\gamma = 1232.2 \pm 0.2$ and 1297.9 ± 0.4 keV (transitions $1.51 \to 0.28$ and $1.54 \to 0.24$, respectively) (1971IT02).
[c] (1970GI09).

4. ^{16}O(^{6}Li, t)^{19}Ne $\quad Q_m = -7.351$

This reaction (and its mirror reaction ^{16}O(^{6}Li, ^{3}He)^{19}F) have been studied at $E(^6\text{Li}) = 24$ MeV (1971BI06, 1972GA08) and 35 and 36 MeV (1972PA29). Observed states are displayed in Table 19.13. The population of states at $E_x = 4.593 \pm 0.006$, 4.71, 4.78 and 5.09 MeV, in addition to states previously reported in this reaction has been observed by (1973BI02). For excitation functions see (1973BI07) and (1978EN06). See also (1976WO1C, 1977MA2G), (1972BA1P, 1973FO1A) and (1973ST1D; theor.).

5. ^{16}O(^{10}B, ^{7}Li)^{19}Ne $\quad Q_m = -9.344$

This reaction, as well as the analog reaction [^{16}O(^{10}B, ^{7}Be)^{19}F], have been studied at $E(^{10}\text{B}) = 100$ MeV. On the basis of similar yields and E_x and in addition to the low-lying analogs it is suggested that the following pairs of states are analogs in ^{19}F–(^{19}Ne): 8.98 (8.94), 11.33 (11.09), 12.79 (12.48), 14.15 (14.17), 14.99 (14.61) and 15.54 (15.40) [± 100 keV]: however, problems of energy resolution are evident (1976HA06).

6. ^{16}O(^{12}C, ^{9}Be)^{19}Ne $\quad Q_m = -11.4297$

At $E(^{12}\text{C}) = 114$ MeV, ^{19}Ne*(4.64) [$J^\pi = \frac{13}{2}^+$] is relatively strongly populated (1971SC1F, 1972SC21).

Table 19.26: Radiative decay of ^{19}Ne levels

E_i (MeV)	J^π_i	E_f (MeV)	J^π_f	Branch (%)	τ_m	Γ_γ [a] (meV)	Refs.
0.24	$\frac{5}{2}^+$	0	$\frac{1}{2}^+$	100	26.6 ± 1.2 nsec		(1967BE14)
					25.5 ± 1.0 nsec		(1969BL02)
0.28	$\frac{1}{2}^-$	0	$\frac{1}{2}^+$	(100) [b]	61.4 ± 3.0 psec		(1970BH02)
1.51	$\frac{5}{2}^-$	0	$\frac{1}{2}^+$	< 3			(1970GI09)
		0.24	$\frac{5}{2}^+$	12 ± 3			(1970GI09)
		0.28	$\frac{1}{2}^-$	88 ± 3	$4.1^{+3.5}_{-1.4}$ psec	0.17 ± 0.08	(1970GI09)
					$1.4^{+0.5}_{-0.6}$ [A] psec [d]		(1971IT02)
1.54	$\frac{3}{2}^+$	0	$\frac{1}{2}^+$	< 6			(1970GI09)
		0.24	$\frac{5}{2}^+$	95 ± 3	28 ± 15 fsec	24^{+27}_{-8}	(1970GI09)
					28^{+18}_{-16} fsec [d]		(1971IT02)
		0.28	$\frac{1}{2}^-$	5 ± 3			(1970GI09)
1.62	$\frac{3}{2}^-$	0	$\frac{1}{2}^+$	20 ± 3	180 ± 60 fsec	$3.7^{+1.8}_{-0.9}$	(1970GI09)
					130 ± 35 fsec		(1977LE03)
		0.24	$\frac{5}{2}^+$	10 ± 3			(1970GI09)
		0.28	$\frac{1}{2}^-$	70 ± 4			(1970GI09)
2.79	$\frac{9}{2}^+$	0	$\frac{1}{2}^+$	< 10			(1970GI09)
		0.24	$\frac{5}{2}^+$	100	330 ± 130 fsec	$2.0^{+1.3}_{-0.6}$	(1970GI09)
					140 ± 35 fsec [A]		(1977LE03)
		0.28	$\frac{1}{2}^-$	< 10			(1970GI09)
		1.51	$\frac{5}{2}^-$	< 12			(1970GI09)
		1.54	$\frac{3}{2}^+$	< 10			(1970GI09)
		1.62	$\frac{3}{2}^-$	< 10			(1970GI09)
4.03	$(\frac{3}{2}, \frac{5}{2})^+$	0	$\frac{1}{2}^+$	80 ± 15	< 50 fsec		(1973DA31)
		0.28	$\frac{1}{2}^-$	5 ± 5			(1973DA31)
		1.54	$\frac{3}{2}^+$	15 ± 5			(1973DA31)
4.14	$(\frac{9}{2})^-$	1.51	$\frac{5}{2}^-$	100	< 0.3 psec		(1973DA31)
4.20	$(\frac{7}{2})^-$	0.24	$\frac{5}{2}^+$	20 ± 5			(1973DA31)
		1.51	$\frac{5}{2}^-$	80 ± 5	< 0.35 psec		(1973DA31)
4.38	$\frac{7}{2}^+$	0.24	$\frac{5}{2}^+$	85 ± 4	< 0.12 psec		(1973DA31)
		2.79	$\frac{9}{2}^+$	15 ± 4			(1973DA31)

Table 19.26: Radiative decay of ^{19}Ne levels (continued)

E_i (MeV)	J^π_i	E_f (MeV)	J^π_f	Branch (%)	τ_m	Γ_γ [a] (meV)	Refs.
4.55	$(\frac{1}{2}, \frac{3}{2})^-$	0	$\frac{1}{2}^+$	35 ± 25			
					< 80 fsec		(1973DA31)
		0.28	$\frac{1}{2}^-$	65 ± 25			
4.60	$(\frac{5}{2}^+)$	0.24	$\frac{5}{2}^+$	90 ± 5	< 0.16 psec		(1973DA31)
		1.54	$\frac{3}{2}^+$	10 ± 5			(1973DA31)
4.64	$\frac{13}{2}^+$	2.79	$\frac{9}{2}^+$	100	> 1 psec		(1973DA31)
5.09 [c]	$(\frac{5}{2}, \frac{7}{2})^-$						(1973DA31)

A = adopted.

[a] Total Γ_γ.

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

[c] Decay not certain: possibly to ^{19}Ne*(0.24, 1.62).

[d] See also (1977LE03).

7. ^{17}O(^{3}He, n)^{19}Ne $\qquad Q_m = 4.299$

Neutron-γ coincidence measurements lead to the determination of excitation energies [$E_x = 4032.9 \pm 2.4, 4140 \pm 4, 4197.1 \pm 2.4, 4379.1 \pm 2.2, 4549 \pm 4, 4605 \pm 5, 4635 \pm 4$ and (5097 ± 10) keV], τ_m and branching ratios (see Table 19.26). 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*(4.558, 4.555) [$J^\pi = \frac{5}{2}^+, \frac{3}{2}^-$]: these assignments disagree with the reports from the ^{16}O(^{6}Li, t)^{19}Ne reaction [see reaction 4 and Table 19.13]. There is no evidence for a reported state at $E_x = 4.78$ MeV [see, however, reactions 4 and 14] (1973DA31).

8. ^{19}F(p, n)^{19}Ne $\qquad Q_m = -4.0207$

For a review of the threshold measurements see (1972AJ02, 1976FR13). Excited states of ^{19}Ne determined from γ-spectra are displayed in Table 19.25: for τ_m and branching ratio measurements see Table 19.26 (1970GI09, 1971IT02, 1977LE03). Earlier neutron measurements are displayed in Table 19.24 of (1972AJ02). The g-factor of ^{19}Ne*(0.24) $= -0.296 \pm 0.003$ (1969BL02). See also (1974DE1N).

9. ^{19}F(^{3}He, t)^{19}Ne $\qquad Q_{\rm m} = -3.2570$

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

10. ^{19}F(^{6}Li, ^{6}He)^{19}Ne $\qquad Q_{\rm m} = -6.748$

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

11. ^{20}Ne(γ, n)^{19}Ne $\qquad Q_{\rm m} = -16.8653$

See (1975WO06) and ^{20}Ne.

12. ^{20}Ne(p, d)^{19}Ne $\qquad Q_{\rm m} = -14.6407$

See (1972AJ02).

13. ^{20}Ne(d, t)^{19}Ne $\qquad Q_{\rm m} = -10.6080$

See (1971IN1C; unpublished thesis).

14. ^{20}Ne(^{3}He, α)^{19}Ne $\qquad Q_{\rm m} = 3.7125$

Alpha groups have been observed to ^{19}Ne states with $E_{\rm x} < 10.6$ MeV: see Tables 19.23 and 19.27. Angular distributions have been measured for $E(^3{\rm He}) = 10$ to 35 MeV: see (1972AJ02). DWBA analysis of the strongest transitions leads to the l and J^π values shown in Table 19.27. Relative spectroscopic factors were also extracted. ^{19}Ne*(0, 0.24, 1.54, 2.79) are identified as members of the $K = \frac{1}{2}^+$ rotational band [with ^{19}Ne*(4.38) as the $\frac{7}{2}^+$ member: see, however, Table 19.13] and ^{19}Ne*(0.28, 1.51, 1.62) with $K = \frac{1}{2}^-$ band. Candidates for the $\frac{7}{2}^-$ and $\frac{9}{2}^-$ members of the $K = \frac{1}{2}^-$ band are thought to be ^{19}Ne*(4.15, 4.20). Possible matching of other ^{19}Ne states with those in ^{19}F is also discussed (1970GA18). For lifetime and radiative decay measurements see Table 19.26.

Table 19.27: ^{19}Ne levels from ^{20}Ne(^{3}He, α)^{19}Ne [a]

E_x (MeV ± keV)		l_n [c]	J^{π} [d]	C^2S [e]
(1970GA18)	(1972HA03) [b]			
0		0	$\frac{1}{2}^+$	0.12
0.238 ± 10	0.2397 ± 2 [g,h]	2	$\frac{5}{2}^+$	1.04
0.273 ± 10	0.2766 ± 2 [g,h]	1	$\frac{1}{2}^-$	1.96
	1.5040 ± 3 [g]		$(\frac{5}{2}^-)$	
1.524 ± 20				
	1.5324 ± 3 [g]	2	$(\frac{3}{2})^+$	0.73
1.615 ± 10	1.6115 ± 3 [g]	1	$(\frac{3}{2})^-$	0.21
2.793 ± 10	2.7917 ± 3	4, 5 [j]	$(\frac{9}{2}^+)$ [j]	
4.036 ± 10		2	$(\frac{3}{2}, \frac{5}{2})^+$	
4.142 ± 10 [f]				
4.200 ± 10				
4.379 ± 10				
4.551 ± 10		1	$(\frac{1}{2}, \frac{3}{2})^-$	
4.625 ± 10				
4.712 ± 10				
4.783 ± 20				
5.093 ± 10	5.086 ± 10			
5.351 ± 10		0	$\frac{1}{2}^+$	0.01
5.426 ± 10	5.423 ± 10			
5.463 ± 20				
5.545 ± 10	5.517 ± 20			
5.831 ± 10	5.837 ± 20			
6.012 ± 10	6.014 ± 10	1	$(\frac{3}{2}, \frac{1}{2})^-$	(3.62)
6.089 ± 10	6.104 ± 15			
6.149 ± 20				
6.290 ± 10	6.289 ± 10			
6.433 ± 20	6.438 ± 10			
6.774 ± 10	6.741 ± 10	1	$(\frac{3}{2}, \frac{1}{2})^-$	
6.866 ± 10	6.858 ± 10			
7.064 ± 20	7.068 ± 10			
	(7.178 ± 15)			
	7.253 ± 10			

Table 19.27: ^{19}Ne levels from ^{20}Ne(^{3}He, α)^{19}Ne [a] (continued)

E_x (MeV ± keV)		l_n [c]	J^π [d]	C^2S [e]
(1970GA18)	(1972HA03) [b]			
	(7.326 ± 15)			
	(7.531 ± 15)			
	7.614 ± 20			
	7.700 ± 10			
	(7.788 ± 10)			
	7.994 ± 15			
	8.063 ± 15			
	8.236 ± 10 [i]			
	8.440 ± 10			
	8.523 ± 10			
	(8.810 ± 25)			
	8.915 ± 10			
	9.013 ± 10			
	9.100 ± 20			
	9.240 ± 20			
	9.489 ± 25			
	9.886 ± 50 [i]			
	10.407 ± 30 [i]			
	10.613 ± 20			

[a] See also Table 19.25 in (1972AJ02).

[b] See also (1971HA2F).

[c] (1970GA18).

[d] (1967OL05, 1970GA18).

[e] (1970GA18, 1972EN03).

[f] 4.152 ± 15 (1967GR04), 4.160 ± 20 (1967OL05).

[g] The energy separations within each multiplet are fixed at the values determined by (1968GU07).

[h] 238.4 and 274.8 ± 0.3 keV (1967OL05), 238.34 ± 0.15 and 275.30 ± 0.2 keV (1970BH02).

[i] Unresolved states.

[j] (1969BA62).

15. ^{21}(p, t)^{19}Ne $\qquad Q_m = -15.145$

At $E_p = 45$ MeV triton groups are observed corresponding to ^{19}Ne*(0, 0.24, 2.79, 4.03, 7.620 ± 0.025). The latter has an angular distribution [$L = 0$] 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 tritons to that state should be 2 (1969HA38). At $E_p = 40$ MeV the ground-state angular distributions in this, and in the (p, ^{3}He) mirror reaction, have been compared: see ^{19}F (1976NA18).

^{19}Na

(Fig. 8)

This nucleus has been observed in the ^{24}Mg(p, ^{6}He)^{19}Na reaction (1969CE01; $E_p = 54.7$ MeV) and in the ^{24}Mg(^{3}He, ^{8}Li)^{19}Na reaction (1975BE38; $E(^3\text{He}) = 76.3$ MeV). The latter experiment leads to an atomic mass excess of 12.928 ± 0.012 MeV for ^{19}Na in its ground state. In addition, an excited state is observed at $E_x = 120 \pm 10$ keV (1975BE38). Assuming the atomic mass excess listed above, ^{19}Na(0) is unstable with respect to breakup into ^{18}Ne+p by 320 ± 13 keV. See also (1972CE1A, 1976BE1L, 1976JA23), (1975BE31, 1977SH13; theor.) and (1972AJ02).

^{19}Mg

(Not illustrated)

^{19}Mg has not been observed: for estimates of its mass excess see (1976WA18).

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(Closed 01 November 1977)

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

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