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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*190 (1972), p. 1. This version of $A = 19$ differs from the published version in that we have corrected some errors discovered after the article went to press. Figures and introductory tables have been omitted from this manuscript. Reference key numbers have been changed to the NNDC/TUNL format.

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Table of Contents for $A = 19$

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

^{19}C

(Not illustrated)

^{19}C may have been observed in the 3 GeV proton bombardment of a ^{197}Au target: if so it is particle stable (1970RA1A). Its mass excess must then be < 37.9 MeV (^{18}C + n). See also (1960ZE03, 1971BU1E).

^{19}N

(Not illustrated)

^{19}N has been observed in the 3 GeV proton bombardment of a ^{197}Au target: it is particle stable (1968TH04). See also (1969AR13, 1970AR1D). The mass excess of ^{19}N is $15.01 < (M - A) < 18.68$ MeV (1970WA1G). See also (1960ZE03, 1961BA1C, 1962GO31, 1966GA25, 1969ST07).

^{19}O

(Figs. 5 and 8)

GENERAL: (See also (1959AJ76).)

Shell model: (1957WI1E, 1959BR1E, 1960TA1C, 1962SH1B, 1962TA1B, 1963PA03, 1964CO24, 1964IN03, 1965FE02, 1966AR10, 1966IN01, 1966LA1E, 1967BO09, 1967EN01, 1967FE01, 1967FL13, 1967IN03, 1967PI1B, 1968AR02, 1968CO1N, 1968EL1C, 1968GU1E, 1968HA17, 1968HA1P, 1968MO1G, 1969FE1A, 1969HO32, 1969KU1G, 1969MA1T, 1970TA1J, 1971AR25, 1971WI01).

Cluster, collective and deformed models: (1963CH02, 1965FE02, 1969FE1A).

Astrophysical questions: (1970BA1M).

Electromagnetic transitions: (1963CH02, 1965FE02, 1967FE01, 1967IN03, 1968EL1C, 1968HA17, 1971AR25).

Special levels: (1959LA1A, 1960GO1C, 1967EN01, 1967PR04, 1968AR02, 1968CO1N, 1968HA1P, 1968YA03, 1969FE1A).

Other theoretical topics: (1964IN03, 1965FO1D, 1967FL13, 1968CO1N, 1968GU1E, 1968MO1G, 1968MU1B, 1968PA1Q, 1968SU1C, 1969MA1T, 1971LA1D, 1971LE1H).

Ground state properties: (1964ST1B, 1968EL1C, 1971AR25, 1971WI01).

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

The half-life of ^{19}O is 29.12 ± 0.26 sec (1962MA38), 27.2 ± 0.3 sec (1965BO42), 26.76 ± 0.08 sec (1967YU01), 27.1 ± 0.1 sec (1970AL21): the weighted mean of the last three values is 26.91 ± 0.08 sec. The decay is complex: see ^{19}F.

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, 3, 8, 11, 12
0.0960 ± 0.5	$\frac{3}{2}^+$	$\tau_m = 1.98 \pm 0.06$ nsec	γ	2, 3, 8, 12
1.4717 ± 0.4	$\frac{1}{2}^+$	$\tau_m = 1.13 \pm 0.14$ psec	γ	2, 3, 8, 12
2.3711 ± 1.0	$(\frac{9}{2})$	$\tau_m \geq 1$ psec	γ	3, 8
2.7787 ± 0.8	$(\frac{7}{2}^+)$	$\tau_m = 93 \pm 19$ fsec	γ	3, 8
3.0671 ± 2.6	$(\frac{3}{2}^+, \frac{5}{2}^+, \frac{7}{2}^+)$	$\tau_m \geq 1$ psec	γ	3, 8
3.1545 ± 2.0	$\frac{5}{2}^+$	$\tau_m \geq 1$ psec	γ	3, 8
3.235 ± 4	$\frac{1}{2}^+$		γ	8
3.9453 ± 2.5	$(\frac{1}{2}^-)$		γ	3, 8
4.116 ± 4	$(\frac{3}{2}, \frac{5}{2})^+$	$\Gamma < 15$ keV		3, 8
4.333 ± 12		< 15		8
4.400 ± 9		< 15		3, 8
4.583 ± 8	$\frac{3}{2}^-$	53 ± 3	γ, n	4, 5, 8
4.707 ± 12	$\frac{5}{2}^+$	< 15		3, 8
4.998 ± 12		< 15		3, 8
5.086 ± 10	$\frac{1}{2}^-$	49 ± 5	n	5
5.149 ± 7	$\frac{3}{2}$	3.4 ± 1.0	n	3, 5, 8
5.455 ± 9	$\frac{5}{2}^+$	330 ± 40	n	5, 8
5.502 ± 12		< 15		3, 8
5.53	$(\frac{1}{2}^-)$	380 ± 100	n	5
5.706 ± 8	$\frac{3}{2}$	7.8 ± 1.4	n	5, 8
6.13	$\frac{3}{2}^+$	150 ± 40	n	5
6.20	$\frac{1}{2}^-$	140 ± 40	n	5
6.276 ± 7	$\frac{7}{2}^-$	19.2 ± 2.4	n	5, 8
6.480 ± 15			(n)	5, 8
6.560 ± 15				8
6.899 ± 15				8
6.997 ± 15				8
7.117 ± 15				8
7.248 ± 15				8
11.25 ± 50		240	n, α	7
11.58 ± 50		330	n, α	7

[a] See also Table 19.5.

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

^{19}O* (MeV)	τ_m	Reaction	Refs.
0.096 [a]	1.75 ± 0.3 nsec	^{18}O(d, p)	(1959ZI16)
	1.89 ± 0.2 nsec	^{9}Be(^{18}O, ^{8}Be)	(1969NI09)
	2.00 ± 0.07 nsec	^{18}O(d, p)	(1965MC10)
	1.98 ± 0.06 nsec		mean
1.472 [b]	1.80 ± 0.29 psec	^{17}O(t, p), ^{18}O(d, p)	(1971BR02)
	1.22 ± 0.36 psec	^{18}O(d, p)	(1971MC11)
	0.90 ± 0.23 psec	^{17}O(t, p), ^{18}O(d, p)	(1971HI06, 1971HIZF)
	1.27 ± 0.2 psec		A
	1.13 ± 0.14 psec		mean of last three values
2.37	≥ 1 psec	^{17}O(t, p), ^{18}O(d, p)	(1971BR02)
	> 3.5 psec	^{17}O(t, p), ^{18}O(d, p)	(1971HI06, 1971HIZF)
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, 1971HIZF)
3.07 [c]	≥ 1 psec	^{17}O(t, p), ^{18}O(d, p)	(1971BR02)
3.16 [c]	≥ 1 psec	^{17}O(t, p), ^{18}O(d, p)	(1971BR02)

A: E.K. Warburton, private communication.

[a] See also (1965AL13, 1967WA1C).

[b] See also (1965MC10, 1969NI09).

[c] See also (1971HIZF).

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

The lifetimes of the excited states of ^{19}O at 95.1 ± 0.1 and 1468 keV are, respectively, $\tau_m = 1.89 \pm 0.2$ nsec and 18 ± 10 psec (1969NI09): see, however, Table 19.2. $|M|^2$ values are also listed. See also (1968FA04, 1970BA1Y, 1970FA01, 1971KN05).

3. ^{17}O(t, p)^{19}O $\quad\quad Q_m = 3.521$

Proton groups corresponding to ^{19}O states with $E_x < 5.6$ MeV have been observed by (1964MO24, 1965MO19: $E_t = 5.55$ MeV) and (1965WI1B, 1966WI05: $E_t = 12.0$ MeV): level parameters and L values derived from angular distribution analyses are displayed in Table 19.3. Excitation energies from E_γ measurements, and lifetime measurements are reported in Tables 19.3 and 19.2, respectively (1971BR02, 1971HI06).

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

E_x (MeV ± keV)											Γ [e] (keV)	l_n a,e,f	L b,e,f	J^π
(1961AR06) a	(1961SJ01) a	(1963YA03) a	(1964EL1A) a	(1964MO24, 1965MO19) b	(1965MO16) a	(1971BR02) c,d	(1965WI1B, 1966WI05) a,b	(1969FI07) a	(1969FI07, 1970FI08) c	(1971HI06) c,d				
0	0	0 [h]	0	0	0		0	0				2	0	$\frac{5}{2}^+$
	0.098 ± 6		0.095 ± 10	0.093 ± 10	0.097 ± 10	0.096 ± 2	0.096 ± 12	0.097 ± 4	0.097 ± 2 [i]			2	2	$\frac{3}{2}^+$
			0.348 ± 10											
	(1.257 ± 30)													
1.469 ± 11	1.469 ± 28	1.468 ± 15	1.467 ± 10	1.468 ± 10	1.468 ± 10	1.470 ± 2	1.467 ± 12	1.468 ± 4	1.470 ± 3 [j]	1.4719 ± 0.5		0	(2)	$\frac{1}{2}^+$
	2.353 ± 29		2.371 ± 10	2.367 ± 10		2.367 ± 4	2.373 ± 12	2.370 ± 5	2.369 ± 4	2.3715 ± 1.0		2	(2)	$(\frac{3}{2}^+)$ [m]
		2.612 ± 15	2.617 ± 10											
	2.765 ± 30		2.794 ± 10	2.775 ± 10		2.774 ± 4 [(2.794 ± 3)]	2.779 ± 12	2.780 ± 5	2.777 ± 3	2.7790 ± 0.9			2	$\frac{9}{2}^+$ [m]
	(3.047 ± 30)			3.061 ± 10	3.064 ± 10	3.066 ± 3	3.070 ± 12	3.070 ± 5					(2)	$(\frac{3}{2}^+, \frac{5}{2}^+, \frac{7}{2}^+)$
3.164 ± 30	3.144 ± 29	3.171 ± 15	3.161 ± 10	3.153 ± 10	3.155 ± 10	3.150 ± 3	3.156 ± 12	3.160 ± 5	3.157 ± 3			2	0	$\frac{5}{2}^+$
			3.243 ± 10	3.223 ± 15	3.233 ± 15		3.229 ± 12	3.237 ± 5				0 [l]		$\frac{1}{2}^+$
	(3.791 ± 31)													
3.948 ± 30	3.942 ± 30	3.942 ± 15	3.953 ± 10	3.946 ± 15	4.055 ± 15		3.945 ± 12	3.951 ± 6	3.944 ± 3			1	k	$(\frac{1}{2}^-)$
(4.123 ± 40)	4.109 ± 20	4.111 ± 15	4.116 ± 10	4.107 ± 15			4.111 ± 12	4.118 ± 5			< 15	2	2	$(\frac{3}{2}, \frac{5}{2})^+$
				(4.328 ± 15)			4.333 ± 12				< 15			
			4.421 ± 10	4.396 ± 15			4.402 ± 12				< 15		k	
(4.586 ± 40)			4.599 ± 10				4.584 ± 12				75 ± 15			
(4.706 ± 40)			4.725 ± 10				4.707 ± 12				< 15		0	$\frac{5}{2}^+$
			4.954 ± 10				4.998 ± 12				< 15		k	
			5.107 ± 10											
(5.165 ± 40)		5.153 ± 15	5.172 ± 10				5.148 ± 12				< 15		0	$\frac{5}{2}^+$
		5.447 ± 15					5.460 ± 12				310 ± 30	(2)		
5.45 [g]							5.502 ± 12				< 15		k	
			5.582 ± 10											
5.707 ± 35		(5.708 ± 15)					5.714 ± 12				< 15	k		
6.279 ± 30		6.282 ± 15					6.280 ± 12				< 15	(3)		
		6.480 ± 15												
		6.560 ± 15												
		6.899 ± 15												
		6.997 ± 15												
		7.117 ± 15												
		7.248 ± 15												

[a] ^{18}O(d, p)^{19}O: proton spectra measurements. [b] ^{17}O(t, p)^{19}O: proton spectra measurements. [c] ^{18}O(d, p)^{19}O: γ-ray measurements. [d] ^{17}O(t, p)^{19}O: γ-ray measurements. [e] (1965WI1B, 1966WI05).

[f] See also (1961AR06, 1963YA03, 1964MO24, 1965MO16, 1965MO19, 1969FI07). [g] Unresolved. [h] Observed but group was weak.

[i] Other values for this level are $E_x = 96 \pm 11$ (1959AJ76), 96 ± 6 (1961JA23), 95 ± 2 (1963GI12) and 96.0 ± 0.5 keV (1971MC11). [j] (1971MC11) find $E_x = 1472 \pm 1$ keV. [k] Angular distribution for l_n or L not obtained.

[l] See also (1969FI07). [m] See however (1971HI06).

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

E_{res} (MeV $\pm$ keV)	$\Gamma_{c.m.}$ (keV)	^{19}O* (MeV)	J^π	Refs.
0.661 ± 10	52 ± 3	4.583	$\frac{3}{2}^-$	(1964DO08, 1965VA03)
1.192 ± 10	49 ± 5	5.086	$\frac{1}{2}^-$	(1964DO08, 1965VA03)
1.256 ± 10	3.4 ± 1.0	5.146	$\frac{3}{2}$	(1965VA03)
1.56	470 ± 80	5.43	$\frac{5}{2}^+$	(1964DO08, 1965VA03)
1.66	380 ± 100	5.53	$(\frac{1}{2}^-)$	(1964DO08)
1.840 ± 10	7.8 ± 1.4	5.699	$\frac{3}{2}$	(1965VA03)
2.30	150 ± 40	6.13	$\frac{3}{2}^+$	(1964DO08, 1965VA03)
2.37	140 ± 40	6.20	$\frac{1}{2}^-$	(1964DO08, 1965VA03)
2.445 ± 10	19.2 ± 2.4	6.272	$\frac{7}{2}^-$	(1964DO08, 1965VA03)
≈ 2.58		(6.40)		(1965SA24)
(2.63)		(6.45)		(1965SA24)

[a] See also (1959SC30, 1965SA24) for evidence of additional structures.

4. ^{18}O(n, γ)^{19}O $\qquad Q_m = 3.957$

In the energy interval $E_n = 0.2$ to 1.0 MeV, the capture cross section displays a resonance at $E_n \approx 0.6$ MeV (1964VA02). Astrophysical considerations are discussed by (1968FOZY, 1970CL1C).

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

The coherent scattering amplitude (bound) is $a = 6.00$ fm (1969BA1P). 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) 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 (1965SA24)] the total cross section shows additional structures. At $E_n = 14.1$ MeV, $\sigma_t = 1610 \pm 70$ mb (1969ME15). See also (1964EX1A) and ^{18}O.

6. ^{18}O(n, d)^{17}N $\qquad Q_m = -13.718 \qquad E_b = 3.957$

See (1964AM02).

7. ^{18}O(n, α)^{15}C $\quad Q_m = -5.009 \quad E_b = 3.957$

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). See also (1964GA1A).

8. ^{18}O(d, p)^{19}O $\quad Q_m = 1.732$

$Q_0 = 1.734 \pm 0.010$ (1965MO16);

$Q_0 = 1.727 \pm 0.008$ (1967SP09).

Angular distributions of proton groups have been measured at $E_d = 0.8$ MeV (1957SJ66), 5 MeV (1969FI07), 5.56 MeV (1964MO25, 1965MO16), 7.0 MeV (1964WI05), 10 MeV (1964EL1A), 12 MeV (1965WI1B, 1966WI05, 1971FO18), 12.3 MeV (1965LU1A), 14.95 MeV (1963YA03) and 15 MeV (1961AR06). l_n values derived from these measurements, as well as other level parameters for ^{19}O states below $E_x = 7.3$ MeV, are displayed in Table 19.3. See also (1959AJ76) and reaction 23 in ^{19}F.

Branching ratios for the decays of ^{19}O*(0.096, 1.47, 2.37, 2.78, 3.16, 3.95) are shown in Table 19.5 (1965AL13, 1969FI07, 1970FI08, 1971BR02, 1971HI06, 1971MC11). Angular correlation measurements 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). These assignments are also consistent with the lifetime measurements for these two states shown in Table 19.2 (1959ZI16, 1965MC10, 1971BR02, 1971HI06, 1971MC11). Measurement of the internal conversion coefficient for the 0.096 MeV transition shows that it is M1 (1963GI12).

See also (1959WI39, 1961LO10, 1964MA57) and (1963RO12, 1966AR10, 1967BU23, 1967ST1H, 1968ST1K, 1968SU1C, 1968YA03; theor.).

9. ^{18}O(t, d)^{19}O $\quad Q_m = -2.301$

Not reported.

10. ^{18}O(α, ^{3}He)^{19}O $\quad Q_m = -16.621$

Table 19.5: Radiative decays in ^{19}O

E_i (MeV)	J_i^π	E_f (MeV)	Branch [a] (%)	Refs.
0.096	$\frac{3}{2}^+$	0	100	
1.47	$\frac{1}{2}^+$	0	3.5 ± 1.6	(1965AL13)
			1.5 ± 0.6	(1970FI08, 1971HIZF)
			1.4 ± 0.2	(1971MC11)
			2.0 ± 0.2	(1971BR02)
		0.096	97 ± 2	(1969FI07)
			96.5 ± 1.6	(1965AL13)
			98.5 ± 0.6	(1970FI08, 1971HIZF)
			98.6 ± 0.2	(1971MC11)
2.37 [b]	$(\frac{3}{2}^+)$	0	100	(1970FI08, 1971HIZF)
		0.096	< 11	(1970FI08, 1971HIZF)
		1.47	< 12	(1970FI08, 1971HIZF)
2.78	$\frac{9}{2}^+$	0	100	(1970FI08, 1971HIZF)
		0.096	< 10	(1970FI08, 1971HIZF)
		1.47	< 5	(1970FI08, 1971HIZF)
		2.37	< 7	(1970FI08, 1971HIZF)
3.07		0.096		(1971HI06)
		1.47		(1971BR02)
3.16	$\frac{5}{2}^+$	0	8 ± 4	(1970FI08, 1971HIZF)
		0.096	92 ± 4	(1970FI08, 1971HIZF)
		1.47	< 6 [c]	(1970FI08, 1971HIZF)
		2.37	< 9	(1970FI08, 1971HIZF)
		2.78	< 10	(1970FI08, 1971HIZF)
3.95	$(\frac{1}{2}^-)$	0	24 ± 8	(1970FI08)
			33 ± 8	(1971HI06, 1971HIZF)
		0.096	48 ± 8	(1970FI08)
			39 ± 8	(1971HI06, 1971HIZF)
		1.47	28 ± 4	(1970FI08)
			28 ± 4	(1971HI06, 1971HIZF)
		2.37	< 15	(1970FI08)
		2.78	< 15	(1970FI08)
		3.16	< 15	(1970FI08)

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

[b] See also (1969FI07).

[c] See, however, (1971BR02).

Not reported.

11. ^{18}O(^{13}C, ^{12}C)^{19}O $\quad Q_{\rm m} = -0.990$

See (1971KN05).

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

Angular distributions are reported at $E_{\rm n} = 14.1$ MeV (1968FA01; p_0, p_1, p_2, $p_{\rm unres.}$) and 14.4 MeV (1968AN1F, 1968RE07; p_{0+1}, p_2, $p_{\rm unres.}$). See also (1961KO06, 1970FO1G), (1959AJ76) and ^{20}F.

13. ^{19}F(t, ^{3}He)^{19}O $\quad Q_{\rm m} = -4.800$

Not reported.

14. ^{21}Ne(n, ^{3}He)^{19}O $\quad Q_{\rm m} = -15.924$

Not reported.

15. ^{22}Ne(n, α)^{19}O $\quad Q_{\rm m} = -5.711$

Not reported.

^{19}F

(Figs. 6 and 8)

GENERAL: (See also (1959AJ76) and (1969BE1V).)

Shell model: (1957WI1E, 1959BR1E, 1960GO1C, 1960TA1C, 1961BA1E, 1962BH09, 1962HO1C, 1963HA05, 1964BR1H, 1964DR1A, 1964HA21, 1964IN03, 1965BA1J, 1965YU1A, 1966BA2E, 1966IN01, 1966LA1E, 1966RI1F, 1967AR02, 1967BO09, 1967EN01, 1967FL13, 1967GU05, 1967GU1D, 1967HA1M, 1967IN03, 1968AR02, 1968CO11, 1968EI1B, 1968EL1C, 1968GU1E, 1968GU1F, 1968GU1G, 1968HA17, 1968HA16, 1968HA26, 1968HA1P, 1968HI08, 1968MO1G, 1968WO1A, 1969BE1V, 1969GU1E, 1969KU1G, 1969MA1T, 1969SE02, 1969SE03, 1969TA1C, 1970EL1G, 1970GI11, 1970MC1J, 1970OL1A, 1971AR25, 1971AR1R, 1971GU1N, 1971LE30, 1971WI01, 1972LE1L).

Collective model: (1960RA1A, 1962DA1B, 1963CH02, 1964HA21, 1966RI1F, 1966ZA1B, 1966ZA1C, 1967BR1H, 1967RI1B, 1967SH1G, 1967ZA1C, 1968EI1B, 1968HA16, 1968RI1M, 1968UN1A, 1969BE1V, 1969BH03, 1969CU07, 1969KR02, 1970WA02, 1972LE1L).

Cluster model: (1959WI1B, 1960SH1A, 1963MA1D, 1964MA1G, 1968ME13, 1969BA2E, 1969HI1B, 1969ME1C, 1969TA1C, 1970BA2B).

Electromagnetic transitions: (1960RA1A, 1960RO1C, 1963BE03, 1963CH02, 1964BR1H, 1964DR1A, 1964HA21, 1966MA44, 1967GU1D, 1967IN03, 1967ZA1C, 1968BA2K, 1968EL1C, 1968GU1G, 1968HA17, 1969BE1V, 1969CU07, 1969HI1B, 1971AR25, 1971GU1N).

Pion and muon reactions † *:* (1967BA78, 1967KA1C, 1967MI1B, 1968BA2G, 1968WI1B, 1969CH1C, 1969MO1E, 1969PL1B, 1969PO07, 1970BA1E, 1970BL07, 1971FA09, 1971TH05).

Special levels: (1959LA1A, 1960SH1A, 1961TR1B, 1964DR1A, 1964HA21, 1966BR1H, 1966MA44, 1967EN01, 1967SH1G, 1968AR02, 1968BA2K, 1968CE01, 1968HA1P, 1968SO1A, 1968YA03, 1969BE1V, 1969CU07, 1969GA1G, 1969HA1G, 1969HA1F, 1971AR1R).

Special reactions: (1967AU1B, 1968MI05).

Astrophysical questions: (1970BA1M).

Other theoretical topics: (1964IN03, 1964KA1A, 1965AM1A, 1965FA1B, 1965GO1F, 1965OK1A, 1965RO1H, 1965WO1C, 1965YO1A, 1966DA1E, 1966DO1C, 1966GI1A, 1966SU1D, 1967FL13, 1967GU05, 1967NE1D, 1967OS02, 1968DW1A, 1968GA03, 1968GU1E, 1968GU1C, 1968GU1G, 1968MO1G, 1968PA1Q, 1969LO06, 1969MA1T, 1971LE1H, 1972LE1L).

Ground state: $\mu = +2.628383 \pm 0.000005$ nm (1964BA11: see also (1969FU11)). See (1963BE36, 1963CA1B, 1964BO37, 1964BR1H, 1964DR1A, 1964LI14, 1964ST1B, 1965HU13, 1966RI12, 1967CO1D, 1967GU1D, 1967PA1G, 1967SH14, 1968EL1C, 1968HI08, 1968LE1L, 1968PE16, 1969HI1B, 1969WU1A, 1970LE1A, 1971AR25, 1971GU1N, 1971WI01, 1972LE1L).

† 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) are reported in pion-induced reactions.

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

E_x (MeV ± keV)	$J^\pi; T$	K^π	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
0	$\frac{1}{2}^+; \frac{1}{2}$	$\frac{1}{2}^+$			1, 3, 4, 9, 11, 12, 13, 23, 27, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 49, 50, 52
0.109893 ± 0.004	$\frac{1}{2}^-$	$\frac{1}{2}^-$	$\tau_m = 0.849 \pm 0.010$ nsec	γ	9, 11, 12, 13, 23, 25, 26, 27, 32, 33, 34, 36, 37, 38, 40, 41, 50
0.197147 ± 0.012	$\frac{5}{2}^+$	$\frac{1}{2}^+$	$\tau_m = 128.8 \pm 1.5$ nsec	γ	7, 11, 12, 13, 23, 26, 31, 32, 33,
			$\mu = 3.69 \pm 0.04$ nm		34, 38, 40, 41, 50
			$Q = -(0.10 \pm 0.02)$ bn		
1.34572 ± 0.11	$\frac{5}{2}^-$	$\frac{1}{2}^-$	$\tau_m = 4.8 \pm 0.4$ psec	γ	9, 11, 12, 13, 23, 31, 32, 33, 34, 37
1.4585 ± 0.4	$\frac{3}{2}^-$	$\frac{1}{2}^-$	$\tau_m = 78 \pm 12$ fsec	γ	9, 11, 12, 13, 23, 27, 32, 33, 34
1.5541 ± 0.2	$\frac{3}{2}^+$	$\frac{1}{2}^+$	$\tau_m = 4.4^{+2.4}_{-2.0}$ fsec	γ	11, 12, 13, 23, 26, 31, 32, 33, 34, 40
2.7798 ± 0.6	$\frac{9}{2}^+$	$\frac{1}{2}^+$	$\tau_m = 261 \pm 24$ fsec	γ	5, 7, 11, 12, 13, 18, 22, 23, 32, 33, 46, 47, 49
3.9071 ± 1.0	$\frac{3}{2}^{(+)}$	$\frac{3}{2}^+$	$\tau_m \leq 20$ fsec	γ	12, 13, 18, 23, 33, 47
3.9985 ± 0.8	$\frac{7}{2}^-$	$\frac{1}{2}^-$	$\tau_m = 23 \pm 10$ fsec	γ	9, 12, 13, 23, 33
4.0325 ± 1.0	$\frac{9}{2}^-$	$\frac{1}{2}^-$	$\tau_m = 73 \pm 11$ fsec	γ	9, 12, 13, 23, 33, 47
4.3777 ± 1.0	$\frac{7}{2}^+$	$\frac{1}{2}^+$		γ	7, 12, 13, 23, 26, 33, 47, 49
4.555 ± 5	$\frac{5}{2}^+$	$\frac{3}{2}^+$	$\tau_m \leq 20$ fsec	γ	12, 23, 47
4.5575 ± 1.0	$\frac{3}{2}^-$		$\tau_m \leq 20$ fsec	γ	12, 33, 46, 47
4.648	$\frac{13}{2}^+$	$\frac{1}{2}^+$	$\tau_m = 2.2 \pm 0.3$ psec	γ	12, 37
4.683 ± 1	$\frac{5}{2}^-$		$\tau_m = 15.4 \pm 3.0$ fsec	γ, α	7, 23, 33, 47
5.106 ± 3	$\frac{5}{2}^{(-)}$			γ, α	7, 12, 22, 23, 33, 47, 49
5.340 ± 5	$\frac{1}{2}$		$\tau_m \leq 15$ fsec	γ, α	7, 12, 23, 33, 47
			$\Gamma < 2$ keV		
5.428 ± 8	$\frac{7}{2}^-$			γ, α	7, 9, 12, 23, 33
5.464 ± 2	$\frac{7}{2}^+$	$\frac{3}{2}^+$	$\tau_m \leq 19$ fsec	γ, α	7, 12, 22, 23
			$\Gamma < 1$ keV		
5.499 ± 3	$\frac{3}{2}^+$			γ, α	7, 8, 22, 23, 33
5.540 ± 5	$\frac{5}{2}^+, \frac{7}{2}^-$			γ, α	7, 23, 33, 47
5.630 ± 10	$(\frac{1}{2}, \frac{3}{2})^-$			γ, α	7, 22, 33, 46, 47
5.943 ± 5	$\frac{1}{2}^{(+)}$			γ, α	7, 22, 23, 33, 47
6.076 ± 6	$(\frac{7}{2}^+)$		1.2	γ, α	7, 8, 22, 33
6.093 ± 4	$(\frac{3}{2}^-)$		4	γ, α	7, 8, 22, 23, 33, 47
6.167 ± 5	$\frac{7}{2}^{(-)}$			γ, α	7, 23, 33, 47
6.250 ± 5	$\frac{1}{2}^+$		8	α	8, 22, 23, 33, 47
6.290 ± 7	$\frac{5}{2}^+$		2.4	γ, α	7, 8, 22, 33

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

E_x (MeV ± keV)	$J^\pi; T$	K^π	$\Gamma_{c.m.}$ (keV)	Decay	Reactions
6.332 ± 7	$\frac{7}{2}^+$		2.4	γ, α	7, 8, 33
6.43	$\frac{1}{2}^-$		280	α	8
6.497 ± 2	$\frac{3}{2}^{(+)}$			γ, α	7, 23
6.499 ± 2	$\frac{11}{2}^+$	$\frac{1}{2}^+$		γ, α	7
6.525 ± 2	$\frac{3}{2}^+$		4	γ, α	7, 8
6.553 ± 2	$\frac{7}{2}$		1.6	γ, α	7, 8
6.592 ± 2	$\frac{9}{2}^+$	$\frac{3}{2}^+$		γ, α	7, 23
6.788 ± 3	$\frac{3}{2}^-$		2.4	γ, α	7, 8, 22, 23, 46
6.838 ± 5	$(\frac{5}{2}, \frac{3}{2})^+$		1.2	γ, α	7, 8
6.890 ± 10	$\frac{5}{2}^-$		28	α	8, 22
6.926 ± 5	$\frac{7}{2}^{(-)}$		2.4	γ, α	7, 8, 22, 23
6.99	$\frac{1}{2}^-$		51	α	8
7.11	$\frac{7}{2}^+$		≈ 32	α	8, 23
7.167 ± 3	$\frac{11}{2}^-(\frac{7}{2}^-)$			γ, α	7
7.12	$\frac{3}{2}^+$		≈ 8	α	8, 23
7.257 ± 5			≈ 6	γ, α	7, 8, 22, 23
7.364 ± 5	$\frac{1}{2}^+$		(≈ 63)	(α)	8, 22, 23
7.539 ± 2	$\frac{5}{2}^+; \frac{3}{2}$			γ, α	7, 23
7.660 ± 2	$\frac{3}{2}^+; \frac{3}{2}$			γ, α	7, 23, 31, 49
7.702 ± 5	$(\frac{3}{2}^-)$		≈ 24	α	8, 22, 23
7.762 ± 5			≈ 6	γ, α	7, 8
7.90			≈ 210	α	8
7.928 ± 3	$(\frac{7}{2}^+, \frac{9}{2})$			γ, α	7
7.935 ± 3	$\frac{11}{2}^+$	$\frac{3}{2}^+$		γ, α	7
(7.961)			(≈ 6)	α	8
(7.972)			(≈ 4)	α	8
8.014 ± 5	$\frac{5}{2}^+$		≈ 6	γ, α	7, 8, 23
8.086 ± 5	$(\frac{5}{2}^+)$		≈ 6	α	8, 23
8.136 ± 5	$(\frac{1}{2}^+)$		≈ 5	α	8, 22, 23
8.155			≈ 51	α	8
8.195 ± 5	$(\frac{5}{2}^+)$		≈ 8	α	8, 23
8.255 ± 5	$(\frac{5}{2}^+)$				23
8.287 ± 3	$(\frac{13}{2}^-)$				7
8.320 ± 10			≈ 8	α	8, 23
8.590 ± 1	$\frac{3}{2}$		2.0 ± 0.1	γ, p	18, 20, 23
8.637	$\frac{1}{2}^+$		95	p	20
8.795 ± 1.3	$\frac{1}{2}^+; \frac{3}{2}$		45 ± 1	γ, p, α	18, 20, 21, 23
8.928 ± 0.8	$\frac{3}{2}^-$		3.6 ± 0.2	p, α	20, 21

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

E_x (MeV $\pm$ keV)	$J^\pi; T$	K^π	$\Gamma_{\mathrm{c.m.}}$ (keV)	Decay	Reactions
8.942 ± 6	$(\frac{11}{2}^-)$				7, 9
9.0984 ± 0.6	$\frac{7}{2}^+; \frac{3}{2}$		$(20 \pm 19) \times 10^{-3}$	γ, p, α	18, 20, 21, 23
9.166 ± 1	$\frac{1}{2}^+$		5.8 ± 0.3	p, (α)	20, 21, 23
9.321 ± 1	$\frac{1}{2}^+$		4.9 ± 0.2	γ, p, α	18, 20, 21
9.527 ± 6	$(\frac{5}{2})$		29	p, α	20, 21
9.578 ± 7	$\frac{3}{2}$		26	p, α	20, 21, 23
9.668 ± 2	$\frac{3}{2}^+$		3.8 ± 1.0	γ, p, α	18, 20, 21, 23
9.819 ± 0.8	$\frac{5}{2}^-$		0.29 ± 0.05	γ, p, α	18, 20, 21
9.888 ± 4	$\frac{1}{2}^+$		31	p, α	20, 21
10.136 ± 0.8	$\frac{3}{2}^-$		4.7 ± 1.0	γ, p, α	18, 21
10.161 ± 3	$\frac{1}{2}^+$		31	p, α	20, 21
10.231 ± 3	$\frac{1}{2}^+$		4.3	(γ), p, α	18, 20, 21
10.253 ± 3	$\frac{3}{2}^+$		23	(γ), p, α	18, 20, 21, 23
10.306 ± 3	$\frac{3}{2}^+$		9.2	(γ), p, α	18, 20, 21, 23
10.496 ± 1	$\frac{3}{2}^+$		6.2 ± 0.5	(γ), n, p, α	18, 19, 20, 21
10.541 ± 1			2.5 ± 0.2	n, p	19, 23
10.554 ± 3	$(\frac{3}{2}^+; \frac{3}{2})$		7.6 ± 2	(γ), p, α	18, 20, 21
10.566 ± 1.0			5.2 ± 0.5	n, p	19
(10.580 ± 4)	$(\frac{5}{2}^+)$		22 ± 3	(γ), p, α	18, 20, 21
10.613 ± 1.5	$\frac{5}{2}^+; \frac{3}{2}$		4.8 ± 0.5	n, p, α	19, 20, 21
10.763 ± 3	$\frac{1}{2}^-$		5.4	p, α	20, 21
10.858 ± 2	$\frac{5}{2}^+$		25 ± 1.5	n, p, α	19, 20, 21
10.972 ± 3	$(\frac{3}{2}, \frac{5}{2})^+$		≈ 11	n, p, α	19, 20, 21
10.988 ± 3			≈ 10	n, p	19
11.070 ± 3	$\frac{1}{2}^+$		31 ± 5	n, p, α	19, 20, 21
11.199 ± 2	$(\frac{1}{2}^-)$		43 ± 2	n, p, α	19, 20, 21
11.288 ± 9			24	n, p, α	19, 20, 21
11.310 ± 9				n, p, α	19, 21
11.43 ± 10			81 ± 19	n, p, α	19, 21
11.51				n, p, α	19, 20, 21
11.56 ± 10			< 48	n, p, α	19, 20, 21
11.65 ± 10			38	n, p, α	19, 20, 21
11.68				p, α	20, 21
11.78				n, p, α	19, 20, 21
11.84 ± 10			< 48	n, p	19
11.93 ± 10			85	n, p, α	19, 20, 21
12.05				p, α	21
12.09				n, p, α	19, 20, 21

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

E_x (MeV ± keV)	$J^\pi; T$	K^π	$\Gamma_{c.m.}$ (keV)	Decay	Reactions
12.13 ± 10			95	n, p, α	19, 20, 21
12.23			48	n, p, α	19, 20, 21
12.33				n, p, α	19, 20, 21
12.44				n, p, t, α	10, 19, 20, 21
12.52	$T = \frac{3}{2}$		14	p	20
12.57				n, p, α	19, 20, 21
12.63				n, p, α	19, 20, 21
12.69				p, t, α	10, 20, 21
12.75				p, t, α	10, 21
12.77 ± 10			190	n, p, (t), α	10, 19, 20, 21
12.92				n, p, t, α	10, 19, 20, 21
13.06				n, p, t, α	10, 19, 20, 21
13.17 ± 15			67	n, p, t, α	10, 19, 21
13.31 ± 15			20	n, p, α	19, 20, 21
13.45				n, p, α	19, 21
13.58				p, α	20, 21
13.73 ± 15			95	n, p, α	19, 20, 21
14.24 ± 15			330	n, p	19
14.29				p, α	20, 21
14.78 ± 20			280	n, p	19
15.00 ± 20				n, p	19
15.75 ± 25			150	n, p	19
16.32 ± 25			190	n, p, α	19, 21
16.80 ± 30				n, p	19
17.9				p, α	20, 21

[a] See also Tables 19.9 and 19.10 and (1969BE1V; theor.).

1. ^{9}Be(^{14}N, α)^{19}F $\quad Q_m = 13.273$

See (1958GO71).

2. (a) ^{12}C(^{7}Li, n)^{18}F $\quad Q_m = 5.964$ $\quad E_b = 16.395$
   (b) ^{12}C(^{7}Li, p)^{18}O $\quad Q_m = 8.402$
   (c) ^{12}C(^{7}Li, d)^{17}O $\quad Q_m = 2.580$

(d) ^{12}C(^{7}Li, t)^{16}O $\qquad Q_m = 4.695$

(e) ^{12}C(^{7}Li, α)^{15}N $\qquad Q_m = 12.382$

The yield of ^{18}F (reaction (a)) has been determined for $E(^7\text{Li}) = 2.5$ to 3.5 MeV (1961NO05). The yields of the α_0, α_{1+2} and α_3 groups (reaction (e)) have been measured for $E(^7\text{Li}) = 3.2$ to 4.0 MeV by (1962HO06), while (1970CA1N) report that the cross sections for reactions (b), (c), (d) and (e) vary strongly over the range $E(^7\text{Li}) = 4$ to 14 MeV but with little, if any, cross-correlation. A coherence energy of about 0.4 MeV is reported (1970CA1N). See also (1967MO23), ^{18}O, ^{16}O and ^{17}O in (1971AJ02) and ^{15}N in (1970AJ04).

3. ^{12}C(^{11}B, α)^{19}F $\qquad Q_m = 7.730$

See (1966KU1D).

4. ^{12}C(^{19}F, ^{12}C)^{19}F

The angular distributions corresponding to the reaction ^{19}F(0) and ^{12}C(0) have been measured at $E(^{19}\text{F}) = 40$ and 60 MeV (1968VO1A, 1969VO10). See also (1971BO1V).

5. ^{14}N(^{6}Li, p)^{19}F $\qquad Q_m = 11.148$

At $E(^6\text{Li}) = 5.3$, 5.6 and 6.0 MeV angular distributions have been obtained for the protons corresponding to ^{19}F*(2.78) (1968RI13).

6. ^{14}N(^{7}Li, d)^{19}F $\qquad Q_m = 6.123$

See (1968MI09).

7. ^{15}N(α, γ)^{19}F $\qquad Q_m = 4.013$

Thirty resonances in the yield of capture γ-rays are observed below $E_\alpha = 5.1$ MeV: the parameters for these are displayed in Table 19.7 (1957PR1A, 1969AI01, 1969AI02, 1970AI01, 1971DI09, 1971DI18, 1972RO01). Branching ratios are shown in Table 19.9 (1969AI01, 1969AI02, 1970AI01, 1971DI18, 1972RO01), and lifetime measurements are listed in Table 19.10 (1968TO11, 1968TOZU, 1972RO01). See also (1967TO1C).

Table 19.7: Resonances in $^{15}N(\alpha, \gamma)^{19}F$ [a]

E_α (MeV ± keV)	Γ (keV)	$\frac{1}{2}(2J+1)\Gamma_\gamma\Gamma_\alpha/\Gamma$ (eV)	J^π [c]	E_x (MeV)	Refs.
0.850 ± 1	$(43.8 \pm 8.5) \times 10^{-6}$	$(6 \pm 1) \times 10^{-3}$ [b]	$\frac{5}{2}^-$	4.684	(1970AI01, 1972RO01)
1.385 ± 3		$(13 \pm 8) \times 10^{-3}$ [b]	$\frac{5}{2}^{(+)}$	5.106	(1970AI01)
1.681 ± 5	< 2	1.64 ± 0.16	$\frac{1}{2}$	5.340	(1957PR1A, 1970AI01, 1971DI09)
1.790		0.42 ± 0.09 [b]	$\frac{7}{2}^-$	5.426	(1970AI01)
1.839 ± 2	< 1	2.5 ± 0.4 [b]	$\frac{7}{2}^+$	5.464	(1957PR1A, 1971DI18)
1.883 ± 3	4 ± 1	4.2 ± 1.1 [b]	$\frac{3}{2}^+$	5.499	(1957PR1A)
1.930		0.48 ± 0.11 [b]	$\frac{5}{2}^+$	5.54	(1970AI01)
2.05				5.63	(1970AI01)
2.44			$\frac{1}{2}^{(-)}$	5.94	A, (1970AI01)
2.61			$(\frac{7}{2}^+)$	6.07	A, (1970AI01)
2.64			$(\frac{3}{2}^-)$	6.10	A, (1970AI01)
2.74			$\frac{7}{2}^{(-)}$	6.18	A, (1970AI01)
2.88			$\frac{5}{2}^+$	6.29	(1970AI01)
2.95			$\frac{7}{2}^+$	6.34	(1970AI01)
3.147 ± 1.5		1.7 ± 0.3	$\frac{3}{2}^{(+)}$	6.497	B, (1970AI01)
3.150 ± 1.5		2.3 ± 0.4	$\frac{11}{2}^+$	6.499	B, (1969AI01, 1970AI01)
3.183 ± 1.5		2.35 ± 0.35	$\frac{3}{2}^+$	6.525	B
3.218 ± 1.5		0.57 ± 0.12	$\frac{7}{2}$	6.553	B
3.268 ± 1.5		1.64 ± 0.25	$\frac{9}{2}^+$	6.592	B, (1971DI18)
3.515 ± 3		10.9 ± 1.5	$\frac{3}{2}^-$	6.787	B
3.58 ± 5				6.838	B
3.691 ± 3		9.7 ± 1.4	$\frac{7}{2}$	6.926	B
3.996 ± 3		1.15 ± 0.23	$\frac{11}{2}^-, (\frac{7}{2}^-)$	7.167	B
4.11 ± 5				7.257	B
4.468 ± 3		17.0 ± 2.7	$\frac{5}{2}^+; T = \frac{3}{2}$	7.539	A, B, (1969AI02)
4.623 ± 3		3.7 ± 0.9	$\frac{3}{2}^+; T = \frac{3}{2}$	7.662	A, B, (1969AI02)
4.75 ± 5				7.762	B
4.96 ± 3		2.3 ± 0.4	$\frac{7}{2}^+; \frac{9}{2}$	7.928	B, (1971DI18)
4.97 ± 3		3.1 ± 0.5	$\frac{11}{2}^+$	7.935	A, B, (1971DI18)
5.07 ± 5				8.014	B
[d]				8.287	C
[d]				8.942	C

A: D. Rogers, private communication.

B: W.R. Dixon and R.S. Storey, private communication.

C: K. Bharuth-Ram, K.P. Jackson, N.A. Jelley, P.G. Lawson and K.W. Allen, private communication.

[a] See also Table 19.9.

[b] Recalculated by D. Rogers (private communication) on basis of results of (1971DI09) for ^{19}F*(5.34).

[c] See (1970AI01) for tentative assignments to rotational bands.

[d] Resonant energies determined to ± 3 and ± 6 keV, respectively. ^{19}F*(8.29) decays only to the $J^\pi = \frac{9}{2}^-$ state at 4.03 MeV and γ-ray angular distribution studies establish $J = \frac{13}{2}$ or $\frac{9}{2}$. The former is favored since no other branches are observed. Of $J^\pi = \frac{13}{2}^-$, and with $\omega\gamma = 1.02 \pm 0.21$ eV, the strength of the transition to ^{19}F*(4.03) is 21.1 ± 4.3 W.u. ^{19}F*(8.94) is weaker than expected for the $\frac{11}{2}^-$ member of the $K^\pi = \frac{1}{2}^-$ band (K.W. Allen, private communication).

Correlation experiments on the transitions $5.47 \to 2.78 \to 0.197$ fix $J = \frac{9}{2}$ for ^{19}F*(2.78) and $J = \frac{7}{2}$ and $\frac{1}{2}$ for ^{19}F*(5.46, 5.34) (1968TO11, 1968TOZU). See, however, reaction 23. Measurements of γ-ray angular distributions and radiative widths lead to the J^π values listed in Table 19.7 (1969AI01, 1969AI02, 1970AI01, 1971DI18) as well as to $J = \frac{7}{2}$ for ^{19}F*(4.39) (1969AI02). The capture yield for $E_\alpha = 4.2$ to 4.7 MeV is dominated by two resonances corresponding to the first two $T = \frac{3}{2}$ states [^{19}F*(7.54, 7.66)] with $J^\pi = \frac{5}{2}^+$ and $\frac{3}{2}^+$ analogous to ^{19}O*(0, 0.097) (1969AI02). The resonance at $E_\alpha = 4.97$ MeV corresponds to a $J = \frac{11}{2}$ state at 7.935 MeV: it appears to be the $\frac{11}{2}^+$ member of a $K = \frac{3}{2}^+$ rotational band based on the $\frac{3}{2}^+$ state at $E_x = 3.91$ MeV (1971DI18). ^{19}F*(6.09) has a very definite non-isotropic decay and hence $J = \frac{1}{2}$ is ruled out: J^π is probably $\frac{3}{2}^-$. ^{19}F*(5.95, 6.08, 6.17) are tentatively assigned $J^\pi = \frac{1}{2}^{(-)}$, $(\frac{7}{2}^+)$, $\frac{7}{2}^{(-)}$ (D. Rogers, private communication) [see, however, Table 19.8].

8. ^{15}N(α, α)^{15}N $\qquad E_b = 4.013$

The elastic scattering has been studied for $E_\alpha = 1.75$ to 5.50 MeV: observed anomalies are shown in Table 19.8 (1959SM02, 1961SM02).

9. ^{15}N(^{7}Li, t)^{19}F $\qquad Q_m = 1.546$

This reaction has been studied at $E(^7\text{Li}) = 15$ and 20 MeV. The spectra have been compared with those from the ^{16}O(^{7}Li, t)^{20}Ne reaction. The similarities suggest that ^{19}F*(0.11) [$J^\pi = \frac{1}{2}^-$] arise from the coupling of a $p_{1/2}$ hole with ^{20}Ne(0); that ^{19}F(1.46, 1.35) [$J^\pi = \frac{3}{2}^-$ and $\frac{5}{2}^-$] and ^{19}F*(4.00, 4.04) [$J^\pi = \frac{7}{2}^-$ and $\frac{9}{2}^-$] correspond respectively to the 2^+ and 4^+ members of the ^{20}Ne ground state band. The $J^\pi = \frac{11}{2}^-$ and $\frac{13}{2}^-$ states in ^{19}F based on the 6^+ state of ^{20}Ne at 8.79 MeV are reported at 8.25 and 8.91 MeV (± 50 keV). [See, however, reaction 7.] Angular distributions for ^{19}F*(0.11, 1.35, 1.46, $4.00 + 4.04$, 5.43, 8.25, 8.91) have been measured (1970MI1E). See also (1971AR1R; theor.).

Table 19.8: Levels of ^{19}F from ^{15}N(α, α_0)^{15}N [a]

E_α (MeV ± keV)	Γ_{lab} (keV)	J^π	E_x (MeV)
1.878 ± 10	4	$\frac{3}{2}^+$	5.495
2.614 ± 10	1.5	$\frac{5}{2}^+$	6.076
2.635 ± 10	5	$\frac{5}{2}^-$	6.093
2.833 ± 10	10	$\frac{1}{2}^+$	6.249
2.883 ± 10	3	$\frac{5}{2}^+$	6.288
2.944 ± 10	3	$\frac{7}{2}^+$	6.336
3.07	360	$\frac{1}{2}^-$	6.44
3.194 ± 10	5	$\frac{1}{2}^+$	6.534
3.229 ± 10	2	$\frac{5}{2}^+$	6.561
3.525 ± 10	3	$\frac{3}{2}^-$	6.795
3.587 ± 10	1.5	$(\frac{5}{2}, \frac{3}{2})^+$	6.844
3.648 ± 10	35	$\frac{5}{2}^-$	6.892
3.705 ± 10	3	$(\frac{9}{2}, \frac{7}{2})^-$	6.937
3.78	64	$\frac{1}{2}^-$	7.00
3.92	≈ 40	$\frac{7}{2}^+$	7.11
3.94	≈ 10	$\frac{3}{2}^+$	7.12
4.127 ± 10	≈ 8		7.270
4.22	≈ 80		7.34
4.49	≈ 90		7.56
(4.53)			(7.59)
4.700 ± 10	≈ 30		7.722
4.780 ± 10	≈ 8		7.785
4.93	≈ 260		7.90
(5.005)	(≈ 8)		(7.963)
(5.018)	(≈ 5)		(7.973)
5.116 ± 10	≈ 8		8.050
5.203 ± 10	≈ 8		8.119
5.232 ± 10	≈ 6		8.142
5.25	≈ 65		8.156
5.284 ± 10	≈ 10		8.183
5.481 ± 10	≈ 10		8.339

[a] (1959SM02, 1961SM02).

Table 19.9: Radiative transitions in ^{19}F [†]

E_i (MeV)	J^π_i	E_f (MeV)	J^π_f	Branching ratio (%)		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 [a]	$\frac{5}{2}^-$	0	$\frac{1}{2}^+$		$\|M\|^2 = 7.6 \pm 1.3$	(1963LI01, 1969AL15)
				< 3	W.u. (E3)	C
		0.110	$\frac{1}{2}^-$	96.8 ± 1 [b]		(1969PO03)
				96.4 ± 3.0		C
		0.197	$\frac{5}{2}^+$	3.2 ± 1		(1969PO03)
				3.6 ± 1.0		C
1.46 [a,b]	$\frac{3}{2}^-$	0	$\frac{1}{2}^+$	22.5 ± 2		(1969PO03)
				21 ± 1		(1970LA02)
				20.0 ± 1		(1971HA30)
		0.110	$\frac{1}{2}^-$	66.6 ± 3		(1969PO03)
				68 ± 3		(1970LA02)
				69.7 ± 1		(1971HA30)
		0.197	$\frac{5}{2}^+$	10.9 ± 2		(1969PO03)
				10.2 ± 1		(1971HA30)
				11 ± 0.5		(1970LA02)
1.55 [a,b]	$\frac{3}{2}^+$	0	$\frac{1}{2}^+$	2.0 ± 0.7		(1969PO03)
				2.4 ± 0.5		(1966OL01)
					$\|M\|^2 = 6.8 \pm 0.7$	(1969AL15)
					W.u. (E2)	
		0.110	$\frac{1}{2}^-$	4.6 ± 0.5		(1959JO26)

Table 19.9: Radiative transitions in ^{19}F [†] (continued)

E_i (MeV)	J^π_i	E_f (MeV)	J^π_f	Branching ratio (%)		Refs.
				5.3 ± 1		(1969PO03)
				5.2 ± 0.7		(1966OL01)
		0.197	$\frac{5}{2}^+$	(95.4 ± 0.5)		(1954JO21)
				92.7 ± 1		(1969PO03)
				92.4 ± 0.9		(1966OL01)
		1.35	$\frac{5}{2}^-$	≤ 4		(1954JO21)
2.78	$\frac{9}{2}^+$	0.197	$\frac{5}{2}^+$	100	$\lvert M\rvert^2 = 7.7 \pm 1.5$ W.u.	(1966TH02, 1968SP01, 1969JA09, 1970CO22)
3.91 [c]	$\frac{3}{2}^{(+)}$	0	$\frac{1}{2}^+$	62		(1969WO1F)
				79 ± 3		(1965AL20)
				47 ± 5		C
		0.110	$\frac{1}{2}^-$	12		(1969WO1F)
				< 10		(1965AL20)
				18 ± 4		C
		0.197	$\frac{5}{2}^+$	10		(1969WO1F)
				< 2		(1965AL20)
				16 ± 4		C
		1.35	$\frac{5}{2}^-$	4		(1969WO1F)
				< 4		(1965AL20), C
		1.46	$\frac{3}{2}^-$	3		(1969WO1F)
				< 4		(1965AL20), C
		1.55	$\frac{3}{2}^+$	16		(1969WO1F)
				21 ± 3		(1965AL20)

Table 19.9: Radiative transitions in ^{19}F † (continued)

E_i (MeV)	J^π_i	E_f (MeV)	J^π_f	Branching ratio (%)		Refs.
				18 ± 4		C
		2.78	$\frac{9}{2}^+$	< 2		(1965AL20)
4.00 [c]	$\frac{7}{2}^-$	0.110	$\frac{1}{2}^+$	(22)		(1965AL20)
		0.197	$\frac{5}{2}^+$	18 ± 4		C
		1.35	$\frac{5}{2}^-$	78		(1965AL20)
				85		(1969WO1F)
				90		(1970AI01)
				70 ± 4		C
		1.46	$\frac{3}{2}^-$	15		(1969WO1F)
				10		(1970AI01)
				12 ± 2		C
4.03	$\frac{9}{2}^-$	1.35	$\frac{5}{2}^-$	100		(1966TH02, 1970AI01)
4.38	$\frac{7}{2}^+$	0	$\frac{1}{2}^+$	< 5		(1966OL01)
		0.110	$\frac{1}{2}^-$	< 2		(1966OL01)
		0.197	$\frac{5}{2}^+$	85 ± 5		(1966TH02)
				82 ± 7		(1966OL01)
		$1.35 + 1.46$		≤ 2		(1966OL01)
		1.55	$\frac{3}{2}^+$	< 4		(1966OL01)
		2.78	$\frac{9}{2}^+$	15 ± 5		(1966TH02)
				18 ± 7		(1966OL01)
4.555 [c]	$\frac{5}{2}^+$	0	$\frac{1}{2}^+$	< 5		C
		0.110	$\frac{1}{2}^-$	< 5		C
		0.197	$\frac{5}{2}^+$	69 ± 7		C

Table 19.9: Radiative transitions in ^{19}F † (continued)

E_i (MeV)	J^π_i	E_f (MeV)	J^π_f	Branching ratio (%)		Refs.
		1.35	$\frac{5}{2}^-$	5 ± 3		C
		1.46	$\frac{3}{2}^-$	8 ± 3		C
		1.55	$\frac{3}{2}^+$	18 ± 4		C
4.558 [c]	$\frac{3}{2}^-$	0	$\frac{1}{2}^+$	36 ± 4		C
		0.110	$\frac{1}{2}^-$	45 ± 5		C
		0.197	$\frac{5}{2}^+$	69 ± 7		C
		1.35	$\frac{5}{2}^-$	5 ± 3		C
		1.46	$\frac{3}{2}^-$	< 4		C
		1.55	$\frac{3}{2}^+$	6 ± 3		C
4.65	$\frac{13}{2}^+$	2.78	$\frac{9}{2}^+$	100	$\|M\|^2 = 5.5 \pm 1.8$ W.u.	(1969BH01, 1969JA09, 1970AI01)
4.68 [c,d,m]	$\frac{5}{2}^-$	0.197	$\frac{5}{2}^+$	6		(1969WO1F, 1970AI01, 1972RO01)
				6 ± 1		(1972RO01)
				4 ± 2		C
		1.35	$\frac{5}{2}^-$	60	$\Gamma_\gamma = \Gamma = 0.95 \pm 0.05$	(1969WO1F)
				63		(1970AI01)
				63 ± 6		(1972RO01)
				64 ± 5		C
		1.46	$\frac{3}{2}^-$	34		(1969WO1F)
				30		(1970AI01)
				31 ± 3		(1972RO01)
				32 ± 3		C
		2.78	$\frac{9}{2}^+$	< 1		(1970AI01)

Table 19.9: Radiative transitions in ^{19}F † (continued)

E_i (MeV)	J_i^π	E_f (MeV)	J_f^π	Branching ratio (%)		Refs.
				< 2		(1972RO01)
5.11 [d]	$\frac{5}{2}^{(-)}$	0.197	$\frac{5}{2}^+$	80		(1970AI01)
		1.46	$\frac{3}{2}^-$	20		(1970AI01)
5.34 [d,e]	$\frac{1}{2}$ [f]	0	$\frac{1}{2}^+$	37		(1970AI01)
		0.110	$\frac{1}{2}^-$	42		(1970AI01)
		0.197	$\frac{5}{2}^+$	< 2		(1970AI01)
		1.46	$\frac{3}{2}^-$	20		(1970AI01)
5.43 [d]	$\frac{7}{2}^-$	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)
5.46 [d,e]	$\frac{7}{2}^-$	0.197	$\frac{5}{2}^+$	4		(1971DI18)
		1.35	$\frac{5}{2}^-$	32		(1971DI18)
		1.55	$\frac{3}{2}^+$	5		(1971DI18)
		2.78	$\frac{9}{2}^+$	59		(1971DI18)
5.50 [d]	$\frac{3}{2}^+$	0.110	$\frac{1}{2}^-$	25 [n]		(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)
5.63		0.197	$\frac{5}{2}^+$	33 [n]		(1970AI01)

Table 19.9: Radiative transitions in ^{19}F † (continued)

E_i (MeV)	J_i^π	E_f (MeV)	J_f^π	Branching ratio (%)		Refs.
		1.35	$\frac{5}{2}^-$	66		(1970AI01)
5.94	$\frac{1}{2}^{(+)}$	0	$\frac{1}{2}^+$	15		(1970AI01)
		0.110	$\frac{1}{2}^-$	38		(1970AI01)
		1.46	$\frac{3}{2}^-$	38		(1970AI01)
		3.91	$\frac{3}{2}^{(+)}$	9		(1970AI01)
6.08	$(\frac{7}{2}^+)$	0.197	$\frac{5}{2}^+$	40 [n]		(1970AI01)
		1.35	$\frac{5}{2}^-$	20		(1970AI01)
		2.78	$\frac{9}{2}^+$	40		(1970AI01)
6.09	$(\frac{3}{2}^-)$	0	$\frac{1}{2}^+$	25 [n]		(1970AI01)
		0.110	$\frac{1}{2}^-$	62		(1970AI01)
		0.197	$\frac{5}{2}^+$	14		(1970AI01)
6.17	$\frac{7}{2}^{(-)}$	0.197	$\frac{5}{2}^+$	32 [n]		(1970AI01)
		1.35	$\frac{5}{2}^-$	68		(1970AI01)
6.29	$\frac{5}{2}^+$	1.35	$\frac{5}{2}^-$	31 [n]		(1970AI01)
		1.46	$\frac{3}{2}^-$	47		(1970AI01)
		1.55	$\frac{3}{2}^+$	22		(1970AI01)
6.33	$\frac{7}{2}^+$	0.197	$\frac{5}{2}^+$	84 [n]		(1970AI01)
		1.35	$\frac{5}{2}^-$	16		(1970AI01)
6.497 [d]	$\frac{3}{2}^{(+)}$	0	$\frac{1}{2}^+$	38		(1970AI01)
		0.110	$\frac{1}{2}^-$	14		(1970AI01)
		0.197	$\frac{5}{2}^+$	9		(1970AI01)
		1.35	$\frac{5}{2}^-$	14		(1970AI01)
		1.46	$\frac{3}{2}^-$	25		(1969AI01, 1970AI01)

Table 19.9: Radiative transitions in ^{19}F † (continued)

E_i (MeV)	J_i^π	E_f (MeV)	J_f^π	Branching ratio (%)		Refs.
6.499 [d]	$\frac{11}{2}^+$	2.78	$\frac{9}{2}^+$	55		(1969AI01)
		4.00	$\frac{7}{2}^-$	< 3		(1969AI01)
		4.03	$\frac{9}{2}^-$	< 3		(1969AI01)
		4.39	$\frac{7}{2}^+$	< 3		(1969AI01)
		4.65	$\frac{13}{2}^+$	45		(1969AI01, 1970AI01)
		5.47	$\frac{7}{2}^+$	< 2		(1969AI01)
6.53	$\frac{3}{2}^+$	0	$\frac{1}{2}^+$	29		B
		0.110	$\frac{1}{2}^-$	59		B
		4.56	$\frac{5}{2}^+$	12		B
6.55	$\frac{7}{2}$	0.197	$\frac{5}{2}^+$	20		B
		1.35	$\frac{5}{2}^-$	55		B
		2.78	$\frac{9}{2}^+$	25		B
6.59	$\frac{9}{2}^+$	0.197	$\frac{5}{2}^+$	13		(1971DI18)
		2.78	$\frac{9}{2}^+$	63		(1971DI18)
		4.00	$\frac{7}{2}^-$	< 4		(1971DI18)
		4.03	$\frac{9}{2}^-$	< 2		(1971DI18)
		4.39	$\frac{7}{2}^+$	24		(1971DI18)
		4.56	$\frac{5}{2}^+$	< 2		(1971DI18)
		4.65	$\frac{13}{2}^+$	< 2		(1971DI18)
		5.43	$\frac{7}{2}^-$	< 3		(1971DI18)
		5.46	$\frac{7}{2}^+$	< 8		(1971DI18)
6.79	$\frac{3}{2}^-$	0	$\frac{1}{2}^+$	16		B
		0.110	$\frac{1}{2}^-$	40		B

Table 19.9: Radiative transitions in ^{19}F † (continued)

E_i (MeV)	J^π_i	E_f (MeV)	J^π_f	Branching ratio (%)		Refs.
		0.197	$\frac{5}{2}^+$	13		B
		1.35	$\frac{5}{2}^-$	5		B
		1.46	$\frac{3}{2}^-$	26		B
6.93	$\frac{7}{2}^{(-)}$	0.197	$\frac{5}{2}^+$	73		B
		1.35	$\frac{5}{2}^-$	5		B
		2.78	$\frac{9}{2}^+$	2.4		B
		4.00	$\frac{7}{2}^-$	1.3		B
		4.03	$\frac{9}{2}^-$	1.3		B
7.17	$\frac{11}{2}^-, (\frac{7}{2}^-)$	4.00	$\frac{7}{2}^-$	6		B
		4.03	$\frac{9}{2}^-$	94		B
7.54 [d,g]	$\frac{5}{2}^+; T = \frac{3}{2}$	0	$\frac{1}{2}^+$	< 1		(1969AI02)
		0.197	$\frac{5}{2}^+$	30		(1969AI02)
					$\Gamma_\gamma/\Gamma \lesssim 0.05$	A
		1.55	$\frac{3}{2}^+$	42		(1969AI02)
		3.91	$\frac{3}{2}^{(+)}$	< 1		(1969AI02)
		4.39	$\frac{7}{2}^+$	28		(1969AI02)
		4.56	$\frac{3}{2}^{(+)}$	< 1		(1969AI02)
		5.34	$\frac{1}{2}$	< 1		(1969AI02)
		5.47	$\frac{7}{2}^+$	< 1		(1969AI02)
7.66 [d,g]	$\frac{3}{2}^+; T = \frac{3}{2}$	0	$\frac{1}{2}^+$	43	$\Gamma_\gamma = 4.7$ eV	(1963BA19, 1969AI02)
					$\Gamma_\gamma/\Gamma = 0.65 \pm 0.10$	A
		0.197	$\frac{5}{2}^+$	17		(1969AI02)
		1.55	$\frac{3}{2}^+$	40		(1969AI02)

Table 19.9: Radiative transitions in ^{19}F [†] (continued)

E_i (MeV)	J_i^π	E_f (MeV)	J_f^π	Branching ratio (%)		Refs.
		3.91	$\frac{3}{2}^{(+)}$	< 3		(1969AI02)
		4.39	$\frac{7}{2}^{+}$	< 7		(1969AI02)
		4.56	$\frac{3}{2}^{(+)}$	< 5		(1969AI02)
		5.34	$\frac{1}{2}$	< 10		(1969AI02)
		5.47	$\frac{7}{2}^{+}$	< 10		(1969AI02)
7.93	$(\frac{7}{2}^{+}, \frac{9}{2})$	0.197	$\frac{5}{2}^{+}$	4		(1971DI18)
		2.78	$\frac{9}{2}^{+}$	96		(1971DI18)
7.94 [d]	$\frac{11}{2}^{+}$	2.78	$\frac{9}{2}^{+}$	11		(1970RO1C)
				10		(1971DI18)
		4.00	$\frac{7}{2}^{-}$	< 7		(1971DI18)
		4.03	$\frac{9}{2}^{-}$	< 7		(1971DI18)
		4.39	$\frac{7}{2}^{+}$	< 7		(1971DI18)
		4.65	$\frac{13}{2}^{+}$	89		(1970RO1C)
				90		(1971DI18)
		5.43	$\frac{7}{2}^{-}$	< 9		(1971DI18)
		5.46	$\frac{7}{2}^{+}$	< 10		(1971DI18)
		6.50	$\frac{11}{2}^{+}$	< 7		(1971DI18)
		6.59	$\frac{9}{2}^{+}$	< 7		(1971DI18)
8.29	$(\frac{13}{2}^{-})$	4.03	$\frac{9}{2}^{-}$	100		C
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		(1965AL20)
8.80 [h]	$\frac{1}{2}^{+}$	0	$\frac{1}{2}^{+}$	< 10		(1965AL20)

Table 19.9: Radiative transitions in ^{19}F [†] (continued)

E_i (MeV)	J_i^π	E_f (MeV)	J_f^π	Branching ratio (%)		Refs.
		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)
E_i (MeV)	J_i^π	E_f (MeV)	J_f^π	Branching ratio (%)	Γ_γ (meV)	Refs.
8.94	$(\frac{11}{2}^-)$	2.78	$\frac{9}{2}^+$	36 ± 10	54 ± 17	C
		4.00	$\frac{7}{2}^-$	19 ± 7	29 ± 12	C
		4.03	$\frac{9}{2}^-$	45 ± 13	68 ± 17	C
9.09 [i]	$\frac{7}{2}^+; T = \frac{3}{2}$	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 [j]		(1965AL20)
		4.00	$\frac{7}{2}^-$	8 ± 2		(1965AL20)
		5.43	$\frac{7}{2}^-$	(8 ± 2)		(1965AL20)
		6.08	$(\frac{7}{2}^+)$	(5 ± 2)		(1962NE03)
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)
9.67 [,h,k]	$\frac{3}{2}^+$	0	$\frac{1}{2}^+$	25		(1969WO1F)
		0.110	$\frac{1}{2}^-$	21		(1969WO1F)

Table 19.9: Radiative transitions in ^{19}F † (continued)

E_i (MeV)	J_i^π	E_f (MeV)	J_f^π	Branching ratio (%)		Refs.
		0.197	$\frac{5}{2}^+$	12		(1969WO1F)
		1.35	$\frac{5}{2}^-$	8		(1969WO1F)
		1.46	$\frac{3}{2}^-$	6		(1969WO1F)
		1.55	$\frac{3}{2}^+$	11		(1969WO1F)
		3.91	$\frac{3}{2}^{(+)}$	6		(1969WO1F)
		4.56	$\frac{5}{2}^+$	5		(1969WO1F)
		7.54	$\frac{5}{2}^+$	3		(1969WO1F)
		7.66	$\frac{3}{2}^+$	3		(1969WO1F)
9.82 [h,l]	$\frac{5}{2}^-$	0.197	$\frac{5}{2}^+$	41		(1969WO1F)
		1.35	$\frac{5}{2}^-$	4		(1969WO1F)
		1.46	$\frac{3}{2}^-$	8		(1969WO1F)
		1.55	$\frac{3}{2}^+$	30		(1969WO1F)
		4.00	$\frac{7}{2}^-$	2		(1969WO1F)
		4.68	$\frac{5}{2}^-$	5		(1969WO1F)
		5.43	$\frac{7}{2}^-$	10		(1969WO1F)
E_i (MeV)	J_i^π	E_f (MeV)	J_f^π	Branching ratio (%)	$\lvert M\rvert^2 \times 10^{-3}$ W.u.	Refs.
10.136	$\frac{3}{2}^-$	0	$\frac{1}{2}^+$	84 ± 3		(1962NE03)
				64	4.9	A
		0.110	$\frac{1}{2}^-$	4 ± 2		(1962NE03)
					< 3	A
		0.197	$\frac{5}{2}^+$	12 ± 2		(1962NE03)
				29	2.4	A
		1.35	$\frac{5}{2}^-$		< 2	A

Table 19.9: Radiative transitions in ^{19}F † (continued)

E_i (MeV)	J_i^π	E_f (MeV)	J_f^π	Branching ratio (%)		Refs.
		1.46	$\frac{3}{2}^-$	2	4.6	A
		1.55	$\frac{3}{2}^+$	2	0.20	A
		3.91	$\frac{3}{2}^{(+)}$	4	0.57	A

† $E_x = 1345.4 \pm 0.6, 1458.6 \pm 0.6, 1553.5 \pm 0.6, 2779.8 \pm 0.6, 3907.1 \pm 1.0, 3998.5 \pm 0.8, 4032.5 \pm 1.0, 4377.7 \pm 1.0, 4557.5 \pm 1.0$ and 4682.5 ± 1.0 keV (K. Bharuth-Ram, K.P. Jackson, N.A. Jelley, P.G. Lawson and K.W. Allen, private communication.

A: I.F. Wright and M.R. Wormald, private communication.

B: W.R. Dixon and R.S. Stroey, private communication.

C: K. Bharuth-Ram, K.P. Jackson, N.A. Jelley, P.G. Lawson and K.W. Allen, private communication.

[a] For partial widths, see (1969PO03).

[b] See also (1968SP01, 1969WO1F).

[c] See also (1966TH02, 1969WO1F).

[d] See also Table 19.7.

[e] See also (1967TO1C) and (1970AI01).

[f] See, however, (1970SC25).

[g] See also (1969WO1F).

[h] See also (1962NE03).

[i] See also (1959BU05, 1963HU07).

[j] $\Gamma_\gamma = 0.84 \pm 0.19$ eV. The total $\Gamma_\gamma(9.07) = 1.31 \pm 0.31$ eV.

[k] $\Gamma_p\Gamma_\gamma/\Gamma = 1.3 \pm 0.3$ eV (1969WO1F).

[l] $\Gamma_p\Gamma_\gamma/\Gamma = 1.7 \pm 0.3$ eV (1969WO1F).

[m] The branching ratios to ^{19}F*(0, 0.11, 1.55) are < 5, < 1.5 and $< 5\%$ respectively (1972RO01).

[n] Values shown are no true branching ratios but are relative intensities observed at 90°. I am indebted to W.R. Dixon and R.S. Storey for calling this to my attention.

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

^{19}F* (MeV)	τ_m	Refs.
0.110 [a]	0.52 ± 0.13 nsec	(1960ST17)
	1.3 ± 0.2 nsec	(1962BO1A, 1962SE12)
	0.92 ± 0.04 nsec	(1963GA14)
	0.87 ± 0.14 nsec	(1963VA01, 1963VA12)
	0.84 ± 0.04 nsec	(1965BO28)
	0.91 ± 0.05 nsec	(1969ME13)
	0.847 ± 0.010 nsec	(1969NI09)
	0.853 ± 0.010 nsec	mean of last five values
0.197 [a]	100 ± 20 nsec	(1954JO21)
	125 ± 25 nsec	(1956JO35)
	114 ± 25 nsec	(1960ST17)
	129.9 ± 2.3 nsec	(1967BE14)
	128 ± 2 nsec	(1968KL05)
	128.8 ± 1.5 nsec	mean of last two values
1.35 [b]	5.2 ± 0.9 psec	(1968PA11)
	4.7 ± 0.6 psec	(1969JO10)
	$5.3^{+1.5}_{-0.9}$ psec	(1969PO03)
	$3.5^{+1.5}_{-1.1}$ psec	A
	4.8 ± 0.4 psec	mean
1.46 [c]	62 ± 20 fsec	(1964BO22)
	102 ± 35 fsec	(1968TOZU)
	57 ± 24 fsec	(1969PO03)
	100 ± 20 fsec	A
	78 ± 12 fsec	mean value
1.55 [d]	≤ 30 fsec	(1968TOZU)
	< 17 fsec	(1969PO03)
	$4.4^{+2.4}_{-2.0}$ fsec	"best" value: see (1969PO03)
2.78	< 190 fsec	(1968RO07)
	246 ± 44 fsec	(1968TO11, 1968TOZU)
	300 ± 60 fsec	(1969JA09)
	270 ± 40 fsec	A

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

^{19}F* (MeV)	$\tau_{\rm m}$	Refs.
	230 ± 60 fsec	see (1969JA09)
	261 ± 24 fsec	mean of the last four values
3.91	≤ 20 fsec	A
4.00	23 ± 10 fsec	A
4.03	60 ± 15 fsec	A
	87 ± 16 fsec	B
4.555, 4.558	≤ 20 fsec	A
4.65	2.3 ± 0.5 psec	(1969BH01)
	2.1 ± 0.4 psec	(1969JA09)
	2.2 ± 0.3 psec	mean
4.68	15.4 ± 3.0 fsec	(1972RO01)
5.34	≤ 15 fsec	(1969PO03)
5.46	≤ 19 fsec	(1969PO03)
5.50	≤ 43 fsec	(1969PO03)

A: Bharuth-Ram, Jackson, Jelley, Lawson and Allen, private communication.
B: W.R. Dixon and R.S. Storey, private communication.
[a] See also (1964LI1B).
[b] See also (1968TOZU, 1971NI05).
[c] See also (1971NI05).
[d] See also (1967WA13, 1969NI09).

10. (a) ^{16}O(t, n)^{18}F $\qquad Q_{\rm m} = 1.269 \qquad E_{\rm b} = 11.700$
(b) ^{16}O(t, p)^{18}O $\qquad Q_{\rm m} = 3.707$
(c) ^{16}O(t, t)^{16}O
(d) ^{16}O(t, α)^{15}N $\qquad Q_{\rm m} = 7.686$

The excitation function for neutrons (reaction (a)) has been measured for $E_{\rm t} = 0.3$ to 2.2 MeV (1961LO14) and 0.7 to 2.1 MeV by (1955JA31). See also (1967CH35). Resonances in the yields of p_0, p_1, α_0 and α_{1+2} (reactions (b) and (d)) are reported by (1967KO11), corresponding to states with $E_{\rm x}$ = 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]. Additional states from the α_0 yield are reported by (1965GE05). See also (1959JO32, 1967KO1G). Two pronounced peaks are observed in the elastic scattering (reaction (c)) at $E_t = 2.6$ and 3.2 MeV [^{19}F*(13.9, 14.4)] (1968ET1A: $E_t = 1.4$ to 3.5 MeV). The elastic scattering has also been studied for $E_t = 9$ to 13 MeV (1965GL04).

11. ^{16}O(α, p)^{19}F $\qquad Q_m = -8.115$

At $E_\alpha = 26.7$ and 33.1 MeV, angular distributions have been measured for the $p_{0\to2}$, $p_{3\to5}$ and p_6 groups (1961YA02).

12. ^{16}O(^{6}Li, ^{3}He)^{19}F $\qquad Q_m = -4.094$

This reaction (and its mirror reaction ^{16}O(^{6}Li, t)^{19}Ne: see ^{19}Ne) have been studied at $E(^6\text{Li}) =$ 24 MeV. The states most strongly excited by both reactions correspond to members of the $K^\pi = \frac{1}{2}^+$ (g.s.) rotational band, with the exception of the $\frac{7}{2}^+$ state. It is suggested that it is the second $\frac{7}{2}^+$ state (at $E_x = 5.46$ MeV) which is a member of the g.s. rotational band although it is more weakly populated in both reactions than predicted [see, however, Table 19.11, footnote [d]]. Up to $J^\pi = \frac{9}{2}^+$, cross sections are observed to increase with increasing spin. Members of a $K^\pi = \frac{1}{2}^-$ rotational band based primarily on a configuration of four s-d shell particles and a p-shell hole are also populated in these reactions: again cross sections increase with increasing spin. Table 19.11 presents the data on the ^{16}O(^{6}Li, ^{3}He)^{19}F and ^{16}O(^{6}Li, t)^{19}Ne reactions (1971BI06). See also (1971GA1H).

13. ^{16}O(^{7}Li, α)^{19}F $\qquad Q_m = 9.233$

At $E(^7\text{Li}) = 20$ MeV, α-particles to the ^{19}F states with $E_x < 4.5$ MeV have been observed (1969BI1A). At $E(^7\text{Li}) = 30.3$ MeV, the excitation of ^{19}F*(7.25, 10.2, 12.1, 13.4), in addition to lower states, is reported by (1969GL06). See also (1969RO1G; theor.).

14. (a) ^{17}O(d, n)^{18}F $\qquad Q_m = 3.384$ $\qquad E_b = 13.815$
(b) ^{17}O(d, p)^{18}O $\qquad Q_m = 5.822$
(c) ^{17}O(d, α)^{15}N $\qquad Q_m = 9.802$

For reaction (a) see ^{18}F and (1950HO80). For reaction (b) see ^{18}O; for reaction (c) see ^{15}N in (1970AJ04).

15. $^{17}O(t, n)^{19}F$ $Q_m = 7.557$

Table 19.11: Levels of ^{19}F and ^{19}Ne from $^{16}O(^6Li, ^3He)$ and $^{16}O(^6Li, t)$ (1971BI06)

J^π	E_x [a] in ^{19}F (MeV)			σ_{max} (θ)	E_x [a] in ^{19}Ne (MeV)			σ_{max} (θ)
	$K^\pi = \frac{1}{2}^+$	$K^\pi = \frac{1}{2}^-$	other	(mb/sr)	$K^\pi = \frac{1}{2}^+$	$K^\pi = \frac{1}{2}^-$	other	(mb/sr)
$\frac{1}{2}^+$	0.0			0.106	0.0			0.095
$\frac{5}{2}^+$	0.197			0.682	0.238			0.612
$\frac{3}{2}^+$	1.55			0.279	1.54 [b]			0.294
$\frac{9}{2}^+$	2.78			1.16	2.79 [b]			0.763
$\frac{13}{2}^+$	4.65			0.197	4.62 [b]			0.125
$\frac{7}{2}^+$	5.46 [d]			0.347	5.43 [b]			0.169
$\frac{1}{2}^-$		0.110		0.026		0.275		0.026
$\frac{5}{2}^-$		1.35		0.173		1.51 [b]		0.082
$\frac{3}{2}^-$		1.46		0.065		1.62 [b]		0.052
$\frac{7}{2}^-$		4.00 }		0.357		4.14 [b]		0.072
$\frac{9}{2}^-$		4.04 }				4.20 [b]		0.083
$\frac{3}{2}^+$			3.91 [b]	0.012			4.03 [b]	0.008
$\frac{7}{2}^+$			4.39	0.037			4.37 [b]	0.016
$\frac{5}{2}^{(+)}$			4.55 }	0.059				
$\frac{3}{2}^-$, $(\frac{1}{2}^-)$			4.56 }				4.55	0.006
$\frac{5}{2}^-$			4.68	[c]				
$\frac{5}{2}^{(-)}$			5.11	0.012				
$\frac{5}{2}^+$			5.34	0.005				
$\frac{7}{2}^-$			5.43	0.215				

[a] Energies are nominal.

[b] J^π assignment based on similarity in σ_{max} in both reactions and on known spin of analog state.

[c] Transition masked by strong group to $E_x = 4.65$ MeV.

[d] See, however, (1971DI18).

Not reported.

16. $^{17}O(^3He, p)^{19}F$ $Q_m = 8.321$

Not reported.

Table 19.12: Resonances in $^{18}O(p, \gamma)^{19}F$ [a]

E_p (keV)	Γ_{lab} (keV)	J^π	E_x (keV)	Refs.
629.6 ± 0.3	2.0 ± 0.3	$\frac{3}{2}^+$	8.5892	(1959BU05, 1962NE03, 1963HU07, 1969DU1A)
848 ± 2	40 ± 5	$\frac{3}{2}$	8.796	(1959BU05, 1962NE03, 1963HU07, 1965AL20)
1166.5 ± 0.4	$(25 \pm 24) \times 10^{-3}$	$\frac{7}{2}^+$ [b]	9.0976	(1959BU05, 1963HU07, 1969DU1A)
1398 ± 3	4		9.317	(1959BU05, 1962NE03, 1963HU07)
1685 ± 5 [d]	< 15		(9.589)	(1959BU05)
1769 ± 2	4.0 ± 1.0	$\frac{3}{2}^+$	9.668	(1959BU05, 1962NE03, 1969WO1F)
1778			(9.677)	(1962NE03)
1790			(9.688)	(1962NE03)
1928.4 ± 0.6 [c]	0.3 ± 0.05	$\frac{5}{2}$ [f]	9.819	(1959BU05, 1962NE03, 1969DU1A, 1969WO1F)
2263.0 ± 0.7	5.0 ± 1.0	$\frac{3}{2}^-$	10.136	A, (1962NE03, 1969DU1A)
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)			(10.45)	(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: M.R. Wormald and I.F. Wright, private communication.

[a] See also Table 19.9.

[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.F. Wright, private communication).

17. ^{17}O(α, d)^{19}F $Q_m = -10.032$

See (1963HA1C).

18. ^{18}O(p, γ)^{19}F $Q_m = 7.993$

Resonances for capture radiation observed for $E_p = 0.3$ to 3.0 MeV are displayed in Table 19.12 (1959BU05, 1962NE03, 1963HU07, 1965AL20, 1969DU1A, 1969WO1F). 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 19.9 (1962NE03, 1965AL20, 1969WO1F). See also (1969SK1A) and (1959LA1A).

19. ^{18}O(p, n)^{18}F $Q_m = -2.438$ $E_b = 7.993$

Recent yield measurements are reported for 2.5 to 3.0 MeV (1967PR04), 2.6 to 3.0 MeV (1960BL05; σ_t), 2.6 to 3.3 MeV (1969BE57: rel. total yield, high resolution), 3.0 to 7.0 MeV (1969DI07; $n_1\gamma$, $n_2\gamma$, $n_3\gamma$ and n), 3.5 to 10 MeV (1964BA16; σ_t), 3.6 to 4.0 MeV (1968BE34; $n_1\gamma$, $n_2\gamma$, $n_3\gamma$) and 6.9 to 13.5 MeV (1965BL07, 1969AN06; σ_t for n_0, n_2 (unresolved), n_5, n_6, n_7, n_8 (unresolved); not all groups over the entire range). See also (1959BR06). Observed resonances are displayed in Table 19.13 (1956MA18, 1964BA16, 1967PR04, 1968BE34, 1969BE57, 1969DI07).

(1969AN06) find that the rather large cross section for the reaction to ^{18}F(0) [$\Delta T = 1, \Delta J = 1$] over the range $E_p = 6.9$ to 13.5 MeV and the cross section for the reaction to ^{18}F*(3.06) [$\Delta T = 0$, $\Delta J = 2$] indicate the operation of a spin-flip mechanism in the effective two-body force, and a sizable value for the quadrupole term in the multipole expansion of that force.

For a summary of threshold measurements and angular distribution studies, see ^{18}F.

20. ^{18}O(p, p)^{18}O $E_b = 7.993$

Scattering studies have been carried out at $E_p = 0.60$ to 1.45 MeV (1962YA03, 1962YA1B; p_0), 0.79 to 3.55 MeV (1961CA02; p_0 (and $p_1\gamma$ at higher energies)), 1.39 to 3.20 MeV (1969SE02, 1969SE03; p_0, high resolution), 1.7 to 3.5 MeV (1962SO01, 1964ST1E; p_0), 2.5 to 3.0 MeV (1967PR04; $p_1\gamma$), 3.0 to 7.0 MeV (1969DI07; $p_1\gamma$), 3.2 to 5.4 MeV (1968BE34, 1969BE13; $p_1\gamma$), and 7.9 to 16.3 MeV (1964ST1D, 1966ST04; p_0, p_1). For a spallation study, see (1969EP1B).

Table 19.13: Resonances in $^{18}O(p, n)^{18}F$ [a]

E_p (MeV ± keV)	Γ_{lab} (keV)	Res. [b] in yield of	J^π	E_x in ^{19}F (MeV)	Refs.
2.643 ± 1.0	6.5 ± 0.5	n	$(\frac{3}{2})$	10.496	(1967PR04, 1969BE57)
2.691 ± 1.0	2.6 ± 0.2	n		10.541	(1967PR04, 1969BE57)
2.717 ± 1.0	5.5 ± 0.5	n		10.566	(1967PR04, 1969BE57)
2.767 ± 1.5	5.0 ± 0.5	n	$\frac{5}{2}^{(+)}$	10.613	(1967PR04, 1969BE57)
3.025 ± 2.0	26.0 ± 1.5	n	$\frac{3}{2}$	10.857	(1956MA18, 1969BE57)
3.145 ± 3.0	≈ 12	n		10.971	(1969BE57)
3.163 ± 3.0	≈ 11	n		10.988	(1969BE57)
3.248 ± 3.0 [c]	33.0 ± 5.0	n	$\frac{3}{2}$	11.069	(1956MA18, 1969BE57)
3.386 ± 2	45 ± 2	n	$(\frac{1}{2})$	11.199	(1956MA18)
3.495 ± 4		n		11.302	(1956MA18)
3.63 ± 10 [e]	85 ± 20	n, n_1		11.43	(1956MA18, 1964BA16, 1969DI07)
3.71		n, n_1		(11.51)	(1964BA16, 1969DI07)
3.77 ± 10	< 50	n, n_2		11.56 [d]	(1964MA12, 1968BE34, 1969DI07)
3.83		n_1		(11.62)	(1964BA16, 1969DI07)
3.86 ± 10	40	n, n_1		11.65	(1964BA16, 1969DI07)
4.00		n_1, n_3		(11.78)	(1969DI07)
4.06 ± 10	< 50	n, n_1		11.84	(1964BA16, 1969DI07)
4.11		n_1		(11.88)	(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)
4.90		n_2		(12.63)	(1969DI07)
5.05 ± 10	200	n, n_1		12.77	(1964BA16, 1969DI07)
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)

Table 19.13: Resonances in ^{18}O(p, n)^{18}F [a] (continued)

E_p (MeV ± keV)	Γ_{lab} (keV)	Res. [b] in yield of	J^π	E_x in ^{19}F (MeV)	Refs.
5.47 ± 15	70	n, n_1		13.17	(1964BA16, 1969DI07)
5.62 ± 15	20	n, n_1		13.31	(1964BA16, 1969DI07)
5.63		n_1		(13.32)	(1969DI07)
5.76		n_1, n_3		(13.45)	(1969DI07)
6.06 ± 15	100	n, n_1, n_2		13.73	(1964BA16, 1969DI07)
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	160	n		15.75	(1964BA16)
8.74 ± 25	200	n		16.27	(1964BA16)
9.30 ± 30		n		16.80	(1964BA16)

[a] See also (1959AJ76).
[b] n means in the total yield.
[c] See also (1956MA18).
[d] $T = \frac{3}{2}$: see (1968BE34).
[e] Errors here and below are estimated from published data of (1964BA16) by H.B. Willard, private communication.

Observed resonances are shown in Table 19.14 (1961CA02, 1962SO01, 1962YA03, 1962YA1B, 1964ST1D, 1964ST1E, 1966ST04, 1967PR04, 1969DI07, 1969SE02, 1969SE03). All the positive-parity states with large proton width observed experimentally up to $E_p = 3.2$ MeV can be associated with a doorway state. Both the experimental data and shell-model calculations indicate that the $\frac{5}{2}^+$ resonance at $E_p = 2.768$ MeV [^{19}F*(10.613)] may be identified as the analog of ^{19}O*(3.16) although isospin impurities are present in ^{19}F*(10.613) (1969SE02, 1969SE03).

21. ^{18}O(p, α)^{15}N $\qquad Q_m = 3.980 \qquad E_b = 7.993$

Yield measurements are reported for $E_p = 0.50$ to 0.75 MeV (1971SK1C; α_0), 0.73 to 1.05 MeV (1963KA25; α_0), 0.79 to 3.55 MeV (1961CA02; α_0 (and $\alpha_{1+2}\gamma$ at the higher energies)), 0.9 to 2.1 MeV (1963AM1A, 1964AM1A; α_0), 1 to 3 MeV (1960CL02; α_0), 1.1 to 2.6 MeV

Table 19.14: 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	$\frac{3}{2}^-$	8.5921	(1962YA03, 1962YA1B)
0.680	100	p_0	5	95	$\frac{1}{2}^+$	8.637	(1962YA03, 1962YA1B)
0.846 ± 1.5	47 ± 1	p_0, α_0	26 ± 1.5	21 ± 1	$\frac{1}{2}^+; T = \frac{3}{2}$	8.794	(1960CL02, 1961CA02, 1962YA03, 1962YA1B, 1963KA25, 1968YA03)
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	(1960CL02, 1961CA02, 1962YA03, 1962YA1B, 1963AM1A, 1963KA25, 1964AM1A)
(1.135)	140					(9.068)	(1963AM1A, 1964AM1A)
1.1685 ± 0.5	0.60 ± 0.03	p_0, α_0	0.005 ± 0.0006	0.595 ± 0.08	$\frac{7}{2}^+$	9.0995	(1960CL02, 1961AM01, 1961CA02, 1962YA03, 1962YA1B, 1963AM1A, 1964AM1A)
1.2390 ± 1	6.1 ± 0.3	p_0, (α_0)	0.40 ± 0.03	5.7 ± 0.4	$\frac{1}{2}^+$	9.166	(1962YA03, 1962YA1B, 1963AM1A, 1964AM1A)
1.4025 ± 1	5.2 ± 0.2	p_0, α_0	0.23 ± 0.02	5.0 ± 0.4	$\frac{1}{2}^+$	9.321	(1960CL02, 1961CA02, 1962YA03, 1962YA1B, 1963AM1A, 1964AM1A, 1964KA1B)
1.620 ± 6	30	p_0, α_0			$(\frac{5}{2})$	9.527	(1960CL02, 1961CA02, 1963AM1A, 1964AM1A, 1964KA1B)
1.668 ± 6	27	p_0, α_0			$\frac{3}{2}$	9.572	(1960CL02, 1961CA02, 1963AM1A, 1964AM1A, 1964KA1B)
1.766 ± 3	3.6	p_0, α_0	2.1	1.5	$\frac{3}{2}^+$	9.665	(1960CL02, 1961CA02, 1962SO01, 1963AM1A, 1964AM1A, 1964KA1B, 1964ST1E, 1969SE02, 1969SE03)
1.928 ± 3	0.16	p_0, α_0	0.09	0.07	$(\frac{5}{2}, \frac{7}{2})^-$	9.819	(1960CL02, 1961CA02, 1962SO01, 1963AM1A, 1964AM1A, 1964KA1B, 1964ST1E, 1969SE02, 1969SE03)
2.001 ± 4	31	p_0, α_0	12	19	$\frac{1}{2}^+$	9.888	(1960CL02, 1961CA02, 1962SO01,

Table 19.14: 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.
							1963AM1A, 1964AM1A, 1964KA1B, 1964ST1E, 1969SE02, 1969SE03)
2.2630 ± 0.7	5.0 ± 1.0	α_0, α_1, α_2	≈ 5	0.004 [d]	$\frac{3}{2}^-$	10.136	A
2.289 ± 3	33	p_0, α_0	2.3	(1.0)	$\frac{1}{2}^+$	10.161	(1960CL02, 1961CA02, 1962SO01, 1963GO08, 1964KA1B, 1964ST1E, 1969SE02, 1969SE03)
2.363 ± 3	4.5	p_0, α_0	2.8	1.7	$\frac{1}{2}^+$	10.231	(1960CL02, 1962SO01, 1963GO08, 1964KA1B, 1964ST1E, 1969SE02, 1969SE03)
2.387 ± 3	24	p_0, α_0	11	13	$\frac{3}{2}^+$	10.253	(1960CL02, 1961CA02, 1962SO01, 1963GO08, 1964KA1B, 1964ST1E, 1969SE02, 1969SE03)
2.443 ± 4	9.7	p_0, α_0	5.2	4.5	$\frac{3}{2}^+$	10.306	(1960CL02, 1961CA02, 1962SO01, 1963GO08, 1964KA1B, 1964ST1E, 1969SE02, 1969SE03)
2.644 ± 3	4.6	p_0, p_1, α_0, α_{1+2}	2.4	(1.0)	$\frac{3}{2}^+$	10.497	(1960BL05, 1960CL02, 1961CA02, 1962SO01, 1963GO08, 1964ST1E, 1967PR04, 1969SE02, 1969SE03)
2.705 ± 3	8 ± 2	p_1, α_0			$\frac{3}{2}(^+)$; $(T = \frac{3}{2})$	10.554	(1960CL02, 1961CA02, 1962SO01, 1963GO08, 1964ST1E, 1967PR04)
2.732 ± 4	23 ± 3	p_1, α_0			$(\frac{5}{2}^+)$	10.580	(1960CL02, 1961CA02, 1962SO01, 1963GO08, 1964ST1E, 1967PR04)
2.768 ± 3	4.0	p_0, p_1, α_0, α_{1+2}	0.7	(1.0)	$\frac{5}{2}^+$; $T = \frac{3}{2}$ [b]	10.614	(1960BL05, 1960CL02, 1961CA02, 1962SO01, 1963GO08, 1964ST1E, 1967PR04, 1969SE02, 1969SE03)
2.925 ± 3	5.7	p_0, p_1, α_0, α_{1+2}	4.5	1.2	$\frac{1}{2}^-$	10.763	(1960BL05, 1960CL02, 1961CA02, 1962SO01, 1963GO08, 1964ST1E, 1967PR04, 1969SE02, 1969SE03)

Table 19.14: 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.
3.029 ± 4	19.5	$p_0, p_1, \alpha_0, \alpha_{1+2}$	13.0		$\frac{5}{2}^+$	10.861	(1960CL02, 1961CA02, 1962SO01, 1963GO08, 1964ST1E, 1969DI07, 1969SE02, 1969SE03)
(3.06)		α_0				(10.89)	(1963GO08)
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	(1961CA02, 1962SO01, 1963GO08, 1964ST1E, 1969DI07, 1969SE02, 1969SE03)
3.266 ± 9	35	$p_0, p_1, \alpha_0, \alpha_{1+2}$			$\frac{1}{2}^+$	11.086	(1961CA02, 1962SO01, 1963GO08, 1964ST1E, 1969DI07)
3.386 ± 9	20	$p_0, p_1, \alpha_0, \alpha_{1+2}$			$(\frac{1}{2}^-)$	11.199	(1961CA02, 1962SO01, 1964ST1E, 1969DI07)
3.480 ± 9	25	$p_0, p_1, \alpha_0, \alpha_{1+2}$				11.288	(1961CA02, 1963GO08, 1969DI07)
3.503 ± 9		α_0, α_{1+2}				11.310	(1961CA02, 1963GO08, 1969DI07)
3.67		α_{1+2}				11.47	(1963GO08, 1969DI07)
3.71		p_1, α_0				11.51	(1963GO08, 1969DI07)
3.75		p_1, α_0				11.54	(1963GO08, 1969DI07)
(3.83)		α_{1+2}				(11.62)	(1969DI07)
3.86	≈ 40	p_1, α_{1+2}				11.65	(1963GO08, 1969DI07)
3.89		$p_1, \alpha_o, \alpha_{1+2}$				11.68	(1963GO08, 1969DI07)
4.00		p_0, α_0				11.78	(1963GO08, 1969DI07)
4.06		$p_1, \alpha_0, \alpha_{1+2}$				11.84	(1963GO08, 1969DI07)
4.11		p_1, α_0				11.88	(1963GO08, 1969DI07)
4.14		p_1, α_0				11.91	(1963GO08, 1969DI07)
4.19		p_1, α_{1+2}				11.96	(1969DI07)
4.28		α_0, α_{1+2}				12.05	(1963GO08, 1969DI07)
4.33		$p_1, \alpha_0, \alpha_{1+2}$				12.09	(1963GO08, 1969DI07)
4.38		$p_1, \alpha_0, \alpha_{1+2}$				12.14	(1963GO08, 1969DI07)
4.48	≈ 80	$p_1, \alpha_0, \alpha_{1+2}$				12.23	(1963GO08, 1969DI07)

Table 19.14: 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.
4.58		p_1, α_0				12.33	(1963GO08, 1969DI07)
4.70		p_1, α_0				12.44	(1963GO08, 1969DI07)
4.78	15	p_1			[c]	12.52	(1969DI07)
4.83		p_1, α_{1+2}				12.57	(1969DI07)
4.90		p_1, α_0				12.63	(1963GO08, 1969DI07)
4.96		p_1, α_0, α_{1+2}				12.69	(1963GO08, 1969DI07)
5.02		α_{1+2}				12.75	(1969DI07)
5.06		p_1, α_0				12.78	(1963GO08, 1969DI07)
5.20		p_1, α_{1+2}				12.92	(1969DI07)
5.35		p_1, α_{1+2}				13.06	(1969DI07)
5.47		α_{1+2}					
5.64	30	p_1, α_0, α_{1+2}				13.17	(1969DI07)
5.76		α_{1+2}				13.33	(1963GO08, 1969DI07)
5.90		p_1, α_{1+2}				13.45	(1969DI07)
6.08		p_1, α_{1+2}				13.58	(1969DI07)
6.65		p_1, α_{1+2}				13.75	(1969DI07)
8.85		α_0				14.29	(1969DI07)
10.5		p_0, p_1, α_0				16.37	(1964ST1D)
						17.9	(1964ST1D, 1966ST04)

A: M.R. Wormald and I.F. Wright, private communication.

[a] Additional resonances are reported by (1956HI35, 1960CL02, 1961CA02, 1962SO01, 1963AM1A, 1963GO08, 1964AM1A, 1964KA1B, 1964ST1E). See also (1959AJ76).

[b] $T = \frac{3}{2}$ (1969SE02, 1969SE03).

[c] $T = \frac{3}{2}$: see (1969DI07). See, however, (1963GO08).

[d] $\alpha_1 + \alpha_2$ only.

Table 19.15: Thresholds in the ^{18}O(d, n)^{19}F reaction

E_d (keV)		E_x
(1956HA1A) [a]	(1958BU12, 1959BU81) [b]	(MeV)
	346 ± 8	6.079
	(370)	(6.101)
497 ± 15	525 ± 8	6.240
	584 ± 10	6.293
	1850 ± 50	7.43
	2150 ± 50	7.70
	2640 ± 50	8.14
3050 ± 20		8.51
	3160 ± 30	8.61

[a] Slow neutron thresholds. See also (1965MA1K).

[b] Thresholds for γ-rays.

(1964KA1B; α_0), 1.39 to 3.20 MeV (1969SE02, 1969SE03; α_0, high resolution), 2.2 to 6 MeV (1963GO08; α_0), 2.5 to 3.0 MeV (1967PR04; $\alpha_{1+2}\gamma$), 3.0 to 7.0 MeV (1969DI07; $\alpha_{1+2}\gamma$), 3.2 to 5.5 MeV (1969BE13; $\alpha_{1+2}\gamma$, $\alpha_3\gamma$), and 7.9 to 14 MeV (1964ST1D; α_0). See also (1960BL05, 1961AM01, 1964EC03, 1964SC01). Observed resonances are displayed in Table 19.14 (1960CL02, 1961AM01, 1961CA02, 1963AM1A, 1963GO08, 1964AM1A, 1964KA1B, 1964ST1D, 1967PR04, 1969DI07, 1969SE02, 1969SE03). See also ^{15}N in (1970AJ04).

22. (a) ^{18}O(d, n)^{19}F $\qquad Q_m = 5.768$

(b) ^{18}O(d, nα)^{15}N $\qquad Q_m = 1.755$

Thresholds for slow neutron production and for γ-rays are shown in Table 19.15 (1956HA1A, 1958BU12, 1959BU81). Angular distributions have been measured at $E_d = 3$ MeV (and analyzed by DWBA) to many of the states with $E_x \leq 7.4$ MeV: the closely spaced states were not resolved; however, $l_p = 4$ for the neutrons corresponding to ^{19}F*(2.78), and therefore $J^\pi = \frac{9}{2}^+, \frac{7}{2}^+$. In addition, neutron groups corresponding to ^{19}F states at 5.11 [$\frac{7}{2}^-, \frac{5}{2}^-$], 5.49 [u], 5.62, 5.94, 6.09 [u], 6.26 [u] [$\frac{1}{2}^+$], 6.53 [u] [$\frac{5}{2}^+, \frac{3}{2}^+, \frac{1}{2}^+$], 6.80 [u] [$\frac{3}{2}^-, \frac{1}{2}^-$], 6.93 [u], 7.26 and 7.40 MeV (± 0.03 MeV) are reported [(u = unresolved states)] [J^π of dominant state(s)] (1968GU07). See also (1963BE05, 1964MO23, 1969HE1P). The lifetime of ^{19}F*(1.55) is < 1 psec (1969NI09); see, however, Table 19.10.

Table 19.16: Energy levels of ^{19}F from ^{18}O(^{3}He, d)^{19}F

E_x (MeV ± keV)		l [a]	$C^2S(2J_f+1)$ [a,b]	J^π [a]
(1970GR04)	(1970SC25)			
0	0	0	0.42	$\frac{1}{2}^+$
0.110 ± 10	0.112 ± 3	1	0.224	$\frac{1}{2}^-$
0.198 ± 10	0.199 ± 3	2	2.45	$\frac{5}{2}^+$
	1.347 ± 5			
1.46 ± 15	1.460 ± 5	1	0.098	$\frac{3}{2}^-$
1.56 ± 10	1.556 ± 5	2	1.01	$\frac{3}{2}^+$
2.790 ± 15	2.784 ± 5	4 [b]	< 0.027 [b]	$\frac{9}{2}^+$
	3.912 ± 5			
4.00 ± 20 [c]	4.002 ± 5	(3)	(0.019)	$(\frac{7}{2}^-)$
	4.036 ± 10			
4.39 ± 20	4.385 ± 5	(4) [b]	(0.048) [b]	$(\frac{7}{2}^+)$
4.56 ± 20	4.555 ± 5	2	0.31	$\frac{3}{2}^+$ [d]
	4.675 ± 10 [c]			
5.10 ± 20	5.113 ± 5	(2, 3) [a,b]		$\frac{5}{2}$
	5.34 ± 5	(2, 3)	0.0065	$\frac{5}{2}^+$
5.43 ± 30 [c]	5.428 ± 8	(2, 3)	(0.042)	$(\frac{3}{2}^+)$
	5.495 ± 5 [c]			
5.55 ± 30 [c]	5.54 ± 5	3	0.14	$\frac{7}{2}^-$
	5.943 ± 5	0	0.014	$\frac{1}{2}^+$
6.08 ± 30 [c]	6.095 ± 5	1	0.12	$\frac{1}{2}^-$
	6.167 ± 5			
6.25 ± 30 [c]	6.255 ± 8	(0)	0.19	$(\frac{1}{2}^+)$
6.47 ± 30 [c]	6.503 ± 5 [c]	2 [b]	0.133 [b]	$\frac{3}{2}^+$
	6.595 ± 10			
6.76 ± 30	6.792 ± 5	1 [b]	0.29 [b]	$\frac{3}{2}^-$
6.90 ± 30 [c]	6.93 ± 5	(2, 3)		$(\frac{5}{2}^+, \frac{7}{2}^-)$
7.10 ± 30 [c]	7.112 ± 8 [c]	2	0.087	$\frac{5}{2}^+$
	7.26 ± 5			
	7.364 ± 5	0	0.091	$\frac{1}{2}^+$
7.56 ± 30	7.540 ± 3	2	0.665	$\frac{5}{2}^+; T = \frac{3}{2}$

Table 19.16: Energy levels of ^{19}F from ^{18}O(^{3}He, d)^{19}F (continued)

E_x (MeV ± keV) (1970GR04)	E_x (MeV ± keV) (1970SC25)	l [a]	$C^2S(2J_f+1)$ [a,b]	J^π [a]
	7.665 ± 5	(2)	0.035	$(\frac{3}{2}^+)$
7.74 ± 30	7.702 ± 5	(0, 1)	(0.052)	$(\frac{3}{2}^-)$
	8.015 ± 5	2	0.26	$\frac{5}{2}^+$
	8.086 ± 5	(2, 3)	0.097	$(\frac{5}{2}^+)$
	8.135 ± 5	(0, 1)	0.156	$(\frac{1}{2}^+)$
	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] (1970SC25): $E(^3\text{He}) = 16$ MeV.

[b] See also (1970GR04).

[c] Unresolved.

[d] 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).

At $E_d = 5.0$ and 5.2 MeV, reaction (b) appears to involve ^{19}F states at ≈ 8 to 10 MeV (1970BO08).

23. ^{18}O(^{3}He, d)^{19}F $\qquad Q_m = 2.499$

Angular distributions of the deuterons corresponding to many states of ^{19}F have been analyzed by DWBA: the results are shown in Table 19.16 (1970SC25: $E(^3\text{He}) = 16$ MeV; (1968LE18, 1970GR04): $E(^3\text{He}) = 11$ MeV). See also (1965ER04).

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). See also (1966LA1E, 1966RO01, 1967RO1F, 1970WA02; theor.).

24. ^{18}O(α, t)^{19}F $\qquad Q_{\rm m} = -11.822$

Not reported.

25. ^{18}O(^{6}Li, αn)^{19}F $\qquad Q_{\rm m} = 4.295$

$\tau_{\rm m}$ of ^{19}F*(0.110) is 847 ± 10 psec: see Table 19.10 (1969NI09).

26. ^{19}O(β^-)^{19}F $\qquad Q_{\rm m} = 4.819$

The decay is primarily by allowed transitions to ^{19}F*(0.197, 1.55), $J^\pi = \frac{5}{2}^+, \frac{3}{2}^+$, with very weak branches also observed to ^{19}F*(0.11), $J^\pi = \frac{1}{2}^-$ ($\log f_1 t = 10.16$) and ^{19}F*(4.39), $J^\pi = \frac{7}{2}^+$ ($\log ft = 3.60$): see Table 19.17 (1959AL06, 1959JO26, 1966OL01, 1970CO22). The half-life is 26.91 ± 0.08 sec: see reaction 1 in ^{19}O. The character of the allowed decay to the $\frac{5}{2}^+$ and $\frac{3}{2}^+$ states, and the forbiddenness of the decay to the ground state of ^{19}F are consistent with $J^\pi = \frac{5}{2}^+$ for the ground state of ^{19}O and then with $(\frac{7}{2}^+)$ for ^{19}F*(4.39): see (1966OL01). Gamma-ray branching ratios are displayed in Table 19.9 (1966OL01, 1970CO22). See also (1961OK1A) and (1970MC23; theor.).

27. ^{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). Lifetimes of ^{19}F*(0.11, 1.46) are shown in Table 19.10 (1962SE12, 1964BO22). The scattering cross section is relatively small and structureless in the range $E_\gamma = 14$ to 30 MeV (1967LO1B). See also (1960BO23, 1960RE05, 1962BO17).

28. ^{19}F(γ, n)^{18}F $\qquad Q_{\rm m} = -10.431$

Table 19.17: Branching in $^{19}O(\beta^-)^{19}F$ [a]

Decay to ^{19}F*	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)
4.39	$\frac{7}{2}^+$	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).

[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).

Maxima are reported at (10.6), 12.4, 14.0, 16.1, 17.2 and 19.3 MeV in the (γ, n) cross section (1960KI06). Three ground state photoneutron groups are reported, corresponding to ^{19}F*(12.10, 12.38, 16.24) ((1971SH1G), and N.K. Sherman, private communication). These states are thought to have $J^\pi = \frac{1}{2}^-$ or $\frac{3}{2}^-$; $T = \frac{1}{2}$. See also (1960GE06, 1967BA28) and (1959AJ76). At $E_\gamma = 20.5$ MeV, the (γ, n) cross section is 3.30 ± 0.41 b (1961DE1A, 1962DE03).

The nuclear absorption cross section shows a peak at $E_\gamma = 20.09 \pm 0.05$ MeV with an integrated cross section of 3.5 MeV $\cdot$ mb (1964TE04) and a very broad giant resonance extending beyond 30 MeV and with considerable strength also below 20 MeV (1969BE92). These results disagree with those of (1966DO1D, 1967NI1B) which show considerable structure. See also (1960SA09, 1965DE1J, 1970JO1H, 1971DI1F, 1971FR11) and (1958SP1A, 1959FU1A, 1971AN08; theor.).

29. (a) $^{19}F(\gamma, 2n)^{17}F$ $\qquad Q_m = -19.581$

(b) $^{19}F(\gamma, 2pn)^{16}N$ $\qquad Q_m = -29.820$

For reaction (a) see (1970JO1H); for reaction (b) see (1968ME23).

30. $^{19}F(\gamma, p)^{18}O$ $\qquad Q_m = -7.993$

Peaks are reported corresponding to ^{19}F states at $E_x = 10.4$, 11.4, 11.9, (12.8), 13.6, 15.4, 16.5 and (18.1) MeV (1960FO10). See also (1963MU08, 1964SE09). See also (1961DO08, 1962BR1E) and (1958SP1A, 1965SH1D; theor.).

31. (a) ^{19}F(e, e)^{19}F
(b) ^{19}F(e, ep)^{18}O $\qquad Q_m = -7.993$

At $E_e = 41.5$ MeV (180°) the elastic scattering cross section has been measured by (1963GO04) and the excitation of a $\frac{3}{2}^+$ state of ^{19}F at $E_x = 7.7$ MeV [$T = \frac{3}{2}$: see Table 19.9] is reported by (1963BA19). The excitation of ^{19}F*(0.197, 1.35, 1.55) has been observed by (1970HA1R): $\Gamma_\gamma(1.35 \to 0) = (8.1 \pm 1.7) \times 10^{-10}$ eV (E3) and $\Gamma_\gamma(1.55 \to 0) = (1.76 \pm 0.15) \times 10^{-4}$ eV (E2) (1970WA08). See also (1970WA1N) and (1965PR1C, 1966GO1C; theor.).

Reaction (b), studied at $E_e = 18$, 24.5 and 30 MeV, shows resonances (assuming ground state transitions) at $E_x = 11.42$, 11.90, 12.74, 15.70 and 18.7 MeV in ^{19}F (1962DO1A).

32. ^{19}F(n, n)^{19}F

Angular distributions have been reported at $E_n = 2.56$ MeV (1960DA08; $\gamma_{0.110}$, $\gamma_{0.197}$), 14.1 MeV (1970CL03; n_{0+1+2}, n_{3+4+5}) and 14.2 MeV (1966BO21; n_{0+1+2}, n_{3+4+5}, n_6 and n to ^{19}F*(4.7, 5.4)). Gamma-ray energy measurements are reported by (1968SP01) and (1969WH1A): see Table 19.18. Branching ratios are listed in Table 19.9 (1968SP01). See also (1959BI1A, 1959KO60, 1960AN14, 1961RO01, 1966VE1B, 1971NI05) and (1963DO1C; theor.).

33. (a) ^{19}F(p, p)^{19}F
(b) ^{19}F(p, 2p)^{18}O $\qquad Q_m = -7.993$

Table 19.19 displays energy levels of ^{19}F derived from measurements of inelastically scattered protons and γ-rays (1956SQ1A, 1961VA28, 1962VA28, 1968GU07, 1969PO03). See also (1959AJ76). Angular distributions of various proton groups have been measured at $E_p = 4.26$, 5.96 and 6.87 MeV (1967TH06; p_0, p_1, p_2), 6.6 MeV (1961VA28, 1962VA28; $p_2 \to p_6$), 6.78 to 7.41 MeV (1961KO08; p_{3+4+5}, p_6), 13.9 MeV (1966LU03; p_0, p_2, p_5) and 17.5 MeV (1968CR03; p_0, $p_2 \to p_7$, p_{8+9}, p_{10}, p_{11} and p to ^{19}F*(5.43)). (1967TH06) report that the scattering below $E_p = 7$ MeV is adequately described as scattering from an axially symmetric quadrupole-deformed potential, and that only positive parity states are strongly excited. Branching ratios for observed transitions are shown in Table 19.9 and lifetimes in Table 19.10 (1969PO03, 1970LA02). (1969PO03) find a pronounced inhibition of the four E1 transitions involved in the decay of

Table 19.18: Energy levels of ^{19}F from ^{19}F(n, n$'$)^{19}F [a]

E_x (keV) [b]	
(1968SP01)	(1969WH1A) [c]
109.8 ± 0.2	109.844 ± 0.030
197.2 ± 0.2	197.147 ± 0.012
1345.4 ± 0.3	1345.81 ± 0.20
1456.9 ± 1.1	1458.16 ± 0.50
1554.0 ± 0.3	1554.01 ± 0.40
2775.1 ± 3.5	

[a] See also (1959MI87) and (1959AJ76).

[b] From γ-ray measurements.

[c] And D.H. White, private communication.

^{19}F*(1.35, 1.46, 1.55) in accord with the predictions of (1964HA21). Partial widths have been determined by (1969PO03). (1970LA02) have studied the decay of ^{19}F*(1.46): from the angular distribution of the γ-rays, measurement of their linear polarization and from τ_m, $|M|^2$(E2) $= 14^{+26}_{-8}$, $|M|^2$(M1) $= 0.10 \pm 0.03$ W.u. The mixing ratios in the γ-decay of ^{19}F*(1.46) are $-0.1 < \delta_{M2/E1} < 0.0$ for $1.46 \rightarrow 0.20$, $0.30 < \delta_{E2/M1} < 0.38$ for $1.46 \rightarrow 0.11$ and $|\delta_{M2/E1}| < 0.06$ for $1.46 \rightarrow 0$. These results indicate that ^{19}F*(1.46) cannot be explained as a $p_{1/2}$ proton hole coupled to the pure ground state rotational band (1971HA30). See also (PR63A) for other linear polarization data and (1965KL01, 1966RO03, 1966TH02, 1967HI1C, 1968HI1F) for other angular correlation work. See also (1964NE08).

Additional parameters measured for the $\frac{5}{2}^+$ state at 0.197 MeV are : $Q = 0.11 \pm 0.02$ b (1964SU01: see also (1958SU58)), $Q = -(0.10 \pm 0.02)$ b (1968RI1N); $\mu = 3.69 \pm 0.04$ nm (1961FR07): [see also (1964BO40)]; $\tau_m = 128 \pm 2$ nsec (1968KL05), 129.9 ± 2.3 nsec (1967BE14): see also Table 19.10 for additional measurements of τ_m for this and for other ^{19}F states (1963GA14, 1963VA01, 1963VA12, 1965BO28, 1969ME13, 1969PO03). See also (PR63A).

See also (1959TR1A, 1968JA1H) and (1967AM1D; theor.). For reaction (b) see the review of (1965RI1A). See also (1961PU1A, 1964GO1C) and (1966JA1A; theor.).

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

Angular distributions of elastically scattered deuterons have been measured at $E_d = 2.0$ and 2.2 MeV (1968BI09), 2.6 to 4.0 MeV (1969ZA01) and at 15 MeV (1965DI1C, 1966DE09, 1970DE06). In addition, angular distributions have been measured at $E_d = 15$ MeV for five groups of inelastically scattered deuterons (1970DE06; $d_1 \rightarrow d_5$). Analysis by DWBA leads to

Table 19.19: States in ^{19}F from ^{19}F(p, p$'$)^{19}F [a]

E_x (MeV ± keV)			
(1956SQ1A)	(1961VA28, 1962VA28)	(1968GU07)	(1969PO03)
0.111 ± 2			
0.197 ± 2	0.198 ± 12		0.1976 ± 0.6
1.350 ± 5	1.344 ± 12		1.3458 ± 0.2
1.462 ± 5	1.458 ± 12		1.4591 ± 0.5
1.558 ± 5	1.553 ± 12		1.5542 ± 0.4
2.784 ± 8	2.789 ± 6		
3.912 ± 10		3.92 ± 10	
4.002 ± 10		4.01 ± 10	
4.036 ± 10		4.04 ± 10	
		4.39 ± 10	
		4.56 ± 10	
		4.69 ± 10	
		5.11 ± 10	
		5.34 ± 10	
		5.42 ± 10	
		5.47 ± 10	
		5.50 ± 10	
		5.54 ± 10	
		5.63 ± 10	
		5.94 ± 10	
		(6.08)	
		6.09 ± 10	
		6.17 ± 10	
		6.25 ± 10	
		6.29 ± 10	
		6.33 ± 10	

[a] See also Table 19.8 in (1959AJ76).

B(E2)↓= 9 ± 3 W.u. for the $0.197 \rightarrow 0$ transition and 10 ± 3 W.u. for the $1.56 \rightarrow 0$ transition, and to B(E3)↓= 1.4 ± 0.6 W.u. for the $1.35 \rightarrow 0$ transition (1970DE06). See also (1969VE09, 1970VE06; theor.).

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

Angular distributions of elastically scattered tritons have been measured at $E_t = 2$ MeV (1969HE08) and at 7.2 MeV (1964PU01). See also (1968HO1C; theor.).

36. ^{19}F(^{3}He, ^{3}He)^{19}F

Angular distributions of elastically scattered ^{3}He particles are reported at $E(^3\text{He}) = 4.0$, 6.0 and 8.0 MeV (1966MA43), at 9 MeV (1965SI18), at 11.0 MeV (1970SC23) and at 29 MeV (1961CA19, 1962GA17). See also (1959BR72) and (1968HO1C; theor.). (1967CO1J) also report the excitation of ^{19}F*(0.11).

37. (a) ^{19}F(α, α)^{19}F
(b) ^{19}F(α, 2α)^{15}N $\quad Q_m = -4.013$

Angular distributions of elastically scattered α-particles have been measured at $E_\alpha = 19.9$ to 23.3 MeV (1968AG1D, 1970AG08, 1970FE1E), and at 38 MeV (1960AG01). The energy of the γ-ray from the $1.35 \rightarrow 0.11$ transition is 1235.8 ± 0.2 keV. Using $E_x = 109.893 \pm 0.004$ keV for the energy of the first excited state, E_x for ^{19}F* is then 1345.7 ± 0.2 keV (1967WA13).

At $E_\alpha = 12.7$ MeV, a state at 4.648 MeV is populated which is then observed to γ-decay to the $\frac{9}{2}^+$ state at 2.78 MeV. The angular distribution of the cascade γ-rays and the lifetime of ^{19}F*(4.65), set $J^\pi = \frac{13}{2}^+$ for ^{19}F*(4.65) (1969JA09). For a listing of the τ_m for this state and ^{19}F*(1.35, 2.78) see Table 19.10 (1968PA11, 1968RO07, 1969JA09, 1969JO10). See also (1958CA97, 1959BR72, 1963FR12, 1964FR03, 1970BL1F). For reaction (b) see (1963LA02).

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

Elastic scattering angular distributions have been reported for both reactions at E(Li) $= 20$ MeV (1969BE90). See also (1959LI55).

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

For reaction (a) see (1971KN05). For reaction (b), see reaction 4.

40. ^{19}F(^{14}N, ^{14}N)^{19}F

B(E2)↑, from the Coulomb excitation of ^{19}F*(1.55) $= 2.44 \times 10^{-51}\ e^2 \cdot$ cm^4 (1966AF01). See also (1956AL1D, 1956AL36, 1956AL55).

41. ^{19}F(^{20}Ne, ^{20}Ne)^{19}F

B(E1)↑, from the Coulomb excitation of ^{19}F*(0.110) $= 6.3 \times 10^{-30}\ e^2 \cdot$ cm^2; B(E2)↑ for ^{19}F*(0.197) $= 5 \times 10^{-51}\ e^2 \cdot$ cm^4. Reported mean lifetimes for these states are displayed in Table 19.10 (1960ST17, 1962RI09).

42. ^{19}Ne(β^+)^{19}F $\qquad Q_{\rm m} = 3.238$

See ^{19}Ne.

43. ^{20}Ne(γ, p)^{19}F $\qquad Q_{\rm m} = -12.845$

See (1962DO1A, 1963FI07, 1969HO16). See also (1962NU1A) and ^{20}Ne.

44. ^{20}Ne(p, pα)^{19}F † $\qquad Q_{\rm m} = -12.845$

See (1967CH04).

† This reaction should be comletely deleted. Please refer to the Errata for this evaluation found directly after the list of references in (1974AJ01).

45. ^{20}Ne(n, d)^{19}F $\qquad Q_{\rm m} = -10.621$

Table 19.20: States of ^{19}F from ^{20}Ne(t, α)^{19}F (1961SI03)

E_x (MeV $\pm$ keV)	E_x (MeV $\pm$ keV)
2.794 ± 15	5.481 ± 15
3.917 ± 15	5.539 ± 15
4.032 ± 15	5.628 ± 15
4.385 ± 15	5.937 ± 20
4.563 ± 15	6.092 ± 15
(4.690 ± 40)	6.169 ± 30
5.102 ± 15	6.247 ± 25
5.343 ± 15	6.501 ± 25

See (1960VE06).

46. ^{20}Ne(d, ^{3}He)^{19}F $\qquad Q_m = -7.351$

At $E_d = 52$ MeV, ^{3}He groups are observed, and angular distributions are reported, corresponding to states at $E_x = 0.15 \pm 0.04$, 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 (1971DU12; theor.).

47. ^{20}Ne(t, α)^{19}F $\qquad Q_m = 6.969$

At $E_t = 2.6$ MeV, alpha groups are observed to states with $2.7 < E_x < 6.6$ MeV: see Table 19.20 (1961SI03). The lifetime, τ_m, of ^{19}F*(4.65), $J^\pi = \frac{13}{2}^+$ [$K^\pi = \frac{1}{2}^+$ rotational band] is 2.3 ± 0.5 psec (see also Table 19.10): the E2 strength of the transition to ^{19}F*(2.78) is 5.0 ± 1.1 W.u. (1969BH01).

48. ^{21}Ne(n, t)^{19}F $\qquad Q_m = -11.124$

Not reported.

49. ^{21}Ne(p, ^{3}He)^{19}F $\qquad Q_m = -11.888$

At $E_p = 45$ MeV, ^{3}He groups are observed to some $T = \frac{1}{2}$ states in ^{19}F and to the $J^{\pi} = \frac{3}{2}^{+}$; $T = \frac{3}{2}$ analog of ^{19}O*(0.095): $E_x = 7.660 \pm 0.035$ MeV (1969HA38): see also reaction 12 in ^{19}Ne.

50. ^{21}Ne(d, α)^{19}F $\quad$ $Q_m = 6.465$

Alpha-particle groups have been observed to ^{19}F* $= 0, 113 \pm 8$ and 192 ± 12 keV (1952MI54).

51. ^{22}Ne(p, α)^{19}F $\quad$ $Q_m = -1.675$

Not reported.

52. ^{23}Na(n, n′α)^{19}F $\quad$ $Q_m = -10.468$

See (1966WO03).

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

GENERAL: (See also (1959AJ76).)

Shell model: (1957WI1E, 1960TA1C, 1962BH09, 1967BO09, 1967GU1D, 1968EL1C, 1968WA04, 1971AR25, 1972LE1L).

Cluster, collective and deformed models: (1960RA1A, 1969BA2E, 1970BA2B, 1972LE1L).

Astrophysical questions: (1970BA1M).

Electromagnetic transitions: (1960RA1A, 1967GU1D, 1968EL1C, 1971AR25).

Special levels: (1960GO1C, 1968CE01, 1969GA1G).

Other theoretical topics: (1968MU1B, 1972LE1L).

Ground state: $\mu = -1.887$ nm (1963CO22, 1967CO1D). See also (1964LI14, 1964ST1B, 1967GU1D, 1967SH14, 1968EL1C, 1968LE1L, 1968PE16, 1970LE1A, 1971AR25, 1972LE1L).

1. ^{19}Ne(β^+)^{19}F $\quad Q_m = 3.238$

The half-life is 17.40 ± 0.04 sec: see Table 19.22 (1962EA02, 1968GO10). The decay is to ^{19}F(0) (1954JO21). $\log ft = 3.23$ [3] . See also (1965HA31, 1970ST04). The allowed nature of the decay sets $J^\pi = \frac{1}{2}^+$ for ^{19}Ne(0).

A test of time reversal invariance and a measurement of positron and neutrino asymmetry has been made by (1969CA14). See also (1959AL1E, 1959AL10, 1961JO03, 1963CO22, 1967CA1M, 1967CO1D, 1969CA1H) and (1965GA1D, 1966MI1F, 1967CA1N, 1969LE1D, 1969SU15, 1970KO41, 1970MC23, 1970PR1G, 1971WE1F; theor.).

2. ^{10}B(^{14}N, αn)^{19}Ne $\quad Q_m = 2.667$

The lifetime, τ_m, of ^{19}Ne*(0.28) is 61^{+4}_{-20} psec (1969NI09) [see Table 19.23].

3. (a) ^{16}O(^{3}He, γ)^{19}Ne $\quad Q_m = 8.443$
   (b) ^{16}O(^{3}He, n)^{18}Ne $\quad Q_m = -3.196$ $\quad E_b = 8.443$
   (c) ^{16}O(^{3}He, p)^{18}F $\quad Q_m = 2.033$
   (d) ^{16}O(^{3}He, ^{3}He)^{16}O

[3] B.A. Zimmerman, private communication.

Table 19.21: Energy levels of ^{19}Ne

E_x (MeV ± keV)	$J^\pi; T$	τ or $\Gamma_{\rm c.m.}$ (keV)	Decay	Reactions
0	$\frac{1}{2}^+; \frac{1}{2}$	$\tau_{1/2} = 17.40 \pm 0.04$ sec	β^+	1, 5, 7, 8, 9, 10, 12, 13
0.23833 ± 0.11	$\frac{5}{2}^+$	$\tau_{\rm m} = 26.0 \pm 0.8$ nsec	γ	5, 6, 7, 8, 12, 13
0.27520 ± 0.14	$\frac{1}{2}^-$	$\tau_{\rm m} = 61.4 \pm 3.0$ psec	γ	2, 5, 7, 12
1.5078 ± 0.4	$\frac{5}{2}^-$	$\tau_{\rm m} = 4.1^{+3.5}_{-1.4}$ psec	γ	4, 5, 6, 7, 12
1.5362 ± 0.5	$\frac{3}{2}^+$	$\tau_{\rm m} = 28 \pm 15$ fsec	γ	4, 5, 6, 7, 8, 12
1.6152 ± 0.7	$\frac{3}{2}^-$	$\tau_{\rm m} = 180 \pm 60$ fsec	γ	4, 5, 6, 7, 12
2.7940 ± 1.3	$\frac{9}{2}^+$	$\tau_{\rm m} = 330 \pm 130$ fsec	γ	4, 5, 6, 7, 8, 12, 13
(3.841 ± 15)				12
4.026 ± 8	$(\frac{3}{2}, \frac{5}{2})^+$			5, 6, 12, 13
4.146 ± 8	$(\frac{7}{2}^-)$		γ	5, 6, 12
4.200 ± 10	$(\frac{9}{2}^-)$			5, 12
4.368 ± 8	$(\frac{7}{2}^+)$			5, 6, 12
4.549 ± 8	$(\frac{1}{2}, \frac{3}{2})^-$			5, 6, 12
4.624 ± 10				5, 6, 12
4.710 ± 9				5, 6, 12
4.783 ± 20				5, 12
5.087 ± 6				5, 6, 12
5.351 ± 10	$\frac{1}{2}^+$			5, 12
5.425 ± 7				5, 12
5.463 ± 20				12
5.545 ± 10				12
5.832 ± 9				12
6.013 ± 7	$(\frac{3}{2}, \frac{1}{2})^-$			12
6.096 ± 7				12
6.149 ± 20				12
6.290 ± 7				12
6.437 ± 9				12
6.743 ± 7	$(\frac{3}{2}, \frac{1}{2})^-$			12
6.862 ± 7				12
7.067 ± 9				12
(7.178 ± 15)				12
7.253 ± 10				12
(7.326 ± 15)				12

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

E_x (MeV ± keV)	$J^\pi; T$	τ or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
(7.531 ± 15)				12
7.616 ± 16	$\frac{3}{2}^+; \frac{3}{2}$			12, 13
7.700 ± 10				12
(7.788 ± 10)				12
7.994 ± 15				12
8.063 ± 15				12
8.236 ± 10 [a]				12
8.440 ± 10				12
8.523 ± 10				12
(8.810 ± 25)				12
8.915 ± 10				12
9.013 ± 10				12
9.100 ± 20				12
9.240 ± 20				12
9.489 ± 25				12
9.886 ± 50 [a]				12
10.46	$\frac{1}{2}^+$	$\Gamma = 355$	p, ^{3}He, α	3, 12
10.48	$\frac{3}{2}^+$	45	p, ^{3}He, α	3, 12
10.613 ± 20				12
11.51	$\frac{3}{2}^-(\frac{1}{2}^-)$	24	^{3}He, α	3
12.23	$\frac{5}{2}^+$	200	^{3}He, α	3
12.50	$\frac{7}{2}^+$	150	^{3}He, α	3
12.69 ± 50	$\frac{1}{2}^+$	180 ± 40	p, ^{3}He, α	3

[a] Broad or unresolved states.

(e) ^{16}O(^{3}He, α)^{15}O $\quad Q_m = 4.909$

(f) ^{16}O(^{3}He, 2n)^{17}Ne $\quad Q_m = -22.430$

(g) ^{16}O(^{3}He, 2α)^{11}C $\quad Q_m = 5.305$

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

Table 19.22: The half-life of ^{19}Ne [a]

$\tau_{1/2}$ (sec)	Refs.
18.5 ± 0.5	(1952SC15)
18.3 ± 0.5	(1957AL29)
17.7 ± 0.1	(1957PE12)
16.72 ± 0.05	(1960JA12)
19.5 ± 1.0	(1960WA04)
$17.43 \pm 0.06^*$	(1962EA02)
16.5 ± 1	(1964VA23)
$17.36 \pm 0.06^*$	(1968GO10)
17.40 ± 0.04	mean of values marked by asterisk

[a] See also (1959AJ76, 1964BAZZ).

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). The capture cross section at the 2.40 MeV resonance (reaction (a)) is < 0.8 μb (1959BR79). 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).

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 (1971OT1C). They report a state at $E_x = 11.51$ MeV [$E(^3\text{He}) = 3.65$ MeV] with $J^\pi = \frac{3}{2}^-$ or $(\frac{1}{2}^-)$, $\Gamma_{\text{c.m.}} = 24$ keV. In addition, two states at $E_x = 12.23$ and 12.50 MeV [$E(^3\text{He}) = 4.50$ and 4.82 MeV], $J^\pi = \frac{5}{2}^+$ and $\frac{7}{2}^+$, $\Gamma_{\text{c.m.}} = 200$ and 150 keV respectively, are indicated by the work of (1971OT1C). See also (1970OT1B, 1970WE1K).

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 reaction (b), see also (1961DU02: 3.4 to 5.6 MeV), (1961TO03: 3.9 to 5.7 MeV), (1968TO09: 9.1 to 10.4 MeV) and (1964BR1G, 1965BR42: 11 to 29 MeV). For reaction (c), see also (1966GO1E: 2.0 to 5.5 MeV), (1966HA21: 3.0 to 9.5 MeV) and (1964BR1G, 1965BR42: 11 to 29 MeV). For reaction (d), see also (1965AL05: 8.1 to 10 MeV) and (1969BR07: 9.8 to 11.7 MeV). For polarization measurements, see (1970MC1F, 1971MC1M). For reaction (e), see also (1966HA21: 3 to 9.5 MeV), (1959HI73: 5.6 to 5.9 MeV), (1965AL05: 8.0 to 10.0 MeV). For reaction (f) see (1967ES02) and for reaction (g) see (1964BR1G, 1965BR42). See also (1965JI1A, 1966MA1R, 1969PA1C).

Table 19.23: Radiative decays of ^{19}Ne levels

E_i (MeV)	J_i^π	E_f (MeV)	J_f^π	Branch (%)	τ_m [a] and Γ_γ	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) [c]	61^{+4}_{-20} psec	(1969NI09)
					61.4 ± 3.0 psec	(1970BH02)
1.51 [b]	$\frac{5}{2}^-$	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; $\Gamma_\gamma = 0.17 \pm 0.08$ meV	(1970GI09)
1.54 [b]	$\frac{3}{2}^+$	0	$\frac{1}{2}^+$	< 6		(1970GI09)
		0.24	$\frac{5}{2}^+$	95 ± 3	28 ± 15 fsec; $\Gamma_\gamma = 24^{+27}_{-8}$ meV	(1970GI09)
		0.28	$\frac{1}{2}^-$	5 ± 3		(1970GI09)
1.62 [b]	$\frac{3}{2}^-$	0	$\frac{1}{2}^+$	20 ± 3	180 ± 60 fsec; $\Gamma_\gamma = 3.7^{+1.8}_{-0.9}$ meV	(1970GI09)
		0.24	$\frac{5}{2}^+$	10 ± 3		
		0.28	$\frac{1}{2}^-$	70 ± 4		(1970GI09)
2.79 [b]	$\frac{9}{2}^+$	0	$\frac{1}{2}^+$	< 10		(1970GI09)
		0.24	$\frac{5}{2}^+$	100	330 ± 130 fsec; $\Gamma_\gamma = 2.0^{+1.3}_{-0.6}$ meV	(1970GI09)
		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)
4.15	$(\frac{7}{2}^-)$	1.51	$\frac{5}{2}^-$	principal		(1967OL05)

[a] τ_m for this state; Γ_γ (total).
[b] See also (1967OL05).
[c] $B(\mathrm{E1}) = (1.06 \pm 0.05) \times 10^{-3}$ W.u. (1970BH02). See also (1969NI09).

4. ^{16}O(α, n)^{19}Ne $\qquad Q_m = -12.135$

At $E_\alpha = 15$ to 19 MeV, lifetime measurements have been obtained for ^{19}Ne*(1.51, 1.54, 1.62, 2.79): see Table 19.23 (1970GI09). See also (1964VA23).

5. ^{16}O(^{6}Li, t)^{19}Ne $\qquad Q_m = -7.350$

This reaction (and its mirror reaction ^{16}O(^{6}Li, ^{3}He)^{19}F) have been studied at $E(^6\text{Li}) = 24$ MeV: see reaction 12 in ^{19}F and Table 19.11 for a summary of the results (1971BI06). See also (1971GA1H, 1971GO1B).

6. ^{17}O(^{3}He, n)^{19}Ne $\qquad Q_m = 4.300$

At $E(^3\text{He}) = 3.1$ MeV, neutron groups have been observed corresponding to states at $E_x = 0.24 \pm 0.07$, 1.55 ± 0.06, 2.78 ± 0.05, (3.70 ± 0.04), 4.01 ± 0.02, 4.13 ± 0.03, 4.36 ± 0.03, 4.54 ± 0.03, 4.61 ± 0.04, 4.69 ± 0.03 and 5.09 ± 0.03 MeV (1968GU07). Angular distributions have been obtained for n_{0+1+2}, n_{3+4+5} and n_6. The latter suggest $L = 2$ and $J^\pi = (\frac{1}{2}, \frac{3}{2}, \frac{7}{2}, \frac{9}{2})^+$ for ^{19}Ne*(2.79) (1968GU07).

7. ^{19}F(p, n)^{19}Ne $\qquad Q_m = -4.021$

$E_{\text{thresh.}} = 4233.2 \pm 2.0$ keV (1961BE13: see also (1966MA60)), 4234.7 ± 1.0 keV (1961RY04), 4234.3 ± 0.8 keV (1966MA60), 4233.7 ± 0.7 keV (1969OV01). See also (1959BR06) and (1959AJ76).

Excited states of ^{19}Ne determined from neutron threshold measurements and the measurement of neutron and γ spectra are displayed in Table 19.24 (1955MA84, 1962FR09, 1963GI09, 1965WE05, 1970GI09). The radiative decay of the first six states has been studied by (1970GI09) who also studied the lifetimes and J^π of ^{19}Ne*(1.51, 1.54, 1.62, 2.79): see Table 19.23. See also (1957BA09). The g-factor of ^{19}Ne*(0.24) $= -0.296 \pm 0.003$ (1969BL02). An angular distribution measurement is reported at $E_p = 6.8$ MeV (1967DR08; $n_{0+1+2+3?}$). See also (1964ST1C). Astrophysical considerations are discussed in (1969BA1N). See also (1962EA02).

8. ^{19}F(^{3}He, t)^{19}Ne $\qquad Q_m = -3.257$

At $E(^3\text{He}) = 26$ 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.

Table 19.24: Excited states of ^{19}Ne from ^{19}F(p, n)^{19}Ne

E_x (MeV ± keV)					J^{π} [a]
(1955MA84)	(1962FR09)	(1963GI09)	(1965WE05)	(1970GI09)	
0.241 ± 4		0.241 ± 4		0.2382 ± 0.2	
			0.25 ± 20		
0.280 ± 4		0.271 ± 4		0.2751 ± 0.2	
	1.506 ± 5			1.5079 ± 0.4	$\frac{5}{2}^-$
			1.51 ± 20		
	1.538 ± 4			1.5363 ± 0.5	$\frac{3}{2}^+$
	1.612 ± 5		1.62 ± 20	1.6155 ± 0.7	$\frac{3}{2}^-$
			2.78 ± 30	2.7946 ± 1.5	$\frac{9}{2}^+$

[a] (1970GI09).

9. ^{20}Ne(γ, n)^{19}Ne $\qquad Q_m = -16.866$

See ^{20}Ne.

10. ^{20}Ne(p, d)^{19}Ne $\qquad Q_m = -14.641$

See (1970PR1B).

11. ^{20}Ne(d, t)^{19}Ne $\qquad Q_m = -10.608$

Not reported.

12. ^{20}Ne(^{3}He, α)^{19}Ne $\qquad Q_m = 3.712$
$Q_0 = 3.750 \pm 0.013$ (1967SP09).

Alpha groups have been observed to many states of ^{19}Ne with $0 < E_x < 9.7$ MeV: see Table 19.25 (1967GR04, 1970GA18, 1972HA03). Angular distributions have been measured at $E(^3\text{He}) = 10$ MeV (1969BA62; α_0, α_6), 15 MeV (1969BA62; α_6), 15 MeV (1970GA18; α to $0 < E_x < 6.87$), 18 MeV (1972HA03) and 35 MeV (1970AR25). DWBA analysis of the strongest transitions leads to the l and J^π values shown in Table 19.25. 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] and ^{19}Ne*(0.28, 1.51, 1.62) with the $K = \frac{1}{2}^-$ band. Candidates for the $\frac{7}{2}^-$ and $\frac{9}{2}^-$ members of the $K = \frac{1}{2}^-$ band are thought to be ^{19}Ne*(4.15, 4.20). Possible matching of other ^{19}Ne states with those in ^{19}F is also discussed (1970GA18).

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

E_x (MeV ± keV)				l_n [e]	J^π [f]
(1967GR04) [a]	(1970GA18) [a]	(1967OL05) [b]	(1972HA03) [a,c]		
	0			0	$\frac{1}{2}^+$
	0.238 ± 10	0.2384 ± 0.3 [d]	0.2397 ± 2 [c]	2	$\frac{5}{2}^+$
	0.273 ± 10	0.2748 ± 0.3 [d]	0.2766 ± 2 [c]	1	$\frac{1}{2}^-$
		[h]	1.5040 ± 3 [c]		$(\frac{5}{2}^-)$
1.521 ± 20	1.524 ± 20				
		[h]	1.5324 ± 3 [c]	2	$(\frac{3}{2})^+$
1.620 ± 15	1.615 ± 10	[h]	1.6115 ± 3 [c]	1	$(\frac{3}{2})^-$
2.778 ± 15	2.793 ± 10	[h]	2.7917 ± 3	4, 5 [g]	$(\frac{9}{2}^+)$ [g]
(3.841 ± 15)					
4.013 ± 15	4.036 ± 10			2	$(\frac{3}{2}, \frac{5}{2})^+$
4.152 ± 15	4.142 ± 10	4.160 ± 20.0			
	4.200 ± 10				
4.344 ± 15	4.379 ± 10				
4.547 ± 15	4.551 ± 10			1	$(\frac{1}{2}, \frac{3}{2})^-$
	4.625 ± 10				
4.689 ± 15					
	4.712 ± 10				
	4.783 ± 20				
5.077 ± 15	5.093 ± 10		5.086 ± 10		
	5.351 ± 10			0	$\frac{1}{2}^+$
	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	$(\frac{3}{2}, \frac{1}{2})^-$

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

E_x (MeV ± keV)				l_n [e]	J^{π} [f]
(1967GR04) [a]	(1970GA18) [a]	(1967OL05) [b]	(1972HA03) [a,c]		
	6.089 ± 10		6.104 ± 15		
	6.149 ± 20				
	6.290 ± 10		6.289 ± 10		
	6.433 ± 20		6.438 ± 10		
	6.744 ± 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		
			(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] From measurements of α-groups.

[b] From measurements of de-excitation γ-rays.

[c] The energy separations within each multiplet are fixed at the values determined by (1970GI09) (1972HA03).

[d] (1970BH02) report $E_x = 238.34 \pm 0.15$ and 275.30 ± 0.2 keV for these states.

[e] (1970GA18). Spectroscopic factors have also been calculated.

[f] (1967OL05, 1970GA18). See also (1970AR25).

[g] (1969BA62).

[h] The excitation energies obtained by (1967OL05) for ^{19}Ne*(1.51, 1.54, 1.62, 2.79) are superseded by those of (1970GI09): see Table 19.24.

[i] Unresolved states.

The mean lifetimes, τ_m, of ^{19}Ne*(0.24, 0.28) are, respectively, 26.6 ± 1.2 nsec (1967BE14) and 61.4 ± 3.0 psec (1970BH02). ^{19}Ne*(0.28) decays to the ground state by E1 emission: $B(\text{E1}) = (1.06 \pm 0.05) \times 10^{-3}$ W.u. The ratio of this value to that for the analog state in ^{19}F is 0.95 ± 0.06 (1970BH02). The γ-decay of seven states of ^{19}Ne has been studied by (1967OL05): see Table 19.23.

13. ^{21}Ne(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 $J^\pi = \frac{3}{2}^+$; $T = \frac{3}{2}$, 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).

^{19}Na

(Fig. 8)

A study of the reaction ^{24}Mg(p, ^{6}He)^{19}Na at $E_p = 54.7$ MeV reveals a group of ^{6}He particles corresponding to a state in ^{19}Na with $M - A = 12.974 \pm 0.070$ MeV. It is presumed to be the ground state of ^{19}Na, although the close proximity of the second $T = \frac{3}{2}$ state in ^{19}O from the first (96 keV), does not permit a definite assignment. If it is assumed that ^{19}Na(0) has $M - A = 12.974 \pm 0.070$ MeV, then ^{19}Na is unbound with respect to decay into ^{18}Ne$+$p by 0.366 ± 0.070 MeV (1969CE01). The mass excess of ^{19}Na is calculated to be 12.965 ± 0.025 MeV, using a seniority scheme, and 12.968 ± 0.025 MeV, using a supermultiplet scheme [both these values were calculated assuming that the lowest $J^\pi = \frac{3}{2}^+$; $T = \frac{3}{2}$ state in ^{19}Na is 0.096 MeV above the $J^\pi = \frac{5}{2}^+$; $T = \frac{3}{2}$ state, as in ^{19}O] (1969HA38). See also (1960BA1F, 1966KE16, 1968MU1B, 1971CE1A).

^{19}Mg

(Not illustrated)

See (1965GO1D).

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(Closed 31 December 1971)

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