Energy Levels of Light Nuclei
$A = 19$

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Abstract: An evaluation of $A = 18$–20 was published in *Nuclear Physics A*300 (1978), p. 1. This version of $A = 19$ differs from the published version in that we have corrected some errors discovered after the article went to press. Figures and introductory tables have been omitted from this manuscript. Reference key numbers have been changed to the NNDC/TUNL format.

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^{19}B

(Not illustrated)

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

^{19}C

(Not illustrated)

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

^{19}N

(Fig. 8)

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

^{19}O

(Figs. 5 and 8)

GENERAL: (See also (1972AJ02).)

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

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

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

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

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

E_x (MeV ± keV)	$J^\pi; T$	τ or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
0	$\frac{5}{2}^+; \frac{3}{2}$	$\tau_{1/2} = 26.91 \pm 0.08$ sec	β^-	1, 2, 3, 4, 5, 10, 12, 14
0.0960 ± 0.5	$\frac{3}{2}^+$	$\tau_m = 2.00 \pm 0.07$ nsec $g = -0.48 \pm 0.06$	γ	3, 4, 10, 14
1.4717 ± 0.4	$\frac{1}{2}^+$	$\tau_m = 1.27 \pm 0.17$ psec	γ	3, 4, 10, 12, 14
2.3715 ± 1.0	$\frac{9}{2}^+$	> 3.5 psec	γ	3, 4, 10
2.7790 ± 0.9	$\frac{7}{2}^+$	93 ± 19 fsec	γ	3, 4, 10
3.067 ± 3	$\frac{3}{2}^+$	≥ 1 psec	γ	3, 4, 10
3.1545 ± 2.5	$\frac{5}{2}^+$	(≥ 1 psec)	γ	3, 4, 10
3.237 ± 5	$\frac{3}{2}^+$			3, 4, 10
3.944 ± 3	$\frac{3}{2}^-$		γ	3, 10
3.9468 ± 2.5	$\frac{7}{2} \rightarrow \frac{13}{2}$			3
4.118 ± 5	$\frac{3}{2}^+$	$\Gamma < 15$ keV		4, 10
4.333 ± 12		< 15		4, 10
4.402 ± 12		< 15		4, 10
4.583 ± 8	$\frac{3}{2}^-$	52 ± 3	n	4, 6, 10
4.707 ± 12	$\frac{5}{2}^+$	< 15		4, 10
4.998 ± 12		< 15		4, 10
5.086 ± 10	$\frac{1}{2}^-$	49 ± 5	n	6
5.146 ± 8	$(\frac{3}{2}, \frac{5}{2}^+)$	3.4 ± 1.0	n	4, 6, 10
5.33	$\frac{3}{2}^+$	330	n	6
5.455 ± 9	$\frac{5}{2}^+$	280	n	6
5.502 ± 12		< 15		4, 10
5.706 ± 8	$\frac{3}{2}^+$	7.8 ± 1.4	n	4, 6, 10
6.13	$\frac{3}{2}^+$	190	n	6
6.20	$\frac{1}{2}^-$	120	n	6
6.276 ± 7	$\frac{7}{2}^-$	19.2 ± 2.4	n	4, 6, 10
6.480 ± 15				6, 10
6.560 ± 15				10
6.899 ± 15				10
6.997 ± 15				10
7.117 ± 15				10

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

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

[a] See also Tables 19.2 and 19.5.

Complex reactions involving ^{19}O: (1973BA81, 1973WI15, 1974BA89, 1975FO09, 1977AR06).

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The coherent scattering amplitude (bound) is $a = 6.00 \pm 0.13$ fm (1973MU14). The total cross section measured for $E_n = 0.14$ to 2.47 MeV shows four resonances at $E_n = 0.66$, 1.19, 1.26, 1.84 and 2.45 MeV [see Table 19.4] in addition to a broad maximum at $E_n = 1.6$ MeV and resonance structure near 2.3 MeV (1965VA03). A phase shift analysis by (1964DO08, 1973DO05) is consistent with the (1965VA03) results and suggests that the two broad structures can each be accounted for in terms of two levels whose parameters are displayed in Table 19.4. At higher energies [$E_n = 2.82$ to 4.17 MeV (1959SC30), 2.45 to 8.50 MeV and 10.6 to 19.0 MeV (1965SA24)] the total cross section shows additional structures. See also (1973MU14, 1976GAYV).

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

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

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

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

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

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

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

[f] Observed but group was weak.

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

[h] (1966WI05, 1973WI05).

[i] $E_{\vec{d}} = 14.8$ MeV; polarization and differential cross-section measurements. The spectroscopic factors for the states with $E_x > 4.1$ MeV have been calculated in the weakly bound neutron approximation (1974SE01).

[j] See (1975CR03).

[k] (1966WI05, 1975CR03).

[l] 0.92 ± 0.14 (1973WI05).

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

E_{res} (MeV $\pm$ keV)	$\Gamma_{c.m.}$ (keV)	^{19}O* (MeV)	J^{π}	Refs.
0.661 ± 10	52 ± 3	4.583	$\frac{3}{2}^-$	(1965VA03, 1964DO08)
1.192 ± 10	49 ± 5	5.086	$\frac{1}{2}^-$	(1965VA03, 1964DO08)
1.256 ± 10	3.4 ± 1.0	5.146	$\frac{3}{2}$	(1965VA03)
1.45	330	5.33	$\frac{3}{2}^+$	(1965VA03, 1973DO05)
1.60	280	5.47	$\frac{5}{2}^+$	(1973DO05)
1.840 ± 10	7.8 ± 1.4	5.699	$\frac{3}{2}$	(1965VA03)
2.30	190	6.13	$\frac{3}{2}^+$	(1965VA03, 1964DO08, 1973DO05)
2.37	120	6.20	$\frac{1}{2}^-$	(1965VA03, 1964DO08, 1973DO05)
2.445 ± 10	19.2 ± 2.4	6.272	$\frac{7}{2}^-$	(1965VA03, 1964DO08)
≈ 2.58		(6.40)		(1965SA24)
(2.63)		(6.45)		(1965SA24)

[a] See also (1959SC30, 1965SA24, 1976GAYV) for evidence of additional structures.

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

See (1972ED01).

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

See (1964AM02).

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

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

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

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

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

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

Not reported.

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

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

13. ^{19}N(β^-)^{19}O $\quad Q_{\rm m} = 12.48$

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

14. ^{19}F(n, p)^{19}O $\quad Q_{\rm m} = -4.036$

Table 19.5: Radiative decays in ^{19}O

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

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

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

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

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

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

These reactions have not been reported.

^{19}F

(Figs. 6 and 8)

GENERAL: (See also (1972AJ02).)

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

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

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

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

Complex reactions involving ^{19}F: (1972PU1B, 1972OH01, 1973WI15, 1974AL17, 1975AR14, 1975HO1K, 1975RE08, 1975VO09, 1976BA08, 1976BR1T, 1976BU16, 1976EG02, 1976HI05, 1976NA11, 1977AR06, 1977BU05, 1977CO14, 1977NA03, 1977PR05, 1977ST1J, 1977TA07, 1977VA02).

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

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

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

Pion capture and reactions[†]*:* (1971GO29, 1972EC1A, 1972HU1A, 1972MI11, 1972PL04, 1973DA1G, 1973HO43, 1973KA19, 1974HU14, 1974LI1H, 1974ST1G, 1974TA18, 1975KA1G, 1975VA1D, 1975VO1D, 1976AS1B, 1976BAYR, 1976EN02, 1976JA04, 1976LI18, 1976SI1J, 1977BA2H, 1977SI01).

Kaon capture: (1972WI04).

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

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

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

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

E_x (MeV $\pm$ keV)	$J^\pi; T$	K^π	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
0	$\frac{1}{2}^+; \frac{1}{2}$	$\frac{1}{2}^+$	stable		1, 3, 4, 7, 8, 12, 13, 14, 15, 17, 18, 20, 22, 23, 28, 29, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 57, 58, 59, 60
0.109894 ± 0.005	$\frac{1}{2}^-$	$\frac{1}{2}^-$	$\tau_m = 0.853 \pm 0.010$ nsec	γ	8, 12, 13, 14, 15, 23, 29, 31, 32, 33, 39, 40, 42, 45, 55, 58
0.19724 ± 0.19	$\frac{5}{2}^+$	$\frac{1}{2}^+$	128.8 ± 1.5 nsec $\mu = +3.60$ n.m. $Q = 0.11$ b	γ	8, 12, 13, 14, 15, 23, 29, 32, 39, 40, 41, 42, 44, 45, 55, 58
1.34567 ± 0.13	$\frac{5}{2}^-$	$\frac{1}{2}^-$	4.8 ± 0.5 psec	γ	8, 13, 14, 15, 23, 29, 39, 40, 41, 43, 45
1.4587 ± 0.3	$\frac{3}{2}^-$	$\frac{1}{2}^-$	75 ± 13 fsec	γ	8, 13, 14, 15, 23, 29, 33, 40, 41, 43, 45, 49, 55
1.5540 ± 0.2	$\frac{3}{2}^+$	$\frac{3}{2}^+$	$4.4^{+2.4}_{-2.0}$ fsec	γ	8, 13, 14, 15, 23, 28, 29, 32, 39, 40, 41, 43, 45, 54, 55
2.7798 ± 0.6	$\frac{9}{2}^+$	$\frac{1}{2}^+$	259 ± 30 fsec	γ	6, 8, 11, 13, 14, 15, 23, 29, 39, 40, 41, 45, 54, 55
3.9057 ± 0.8	$\frac{3}{2}^+$		9 ± 5 fsec	γ	8, 14, 15, 23, 28, 33, 41, 45, 54, 55
3.9987 ± 0.7	$\frac{7}{2}^-$	$\frac{1}{2}^-$	< 40 fsec	γ	8, 14, 15, 23, 28, 29, 39, 41, 45, 54, 55
4.0325 ± 1.2	$\frac{9}{2}^-$	$\frac{1}{2}^-$	71 ± 10 fsec	γ	8, 11, 13, 14, 15, 29, 39, 41, 45, 54, 55
4.3767 ± 0.7	$\frac{7}{2}^+$		< 11 fsec	γ	8, 13, 14, 15, 21, 28, 29, 32, 41, 45, 54, 55
4.5499 ± 0.8	$\frac{5}{2}^+$		< 50 fsec	γ	14, 25, 28, 29, 39, 41, 45, 55
4.5561 ± 0.5	$\frac{3}{2}^-$		17^{+10}_{-8} fsec	γ	14, 15, 28, 41, 45, 54, 55
4.647 ± 20	$\frac{13}{2}^+$	$\frac{1}{2}^+$	2.2 ± 0.3 psec	γ	11, 13, 14, 15, 23, 45, 55
4.6825 ± 0.7	$\frac{5}{2}^-$		15.4 ± 3.0 fsec	γ, α	8, 14, 28, 29, 41, 45, 54, 55
5.1053 ± 1.7	$\frac{5}{2}^+$		< 30 fsec	γ, α	8, 14, 15, 28, 29, 41, 45, 54, 55
5.337 ± 2	$\frac{1}{2}^{(+)}$		≤ 15 fsec	γ, α	8, 14, 15, 29, 41, 45, 54
5.425 ± 7	$\frac{7}{2}^-$			γ, α	8, 13, 14, 23, 29, 39, 41, 45, 54
5.465 ± 2	$\frac{7}{2}^+$	$\frac{1}{2}^+$	$\Gamma < 1$ keV	γ, α	8, 13, 14, 15, 21, 41, 45, 54
5.500 ± 3	$\frac{3}{2}^+$		$\Gamma = 4 \pm 1$	γ, α	8, 9, 15, 29, 41, 45
5.54 ± 5	$\frac{5}{2}^+$			γ, α	8, 29, 41, 45, 54
5.623 ± 3	$\frac{3}{2}^-$		$\tau_m < 45$ fsec	γ, α	8, 28, 41, 45, 54, 55

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

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

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

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

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

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

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

E_x (MeV ± keV)	$J^\pi; T$	K^π	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
15.00 ± 20				n, p	13, 24
15.75 ± 25			150	n, p	24
16.27 ± 25			200	γ, n, p	24, 34
16.80 ± 30				n, p	24
17.9				p, α	25, 27

[a] See also Tables 19.7 and 19.10.

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

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

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

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

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

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

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

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

See (1972AJ02).

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

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

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

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

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

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

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

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

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

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

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

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

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

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

A = adopted.

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

[b] See also (1965AL20).

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

[d] See also (1972LE20).

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

[f] See also (1970AI01).

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

[h] See also (1974UN01).

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

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

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

[l] See also Table 19.8.

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

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

See (1975VE10).

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

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

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

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

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

E_α (MeV ± keV)	$\Gamma_{\rm c.m.}$ (keV)	$\omega\Gamma_\gamma$ (eV)	J^π	$E_{\rm x}$ (MeV ± keV)	Refs.
0.85	$(42.8 \pm 8.5) \times 10^{-6}$ [b]	$(6.0 \pm 1.0) \times 10^{-3}$	$\frac{5}{2}^-$	4.681 ± 1	(1972RO01)
1.385 ± 3		$(13 \pm 8) \times 10^{-3}$ [c]	$\frac{5}{2}^{(+)}$	5.105 ± 2	(1970AI01, 1976RO07)
1.678 ± 3		1.64 ± 0.16	$\frac{1}{2}^{(+)}$	5.337 ± 2	A, (1972RO33)
1.790		0.42 ± 0.09 [c]	$\frac{7}{2}^-$	5.427	(1970AI01)
1.839 ± 2	< 1	2.5 ± 0.4 [c]	$\frac{7}{2}^+$	5.465	A
1.883 ± 3	4 ± 1	4.2 ± 1.1 [c]	$\frac{3}{2}^+$	5.500	A
1.930		0.48 ± 0.11 [c]	$\frac{5}{2}^+$	5.54	(1970AI01)
2.035 ± 4		0.37 ± 0.09	$\frac{3}{2}^-$	5.620	(1972RO33)
2.441 ± 4		0.53 ± 0.13	$\frac{1}{2}^+$	5.938 ± 3	(1972RO33)
2.608 ± 2		2.70 ± 0.54	$\frac{7}{2}^+$	6.070 ± 1	(1972RO33)
2.631 ± 4		4.50 ± 0.90	$\frac{3}{2}^-$	6.088 ± 3	(1972RO33)
2.722 ± 2		2.40 ± 0.60	$\frac{7}{2}^-$	6.160 ± 1	(1972RO33)
2.873 ± 3		1.0 ± 0.2	$\frac{5}{2}^+$	6.282 ± 2	(1970AI01, 1977DI08)
2.935 ± 3		0.76 ± 0.15	$\frac{7}{2}^+$	6.330 ± 2	(1970AI01, 1977DI08)
3.1468 ± 1.5		1.7 ± 0.3	$\frac{3}{2}^+$	6.4976 ± 1.5	(1970AI01, 1977DI08)
3.1498 ± 1.5		2.3 ± 0.4	$\frac{11}{2}^+$	6.5000 ± 1.5	(1977DI08)
3.183 ± 2		2.4 ± 0.4	$\frac{3}{2}^+$	6.526 ± 2	(1977DI08)
3.218 ± 2		0.63 ± 0.13	$\frac{7}{2}$	6.554 ± 2	(1977DI08)
3.267 ± 2		1.6 ± 0.3	$\frac{9}{2}^+$	6.592 ± 2	(1977DI08)
3.511 ± 3		10.9 ± 1.5	$\frac{3}{2}^-$	6.785 ± 2	(1977DI08)
3.576 ± 3		1.0 ± 0.2	$\frac{5}{2}$	6.836 ± 2	(1977DI08)
3.645 ± 5		6.1 ± 1.3	$\frac{3}{2}^-$	6.891 ± 4	(1977DI08)
3.688 ± 3		9.7 ± 1.4	$\frac{7}{2}$	6.925 ± 2	(1977DI08)
3.993 ± 2		1.00 ± 0.12	$\frac{11}{2}^-$	7.1662 ± 0.7	(1973RO09, 1974UN01, 1977DI08, 1977FI06)
4.465		17.0 ± 2.7	$\frac{5}{2}^+; T = \frac{3}{2}$	7.538 ± 2	A, (1976RO07)
4.618		3.7 ± 0.9	$\frac{3}{2}^+; T = \frac{3}{2}$	7.659 ± 2	A, (1976RO07)
4.96 ± 3		2.3 ± 0.4	$\frac{7}{2}^+, \frac{9}{2}$	7.929	A
4.97 ± 3		3.1 ± 0.5	$\frac{11}{2}^+$	7.937	A
5.413 ± 5		0.53 ± 0.08	$\frac{13}{2}^-$	8.288 ± 2	(1974UN01, 1977FI06)
6.258 ± 5		0.91 ± 0.17	$\frac{11}{2}^+$	8.957 ± 2	(1974UN01, 1977FI06)
			$\frac{11}{2}^+$	9.27	(1977SY1A)
			$\frac{11}{2}^-$	9.88	(1977FI06)
7.75	< 3	[d]		(10.127 ± 2)	(1972WO15)
8.105	< 1	15.0 ± 3.0	$\frac{13}{2}^+$	10.411 ± 3	(1976SY01)
			$\frac{11}{2}^+$	11.217	(1977SY1A)

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

[a] See also Table 19.7 here.

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

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

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

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

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

7. (a) ^{14}N(^{7}Li, d)^{19}F $Q_m = 6.123$
   (b) ^{14}N(^{10}B, αp)^{19}F $Q_m = 6.6886$

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

8. ^{15}N(α, γ)^{19}F $Q_m = 4.0138$

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

9. (a) ^{15}N(α, α)^{15}N $E_b = 4.0138$
   (b) ^{15}N(α, ^{8}Be)^{11}B $Q_m = -11.0832$

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

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

E_α (MeV $\pm$ keV)	$\Gamma_{\rm lab}$ (keV)	J^π	E_x (MeV)
1.878 $\pm$ 10	4	$\frac{3}{2}^+$	5.496
2.614 $\pm$ 10	1.5	$\frac{5}{2}^+$	6.077
2.635 $\pm$ 10	5	$\frac{5}{2}^-$	6.094
2.833 $\pm$ 10	10	$\frac{1}{2}^+$	6.250
2.883 $\pm$ 10	3	$\frac{5}{2}^+$	6.289
2.944 $\pm$ 10	3	$\frac{7}{2}^+$	6.338
3.060 $\pm$ 10 [b]	360	$\frac{1}{2}^-$	6.429 $\pm$ 0.008
3.194 $\pm$ 10	5	$\frac{1}{2}^+$	6.535
3.229 $\pm$ 10	2	$\frac{5}{2}^+$	6.563
3.525 $\pm$ 10	3	$\frac{3}{2}^-$	6.796
3.587 $\pm$ 10	1.5	$(\frac{5}{2}, \frac{3}{2})^+$	6.845
3.648 $\pm$ 10	35	$\frac{5}{2}^-$	6.893
3.705 $\pm$ 10	3	$(\frac{9}{2}, \frac{7}{2})^-$	6.938
3.770 $\pm$ 10 [b]	64	$\frac{1}{2}^-$	6.989 $\pm$ 0.008
3.930 $\pm$ 10 [b]	40	$\frac{7}{2}^+$	7.116 $\pm$ 0.008
4.127 [c]	$\lesssim$ 8		7.271
4.23	$\lesssim$ 82	$\frac{7}{2}^+$	7.35
4.49	$\lesssim$ 110	$\frac{7}{2}^+$	7.56
4.53	$\lesssim$ 50	$\frac{5}{2}^+$	7.59
4.710	$\lesssim$ 40	$\frac{1}{2}^-$	7.731
4.780	$\lesssim$ 8		7.787
4.93	$\lesssim$ 260		7.90
(5.005)	($\lesssim$ 8)		(7.964)
(5.018)	($\lesssim$ 5)		(7.974)
5.116	$\lesssim$ 8		8.052
5.203	$\lesssim$ 8		8.120
5.232	$\lesssim$ 6		8.143
5.25	$\lesssim$ 65		8.16
5.284	$\lesssim$ 10		8.184
5.481	$\lesssim$ 10		9.340

[a] (1959SM02, 1961SM02, 1972MO42).
[b] See also (1977DI08).
[c] I am indebted to Prof. C. Rolfs for his comments on the resonances above 4 MeV.

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

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

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

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

A = adopted.

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

[b] See also (1972LE20).

[c] See also (1976BH03).

[d] See also (1976RO07).

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

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

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

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

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

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

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

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

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

Resonances in the yields of p_0, p_1, α_0 and α_{1+2} are reported by (1967KO11) corresponding to states with $E_{\rm x} = 12.42$, 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]. See also (1974KA1N). An analysis by the Humblet-Rosenfeld theory of the elastic yield (reaction (d)) in the range $E_{\rm t} = 1.4$ to 3.7 MeV suggests a large number of resonances: their parameters are displayed in Table 19.11 (1973WE11). See also (1972AJ02), (1976LE19; theor.), (1973BA1R, 1977RE01; applied), ^{18}O and ^{18}F here, and ^{15}N in (1976AJ04).

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

Angular distributions have been measured at $E_{\alpha} = 20.1$ MeV (1975PO1F; $p_0 \rightarrow p_5$), 26.7 and 33.1 MeV (1961YA02; $p_{0\rightarrow 2}$, $p_{3\rightarrow 5}$) and at 40 MeV (1976VA26): see Table 19.12. At $E_{\alpha} = 40$ MeV ^{19}F*(9.872) is strongly excited: it is suggested that it is a $\frac{11}{2}^{-}$ state and that the $\frac{11}{2}^{-}$ cluster

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

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

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

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

[c] From Table 19.6.

[d] Angular distribution obtained for this state.

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

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

J^{π} [c]	E_x [b] in ^{19}F (MeV)			E_x [b] in ^{19}Ne (MeV)		
	$K^{\pi} = \frac{1}{2}^{+}$	$K^{\pi} = \frac{1}{2}^{-}$	other	$K^{\pi} = \frac{1}{2}^{+}$	$K^{\pi} = \frac{1}{2}^{-}$	other
$\frac{1}{2}^{+}$	0			0		
$\frac{3}{2}^{+}$	1.56			1.54 [e]		
$\frac{5}{2}^{+}$	0.20			0.24		
$\frac{7}{2}^{+}$	5.47			5.42		
$\frac{9}{2}^{+}$	2.78			2.79 [e]		
$\frac{11}{2}^{+}$	(6.50) [d]					
$\frac{13}{2}^{+}$	4.65			4.64		
$\frac{1}{2}^{-}$		0.11			0.28	
$\frac{3}{2}^{-}$		1.46			1.62 [e]	
$\frac{5}{2}^{-}$		1.35			1.51 [e]	
$\frac{7}{2}^{-}$		4.00			4.20 [g]	
$\frac{9}{2}^{-}$		4.03			4.14 [g]	
$\frac{3}{2}^{+}$			3.91 [e]			4.03 [e]
$\frac{7}{2}^{+}$			4.38			4.38 [e]
$\frac{5}{2}^{(+)}$			4.55			4.55 [e]
$\frac{3}{2}^{-}$ $(\frac{1}{2}^{-})$			4.56			4.593 ± 0.006
$\frac{5}{2}^{-}$			4.68			4.71
$\frac{5}{2}^{(-)}$			5.11			5.09 [f]
$\frac{5}{2}^{+}$			5.34			
$\frac{7}{2}^{-}$			5.43			
						(6.12)
$(\frac{5}{2}, \frac{7}{2})^{-}$						6.29
$(\frac{11}{2}, \frac{9}{2})^{-}$						6.86

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

[b] Energies are nominal.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

18. (a) ^{17}O(d, n)^{18}F $\qquad Q_{\rm m} = 3.382$ $\qquad E_{\rm b} = 13.813$
(b) ^{17}O(d, p)^{18}O $\qquad Q_{\rm m} = 5.8199$
(c) ^{17}O(d, α)^{15}N $\qquad Q_{\rm m} = 9.799$

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

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

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

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

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

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

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

Not reported.

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

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

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

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

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

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

See (1977CH22).

23. ^{18}O(p, γ)^{19}F $Q_m = 7.9934$

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

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

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

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

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

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

[a] See also Table 19.7.

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

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

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

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

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

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

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

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

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

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

[b] n means total yield.

[c] See (1968BE34).

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

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

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

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

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

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

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

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

E_p [a] (MeV ± keV)	Γ_{lab} (keV)	Particles out	Γ_p (keV)	Γ_α (keV)	J^π	E_x (MeV)	Refs.
10.5		p_0, p_1, α_0				17.9	(1966ST04)

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

B: (1972WO15) and private communication.

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

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

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

[d] See also (1975AL20).

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

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

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

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

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

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

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

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

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

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

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

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

E_x (MeV ± keV)		l_p [a]	l [b]	$C^2S(2J_f+1)$		J^π [b]
(1975LE16) [a]	(1970SC25) [b]			[d]	[b]	
	0	0	0	0.29	0.42	$\frac{1}{2}^+$
	0.112 ± 3		1		0.224	$\frac{1}{2}^-$
	0.199 ± 3	2	2	1.68	2.45	$\frac{5}{2}^+$
	1.347 ± 5					
	1.460 ± 5		1		0.098	$\frac{3}{2}^-$
1.5544 ± 0.6	1.556 ± 5		2		1.01	$\frac{3}{2}^+$
	2.784 ± 5	4	4 [f]		0.027 [f]	$\frac{9}{2}^+$
3.9048 ± 0.8	3.912 ± 5					
3.999 ± 1	4.002 ± 5		(3)		(0.019)	$(\frac{7}{2}^-)$
	4.036 ± 10					
4.3761 ± 0.8	4.385 ± 5		(4) [f]		(0.048) [f]	$(\frac{7}{2}^+)$
4.551 ± 1	4.555 ± 5		2		0.31	$\frac{3}{2}^+$ [g]
4.5557 ± 0.5						
4.684 ± 1	4.675 ± 10 [e]					
5.106 ± 3	5.113 ± 5	3	(2, 3) [f]			$\frac{5}{2}^-, \frac{7}{2}^-$ [h]
	5.34 ± 5		(2, 3)		0.0065	$\frac{5}{2}^+$
	5.428 ± 8		(2, 3)		(0.042)	$(\frac{3}{2}^+)$
	5.495 ± 5 [e]					
	5.54 ± 5		3		0.14	$\frac{7}{2}^-$
5.625 ± 4						
	5.943 ± 5		0		0.014	$\frac{1}{2}^+$
	6.095 ± 5		1		0.12	$\frac{1}{2}^-$
	6.167 ± 5					
	6.255 ± 8	0	(0)	0.24	0.19	$\frac{1}{2}^+$ [d]
	6.503 ± 5 [e]		2 [f]		0.133 [f]	$\frac{3}{2}^+$
	6.595 ± 10					
	6.792 ± 5	1	1 [f]	0.27	0.29 [f]	$\frac{3}{2}^-$
	6.93 ± 5		(2, 3)			$(\frac{5}{2}^+, \frac{7}{2}^-)$
	7.112 ± 8 [e]		2		0.087	$\frac{5}{2}^+$
	7.26 ± 5					

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

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

[a] ^{18}O(d, nγ) (1975LE16). For τ_m, see Table 19.10.

[b] ^{18}O(^{3}He, d): $E(^{3}\text{He}) = 16$ MeV (1970SC25).

[c] ^{18}O(d, n): $E_d = 3$ MeV (1968GU07) and 4 MeV (1972TA26).

[d] Using DWUCK (1972TA26).

[e] Unresolved.

[f] See also (1970GR04).

[g] J probably $\frac{5}{2}$. This appears to be a different state from the one involved in the ^{20}Ne(d, ^{3}He)^{19}F reaction, with $J^{\pi} = \frac{3}{2}^{-}$; see (1970KA31).

[h] (1968GU07).

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

Not reported.

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

For $\tau_{\rm m}$ of ^{19}F*(0.110) see Table 19.10 (1969NI09).

32. ^{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), $J^\pi = \frac{5}{2}^+$ and $\frac{3}{2}^+$, respectively. Very weak branches are also observed to ^{19}F*(0.11, 4.39), $J^\pi = \frac{1}{2}^-$ and $\frac{7}{2}^+$, respectively: see Table 19.19. The half-life is 26.91 ± 0.08 sec: see reaction 1 in ^{19}O. The character of the allowed decay to the $\frac{5}{2}^+$ and $\frac{3}{2}^+$ states, and the forbiddeness of the decay to the ground state of ^{19}F are consistent with $J^\pi = \frac{5}{2}^+$ for the ground state of ^{19}O, and then with $(\frac{7}{2}^+)$ for ^{19}F*(4.39): see (1966OL01). Gamma-ray branching ratios are displayed in Table 19.7 (1966OL01, 1970CO22). See also (1970CO1D). A preliminary study of the allowed decay to ^{19}F*(0.197) has been carried out to measure the F/GT mixing ratio (1976PE1D).

33. ^{19}F(γ, γ)^{19}F

The energy of the first excited state is 109.894 ± 0.005 keV: its width is $(5.1 \pm 0.7) \times 10^{-7}$ eV (1962BO1A, 1962SE12). ^{19}F*(1.46, 3.91, 7.66) are also excited: for $\tau_{\rm m}$ of the first of these states see Table 19.10 (1964BO22); $E_{\rm x} = 3906 \pm 6$ and 7663 ± 4 keV for the latter (1972SH07) [see also for Γ_γ]. The scattering cross section is relatively small and structureless for $E_\gamma = 14$ to 30 MeV (1967LO1B).

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

The (γ, n$_0$) and (γ, n$_1$) cross section, derived from bremsstrahlung show peaks at $E_\gamma = 12.10 \pm 0.04$ [0.20 ± 0.05], 12.38 ± 0.04 [0.17 ± 0.05], 13.82 ± 0.05 [0.25 ± 0.10] and 16.24 ± 0.05 [0.30 ± 0.15] MeV [Γ in brackets]. It is suggested that the two lower states have $J^\pi = \frac{1}{2}^-$ and the two upper states have $J^\pi = \frac{3}{2}^-$. The integrated cross section in the interval $E_\gamma = 11.9 \rightarrow 17.9$ is 14.4 ± 2.2 MeV·mb (1976SH12). The cross section for (γ, Tn) has been measured for $E_\gamma = 10.5$ to 28 MeV: it shows a clear resonance at $E_\gamma \approx 12$ MeV and unresolved structures at higher energies.

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

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

[a] See also (1959AJ76).
[b] $E_\gamma = 111.5 \pm 1.5$ keV (1954JO21), 112 ± 2 keV (1959JO26).
[c] $E_\gamma = 199.6 \pm 1.5$ keV (1954JO21).
[d] $E_x = 1.5539 \pm 0.0013$ MeV (1966AL12).
[e] log f_1t (1970CO22). See also (1971TO08).
[f] Based on Q_m and $\tau_{1/2} = 26.91 \pm 0.08$ sec: see ^{19}O, reaction 1 (B.A. Zimmerman, private communication).

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

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

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

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

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

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

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

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

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

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

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

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

40. ^{19}F(n, n$'$)^{19}F

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

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

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

[a] Abstract.

[b] See also (1973HA13).

41. (a) ^{19}F(p, p)^{19}F

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

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

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

Angular distributions of elastically scattered deuterons have been measured for $E_d = 2.0$ to 15 MeV: see (1972AJ02). In addition, angular distributions have been measured at $E_d = 15$ MeV for $d_1 \rightarrow d_5$ (1970DE06) and $B(E\lambda)$ have been derived. See also (1971BE2F). For polarization measurements see (1971BO39, 1977AN24) and (1978EN06). See also (1972SC1F; theor.).

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

[a] (1973KR20): $E_\alpha = 25$ MeV.
[b] Energies are nominal unless uncertainty is indicated. Authors state accuracy of E_x is in range $\pm 8 \rightarrow 20$ keV.
[c] If L is in parentheses, fit DWBA was not possible: value of L shown is that implied by the selection rules for one-step excitation.
[d] Only those J^π determined by (1973KR20).

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

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

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

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

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

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

See (1972AJ02).

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

See ^{19}Ne.

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

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

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

See (1976KI1D).

54. ^{20}Ne(d, ^{3}He)^{19}F $\quad Q_m = -7.3515$

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 (1971IN1C) and (1972EN03, 1973EL07, 1973SA1A; theor.).

55. ^{20}Ne(t, α)^{19}F $\quad Q_m = 6.9694$

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

56. ^{21}Ne(n, t)^{19}F $\quad Q_m = -11.124$

Not reported.

57. ^{21}Ne(p, ^{3}He)^{19}F $\quad Q_m = -11.888$

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

58. ^{21}Ne(d, α)^{19}F $\quad Q_m = 6.465$

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

59. ^{22}Ne(p, α)^{19}F $\quad Q_m = -1.675$

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

60. ^{23}Na(n, n′α)^{19}F $\quad Q_m = -10.467$

See (1966WO03).

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

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

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

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

GENERAL: (See also (1972AJ02).)

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

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

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

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

Astrophsyical questions: (1973CL1E).

Muon capture: (1972MI11).

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

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

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

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

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

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

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

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

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

E_x (MeV ± keV)	$J^\pi; T$	K^π	τ or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
0	$\frac{1}{2}^+; \frac{1}{2}$	$\frac{1}{2}^+$	$\tau_{1/2} = 17.22 \pm 0.02$ sec	β^+	1, 3, 4, 8, 9, 10, 11, 14, 15
0.23827 ± 0.11	$\frac{5}{2}^+$	$\frac{1}{2}^+$	$\tau_m = 26.0 \pm 0.8$ nsec $g = -0.296 \pm 0.003$	γ	3, 4, 8, 9, 10, 14, 15
0.27509 ± 0.13	$\frac{1}{2}^-$	$\frac{1}{2}^-$	$\tau_m = 61.4 \pm 3.0$ psec	γ	3, 4, 8, 14
1.50756 ± 0.3	$\frac{5}{2}^-$	$\frac{1}{2}^-$	$1.4^{+0.5}_{-0.6}$ psec	γ	3, 4, 8, 14
1.5360 ± 0.4	$\frac{3}{2}^+$	$\frac{1}{2}^+$	28 ± 11 fsec	γ	3, 4, 5, 8, 9, 10, 14
1.6156 ± 0.5	$\frac{3}{2}^-$	$\frac{1}{2}^-$	143 ± 31 fsec	γ	3, 4, 8, 14
2.7947 ± 0.6	$\frac{9}{2}^+$	$\frac{1}{2}^+$	140 ± 35 fsec	γ	3, 4, 5, 8, 9, 10, 14, 15
4.0329 ± 2.4	$(\frac{3}{2}, \frac{5}{2})^+$		< 50 fsec	γ	4, 7, 14
4.140 ± 4	$(\frac{9}{2})^-$	$(\frac{1}{2}^-)$	< 0.3 psec	γ	4, 7, 14
4.1971 ± 2.4	$(\frac{7}{2})^-$	$(\frac{1}{2}^-)$	< 0.35 psec	γ	4, 5, 7, 14
4.3791 ± 2.2	$\frac{7}{2}^+$		< 0.12 psec	γ	4, 7, 10, 14
4.549 ± 4	$(\frac{1}{2}, \frac{3}{2})^-$		< 80 fsec	γ	4, 7, 14
4.600 ± 4	$(\frac{5}{2}^+)$		< 0.16 psec	γ	4, 7, 14
4.635 ± 4	$\frac{13}{2}^+$	$\frac{1}{2}^+$	> 1 psec	γ	4, 5, 6, 7, 14
4.712 ± 10	$(\frac{5}{2}^-)$				4, 14
4.783 ± 20					4, 14
5.092 ± 6	$(\frac{5}{2}, \frac{7}{2})^-$			γ	14
5.351 ± 10	$\frac{1}{2}^+$				14
5.424 ± 7	$(\frac{7}{2}^+)$	$\frac{1}{2}^+$			4, 14
5.463 ± 20					14
5.539 ± 9					14
5.832 ± 9					14
6.013 ± 7	$(\frac{3}{2}, \frac{1}{2})^-$				14
6.094 ± 8					14
6.149 ± 20					14
6.289 ± 7					4, 5, 14
6.437 ± 9					14
6.742 ± 7	$(\frac{3}{2}, \frac{1}{2})^-$				5, 14
6.862 ± 7					4, 14
7.067 ± 9					14
(7.178 ± 15)					14

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

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

[a] See also Tables 19.13 and 19.26.

[b] Broad or unresolved states.

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

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

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

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

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

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

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

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

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

[a] See also Table 19.24 in (1972AJ02).

[b] Observed via $E_\gamma = 1232.2 \pm 0.2$ and 1297.9 ± 0.4 keV (transitions $1.51 \to 0.28$ and $1.54 \to 0.24$, respectively) (1971IT02).

[c] (1970GI09).

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

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

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

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

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

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

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

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

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

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

A = adopted.

[a] Total Γ_γ.

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

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

[d] See also (1977LE03).

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

Neutron-γ coincidence measurements lead to the determination of excitation energies [$E_x = 4032.9 \pm 2.4, 4140 \pm 4, 4197.1 \pm 2.4, 4379.1 \pm 2.2, 4549 \pm 4, 4605 \pm 5, 4635 \pm 4$ and (5097 ± 10) keV], τ_m and branching ratios (see Table 19.26). On the basis of these it is suggested that ^{19}Ne*(4.14, 4.20) are the analogs of ^{19}F*(4.03, 4.00) [$J^\pi = \frac{9}{2}^-, \frac{7}{2}^-$] and that ^{19}Ne*(4.55, 4.60) are the analogs of ^{19}F*(4.558, 4.555) [$J^\pi = \frac{5}{2}^+, \frac{3}{2}^-$]: these assignments disagree with the reports from the ^{16}O(^{6}Li, t)^{19}Ne reaction [see reaction 4 and Table 19.13]. There is no evidence for a reported state at $E_x = 4.78$ MeV [see, however, reactions 4 and 14] (1973DA31).

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

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

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

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

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

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

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

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

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

See (1972AJ02).

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

See (1971IN1C; unpublished thesis).

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

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

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

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

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

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

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

[b] See also (1971HA2F).

[c] (1970GA18).

[d] (1967OL05, 1970GA18).

[e] (1970GA18, 1972EN03).

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

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

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

[i] Unresolved states.

[j] (1969BA62).

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

At $E_p = 45$ MeV triton groups are observed corresponding to ^{19}Ne*(0, 0.24, 2.79, 4.03, 7.620 ± 0.025). The latter has an angular distribution [$L = 0$] similar to that for ^{19}F*(7.66): both are thought to be the analogs of the $J^\pi; T = \frac{3}{2}^+; \frac{3}{2}$ 0.096 MeV first excited state of ^{19}O. The ground state of ^{19}O has $J^\pi = \frac{5}{2}^+$; L for the tritons to that state should be 2 (1969HA38). At $E_p = 40$ MeV the ground-state angular distributions in this, and in the (p, ^{3}He) mirror reaction, have been compared: see ^{19}F (1976NA18).

^{19}Na

(Fig. 8)

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

^{19}Mg

(Not illustrated)

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

References

(Closed 01 November 1977)

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

1952MI54 C. Mileikowsky and W. Whaling, Phys. Rev. 88 (1952) 1254

1954JO21 G.A. Jones, W.R. Phillips, C.M.P. Johnson and D.H. Wilkinson, Phys. Rev. 96 (1954) 547

1959AJ76 F. Ajzenberg and T. Lauritsen, Nucl. Phys. 11 (1959) 1

1959AL06 D.E. Alburger, A. Gallmann and D.H. Wilkinson, Phys. Rev. 116 (1959) 939

1959BR79 D.A. Bromley, J.A. Kuehner and E. Almqvist, Nucl. Phys. 13 (1959) 1

1959BU05 J.W. Butler and J.D. Holmgren, Phys. Rev. 116 (1959) 1485

1959JO26 C.M.P. Johnson, G.A. Jones, W.R. Phillips and D.H. Wilkinson, Proc. Roy. Soc. A252 (1959) 1

1959SC30 L. Schellenberg, E. Baumgartner, P. Huber and F. Seiler, Helv. Phys. Acta 32 (1959) 357

1959SM02 H.H. Smotrich, Thesis, Columbia Univ. (1959); CU-188 (1959)

1960FO10 B. Forkman and I. Wahlstrom, Ark. Fys. 18 (1960) 339

1961NO05 E. Norbeck, Phys. Rev. 121 (1961) 824

1961SI03 M.G. Silbert and N. Jarmie, Phys. Rev. 123 (1961) 221

1961SI09 E.A. Silverstein, S.R. Salisbury, G. Hardie and L.D. Oppliger, Phys. Rev. 124 (1961) 868

1961SM02 H. Smotrich, K.W. Jones, L.C. McDermott and R.E. Benenson, Phys. Rev. 122 (1961) 232

1961YA02 H. Yamaguchi, J. Phys. Soc. Jpn. 16 (1961) 583

1962BO1A Boehm, Dumond, Hendrikson and Seppi, Electromag. Lifetimes Prop. of Nucl. States, N.A.S.-N.R.C. Publ. 974 (1962) 106

1962EA02 L.G. Earwaker, J.G. Jenkin and E.W. Titterton, Nature 195 (1962) 271

1962HO06 R.K. Hobbie and F.F. Forbes, Phys. Rev. 126 (1962) 2137

1962NE03 J.W. Nelson and E.L. Hudspeth, Phys. Rev. 125 (1962) 301

1962SE12 E.J. Seppi and F. Boehm, Phys. Rev. 128 (1962) 2334

1963YA03 K. Yagi, Y. Nakajima, K. Katori, Y. Awaya and M. Fujioka, Nucl. Phys. 41 (1963) 584

1964AM02 S. Amiel and J. Gilat, Nucl. Sci. Eng. 18 (1964) 105

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

1964BO22 E.C. Booth, B. Chasan and K.A. Wright, Nucl. Phys. 57 (1964) 403

1964DO08 T.R. Donoghue, A.F. Behof and S.E. Darden, Nucl. Phys. 54 (1964) 33

1965AL13 J.P. Allen, A.J. Howard, D.A. Bromley and J.W. Olness, Nucl. Phys. 68 (1965) 426

1965AL20 J.P. Allen, A.J. Howard, D.A. Bromley and J.W. Olness, Phys. Rev. 140 (1965) B1245

1965MC10 R.E. McDonald, D.B. Fossan, L.F. Chase, Jr. and J.A. Becker, Phys. Rev. 140 (1965) B1198

1965SA24 S.R. Salisbury, D.B. Fossan and F.J. Vaughn, Nucl. Phys. 64 (1965) 343

1965VA03 F.J. Vaughn, H.A. Grench, W.L. Imhof, J.H. Rowland and M. Walt, Nucl. Phys. 64 (1965) 336

1966AL12 D.E. Alburger and K.W. Jones, Phys. Rev. 149 (1966) 743

1966OL01 J.W. Olness and D.H. Wilkinson, Phys. Rev. 141 (1966) 966

1966ST04 J. Stevens, H.F. Lutz and S.F. Eccles, Nucl. Phys. 76 (1966) 129

1966TH02 M.F. Thomas, J.S. Lopes, R.W. Ollerhead, A.R. Poletti and E.K. Warburton, Nucl. Phys. 78 (1966) 298

1966WI05 J.L. Wiza and R. Middleton, Phys. Rev. 143 (1966) 676

1966WO03 G. Wolfer and M. Bormann, Z. Phys. 194 (1966) 75

1967BE14 J.A. Becker, J.W. Olness and D.H. Wilkinson, Phys. Rev. 155 (1967) 1089

1967GR04 M.W. Greene and E.B. Nelson, Phys. Rev. 153 (1967) 1068

1967KO11 A.P. Kobzev, A.V. Gromov, K. Kashlik, K. Nedvedyuk, V.I. Salatskii and S.A. Telezhnikov, Yad. Fiz. 5 (1967) 510; Sov. J. Nucl. Phys. 5 (1967) 359

1967LE1C Lemeille, Marquez and Saunier, Compt. Rend. B265 (1967) 1050

1967LO1B J.-M. Loiseaux, J.-M. Maison and M. Langevin, J. Phys. (France) 28 (1967) 11

1967OL05 J.W. Olness, A.R. Poletti and E.K. Warburton, Phys. Rev. 161 (1967) 1131

1967RO10 H. Ropke, K.P. Lieb and R. Konig, Nucl. Phys. A97 (1967) 609

1967ST28 T. Stammbach, S.E. Darden, P. Huber and I. Sick, Helv. Phys. Acta 40 (1967) 915

1967WA13 E.K. Warburton, J.W. Olness and A.R. Poletti, Phys. Rev. 160 (1967) 938

1968BE34 A.-M. Bergdolt and G. Bergdolt, Compt. Rend. B267 (1968) 455

1968ET1A Eto, Kawai, Matsuda and Mirata, J. Phys. Soc. Jpn. 24 (1968) 422

1968GO10 J.D. Goss, F.L. Riffle, D.R. Parsignault and J.C. Harris, Nucl. Phys. A115 (1968) 113

1968GU07 K. Gul, B.H. Armitage and B.W. Hooton, Nucl. Phys. A122 (1968) 81

1968KL05 O. Klepper and H. Spehl, Z. Phys. 215 (1968) 17

1968MI09 R. Middleton, L.M. Polsky, C.H. Holbrow and K. Bethge, Phys. Rev. Lett. 21 (1968) 1398

1968PA11 P. Paul, J.W. Olness and E.K. Warburton, Phys. Rev. 173 (1968) 1063

1968RI13 L.R. Rice and R.T. Carpenter, Nucl. Phys. A120 (1968) 220

1968SP01 P. Spilling, H. Gruppelaar, H.F. De vries and A.M.J. Spits, Nucl. Phys. A113 (1968) 395

1968TO11 D.D. Tolbert, P.M. Cockburn and F.W. Prosser, Jr., Phys. Rev. Lett. 21 (1968) 1535

1969AI01 J.H. Aitken, K.W. Allen, R.E. Azuma, A.E. Litherland and D.W.O. Rogers, Phys. Lett. B28 (1969) 653

1969BA62 D.J. Baugh, J. Nurzynski, D.M. Rosalky and C.H. Osman, Aust. J. Phys. 22 (1969) 555

1969BE57 P.M. Beard, P.B. Parks, E.G. Bilpuch and H.W. Newson, Ann. Phys. 54 (1969) 566

1969BE90 K. Bethge, C.M. Fou and R.W. Zurmu, Nucl. Phys. A123 (1969) 521

1969BH01 K. Bharuth-Ram, K.P. Jackson, K.W. Jones and E.K. Warburton, Nucl. Phys. A137 (1969) 262

1969BL02 J. Bleck, D.W. Haag, W. Leitz, R. Michaelsen, W. Ribbe and F. Sichelschmidt, Nucl. Phys. A123 (1969) 65

1969BR07 K.H. Bray and J. Nurzynski, Nucl. Phys. A127 (1969) 622

1969CE01 J. Cerny, R.A. Mendelson, Jr., G.J. Wozniak, J.E. Esterl and J.C. Hardy, Phys. Rev. Lett. 22 (1969) 612

1969DA08 C.M. da Silva, J.O. Newton, J.C. Lisle and M.F. da Silva, Nucl. Phys. A132 (1969) 9

1969DI07 G.U. Din, Nucl. Phys. A134 (1969) 655

1969DU1A Dunning, Thesis, Catholic Univ. (1969)

1969FI07 P. Fintz, F. Hibou, B. Rastegar and A. Gallmann, Nucl. Phys. A132 (1969) 265

1969GL06 Y.A. Glukhov, B.G. Novatskii, A.A. Ogloblin, S.B. Sakuta and D.N. Stepanov, Izv. Akad. Nauk SSSR Ser. Fiz. 33 (1969) 609; Bull. Acad. Sci. USSR Phys. Ser. 33 (1970) 561

1969HA38 J.C. Hardy, H. Brunnader, J. Cerny and J. Janecke, Phys. Rev. 183 (1969) 854

1969JA09 K.P. Jackson, K. Bharuth Ram, P.G. Lawson, N.G. Chapman and K.W. Allen, Phys. Lett. B30 (1969) 162

1969JO10 K.W. Jones, A.Z. Schwarzschild, E.K. Warburton and D.B. Fossan, Phys. Rev. 178 (1969) 1773

1969NI09 R.J. Nickles, Nucl. Phys. A134 (1969) 308

1969PO03 A.R. Poletti, J.A. Becker and R.E. McDonald, Phys. Rev. 182 (1969) 1054

1969PO07 G. Poelz, H. Schmitt, L. Tauscher, G. Backenstoss, S. Charalambus, H. Daniel and H. Koch, Z. Phys. 227 (1969) 311

1969SE02 D.L. Sellin, H.W. Newson and E.G. Bilpuch, Ann. Phys. 51 (1969) 461

1969SE03 D.L. Sellin, W.P. Beres and E.G. Bilpuch, Ann. Phys. 51 (1969) 476

1969VO10 U.C. Voos, W. von Oertzen and R. Bock, Nucl. Phys. A135 (1969) 207

1970AD02 E.G. Adelberger and A.B. McDonald, Nucl. Phys. A145 (1970) 497

1970AI01 J.H. Aitken, R.E. Azuma, A.E. Litherland, A.M. Charlesworth, D.W.O. Rogers and J.J. Simpson, Can. J. Phys. 48 (1970) 1617

1970AJ04 F. Ajzenberg-Selove, Nucl. Phys. A152 (1970) 1

1970BH02 K. Bharuth-Ram, R.D. Gill, K.P. Jackson, B. Povh and E.K. Warburton, Phys. Rev. C2 (1970) 1210

1970BL07 R. Blomquist, M. Eckhause, F.R. Kane, J.R. Kane, P. Martin, G.H. Miller, W.W. Sapp, C.B. Spence and R.E. Welsh, Nucl. Phys. B19 (1970) 632

1970BO08 T.I. Bonner, Phys. Rev. C1 (1970) 1699

1970CA14 R.R. Carlson and D.J. Johnson, Phys. Rev. Lett. 25 (1970) 172

1970CO1D Cooper, Thesis, Univ. of Oregon (1970)

1970CO22 J.C. Cooper and B. Crasemann, Phys. Rev. C2 (1970) 451

1970DE06 D. Dehnhard and N.M. Hintz, Phys. Rev. C1 (1970) 460

1970FI08 P. Fintz, F. Hibou, B. Rastegar and A. Gallman, Nucl. Phys. A150 (1970) 49

1970FL1A Flowers, Meth. and Problems of Theor. Phys. (1970) 289

1970GA18 J.D. Garrett, R. Middleton and H.T. Fortune, Phys. Rev. C2 (1970) 1243

1970GI09 R.D. Gill, K. Bharuth-Ram, K.P. Jackson, R.A.I. Bell, B.C. Robertson, J. L'Ecuyer, N.G. Chapman and H.J. Rose, Nucl. Phys. A152 (1970) 369

1970GR04 L.L. Green, C.O. Lennon and I.M. Naqib, Nucl. Phys. A142 (1970) 137

1970KA31 G.T. Kaschl, G.J. Wagner, G. Mairle and U. Schmidt-Rohr, Nucl. Phys. A155 (1970) 417

1970LA02 S.T. Lam, A.E. Litherland and J.J. Simpson, Can. J. Phys. 48 (1970) 827

1970MI1E Middleton, Proc. Int. Conf. Nucl. Reactions Induced by Heavy Ions, Heidelberg, 1969 (1970) 263

1970MI1K Midy, Thesis, Univ. of Lyon (1970)

1970RO1C Rogers et al., Bull. Amer. Phys. Soc. 15 (1970) 542

1970SC05 J.J. Schwartz and B.A. Watson, Phys. Rev. Lett. 24 (1970) 322

1970SC25 C. Schmidt and H.H. Duhm, Nucl. Phys. A155 (1970) 644

1971BA2V Bassani, CEA N 1474 (1971)

1971BA2W Baciu, Research Studies Phys. (Romania) 23 (1971) 773

1971BA68 P.H. Barker, P.M. Cockburn, A. Huber, H. Knoth, U. Matter, H.-P. Seiler and P. Marmier, Ann. Phys. 66 (1971) 705

1971BE2F Beckert, Zentral. Kernf. Rossendorf Bei Dresden, Rept. No. Zfk 222 (1971)

1971BE60 Z. Berant, M.B. Goldberg, G. Goldring, S.S. Hanna, H.M. Loebenstein, I. Plesser, M. Popp, J.S. Sokolowski, P.N. Tandon and Y. Wolfson, Nucl. Phys. A178 (1971) 155

1971BI06 H.G. Bingham, H.T. Fortune, J.D. Garrett and R. Middleton, Phys. Rev. Lett. 26 (1971) 1448

1971BL05 W. Blaser, A. Wyttenbach and P. Baertschi, J. Inorg. Nucl. Chem. 33 (1971) 1221

1971BO39 V.I. Borovlev, R.P. Slabospitskii, A.P. Klyucharev, G.B. Andreev and I.D. Lopatko, Yad. Fiz. 14 (1971) 47; Sov. J. Nucl. Phys. 14 (1972) 27

1971BR02 C. Broude, U. Karfunkel and Y. Wolfson, Nucl. Phys. A161 (1971) 241

1971DE1W Desgrolard, U. Lyon, Rept. No. Lycen 7177 (1971)

1971DI18 W.R. Dixon, R.S. Storey, J.H. Aitken, A.E. Litherland and D.W.O. Rogers, Phys. Rev. Lett. 27 (1971) 1460

1971DU13 E.I. Dubovoi, Izv. Akad. Nauk SSSR Ser. Fiz. 35 (1971) 199; Bull. Acad. Sci. USSR Phys. Ser. 35 (1972) 180

1971FO18 H.T. Fortune and C.M. Vincent, Phys. Rev. C4 (1971) 1994

1971GO29 N.V. Goncharov, A.I. Derebchinskii, O.G. Konovalov, S.G. Tonapetyan and V.M. Khvorostyan, Yad. Fiz. 14 (1971) 922; Sov. J. Nucl. Phys. 14 (1972) 516

1971HA2F Haynes, Thesis, Florida State Univ. (1971)

1971HA30 K.A. Hardy, A.H. Lumpkin, Y.K. Lee and G.E. Owen, Phys. Rev. C4 (1971) 317

1971HI06 F. Hibou, P. Fintz, B. Rastegar and A. Gallmann, Nucl. Phys. A171 (1971) 603

1971IN1C Ingalls, Thesis, Princeton Univ. (1971)

1971IT02 T. Itahashi, T. Shibata and T. Wakatsuki, J. Phys. Soc. Jpn. 31 (1971) 961

1971KN05 H. Knoth, P.H. Barker, A. Huber, U. Matter, P.M. Cockburn and P. Marmier, Nucl. Phys. A172 (1971) 25

1971MC11 R.E. McDonald, J.A. Becker, A.D.W. Jones and A.R. Poletti, Phys. Rev. C4 (1971) 377

1971NI04 R.J. Nickles, P.L. Jolivette and G.M. Klody, Izv. Akad. Nauk SSSR Ser. Fiz. 35 (1971) 65; Bull. Acad. Sci. USSR Phys. Ser. 35 (1972) 60

1971RO1C Rogers, Thesis, Univ. of Toronto (1971)

1971SC1F Scott et al., Suppl. J. Phys. 32 (1971) C6-275

1971SH26 V.S. Shirley, Proc. Int. Conf. Hyperfine Interactions Detected by Nucl. Radiation, Israel, 1970 (1971) 1255

1971SY1A Synder, Thesis, Univ. of Iowa (1972)

1971TA1A Talmi, Proc. Conf. Hyperfins Interactions Detected by Nucl. Radiation, Israel, 1970 (1971) 1133

1971TO08 I.S. Towner, E.K. Warburton and G.T. Garvey, Ann. Phys. 66 (1971) 674

1971WO12 M.R. Wormald and I.F. Wright, Part. Nucl. 2 (1971) 168

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

1972AL33 J.F. Allard, S. Bendjaballah, P. Desgrolard and T.F. Hammann, Nuovo Cim. A9 (1972) 561

1972BA1P Bassani et al., Communications, Proc. Aix-en-Provence Conf. 2 (1972) 68

1972BA1R Balakrishnan, Metha and Divatia, Nucl. Phys. Solid State Phys. Symp. Ab., Bombay, 1972 (1972)

1972BA25 W.H. Bassichis and I. Kelson, Phys. Rev. C5 (1972) 1169

1972BI14 H.G. Bingham and H.T. Fortune, Phys. Rev. C6 (1972) 1900

1972BU29 A.P. Bukhvostov, A.M. Chatrchyan, G.E. Dogotar, R.A. Eramzhyan, N.P. Popov and V.A. Vartanjan, Acta Phys. Pol. B3 (1972) 375

1972CA37 P. Camiz, E. Olivieri, M. Scalia and A. D'Andrea, Nuovo Cim. A12 (1972) 71

1972CE1A Cerny, At. Masses Fund. Constants, Teddington, 1971 (1972) 26

1972CH18 M. Chevallier, P. Gaillard, J.Y. Grossiord, M. Gusakow, J.R. Pizzi and C. Ruhla, J. Phys. (Paris) 33 (1972) 177

1972CL1A Clayton, Encyclopedia of the Twentieth Century (1972)

1972CR06 D.J. Crozier, H.T. Fortune, R. Middleton, J.L. Wiza and B.H. Wildenthal, Phys. Lett. B41 (1972) 291

1972CR1B Crozier, Bingham, Courtney and Fortune, Bull. Amer. Phys. Soc. 17 (1972) 465

1972EC1A Eckhause et al., Nucl. Phys. B44 (1972) 83

1972ED01 G. Eder, G. Winkler and P. Hille, Z. Phys. 253 (1972) 335

1972EN03 T. Engeland and P.J. Ellis, Nucl. Phys. A181 (1972) 368

1972EY01 Y. Eyal, I. Dostrovsky and Z. Fraenkel, Nucl. Phys. A180 (1972) 545

1972FA19 M. Fasla and H. Beaumevieille, Nuovo Cim. A9 (1972) 547

1972FO29 H.T. Fortune, Part. Nucl. 4 (1972) 245

1972GA08 J.D. Garrett, H.G. Bingham, H.T. Fortune and R. Middleton, Phys. Rev. C5 (1972) 682

1972GA14 J.D. Garrett and O. Hansen, Nucl. Phys. A188 (1972) 139

1972GA1F Garvey, Comments Nucl. Part. Phys. 5 (1972) 85

1972GU05 M.R. Gunye and C.S. Warke, Phys. Rev. C5 (1972) 1860

1972HA03 D.S. Haynes, K.W. Kemper and N.R. Fletcher, Phys. Rev. C5 (1972) 5

1972HI10 M.D. High, J.F. Bedi, D.W. Devins, P. Shapiro and P.A. Deutchman, Phys. Lett. B41 (1972) 588

1972HI17 J. Hiura, F. Nemoto and H. Bando, Suppl. Prog. Theor. Phys. 52 (1972) 173

1972HO14 B.R. Holstein, Phys. Rev. C5 (1972) 1529

1972HU1A W.T. Huang, C.A. Levinson and M.K. Banerjee, Phys. Rev. C5 (1972) 651

1972KH1A Khok, Izv. Akad. Nauk SSSR Ser. Fiz. 36 (1972) 786

1972KU13 K.-I. Kubo, Nucl. Phys. A187 (1972) 205

1972LE06 R. Leonardi, Phys. Rev. Lett. 28 (1972) 836

1972LE13 T.Y. Lee, S.T. Hsieh and C.M. Yang, Phys. Rev. C5 (1972) 2013

1972LE20 C. Lebrun, F. Guilbault, Y. Deschamps, L.-H. Rosier and P. Avignon, Compt. Rend. B274 (1972) 1245

1972LE33 W. Leiper and R.W.P. Drever, Phys. Rev. C6 (1972) 1132

1972MC01 W.S. McEver, T.B. Clegg, J.M. Joyce and E.J. Ludwig, Nucl. Phys. A178 (1972) 529

1972MI11 G.H. Miller, M. Eckhause, P. Martin and R.E. Welsh, Phys. Rev. C6 (1972) 487

1972MO42 T. Mo and H.R. Weller, Nucl. Phys. A198 (1972) 153

1972NE1B Nemoto and Bando, Prog. Theor. Phys. 47 (1972) 1210

1972NI05 L. Nichol and T.J. Kennett, Can. J. Phys. 50 (1972) 553.

1972OH01 I.K. Oh, C.S. Zaidins, C.D. Zafiratos and S.I. Hayakawa, Nucl. Phys. A178 (1972) 497

1972OP01 A.M.F. Op den Kamp and A.M.J. Spits, Nucl. Phys. A180 (1972) 569

1972OT01 W.R. Ott and H.R. Weller, N ucl. Phys. A179 (1972) 625

1972PA29 A.D. Panagiotou and H.E. Gove, Nucl. Phys. A196 (1972) 145

1972PL04 H.S. Plendl, D. Burch, K.A. Eberhard, M. Hamm, A. Richter, C.J. Umbarger and W.P. Trower, Nucl. Phys. B44 (1972) 413

1972PO07 J.E. Poling, E. Norbeck and R.R. Carlson, Phys. Rev. C5 (1972) 1819

1972PU1B Puhlhofer et al., Communications, Proc. of Aix-en-Provence Conf., 2 (1972) 55

1972RO01 D.W.O. Rogers, J.G. Aitken and A.E. Litherland, Can. J. Phys. 50 (1972) 268

1972RO33 D.W.O. Rogers, R.P. Beukens and W.T. Diamond, Can. J. Phys. 50 (1972) 2428

1972SC03 U.C. Schlotthauer-Voos, H.G. Bohlen, W. von Oertzen and R. Bock, Nucl. Phys. A180 (1972) 385

1972SC17 U.C. Schlotthauer-Voos, R. Bock, H.G. Bohlen, H.H. Gutbrod and W. von Oertzen, Nucl. Phys. A186 (1972) 225

1972SC1F Schuler and Ober, Bull. Amer. Phys. Soc. 17 (1972) 185

1972SC21 D.K. Scott, P.N. Hudson, P.S. Fisher, C.U. Cardinal, N. Anyas-Weiss, A.D. Panagiotou and P.J. Ellis, Phys. Rev. Lett. 28 (1972) 1659

1972SH07 N. Shikazono and Y. Kawarasaki, Nucl. Phys. A188 (1972) 461

1972SO1A Southon and Poletti, 4th Ainse Nucl. Phys. Conf., Sydney, 1972 (1972) 49

1972SP1B Spicer, 4th Ainse Nucl. Phys. Conf., Sydney, 1972 (1972) 29, 33

1972TA26 R. Tamisier, D. Ardouin, B. Ramstein, Y. Deschamps, L.H. Rosier and P. Avignon, J. Phys. (Paris) 33 (1972) 625

1972TH13 C. Thibault and R. Klapisch, Phys. Rev. C6 (1972) 1509

1972TH15 B.J. Thomas, A. Buchnea, J.D. Irish and K.G. McNeill, Can. J. Phys. 50 (1972) 3085

1972THZF H. Theissen, Springer Tracts in Mod. Phys.; Ed., Hohler, Vol. 65 (1972) 1

1972VA32 R.E. van de Vyver, H. Ferdinande, G. Knuyt, R. Carchon and J. Devos, Nucl. Phys. A198 (1972) 144

1972VA36 J.F.A. Van Hienen and P.W.M. Glaudemans, Phys. Lett. B42 (1972) 301

1972WA07 G.E. Walker and R.H. Stokes, Part. Nucl. 3 (1972) 1

1972WA31 J.W. Watson, Nucl. Phys. A198 (1972) 129

1972WE01 H.R. Weller, Phys. Rev. Lett. 28 (1972) 247

1972WI04 C.E. Wiegand, J.M. Gallup and G.L. Godfrey, Phys. Rev. Lett. 28 (1972) 621

1972WO15 M.R. Wormald and I.F. Wright, Part. Nucl. 3 (1972) 253

1972YO02 F.C. Young and A.R. Knudson, Nucl. Phys. A184 (1972) 563

1973AU1B Audouze, Truran and Zimmerman, OAP-315 (1973)

1973AU1C Audouze, Explosive Nucleosynthesis (1973) 47

1973BA1R Barrandon and Seltz, Nucl. Instrum. Meth. Phys. Res. 111 (1973) 595

1973BA31 J.K. Bair, Phys. Rev. C8 (1973) 120

1973BA81 L.K. Batist, E.E. Berlovich, Y.S. Blinnikov, Y.V. Elkin, Y.N. Novikov, B.M. Ovchinnikov and V.K. Tarasov, Izv. Akad. Nauk SSSR Ser. Fiz. 37 (1973) 1944; Bull. Acad. Sci. USSR Phys. Ser. 37 (1974) 124

1973BI02 H.G. Bingham, H.T. Fortune, J.D. Garrett and R. Middleton, Phys. Rev. C7 (1973) 60

1973BI07 H.G. Bingham and H.T. Fortune, Phys. Rev. C7 (1973) 2602

1973BR1C Bromley, in Munich, 2 (1973) 22

1973CA19 D. Catana, G. Baciu, C. Iliescu and V.I.R. Niculescu, Z. Phys. 261 (1973) 125

1973CA1B Cameron, Explosive Nucleosynthesis (1973) 3

1973CL1E Clayton and Woosley, in Munich, 2 (1973) 718

1973CO03 M. Conze, H. Feldmeier and P. Manakos, Phys, Lett. B43 (1973) 101

1973CO1F Conze, Feldmeier and Manakos, Asilomar (1973) Paper 2A13

1973DA1G Das, Gupta and Biswas, Nucl. Phys. B66 (1973) 482

1973DA31 J.M. Davidson and M.L. Roush, Nucl. Phys. A213 (1973) 332

1973DE06 R. de Swiniarski, A. Genoux-Lubain, G. Bagieu, J.F. Cavaignac, D.H. Worledge and J. Raynal, Phys. Lett. B43 (1973) 27

1973DE13 R.J. de Meijer, Nucl. Phys. A204 (1973) 427

1973DE1J Delacroix, Labie, Lega and Macq, J. Phys. (Paris) 34 (1973) 427

1973DO02 E.I. Dolinsky, P.O. Dzhamalov and A.M. Mukhamedzhanov, Nucl. Phys. A202 (1973) 97

1973DO05 T.R. Donoghue, Phys. Rev. C7 (1973) 1270

1973EL07 P.J. Ellis and A. Dudek, Part. Nucl. 5 (1973) 1; Erratum Part. Nucl. 6 (1973) 95

1973EN1B Endt, 5th Symp. Struct. Low-Medium Mass Nuclei (1973) 122

1973FO1A Fortune, Heavy Ion Lecture Series, Kansas State Univ. (1973) 1

1973FR10 W. Fritsch, K.-D. Buchs, E. Finckh, P. Pietrzyk and B. Schreiber, Z. Phys. 262 (1973) 65

1973GA14 A. Gamp, W. von Oertzen, H.G. Bohlen, M. Feil, R.L. Walter and N. Marquardt, Z. Phys. 261 (1973) 283

1973GA1H Gari, Phys. Rept. C6 (1973) 317

1973GR11 R. Gross and I. Talmi, Phys. Lett. B44 (1973) 147

1973HA13 P.L. Hallowell, W. Bertozzi, J. Heisenberg, S. Kowalski, X. Maruyama, C.P. Sargent, W. Turchinetz, C.F. Williamson, S.P. Fivozinsky, J.W. Lightbody, Jr. et al., Phys. Rev. C7 (1973) 1396

1973HA53 M. Harvey and F.C. Khanna, Phys. Lett. B47 (1973) 8

1973HE1E Heusinger et al., in Munich, 1 (1973) 275

1973HO1R Holmgren, Woody, Roos and Cowley, Bull. Amer. Phys. Soc. 18 (1973) 79

1973HO32 V. Horsfjord, Phys. Lett. B45 (1973) 455

1973HO34 G. Hock and Z. Oziewicz, Acta Phys. Pol. B4 (1973) 43

1973HO43 K.R. Hogstrom, B.W. Mayes, L.Y. Lee, J.C. Allred, C. Goodman, G.S. Mutchler, C.R. Fletcher and G.C. Phillips, Nucl. Phys. A215 (1973) 598

1973JU1A Junkin and Suen, in Munich, 1 (1973) 77

1973KA19 P.J. Karol, A.A. Caretto, Jr., R.L. Klobuchar, D.M. Montgomery, R.A. Williams and M.V. Yester, Phys. Lett. B44 (1973) 459

1973KR20 T.P. Krick, N.M. Hintz and D. Dehnhard, Nucl. Phys. A216 (1973) 549

1973LA03 W.A. Lanford and B.H. Wildenthal, Phys. Rev. C7 (1973) 668

1973LA1D Lanford and Wildenthal, Bull. Amer. Phys. Soc. 18 (1973) 578

1973LA27 M. Lambert, P. Midy and P. Desgrolard, Phys. Rev. C8 (1973) 1728

1973LE1C Leitz et al., J. Phys. Soc. Jpn. Suppl. 34 (1973) 174

1973MA1K Maripuu, 5th Symp. Struct. Low-Medium Mass Nuclei (1973) 63

1973MA48 F. Malaguti and P.E. Hodgson, Nucl. Phys. A215 (1973) 243

1973MC06 J.B. McGrory and B.H. Wildenthal, Phys. Rev. C7 (1973) 974

1973MC1E McGrory, in Munich, 2 (1973) 146

1973ME1D Meijer, Bull. Amer. Phys. Soc. 18 (1973) 578

1973ME1E Meyer and Elbaz, in Munich, 1 (1973) 251

1973MU14 S.F. Mughabghab and D.I. Garber, BNL 325, 3rd Edition, Vol. 1 (1973)

1973MU18 A. Muller-Arnke, Phys. Lett. B46 (1973) 325

1973MU1D N.C. Mukhopadhyay and L.D. Miller, Phys. Lett. B47 (1973) 415

1973NE1C Nemoto and Bando, Prog. Theor. Phys. 47 (1973) 120

1973OR01 H. Orihara, G. Rudolf and P. Gorodetzky, Nucl. Phys. A203 (1973) 78

1973PE09 S.M. Perez and H.G. Benson, Nucl. Phys. A208 (1973) 449

1973PI09 M. Pignanelli, J. Gosset, F. Resmini, B. Mayer and J.L. Escudie, Phys. Rev. C8 (1973) 2120

1973RO09 D.W.O. Rogers, W.R. Dixon and R.S. Storey, Can. J. Phys. 51 (1973) 1

1973RO19 D.W.O. Rogers, Nucl. Phys. A207 (1973) 465

1973RU1B Rudolph, Kraushard, Ristinen and Meglen, Bull. Amer. Phys. Soc. 18 (1973) 579

1973SA1A Satchler, in Munich, 2 (1973) 570

1973SC1G Schaeffer, Gegre, Blatt and Sufferi, in Munich, 1 (1973) 642

1973SM1C Smirnov, Shitikova and Orlova, Moscow Univ. Phys. Bull. 28 (1973) 32

1973SP1A Sprung, Nucl. Many-Body Problem, Vol. 2, 1972 (1973) 123

1973ST1B Stephenson, Hichwa and Meyer, Bull. Amer. Phys. Soc. 18 (1973) 1390

1973ST1D Strottman and Millener, in Munich, 1 (1973) 107

1973SU1B Sugimoto, J. Phys. Soc. Jpn. Suppl. 34 (1973) 197

1973SU1C Sugimoto and Tanihata, J. Phys. Soc, Jpn. Suppl. 34 (1973) 245

1973TA1D Talbot, Explosive Nucleosynthesis (1973) 47

1973TO16 L. Tomlinson, At. Data Nucl. Data Tables 12 (1973) 179

1973TR1B Truran, Cosmochemistry; Ed., Cameron (1973) 23

1973TS02 I. Tserruya, B. Rosner and K. Bethge, Nucl. Phys. A213 (1973) 22

1973TU1B Turos, Wielunski and Jelinska, Acta Phys. Pol. A43 (1973) 657

1973VI01 C.M. Vincent and H.T. Fortune, Phys. Rev. C7 (1973) 865

1973VO1D Volkov, in Munich, 2 (1973) 280

1973VO1E von Oertzen, Lect. Notes in Phys. 23 (1973) 267

1973WA10 E.K. Warburton, J.W. Olness, G.A.P. Engelbertink and T.K. Alexander, Phys. Rev. C7 (1973) 1120

1973WE11 M. Wery, Nucl. Phys. A210 (1973) 329

1973WE1P Weller et al., Bull. Amer. Phys. Soc. 18 (1973) 1390

1973WI04 D.H. Wilkinson, Phys. Rev. C7 (1973) 930

1973WI05 J.L. Wiza and H.T. Fortune, Phys. Rev. C7 (1973) 1267

1973WI08 J.L. Wiza, H.G. Bingham and H.T. Fortune, Phys. Rev. C7 (1973) 2175

1973WI11 D.H. Wilkinson, Nucl. Phys. A209 (1973) 470

1973WI15 J. Wilczynski, Phys. Lett. B47 (1973) 124

1973YO1A Yoro and Une, J. Phys. Soc. Jpn. Suppl. 34 (1973) 535

1974AL17 V.P. Aleshin, Yad. Fiz. 20 (1974) 497; Sov. J. Nucl. Phys. 20 (1975) 267

1974BA89 L.K. Batist, E.E. Berlovich, L.A. Vaishnene, V.G. Konev, K.A. Mezilev and Y.N. Novikov, Yad. Fiz. 20 (1974) 850; Sov. J. Nucl. Phys. 20 (1975) 453

1974BI1C Bishop, Medsker, Fortune and Headley, Bull. Amer. Phys. Soc. 19 (1974) 993

1974BO05 J.D. Bowman, A.M. Poskanzer, R.G. Korteling and G.W. Butler, Phys. Rev. C9 (1974) 836

1974BU1A Bulow and Forkman, IAEA, STI/DOC/10/156 (1974) 475

1974CH1Q Chechik, Stocker, Eyal and Fraenkel, Proc. Conf. Reactions Between Complex Nuclei, Vol. 1 (1974) 6

1974CO13 W.J. Courtney, K.W. Kemper, G.E. Moore and R.L. White, Phys. Rev. C9 (1974) 1273

1974CO39 B.J. Cole, A. Watt and R.R. Whitehead, J. Phys. (London) A7 (1974) 1374

1974DE1E De Jager, De Vries and De Vries, At. Data Nucl. Data Tables 14 (1974) 479

1974DE1N Del Vecchio and Freedman, Bull. Amer. Phys. Soc. 19 (1974) 470

1974DE46 R. de Swiniarski, A. Genoux-Lubain, G. Bagieu and J.F. Cavaignac, Can. J. Phys. 52 (1974) 2422

1974DO1C T.W. Donnelly, D. Hitlin, M. Schwartz, J.D. Walecka and S.J. Wiesner, Phys. Lett. B49 (1974) 8

1974EN10 R. Engfer, H. Schneuwly, J.L. Vuilleumier, H.K. Walter and A. Zehnder, At. Data Nucl. Data Tables 14 (1974) 509

1974ES02 J.L. Escudie, R. Lombard, M. Pignanelli, F. Resmini and A. Tarrats, Phys. Rev. C10 (1974) 1645; Erratum Phys. Rev. C11 (1975) 639

1974FO1J Fortune, Proc. Int. Conf. Nucl. Struct. Spectroscopy, Amsterdam, 1974 (1974) 341

1974FO26 H.T. Fortune and H.G. Bingham, Phys. Rev. C10 (1974) 2174

1974GA11 C. Gaarde and T. Kammuri, Nucl. Phys. A221 (1974) 238

1974GA28 J.D. Garrett and O. Hansen, Nucl. Phys. A229 (1974) 204

1974GA36 M. Gari and J.H. Reid, Phys. Lett. B53 (1974) 237

1974GU19 G. Guillaume, P. Fintz, F. Jundt, I. Ordonez, A. Gallmann, D.E. Alburger and K.W. Jones, Nucl. Phys. A233 (1974) 357

1974HU14 J. Hufner, L. Tauscher and C. Wilkin, Nucl. Phys. A231 (1974) 455

1974JE1A Jelley, Wozniak, Nagarajan and Cerny, Bull. Amer. Phys. Soc. 19 (1974) 431

1974JO12 I.P. Johnstone and B. Castel, Can. J. Phys. 52 (1974) 1998

1974KA1N Kahana, Casten, Olness and Kolata, Bull. Amer. Phys. Soc. 19 (1974) 470

1974KU07 K.I. Kubo, F. Nemoto and H. Bando, Nucl. Phys. A224 (1974) 573

1974LA1F Lawson, Proc. Int. Conf. Nucl. Struct. Spectroscopy, Amsterdam, 1974 (1974) 464

1974LE1G K.W.D. Ledingham, J.Y. Gourlay, M. Campbell, M.L. Fitzpatrick and A.D. Baillie, Phys. Lett. B50 (1974) 247

1974LI1H V.G. Lind, H.S. Plendl, H.O. Funsten, W.J. Kossler, B.J. Lieb, W.F. Lankford and A.J. Buffa, Phys. Rev. Lett. 32 (1974) 479

1974LO1B Lorenzen and Brune, IAEA, STI/DOC/10/156 (1974) 325

1974MA31 F.M. Mann and R.W. Kavanagh, Phys. Lett. B51 (1974) 49

1974MC1F McGrory, Proc. Int. Conf. Nucl. Struct. Spectroscopy, Amsterdam, 1974 (1974) 73

1974MI21 T. Minamisono, Y. Nojiri, A. Mizobuchi and K. Sugimoto, Nucl. Phys. A236 (1974) 416

1974MUZP A. Muller-Arnke, Proc. Int. Conf. Nucl. Struct. Spectroscopy, Amsterdam 1974 (1974) 40

1974NI1A N.N. Nikolaev and M.Zh. Shmatikov, Phys. Lett. B52 (1974) 293

1974OLZT T.H. Olsen and E. Osnes, Proc. Int. Conf. Nucl. Struct. Spectroscopy, Amsterdam, 1974 (1974) 27

1974PI05 M. Pignanelli, S. Micheletti, I. Iori, P. Guazzoni, F.G. Resmini and J.L. Escudie, Phys. Rev. C10 (1974) 445

1974PL05 A.V. Plavko, Izv. Akad. Nauk SSSR Ser. Fiz. 38 (1974) 2618; Bull. Acad. Sci. USSR Phys. Ser. 38 (1974) 137

1974RE03 N.E. Reid, N.E. Davison and J.P. Svenne, Phys. Rev. C9 (1974) 1882

1974RO03 V.C. Rogers, Phys. Rev. C9 (1974) 527

1974RO1N Rolfs and Rodney, Astrophys. J. 194 (1974) L63

1974SE01 S. Sen, S.E. Darden, H.R. Hiddleston and W.A. Yoh, Nucl. Phys. A219 (1974) 429

1974SH1E Sher, IAEA, STI/DOC/10/156 (1974) 1

1974SHYR V.S. Shirley and C.M. Lederer, LBL-3450 (1974)

1974SK04 D.M. Skopik and Y.M. Shin, Nucl. Phys. A223 (1974) 409

1974ST1G G.L. Strobel, Nucl. Phys. A232 (1974) 502

1974TA18 L. Tauscher and W. Schneider, Z. Phys. 271 (1974) 409

1974TH01 C. Thibault and R. Klapisch, Phys. Rev. C9 (1974) 793

1974TS03 I. Tserruya, B. Rosner and K. Bethge, Nucl. Phys. A235 (1974) 75

1974UN01 B.Y. Underwood, M.R. Wormald, N. Anyas-Weiss, N.A. Jelley and K.W. Allen, Nucl. Phys. A225 (1974) 253

1974VA1J Vantine, Thesis, Princeton Univ. (1974)

1974VE03 T. Vertse, A. Dudek-Ellis, P.J. Ellis, T.A. Belote and D. Roaf, Nucl. Phys. A223 (1974) 207

1974VE06 A. Veyssiere, H. Beil, R. Bergere, P. Carlos, A. Lepretre and A. de Miniac, Nucl. Phys. A227 (1974) 513

1974WI14 D.H. Wilkinson and D.E. Alburger, Phys. Rev. C10 (1974) 1993

1974WI1M D.H. Wilkinson, Nucl. Phys. A225 (1974) 365

1975AB1F Abramov, INDC(CCP)-52/LN, Vienna (1975)

1975AD01 E.G. Adelberger, H.E. Swanson, M.D. Cooper, J.W. Tape and T.A. Trainor, Phys. Rev. Lett. 34 (1975) 402

1975AL20 R. Almanza, G. Murillo, S.E. Darden and S. Sen, Nucl. Phys. A248 (1975) 214

1975AR14 A.G. Artyukh, V.V. Volkov, G.F. Gridnev and V.L. Mikheev, Izv. Akad. Nauk SSSR Ser. Fiz. 39 (1975) 2; Bull. Acad. Sci. USSR Phys. Ser. 39 (1975) 1

1975AR1J Arima, Clustering Phenom. in Nucl., II, ORO-4856-26 (1975) 38

1975AZ01 G. Azuelos and J.E. Kitching, Phys. Rev. C12 (1975) 563

1975BA05 S. Barshay, C.B. Dover and J.P. Vary, Phys. Rev. C11 (1975) 360

1975BA81 B.R. Barrett, E.C. Halbert and J.B. McGrory, Ann. Phys. 90 (1975) 321

1975BE1G Bertozzi, AIP Conf. Proc. 26 (1975) 409

1975BE1T Bertozzi, Bull. Amer. Phys. Soc. 20 (1975) 708

1975BE1U Beranger, David, Garcia and Lucas, Rev. Phys. Appliquee 10 (1975) 87

1975BE31 M. Beiner, R.J. Lombard and D. Mas, Nucl. Phys. A249 (1975) 1

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

1975BL1F Bleuler, Few Body Problems, Quebec, 1974 (1975) 76

1975BO12 M.A. Box and B.H.J. McKellar, Phys. Rev. C11 (1975) 1859

1975BO1T Boehm, AIP Conf. Proc. 26 (1975) 41

1975BR1F Brown, At. Data Nucl. Data Tables 15 (1975) 111

1975BU1H Burnett, Goldberg and Tombrello, Bull. Amer. Phys. Soc. 20 (1975) 32

1975CA1F Calprice, Proc. Int. Symp. on Interaction Studies in Nucl., Germany, 1975 (1975) 83

1975CA1H Cannata, Lett. Nuovo Cim. 13 (1975) 319

1975CA28 F.P. Calaprice, S.J. Freedman, W.C. Mead and H.C. Vantine, Phys. Rev. Lett. 35 (1975) 1566

1975CA35 F.P. Calaprice, Phys. Rev. C12 (1975) 2016

1975CR03 D.J. Crozier, H.T. Fortune, R. Middleton and J.L. Wiza, Phys. Rev. C11 (1975) 393

1975FO07 H.T. Fortune, L.R. Medsker, W.S. Chien, H. Nann and B.H. Wildenthal, Phys. Rev. C12 (1975) 359

1975FO09 H.T. Fortune, W. Henning, D.C. Kovar, B. Zeidman and Y. Eisen, Phys. Lett. B57 (1975) 445

1975FO19 W.A. Fowler, G.R. Caughlan and B.A. Zimmerman, Ann. Rev. Astron. Astrophys. 13 (1975) 69

1975FR15 S.J. Freedman, R.M. Del Vecchio and C. Callias, Phys. Rev. C12 (1975) 315

1975GA06 M. Gari, A.H. Huffman, J.B. McGrory and R. Offermann, Phys. Rev. C11 (1975) 1485

1975GA1L Gari, Huffman, McGrory and Offerman, Proc. Int. Symp. on Interaction Studies in Nucl., Germany, 1975 (1975) 119

1975GE18 H.V. Geramb, T. Terasawa and K. Amos, Z. Phys. A275 (1975) 373

1975GO15 V.Z. Goldberg, V.P. Rudakov and V.A. Timofeev, Yad. Fiz. 21 (1975) 1001; Sov. J. Nucl. Phys. 21 (1975) 513

1975GO1T Goldberg, Burnett, Furst and Tombrello, Bull. Amer. Phys. Soc. 20 (1975) 32

1975GO1U Goldberg, Burnett and Tombrello, Bull. Amer. Phys. Soc. 20 (1975) 1487

1975GR41 K.A. Gridnev and A.A. Ogloblin, Fiz. Elem. Chastits At. Yad. (USSR) 6 (1975) 393; Sov. J. Part. Nucl. 6 (1976) 158

1975HE10 K.T. Hecht and D. Braunschweig, Nucl. Phys. A244 (1975) 365

1975HE1K Herczeg, AIP Conf. Proc. 26 (1975) 504

1975HO1K Hornyak, Chang and Walters, Clustering Phenom. in Nucl., II, ORO-4856-26 (1975) 354

1975JE02 N.A. Jelley, J. Cerny, D.P. Stahel and K.H. Wilcox, Phys. Rev. C11 (1975) 2049

1975KA1G P.J. Karol, M.V. Yester, R.L. Klobuchar and A.A. Caretto, Phys. Lett. B58 (1975) 489

1975LE16 C. Lebrun, F. Guilbault, P. Avignon and Y. Deschamps, J. Phys. Lett. (Paris) 36 (1975) L201; Erratum J. Phys. Lett. (Paris) 37 (1976) L57

1975MA1R Maehl, Fisher, Hagan and Ormes, Astrophys. J. 202 (1975) L119

1975MA1U Mankoc-Borstnik, Brut and Jang, Proc. Int. Conf. on Nucl. Self-Consistent Fields, Italy, 1975 (1975) 81

1975MAXA F.M. Mann, Thesis, California Institute of Technology (1975)

1975MC1H B.H.J. McKellar, Nucl. Phys. A254 (1975) 349

1975MI07 V.E. Mitroshin, Izv. Akad. Nauk SSSR Ser. Fiz. 39 (1975) 93; Bull. Acad. Sci. USSR Phys. Ser. 39 (1975) 80

1975MO31 T. Motobayashi, I. Yamane, Y. Nogami, N. Takahashi, M. Hara, K. Sagara, M. Katoh, H. Yamashita and B. Imanishi, Phys. Lett. B59 (1975) 421

1975NA20 Y.V. Naumov and O.E. Kraft, Izv. Akad. Nauk SSSR Ser. Fiz. 39 (1975) 1656; Bull. Acad. Sci. USSR Phys. Ser. 39 (1975) 76

1975NA21 Y.V. Naumov and O.E. Kraft, Fiz. Elem. Chastits At. Yad. (USSR) 6 (1975) 892; Sov. J. Part. Nucl. 6 (1976) 361

1975NO10 V.I. Noga, Y.N. Ranyuk and P.V. Sorokin, Yad. Fiz. 21 (1975) 464; Sov. J. Nucl. Phys. 21 (1975) 243

1975OY01 M. Oyamada, T. Terasawa, K. Nakahara, Y. Endo, H. Saito and E. Tanaka, Phys. Rev. C11 (1975) 1578

1975PO1F Posada and Senent, Anales Fis. 71 (1975) 34

1975RE08 L.P. Remsberg and D.G. Perry, Phys. Rev. Lett. 35 (1975) 361

1975SC1Y Scalo and Despain, OAP-403 (1975)

1975SH20 R. Sherr and G. Bertsch, Phys. Rev. C12 (1975) 1671

1975SK1B Skalsey, Overway and Parkinson, Bull. Amer. Phys. Soc. 20 (1975) 573

1975SM02 L.G. Smith and A.H. Wapstra, Phys. Rev. C11 (1975) 1392

1975ST1P Stephenson, Hichwa, Hutton and Haeberli, Bull. Amer. Phys. Soc. 20 (1975) 597

1975SUZR K. Suzuki and H. Kumagai, Bull. Kyushu Inst. Tech. Math. Nat. Sci. 22 (1975) 49

1975TR1A Trimble, Rev. Mod. Phys. 47 (1975) 877

1975TS03 H. Tsubota, N. Kawamura, S. Oikawa and J. Uegaki, J. Phys. Soc. Jpn. 38 (1975) 299

1975VA1D Vasil'kova et al., Sov. J. Nucl. Phys. 21 (1975) 525

1975VE10 N.I. Venikov, Y.A. Glukhov, V.I. Manko, B.G. Novatskii, A.A. Ogloblin, S.B. Sakuta, D.N. Stepanov, V.N. Unezhev, V.I. Chuev and N.I. Chumakov, Yad. Fiz. 22 (1975) 924; Sov. J. Nucl. Phys. 22 (1976) 481

1975VO09 V.V. Volkov, Fiz. Elem. Chastits At. Yad. (USSR) 6 (1975) 1040; Sov. J. Part. Nucl. 6 (1976) 420

1975VO1B Von Oertzen and Bohlen, Phys. Rept. 19 (1975) 1

1975VO1D K.G. Vosburgh, W. Schimmerling, K. Koepke and W.D. Wales, Phys. Rev. D11 (1975) 1743

1975WI1H Williamson et al., Bull. Amer. Phys. Soc. 20 (1975) 567

1975WI30 M.E. Williams-Norton, G.M. Hudson, K.W. Kemper, G.E. Moore, G.A. Norton, R.J. Puigh and A.F. Zeller, Phys. Rev. C12 (1975) 1899

1975WO04 E. Wolynec, G. Moscati, J.R. Moreira, O.D. Goncalves and M.N. Martins, Phys. Rev. C11 (1975) 1083

1975WO06 J.G. Woodworth, J.W. Jury, K.H. Lokan and N.K. Sherman, Can. J. Phys. 53 (1975) 795

1976AD1B Adelberger, Polarization, Zurich, 1975 (1976) 97

1976AJ04 F. Ajzenberg-Selove, Nucl. Phys. A268 (1976) 1

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

1976AN06 D.W. Anderson, R.F. Petry and H.J. Fishbeck, Nucl. Phys. A262 (1976) 91

1976AS1B Aslanides, Meson-Nucl. Phys., 1976 (1976) 204

1976BA08 R. Babinet, L.G. Moretto, J. Galin, R. Jared, J. Moulton and S.G. Thompson, Nucl. Phys. A258 (1976) 172

1976BAYR A.D. Bacher, P.T. Debevec, G.T. Emery, M.A. Pickar, K. Gotow and D.A. Jenkins, Bull. Amer. Phys. Soc. 21 (1976) 983, CB5

1976BE1H Berman, Preprint UCRL-78482 (1976)

1976BE1L Benenson, Kashy, Mueller and Nann, Cargese Conf., CERN 76-13 (1976) 235

1976BH03 K. Bharuth-Ram, K.P. Jackson, P.G. Lawson, N.A. Jelley and K.W. Allen, Nucl. Phys. A269 (1976) 327

1976BL1C Bleuler, Proc. 7th Int. Conf. on Few Body Problems in Nucl. Part. Phys., Delhi, 1975 (1976) 335

1976BO1M Bouvier and Weibel, Arch. Sci. (Geneva) 29 (1976) 163

1976BO1T Box, Gabric, Lassey and McKellar, J. Phys. (London) G2 (1976) L107

1976BO38 M.A. Box, A.J. Gabric and B.H.J. McKellar, Nucl. Phys. A271 (1976) 412

1976BO43 M.A. Box and B.H.J. McKellar, J. Phys. (London) G2 (1976) 803

1976BR1T Brenn, Hopkins and Sprouse, Hyperfine Interactions 2 (1976) 393

1976BR20 R. Brenn, G.D. Sprouse, C. Yu and O. Klepper, Nucl. Phys. A265 (1976) 35

1976BU16 M. Buenerd, C.K. Gelbke, B.G. Harvey, D.L. Hendrie, J. Mahoney, A. Menchaca-Rocha, C. Olmer and D.K. Scott, Phys. Rev. Lett. 37 (1976) 1191

1976CA1E Calprice, Bull. Amer. Phys. Soc. 21 (1976) 507

1976CA1R Calboreanu, Cargese Conf., CERN 76-13 (1976) 166

1976CH1T Chung and Wildenthal, MSUCL-214 (1976)

1976DA07 R.A. Dayras, R.G. Stokstad, Z.E. Switkowski and R.M. Wieland, Nucl. Phys. A261 (1976) 478

1976DA1K Darden and Haeberli, Polarization, Zurich, 1975 (1976) 229

1976DU04 J.L. Durell, P.J.A. Buttle, L.J.B. Goldfarb, W.R. Phillips, G.D. Jones, B.W. Hooton and M. Ivanovich, Nucl. Phys. A269 (1976) 443

1976EA1A Earwacker and Walker, Lowell Conf., CONF-760715-P2 (1976)

1976EC1B Economou and Turkevich, Nucl. Instrum. Meth. 134 (1976) 391

1976EG02 R. Eggers, M.N. Namboodiri, P. Gonthier, K. Geoffroy and J.B. Natowitz, Phys. Rev. Lett. 37 (1976) 324

1976EN02 H.D. Engelhardt, C.W. Lewis and H. Ullrich, Nucl. Phys. A258 (1976) 480

1976ES1B Escudie, Fabroco, Pignanelli and Resmini, Polarization, Zuriich, 1975 (1976) 721

1976FI03 P. Fintz, G. Guillaume, F. Jundt, I. Ordonez, A. Gallmann and D.E. Alburger, Nucl. Phys. A259 (1976) 493

1976FR13 J.M. Freeman, Nucl. Instrum. Meth. Phys. Res. 134 (1976) 153

1976FU06 G.H. Fuller, J. Phys. Chem. Ref. Data 5 (1976) 835

1976GA27 J. Gass and H.H. Muller, Nucl. Instrum. Meth. Phys. Res. 136 (1976) 559

1976GAYV D.I. Garber and R.R. Kinsey, BNL 325, Vol. 2 (1976)

1976GI1C Ginzburg and Ptjskin, Rev. Mod. Phys. 48 (1976) 161

1976GO09 G. Goldring, B. Richter, Z. Shkedi and Y. Wolfson, Nucl. Phys. A262 (1976) 214

1976GO1P Goldberg, Tombrello and Burnett, Private Communication (1976)

1976HA06 M. Hamm, C.W. Towsley, R. Hanus, K.G. Nair and K. Nagatani, Phys. Rev. Lett. 36 (1976) 846

1976HI05 M.D. High and B. Cujec, Nucl. Phys. A259 (1976) 513

1976JA04 N.P. Jacob, Jr. and S.S. Markowitz, Phys. Rev. C13 (1976) 754

1976JA23 J. Janecke, At. Data Nucl. Data Tables 17 (1976) 455

1976KI1D King et al., Lowell Conf., CONF-760715-P2 (1976) 1344

1976LE19 M. LeMere, Y.C. Tang and D.R. Thompson, Phys. Lett. B63 (1976) 1

1976LI18 B.J. Lieb, W.F. Lankford, S.H. Dam, H.S. Plendl, H.O. Funsten, W.J. Kossler, V.G. Lind and A.J. Buffa, Phys. Rev. C14 (1976) 1515

1976MA04 F. Malaguti and P.E. Hodgson, Nucl. Phys. A257 (1976) 37

1976MA54 K. Malushinska, K. Nedvedyuk, V.I. Salatskii and K. Karpik, Acta Phys. Pol. B7 (1976) 365

1976MA62 J.B. Martins, O.A.P. Tavares, M.L. Terranova and V. di Napoli, Lett. Nuovo Cim. 15 (1976) 364

1976MUZP G. Murillo, M. Fernandez, L. Montestruque and S.E. Darden, Bull. Amer. Phys. Soc. 21 (1976) 990, CF7

1976NA11 M.N. Namboodiri, E.T. Chulick and J.B. Natowitz, Nucl. Phys. A263 (1976) 491

1976NA18 H. Nann and B.H. Wildenthal, Phys. Rev. Lett. 37 (1976) 1129

1976OH03 M. Ohta, Prog. Theor. Phys. 55 (1976) 1782

1976PE1D Perlman, Grodzins, Klepper and Thorn, Bull. Amer. Phys. Soc. 21 (1976) 82

1976PI16 A.A. Pilt, D.J. Millener, H. Bradlow, O. Dietzsch, P.S. Fisher, W.J. Naude, W.D.M. Rae and D. Sinclair, Nucl. Phys. A273 (1976) 189

1976PL1C Plavko et al., Izv. Akad. Nauk SSSR Ser. Fiz. 40 (1976) 828

1976PR08 G.A. Prokopets, B. Holmqvist and A.V. Murzin, Yad. Fiz. 23 (1976) 935; Sov. J. Nucl. Phys. 23 (1976) 492

1976RA1J Randle, Green and Earwaker, Lowell Conf., CONF-760715-P2 (1976) 1269

1976RO07 D.W.O. Rogers, A.L. Carter, T.J.M. Symons, S.P. Dolan, N. Anyas-Weiss and K.W. Allen, Can. J. Phys. 54 (1976) 938

1976RO1J Ross and Aller, Science 191 (1976) 1223

1976SH12 N.K. Sherman, K.H. Lokan and R.W. Gellie, Can. J. Phys. 54 (1976) 1178

1976SI1D Silberberg, Tsao and Shapiro, Spallation Nucl. Reactions and Their Applications; Eds., Shen and Merker (1976) 49

1976SI1H Simonius, Polarization, Zurich, 1975 (1976) 75

1976SI1J Silbar, Meson-Nucl. Phys., 1976 (1976) 297

1976SO08 J.R. Southon, A.R. Poletti and D.J. Beale, Aust. J. Phys. 29 (1976) 355

1976SY01 T.J.M. Symons, L.K. Fifield, M.J. Hurst, A. Pakkanen, F. Watt, C.H. Zimmerman and K.W. Allen, Phys. Lett. B63 (1976) 409

1976TH1E Thomson, Thesis, Univ. of Melbourne (1976)

1976VA26 K. Van der Borg, R.J. De Meijer and A. Van der Woude, Nucl. Phys. A273 (1976) 172

1976WA18 A.H. Wapstra and K. Bos, At. Data Nucl. Data Tables 17 (1976) 474

1976WOZX C.W. Woods, N. Stein and J.W. Sunier, Bull. Amer. Phys. Soc. 21 (1976) 554, DE10

1977AD1C Adelberger et al., in Tokyo (1977) 786

1977AJ02 F. Ajzenberg-Selove, Nucl. Phys. A281 (1977) 1

1977AN12 G.S. Anagnostatos, Atomkernenergie 29 (1977) 207

1977AN24 G.B. Andreev, A.P. Tomozov and V.A. Lutsik, Izv. Akad. Nauk SSSR Ser. Fiz. 41 (1977) 1661; Bull. Acad. Sci.USSR Phys. Ser. 41 (1977) 107

1977AR06 A.G. Artukh, G.F. Gridnev, V.L. Mikheev and V.V. Volkov, Nucl. Phys. A283 (1977) 350

1977AZ02 G. Azuelos and J.E. Kitching, Nucl. Phys. A285 (1977) 19

1977BA08 R.M. Baltrusaitis and F.P. Calaprice, Phys. Rev. Lett. 38 (1977) 464

1977BA2H Bacher et al., in Tokyo (1977) 812

1977BA3E R. Bass, Phys. Rev. Lett. 39 (1977) 265

1977BA3V Ball et al., Bull. Amer. Phys. Soc. 22 (1977) 552

1977BA48 W. Bambynek, H. Behrens, M.H. Chen, B. Crasemann, M.L. Fitzpatrick, K.W.D. Ledingham, H. Genz, M. Mutterer and R.L. Intemann, Rev. Mod. Phys. 49 (1977) 77; Erratum Rev. Mod. Phys. 49 (1977) 961

1977BH1B Bhatia et al., in Tokyo (1977) 181

1977BU05 B. Buck and A.A. Pilt, Nucl. Phys. A280 (1977) 133

1977CH22 R. Chechik, Z. Fraenkel, H. Stocker and Y. Eyal, Nucl. Phys. A287 (1977) 353

1977CL1F Clayton, Dwek and Woosley, Astrophys. J. 214 (1977) 300

1977CO14 T.M. Cormier, P. Braun-Munzinger, P.M. Cormier, J.W. Harris and L.L. Lee, Jr., Phys. Rev. C16 (1977) 215

1977CO1F Cox and Pourmansoori, Int. J. Appl. Rad. Isotopes 28 (1977) 235

1977DA10 B.J. Dalton, J.P. Vary and W.J. Baldridge, Phys. Rev. Lett. 38 (1977) 1348

1977DA1B Davydov, Naumov and Shcherbachenko, INDC(CCP)-104/LN (1977)

1977DE14 C. Detraz, F. Naulin, M. Langevin, P. Roussel, M. Bernas, F. Pougheon and J. Vernotte, Phys. Rev. C15 (1977) 1738

1977DE17 P.A. Deutchman and J.G. Old, Nucl. Phys. A283 (1977) 289

1977DI08 W.R. Dixon and R.S. Storey, Nucl. Phys. A284 (1977) 97

1977DI18 W.R. Dixon, T.J.M. Symons, A.A. Pilt, K.W. Allen, C.H. Zimmerman, F. Watt and S.P. Dolan, Phys. Lett. A62 (1977) 479

1977FI06 L.K. Fifield, T.J.M. Symons, C.H. Zimmerman, M.J. Hurst, F. Watt and K.W. Allen, Phys. Lett. B68 (1977) 125

1977HA33 C.S. Han, D.S. Chuu, M.C. Wang and S.T. Hsieh, Phys. Rev. C16 (1977) 1645

1977HI01 M.D. High and B. Cujec, Nucl. Phys. A278 (1977) 149

1977HO16 B.R. Holstein, Phys. Rev. C16 (1977) 753

1977HO1F Horiuchi, Proc. Int. Conf. Nucl. Struct., Tokyo (1977); J. Phys. Soc. Jpn. Suppl. 44 (1978) 85

1977KA2E Kalinsky, Melnik, Smilansky and Trautner, in Tokyo (1977) 612

1977KL1F Kleppinger, Calaprice and Holstein, Bull. Amer. Phys. Soc. 22 (1977) 27

1977KO2L Kouzes, Mueller, Calaprice and Millener, Bull. Amer. Phys. Soc., 22 (1977) 553

1977KU1E K. Kubodera, J. Delorme and M. Rho, Phys. Rev. Lett. 38 (1977) 321

1977KU1L Kubo and Amakawa, in Tokyo (1977) 551

1977LE03 Lebrun, Guilbault, Avignon and Deschamps, Phys. Rev. C15 (1977) 1174

1977LE1R Lee and Khanna, Can. J. Phys. 55 (1977) 578

1977LO1M Long, Peschel and Bromley, in Tokyo (1977) 643

1977MA2G Martz et al., Bull. Amer. Phys. Soc. 22 (1977) 634

1977MU1A Mukhopadhyay, Phys. Rept. C30 (1977) 1

1977NA03 J.B. Natowitz, M.N. Namboodiri, R. Eggers, P. Gonthier, K. Geoffroy, R. Hanus, C. Towsley and K. Das, Nucl. Phys. A277 (1977) 477; Erratum Nucl. Phys. A285 (1977) 532

1977PE1J Peng and Nagatani, in Tokyo (1977) 658, 659

1977PL1A Plavko, Izv. Akad. Nauk SSSR Ser. Fiz. 41 (1977) 1293

1977PR05 P.B. Price, J. Stevenson and K. Frankel, Phys. Rev. Lett. 39 (1977) 177

1977RE01 G. Revel, M. Da Cunha Belo, I. Linck and L. Kraus, Rev. Phys. Appl. 12 (1977) 81

1977SC08 K.W. Schmid and G. Do Dang, Phys. Rev. C15 (1977) 1515

1977SC1K Schimuzi, Fujii and Takimoto, Prog. Theor. Phys. 57 (1977) 680

1977SH11 J. Shurpin, D. Strottman, T.T.S. Kuo, M. Conze and P. Manakos, Phys. Lett. B69 (1977) 395

1977SH13 R. Sherr, Phys. Rev. C16 (1977) 1159

1977SI01 R.R. Silbar, J.N. Ginocchio and M.M. Sternheim, Phys. Rev. C15 (1977) 371

1977SP06 B.M. Spicer, Aust. J. Phys. 30 (1977) 127

1977ST1J J. Stevenson, P.B. Price and K. Frankel, Phys. Rev. Lett. 38 (1977) 1125

1977SY1A Symons et al., in Tokyo (1977) 192

1977TA07 S.L. Tabor, Y. Eisen, D.G. Kovar and Z. Vager, Phys. Rev. C16 (1977) 673

1977VA02 K. Van Bibber, R. Ledoux, S.G. Steadman, F. Videbaek, G. Young and C. Flaum, Phys. Rev. Lett. 38 (1977) 334

1977VIZZ T.M. Vitale, F.P. Calaprice, F.W. Loeser and R.A. Naumann, Bull. Amer. Phys. Soc. 22 (1977) 27, AH4

1977WA08 A.H. Wapstra and K. Bos, At. Data Nucl. Data Tables 19 (1977) 175; Erratum At. Data Nucl. Data Tables 20 (1977) 1

1978BH01 R.S. Bhalerao and Y.R. Waghmare, Nucl. Phys. A298 (1978) 367

1978EN06 P.M. Endt and C. van der Leun, Nucl. Phys. A310 (1978) 96