Energy Levels of Light Nuclei
$A = 18$

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Abstract: An evaluation of $A = 18$–20 was published in *Nuclear Physics A*392 (1983), p. 1. This version of $A = 18$ 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. Also, Reference key numbers have been changed to the NNDC/TUNL format.

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^{18}Be

(Not illustrated)

^{18}Be has not been observed: it is predicted to have a mass excess of 78.43 MeV (1976JA23). ^{18}Be is then unstable with respect to breakup into ^{16}Be + 2n, ^{15}Be + 3n, ^{14}Be + 4n, ^{13}Be + 5n, ^{12}Be + 6n, ^{11}Be + 7n and ^{10}Be + 8n by, respectively, 3.1, 3.0, 5.45, 3.17, 4.92, 1.75 and 1.25 MeV using the masses for the residual nuclei adopted by (1977WA08, 1980AJ01, 1981AJ01).

^{18}B

(Not illustrated)

^{18}B has not been observed: it is predicted to have a mass excess of 53.85 MeV. ^{18}B is then unstable with respect to ^{17}B + n by 1.4 MeV (1976JA23).

^{18}C

(Not illustrated)

The mass of ^{18}C has been determined in studies of the ^{18}O(π^-, π^+)^{18}C reaction at $E_\pi = 164$ MeV (1978SE07) and of the ^{48}Ca(^{18}O, ^{48}Ti)^{18}C reaction at $E(^{18}\text{O}) = 100$ MeV (1982NA04): the weighted mean of the atomic mass excess is 24.89 ± 0.14 MeV. ^{18}C is bound with respect to particle decay by 4.20 MeV for ^{17}C + n and 4.94 MeV for ^{16}C + 2n. [For masses of ^{16}C, ^{17}C see (1982AJ01)]. For the earlier work on ^{18}C see (1978AJ03). See also (1980NA1D, 1981SEZR) and (1981KI04; theor.).

^{18}N

(Figs. 1 and 4)

GENERAL: (See also (1978AJ03).)

See (1979KN1G, 1979PO1G).

Mass of ^{18}*N:* The mass excesses of ^{18}N derived from the ^{14}C(^{18}O, ^{14}N)^{18}N and ^{18}O(t, ^{3}He)^{18}N reactions are 13.217 ± 0.040 and 13.274 ± 0.030 MeV: the weighted mean is 13.254 ± 0.024 MeV. However (1982OL01) suggest, on the basis of theoretical considerations, that the first three excited states of ^{18}N may lie within 150 keV of the ground state, and that the resolution of the above experiments was such that the ground state may not have been the state primarily populated: we therefore adopt 13.25 ± 0.10 MeV.

1. ^{18}N(β^-)^{18}O $\qquad Q_\text{m} = 14.03$

Table 18.1: Energy levels of ^{18}N

E_x (MeV)	$J^\pi; T$	$\tau_{1/2}$ (msec)	Decay	Reactions
0	$1^-; 2$	624 ± 12	β^-	1, 2, 3, 4, 5, 6
0.575 ± 0.025 [a]				2, 3

[a] See also the discussion in (1982OL01).

The half-life of ^{18}N is 0.624 ± 0.012 sec (1982OL01). The decay branches are displayed in Table 18.8. The nature of the decay leads to $J^\pi = 1^-$ for the ^{18}N ground state (1982OL01).

2. ^{14}C(^{7}Li, ^{3}He)^{18}N $\qquad Q_m = -10.25$

The ^{18}N mass excess is reported to be 13.29 ± 0.06 MeV. There is some suggestion of excited states at $E_x = 0.53 \pm 0.06$ and 0.83 ± 0.06 MeV (1980KRZX; prelim.).

3. ^{14}C(^{18}O, ^{14}N)^{18}N $\qquad Q_m = -13.87$

At $E(^{18}\text{O}) = 92.2$ MeV two groups are observed with differential cross sections of 16.5 and 3.3 μb/sr at $\theta_{\text{c.m.}} \approx 6°$, corresponding to the ground state of ^{18}N (see "*Mass of* ^{18}*N*" above) and to an excited state at $E_x = 575 \pm 25$ keV (1980NA14).

4. ^{18}O(π^-, γ)^{18}N $\qquad Q_m = 125.53$

See (1979PE1C) and (1978AJ03, 1981RI1A, 1982RI1B).

5. ^{18}O(n, p)^{18}N $\qquad Q_m = -13.25$

See (1978AJ03).

6. ^{18}O(t, ^{3}He)^{18}N $\qquad Q_m = -14.01$

$Q_0 = -14.038 \pm 0.030$ MeV (1969ST07).

^{18}O

(Figs. 1 and 4)

GENERAL: (See also (1978AJ03).)

Shell model: (1977AN1P, 1977GR16, 1977SO11, 1977ZH1A, 1978CH26, 1978CO08, 1978DA1N, 1978MA2H, 1978MO06, 1978RU02, 1979DA15, 1979WU06, 1980GO01, 1980KU05, 1980MA18, 1981EL1D, 1982KI02, 1982OL01).

Cluster, collective and deformed models: (1977BU22, 1978BU03, 1978CH26, 1978PI1E, 1978RU02, 1978SA15, 1979SA31, 1980BA1T, 1980ZH01).

Electromagnetic transitions and giant resonances: (1976MC1G, 1977BU22, 1977HA1Z, 1978BU03, 1978MO06, 1978SA15, 1979KO07, 1979SA31, 1980BA1T, 1980BR08, 1980BR09, 1980KO1L, 1980KU05, 1980MI1G, 1982LA26).

Special states: (1977AN1P, 1977GR16, 1977HE18, 1977SH18, 1978AN1P, 1978BA10, 1978BU03, 1978EN1D, 1978FO18, 1978KR1G, 1978MA2H, 1978MO06, 1978PI1E, 1978SA15, 1978ZA04, 1979BA35, 1979CHZL, 1979DA15, 1979KO07, 1979KU04, 1979SA31, 1979ZA07, 1980GO01, 1980MA18, 1980SH1K, 1981AR1D, 1981EL1D, 1981SO03, 1982KI02, 1982NA03, 1982ZH1D).

Astrophysical questions: (1977AU1E, 1977CA1K, 1977CL1C, 1977CO1W, 1977DE1N, 1977DI1C, 1977EN1B, 1977SI1F, 1977TR1D, 1977WA1P, 1978CL1F, 1978LE1W, 1978PO1B, 1978TR05, 1978TR1C, 1979CH1T, 1979GU1D, 1979JA1M, 1979LA1H, 1979LE1F, 1979PE1E, 1979RO1A, 1979TU1A, 1979WO07, 1980CL1B, 1980MC1G, 1980PE1F, 1980WA1M, 1981BL1J, 1981GU1D, 1981PE1F, 1981WE1F, 1981WI1D, 1981WI1G, 1981WO1B).

Applied work: (1977EP1A, 1977GR1L, 1977SH1E, 1978AM1D, 1978EM1A, 1978HA2B, 1979JU1D, 1979LE1L, 1980SI1G, 1981BU1B).

Complex reactions involving ^{18}O: (1977LO1K, 1978FO05, 1978FR19, 1978FR1B, 1978KO01, 1978LI1F, 1978SH18, 1978SP1D, 1978TA15, 1979AL22, 1979FE06, 1979HE1D, 1979LA16, 1979PO08, 1979SA27, 1980BR09, 1980OLZW, 1981GR08).

Muon and neutrino capture and reactions: (1977BA1P, 1980BA36).

Pion capture and reactions (See also reaction 29.): (1977AL2B, 1977BA2G, 1977BO1E, 1977EI1A, 1977LE16, 1977MI1E, 1977PE12, 1977SP1B, 1977ST27, 1978IV01, 1978JA13, 1978LE1Y, 1978LU09, 1978OS02, 1978SE07, 1978SP07, 1979AB1H, 1979AL1J, 1979AR1M, 1979CO1H, 1979GO1X, 1979GR18, 1979IN1A, 1979IV03, 1979LE1Q, 1979LU09, 1979MO2C, 1979OS05, 1979SE08, 1980AR1E, 1980AS1A, 1980BR08, 1980BR09, 1980DE24, 1980FR09, 1980GE09, 1980JO06, 1980KA1L, 1980LE04, 1980LI1H, 1980LI1L, 1980NA1D, 1980SA04, 1980SC24, 1980TH01, 1981BE31, 1981FR17, 1981KA1N, 1981LI04, 1981LI1J, 1981LI1L, 1981LI1M, 1981LI1Q, 1981LI1W, 1981MI09, 1981OS1F, 1981RI1A, 1981TH1B, 1982DE1K, 1982GR02, 1982GR1F, 1982IN1A, 1982TH1C).

K-mesons and other meson interactions: (1980DO1E, 1981BA1H, 1981MA27, 1982BA1R).

Table 18.2: Energy levels of ^{18}O [a]

E_x (MeV ± keV)	$J^\pi; T$	τ_m [b] or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
0	$0^+; 1$		stable	3, 4, 5, 6, 7, 8, 10, 11, 12, 16, 19, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56
1.98207 ± 0.09	2^+	$\tau_m = 2.80 \pm 0.07$ psec [c] $g = -0.287 \pm 0.015$	γ	3, 5, 6, 7, 8, 10, 11, 16, 18, 23, 24, 25, 28, 29, 30, 31, 32, 34, 35, 40, 41, 43, 47, 48, 50, 51, 54, 56
3.55484 ± 0.40	4^+	$\tau_m = 24.8 \pm 1.2$ psec $g = -0.62 \pm 0.10$	γ	3, 5, 6, 8, 10, 11, 16, 17, 18, 23, 24, 25, 28, 31, 35, 40, 41, 48, 51, 54
3.63376 ± 0.11	0^+	$\tau_m = 1.38 \pm 0.16$ psec	γ	3, 5, 8, 10, 11, 16, 23, 25, 28, 31, 35, 40, 41, 47, 48, 50, 51
3.92044 ± 0.14	2^+	26.5 ± 2.9 fsec [d]	γ	3, 5, 8, 10, 11, 16, 23, 25, 28, 31, 35, 40, 51
4.45554 ± 0.10	1^-	65 ± 15 fsec	γ	3, 8, 10, 11, 16, 23, 25, 31, 35, 40, 41, 50, 51
5.09778 ± 0.54	3^-	62 ± 25 fsec	γ	3, 10, 11, 16, 23, 25, 28, 29, 30, 31, 35, 40, 41, 51, 54
5.2604 ± 1.2	2^+	10.1 ± 0.5 fsec [e]	γ	3, 8, 10, 11, 16, 18, 23, 28, 31, 35, 50, 51
5.3364 ± 0.6	0^+	200 ± 40 fsec	γ	3, 8, 10, 16, 23, 28, 35, 50, 51
5.3778 ± 1.2	3^+	< 30 fsec	γ	3, 16, 23, 51
5.53024 ± 0.29	2^-	< 25 fsec	γ	3, 16, 25, 31, 35, 51
6.19822 ± 0.40	1^-	(3.7 ± 0.6) fsec	γ	3, 10, 16, 23, 25, 27, 35, 50, 51

Table 18.2: Energy levels of ^{18}O [a] (continued)

E_x (MeV ± keV)	$J^\pi; T$	τ_m [b] or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
6.3513 ± 0.6	(2^-)	< 35 fsec	γ	3, 16, 23, 25, 35, 51
6.4044 ± 1.2	3^-	30 ± 15 fsec	γ	3, 16, 35, 51, 54
6.88045 ± 0.27	0^-	< 25 fsec	γ	3, 16, 25, 35, 50, 51
7.1169 ± 1.2	4^+	< 25 fsec	γ, α	3, 8, 10, 11, 16, 18, 23, 28, 31, 35, 40, 41, 51
7.618 ± 4	1^-	$\Gamma < 2.5$	γ, α	3, 8, 10, 16, 35, 50, 51
7.77107 ± 0.50	2^-		γ	3, 16, 25, 50, 51
7.860 ± 4	(4^+)		γ	3, 8, 10, 11, 16, 23, 28, 35, 51
7.977 ± 4	$(3^+, 4^-)$		γ	3, 16, 23, 51
8.038 ± 3	1^-	< 2.5	γ, α	3, 8, 16, 51
8.126 ± 3	5^-		γ, α	3, 8, 10, 11, 16, 51
8.216 ± 3	2^+	1.0 ± 0.8	γ, n, α	3, 8, 9, 16, 35, 51
8.287 ± 3	3^-	8 ± 1	γ, n, α	3, 8, 9, 10, 11, 16, 18, 35, 51
8.411 ± 8		8 ± 6	n, α	9, 16, 51
8.521 ± 6				16, 51
8.660 ± 6				16, 51
8.817 ± 12		70 ± 12	n, α	8, 9, 35
8.956 ± 4		43 ± 3	n, α	8, 9, 35
(9.03)				8, 35
(9.10)				8, 35
9.362 ± 6		27 ± 15	n, α	8, 9, 11, 16, 35
9.414 ± 18		≈ 120	n, α	8, 9, 11, 16, 35
9.48 ± 24		≈ 65	n, α	8, 9, 16
9.673 ± 7		60 ± 30	n, α	8, 9, 16, 35
9.713 ± 7				16, 35, 50
9.890 ± 11		≈ 150	n, α	8, 9, 16, 35
10.119 ± 10	3^-	16 ± 4	n, α	8, 9, 10, 16, 35
10.295 ± 14	4^+		n, α	8, 9, 10, 11, 16, 17, 35
10.396 ± 9	3^-		n, α	8, 9, 16, 35

Table 18.2: Energy levels of ^{18}O [a] (continued)

E_x (MeV $\pm$ keV)	$J^\pi; T$	τ_m [b] or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
10.595 ± 15			n, α	8, 9, 16
10.82 ± 20			n, α	8, 9
10.91 ± 20			n, α	8, 9, 11
10.99 ± 20			n, α	8, 9, 15
11.13 ± 20			n, α	8, 9, 11, 15, 50
11.39 ± 20	(2^+)		n, α	8, 9, 10
11.41 ± 20	(4^+)		n, α	8, 9, 10
11.62 ± 20	5^-		n, α	8, 9, 10, 11, 35
11.69 ± 20	6^+		n, α	8, 9, 10, 11, 35
11.82 ± 20	(3^-)		n, α	8, 9, 15
12.04 ± 20	(2^+)		n, α	8, 9, 10
12.25 ± 20	(1^-)		n, α	8, 9, 10, 50
12.33 ± 20	5^-		n, α	8, 9, 10, 11
12.50 ± 20	4^+		n, α	8, 9
12.53 ± 20	6^+		n, α	8, 9, 10, 11
13.1	1^-	700	γ, n	26
13.8	1^-	600	γ, n	26
14.7	1^-	800	γ, n	26
15.8	1^-	700	γ, n	26
16.38 ± 10	$T = 2$	≤ 30	γ	28
17.3	$1^-, (T = 2)$	600	γ, n, p	26
18.86 ± 10	$T = 2$	≤ 60	γ	28
19.4	$1^-, (T = 2)$	900	γ, p	26
21.1	$1^-, (T = 1)$		γ, n, p	26
22.7	1^-		γ, n, p	26
23.7	$1^-, (T = 1)$	1600	γ, n, p	26, 28
27	$1^-, (T = 2)$		γ, n, p	26
30			γ, n	26
36			γ	26

[a] See also Table 18.3.

[b] See Table 18.4 in (1978AJ03) for a display of τ_m measurements.

[c] (1982BA06) [see also for discussion of other values]. See also reaction 28.

[d] From reaction 28.

[e] From B(E2) determined in ^{18}O(e, e′) (reaction 28) and Table 18.3. The earlier result of (1973OL02) is withdrawn (E.K. Warburton and M. Gai, private communications).

Anti-proton interactions: (1977BA1W, 1977WE1E, 1978PO02).

Other topics: (1977AN1P, 1977GR16, 1977SH18, 1977SO11, 1978AN1P, 1978CO08, 1978DA03, 1978EN1D, 1978GA1C, 1978GO1U, 1978KR1G, 1978MA2H, 1978SH1B, 1979BA35, 1979BR30, 1979CO10, 1979CO09, 1979GO1W, 1979HE1F, 1979KU04, 1979WU06, 1980GO01, 1980ZH01, 1981AR1D, 1981BE31, 1981EL1D, 1981MA27, 1981SH17, 1981SO03, 1982BA1R, 1982KI02, 1982LA02, 1982NA03).

Ground and 1.98 MeV states of ^{18}O: (1976MC1G, 1977BA2E, 1977GO18, 1977HA1Z, 1978AN07, 1978CH26, 1978FO05, 1978HE1D, 1978LE1X, 1978RU02, 1978SM02, 1978TA09, 1979BR17, 1979BR30, 1979KO07, 1979KO28, 1979SA27, 1979WU06, 1980BA36, 1980BR09, 1980BR13, 1980DE24, 1980MA18, 1980MO05, 1981AR1D, 1981AV02, 1981SI1B, 1982LA02, 1982ZH1D).

$$\langle r^2 \rangle^{1/2} = 2.784 \pm 0.020 \text{ fm: see reaction 28.}$$

^{18}O*(1.98):

$$|\mathrm{g}| = 0.287 \pm 0.015 \text{ (1976AS04);}$$

$$\mathrm{g} = -0.35 \pm 0.04 \text{ (1975FO03, 1975SP03);}$$

$$Q = -0.023 \pm 0.021 \text{ b} \cdot e \text{ (1979FE06) [(1981SP07) adopts } -0.02 \pm 0.03 \text{ b} \cdot e\text{];}$$

$$B(\text{E2}; 0^+ \rightarrow 2^+) = 39.0 \pm 1.8\, e^2 \cdot \text{fm}^4 \text{ (1979FE06) [1] ;}$$

$$= 44.8 \pm 1.3\, e^2 \cdot \text{fm}^4 \text{ (1982NO04);}$$

$$= 47.6 \pm 1.0\, e^2 \cdot \text{fm}^4 \text{ (1982BA06).}$$

1. ^{9}Be(^{9}Be, ^{9}Be)^{9}Be $\qquad E_b = 23.4790$

Yield measurements are reported at a number of energies for $E(^9\text{Be}) = 3.0$ to 16.0 MeV (1977YO02).

[1] Assuming destructive interference (see (1979KO28)) from the coupling through the second 2^+ state. See however the discussion in (1982BA06).

Table 18.3: Radiative decays in ^{18}O [a]

E_i (MeV)	J_i^π	E_f (MeV)	Branch (%)	Comments
1.98	2^+	0	100	
3.55	4^+	1.98	100	
3.63	0^+	0	0.30 ± 0.06 [b]	$\Gamma_\pi/\Gamma = (3.0 \pm 0.6) \times 10^{-3}$
		1.98	99.70 ± 0.06 [b]	
3.92	2^+	0	13.3 ± 1.2 [b]	
		1.98	86.7 ± 1.2 [b]	$\delta = 0.12 \pm 0.4$ [c]
4.46 [g]	1^-	1.98	25.0 ± 1.1 [b]	$\delta = -(0.09 \pm 0.36)$ [c]
		3.63	71.6 ± 1.1 [b]	$\delta = 0$
		3.92	3.4 ± 0.2 [b]	
5.10	3^-	1.98	75 ± 2 [b]	$\delta = 0$ [c]
		3.55	8 ± 2 [c]	$\delta = (0)$
		3.92	17 ± 2 [b]	$\delta = (0)$
5.26 [j]	2^+	0	28.1 ± 0.8	$\delta = 0$ [c]
		1.98	67.1 ± 1.0	$\delta = 0.15 \pm 0.04$ [c]
		3.55	1.0 ± 0.4	
		3.63	0.8 ± 0.4	
		3.92	< 5	
		4.46	3.0 ± 0.3	
5.34	0^+	0		$\Gamma_\pi/\Gamma \leq 2.3 \times 10^{-3}$
		1.98	60 ± 2	
		3.92	< 5	
		4.46	40 ± 2	$\delta = 0$
5.38	3^+	0	< 2	
		1.98	86.5 ± 2.2	$\delta = 0.00 \pm 0.05$ [c]
		3.55	< 3	
		3.92	13.5 ± 2.2	$\delta = (0)$
5.53	2^-	1.98	49 ± 2 [b]	$\delta = 0.00 \pm 0.02$ [c]
		3.92	24 ± 2	
		4.46	27 ± 2 [b]	$\delta = 0.00 \pm 0.04$ [c]
6.20	1^-	0	88 ± 2	
		1.98	≤ 10	

Table 18.3: Radiative decays in ^{18}O [a] (continued)

E_i (MeV)	J^π_i	E_f (MeV)	Branch (%)	Comments
		4.46	6 ± 2	
		$5.26 + 5.34$	6 ± 2	
6.35	(2^-)	1.98	32 ± 2	$\delta = (0)$
		3.92	55 ± 2	$\delta = (0)$
		4.46	12 ± 2	$\delta = (0)$
6.40	3^-	1.98	90 ± 5	$\delta = 0$ [c]
		3.92	10 ± 5	$\delta = (0)$ [c]
6.88 [h]	0^-	4.46	100	$\delta = 0$ [c]
7.12 [e,f]	4^+	1.98	27.1 ± 1.5	$\delta = -(0.052 \pm 0.035)$
		3.55	69.0 ± 1.7	$\Gamma_\gamma/\Gamma_\alpha = 0.9 \pm 0.1$
		3.92	3.9 ± 1	
7.62 [i]	1^-	0	14 ± 1	
		1.98	54 ± 1	$\Gamma_\alpha\Gamma_\gamma/\Gamma = 0.34$ eV [d]
		3.92	5 ± 1	
		4.46	12 ± 1	
		5.34	8 ± 1	
		6.20	7 ± 1	
7.77	2^-	1.98	53 ± 3 [b]	
		4.46	11 ± 2	
		5.10	36 ± 3 [b]	
7.86 [i]	(4^+)	3.55	> 95	
7.98	$(3^+, 4^-)$	3.55	67 ± 2	
		5.10	12 ± 2	
		5.38	21 ± 2	
8.04 [i]	1^-	0	14 ± 1	
		1.98	63 ± 1	$\Gamma_\alpha\Gamma_\gamma/\Gamma = 0.89$ eV [d]
		3.63	13 ± 1	
		4.46	2 ± 1	
		5.10	2 ± 1	
		5.26	6 ± 1	
8.13 [i]	5^-	3.55	94 ± 1	$\Gamma_\alpha\Gamma_\gamma/\Gamma = 0.22$ eV [d]

Table 18.3: Radiative decays in ^{18}O [a] (continued)

E_i (MeV)	J_i^π	E_f (MeV)	Branch (%)	Comments
		5.10	6 ± 2	
8.22 [i]	2^+	1.98	22 ± 1	
		3.55	3 ± 1	
		3.92	1.0 ± 0.5	
		4.46	49 ± 1	
		5.10	25 ± 1	
8.29 [i]	3^-	3.55	49 ± 1	
		4.46	4 ± 1	
		5.26	47 ± 1	

[a] See Table 18.3 in (1978AJ03) for references and for additional information.
[b] See (1982OL01).
[c] See Table IV in (1973OL02).
[d] For all transitions from this state.
[e] Recalculated to give total of 100%.
[f] $\Gamma_\alpha\Gamma_\gamma/\Gamma = 42$ meV (1967LE02).
[g] Transitions to ^{18}O*(0, 3.55) are < 1 and $< 0.5\%$ (1982OL01).
[h] Transitions to ^{18}O*(5.53, 6.20) are < 8 and $< 2\%$ (1982OL01).
[i] (1982GA1D; preliminary). For earlier work see (1978AJ03).
[j] M. Gai *et al.*, private communication, 1982. The weak transitions are not shown in Fig. 1 because it was prepared prior to this communication.

2. (a) ^{11}B(^{7}Li, p)^{17}N $\quad Q_m = 8.417 \quad E_b = 24.359$
   (b) ^{11}B(^{7}Li, d)^{16}N $\quad Q_m = 4.749$
   (c) ^{11}B(^{7}Li, t)^{15}N $\quad Q_m = 8.525$
   (d) ^{11}B(^{7}Li, α)^{14}C $\quad Q_m = 18.131$

Cross sections to various of the final states have been measured at $E(^7\text{Li}) = 5.00$ MeV (1966MC05).

3. ^{12}C(^{7}Li, p)^{18}O $\quad Q_m = 8.402$

Table 18.4: States of ^{18}O from ^{12}C(^{7}Li, p) [a]

E_x (keV) [b]	E_x (keV) [b]
0	6351.1 ± 4.5 [d]
1982.4 ± 4.2	6402.1 ± 4.5
$\equiv 3555.0$	6888.1 ± 6.1
3636.1 ± 3.5	7119.8 ± 5.1 [e]
3922.4 ± 3.1	7619.4 ± 5.0
4457.8 ± 3.0	7779.3 ± 4.8 [f]
5099.3 ± 3.8	7858.7 ± 4.9 [g]
5252.1 ± 4.9	7972.7 ± 4.8
5331.6 ± 3.8	8041.5 ± 5.0
5377.6 ± 3.6 [c]	8133.9 ± 5.3
5532.2 ± 3.7	8218.3 ± 5.2 [h]
6194.9 ± 3.8	8291.7 ± 5.6

[a] (1978FO29). Angular distributions have been measured at $E(^7\text{Li}) = 16.0$ and 18.0 MeV. The total cross sections generally agree with a $(2J + 1)$ relationship.

[b] From the results at $E(^7\text{Li}) = 18.0$ MeV.

[c] Cross section much smaller than expected from a $(2J+1)$ relationship.

[d] On the basis of the $(2J + 1)$ relationship, and results from other reactions, 2^- is suggested.

[e] Cross section is enhanced. It is suggested that this group corresponds to an unresolved doublet. See also text of reaction 3.

[f] $J = (2, 3)$.

[g] $J^\pi = (4^+, 5^-)$.

[h] Cross section is enhanced: either $J \neq 2$, or there is another unresolved state, or there is an appreciable non-compound reaction component.

Observed proton groups are displayed in Table 18.4. See also (1978AJ03). (1978FO18) suggests that an unresolved 0^+ state at $E_x = 7.11$ MeV and the 2^+, 4^+ and 6^+ states at 3.21, 10.29 and 12.53 MeV are 6p-4h states.

4. ^{12}C(^{20}Ne, ^{14}O)^{18}O $\qquad Q_m = 14.2683$

See (1979OR01).

5. ^{13}C(^{7}Li, d)^{18}O $\qquad Q_m = 5.680$

See (1978AJ03).

6. (a) ^{13}C(^{9}Be, α)^{18}O $\qquad Q_m = 12.8311$
(b) ^{13}C(^{13}C, 2α)^{18}O $\qquad Q_m = 2.1832$

Angular distributions for α_0 and α_1 [reaction (a)] have been measured at $E(^9\text{Be}) = 27.9$ MeV (1980BO21). For yields see (1981PO05). For reaction (b) see (1982CH05).

7. ^{13}C(^{17}O, ^{12}C)^{18}O $\qquad Q_m = 3.098$

Angular distributions for the transitions to ^{18}O*(0, 1.98) are reported at $E(^{17}\text{O}) = 29.8$ and 32.3 MeV (1978CH16).

8. (a) ^{14}C(α, γ)^{18}O $\qquad Q_m = 6.2279$
(b) ^{14}C(α, α)^{14}C $\qquad E_b = 6.2279$

Resonances in the yields of capture γ-rays [reaction (a)] are observed at $E_\alpha = 1.14$, 1.79, 2.09, 2.33, 2.44, 2.55 and 2.64 MeV: see (1978AJ03) and (1982GA1D). Gamma-ray angular distribution and correlation measurements lead to $J^\pi = 4^+, 1^-, 1^-$ and 5^- for ^{18}O*(7.12, 7.62, 8.04, 8.13), as well as to J^π assignments for lower states involved in the cascade decay: see Tables 18.3 and 18.5. See also (1980SP1B; astrophys.) and (1978AJ03).

Observed anomalies in the scattering [reaction(b)] for $E_\alpha = 2$ to 8.2 MeV are shown in Table 18.5. The yield of elastic scattering has been measured up to $E_\alpha = 16.5$ MeV (1970MO13). See also ^{14}C in (1981AJ01).

Table 18.5: Resonances in $^{14}C(\alpha, \gamma)^{18}O$, $^{14}C(\alpha, n)^{17}O$ and $^{14}C(\alpha, \alpha)^{14}C$ [a]

E_α (MeV $\pm$ keV)	Γ_{lab} (keV)	Particles out	^{18}O* (MeV)	J^π
1.140 ± 2		γ	7.114	4^+
1.787 ± 4	< 3	γ	7.618	1^-
2.090 ± 5		γ	7.853	$(4^+, 5^-)$
2.327 ± 3	< 3	γ, α_0	8.038	1^-
2.435 ± 3		γ	8.122	5^-
2.553 ± 3	1.3 ± 1	γ, n, α_0	8.213	2^+
2.644 ± 3	10 ± 1	γ, n, α_0	8.284	3^-
2.800 ± 7	10 ± 7	n	8.405	
3.330 ± 12	90 ± 15	n, α_0	8.817	
3.508 ± 4	55 ± 3	n, α_0	8.956 [h]	
4.030 ± 15	35 ± 20	n, (α_0)	9.362	
4.07 ± 40	≈ 150	n, (α_0)	9.39	
4.17 ± 40	≈ 70	n, (α_0)	9.47	
4.434 ± 10	80 ± 40	n, (α_0)	9.676	
4.70 ± 40	≈ 200	n, (α_0)	9.88	
5.004 ± 10	21 ± 5	n, α_0	10.119	3^-
5.23 [g]	[b]	n, α_0	10.29	4^+
5.34	[b]	n, α_0	10.38	3^-
5.60	[c]	n, α_0	10.58	
5.90	[d]	n, α_0	10.82	
6.02	[d]	n, α_0	10.91	
6.13	[d]	n, α_0	10.99	
6.30	[c]	n, α_0	11.13	
6.64	[b]	n, α_0	11.39	(2^+)
6.67	[b]	n, α_0	11.41	(4^+)
6.93	[b]	n, α_0	11.62	5^-
7.03	[b]	n, α_0	11.69	6^+
7.19	[d]	n, α_0	11.82	(3^-)
7.47	[d]	n, α_0	12.04	(2^+)
7.75	[c]	n, α_0	12.25	$(0^+, 1^-)$
7.85	[b]	n, α_0	12.33	5^-

Table 18.5: Resonances in ^{14}C(α, γ)^{18}O, ^{14}C(α, n)^{17}O and ^{14}C(α, α)^{14}C [a] (continued)

E_α (MeV $\pm$ keV)	$\Gamma_{\rm lab}$ (keV)	Particles out	^{18}O* (MeV)	J^π
8.06	[b]	n, α_0	12.50	4^+
8.10	[b]	n, α_0	12.53	6^+

[a] For the first four states, see also Table 18.3. For references see Table 18.5 in (1978AJ03).
[b] Γ_α, large; $\Gamma_{\rm n}$, large.
[c] Γ_α, small; $\Gamma_{\rm n}$, small.
[d] Γ_α, small; $\Gamma_{\rm n}$, large.
[e] Γ_α, large; $\Gamma_{\rm n}$, small.
[f] (1982GA1D; prelim.): θ^2_α = < 1, 0.8 and 20%, respectively for ^{18}O*(8.04, 8.21, 8.28). See also (1978AJ03).
[g] $\pm 10 - 20$ keV for this and all higher resonances (G.E. Mitchell, private communication).
[h] Two states with $E_{\rm x} = 9.0$ to 9.2 MeV and $J^\pi = (2^+, 3^-)$ or $(4^+, 3^-)$ are reported by (1958WE29).

9. ^{14}C(α, n)^{17}O $\quad Q_{\rm m} = -1.8167 \quad E_{\rm b} = 6.2279$

The relative neutron yield has been measured for $E_\alpha = 2.3$ to 8.5 MeV: the parameters of observed resonances are displayed in Table 18.5.

10. ^{14}C(^{6}Li, d)^{18}O $\quad Q_{\rm m} = 4.7544$

At $E(^6{\rm Li}) = 34$ MeV the spectra are dominated by the groups to ^{18}O*(5.10, 7.12) [$J^\pi = 3^-$, 4^+]. Angular distributions, analyzed in terms of HF and FRDWBA, are reported for ^{18}O*(0, 1.98, $3.55 + 3.63$, 3.92, 4.46, 5.10, $5.26 + 5.34$, 6.2, 7.12, 7.62, 7.86, 8.14, 8.29, 8.9, 10.12, 10.30, $11.39 + 11.41$, $11.62 + 11.69$, 12.04, $12.25 + 12.23$, 12.53, 14.6, 17.0). Differential cross sections are also reported for ^{18}O*($9.36 + 9.41$, $10.91 + 10.99$, 11.13, 12.9). $J^\pi = 4^+, 2^+, 2^+, (4^+)$, and (4^+) are suggested for ^{18}O*(7.86, 8.9, 12.04, 14.6, 17.0). The results indicate that ^{18}O*(5.26, 7.12, 11.69) are the 2^+, 4^+ and 6^+ members of the $K^\pi = 0^+_2$ rotational band based on ^{18}O*(3.63) (1981CU07). See also (1982AR1F).

11. ^{14}C(^{7}Li, t)^{18}O $\quad Q_{\rm m} = 3.761$

At $E(^7\mathrm{Li}) = 20.4$ MeV, triton groups are observed corresponding to a number of states of ^{18}O with $E_x < 12.6$ MeV. Angular distributions were obtained for some of these, including ^{18}O*(0, 1.98, 7.12, 11.69) with $J^\pi = 0^+, 2^+, 4^+, 6^+$. The latter two are the most strongly populated in this reaction: they appear to be part of the ground-state rotational band (1970MO17). See also (1978FO16; theor.).

12. ^{14}C(^{16}O, ^{12}C)^{18}O $\quad Q_m = -0.9341$

Angular distributions at $E(^{16}\mathrm{O}) = 20$, 25 and 30 MeV have been studied by (1973SC24, 1975SC35). See also (1978KA23; theor.).

13. ^{15}N(t, α)^{14}C $\quad Q_m = 9.6066 \quad E_b = 15.8345$

See (1978AJ03).

14. (a) ^{15}N(α, p)^{18}O $\quad Q_m = -3.9796$
(b) ^{15}N(^{6}Li, ^{3}He)^{18}O $\quad Q_m = 0.041$

For reaction (a) see ^{19}F. The work reported in (1978AJ03) for reaction (b) has not been published.

15. ^{15}N(^{13}C, ^{10}B)^{18}O $\quad Q_m = -8.0421$

At $E(^{13}\mathrm{C}) = 105$ MeV ^{18}O*(11.06, 11.79) [$J^\pi = (7^-), (6^-)$] are relatively strongly populated (1979RA10). See also (1977FO1E).

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

Proton groups corresponding to states of ^{18}O are displayed in Table 18.6 (1981CO13). Angular distributions have been measured at many energies up to $E_t = 15$ MeV: see (1978AJ03) and Table 18.6. Analysis of spectroscopic factors suggest that ^{18}O*(5.34) [0^+_3] is largely $(\mathrm{s}_{1/2})^2$ while ^{18}O*(3.63) [0^+_2] has a dominantly collective nature as does ^{18}O*(5.25) [2^+_3] (1974FO14, 1976LA13): see (1976LA13) for a general discussion of the properties of the states of ^{18}O. Lifetime measurements are reported in Table 18.4 of (1978AJ03). See also (1977CI1D, 1979PI01) and (1977PI10, 1978PI10, 1979PI10; theor.).

Table 18.6: States in ^{18}O from ^{16}O(t, p) [a]

E_x (MeV ± keV)	L	J^π	E_x (MeV ± keV)	E_x (MeV ± keV)
0	0	0^+	7623 ± 18	9713 ± 7
1986 ± 4	2	2^+	7782 ± 6	9890 ± 11
3556 ± 2	4	4^+	7871 ± 2 [d]	10120 ± 40
3634 [b]	0	0^+	7983 ± 3 [d]	10300 ± 20
3915 ± 2	2	2^+	8046 ± 7	10400 ± 10
4458 ± 3	1	1^-	8140 ± 10	10610 ± 20
5105 ± 2	3	3^-	8233 ± 9	
5258 ± 6	2	2^+	8294 ± 5 [d]	
5340 ± 4	0	0^+	8430 ± 12	
5382 ± 4			8521 ± 3 [d]	
5530 ± 4			8660 ± 6	
6197 ± 3	1	1^-	9030 ± 15	
6356 ± 7	1, 2	$(1^-, 2^+)$ [c]	9362 ± 5 [d]	
6399 ± 3	3	3^-	9420 ± 20	
6885 ± 9			9480 ± 30	
7123 ± 7	4	4^+	9671 ± 8	

[a] (1981CO13): $E_t = 15$ MeV; DWBA analysis. See also (1979FO17) and Table 18.6 in (1978AJ03).

[b] Nominal energy.

[c] See, however, Table 18.8.

[d] Comparisons of E_x shown here with those displayed in Table 18.2 for ^{18}O*(3.92, 5.01, 6.40, 7.77) suggest that the uncertainty shown may be low: ±6 keV was arbitrarily used in calculating the best value for E_x for this state in Table 18.2.

17. ^{16}O(α, 2p)^{18}O $\qquad Q_{\rm m} = -16.1071$

At $E_\alpha = 65$ MeV, the angular distribution to ^{18}O*(3.55) [$J^\pi = 4^+$] has been studied. In addition ^{18}O*(8.04, 9.15, 10.3) are also populated (1978JA10).

18. (a) ^{16}O(^{10}B, ^{8}B)^{18}O $\qquad Q_{\rm m} = -14.824$
(b) ^{16}O(^{12}C, ^{10}C)^{18}O $\qquad Q_{\rm m} = -19.6569$
(c) ^{16}O(^{13}C, ^{11}C)^{18}O $\qquad Q_{\rm m} = -11.479$
(d) ^{16}O(^{14}C, ^{12}C)^{18}O $\qquad Q_{\rm m} = -0.9341$

At $E(^{10}{\rm B}) = 100$ MeV, reaction (a) preferentially populates ^{18}O*(3.55) [first $({\rm d}_{5/2})^2_{4+}$ state]. ^{18}O*(1.98, 5.26, 7.12, 8.0, 8.3, 9.1) are also populated (1978HA10). For reaction (b) see (1978AJ03). At $E(^{13}{\rm C}) = 105$ MeV [reaction (c)] the angular distribution to ^{18}O*(3.55) has been measured (1979RA10, 1980PR09). For reaction (d) see (1979HAYV).

19. ^{17}O(n, γ)^{18}O $\qquad Q_{\rm m} = 8.0446$

The thermal capture cross section of ^{17}O is 538 ± 65 μb (1979LOZK; prelim.).

20. ^{17}O(n, n)^{17}O $\qquad E_{\rm b} = 8.0446$

The scattering amplitude (bound) $a = 5.62 \pm 0.45$ fm, $\sigma_{\rm free} = 3.55 \pm 0.25$ b (1979KO26). See also (1981MA16) and (1978AJ03, 1981MUZQ).

21. ^{17}O(n, p)^{17}N $\qquad Q_{\rm m} = -7.898 \qquad E_{\rm b} = 8.0446$

See (1978AJ03).

22. ^{17}O(n, α)^{14}C $\qquad Q_{\rm m} = 1.8167 \qquad E_{\rm b} = 8.0446$

The thermal cross section is 235 ± 10 mb: see (1973MU14).

23. ^{17}O(d, p)^{18}O $\qquad Q_{\rm m} = 5.8199$

Table 18.7: States of ^{18}O from ^{17}O(d, p) [a]

E_x (MeV $\pm$ keV) [b]	l_n [b]	J^π [b]	S [c]
0	2	0^+	1.22
1.982 ± 10	$0 + 2$	2^+	$0.21 + 0.83$
3.552 ± 10	2	4^+	1.57
3.63	2	0^+	0.28
3.92	$0 + 2$	2^+	$0.35 + 0.66$
4.46	1	1^-	0.03
5.10	3	3^-	0.03
5.255 ± 10	0	2^+	0.35
5.34	2	0^+	0.16
5.375 ± 10	0	3^+	1.01
6.20	1	1^-	0.03
6.35	1	$\leq 3^{(-)}$	$0.03 - 0.04$
7.110 ± 15	2	4^+	
7.855 ± 20			
7.962 ± 20			

[a] See also Tables 18.7 in (1972AJ02) and in (1978AJ03).

[b] See references in Table 18.7 in (1978AJ03). E_x values without uncertainties are nominal. J are consistent with l_n and used to calculate S.

[c] (1976LI01): $E_d = 18$ MeV. See also Table 18.7 in (1978AJ03).

Observed proton groups are displayed in Table 18.7. Proton-γ coincidence measurements are shown in Table 18.3. See also (1977PE08, 1978AJ03) and (1979SA31; theor.).

24. (a) ^{17}O(^{12}C, ^{11}C)^{18}O $\qquad Q_m = -10.677$

(b) ^{17}O(^{17}O, ^{16}O)^{18}O $\qquad Q_m = 3.900$

Angular distributions [reaction (a)] involving ^{18}O*(0, 1.98, 3.55) have been studied at $E(^{12}\text{C}) = 115$ MeV (1980PR09). For reaction (b) see (1972AJ02).

25. ^{18}N(β^-)^{18}O $\qquad Q_m = 14.03$

Table 18.8: Branching in ^{18}N(β^-)^{18}O [a]

Decay to ^{18}O* [b] (keV)	J^π	Branch (%) [c]	$\log ft$ [c]
1982.05 ± 0.09 [d]	2^+	3.9 ± 1.5	6.75 ± 0.30
3554.13 ± 0.80	4^+	< 0.6	> 7.27
3633.70 ± 0.11	0^+	< 0.35	> 7.50
3920.42 ± 0.14	2^+	< 0.43	> 7.35
4455.52 ± 0.10	1^-	54.6 ± 1.1	5.146 ± 0.054
5097.60 ± 0.60	3^-	< 0.43	> 7.09
5530.17 ± 0.32	2^-	3.1 ± 0.4	6.15 ± 0.07
6198.22 ± 0.40	1^-	1.4 ± 0.2	6.33 ± 0.08
6349.76 ± 1.0	(2^-)	2.2 ± 0.3	6.09 ± 0.08
6880.45 ± 0.27	0^- [e]	14.8 ± 0.8	5.118 ± 0.070
7771.07 ± 0.50	2^- [e]	5.0 ± 0.5	5.32 ± 0.09

[a] (1982OL01).

[b] For γ-ray branchings see Table 18.3.

[c] It is estimated that $(15 \pm 6)\%$ of the transitions are to states of ^{18}O which do not γ-decay. The uncertainty in this number is reflected in the $\log ft$ values but not in the branching ratios. The $\log ft$ values were calculated using 14036 ± 200 keV for the ^{18}N(β^-)^{18}O Q-value (see also "*Mass of* ^{18}*N*" in the "GENERAL" section of ^{18}N) and the $\tau_{1/2}$ value given in reaction 1 of ^{18}N, 624 ± 12 msec (1982OL01).

[d] $E_\gamma = 1981.933 \pm 0.09$ keV is adopted by (1982OL01).

[e] See (1982OL01).

The transitions observed in the β^- decay are displayed in Table 18.8 (1982OL01).

26. (a) ^{18}O(γ, n)^{17}O $\quad Q_m = -8.0446$

(b) ^{18}O(γ, 2n)^{16}O $\quad Q_m = -12.1889$

(c) ^{18}O(γ, p)^{17}N $\quad Q_m = -15.942$

(d) ^{18}O(γ, t)^{15}N $\quad Q_m = -15.8345$

(e) ^{18}O(γ, α)^{14}C $\quad Q_m = -6.2279$

The cross sections for the (γ, p), (γ, n), (γ, 2n) and (γ, tot) [tot = total absorption] have been measured with monoenergetic photons to 42 MeV: observed resonances are displayed in Table

18.9. All three of the partial cross sections have substantial strength in the giant resonance region; the (γ, 2n) cross section is a significant fraction of $\sigma(\gamma$, tot) and is even larger than $\sigma(\gamma$, p). Above the GDR the partial cross sections decrease but the integrated $\sigma(\gamma$, tot) between 29 and 42 MeV is about one-third of the value integrated from threshold to 42 MeV. The relative strengths of partial cross sections leads to the T assignments shown in Table 18.8. The $T_<$ and $T_>$ components of the ^{18}O photo absorption cross section are also derived (1979WO04). Structures in the (γ, α_0) cross section are reported at E_x = 18.2, 20.9, 22.1 and 24.2 MeV (1982BA03; $E_{\rm brems.}$). See also (1980PY01). The decay of the GDR to ^{14}C, ^{15}N, ^{16}O, ^{17}N and ^{17}O states has been studied by (1976BA41, 1982BA03). See also (1978AJ03) for the earlier work, (1979BE1X) and (1981BA04; theor.).

27. ^{18}O(γ, γ)^{18}O

The γ_0 width of ^{18}O*(6.20) is 0.18 ± 0.03 eV, assuming $\Gamma_{\gamma_0}/\Gamma = 0.88$; $E_x = 6202.7 \pm 0.8$ keV (1974HA15).

28. ^{18}O(e, e)^{18}O

The ^{18}O charge radius, $\langle r^2\rangle^{1/2} = 2.784 \pm 0.020$ fm, based on studies of the elastic charge form factors for E_e = 70 to 370 MeV, the resulting determination of the difference in the ^{18}O and ^{16}O radii [$+0.074 \pm 0.005$ fm] (1979MI09) and the rms radius of ^{16}O quoted in (1982AJ01). [The Δr from muon studies is 0.076 ± 0.005 fm (1980BA36)]. See also (1982NO04). For earlier values see (1978AJ03).

Inelastic scattering has been reported to ^{18}O*(1.98, 3.55, 3.63, 3.92, 5.10, 5.26, 5.34, 7.12, 7.86) [see (1978AJ03, 1982NO04)], to states at E_x = 11.6, 12.1, 12.5, 14.8, 15.8, 18.0 and 20.8 MeV (most probable assignments 2^+) [or (2^+, 4^+) for the 11.6 and 12.5 MeV levels] (1980AN17: E_e = 80 to 166 MeV). [Several weak and broad bumps are also reported at E_x = 31.2, 34.0 and 36.8 MeV, and some transverse contributions are suggested in the range 14.8 to 21.8 MeV (1980AN17). In addition to determining the form factors at 90° and 160° in the range $0.6 \leq q \leq$ 2.7 fm^{-1} for the 0^+ states ^{18}O*(3.63, 5.34), the 2^+ states ^{18}O*(1.98, 3.92, 5.26) and the 4^+ states ^{18}O*(3.55, 7.12, 7.86). (1982NO04) report transition charge density parameters for ^{18}O*(1.98, 3.92, 5.26, 7.11) as well as $B({\rm E}L; 0^+_1 \to L^+)$. The B(E2) are 44.8 ± 1.3, 22.2 ± 1.0 and 28.3 ± 1.5 $e^2 \cdot {\rm fm}^4$ for ^{18}O*(1.98, 3.92, 5.26) and the $B({\rm E4}) = (9.04\pm0.90)\times10^2$ and $(1.31\pm0.06)\times10^4$ $e^2 \cdot {\rm fm}^8$ for ^{18}O*(3.55, 7.12) (1982NO04). At E_e = 45 to 59 MeV sharp states are observed at E_x = 16.38 and 18.86 ± 0.01 MeV (≤ 30 and ≤ 60 keV). It is suggested that both are $T = 2$ states with the first the analog of the ground state of ^{18}N. B(M2)↑$= 58 \pm 8$ $\mu_k^2 \cdot {\rm fm}^2$ and B(M1)↑$= 0.28 \pm 0.04$ μ_k^2 for ^{18}O*(16.38, 18.86). In addition a structure at E_x = 23.7 MeV is also reported (1980AN18). See also (1981RI1A, 1982BE1J, 1982RI1B) and (1981PE1C; theor.).

Table 18.9: Resonances in $^{18}O + \gamma$

E_x (MeV) [a]				σ (mb)	Γ (MeV)
(γ, tot)	(γ, n)	(γ, 2n)	(γ, p)		
9.1	9.1			1.1 [b]	0.6
10.3	10.3			5.3 [b]	0.9
11.4	11.4			9.0 [b]	0.7
13.1	13.1	13.2		8.6 [b]	0.7
13.8	13.8	13.9		6.9 [b]	0.6
14.7	14.7	14.8		13.1 [b]	0.8
15.8	15.7	15.8		10.9 [b]	0.7
17.3 [e]	17.1		17.5	10.1 [b], 1.2 [c]	0.6
19.4 [e]		(19.1)	19.4	10.0 [b], 1.8 [c]	0.9
21.1 [d]		21.1	21.0	9.7 [b], 1.2 [c]	
22.6	(22.6)	22.7	22.7		
23.7 [d]	23.7	23.5	23.7	17.7 [b], 6.1 [c]	1.6
27 [e]	27		27 − 28		
30 [f]	30				
36 [f]					

[a] (1979WO04). See also (1982BA03) and (1977AJ02, 1979BE1X) and (1980PY01).

[b] $\alpha(\gamma, n) + 2\sigma(\gamma, 2n)$.

[c] $\sigma(\gamma, p)$.

[d] $T = 1$: see (1979WO04).

[e] $T = 2$: see (1979WO04).

[f] Weak and broad resonances: may indicate the presence of particle-hole states at these high energies.

29. ^{18}O(π, π)^{18}O

Angular distributions for the elastic scattering and the inelastic scattering to ^{18}O*(1.98) have been studied at $E_{\pi^\pm} = 29.2$ MeV (1979JO08), 163 MeV (1978JA13; also to ^{18}O*(5.10)), 180 MeV (1978LU09) and 164 and 230 MeV (1978IV01, 1979IV03; also to ^{18}O*(5.10)). See also (1982SEZZ). The ratio $\sigma(\pi^-)/\sigma(\pi^+)$ for the 2^+ state is 1.86 ± 0.16 while for the 3^- state it is 0.89 ± 0.06. An optical model analysis leads to $\langle r_n^2 \rangle^{1/2} - \langle r_p^2 \rangle^{1/2} = 0.03 \pm 0.03$ fm (1979IV03). (1979JO08) report $\langle r_n^2 \rangle^{1/2} = 2.81 \pm 0.03$ fm. The inclusive inelastic scattering and true absorption cross sections have been measured at $E_{\pi^\pm} = 165$ MeV and $E_{\pi^+} = 315$ MeV (1980NA10). See also the "GENERAL" section here.

30. ^{18}O(n, n)^{18}O

Angular distributions have been measured at $E_n = 24$ MeV (1980GR15; n_0, n_1 and n to ^{18}O*(5.10): deformation and isospin effects are discussed). See also Table 18.8 in (1972AJ02) and (1981DI1C; theor.).

31. ^{18}O(p, p)^{18}O

Angular distributions have been measured for $E_p = 0.84$ to 135 MeV: see (1978AJ03) and (1979MU05; $6.1 - 16.6$ MeV; p_0, p_1 [and p to ^{18}O*(3.55, 5.09, 7.11) at 16.2 MeV]), (1980FA06, 1980FA07; $17.7 - 44.1$ MeV; p_0), (1978NO1G, 1980KE1C, 1981KE1B; 135 MeV; all abstracts) and (1981GL1B; $E_{\vec{p}} = 800$ MeV; p_0, p_1, p_4, p_5, p_6 and p to ^{18}O*(7.12)).

At $E_p = 24.5$ MeV (1974ES02) have studied the angular distributions of the proton groups to ^{18}O*(1.98, 3.55, 3.63, 3.92, 4.46, 5.10, 5.26, 5.53, 7.12): a modified DWBA analysis leads to $J^\pi = 2^+, 4^+, 0^+, 2^+, 1^-, 3^-, 2^+, 2^-$ and 4^+ for these states. A coupled-channels calculation suggests $\beta_2 = 0.37 \pm 0.03, 0.56 \pm 0.06$ and 0.18 ± 0.04 for ^{18}O*(1.98, 5.10, 7.12). Such calculations also support evidence for a rotational band involving ^{18}O*(0, 1.98, 7.12). The 3^- state at 5.10 MeV is strongly excited and collective in nature: $B(\text{E3}) = 1120\ e^2 \cdot \text{fm}^6$. For ^{18}O*(1.98, 3.92, 5.26), $B(\text{E2}) = 45$, 8.3 and 24 $e^2 \cdot \text{fm}^4$ (1974ES02).

^{18}O*(1.98) has $|g| = 0.287 \pm 0.015$ [$\tau_m = 2.99 \pm 0.12$ psec] (1976AS04). ^{18}O*(3.55) has $|g| = 0.62 \pm 0.10$ suggesting a mainly $(d_{5/2})^2$ configuration for this state (1974BE63). The work on $T = 2$ states reported earlier has not been published: see (1978AJ03). For polarization measurements see ^{19}F. See also (1978DI13) and (1978KU03, 1978MO06, 1981PI11; theor.).

32. ^{18}O(d, d)^{18}O

Angular distributions of elastically scattered deuterons have been measured for $E_{\rm d} = 7.0$ to 15.0 MeV (also d_1 at 15 MeV): see (1978AJ03) and (1979ST21; $E_{\vec{\rm d}} \approx 10$ MeV; d_0). See (1972AJ02) for the population of other states of ^{18}O and see ^{20}F.

33. ^{18}O(t, t)^{18}O

The elastic scattering has been studied at $E_{\rm t} = 6.4$ and 7.2 MeV (1964PU01).

34. ^{18}O(^{3}He, ^{3}He)^{18}O

The elastic scattering has been studied at $E(^3{\rm He}) = 11.0$ to 17.3 MeV [see (1972AJ02)] and at $E(^3\vec{\rm He}) = 33$ MeV (1981LE1H; also inelastic to ^{18}O*(1.98) and analyzing powers) and $E(^3{\rm He}) = 41$ MeV (1980TR02). See also (1981CO15; theor.).

35. ^{18}O(α, α)^{18}O

Angular distributions of many α-groups have been measured in the range $E_\alpha = 21$ to 40.5 MeV: see (1978AJ03). The transitions to ^{18}O*(4.46, 5.10) are $L = 1$ and 3, respectively, fixing $J^\pi = 1^-$ and 3^- for these states (1966HA19). Measurements of α-groups near $180°$ for $E_\alpha = 20.0$ to 23.4 MeV confirm assignments of natural parity for ^{18}O*(1.98, 3.55, 3.63, 3.92, 4.46, 5.10, 5.26, 5.34, 6.20, 6.40, 7.12, 7.62, 7.86, 8.22, 8.29, 8.82, 8.96, 9.03, 9.10, 9.36, 9.41, 9.68, 9.72 ± 0.03, 9.88, 10.12, 10.29, 10.40, 11.62, 11.69). The levels at $E_{\rm x} = 5.38$, 8.48 and 8.64 MeV were not observed, and those at 5.53, 6.35 and 6.88 MeV were populated weakly indicating unnatural parity: $J^\pi = 3^+$ and 2^- respectively for ^{18}O*(5.38, 5.53) (1971OL06).

Alpha-gamma correlation measurements involving ^{18}O states below $E_{\rm x} = 6.4$ MeV [see Table 18.3] lead to $J^\pi = 1^-$ and 3^- for ^{18}O*(6.20, 6.40). Other J^π values agree with previous assignments. The transitions $3.92 \to 1.98$ and $5.26 \to 1.98$ are almost pure M1 (1971BE45). For $\tau_{\rm m}$ measurements see Table 18.4 in (1978AJ03). ^{18}O*(1.98) has a negative g-factor (1975FO03), $|g| = 0.35 \pm 0.04$ (1975SP03). See also (1977MA2E, 1979KN1F) and (1981CA1E, 1981LA1G; theor.).

36. (a) ^{18}O(^{6}Li, ^{6}Li)^{18}O
(b) ^{18}O(^{7}Li, ^{7}Li)^{18}O

An elastic angular distribution has been measured at $E(^6{\rm Li}) = 32$ MeV (1975WH01). For reaction (b) see (1972AJ02).

37. ^{18}O(^{9}Be, ^{9}Be)^{18}O

See (1971KN05).

38. (a) ^{18}O(^{10}B, ^{10}B)^{18}O
(b) ^{18}O(^{11}B, ^{11}B)^{18}O

An elastic angular distribution has been reported at $E(^{11}\mathrm{B}) = 115$ MeV (1980PR09). For reaction (a) see (1971KN05). See also (1979HU1B; theor.).

39. (a) ^{18}O(^{12}C, ^{12}C)^{18}O
(b) ^{18}O(^{13}C, ^{13}C)^{18}O

Elastic angular distributions have been studied at $E(^{18}\mathrm{O}) = 32.3$ and 35 MeV (1978CH03) and 47.5, 55 and 57.5 MeV (1976WE05) for reaction (a) and at $E(^{18}\mathrm{O}) = 31$ MeV for reaction (b) (1978CH03). Yields and fusion cross sections are reported by (1976SP07, 1978CH03, 1978CO07, 1978FR05, 1979CH07, 1979KO20, 1980WI09). See also (1979DAZK, 1979EN1F, 1979GAZV, 1981HEZW), (1978LE1T, 1978TS04) and (1978BI1G, 1978VA1A, 1979KR07, 1979NA03, 1980CH1J, 1980LE11, 1980LO02, 1980VA03, 1981HA18; theor.).

40. ^{18}O(^{16}O, ^{16}O)^{18}O

Angular distributions have been measured at many energies for $E(^{16}\mathrm{O}) = 24$ to 54.5 MeV and $E(^{18}\mathrm{O}) = 25$ to 52 MeV, involving besides $^{18}\mathrm{O}_{\mathrm{g.s.}}$, ^{18}O*(1.98, $3.55 + 3.63$, 3.92, 4.46, 5.10, 7.12) at some energies [see (1978AJ03)], and at $E(^{18}\mathrm{O}) = 35$ MeV (1981CA1E; to ^{18}O*(0, 1.98, 4.46, 5.10)). At $E(^{18}\mathrm{O}) = 126$ MeV ^{18}O*(9.0) is relatively strongly populated (1979RA10). For yield measurements see (1978FR05). See also (1974FI1D, 1978HO1C) and (1978LE16, 1981CA09, 1981LA16; theor.).

41. (a) ^{18}O(^{17}O, ^{17}O)^{18}O
(b) ^{18}O(^{18}O, ^{18}O)^{18}O

Angular distributions involving ^{18}O*(0, 1.98) are reported at $E(^{17}\mathrm{O}) = 36$ MeV (1977KA1Y). Angular distributions [reaction (b)] have been studied at $E(^{18}\mathrm{O}) = 42$ and 52 MeV [see (1978AJ03)] and at $E(^{18}\mathrm{O}) = 20$ to 36 MeV (1977KA21; to ^{18}O*(0, 1.98), the latter from 24 MeV). ^{18}O*(3.55+

3.63, 4.46, 5.10, 7.12) are also populated: see (1978AJ03). For yield measurements [reaction (b)] see (1977KA21). See also (1979GAZV) and (1978CH10, 1978VO06, 1978VO13, 1981CA09, 1982LA04; theor.).

42. ^{18}O(^{19}F, ^{19}F)^{18}O

The elastic scattering has been studied at $E(^{19}\text{F}) = 27$, 30 and 33 MeV (1973GA14). See also (1979GAZV).

43. ^{18}O(^{24}Mg, ^{24}Mg)^{18}O

Angular distributions are reported at $E(^{18}\text{O}) = 29$ and 35 MeV to ^{18}O*(0, 1.98) (1978CA07). For fusion measurements see (1978TA05, 1981RAZN). See also (1980RA1F).

44. ^{18}O(^{27}Al, ^{27}Al)^{18}O

For fusion measurements see (1977EI01, 1979RA21). See also (1980MI1B, 1980SA1L, 1981TA16, 1981WUZZ), (1977SC1G) and (1978VA1A; theor.).

45. (a) ^{18}O(^{28}Si, ^{28}Si)^{18}O
(b) ^{18}O(^{40}Ca, ^{40}Ca)^{18}O

Elastic angular distributions are reported at $E(^{18}\text{O}) = 36$ MeV (1973GA09, 1977EC04), 40 MeV (1978CA07) and 56 MeV (1979ME04, 1979ME12). For fusion measurements see (1979RA21, 1981WUZZ). See also (1979SA27; theor.). For reaction (b) see (1982DA07, 1982LA02; theor.).

46. ^{18}F(β^+)^{18}O $\qquad Q_\text{m} = 1.6555$

See ^{18}F.

47. (a) ^{19}F(γ, p)^{18}O $\qquad Q_\text{m} = -7.9934$
(b) ^{19}F(e, ep)^{18}O $\qquad Q_\text{m} = -7.9934$

In reaction (a) ^{18}O*(1.98, 3.63) are involved: see (1978AJ03), (1979KE1B, 1979TH05) and ^{19}F. Proton spectra [reaction (b)] have been measured for $E_e = 15$ to 26 MeV (1975TS03): see ^{19}F.

48. ^{19}F(n, d)^{18}O $\qquad Q_m = -5.7688$

Angular distributions have been measured at $E_n = 14$ to 14.4 MeV: see (1972AJ02). Gamma rays from the de-excitation of ^{18}O*(1.98, 3.55, 3.63) are reported by (1976PR08). See also (1978CO18, 1980CO1U) and ^{20}F.

49. ^{19}F(p, 2p)^{18}O $\qquad Q_m = -7.9934$

The reaction to the ground state has been studied at $E_p = 42.7$ MeV (1972HI10).

50. ^{19}F(d, ^{3}He)^{18}O $\qquad Q_m = -2.4998$

Many states of ^{18}O ($E_x < 14.6$ MeV) have been populated in this reaction: see Table 18.8 in (1978AJ03). Analyzing powers for the ground-state transitions are reported at $E_{\vec{d}} = 12.4$ MeV (1981EN1A). See also (1978RO01).

51. ^{19}F(t, α)^{18}O $\qquad Q_m = 11.8207$

Table 18.10 displays the very accurate E_x measurements of (1973OL02) obtained from γ-measurements. This study, as well as the angular correlation work of (1973BE48), leads to some J-assignments, and to the branching ratios displayed in Table 18.3. (1975SO05) have determined Γ_π/Γ for the $0^+ \to 0^+$ transitions from ^{18}O*(3.63, 5.34) to be $(3.0 \pm 0.6) \times 10^{-3}$ and $\leq 2.3 \times 10^{-3}$. Using the adopted values of τ_m for these states [see Table 18.4 in (1978AJ03)] $\langle M \rangle_\pi = 6.0 \pm 0.7$ fm^2 and ≤ 4.5 fm^2. ^{18}O*(5.34) appears to be the expected nearly spherical $(s_{1/2})^2$ state (1975SO05).

52. ^{19}F(α, αp)^{18}O $\qquad Q_m = -7.9934$

This reaction, leading to ^{18}O$_{g.s.}$, has been studied at $E_\alpha = 140$ MeV: DWIA provides a fairly good fit to the data (1979NA06).

Table 18.10: ^{18}O states from ^{19}F(t, $\alpha\gamma$) [a]

E_x (keV)	J^π	E_x (keV)	J^π
1982.16 ± 0.20		5530.5 ± 0.6	1, 2
3555.07 ± 0.45		6196.3 ± 1.2	1 [b]
3634.50 ± 0.40		6351.3 ± 0.6	1, 2
3920.6 ± 0.4		6404.4 ± 1.2	
4456.1 ± 0.5		6881.6 ± 1.2	0, (1) [b]
5098.5 ± 1.2		7116.9 ± 1.2	
5260.4 ± 1.2		7.75	$1 \rightarrow 4$ [b]
5336.4 ± 0.6		7.98	$1 \rightarrow 5$ [b]
5377.8 ± 1.2		[c]	

[a] (1973OL02): see Table 18.3 for branching ratios and Table 18.2 for τ_m.
[b] (1973BE48).
[c] (1962HI06) report α-groups to ^{18}O states with E_x = 7.60, 7.75, 7.84, 7.96, 8.02, 8.11, 8.19, 8.26, 8.39, 8.48, 8.64 MeV ($\pm$20 keV).

53. ^{21}Ne(n, α)^{18}O $\qquad Q_m = 0.696$

See (1978AJ03).

54. ^{22}Ne(d, ^{6}Li)^{18}O $\qquad Q_m = -8.195$

At $E_d = 55$ MeV ^{18}O*(1.98, 3.55, 5.10, 6.40) are preferentially populated (1981JAZV). See also (1978BE1H).

55. ^{22}Ne(^{3}He, ^{7}Be)^{18}O $\qquad Q_m = -8.082$

See (1978AJ03).

56. ^{26}Mg(α, ^{12}C)^{18}O $\qquad Q_m = -13.004$

This reaction has been studied at $E_\alpha = 90.3$ MeV (1980BE15).

^{18}F

(Figs. 2 and 4)

GENERAL: (See also (1978AJ03).)

Shell model: (1977AN1P, 1977GR16, 1977SO11, 1978CO08, 1978DA1N, 1978MA2H, 1979BU12, 1979DA15, 1980GO01, 1980KU05, 1980MA18, 1981EL1D, 1981ER03, 1981GR06, 1982KI02).

Cluster, collective and deformed models: (1977BU22, 1978BU03, 1978PI1E, 1978SA15, 1978TA1A, 1979BU12, 1979SA31, 1980RO19, 1981CH24).

Electromagnetic transitions: (1976MC1G, 1977BU22, 1977HA1Z, 1977HE1L, 1978BU03, 1978DE1K, 1978SA15, 1979SA31, 1980KO1L, 1980KU05, 1981CH24).

Special states: (1977AN1P, 1977GR16, 1977HE18, 1977SH18, 1978AN1P, 1978BU03, 1978EN1D, 1978ER1C, 1978KO1W, 1978KR1G, 1978MA2H, 1978PI1E, 1978SA15, 1978TA1A, 1979BA35, 1979BU12, 1979DA15, 1979SA31, 1979WI1Q, 1979ZA07, 1980BR21, 1980GO01, 1980HA41, 1980MA18, 1980RO19, 1980SH1K, 1981AD1E, 1981AR1D, 1981BI03, 1981EL1D, 1981ER03, 1981SO03, 1982KI02, 1982NA03).

Astrophysical questions: (1977SI1D, 1979WO07, 1981WE1F).

Applied topics: (1977FI13, 1978FR1R, 1978WI1F, 1978WO1C, 1979BA52, 1979KA07, 1979WI1G, 1980LA1K, 1980YA08).

Complex reactions involving ^{18}F: (1977AS03, 1977SC1G, 1977YA1B, 1978SH18, 1979BO22, 1979VI09, 1980EV1A, 1980WI1K, 1980WI1L, 1980YA08, 1981GR08).

Pion induced capture and reactions: (1977ST27, 1978SP07, 1981NI03).

Other topics: (1977AN1P, 1977GR16, 1977SH18, 1977SO11, 1978AN1P, 1978CO08, 1978DE1K, 1978EN1D, 1978GO1U, 1978JO1C, 1978KR1G, 1978MA2H, 1978SH1B, 1979BA35, 1979BE2L, 1979CO09, 1979DE18, 1979GO1W, 1979HW01, 1979KU04, 1979WI1Q, 1980BR21, 1980DE1F, 1980GO01, 1980TA1L, 1981AR1D, 1981BI03, 1981CH24, 1981EL1D, 1981ER03, 1981SO03, 1982FI1C, 1982KI02, 1982NA03).

Ground and 1.12 MeV states of ^{18}F: (1976MC1G, 1977HA1Z, 1978ZA1D, 1980MA18, 1981AR1D).

$$\mu_{1.12} = +2.86 \pm 0.03 \text{ nm (1978LEZA)};$$

$$Q_{1.12} = 0.13 \pm 0.03 \text{ b (1974MI21); see also (1978LEZA).}$$

1. ^{18}F(β^+)^{18}O $\qquad Q_m = 1.6555$

The positron decay is entirely to the ground state of ^{18}O [$J^\pi = 0^+$, $T = 1$]; the half-life is 109.77 ± 0.05 min [see Table 18.11 in (1972AJ02)]; $\log ft = 3.554$. The fact that the β^+

transition to $^{18}O_{g.s.}$ is allowed indicates $J^\pi = 1^+$ for $^{18}F_{g.s.}$. The ratio $\epsilon_K/\beta^+ = 0.030 \pm 0.002$; see (1978AJ03). See also (1976BE1E, 1981BE2N, 1982PI1B) and (1980AN31; theor.).

Table 18.11: Energy levels of ^{18}F [a]

E_x (MeV ± keV)	$J^\pi; T$	K^π	τ or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
0	$1^+; 0$	0^+	$\tau_{1/2} = 109.77 \pm 0.05$ min	β^+	1, 3, 4, 5, 6, 7, 8, 13, 14, 16, 19, 20, 22, 29, 30, 32, 35, 37, 42, 43, 45, 46, 47, 48, 50, 51, 52, 53, 55, 56, 58
0.93720 ± 0.06	$3^+; 0$	0^+	$\tau_m = 67.6 \pm 2.5$ psec $g = +0.56 \pm 0.05$	γ	8, 13, 14, 20, 30, 32, 37, 43, 45, 46, 47, 49, 51, 52, 53, 56
1.04155 ± 0.08	$0^+; 1$		2.7 ± 0.4 psec	γ	8, 13, 30, 37, 43, 45, 46, 48, 49, 51, 53, 55
1.08054 ± 0.12	$0^-; 0$	0^-	27.5 ± 1.9 fsec	γ	8, 13, 14, 30, 37, 45, 46, 48, 49, 51, 52, 53, 56
1.12136 ± 0.15	$5^+; 0$	0^+	218 ± 8 nsec $\mu = +2.86 \pm 0.03$ n.m. $Q = 0.13 \pm 0.036$	γ	8, 13, 14, 20, 30, 31, 34, 37, 43, 44, 45, 46, 51, 53, 56
1.70081 ± 0.18	$1^+; 0$	1^+	1.09 ± 0.10 psec	γ	8, 14, 30, 37, 45, 46, 48, 51, 53, 55, 56
2.10061 ± 0.10	$2^-; 0$	0^-	4.3 ± 1.4 psec	γ	8, 14, 20, 30, 32, 37, 45, 46, 51, 53, 56
2.52335 ± 0.18	$2^+; 0$	1^+	0.68 ± 0.11 psec	γ	8, 14, 30, 37, 43, 45, 51, 53
3.06184 ± 0.18	$2^+; 1$		< 1.5 fsec	γ	8, 30, 37, 43, 45, 46, 49, 51, 53, 55
3.13387 ± 0.15	$1^-; 0$	1^-	0.32 ± 0.10 psec	γ	8, 14, 30, 37, 46, 49, 51, 53
3.3582 ± 1.0	$3^+; 0$	1^+	0.49 ± 0.07 psec	γ	8, 14, 30, 46, 51, 53, 56
3.72419 ± 0.22	$1^+; 0$		4 ± 2 fsec	γ	8, 14, 30, 32, 37, 46, 51, 53, 56
3.79149 ± 0.22	$3^-; 0$	1^-	224 ± 35 fsec	γ	8, 14, 30, 32, 37, 46, 51, 53, 56
3.83917 ± 0.22	$2^+; 0$		29 ± 9 fsec	γ	8, 14, 30, 32, 37, 43, 46, 51, 53, 56
4.11590 ± 0.25	$3^+; 0$		91 ± 22 fsec	γ	8, 14, 30, 32, 37, 43, 46, 51, 53, 56
4.2258 ± 0.7	$2^-; 0$	(1^-)	110 ± 15 fsec	γ	8, 14, 30, 32, 46, 51, 53, 56
4.36015 ± 0.26	$1^+; 0$		27 ± 10 fsec	γ	14, 30, 37, 46, 51, 53, 56
4.3981 ± 0.7	$4^-; 0$	0^-	58 ± 12 fsec	γ	8, 14, 20, 21, 30, 46, 51, 53, 56
4.652 ± 2	$4^+; 1$		< 10 fsec	γ	8, 30, 33, 34, 43, 46, 51, 53
4.753 ± 3	$0^+; 1$			γ	30, 46, 49, 51, 53, 56
4.860 ± 2	$1^-; 0$		66 ± 18 fsec	γ, α	8, 30, 51, 53, 56

Table 18.11: Energy levels of ^{18}F [a] (continued)

E_x (MeV ± keV)	$J^\pi; T$	K^π	τ or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
4.9636 ± 0.8	$2^+; 1$		< 4 fsec	γ	8, 30, 43, 51, 53
5.2976 ± 1.5	$4^+; 0$	1^+	30 ± 5 fsec	γ, α	8, 14, 15, 30, 51, 53
5.502 ± 2	$3^{(-)}; 0$		63 ± 25 fsec	γ, α	8, 14, 30, 51, 53
5.60338 ± 0.27	1^+		15 ± 10 fsec	γ, α	8, 11, 37, 51, 56
5.60486 ± 0.28	$1^-; 0+1$		$\Gamma < 1.2$ keV	γ, α	8, 11, 14, 30, 37, 51, 56
5.674 ± 2	$1^-; 0+1$		< 0.8	γ, α	8, 11, 14, 30, 37, 51, 53, 56
5.786 ± 2.4	$2^-; 0$		$\tau_m = 15 \pm 10$ fsec	γ, α	8, 30, 37, 51, 53, 56
6.0964 ± 1.1	$4^-; 0$	1^-	$\Gamma = 0.24 \pm 0.03$	γ, p, α	8, 14, 30, 37, 41, 51, 53, 56
6.100 ± 7	$(1^+); 0$		0.034 ± 0.003	γ, p, α	8, 11, 30, 32, 41, 56
6.13647 ± 0.33	$0^+; 1$		≤ 1	γ, p	30, 37, 53, 56
6.1632 ± 0.9	$3^+; 1$		14 ± 0.5	γ, p, α	30, 37, 39, 41, 56
6.2409 ± 0.9	$3^-; 0+1$		0.19 ± 0.03	γ, p, α	8, 30, 37, 39, 41
6.242 ± 3	$3^-; 0+1$		0.18 ± 0.04	γ, p, α	8, 11, 41
6.262 ± 2.5	$1^+; 0$		0.60 ± 0.12	γ, p, α	8, 11, 14, 30, 41, 53
6.2832 ± 0.9	$2^+; 1$		10.0 ± 0.5	γ, p, α	30, 37, 39, 41
6.3105 ± 0.8	$3^+; 0$		0.95 ± 0.14	γ, p, α	8, 30, 37, 39, 41, 56
6.3855 ± 1.7	$2^+; 0+1$		0.40 ± 0.09	γ, p, α	8, 30, 37, 41, 53
6.480 ± 1.5	$3^+; 0$		0.40 ± 0.10	γ, p, α	8, 30, 37, 41, 53, 56
6.5670 ± 1.5	$5^+; 0$	1^+	0.56 ± 0.13	γ, p, α	8, 11, 14, 15, 30, 41
6.635	1		80 ± 2	p, α	41, 53
6.6437 ± 1.2	$2^-; 1$		0.60 ± 0.07	γ, p, α	8, 10, 30, 37
6.647 ± 4	1^-		91 ± 4	p, α	11, 14, 41
6.777 ± 2	$4^+; 0$		9.2 ± 1.0	γ, p, α	30, 37, 39, 41, 53
6.8031 ± 1.5	$1^+, 2, 3^+; 0$		≤ 2	γ, p	14, 30, 37, 39
6.810 ± 5	2^-		88 ± 2	p, α	10, 11, 41
6.811	(2^+)		3.0 ± 0.5	p, α	41
6.869	(3^-)		5.0 ± 1.0	p, α	41, 53
6.878 ± 2	$3, 4^-; 0$		≤ 2	γ, p, α	30, 37, 41
7.201 ± 2	$(4^+); 0$		6.5	p, α	11, 41, 53
7.248 ± 2	$(1^+); 0$		46.5	p, α	11, 41
7.292 ± 2	3^-		38	p, α	10, 11, 41
7.316 ± 4	$(3^-; 0)$		52	p, α	41, 53
7.338 ± 2	$1^-; 1$		16 ± 2	γ, p	37, 39
7.407 ± 2	1^+		14.6 ± 1.4	p	39
7.449 ± 10			140	p, α	41
7.455 ± 2	1^-		6	p	37
7.480 ± 2	(2)		12 ± 3	γ, p, α	37, 39, 41
(7.486 ± 2)	(1^-)		32	p	39

Table 18.11: Energy levels of ^{18}F [a] (continued)

E_x (MeV ± keV)	$J^\pi; T$	K^π	τ or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
7.507 ± 2	4^-		12 ± 2	p, α	39, 41
7.515 ± 2			< 4	γ, p	37
7.530 ± 2	$2^-; 1$		16.5 ± 3.0	γ, p, α	37, 39, 41
7.534 ± 5			75	p, α	39, 41
7.556 ± 2	(1^-)		30	p	39
7.586 ± 2			9 ± 2	γ, p, α	37, 39, 41
7.687 ± 2	$3^+, 4^+$		36 ± 4	p, α	39, 41
7.730 ± 4	≥ 1		66 ± 5	p, α	39, 41
7.764 ± 4			70	p	39
7.879 ± 3	≥ 2		20	p, α	39, 41
7.901 ± 2	(2^-)		38	p, α	10, 11, 41
7.943 ± 12	(1^+)		112	p, α	10, 11, 41
8.065 ± 6	≥ 4		60	p, α	39, 41
8.116 ± 8			96	p	39
8.211 ± 2	2^-		52	p, α	39, 41
8.240 ± 2	4^+		20	p	39
9.207 ± 15 [b]	$3, 4^-; 0$			p, d, α	24, 25, 27
9.50	$2, 3^+; 0$			n, d, α	23, 27
9.58 ± 20 [c]	6^+	1^+			14, 15
10.58 ± 50					15
11.22 ± 30	7^+	1^+			14, 15
13.83	$4^-, 5^+$		60	d, α	27
14.02	$4^-, 5^+$		60	d, α	27
14.10	$4^-, 5^+$		60	d, α	27
14.18 ± 40					14, 15
15.09	$4^-, 5^+$			d, α	27
15.34	$5^+, 6^-$			d, α	27
15.79 ± 100					15
16.07	$4^-, 5^+$		220	d, α	27
16.72	$4^-, 5^+$		60	d, α	27
17.43	$4^-, 5^+, 6^-$		70	d, α	27
18.62 ± 120					15
(19.00 ± 150)			(500 ± 150)	γ, ^{3}He	17
20.1 ± 200	$(2^-; 1)$		1600 ± 100	γ, ^{3}He	17
22.7 ± 200	$(2^-; 1)$		1200 ± 100	γ, ^{3}He	17
(24.1 ± 200)			(1400 ± 300)	γ, ^{3}He	17

[a] See also Table 18.12 for radiative transitions and Table 18.13 for τ_m.

[b] Uncertainty estimated by reviewer.

[c] For other states with $E_x < 9.6$ MeV see footnote [e] in Table 18.17 of (1978AJ03) and Table 18.14 here. For other states with $10.0 < E_x < 19.6$ MeV see Table 18.14 here, and Tables 18.14 and 18.16 in (1978AJ03). These two tables in (1978AJ03) display the states deduced from the yields of the isospin-forbidden α_1 groups in ^{14}N + α and ^{16}O + d, respectively. (1976CH24) reports 151 isospin mixed natural-parity states with $10.4 < E_x < 17.5$ MeV [^{14}N(α, α_1)] and (1973JO13) reports 138 such states with $9.2 < E_x < 19.4$ MeV [^{16}O(d, α_1)] of which 16 have $E_x > 17.5$ MeV. In the region $10.4 < E_x < 20.8$ MeV some 167 states with mixed isospin and natural parity have been reported.

2. (a) ^{12}C(^{6}Li, n)^{17}F	$Q_m = 4.064$	$E_b = 13.215$
(b) ^{12}C(^{6}Li, p)^{17}O	$Q_m = 7.608$	
(c) ^{12}C(^{6}Li, d)^{16}O	$Q_m = 5.6885$	
(d) ^{12}C(^{6}Li, t)^{15}O	$Q_m = -3.718$	
(e) ^{12}C(^{6}Li, α)^{14}N	$Q_m = 8.7989$	
(f) ^{12}C(^{6}Li, ^{6}Li)^{12}C		

Cross-section measurements have been carried out in the range $E(^6\text{Li}) = 1.9$ to 36 MeV: see (1978AJ03) and (1976PO02; 4 to 13 MeV; ^{6}Li elastic), (1978SO01; 9 to 14 MeV and 20 MeV; α_0, α_1, α_2), (1980FU06; 20 to 36 MeV; ^{6}Li to ^{12}C*(0, 4.43)) and (1978CU03; 20 to 34 MeV; d to ^{16}O*(0, 6.13, 6.92, 7.12, 8.87, 10.36, 11.09, 16.3)).

The cross section for the isospin-forbidden α_1 group [to ^{14}N*(2.31), 0^+, $T = 1$] is 1 to 2% of the cross section to the allowed α_0 and α_2 groups for $E(^6\text{Li}) = 3.2$ to 6 MeV (1981SC13) while for 9 to 14 MeV it varies from 0.4 to 1.8% (1978SO01). At 20 MeV, the α_1 yield is 0.02% of the allowed yield (1978SO01). Structures are reported at $E(^6\text{Li}) = 11.0$ and 13.0 MeV in the α_0 yield, at 11.5 and (13.0) MeV in the α_1 yield and at ≈ 11.7 and 12.8 MeV in the α_2 yield (1978SO01), while (1981SC13) report a resonance in the α_1 yield at $E(^6\text{Li}) = 4.2$ MeV: $E_x = 15.99 \pm 0.02$ MeV, $\Gamma_{\text{c.m.}} = 290 \pm 30$ keV, $J^\pi = 2^+$ (one-level BW fit). It is suggested that this resonance is due to 2^+ states with $T = 0$ and $T = 1$ which are unresolved (1981SC13). The excitation functions for the ^{6}Li ions to ^{12}C*(0, 4.43) shows a single isolated structure at $E(^6\text{Li}) = 22.8$ MeV, in the range $20 - 36$ MeV, with $\Gamma \approx 0.8$ MeV. It is unlikely to be due to an isolated state in ^{18}F (1980FU06). At $E(^6\vec{\text{Li}}) = 20$ MeV analyzing power measurements are reported for many deuteron and α groups and for elastically scattered ^{6}Li ions (1978MA13, 1979MA1T). Breakup processes have been studied by (1980NE05), cross sections at very high energies by (1980SK1A), fusion by (1981DEZE, 1981DEZW). See also ^{16}O, ^{17}O in (1982AJ01), and ^{14}N, ^{15}N in (1981AJ01) and ^{12}C in (1980AJ01).

For a discussion of the earlier work see (1978AJ03). See also (1979TU1B, 1981KR1K), (1978FI1E, 1978HO1C) and (1978ME1J, 1978ME20, 1978ME14, 1979BE59, 1979SU1F, 1981ME1E, 1981ME1F, 1981OS1D; theor.).

Table 18.12: Radiative decays in ^{18}F [a]

$E_{\rm i}$ (MeV)	$J^{\pi}_{\rm i}; T$	$E_{\rm f}$ (MeV)	) Branch (%))	
0.94	$3^+; 0$	0	100	
1.04	$0^+; 1$	0	100	
1.08	$0^-; 0$	0	100	
1.12	$5^+; 0$	0.94	100	
1.70 [b]	$1^+; 0$	0	29.8 ± 1.3	
		1.04	70.2 ± 1.3	
2.10 [c]	$2^-; 0$	0	38 ± 1	$\Gamma_\gamma = (4.6 \pm 2.2) \times 10^{-5}$ eV
		0.94	31 ± 1	$\Gamma_\gamma = (4.0 \pm 1.9) \times 10^{-5}$ eV
		1.08	31 ± 1	
2.52 [d]	$2^+; 0$	0	74.9 ± 1.8	$\delta = 3.0 \pm 1.0$
		0.94	21.5 ± 1.2	$\delta = -(1.5 \pm 0.6)$
		1.70	3.9 ± 0.6	$\delta = 0.94 \pm 0.4$
3.06 [e]	$2^+; 1$	0	23.2 ± 0.8	
		0.94	76.7 ± 0.8	
		1.04	0.11 ± 0.03	
3.13 [f]	$1^-; 0$	0	39 ± 2	$\delta = +(0.07 \pm 0.05)$
				$\Gamma_\gamma = (5.7 \pm 2) \times 10^{-4}$ eV
		1.04	34 ± 2	$\Gamma_\gamma = (7.3 \pm 2.7) \times 10^{-4}$ eV
		1.08	25 ± 2	$\Gamma_\gamma = (4.8 \pm 1.8) \times 10^{-4}$ eV
		1.70	2.0 ± 0.5	$\delta = +(0.22 \pm 0.15)$
3.36 [g]	$3^+; 0$	0	45 ± 5	
		0.94	9 ± 3	
		1.70	40 ± 4	
		2.10	< 3	
		2.52	6 ± 3	$\delta = -0.4^{+0.3}_{-0.5}$
3.72 [h]	$1^+; 0$	0	5 ± 2	
		1.04	91 ± 2	$\Gamma_\gamma = (1.3 \pm 0.2) \times 10^{-3}$ eV
		3.06	4 ± 2	
3.79 [i]	$3^-; 0$	2.10	68 ± 4	$\delta = -(0.22 \pm 0.06)$
		2.52	2.2 ± 1.1	
		3.06	30 ± 3	$\delta = -(0.09 \pm 0.09)$
3.84 [j]	$2^+; 0$	0	38 ± 2	$\delta = -(1.8 \pm 0.5)$
		0.94	8.9 ± 1.4	$\delta = -(0.3 \pm 0.3)$
		1.70	3.0 ± 1.0	
		3.06	50 ± 3	$\delta = -(0.1 \pm 0.3)$
4.12 [k]	$3^+; 0$	0	5 ± 3	
		3.06	95 ± 3	$\delta = +0.06 \pm 0.07$
4.23 [l]	$2^-; 0$	0	23 ± 2	$\delta = 0.15 \pm 0.15$

Table 18.12: Radiative decays in ^{18}F [a] (continued)

E_i (MeV)	$J^\pi_i; T$	E_f (MeV)	) Branch (%))	
		0.94	49 ± 3	$\delta = 0.0 \pm 0.2$
		1.08	3.2 ± 1.0	
		1.70	9.3 ± 1.2	
		2.10	15 ± 5	
		3.13	0.9 ± 0.6	
4.36 [m]	1^+	3.06	100	
4.40 [n]	$4^-; 0$	0.94	13 ± 4	$\delta = -(0.2 \pm 0.3)$
		1.12	60 ± 6	$\delta = -(0.2 \pm 0.2)$
		2.10	27 ± 3	
4.65 [o]	$4^+; 1$	0.94	17 ± 3	
		1.12	83 ± 3	$\delta = 0.15 \pm 0.15$
4.75 [p]	$0^+; 1$	0	92 ± 4	
		1.70	8 ± 4	
4.86 [q]	$1^-; 0$	1.04	65 ± 11	
		1.08	8 ± 6	
		3.06	23 ± 7	$\delta = -(0.4 \pm 0.4)$
		3.13	4 ± 3	
4.96 [r]	$2^+; 1$	0	100	$\delta = 1.2 \pm 0.7$
5.30 [s]	$4^+; 0$	0.94	9 ± 2	$\delta = -(0.3 \pm 0.1)$
		1.12	7 ± 2	$\delta = -(1.1 \pm 0.5)$
		2.52	78 ± 3	$\Gamma_\gamma = 12 \pm 4$ meV [pp]
		3.36	5 ± 1	$\delta = 2.5 \pm 0.8$
		4.65	1.3 ± 0.3	
5.50 [t]	$3^{(-)}; 0$	3.06	100	$\Gamma_\gamma = 2.1 \pm 0.7$ meV [nn]
5.603 [u]	1^+	0	16.7 ± 2.3	
		1.04	3.8 ± 1.2	
		3.06	79.5 ± 5.9	$\Gamma_\gamma = 0.48 \pm 0.05$ eV [qq]
5.605 [v]	$1^-; 0 + 1$	0	6.7 ± 1.2	
		1.04	4.2 ± 0.8	
		1.08	54.3 ± 3.1	$\Gamma_\gamma = 0.87 \pm 0.07$ eV [qq]
		3.06	2.6 ± 1.4	
		3.13	32.2 ± 2.5	$\delta = -0.05 \pm 0.02$
5.67 [w]	$1^-; 0 + 1$	0	6.2 ± 0.4	$\delta = -0.01 \pm 0.04$
		1.04	8.1 ± 0.7	
		1.08	52 ± 3	$\Gamma_\gamma = 0.46 \pm 0.06$ eV [qq]
		1.70	0.8 ± 0.3	
		2.10	0.4 ± 0.2	
		3.06	4.0 ± 0.4	$\delta = 0.04 \pm 0.06$

Table 18.12: Radiative decays in ^{18}F [a] (continued)

E_i (MeV)	$J^\pi_i; T$	E_f (MeV)	) Branch (%))	
		3.13	28.5 ± 2.0	$\delta = +0.10 \pm 0.03$
5.79 [x]	$2^-; 0$	0.94	40 ± 8	
		1.08	60 ± 8	
6.10 [y]	$4^-; 0$	0.94	4.9 ± 0.9	$\Gamma_\gamma = 51 \pm 10$ meV [nn]
		1.12	55 ± 3	
		2.10	27 ± 2	
		3.79	1.4 ± 0.3	
		4.12	1.8 ± 0.3	
		4.40	0.7 ± 0.3	
		4.65	8.7 ± 0.7	
6.10 [z]	$(1^+); 0$	0	24 ± 3	
		0.94	11 ± 3	
		2.10	20 ± 6	
		3.06	45 ± 5	
6.14 [aa]	$0^+; 1$	0	50 ± 3	$\Gamma_\gamma > 1.6$ eV
		1.70	12 ± 2	
		3.72	36 ± 3	
		4.36	2.1 ± 0.4	
		5.603	0.19 ± 0.02	
6.16 [bb]	$3^+; 1$	0	0.2 ± 0.2	$\Gamma_\gamma = 0.96 \pm 0.26$ eV [nn]
		0.94	51 ± 3	
		1.12	1.0 ± 0.1	
		2.52	5.5 ± 0.4	
		3.06	1.3 ± 0.3	
		3.79	11.6 ± 1.3	
		3.84	25.0 ± 1.6	
		4.12	1.5 ± 0.3	
		4.23	0.9 ± 0.3	
		4.40	2.0 ± 0.2	
6.241 [cc]	$3^-; 0 + 1$	0.94	4.6 ± 0.3	
		2.10	71.5 ± 3.0	$\Gamma_\gamma = 0.80 \pm 0.11$ eV [nn]
		3.36	1.1 ± 0.4	
		3.79	10.6 ± 0.5	
		3.84	1.0 ± 0.2	
		4.12	0.5 ± 0.2	
		4.23	7.8 ± 0.4	
		4.40	2.9 ± 0.3	
6.242 [cc]	$3^-; 0 + 1$	0.94	4.1 ± 0.3	

Table 18.12: Radiative decays in ^{18}F [a] (continued)

E_i (MeV)	$J_i^\pi; T$	E_f (MeV)	) Branch (%))	
		2.10	71.2 ± 3.0	$\Gamma_\gamma = 0.73 \pm 0.11$ eV [nn]
		3.36	0.8 ± 0.3	
		3.79	11.6 ± 0.6	
		3.84	0.9 ± 0.2	
		4.12	1.1 ± 0.4	
		4.23	8.2 ± 0.4	
		4.40	2.1 ± 0.3	
6.26	$1^+; 0$	0	(100)	
6.28 [dd]	$2^+; 1$	0	0.3 ± 0.1	$\Gamma_\gamma = 1.8 \pm 0.5$ eV [nn]
		0.94	67 ± 3	
		1.04	1.3 ± 0.1	
		1.70	5.7 ± 0.6	
		2.10	1.2 ± 0.3	
		2.52	0.3 ± 0.2	
		3.13	0.7 ± 0.3	
		3.36	2.3 ± 0.3	
		3.72	1.4 ± 0.5	
		3.84	15.8 ± 1.4	
		4.12	3.9 ± 0.2	
		4.36	0.5 ± 0.4	
6.31 [ee]	$3^+; 0$	0	4.0 ± 0.7	$\Gamma_\gamma = 0.17 \pm 0.04$ eV [nn]
		0.94	10.6 ± 1.0	
		1.70	3.0 ± 0.8	
		2.52	4.0 ± 0.5	
		3.06	57 ± 3	$\delta = -(0.03 \pm 0.10)$
		3.72	1.4 ± 0.7	
		3.84	4.6 ± 1.0	
		4.12	2.4 ± 1.7	
		4.96	13.0 ± 1.5	$\delta = -(0.01 \pm 0.14)$
6.39 [ff]	$2^+; 0+1$	0	1.5 ± 0.5	$\Gamma_\gamma = 0.44 \pm 0.18$ eV [nn]
		0.94	75 ± 3	$\delta = -(0.25 \pm 0.10)$
		1.70	6.8 ± 1.7	
		3.84	14.1 ± 1.6	$\delta = 0.1 \pm 0.2$
		4.12	2.3 ± 0.5	
6.48 [gg]	$3^+; 0$	0	13 ± 2	$\Gamma_\gamma = 74 \pm 21$ meV [nn]
		0.94	33 ± 2	
		1.12	10 ± 2	
		1.70	4 ± 2	

Table 18.12: Radiative decays in ^{18}F [a] (continued)

E_i (MeV)	$J_i^{\pi}; T$	E_f (MeV)	) Branch (%))	
		2.52	4 ± 2	
		3.06	21 ± 3	
		3.79	4 ± 2	
		3.84	9 ± 2	
		4.96	2 ± 2	
6.57 [hh]	$5^+; 0$	0.94	15.2 ± 1.6	
		3.36	83 ± 3	$\Gamma_\gamma = 26 \pm 5$ meV [nn,oo]
		5.30	2.3 ± 0.6	
6.64 [ii]	$2^-; 1$	0.94	8.9 ± 0.6	$\Gamma_\gamma = 1.4 \pm 0.4$ eV [nn]
		2.10	58 ± 3	
		3.13	22.0 ± 1.3	
		3.72	0.9 ± 0.2	
		3.79	2.4 ± 0.2	
		4.12	1.0 ± 0.3	
		4.86	2.6 ± 0.2	
		5.50	4.0 ± 0.3	
6.78 [jj]	$4^+; 0$	0.94	12.6 ± 0.9	$\Gamma_\gamma = 0.31 \pm 0.08$ eV [nn]
				$\delta = -(0.35 \pm 0.18)$
		1.12	25.2 ± 1.3	$\delta = -(1.4 \pm 1.1)$
		4.65	62 ± 2	$\delta = 0.13 \pm 0.13$
6.80 [kk]	$1^+, 2, 3^+; (0)$	0	20 ± 2	
		0.94	20 ± 2	
		3.06	50 ± 3	
		3.84	3.0 ± 1.6	
		4.96	7.0 ± 1.7	
6.88 [ll]	$3, 4^-; 0$	2.10	9 ± 2	
		4.65	91 ± 2	
7.34 [mm]	$1^-; 1$	0	4 ± 0.5	
		1.08	54 ± 2	
		2.10	18 ± 1	
		3.06	1 ± 0.5	
		3.13	8 ± 0.5	
		4.23	15 ± 0.6	
7.48 [mm]	(2)	0.94	100	
7.52 [mm]		0.94	5 ± 4	
		2.10	7 ± 5	
		3.79	33 ± 5	
		4.40	55 ± 7	

Table 18.12: Radiative decays in ^{18}F [a] (continued)

E_i (MeV)	$J^\pi_i; T$	E_f (MeV)	) Branch (%))	
7.53 [mm]	2^-	0	10 ± 3	
		0.94	14 ± 6	
		2.10	50 ± 9	
		3.79	26 ± 7	
7.59 [mm]		0	18 ± 7	
		0.94	14 ± 12	
		1.12	9 ± 7	
		4.65	59 ± 16	

[a] For references see Table 18.11 in (1978AJ03).
[b] Transitions to ^{18}F*(1.04, 1.08) are < 0.1 and $< 0.2\%$.
[c] Transitions to ^{18}F*(1.04, 1.13, 1.70) are < 0.4, < 2 and $< 0.2\%$.
[d] Transitions to ^{18}F*(1.04, 1.08, 2.10) are < 0.3, < 0.3 and $< 0.2\%$.
[e] Transitions to ^{18}F*(1.08, 1.13, 1.70, 2.10, 2.53) are < 8, < 14, < 8, < 5 and $< 5\%$.
[f] Transitions to ^{18}F*(0.94, 1.13, 2.10, 2.53) are < 0.6, < 8, < 3.0, $< 0.3\%$.
[g] Transitions to ^{18}F*(1.04, 1.08, 1.12, 3.06) are < 5, < 5, < 3 and $< 5\%$.
[h] Transitions to ^{18}F*(0.94, 1.08, 1.12, 1.70, 2.10, 2.53, 3.13, 3.36) are < 2, < 1, < 10, < 1, < 1, < 1, < 1 and $< 4\%$.
[i] Transitions to ^{18}F*(0, 0.94, 1.12, 1.70, 3.13, 3.36) are < 1.5, < 2.0, < 1.0, < 1.7, < 0.9 and $< 1.8\%$.
[j] Transitions to ^{18}F*(1.04, 1.08, 2.10, 2.52, 3.13, 3.36) are < 1.3, < 1.3, < 0.8, < 1.3, < 0.7 and $< 1.5\%$.
[k] Upper limits for branching ratios to other states are 4 to 8%.
[l] Upper limits for branching ratios to other states are 1.2 to 2.4%.
[m] Upper limits for branching ratios to other states are 8 to 10%.
[n] Upper limits for branching ratios to other states are 4 to 6%.
[o] Upper limits for transitions to other states are 0.9 to 1.5%.
[p] Upper limits for transitions to other states are 10% (for each transition).
[q] Upper limits for transitions to other states are 4 to 8%.
[r] Upper limits for transitions to other states are 2 to 7%.
[s] Upper limits for transitions to other states are 0.4 to 1.5%. $\Gamma_\gamma/\Gamma = 0.55 \pm 0.18$; $\Gamma_\alpha = 10 \pm 4$ meV.
[t] Upper limits for branching ratios to other states are 2.2 to 4.2%.
[u] Upper limits for transitions to other states are 0.5 to 2.6%.
[v] Upper limits for transitions to other states range from 0.3 to 1.5%.
[w] Upper limits for transitions to other states range from 0.3 to 0.6%.
[x] Upper limits for transitions to other states range from 5 to 19%.
[y] Upper limits for transitions to other states are 0.4% (for each transition).
[z] Upper limits for transitions to other states range from 3 to 8%.
[aa] Upper limits for transitions to other states are 1% (for each transition).
[bb] Upper limits for transitions to other states range from 0.2 to 0.5%.
[cc] (1979KI12).

[dd] Upper limits for transitions to other states are 0.2 to 0.8%.
[ee] Upper limits for transitions to other states range from 0.2 to 1.0%.
[ff] Upper limits for transitions to other states range from 0.4 to 3.0%.
[gg] Upper limits for transitions to other states range from 1 to 4%. This state may correspond to an unresolved doublet.
[hh] Upper limits for transitions to other states range from 0.7 to 1.9%.
[ii] Upper limits for transitions to other states range from 0.2 to 0.6%.
[jj] Upper limits for transitions to other states range from 0.7 to 2.5%.
[kk] Upper limits for transitions to other states range from 1.0 to 5%.
[ll] Upper limits for transitions to other states range from 0.7 to 5.2%.
[mm] (1978SE08).
[nn] Γ_γ = total radiative width for this state.
[oo] $\Gamma_\alpha = \Gamma \approx 560$ eV, $\Gamma_p < 4.5$ eV.
[pp] (1973RO05).
[qq] (1977BE46).

3. ^{12}C(^{7}Li, n)^{18}F $\qquad Q_m = 5.964$

See (1972AJ02).

4. ^{12}C(^{9}Be, t)^{18}F $\qquad Q_m = -4.4744$

Angular distributions are reported at $E(^9\text{Be}) = 12$ to 27 MeV to ^{18}F$_{\text{g.s.}}$ and to the unresolved states at 1 MeV (1979JA22, 1981JA09).

5. (a) ^{12}C(^{10}B, α)^{18}F $\qquad Q_m = 8.754$
(b) ^{12}C(^{11}B, αn)^{18}F $\qquad Q_m = -2.701$

See (1978AJ03). The work on reaction (b) displayed there has not been published.

6. ^{12}C(^{12}C, ^{6}Li)^{18}F $\qquad Q_m = -14.960$

See (1980KO02).

Table 18.13: Lifetime measurements of some ^{18}F states [a]

^{18}F* (MeV)	τ_m	Refs.
0.94	67.6 ± 2.5 psec	mean
1.04	2.7 ± 0.4 fsec	(1980KE05, 1981KE04)
1.08	27.5 ± 1.9 psec	mean
1.12	218 ± 8 nsec	(1972BE37)
	238 ± 4 nsec	(1979HA60)
	234 ± 10 nsec	mean
1.70	1.09 ± 0.10 psec	mean
2.10	4.3 ± 1.4 psec	(1966OL03)
2.52	0.68 ± 0.11 psec	mean
3.06	< 1.5 fsec	(1972RO24)
3.13	0.32 ± 0.10 psec	(1967WA06, 1972RO04)
3.36	0.49 ± 0.07 psec	mean
3.72	4 ± 2 fsec	(1973RO04)
3.79	224 ± 35 fsec	(1973RO06) [b]
3.84	29 ± 9 fsec	(1973RO06)
4.12	91 ± 22 fsec	(1973RO06)
4.23	110 ± 15 fsec	(1973RO06)
4.36	27 ± 10 fsec	(1973RO04)
4.40	58 ± 12 fsec	(1973RO06)
4.65	< 10 fsec	(1973RO06)
4.86	66 ± 18 fsec	(1973RO06)
4.96	< 4 fsec	(1973RO06)
5.30	30 ± 5 fsec	(1973RO05)
5.50	63 ± 25 fsec	(1973RO06)
5.79	15 ± 10 fsec	(1973RO06)

[a] For reactions in which the ^{18}F states were produced, see Table 18.12 in (1978AJ03). For weighted mean values see references in that table.

[b] See also (1973RO04).

Table 18.14: Resonances in $^{14}N + \alpha$ below $E_\alpha = 5$ MeV [a]

E_α (MeV ± keV)	Particles out	$\Gamma_{c.m.}$ (keV)	$(2J+1)\Gamma_\gamma\Gamma_\alpha/\Gamma$ (eV)	$J^\pi; T$	E_x (MeV)
			$< 2 \times 10^{-5}$		4.657
0.559	γ		$(2.8 \pm 0.5) \times 10^{-4}$	1; 0	4.851
0.698			$< 0.5 \times 10^{-4}$	$2^+; 1$	4.959
1.136 ± 3	γ		0.084 ± 0.004	$4^+; 0$	5.299
1.398 ± 3	γ		0.022 ± 0.003	$3^{(-)}; 0$	5.503
1.527	γ, α_0		1.44 ± 0.14	1^+	5.603 [d]
1.529 ± 2	γ, α_0	< 1.2	2.60 ± 0.21	$1^-; 0+1$	5.605 [e]
1.618 ± 2	γ, α_0	< 0.8	1.4 ± 0.2	$1^-; 0+1$	5.674 [f]
1.765 ± 4	γ		0.047 ± 0.018	$2^-; 0$	5.788
2.160 ± 4	γ		0.20 ± 0.04	$4^-; 0$	6.096
2.166 ± 7	γ, α_0		0.08 ± 0.03	$1, 2, 3^{(-)}; 0$	6.100
			[b]		
2.348 ± 3	γ, α_0	< 0.8		$3^-; 0+1$	6.242 [g]
2.372 ± 3	γ, α_0	< 3		1^+; (0)	6.261 [h]
			[c]		
2.438 ± 4	γ		0.52 ± 0.12	$3^+; 0$	6.312
2.532 ± 4	γ		1.6 ± 0.4	$2^+; 0+1$	6.385
	γ		0.16 ± 0.06	3^+; (0)	6.480
2.767 ± 4	γ, α_0	(< 0.8)	0.29 ± 0.06	$5^+; 0$	6.568
2.870 ± 4	γ, p_0	< 1.6	2.7 ± 0.5	$2^-; 1$	6.648
2.870 ± 6	α_0	93 ± 5	$\Gamma_\alpha/\Gamma = 0.85$	1^-	6.648
			0.12 ± 0.07	$4^+; 0$	6.78
			< 0.2	$1^+, 2, 3^+$; (0)	6.803
3.080 ± 6	p_0, α_0	101 ± 5		2^-	6.811
3.576 ± 4	α_0	< 4		(4^+)	7.197
3.67	α_0	45 ± 10		(1^+)	7.27
3.72	p_0, α_0	53 ± 6		(3^-)	7.31
4.00	p_0, α_0	35		(3^-)	7.53
4.05	p_0, α_0	60			7.57
4.11	p_0, α_0	40			7.61

Table 18.14: Resonances in ^{14}N + α below $E_\alpha = 5$ MeV [a] (continued)

E_α (MeV ± keV)	Particles out	$\Gamma_{\rm c.m.}$ (keV)	$(2J+1)\Gamma_\gamma\Gamma_\alpha/\Gamma$ (eV)	$J^\pi; T$	$E_{\rm x}$ (MeV)
4.28	p_0, α_0	120			7.74
4.50	p_0, α_0	30		(2^-)	7.92
4.55	p_0, α_0	70		(1^+)	7.95

[a] References are displayed in Tables 18.13 of (1972AJ02, 1978AJ03). Higher resonances observed in ^{14}N(α, α_1) are listed in Table 18.14 of (1978AJ03).
[b] ≤ 0.07 for ^{18}F*(6.11, 6.16) (1973RO03). See also (1978BE63).
[c] ≤ 0.03 for ^{18}F*(6.28) (1973RO03).
[d] $\Gamma_\alpha = 42.8 \pm 1.6$ eV, $\Gamma_\gamma = 0.485 \pm 0.046$ eV, $l_\alpha = 0$ (1980MA26). See also Table 18.17.
[e] $\Gamma_\alpha = 32.0 \pm 2.1$ eV, $\Gamma_\gamma = 0.891 \pm 0.074$ eV, $l_\alpha = 1$. $\Delta E_{\rm x}$ for ^{18}F*(5.603, 5.605) is 1.84 ± 0.04 keV (1980MA26). See also Table 18.17.
[f] $\Gamma_\alpha = 130 \pm 5$ eV, $\Gamma_\gamma = 1.4 \pm 0.3$ eV, $l_\alpha = 1$ (1980MA26).
[g] This resonance corresponds to two states at $E_{\rm x} = 6240$ and 6242 keV. The lower member of the doublet (both of which have $J^\pi = 3^-$ and mixed isospin) has $\Gamma_\alpha = 133 \pm 4$ eV, $\Gamma_\gamma = 0.80 \pm 0.11$ eV; the higher has $\Gamma_\alpha = 137 \pm 4$ eV, $\Gamma_\gamma = 0.73 \pm 0.11$ eV (1979KI12). See also (1978BE63).
[h] $\Gamma_\alpha = 580 \pm 12$ eV, $\Gamma_{\rm p} = 25^{+35}_{-25}$ eV (1979KI12).

7. ^{13}C(^{14}N, ^{9}Be)^{18}F $\qquad Q_{\rm m} = -6.232$

See (1978PI1E).

8. ^{14}N(α, γ)^{18}F $\qquad Q_{\rm m} = 4.4159$

A number of resonances have been observed for $E_\alpha < 3$ MeV: see Table 18.14. Studies of these, principally by the Toronto and Queen's groups [see references in (1978AJ03) and (1977BE46, 1979KI12, 1980MA26)] in conjunction with work on ^{14}N(α, α), ^{16}O(^{3}He, p), ^{17}O(p, γ) and ^{17}O(p, α) [see Tables 18.16, 18.17, 18.18] have led to the determination of branching ratios, mixing ratios and widths (Table 18.12), lifetimes (Table 18.13) and the $E_{\rm x}$, J^π and K^π assignments for ^{18}F states with $E_{\rm x} < 6.9$ MeV. The reader is referred to the series of papers by the Toronto group for the most complete and definitive arguments on the parameters of the low-lying states of ^{18}F.

The non-resonant S-factor for this reaction, $S \approx 0.7$ MeV · b (1972CO1C). See also (1978TA1U; astrophys.).

Table 18.15: Maxima in the yields of $^{16}O + d$ [a]

E_d (MeV ± keV)	Particles out	$\Gamma_{c.m.}$ (keV)	$J^\pi; T$	E_x (MeV)
0.895	p_1, α_0	210 ± 25		(8.321)
1.048	p_1, d_0, α_0	88 ± 10	1^+	8.457
1.199	α_0	230 ± 30		(8.591)
1.298	p_1, d_0, α_0	13 ± 3		(8.679)
1.325	d_0, α_0			(8.703)
1.482	α_0	40 ± 5		(8.843)
1.563	d_0, α_0	121 ± 15		(8.914)
1.616	α_0	19 ± 15		(8.962)
1.765	d_0, α_0	141 ± 10		(9.094)
1.885	p_0, p_1, d_0, α_0	108 ± 12	$3, 4^-; 0$	9.20
2.22	n_0, α_0		$2, 3^+; 0$	9.50
2.28	α_0		$2, 3^+; 0$	(9.55)
2.34	n_0, p_1			(9.60)
2.55	p_1			(9.79)
2.92	n, p_0, p_1			10.12
3.05	α_0		$3, 4^-; 0$	10.24
3.13	n, p_1, α_0, α_1		$\geq 2; 0$	10.31
3.37	n_0, p_0, p_1, α_1			10.52
3.47	α_0		$4, 5^+; 0$	10.61
3.68	n, p_0, p_1, α_1		2^+	10.79
3.80	p_0, α_0		$\geq 2^+; 0$	10.90
3.94	n, p_1, α_1			11.03
3.95	p_1, α_0	≈ 35	$3, 4^-; 0$	11.03
4.07	n, p_1			11.14
4.38	p_1, α_0		$4, 5^+; 0$	11.42
4.57	α_0		$5, 6^-; 0$	11.58
4.80	d_0, α_0		$\geq 3; 0$	11.79
4.93	α_0		$5, 6^-; 0$	11.90
5.05 ± 15	α_4	40		12.01
5.11	α_0, α_2, α_4	60	$4, 5^+; 0$	12.06
5.17	α_0	55	$T = 0$	12.12

Table 18.15: Maxima in the yields of $^{16}O + d$ [a] (continued)

E_d (MeV $\pm$ keV)	Particles out	$\Gamma_{c.m.}$ (keV)	$J^\pi; T$	E_x (MeV)
5.32	α_0	70		12.25
5.34	α_0, α_2	170		12.27
5.40	α_0, α_4	130		12.32
5.47	α_4	80		12.38
5.49	$\alpha_2, \alpha_3, \alpha_4$	120		12.40
5.59	α_0, α_2	120		12.49
5.65	α_0, α_2	140		12.54
5.77	α_0	180	2^+	12.65
5.80	$\alpha_0, \alpha_2, \alpha_4$	160		12.68
5.81	α_3, α_4	80	5^-	12.69
5.91	α_2	160		12.77
6.00	α_0	120		12.85
6.11	α_0, α_4	120		12.95
6.19	α_2, α_3	200	$\geq 4; 0$	13.02
6.25	α_0, α_4	150	$T = 0$	13.08
6.30	α_0, α_2	160		13.12
6.34	α_0, α_3	160	$5, 6^-; 0$	13.16
6.38	α_0, α_3	145	$T = 0$	13.19
6.43	α_0, α_2	120		13.24
6.46	α_0, α_4	100		13.26
6.54	α_0, α_2	135		13.33
6.61	$\alpha_2, \alpha_3, \alpha_4$	120		13.40
6.64	α_0, α_2	200		13.42
6.66	α_0	100		13.44
6.72	α_2	100		13.49
6.73	α_2	100		13.50
6.80	α_2, α_3	140		13.56
6.84	$\alpha_0, \alpha_2, \alpha_4$	150		13.60
6.94	α_0, α_3	90		13.69
7.10	α_3, α_4	60	$4^-, 5^+$	13.83 [b]
7.27	α_3	150		13.98

Table 18.15: Maxima in the yields of ^{16}O + d [a] (continued)

E_d (MeV ± keV)	Particles out	$\Gamma_{c.m.}$ (keV)	$J^\pi; T$	E_x (MeV)
7.31	α_2	60	$4^-, 5^+$	14.02 [b]
7.34	$\alpha_0, \alpha_3, \alpha_4$	200		14.04
7.38	α_0, α_3	210		14.08
7.41	α_3	60	$4^-, 5^+$	14.10 [b]
7.49	α_0	220		14.18
7.58	α_0	200	$\geq 4; 0$	14.26
7.62	α_4	85		14.29
7.66	$\alpha_0, \alpha_2, \alpha_4$	130	$T = 0$	14.33
7.67	$\alpha_0, \alpha_2, \alpha_3, \alpha_4$	250	$T = 0$	14.34
7.74	α_3	200	$3^+, 4^-$	14.40
7.80	α_0, α_4	70		14.45
7.82	α_0, α_2	225		14.47
7.99	α_4	200		14.62
8.02	α_0	150		14.65
8.03	α_3	310		14.66
8.07	α_0	120		14.69
8.08	α_3, α_4	310		14.70
8.21	α_2	250		14.82
8.25	α_4	380		14.85
8.30	$\alpha_0, \alpha_2, \alpha_3$	210		14.90
8.34	α_4	115		14.93
8.37	α_0	130		14.96
8.37	α_0, α_3	250		14.96
8.40	α_0	310		14.99
8.43	α_4	120		15.01
8.52	α_3, α_4	160	$4^-, 5^+$	15.09 [b]
8.52	α_2	150		15.09
8.56	α_2	220		15.13
8.58	α_4	180		15.15
8.61	α_0, α_3	200		15.17
8.65	α_0, α_2	135		15.21

Table 18.15: Maxima in the yields of ^{16}O + d [a] (continued)

E_d (MeV ± keV)	Particles out	$\Gamma_{c.m.}$ (keV)	$J^\pi; T$	E_x (MeV)
8.72	α_2, α_4	120		15.27
8.76	α_2	160		15.30
8.79	α_0	200		15.33
8.80	$\alpha_0, \alpha_3, \alpha_4$	200	$5^+, 6^-$	15.34 [b]
8.89	α_3	110		15.42
8.93	α_3, α_4	190		15.46
8.97	α_2, α_4	210		15.49
9.00	α_0, α_2	190		15.52
9.62	α_3	220	$4^-, 5^+$	16.07 [b]
10.35	α_3	60	$4^-, 5^+$	16.72 [b]
11.15	α_3	70	$4^-, 5^+, 6^-$	17.43 [b]

[a] For references see Table 18.15 in (1978AJ03). This table does not include the structures in α_1 leading to mixed isospin states in ^{18}F: for the latter see Table 18.16 in (1978AJ03).
[b] (1978RI05).

9. ^{14}N(α, n)^{17}F $\qquad Q_m = -4.7347 \qquad E_b = 4.4159$

See (1978AJ03).

10. ^{14}N(α, p)^{17}O $\qquad Q_m = -1.1908 \qquad E_b = 4.4159$

Observed resonances are displayed in Table 18.14. See also (1978AJ03).

11. ^{14}N(α, α)^{14}N $\qquad E_b = 4.4159$

Observed anomalies in the elastic scattering are exhibited in Table 18.14. Resonances in the α_1 isospin-forbidden yield are displayed in Table 18.14 of (1978AJ03). In the α_1 study, carried out for $E_\alpha = 7.6 - 16.9$ MeV, a partial-wave analysis involving a method of removing ambiguities and parametrizing S-matrix elements gives the level parameters of 151 isospin mixed, natural-parity states in ^{18}F with $10.4 < E_x < 17.5$ MeV. Many of these states have also been reported in the

^{16}O(d, α_1) reaction [Table 18.16 of (1978AJ03)]. The agreement is best for low-lying 2^+ or 4^+ states, and is quite good for 3^- and 5^- states, while for high-J states the greater centrifugal barrier for ^{16}O + d at the same E_x relatively suppresses high-J states in the ^{16}O + d work. A study of the energy dependence of averaged intensities of the partial waves shows some indication that the lower partial waves reconserve isospin as E_x increases (1976CH24).

Table 18.16: States in ^{18}F from ^{16}O(^{3}He, pγ)^{18}F [a]

E_x (keV) [b]	l [a]	$J^\pi; T$ [c]	K^π [c]
0	0	$1^+; 0$	0^+
937.1 ± 0.4	2	$3^+; 0$	0^+
1040.9 ± 0.5	0	$0^+; 1$	
1080.1 ± 0.5		$0^-; 0$	0^-
1119.0 ± 0.6	4	$5^+; 0$	0^+
1701.4 ± 0.7	0	$1^+; 0$	1^+
2099.9 ± 0.6		$2^-; 0$	0^-
2523.4 ± 0.7	2	$2^+; 0$	1^+
3061.2 ± 0.5	2	$2^+; 1$	
3132.8 ± 0.6		$1^-; 0$	1^-
3358.2 ± 1.0		$3^+; 0$	1^+
3725.4 ± 0.8		$1^+; 0$	
3790.6 ± 0.9		$3^-; 0$	1^-
3838.4 ± 0.7	2	$2^+; 0$	
4114.5 ± 0.9		$3^+; 0$	
4225.8 ± 0.7		$2^{(-)}; 0$	(1^-)
4361.0 ± 0.7		$1^{(+)}$	
4398.1 ± 0.7		$3^-, 4^-; 0$ [d]	(0^-)
4652 ± 2	4	$4^+; 1$	
4753 ± 3		$(0^+; 1)$	
4860 ± 2		$1^{(-)}; 0$	
4963.6 ± 0.8		$2^+; 1$	
5297.6 ± 1.5		4^+	1^+
5502 ± 2		$3^{(-)}; 0$	
5603 ± 2		$1^-; 0 + 1$	
5669 ± 2		$1^-; 0 + 1$	
5785 ± 3		$2^-; 0$	

Table 18.16: States in ^{18}F from ^{16}O(^{3}He, pγ)^{18}F [a] (continued)

E_x (keV) [b]	l [a]	$J^\pi; T$ [c]	K^π [c]
6097.4 ± 1.4		$4^-; 0$	1^-
6108 ± 3		$1, 2, 3^{(-)}; 0$	
6138.3 ± 1.0		$0^+; 1$	
6164.0 ± 1.0		$3^+; 1$	
6241.2 ± 1.0		$3^-; 1$	
6263 ± 3		1^+	
6284.0 ± 1.0		$2^+; 0 + 1$	
6310.5 ± 0.8		$3^+; 0$	
6383 ± 3		$2^+; 0 + 1$	
6480 ± 2		3^+; (0)	
6567.0 ± 1.5		5^+	1^+
6643.0 ± 1.5		$2^-; 1$	
6777 ± 2 [c]		4^+	
6803.0 ± 1.5		1^+, 2, 3^+; (0)	
6878 ± 2		$3^{(-)}$, 4^-; (0)	
[c]			

[a] For earlier results derived from measurements of proton spectra and of γ-rays, see Table 18.18 in (1972AJ02). See also Tables 18.12 and 18.13 here.
[b] (1973RO03): γ-ray measurements.
[c] See Table 18.17 in (1978AJ03).
[d] See p. 179 of (1979KI12).

12. (a) ^{14}N(α, 2α)^{10}B $\quad Q_m = -11.6132 \quad E_b = 4.4159$
(b) ^{14}N(α, ^{6}Li)^{12}C $\quad Q_m = -8.7989$

The total cross section for formation of ^{10}B and ^{6}Li have been studied for $E_\alpha = 21$ to 42 MeV by (1974JA11) who discuss the astrophysical importance of these processes. For spallation studies see (1979VI05, 1980RE1B, 1981GOZY). See also (1980BA2K; theor.).

13. ^{14}N(^{6}Li, d)^{18}F $\quad Q_m = 2.942$

Table 18.17: Excited states of ^{18}F from ^{17}O(p, γ)^{18}F (1977BE46) [a]

E_x (keV)	E_x (keV)
937.18 ± 0.06	3724.19 ± 0.22
1041.55 ± 0.08	3791.49 ± 0.22
1080.54 ± 0.12	3839.17 ± 0.22
[b]	4115.90 ± 0.25
1700.81 ± 0.18	4360.15 ± 0.26
2100.52 ± 0.13 [c]	5603.38 ± 0.27
2523.35 ± 0.18	5604.86 ± 0.28
3061.84 ± 0.18	5668 ± 2
3133.87 ± 0.15 [d]	6136.47 ± 0.33

[a] See also Table 18.18.

[b] 1119.1 ± 0.5 keV (1972BE37), 1121.3 ± 0.2 keV (1973SE03).

[c] 2100.68 ± 0.14 keV (1975RO05).

[d] (1975RO05).

Angular distributions have been measured for $E(^6\text{Li}) = 5.3$ to 6 MeV: see (1978AJ03).

14. ^{14}N(^{7}Li, t)^{18}F $\qquad Q_m = 1.949$

At $E(^7\text{Li}) = 15$ MeV, triton groups are observed to the known $T = 0$ states with $E_x < 7.4$ MeV: the $T = 1$ states are not excited although such transitions are not forbidden in principle, suggesting a direct α-transfer mechanism. The transitions to ^{18}F*(1.70, 2.53, 3.36, 4.23, 5.30, 6.57) account for more than one-half of the summed cross section at $15°$. It is proposed that these states (which are only weakly excited in ^{16}O(^{3}He, p)^{18}F and ^{17}O(^{3}He, d)^{18}F) are predominantly of a 4p-2h nature and are excited by the transfer of four nucleons into the (2s, 1d) shell (1968MI09). At $E(^7\text{Li}) = 36$ MeV the $K^\pi = 1^+$ band also appears to be selectively populated. States at $E_x = 9.58 \pm 0.02$, 11.22 ± 0.03 and 14.18 ± 0.04 MeV are strongly populated. It is suggested that the first two are the 6^+ and 7^+ members of that band (1977CO09). [Angular distributions are reported for ^{18}F*(1.70, 2.10, 2.52, 3.36, 4.40, 5.30, 6.57, 9.58, 11.22, 14.18).] See also (1979SA31; theor.).

15. (a) ^{14}N(^{11}B, ^{7}Li)^{18}F $\qquad Q_m = -4.249$

(b) ^{14}N(^{13}C, ^{9}Be)^{18}F $\qquad Q_m = -6.2320$

Table 18.18: Resonances in $^{17}O + p$ [a]

E_p (keV)	Yield of [b]	$\Gamma_{c.m.}$ (keV)	$(2J+1)\Gamma_\gamma\Gamma_p/\Gamma$ (eV)	$J^\pi; T$	E_x (MeV ± keV)
517.0 ± 1.0	γ, α_0	0.24 ± 0.03	0.26 ± 0.05	$4^-; 0$	6.095
525	α_0	0.034 ± 0.003		(1^+)	6.102
561.2 ± 1.0	γ	≤ 1	2.2 ± 0.6	$0^+; 1$	6.137
587.1 ± 1.0	γ, p_0, α_0	14 ± 0.5	6.7 ± 1.8	$3^+; 1$	6.161
670.5 ± 1.0	γ, p_0, α_0	0.19 ± 0.03	[h]	$3^-; 0+1$	6.240
673.0	γ, α_0	0.18 ± 0.04	[h]	$3^-; 0+1$	6.242
690 ± 4	α_0	0.60 ± 0.12	≤ 0.02	$1^+; 0$	6.258
714.2 ± 1.0	γ, p_0, α_0	10.0 ± 0.5	9.1 ± 2.3	$2^+; 1$	6.281
741 ± 2	γ, p_0, α_0	0.95 ± 0.14	0.64 ± 0.17	$3^+; 0$	6.307
826 ± 2	γ, α_0	0.40 ± 0.09	0.60 ± 0.18	$2^+; 0+1$	6.387
926 ± 2	γ, α_0	0.40 ± 0.10	0.36 ± 0.15	$3^+; 0$	6.481
1015	α_0	0.56 ± 0.13	≤ 0.0023	$5^+; 0$	6.564
1090	α_0	80 ± 2		1	6.635
1098.9 ± 0.4	γ, α	0.60 ± 0.07	4.3 ± 1.2	$2^-; 1$	6.6444
1101 ± 4	α_0	89 ± 5			6.646
1240 ± 2 [c]	γ, p_0, α_0	9.2 ± 1.0	2.8 ± 0.7	$4^+; 0$	6.778
1269	γ, p_0	≤ 2	0.54 ± 0.20	$1^+, 2, 3^+; 0$	6.8031 ± 1.5
1274 ± 5	α_0	88 ± 2		2^-	6.810
1276	α_0	3.0 ± 0.5		(2^+)	6.811
1338	α_0	5.0 ± 1.0		(3^-)	6.869
1345 ± 3	γ, α_0	≤ 2	1.0 ± 0.4	$3, 4^-; 0$	6.877
E_p (keV)	Yield of [b]	$\Gamma_{c.m.}$ (keV)	$(2J+1)\Gamma_p\Gamma_\alpha/\Gamma$ (keV)	$J^\pi; T$	E_x (MeV ± keV)
1687.5 ± 1	α_0	6.5	3.9	$(4^+); 0$	7.201
1738 ± 2	α_0	46.5	8.8	$(1^+); 0$	7.248
1784 ± 2	p_0, α_0	38	47	3^-	7.292
1810 ± 4	α_0	52	8.5	$(3^-; 0)$	7.316
1832.5 ± 1	γ, p_0, p_1	16 ± 2	[d]	$1^-; 1$	7.338
1906 ± 2	p_0, p_1	14.6 ± 1.4		1^+	7.407
1950 ± 10	α_0	140	5.6		7.449

Table 18.18: Resonances in $^{17}O + p$ [a] (continued)

E_p (keV)	Yield of [b]	$\Gamma_{c.m.}$ (keV)	$(2J+1)\Gamma_p\Gamma_\alpha/\Gamma$ (keV)	$J^\pi; T$	E_x (MeV ± keV)
1957 ± 2	p_0	6		1^-	7.455
1983 ± 2	γ, p_1, α_0	12 ± 3	1.5	(2)	7.480
(1990 ± 2)	p_0	32		(1^-)	(7.486)
2012 ± 2	p_0, α_0	12 ± 2	7.2	4^-	7.507
2020 ± 2	γ	< 4			7.515
2036 ± 2	$\gamma, p_0, p_1, \alpha_0$	16.5 ± 3.0	5.5 [e]	$2^-; 1$	7.530
2040 ± 5	p_1, α_0	75			7.534
2064 ± 2	p_0	30		(1^-)	7.556
2095 ± 2	$\gamma, p_0, p_1, \alpha_0$	9 ± 2	3.7 [f]	[g]	7.586
2202 ± 2	p_0, p_1, α_0	36 ± 4	25.1	$3^+, 4^+$ [g]	7.687
2248 ± 4	p_1, α_0	66 ± 5	28.2	≥ 1	7.730
2284 ± 4	p_1	70			7.764
2406 ± 3	p_1, α_0	20	24.4	≥ 2	7.879
2429 ± 2	α_0	38	42	(2^-)	7.901
2473 ± 12	α_0	112	80	(1^+)	7.943
2603 ± 6	p_1, α_0	60	11	≥ 4	8.065
E_p (keV)	Yield of [b]	$\Gamma_{c.m.}$ (keV)	$(2J+1)\Gamma_p\Gamma_\alpha/\Gamma$ (eV)	$J^\pi; T$	E_x (MeV ± keV)
2657 ± 8	p_1	96			8.116
2757 ± 2	p_0, α_0	52	63	2^-	8.211
2788 ± 2	p_0	20		4^+	8.240
2928	α_0	≈ 50			8.371
3915 ± 20	n	95			9.302
(4163 ± 20)	n	19			(9.537)
4235 ± 10	n	33			9.605
4330 ± 10	n	33			9.694
4490 ± 20	n	≈ 100			9.845
(4790 ± 10)	n	28			(10.128)
4900 ± 20	n	≈ 140			10.232

[a] For references see able 18.18 in (1978AJ03). For resonances with $E_p < 1.8$ MeV see (1979KI13) [R-matrix analysis]; for resonances with $1.69 < E_p < 2.8$ MeV see (1977SE12, 1978SE08) [values of Γ_p, $\Gamma_{p'}$, and Γ_α are also obtained].
[b] See also Table 18.11.
[c] See reference in footnote [d] in Table 18.18 (1978AJ03).
[d] $\Gamma_\gamma = 3.5 \pm 1.0$ eV (1978SE08).
[e] $\Gamma_\gamma = 0.44 \pm 0.10$ eV (1978SE08).
[f] $\Gamma_\gamma = 0.11 \pm 0.03$ eV (1978SE08).
[g] Assumed to be unresolved.
[h] This corresponds to a doublet of 3^-, mixed isospin states, separated by 2.09 ± 0.04 keV. $\omega\gamma_{p,\gamma} = 2.04 \pm 0.45$ eV for the lower resonance and 1.16 ± 0.26 eV for the higher one (1979KI12).

These reactions have been studied at $E(^{11}B) = 115$ MeV and $E(^{13}C) = 105$ MeV. Differential cross sections at three angles are reported for the transitions to ^{18}F*(9.58, 10.57 ± 0.07, 11.2) in reaction (a) and to ^{18}F*(5.30, 6.57, 9.58, 10.60 ± 0.08, 11.2) in reaction (b). In addition to these states ^{18}F*(14.18) is strongly excited in both reactions, and transitions to ^{18}F*(15.79 ± 0.10, 18.62 ± 0.12) are also reported (1979BR04).

16. $^{14}N(^{16}O, ^{12}C)^{18}F$ $\qquad Q_m = -2.7461$

See (1977VO08).

17. $^{15}N(^{3}He, \gamma)^{18}F$ $\qquad Q_m = 14.1603$

Excitation functions have been measured for $E(^3He) = 2.5$ to 16 MeV for the γ_0 and $\gamma_{1\to4}$ yields. Resonances are observed corresponding to $E_x = (19.00 \pm 0.15)$ [$\gamma_{1\to4}$], 20.1 ± 0.2 [γ_0, $\gamma_{1\to4}$], 22.7 ± 0.2 [γ_0, $\gamma_{1\to4}$] and (24.1 ± 0.2) MeV [$\gamma_{1\to4}$], with $\Gamma_{c.m.} = 0.5 \pm 0.15$, 1.6 ± 0.1, 1.2 ± 0.1 and 1.4 ± 0.3 MeV, respectively. The γ_0 yield is dominated by ^{18}F*(20.1) (1981WA1R) [see for $(2J+1)\Gamma_{^3He}\Gamma_\gamma$ values]. It is suggested that the structures decaying by γ_0 have $J^\pi = 2^-$ (and possibly $T = 1$) (1981WA1R, and J. Lowe, private communication).

18. $^{15}N(^{3}He, p)^{17}O$ $\qquad Q_m = 8.554$ $\qquad E_b = 14.1603$

See ^{17}O in (1982AJ01).

19. $^{15}N(\alpha, n)^{18}F$ $\qquad Q_m = -6.4175$

See (1978AJ03).

20. ^{15}N(^{6}Li, t)^{18}F $\qquad Q_m = -1.634$

At $E(^{6}\text{Li}) = 30$ MeV preferential excitation of odd-parity states of ^{18}F below $E_x = 5$ MeV is reported. Angular distributions of the tritons to ^{18}F*(0, 0.94, 2.10, 4.40) [$J^\pi = 1^+, 3^+, 2^-, 4^-$] are all strongly forward peaked (1972LI24).

21. (a) ^{15}N(^{11}B, ^{8}Li)^{18}F $\qquad Q_m = -13.050$
(b) ^{15}N(^{12}C, ^{9}Be)^{18}F $\qquad Q_m = -12.1190$

These reactions have been studied with $E(^{11}\text{B}) = E(^{12}\text{C}) = 115$ MeV. Reaction (a) is dominated by the transitions to ^{18}F*(1.12) [presumably the $J^\pi = 5^+$ state, although the group is unresolved] and to ^{18}F*(7.15, 9.45) [$J^\pi = (7^-)$ and (6^-)]. In reaction (b) no single state is strongly preferentially populated (1979RA10, 1981GO11). Differential cross sections for ^{18}F*(4.40, 6.10, 7.15, 9.45) [$J^\pi = 4^-, (5^-), (7^-), (6^-)$], fitted by FRDWBA, are discussed by (1981GO11). See also (1977FO1E).

22. ^{16}O(d, γ)^{18}F $\qquad Q_m = 7.5263$

The capture cross section rises from 0.1 μb at $E_d = 0.4$ MeV to 25 μb at 3.5 MeV: Γ_γ over this range is ≈ 2 eV. The results can be interpreted satisfactorily in terms of compound nucleus formation (1965OW01).

23. ^{16}O(d, n)^{17}F $\qquad Q_m = -1.6243 \qquad E_b = 7.5263$

Excitation functions have been measured for the n_0 and n_1 groups from threshold to 17 MeV: see (1978AJ03). Some structure is observed: that which is attributed to states of ^{18}F is displayed in Table 18.15. Polarization measurements are reported for $E_d = 3$ to 15 MeV: see (1978AJ03) and at $E_{\vec{d}} = 5$ to 15 MeV (1981LI23; $\vec{n}_{0+1}$). See also ^{17}F in (1982AJ01), (1980HU1J, 1980HU1D) and (1981NO1B).

24. ^{16}O(d, p)^{17}O $\qquad Q_m = 1.9197 \qquad E_b = 7.5263$

Excitation functions and polarization studies have been reported for several proton groups for $E_{\mathrm{d}} = 0.3$ to 17 MeV: see (1978AJ03) and (1978RO1M; $E_{\vec{\mathrm{d}}} = 14$ to 17 MeV). Some of the maxima in the yield measurements are interpreted in terms of resonances: these are shown in Table 18.15. See also ^{17}O in (1982AJ01).

25. ^{16}O(d, d)^{16}O $\qquad E_{\mathrm{b}} = 7.5263$

The yield of elastically scattered deuterons and elastic polarization measurements have been reported for $E_{\mathrm{d}} = 0.65$ to 56 MeV: see (1978AJ03) and (1982AOZZ; $E_{\mathrm{d}} = 13.8$ to 16.5 MeV), (1981FR1C; TAP; $E_{\vec{\mathrm{d}}} = 20$ MeV), (1981CL1C; VAP; $E_{\vec{\mathrm{d}}} = 20.5$ MeV; also to ^{16}O*(6.13)), (1980MA10; VAP; $E_{\vec{\mathrm{d}}} = 52$ MeV), (1980HA14; VAP; $E_{\vec{\mathrm{d}}} = 56$ MeV). For total cross sections at high energies see (1979DE31). See also ^{16}O in (1982AJ01), (1978RO1M) and (1979NI1B, 1980AY01, 1981AO01, 1982YA1A; theor.).

26. (a) ^{16}O(d, t)^{15}O $\qquad Q_{\mathrm{m}} = -9.4065 \qquad E_{\mathrm{b}} = 7.5263$
(b) ^{16}O(d, ^{3}He)^{15}N $\qquad Q_{\mathrm{m}} = -6.6340$

Vector analyzing powers have been studied at $E_{\vec{\mathrm{d}}} = 29$ MeV (1978CO13: to ^{15}N*(0, 6.32) and ^{15}O*(0, 6.18)) and 52 MeV (1977BE70: to ^{15}N*(0, 6.32, 9.94, 10.71)). See also (1978AJ03) and (1981MA14).

27. ^{16}O(d, α)^{14}N $\qquad Q_{\mathrm{m}} = 3.1104 \qquad E_{\mathrm{b}} = 7.5263$

The yields of various groups of α-particles have been measured for $E_{\mathrm{d}} \leq 20$ MeV: see (1978AJ03) and (1979MA2Q; 0.65 to 1.1 MeV; α_0), (1978RI05; 6.7 to 12.5 MeV; α_3) and (1982AOZZ; 13.8 to 16.5 MeV; α_0). The yield curves have been fitted in terms of a large number of states in ^{18}F: see Tables 18.15 here and 18.16 in (1978AJ03).

A detailed study by (1973JO13) of the isospin-forbidden α_1 yield, analyzed by S-matrix theory, identifies a large number of isospin mixed states in ^{18}F, possibly as many as 138 with $9.2 < E_{\mathrm{x}} < 19.4$ MeV. The reaction mechanism appears to be almost entirely compound nuclear. The isospin impurity, averaged over 1 MeV intervals, is $3-10\%$ for the above E_{x} range. The average coherence width increases from ≈ 100 keV at $E_{\mathrm{x}} = 14$ MeV to ≈ 500 keV at $E_{\mathrm{x}} = 20$ MeV. The level densities appear to be consistent with predictions of the Fermi-gas model (1973JO13). See also (1981JO1D). [For mixed isospin states observed in ^{14}N(α, α_1) see Table 18.14 in (1978AJ03)].

Polarization measurements are reported for $E_{\mathrm{d}} = 6.8$ to 16 MeV: see (1978AJ03). The T_{21} analyzing power of the transition to ^{14}N*(4.91) [0^-] has been measured at $E_{\mathrm{d}} = 8.06$ MeV ($\theta = 45°$) to 0.5% (1981KA21). See also (1979TO1A, 1980PR1A, 1981TO1G), (1979MA2Q: applications), (1978SE01, 1979SE04; theor.) and ^{14}N in (1981AJ01).

28. ^{16}O(d, ^{6}Li)^{12}C $Q_{\rm m} = -5.6885$ $E_{\rm b} = 7.5263$

See (1978AJ03).

29. ^{16}O(t, n)^{18}F $Q_{\rm m} = 1.2690$

See (1978AJ03). See also (1976HE1N) and (1980KU1H; applied).

30. ^{16}O(^{3}He, p)^{18}F $Q_{\rm m} = 2.0328$

Excitation energies derived from measurements of γ-rays are displayed in Table 18.16, together with l-assignments obtained from distorted-wave analyses, and J^{π}; T and K^{π} assignments from branching ratios, radiative widths, linear polarization, γ-ray angular distributions and $\tau_{\rm m}$ measurements [see also Tables 18.12 and 18.13]. Studies of this reaction, together with the work on ^{14}N(α, γ) and ^{17}O(p, γ), have defined the low-lying states of ^{18}F.

The g-factor of ^{18}F*(0.94) [$J^{\pi} = 3^{+}$] is $+0.54 \pm 0.06$ (1981ST21), 0.58 ± 0.07 (1978GO22). $\tau_{\rm m}$ of ^{18}F*(1.04) $= 2.7 \pm 0.7$ fsec. The weighted mean "best" value [see Table 18.12] is 2.7 ± 0.4 fsec. This leads to $|M|^2 = 10.3 \pm 1.5$ W.u., and using the E1 strength of the ^{18}F*(1.08 $\rightarrow$ g.s.) decay leads to a value for the circular polarization of the $1.08 \rightarrow$ g.s. γ-ray [P_{γ}] [0^{-}; $T = 0$ to 1^{+}; 0] $= \pm(5.8 \pm 0.4)$ keV$^{-1}\langle 1.04|V^{\rm PNC}|1.08\rangle$ (1981KE04). The experimental value for $P_{\gamma} = (-0.7 \pm 2.0) \times 10^{-3}$ (1978BA08). (1981AD1E) reports a best value of $P_{\gamma} = (-0.1 \pm 1.2) \times 10^{-3}$. The importance of the decays of ^{18}F*(1.04, 1.08) [$J^{\pi} = 0^{+}$, $T = 1$; $J^{\pi} = 0^{-}$, $T = 1$, respectively] lies in testing the parity non-conserving (PNC) component of nuclear forces: see also (1980BI11), (1981HA1H) and (1980HA41; theor.). The magnetic moment of ^{18}F*(1.13) $= +2.855 \pm 0.030$ nm, in agreement with shell-model predictions for a $(1{\rm d}^2_{5/2})_{5^+}$ state: see (1978AJ03). See also (1979HAYZ), (1977FI13, 1980HE06; applied) and ^{19}Ne.

31. ^{16}O(α, d)^{18}F $Q_{\rm m} = -16.3204$

Angular distributions of the deuteron groups to ^{18}F*(1.12) [$J^{\pi} = 5^{+}$] have been studied at $E_{\alpha} = 28.0$ to 33.6 MeV (1978CO10, 1979CO1P). See also ^{20}Ne and (1972AJ02).

32. ^{16}O(^{6}Li, α)^{18}F $Q_{\rm m} = 6.053$

Angular distributions for α_0 are reported at $E(^6Li) = 5.5$ to 13.3 and 26 MeV: see (1978AJ03). At $E(^6Li) = 34$ MeV angular distributions are reported to ^{18}F*(0, 0.94, 1.1 [unres.]) and forward angle data has been obtained for ^{18}F*(2.10, 3.72, 3.79, 3.84). The angular distributions for the first three groups are forward peaked and show little structure at back angles. ^{18}F*(1.04, 3.06) are not observed, as expected from isospin conservation. States at $E_x = 4.12$, 4.23, 4.4, 5.61, 6.11, 6.20, 6.53, 6.80 and 6.88 were populated (1976MO24). See also (1981MA26; theor.).

33. $^{16}O(^{11}B, ^9Be)^{18}F$ $\qquad Q_m = -8.290$

Forward angle differential cross sections are reported at $E(^{11}B) = 115$ MeV to ^{18}F*(1.1) [$J^\pi = 3^+ + 5^+$] and to ^{18}F*(4.65) [$J^\pi = 4^+$] (1980PR09). See also (1979RA10).

34. (a) $^{16}O(^{12}C, ^{10}B)^{18}F$ $\qquad Q_m = -17.661$

(b) $^{16}O(^{13}C, ^{11}B)^{18}F$ $\qquad Q_m = -9.4074$

Forward angle differential cross sections are reported at $E(^{13}C) = 105$ MeV ^{18}F*(1.12, 4.65) (1980PR09). For reaction (a) see (1978AJ03).

35. $^{16}O(^{14}N, ^{12}C)^{18}F$ $\qquad Q_m = -2.7461$

Angular distributions are reported at $E(^{14}N) = 76.2$ MeV to $^{18}F_{g.s.}$ (1977MO1A).

36. $^{16}O(^{16}O, ^{14}N)^{18}F$ $\qquad Q_m = -13.2100$

See (1978AJ03).

37. $^{17}O(p, \gamma)^{18}F$ $\qquad Q_m = 5.607$

$Q_0 = 5606.2 \pm 0.6$ keV (1976RO1T); see also (1978SE08).

Gamma-ray measurements lead to the very accurate E_x determinations for ^{18}F states below 6.2 MeV: see Table 18.17. Observed resonances are displayed in Table 18.18; branching ratios, radiative widths and multipole mixing ratios are shown in Table 18.12; and τ_m in Table 18.13.

The direct capture cross section has been studied for $E_p = 0.3$ to 1.9 MeV: ^{18}F*(5.603, 5.605, 5.668, 5.786) have $J^\pi = 1^+, 1^-, 1^-$ and 2^-. The 1^- states have mixed isospin. Astrophysical considerations are discussed in (1978AJ03) and (1975ZI1A, 1977RO1H, 1978RO1D).

38. ^{17}O(p, n)^{17}F $Q_m = -3.544$ $E_b = 5.607$

Observed resonances are displayed in Table 18.18. See also (1978AJ03).

39. ^{17}O(p, p)^{17}O $E_b = 5.607$

The elastic scattering has been studied for $E_p = 0.5$ to 13 MeV [see (1978AJ03)] and 1.4 to 3.0 MeV (1977SE12, 1978SE08): observed anomalies are displayed in Table 18.18.

40. ^{17}O(p, d)^{16}O $Q_m = -1.920$ $E_b = 5.607$

See (1978AJ03).

41. ^{17}O(p, α)^{14}N $Q_m = 1.191$ $E_b = 5.607$

The yield of α_0 shows a number of resonances for $E_p = 0.49$ to 3.0 MeV: see Table 18.18. The R-matrix fit of (1979KI13), obtained from data from $E_p = 400$ to 1400 keV, confirms the earlier result [see, e.g., reaction 31 in (1978AJ03)] that a significant quantity of ^{17}O is burned up in the (p, γ) rather than in the (p, α) reaction for a wide range of stellar temperatures (1979KI13). See also (1977RO1H, 1978RO1D; astrophys.).

42. ^{17}O(d, n)^{18}F $Q_m = 3.382$

See (1972AJ02).

43. ^{17}O(^{3}He, d)^{18}F $Q_m = 0.113$

At $E(^3\text{He}) = 15$ MeV, DWBA analysis of angular distributions of deuteron groups corresponding to the ground state of ^{18}F [$l = 2$] and to the excited states at 0.94 [$l = 0+2$], 1.04 [2], 1.12 [2], 2.53 [$0+2$], 3.06 [$0+2$], 3.84 [$0+2$], 4.12 [$0+2$], 4.66 [2] and 4.96 [$l = 0+2$] have been obtained by (1969PO11) who also report spectroscopic information. Thus all these states have even parity and ^{18}F*(4.11) may be assigned $J^\pi = (2^+)$ or 3^+. Since $l = 2$ for ^{18}F*(4.65), $J^\pi \leq 5^+$, with 4^+ most likely (1969PO11). See also (1979SA31; theor.).

44. ^{17}O(^{12}C, ^{11}B)^{18}F $\qquad Q_m = -10.350$

Forward angle differential cross sections are reported for the transition to ^{18}F*(1.12) at $E(^{12}\text{C}) =$ 115 MeV (1980PR09).

45. ^{18}O(p, n)^{18}F $\qquad Q_m = -2.4379$

Angular distributions of a number of neutron groups are reported for $E_p = 5.5$ to 13.5 MeV: see (1978AJ03). The τ_m of ^{18}F*(1.04) [$J^\pi = 0^+$; $T = 1$] is $2.7^{+0.6}_{-0.4}$ fsec (1980KE05): see Table 18.13. See also ^{19}F.

46. ^{18}O(^{3}He, t)^{18}F $\qquad Q_m = -1.6742$

At $E(^3\text{He}) = 16$ MeV, the triton spectrum is dominated by strong groups to the ground and 0.94 MeV excited states and to the 0^+ and 2^+, $T = 1$ states at $E_x = 1.04$ and 3.06 MeV. Angular distributions have been measured and analyzed by DWBA for the tritons corresponding to these states and to ^{18}F*(1.08, 1.12, 1.70, 2.10, 3.13, 3.36, 3.72, 3.79, 3.84, 4.12, 4.23, 4.36, 4.40, 4.65, 4.75). The angular distributions are consistent with the J^π assignments shown in Table 18.11, except for the distribution to ^{18}F*(1.04) (1970DU08). At $E(^3\text{He}) = 17.3$ MeV, angular distributions to ^{18}F states with $E_x < 4$ MeV have been analyzed using DWBA and a two-body interaction between the incident and target nucleons. An exact coupled-channel calculation was also made for the transition to ^{18}F*(1.04) (1968HA30). At $E(^3\vec{\text{He}}) = 33$ MeV the analyzing power angular distribution for t_0 has been measured by (1981BA1G).

47. ^{18}O(^{6}Li, ^{6}He)^{18}F $\qquad Q_m = -5.165$

At $E(^6\text{Li}) = 34$ MeV angular distributions have been obtained for the transitions to ^{18}F*(0, 0.94): there appears to be a sizeable contribution due to two-step processes: see (1978AJ03).

48. ^{18}Ne(β^+)^{18}F $\qquad Q_m = 4.447$

The half-life of ^{18}Ne is 1672 ± 4 msec (see ^{18}Ne). The decay is to ^{18}F*(0, 1.04, 1.08, 1.70): see Table 18.19 for the branching ratios and $\log ft$ values.

49. ^{19}F(γ, n)^{18}F $\qquad Q_m = -10.4313$

Table 18.19: Branching in ^{18}Ne(β^+)^{18}F [a]

Decay to ^{18}F* (MeV)	$J^\pi; T$	E_{γ_0} (keV)	Branch (%)	$\log f_0 t$ [b]
0	$1^+; 0$		92.11 ± 0.21	3.094 (5)
1.04	$0^+; 1$	1041.3 ± 1.0	7.66 ± 0.21 [d]	3.456 (12)
1.08	$0^-; 0$	1080.5 ± 0.1	$(1.3 \pm 0.3) \times 10^{-3}$ [e,f]	7.20 (11)
1.70	$1^+; 0$	1699.6 ± 2.0 [c]	0.23 ± 0.03	4.43 (6) [g]
			0.19 ± 0.04 [e]	

[a] (1975HA21, 1981AD01). See Table 18.20 in (1978AJ03) for the earlier work.

[b] Based on Q_m and $\tau_{1/2} = 1672 \pm 5$ msec.

[c] And 659.4 ± 1.0 keV for the 70% transition to ^{18}F*(1.04).

[d] See also (1981AD05).

[e] (1981AD01) and E.G. Adelberger, private communication.

[f] $(2.28 \pm 0.17) \times 10^{-3}$ (1982DAZZ; preliminary).

[g] Calculated assuming branch $= 0.21 \pm 0.03$%.

Cross sections to 30 MeV for the transitions to ^{18}F*(0.94, 1.04, 1.08, 3.06, 3.13, 4.75) are reported by (1979TH05). See also (1978AJ03), (1980YA08; applied) and ^{19}F.

50. ^{19}F(n, 2n)^{18}F $\quad Q_m = -10.4313$

See (1978CO18, 1980CO1U). See also ^{20}F and (1978AJ03).

51. ^{19}F(p, d)^{18}F $\quad Q_m = -8.2067$

Angular distributions of the d_0 group have been measured at $E_p = 16$ to 155.6 MeV: $l_n = 0$: see (1972AJ02) and (1977GU14: 17.7 MeV). At $E_p = 19.3$ MeV angular distributions are also reported to excited states of ^{18}F: see Table 18.20. The angular distributions associated with 0h-2p states in ^{18}F are only qualitatively accounted for by DWBA. Those corresponding to 1h-3p negative-parity states generally cannot be accounted for by a single-step mechanism, while the distributions to states arising from 2p-4h configurations do not show the features associated with direct interaction (1980DE05). See also (1982MA1H) and (1978AJ03).

52. ^{19}F(d, t)^{18}F $\quad Q_m = -4.1740$

Table 18.20: States of ^{18}F from ^{19}F(p, d) [a]

E_x (MeV) [b]	$J^\pi; T$ [b]	l_n	C^2S
0.0	$1^+; 0$	0	0.65
0.94	$3^+; 0$	2	1.47
1.04	$0^+; 1$	0	0.27
1.08	$0^-; 0$	1	0.38
1.12	$5^+; 0$		
1.70	$1^+; 0$	0	0.07
2.10	$2^-; 0$	1	(0.03)
2.52	$2^+; 0$	2	≈ 0
3.06	$2^+; 1$	2	0.74
3.13	$1^-; 0$	1	1.04
3.36	$3^+; 0$	2	≈ 0
3.72	$1^+; 0$	$0 + 2$	$0.015 + 0.22$
3.79	$3^-; 0$		
3.84	$2^+; 0$	2	0.50
4.12	$3^+; 0$		≈ 0
4.23	$2^-; 0$	1	(0.015)
4.36	$(1^{(+)})$	$0 + 2$	$0.04 + 0.13$
4.40	$4^-; 0$		
4.65	$4^+; 1$		
4.75	$(0^+; 1)$	$0 + 2$	$0.03 + 0.08$
4.86	$1^-; 0$	1	(0.11)
4.96	$2^+; 1$	2	≈ 0
5.30	$4^+; 0$		
5.50	$3^{(-)}; 0$		
5.603	1^+		
5.605	$1^-; 0 + 1$	1	(0.82)
5.67	$1^-; 0 + 1$	1	(0.44)
5.79	$2^-; 0$		
6.10	$4^-; 0$		

[a] (1980DE05): $E_p = 19.3$ MeV; DWBA analysis.

[b] Values from Table 18.11.

Angular distributions of triton groups have been reported at $E_d = 8.9$ (t_0, t_1, t_3) and 14.8 MeV (t_0): see (1972AJ02). See also (1978AJ03).

53. $^{19}F(^3He, \alpha)^{18}F$ $\qquad Q_m = 10.1465$

Many α-particle groups have been observed [see Table 18.21 in (1978AJ03)].

54. (a) $^{19}F(^{10}B, ^{11}B)^{18}F$ $\qquad Q_m = 1.024$
(b) $^{19}F(^{14}N, ^{15}N)^{18}F$ $\qquad Q_m = 0.4021$
(c) $^{19}F(^{19}F, ^{20}F)^{18}F$ $\qquad Q_m = -3.830$

See (1972AJ02).

55. $^{20}Ne(p, ^3He)^{18}F$ $\qquad Q_m = -15.558$

At $E_p = 45$ MeV, ^{18}F*(0, 1.04, 1.70, 3.06, 6.27) are populated: see (1978AJ03).

56. $^{20}Ne(d, \alpha)^{18}F$ $\qquad Q_m = 2.7954$

At $E_d = 11$ MeV α-groups are observed to many states of ^{18}F with $E_x < 7$ MeV. Weak or absent (each $\leq 0.3\%$ of the total yield at 30°) are the groups corresponding to ^{18}F*(1.04, 3.06, 4.66, 4.74, 4.96): $T = 1$ for these states (1969PO11). Angular distributions at $E_d = 6.66$, 7.29, 7.93 and 12.95 MeV have been obtained for the α-groups to ^{18}F*(2.10 [not 12.95 MeV], 2.52, 3.06 [2^+; 1], 3.13, 3.36, 4.12). The ratio of the total cross section for the isospin-forbidden transition to ^{18}F*(3.06) to the total cross section of four $T = 0$ states ranges from 6% to 40%. The average is 21% suggesting isospin mixing in the compound nucleus: the yield curves show strong structures particularly in the range 5 to 9 MeV (1973HR03). Angular distributions have also been measured at $E_d = 2$ to 14.7 MeV: see (1978AJ03). Measurements of the tensor analyzing power for $E_{\vec{d}} = 10.25$ to 12.0 MeV leads to assignments of unnatural parity for ^{18}F*(0, 0.94, $1.08 + 1.12$, 1.70, 2.10, 3.36, 3.72, 4.12, 4.23, 4.36, 4.40, $5.603 + 5.605 + 5.67$, 5.79, $6.10 + 6.10$, $6.14 + 6.16$, 6.31, 6.48) and to natural parity for ^{18}F*(3.79, 3.84, 4.86): assignments of $J^\pi = 2^-, 1^+, 0^+, 1^-, 1^+, 3^+, 3^+$ are made for ^{18}F*(4.23, 4.36, 4.75, 4.86, 5.603, 6.16, 6.48) [all $T = 0$ except ^{18}F*(4.75)] (1978DA02).

57. $^{20}Ne(\alpha, ^6Li)^{18}F$ $\qquad Q_m = -19.578$

See (1979LE1R, 1980LE21; theor.).

58. ^{24}Mg(^{12}C, ^{18}F)^{18}F $Q_{\rm m} = -15.676$

See (1978NO02).

^{18}Ne

(Figs. 3 and 4)

GENERAL: (See also (1978AJ03).)

Model calculations: (1979DA15, 1979SA31, 1980ZH01).

Electromagnetic transitions: (1977HA1Z, 1979SA31, 1982LA26).

Special states: (1977HE18, 1978KR1G, 1979DA15, 1979SA31, 1980OK01, 1982ZH1D).

Astrophysical questions: (1979WO07).

Complex reactions involving ^{18}Ne: (1979HE1D).

Pion-induced capture and reactions (See also reaction 6.): (1977PE12, 1977SP1B, 1978BU09, 1978OS02, 1978SC1G, 1978SP07, 1979AL1J, 1979GR18, 1979SE08, 1980JO06, 1981LI04, 1981LI1L, 1981LI1M, 1981LI1W, 1981MI09, 1981OS1F, 1982IN1A).

Other topics: (1978KR1G, 1978SH1B, 1980ZH01, 1981SH17).

Ground state of ^{18}Ne: (1977HA1Z, 1982ZH1D).

1. ^{18}Ne(β^+)^{18}F $\quad\quad$ $Q_{\rm m} = 4.447$

The half-life of ^{18}Ne is 1672 ± 5 msec: see (1978AJ03). The decay is primarily to ^{18}F*(0, 1.04, 1.70) [$J^\pi = 1^+$, 0^+, 1^+; $T = 0$, 1, 0, respectively]. In addition there is an extremely weak branch $(1.3 \pm 0.3) \times 10^{-3}$% to ^{18}F*(1.08) [$0^-$; 0] (1981AD01): see Table 18.19 for the parameters of the decay. The ($0^+ \rightarrow 0^-$) transition yields an upper limit of $\pm(0.5 \pm 1.3) \times 10^{-6}$ for the parity mixing in the ^{18}F*(1.04, 1.08) 0^+, 0^- doublet (1981AD01). [See also the discussion in (1981HA06)]. See also (1980LO1B, 1981BOZY) and (1978SZ03, 1979WI1Q, 1980OK01, 1981HA1Q; theor.).

2. ^{16}O(^{3}He, n)^{18}Ne $\quad\quad$ $Q_{\rm m} = -3.196$

Excitation energies of ^{18}Ne states derived from neutron spectra and γ-ray measurements are displayed in Table 18.23. Branching ratios and $\tau_{\rm m}$ are summarized in Table 18.22. For angular distributions see (1978AJ03) and (1981NE09). Comparison of the $\tau_{\rm m}$ of ^{18}Ne*(1.89), which leads to B(E2) $= 52 \pm 5$ $e^2 \cdot {\rm fm}^4$, with that of ^{18}O*(1.98), its analog, suggests the presence of two-body contributions to the E2 transition strength (1976MC02). See also (1977FI13; applications).

3. ^{16}O(^{10}B, ^{8}Li)^{18}Ne $\quad\quad$ $Q_{\rm m} = -18.951$

Table 18.21: Energy levels of ^{18}Ne [a]

E_x (MeV $\pm$ keV)	$J^\pi; T$	τ or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
0	$0^+; 1$	$\tau_{1/2} = 1672 \pm 5$ msec	β^+	1, 2, 6, 7
1.8873 ± 0.2	2^+	$\tau_m = 0.67 \pm 0.06$ psec	γ	2, 6, 7
3.3762 ± 0.4	4^+	$\tau_m = 4.4 \pm 0.6$ psec	γ	2, 3, 4, 7
3.5763 ± 2.0	0^+	$\tau_m = 4 \pm 2$ psec	γ	2, 7
3.6164 ± 0.6	2^+	$\tau_m = 63^{+30}_{-20}$ fsec	γ	2, 7
4.519 ± 8	1^-	$\Gamma \leq 20$	(p)	2, 7
4.590 ± 8	0^+	≤ 20	(p)	2, 7
5.090 ± 8	$(2^+, 3^-)$	40 ± 20	(p)	2, 7
5.146 ± 7	$(2^+, 3^-)$	25 ± 15		2, 7
5.453 ± 10		≤ 50		7
6.297 ± 10	(4^+)	≤ 60		2, 7
6.353 ± 10		≤ 60		7
7.059 ± 10	$(1^-, 2^+)$	180 ± 50		2
7.713 ± 10		≤ 50		2, 7
7.910 ± 10	$(1^-, 2^+)$	≤ 50		2
7.950 ± 10		≤ 60		7
8.086 ± 10		≤ 50		2
8.500 ± 30		≤ 120		2
9.201 ± 9		≤ 50		7

[a] See also Table 18.22.

Table 18.22: Branching ratios and lifetimes of ^{18}Ne states [a]

E_i (MeV)	J^{π}_i	E_f (MeV)	Branch (%)	τ_m (psec)
1.89	2^+	0	100	0.67 ± 0.06
3.38	4^+	0	< 1	
		1.89	100	4.4 ± 0.6
3.58	0^+	0	< 5	
		1.89	100	4 ± 2
3.62	2^+	0	9 ± 2	
		1.89	91 ± 2 [b]	$0.063^{+0.030}_{-0.020}$

[a] For references see Table 18.24 in (1978AJ03).

[b] The mixing ratio, δ, is consistent with 0.

At $E(^{10}\text{B}) = 100$ MeV the angular distribution to ^{18}Ne*(3.38) $[(\text{d}_{5/2})^2_{4^+}$ state] which is preferentially populated, has been studied by (1978HA10): ^{18}Ne*(1.89) is also observed.

4. ^{16}O(^{11}B, ^{9}Li)^{18}Ne $\qquad Q_m = -26.344$

At $E(^{11}\text{B}) = 115$ MeV ^{18}Ne*(3.38) $[J^{\pi} = 4^+]$ is selectively populated (1979RA10).

5. ^{16}O(^{12}C, ^{10}Be)^{18}Ne $\qquad Q_m = -22.664$

See (1978AJ03).

6. ^{18}O(π^+, π^-)^{18}Ne $\qquad Q_m = -6.101$

Angular distributions of the transition to $^{18}\text{Ne}_{\text{g.s.}}$ have been studied at $E_{\pi^+} = 164$ MeV (1979GR18, 1979SE08, 1982GR1F; also to ^{18}Ne*(1.89)), and at 292 MeV (1982GR1F). The excitation function for production of ^{18}Ne*(0, 1.89) have been measured by (1979GR18, 1982GR02, 1982GR1F) for $E_{\pi^+} = 80$ to 292 MeV. See also (1978AJ03), (1977PE12, 1978BU09, 1982GRZZ) and the "GENERAL" section here.

7. ^{20}Ne(p, t)^{18}Ne $\qquad Q_m = -20.023$

Table 18.23: States in ^{18}Ne from ^{16}O(^{3}He, n) and ^{20}Ne(p, t) [a]

E_x (MeV ± keV)		$\Gamma_{c.m.}$ (keV) [b]	J^{π} [a,b]
A	B		
0			0^+
1.8873 ± 0.2	1.886 ± 10		2^+
3.3762 ± 0.4	3.375 ± 10		4^+
3.5763 ± 2.0	3.580 ± 10		0^+
3.6164 ± 0.6	3.612 ± 10		2^+
4.513 ± 13	4.522 ± 10	≤ 20	1^-
4.587 ± 13	4.592 ± 10	≤ 20	0^+
5.075 ± 13	5.099 ± 10	40 ± 20	$(2^+, 3^-)$
5.141 ± 10	5.151 ± 10	25 ± 15	$(2^+, 3^-)$
	5.453 ± 10	≤ 50	
6.291 ± 30 [c]	6.297 ± 10	≤ 60	(4^+)
	6.353 ± 10	≤ 60	
7.062 ± 12 [a]		180 ± 50	$(1^-, 2^+)$
7.712 ± 20	7.713 ± 10	≤ 50	
7.915 ± 12 [a]		≤ 50	$(1^-, 2^+)$
	7.949 ± 10	≤ 60	
8.100 ± 14 [a]		≤ 50	
8.50 ± 30		≤ 120	
	9.198 ± 10	≤ 50	

A: ^{16}O(^{3}He, n)^{18}Ne: for references see Table 18.23 (1978AJ03) and (1981NE09).

B: ^{20}Ne(p, t)^{18}Ne: (1981NE09).

[a] See also Table 18.23 in (1978AJ03).

[b] (1981NE09).

[c] $\Gamma = 180 \pm 60$ keV.

Observed triton groups are displayed in Table 18.23 as are J^π derived from DWBA analysis of angular distributions. The 0_3^+ state, identified at $E_x = 4.59$ MeV, appears to have a largely $s_{1/2}^2$ configuration based on its large downward shift with respect to the analog state in ^{18}O (1981NE09). See also (1978AJ03).

^{18}Na

(Not illustrated)

^{18}Na has not been observed: its atomic mass excess has been estimated to be 25.32 MeV: it is then unbound with respect to proton emission by 1.55 MeV (1977WA08). See also (1978GU10; theor.).

References

(Closed 01 May 1982)

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

1958WE29 J.A. Weinman and E.A. Silverstein, Phys. Rev. 11 (1958) 277

1962HI06 S. Hinds, H. Marchant and R. Middleton, Nucl. Phys. 38 (1962) 81

1964PU01 D.J. Pullen, J.R. Rook and R. Middleton, Nucl. Phys. 51 (1964) 88

1965OW01 R.O. Owens and R.G. Winter, Nucl. Phys. 71 (1965) 625

1966HA19 B.G. Harvey, J.R. Meriwether, J. Mahoney, A. Bussiere de Nercy and D.J. Horen, Phys. Rev. 146 (1966) 712

1966MC05 R.L. McGrath, Phys. Rev. 145 (1966) 802

1966OL03 J.W. Olness and E.K. Warburton, Phys. Rev. 151 (1966) 792

1967LE02 F.D. Lee, R.W. Krone and F.W. Prosser, Jr., Nucl. Phys. A96 (1967) 209

1967WA06 E.K. Warburton, J.W. Olness and A.R. Poletti, Phys. Rev. 155 (1967) 1164

1968HA30 L.F. Hansen, M.L. Stelts, J.G. Vidal, J.J. Wesolowski and V.A. Madsen, Phys. Rev. 174 (1968) 1155

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

1969PO11 L.M. Polsky, C.H. Holbrow and R. Middleton, Phys. Rev. 186 (1969) 966

1969ST07 R.H. Stokes and P.G. Young, Phys. Rev. 178 (1969) 1789

1970DU08 H.H. Duhm, K. Peterseim, R. Seehars, R. Finlay and C. Detraz, Nucl. Phys. A151 (1970) 579

1970MO13 G.L. Morgan, D.R. Tilley, G.E. Mitchell, R.A. Hilko and N.R. Roberson, Nucl. Phys. A148 (1970) 480

1970MO17 G.L. Morgan, D.R. Tilley, G.E. Mitchell, R.A. Hilko and N.R. Roberson, Phys. Lett. B32 (1970) 353

1971BE45 Z. Berant, M.B. Goldberg, M. Popp, J.S. Sokolowski, P.N. Tandon and Y. Wolfson, Nucl. Phys. A173 (1971) 401

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

1971OL06 R.W. Ollerhead, G.F.R. Allen, A.M. Baxter and J.A. Kuehner, Can. J. Phys. 49 (1971) 2589

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

1972BE37 I. Berka, C. Rolfs and R.E. Azuma, Can. J. Phys. 50 (1972) 1682

1972CO1C Couch, Spinka, Tombrello and Weaver, Astrophys. J. 172 (1972) 395

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

1972LI24 R.A. Lindgren, H.H. Gutbrod, H.W. Fulbright and R.G. Markham, Phys. Rev. Lett. 29 (1972) 798

1972RO04 C. Rolfs, Z. Phys. 249 (1972) 312

1972RO24 C. Rolfs, Can. J. Phys. 50 (1972) 1791

1973BE48 J.A. Becker, L.F. Chase, Jr., D. Kohler and R.E. McDonald, Phys. Rev. C8 (1973) 2007

1973GA09 D.S. Gale and J.S. Eck, Phys. Rev. C7 (1973) 1950

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

1973HR03 A.F. Hrejsa and C.P. Browne, Phys. Rev. C8 (1973) 230

1973JO13 P.L. Jolivette, Phys. Rev. C8 (1973) 1230

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

1973OL02 J.W. Olness, E.K. Warburton and J.A. Becker, Phys. Rev. C7 (1973) 2239

1973RO03 C. Rolfs, A.M. Charlesworth and R.E. Azuma, Nucl. Phys. A199 (1973) 257

1973RO04 C. Rolfs, W.E. Kieser, R.E. Azuma and A.E. Litherland, Nucl. Phys. A199 (1973) 274

1973RO05 C. Rolfs, H.P. Trautvetter, R.E. Azuma and A.E. Litherland, Nucl. Phys. A199 (1973) 289

1973RO06 C. Rolfs, I. Berka and R.E. Azuma, Nucl. Phys. A199 (1973) 306

1973SC24 W.F.W. Schneider, B. Kohlmeyer, F. Puhlhofer and R. Bock, Phys. Lett. B46 (1973) 195

1973SE03 J.C. Sens, A. Pape and R. Armbruster, Nucl. Phys. A199 (1973) 241

1974BE63 Z. Berant, C. Broude, S. Dima, G. Goldring, M. Hass, Z. Shkedi, D.F.H. Start and Y. Wolfson, Nucl. Phys. A235 (1974) 410

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

1974FI1D D. Fick, Nukleonika 19 (1974) 693

1974FO14 H.T. Fortune and S.C. Headley, Phys. Lett. B51 (1974) 136

1974HA15 M. Hass, Z. Shkedi, D.F.H. Start, Y. Wolfson and Y.S. Horowitz, Nucl. Phys. A220 (1974) 217

1974JA11 W.W. Jacobs, D. Bodansky, D. Chamberlin and D.L. Oberg, Phys. Rev. C9 (1974) 2134

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

1975FO03 M. Forterre, J. Gerber, J.P. Vivien, M.B. Goldberg and K.-H. Speidel, Phys. Lett. B55 (1975) 56

1975HA21 J.C. Hardy, H. Schmeing, J.S. Geiger and R.L. Graham, Nucl. Phys. A246 (1975) 61

1975RO05 C. Rolfs, W.S. Rodney, S. Durrance and H. Winkler, Nucl. Phys. A240 (1975) 221

1975SC35 W.F.W. Schneider, B. Kohlmeyer, F. Puhlhofer and R. Bock, Nucl. Phys. A251 (1975) 331

1975SO05 K.H. Souw, J.C. Adloff, D. Disdier and P. Chevallier, Phys. Rev. C11 (1975) 1899

1975SP03 K.-H. Speidel, M.B. Goldberg, K. Hagemeyer, G.J. Kumbartzki, G. Goldring, Z. Shkedi, M. Schramm, G. Kraft and H.A. Doubt, Phys. Lett. B57 (1975) 143

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

1975WH01 W.R. Wharton and P.T. Debevec, Phys. Rev. C11 (1975) 1963

1975ZI1A Zimmerman, Fowler and Caughlan, OAP-399 (1975)

1976AS04 J. Asher, M.A. Grace, P.D. Johnston, J.W. Koen, P.M. Rowe and W.L. Randolph, J. Phys. (London) G2 (1976) 477

1976BA41 K. Bangert, U.E.P. Berg, K. Wienhard and H. Wolf, Z. Phys. A278 (1976) 295

1976BE1E Behrens and Lzybisz, Phys. Data 6-1; ZAED (1976)

1976CH24 L.C. Chen, Phys. Rev. C14 (1976) 2069

1976HE1N Heusch, 1974 Gamma Ray Transition Probabilities (1976) 92

1976JA23 J. Janecke, At. Data Nucl. Data Tables 17 (1976) 455

1976LA13 R.D. Lawson, F.J.D. Serduke and H.T. Fortune, Phys. Rev. C14 (1976) 1245

1976LI01 T.K. Li, D. Dehnhard, R.E. Brown and P.J. Ellis, Phys. Rev. C13 (1976) 55

1976MC02 A.B. McDonald, T.K. Alexander, C. Broude, J.S. Forster, O. Hausser, F.C. Khanna and I.V. Mitchell, Nucl. Phys. A258 (1976) 152

1976MC1G McGrory, 1974 Gamma Ray Transition Probabilities (1976) 469

1976MO24 G.E. Moore and K.W. Kemper, Phys. Rev. C14 (1976) 977

1976PO02 J.E. Poling, E. Norbeck and R.R. Carlson, Phys. Rev. C13 (1976) 648

1976PR08 G.A. Prokopets, B. Holmqvist and A.V. Murzin, Yad. Fiz. 23 (1976) 935; Sov. J. Nucl. Phys. 23 (1976) 492

1976RO1T Rolfs, Rodney and Winkler, At. Masses Fund. Constants; Eds., Sanders and Wapstra (1976) 60

1976SP07 P. Sperr, T.H. Braid, Y. Eisen, D.G. Kovar, F.W. Prosser, Jr., J.P. Schiffer, S.L. Tabor and S. Vigdor, Phys. Rev. Lett. 37 (1976) 321

1976WE05 M.P. Webb, R. Vandenbosch, K.A. Eberhard, K.G. Bernhardt and M.S. Zisman, Phys. Rev. Lett. 36 (1976) 779

1977AJ02 F. Ajzenberg-Selove, Nucl. Phys. A281 (1977) 1

1977AL2B Albanese et al., Proc. Int. Conf. Nucl. Struct., Tokyo, (1977); J. Phys. Soc. Jpn. Suppl. 44 (1978) 487

1977AN1P Ando, Bando and Nagata, Prog. Theor. Phys. 57 (1977) 1584

1977AS03 V.M. Asaturyan, E.O. Grigoryan, G.A. Vartapetyan, A.S. Danagulyan, N.A. Demekhina and A.G. Khudaverdyan,Yad. Fiz. 25 (1977) 1133; Sov. J. Nucl. Phys. 25 (1977) 601

1977AU1E Audouze, CNO Isotopes in Astrophys.; Ed., J. Audouze (1977) 3

1977BA1P Batusov and Eramzhyan, Fiz. Elem. Chastits At. Yad. (USSR) 8 (1977) 229

1977BA1W Backenstoss, Acta Phys. Austriaca Suppl. 18 (1977) 593

1977BA2E Bansal and Kumar, Pramana 9 (1977) 273

1977BA2G Barnes, Proc. Int. Conf. Nucl. Struct., Tokyo (1977); J. Phys. Soc. Jpn. Suppl. 44 (1978) 783

1977BE46 I. Berka, K.P. Jackson, C. Rolfs, A.M. Charlesworth and R.E. Azuma, Nucl. Phys. A288 (1977) 317

1977BE70 V. Bechtold, L. Friedrich, P. Doll, K.T. Knopfle, G. Mairle and G.J. Wagner, Phys. Lett. B72 (1977) 169

1977BO1E Boschitz, High Energy Phys. Nucl. Struct., Zurich, 1977 (1977) 133

1977BU22 B. Buck, H. Friedrich and A.A. Pilt, Nucl. Phys. A290 (1977) 205

1977CA1K Caughlan, CNO Isotopes in Astrophys.; Ed., J. Audouze (1977) 121

1977CI1D Ciric et al., Sb. Rad. Prir.-Mat. Fak. Ser. Fiz. Univ. 7 (1977) 61

1977CL1C Clayton, CNO Isotopes in Astrophys.; Ed., J. Audouze (1977) 15

1977CO09 M.E. Cobern and P.D. Barker, Phys. Rev. C15 (1977) 1929; Erratum Phys. Rev. C16 (1977) 920

1977CO1W Cowan and Rose, Astrophys. J. 217 (1977) 51

1977DE1N Dearborn, CNO Isotopes in Astrophys.; Ed., J. Audouze (1977) 39

1977DI1C Dickman, Langer, McCutcheon and Shuter, CNO Isotopes in Astrophys.; Ed., J. Audouze (1977) 95

1977EC04 J.S. Eck, T.J. Gray and R.K. Gardner, Phys. Rev. C16 (1977) 1873

1977EI01 Y. Eisen, I. Tserruya, Y. Eyal, Z. Fraenkel and M. Hillman, Nucl. Phys. A291 (1977) 459

1977EI1A Eisenstein, High-Energy Phys. Nucl. Struct., Zurich (1977) 209

1977EN1B Encrenaz, CNO Isotopes in Astrophys.; Ed., J. Audouze (1977) 79

1977EP1A Epstein, Thompson and Yapp, Science 198 (1977) 1209

1977FI13 J. Fitschen, R. Beckmann, U. Holm and H. Neuert, Int. J. Appl. Radiat. Isotop. 28 (1977) 781

1977FO1E Fortune, Proc. Int. Conf. Nucl. Struct., Tokyo, (1977); J. Phys. Soc. Jpn. Suppl. 44 (1978) 99

1977GO18 V.Y. Gonchar, E.V. Inopin and V.I. Kuprikov, Yad. Fiz. 25 (1977) 46; Sov. J. Nucl. Phys. 25 (1977) 25

1977GR16 R. Gross and I. Talmi, Nucl. Phys. A286 (1977) 211

1977GR1L Gray and Thompson, Nature 270 (1977) 708

1977GU14 M.G. Gulyamov, B.S. Mazitov, G.A. Radyuk, E.I. Rasulov and R. Yarmukhamedov, Izv. Akad. Nauk SSSR Ser. Fiz. 41 (1977) 2214; Bull. Acad. Sci. USSR Phys. Ser. 41 (1977) 189

1977HA1Z Harvey, Proc. Int. Conf. Nucl. Struct., Tokyo, (1977); J. Phys. Soc. Jpn. Suppl. 44 (1978) 127

1977HE18 W.D. Heiss, C.A. Engelbrecht and F.J.W. Hahne, Nucl. Phys. A289 (1977) 386

1977HE1L Henley, Proc. Int. Conf. Nucl. Struct., Tokyo, (1977); J. Phys. Soc. Jpn. Suppl. 44 (1978) 812

1977KA1Y Kalinsky, Melnik, Smilansky and Trautner, Proc. Int. Conf. Nucl. Struct., Tokyo, (1977); J. Phys. Soc. Jpn. Suppl. 44 (1978) 263

1977KA21 D. Kalinsky, D. Melnik, U. Smilansky, N. Trautner, Y. Horowitz and S. Mordechai, Nucl. Phys. A289 (1977) 205

1977LE16 T.-S.H. Lee, D. Kurath and B. Zeidman, Phys. Rev. Lett. 39 (1977) 1307

1977LO1K Low, Proc. Int. Conf. Nucl. Struct., Tokyo, (1977); J. Phys. Soc. Jpn. Suppl. 44 (1978) 267

1977MA2E Mayer-Boricke, Nukleonika 22 (1977) 1131

1977MI1E Miller, Proc., Zurich-Sin (1977) 100

1977MO1A T. Motobayashi, Rept. Inst. Phys. Chem. Res. 53 (1977) 81

1977PE08 J.F. Petersen, D. Dehnhard and B.F. Bayman, Phys. Rev. C15 (1977) 1719

1977PE12 C. Perrin, J.-P. Albanese, R. Corfu, J.-P. Egger, P. Gretillat, C. Lunke, J. Piffaretti, E. Schwarz, J. Jansen and B.M. Preedom, Phys. Lett. B69 (1977) 301

1977PI10 W.T. Pinkston, Nucl. Phys. A291 (1977) 342

1977RO1H Rolfs, CNO Isotopes in Astrophys.; Ed., J. Audduze (1977) 133

1977SC1G Schroder and Huizenga, Ann. Rev. Nucl. Sci. 27 (1977) 465

1977SE12 J.C. Sens, S.M. Refaei, A. Ben Mohamed and A. Pape, Phys. Rev. C16 (1977) 2129

1977SH18 J. Shurpin, H. Muther, T.T.S. Kuo and A. Faessler, Nucl. Phys. A293 (1977) 61

1977SH1E Shackleton and Opdyke, Nature 270 (1977) 216

1977SI1D Silberberg and Tsao, Astrophys. J. Suppl. 35 (1977) 129

1977SI1F Silberberg and Tsao, Astrophys. J. Suppl. 35 (1977) 137

1977SO11 M. Sotona, Czech. J. Phys. B27 (1977) 516

1977SP1B Spencer, High Energy Phys. Nucl. Struct., Zurich (1977) 153

1977ST27 M.M. Sternheim and R.R. Silbar, Phys. Rev. C16 (1977) 2059

1977TR1D Truran, CNO Isotopes in Astrophys.; Ed., J. Audouze (1977) 145

1977VO08 C. Volant, M. Conjeaud, S. Harar and E.F. da Silveira, J. Phys. (Paris) 38 (1977) 1179

1977WA08 A.H. Wapstra and K. Bos, At. Data Nucl. Data Tables 19 (1977) 175; Erratum At. Data Nucl. Data Tables 20 (1977) 1

1977WA1P Wannier, CNO Isotopes in Astrophys.; Ed., J. Audouze (1977) 71

1977WE1E Welsh, High Energy Phys. Nucl. Struct., Zurich, 1977 (1977) 95

1977YA1B Yakovlev, Fiz. Elem. Chastits At. Yadra 8 (1977) 255

1977YO02 R.C. York and R.T. Carpenter, Nucl. Phys. A282 (1977) 351

1977ZH1A Zhang, Zhao and Li, Acta Phys. Sin. (China) 26 (1977) 54

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

1978AM1D Amsel et al., Nucl. Instrum. Meth. Phys. Res. 149 (1978) 705, 713

1978AN07 I. Angeli and M. Csatlos, Atomki Kozlem. 20 (1978) 1

1978AN1P K. Ando, H. Bando and E.M. Krenciglowa, Nucl. Phys. A309 (1978) 59

1978BA08 C.A. Barnes, M.M. Lowry, J.M. Davidson, R.E. Marrs, F.B. Morinigo, B. Chang, E.G. Adelberger and H.E. Swanson, Phys. Rev. Lett. 40 (1978) 840

1978BA10 A.J. Baltz and S. Kahana, Phys. Rev. C17 (1978) 555

1978BE1H Becchetti, AIP Conf. Proc. 47 (1978) 308

1978BE63 E. Bellotti, E. Fiorini, P. Negri and L. Zanotti, Nuovo Cim. A47 (1978) 106

1978BI1G J.R. Birkelund and J.R. Huizenga, Phys. Rev. C17 (1978) 126

1978BU03 B. Buck and A.A. Pilt, Nuncl. Phys. A295 (1978) 1

1978BU09 R.L. Burman, M.P. Baker, M.D. Cooper, R.H. Heffner, D.M. Lee, R.P. Redwine, J.E. Spencer, T. Marks, D.J. Malbrough, B.M. Preedom et al., Phys. Rev. C17 (1978) 1774

1978CA07 J. Carter, R.G. Clarkson, V. Hnizdo and J.P.F. Sellschop, Nucl. Phys. A297 (1978) 520

1978CH03 R. Chechik, Y. Eyal, H. Stocker and Z. Fraenkel, Nucl. Phys. A296 (1978) 307

1978CH10 H. Chandra and U. Mosel, Nucl. Phys. A298 (1978) 151

1978CH16 R. Chechik, Z. Fraenkel, Y. Eyal and H. Stocker, Nucl. Phys. A304 (1978) 243

1978CH26 W. Chung, J. van Hienen, B.H. Wildenthal and C.L. Bennett, Phys. Lett. B79 (1978) 381

1978CL1F Clayton, Ann. Rev. Nucl. Part. Sci. 28 (1978) 501

1978CO07 J.P. Coffin, P. Engelstein, A. Gallmann, B. Heusch, P. Wagner and H.E. Wegner, Phys. Rev. C17 (1978) 1607

1978CO08 S.A. Coon, R.J. McCarthy and C.P. Malta, J. Phys. (London) G4 (1978) 183

1978CO10 A.A. Cowley, S.J. Mills and G. Heymann, J. Phys. (London) G4 (1978) L149

1978CO13 J.D. Cossairt, S.B. Talley, D.P. May, R.E. Tribble and R.L. Spross, Phys. Rev. C18 (1978) 23

1978CO18 V. Corcalciuc, B. Holmqvist, A. Marcinkowski and G.A. Prokopets, Nucl. Phys. A307 (1978) 445

1978CU03 A. Cunsolo, A. Foti, G. Pappalardo, G. Raciti and N. Saunier, Phys. Rev. C18 (1978) 856

1978DA02 C.A. Davis and R. Abegg, Phys. Rev. C17 (1978) 1277

1978DA03 F. Darema-Rogers and C.M. Vincent, Phys. Rev. C17 (1978) 1461

1978DA1N Darema-Rogers and Millener, Bull. Amer. Phys. Soc. 23 (1978) 938

1978DE1K B. Desplanques and J. Missimer, Nucl. Phys. A300 (1978) 286

1978DI13 G.U. Din, Aust. J. Phys. 31 (1978) 267

1978EM1A Emiliani, Hudson, Shinn and George, Science 202 (1978) 627

1978EN1D Engelbrecht, Hahne and Heiss, S. African J. Phys. 1 (1978) 41

1978ER1C Ericson, Proc. Int. Conf. Nucl. Struct., Tokyo, (1977); J. Phys. Soc. Jpn. Suppl. 44 (1978) 27

1978FI1E Fick, Invited Talk, 3rd Int. Conf. on Clustering Aspects of Nucl. Struct. Nucl. Reactions, Winnipeg (1978)

1978FO05 H.T. Fortune, M.E. Cobern and G.E. Moore, Phys. Rev. C17 (1978) 888

1978FO16 H.T. Fortune and D. Kurath, Phys. Rev. C18 (1978) 236

1978FO18 H.T. Fortune, Phys. Rev. C18 (1978) 1053

1978FO29 H.T. Fortune, L.R. Medsker and J.N. Bishop, Nucl. Phys. A309 (1978) 221

1978FR05 R.M. Freeman and F. Haas, Phys. Rev. Lett. 40 (1978) 927

1978FR19 M.A. Franey, B.F. Bayman, J.S. Lilley and W.R. Phillips, Phys. Rev. Lett. 41 (1978) 837

1978FR1B Frahn, S. African J. Phys. 1 (1978) 133

1978FR1R Fry, Whitford and Pashley, Int. J. Appl. Radiat. Isotop. 29 (1978) 123

1978GA1C Gal, Soper and Dalitz, Ann. Phys. 113 (1978) 79

1978GO1U P.R. Goode and B.R. Barrett, Phys. Rev. C17 (1978) 1848

1978GO22 G. Goldring, K. Hagemeyer, N. Benczer-Koller, Y. Lipshitz, Z. Shkedi and A. Zemel, Hyperfine Interactions 4 (1978) 183

1978GU10 K. Gul, J. Phys. Soc. Jpn. 44 (1978) 353

1978HA10 M. Hamm and K. Nagatani, Phys. Rev. C17 (1978) 586; Erratum Phys.Rev. C17, 2258 (1978)

1978HA2B Hanshaw and Hallett, Science 200 (1978) 1267

1978HE1D Heitzmann, Atomkernenergie 31 (1978) 262

1978HO1C Hodgson, Riv. Nuovo Cim. 1 (1978) 1

1978IV01 S. Iversen, A. Obst, K.K. Seth, H.A. Thiessen, C.L. Morris, N. Tanaka, E. Smith, J.F. Amann, R. Boudrie, G. Burleson et al., Phys. Rev. Lett. 40 (1978) 17

1978JA10 R. Jahn, D.P. Stahel, G.J. Wozniak, R.J. de Meijer and J. Cerny, Phys. Rev. C18 (1978) 9

1978JA13 J. Jansen, J. Zichy, J.P. Albanese, J. Arvieux, J. Bolger, E. Boschitz, C.H.Q. Ingram and L. Pflug, Phys. Lett. B77 (1978) 359

1978JO1C K.P. Joshi, S.C. Gupta, S. Bennikutty and A.N. Mishra, Phys. Rev. C18 (1978) 1924

1978KA23 T. Kammuri, Z. Phys. A287 (1978) 85

1978KO01 D.G. Kovar, W. Henning, B. Zeidman, Y. Eisen, J.R. Erskine, H.T. Fortune, T.R. Ophel, P. Sperr and S.E. Vigdor, Phys. Rev. C17 (1978) 83

1978KO1W Konuma and Oka, Prog. Theor. Phys. 60 (1978) 1073

1978KR1G E.M. Krenciglowa, K. Ando and H. Bando, Nucl. Phys. A301 (1978) 29

1978KU03 K.-i. Kubo and H. Amakawa, Phys. Rev. C17 (1978) 1271

1978LE16 S.Y. Lee, N. Takigawa and C. Marty, Nucl. Phys. A308 (1978) 161

1978LE1T Lefort and Ngo, Ann. Phys. 3 (1978) 5

1978LE1W Lee, Astrophys. J. 224 (1978) 217

1978LE1X Levine, Bull. Amer. Phys. Soc. 23 (1978) 42

1978LE1Y Lee and Miller, Bull. Amer. Phys. Soc. 23 (1978) 935

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

1978LI1F Liu, von Oertzen and Wolter, Proc. Cluster, Winnipeg (1978) F27

1978LU09 C. Lunke, R. Corfu, J.-P. Egger, P. Gretillat, J. Piffaretti, E. Schwarz, J. Jansen, C. Perrin and B.M. Preedom, Phys. Lett. B78 (1978) 201

1978MA13 M. Makowska-Rzeszutko, P. Egelhof, D. Kassen, E. Steffens, W. Weiss, D. Fick, W. Dreves, K.-I. Kubo and T. Suzuki, Phys. Lett. B74 (1978) 187

1978MA2H Mavromatis, Muther and Faessler, Z. Phys. A284 (1978) 195

1978ME14 J. Meyer, R.S. Nahabetian and E. Elbaz, Lett. Nuovo Cim. 22 (1978) 355

1978ME1J Meyer, Nahabetian and Elbaz, Proc., Cluster, Winnipeg (1978) G4

1978ME20 J. Meyer, R.S. Nahabetian and E. Elbaz, J. Phys. Lett. 39 (1978) L-158

1978MO06 I. Morrison, R. Smith, P. Nesci and K. Amos, Phys. Rev. C17 (1978) 1485

1978NO02 R. Novotny, G. Hammer, D. Pelte, H. Emling and D. Schwalm, Nucl. Phys. A294 (1978) 255

1978NO1G Norum et al., Bull. Amer. Phys. Soc. 23 (1978) 960

1978OS02 E. Oset, D. Strottman and G.E. Brown, Phys. Lett. B73 (1978) 393

1978PI10 W.T. Pinkston, M. Vallieres and D.H. Feng, Phys. Rev. C18 (1978) 1011

1978PI1E Pilt, AIP Conf. Proc. 47 (1978) 173

1978PO02 H. Poth, G. Backenstoss, I. Bergstrom, P. Blum, J. Egger, W. Fetscher, R. Guigas, R. Hagelberg, N. Hassler, C.J. Herrlander et al., Nucl. Phys. A294 (1978) 435

1978PO1B Podosek, Ann. Rev. Astron. Astrophys. 16 (1978) 293

1978RI05 S. Riedhauser, Phys. Rev. C18 (1978) 1547

1978RO01 R.G.H. Robertson, E. Kashy, W. Benenson and A. Ledebuhr, Phys. Rev. C17 (1978) 4

1978RO1D Rolfs and Trautvetter, Ann. Rev. Nucl. Part. Sci. 28 (1978) 115

1978RO1M Rozak, Montestruqe and Darden, Bull. Amer. Phys. Soc. 23 (1978) 501

1978RU02 N. Rudra, Nucl. Phys. A312 (1978) 33

1978SA15 T. Sakuda, S. Nagata and F. Nemoto, Prog. Theor. Phys. 59 (1978) 1543

1978SC1G Schiffer, Proc. Int. Conf. Nucl. Struct., Tokyo, (1977), J. Phys. Soc. Jpn. Suppl. 44 (1978) 9

1978SE01 F. Seiler, F.N. Rad, H.E. Conzett and R. Roy, Nucl. Phys. A296 (1978) 205

1978SE07 K.K. Seth, H. Nann, S. Iversen, M. Kaletka, J. Hird and H.A. Thiessen, Phys. Rev. Lett. 41 (1978) 1589

1978SE08 J.C. Sens, S.M. Refaei and A. Pape, Phys. Rev. C18 (1978) 2007

1978SH18 T. Shibata, H. Ejiri, J. Chiba, S. Nagamiya and K. Nakai, Nucl. Phys. A308 (1978) 513

1978SH1B Shlomo, Rept. Prog. Phys. (GB) 41 (1978) 957

1978SM02 Y.F. Smirnov and G.F. Filippov, Yad. Fiz. 27 (1978) 73; Sov. J. Nucl. Phys. 27 (1978) 39

1978SO01 J.P. Sokol and C.P. Browne, Phys. Rev. C17 (1978) 388

1978SP07 D.A. Sparrow and A.S. Rosenthal, Phys. Rev. C18 (1978) 1753

1978SP1D R.H. Spear, T.H. Zabel, D.C. Kean, A.M.R. Joye, A.M. Baxter, M.P. Fewell and S. Hinds, Phys. Lett. B76 (1978) 559

1978SZ03 L. Szybisz, Z. Phys. A285 (1978) 223

1978TA05 S.L. Tabor, D.F. Geesaman, W. Henning, D.G. Kovar, K.E. Rehm and F.W. Prosser, Jr., Phys. Rev. C17 (1978) 2136

1978TA09 T. Takemasa and H. Yoshida, Nucl. Phys. A304 (1978) 229

1978TA15 T. Takemasa, Phys. Rev. C18 (1978) 1677

1978TA1A Tang, Lemere and Thompson, Phys. Rept. 47 (1978) 167

1978TA1U R.E. Taam and R.E. Picklum, Astrophys. J. 224 (1978) 210

1978TR05 H.P. Trautvetter, M. Wiescher, K.-U. Kettner, C. Rolfs and J.W. Hammer, Nucl. Phys. A297 (1978) 489

1978TR1C Truran, Cowan and Cameron, Astrophys. J. 222 (1978) L63

1978TS04 I. Tserruya, Y. Eisen, D. Pelte, A. Gavron, H. Oeschler, D. Berndt and H.L. Harney, Phys. Rev. C18 (1978) 1688

1978VA1A L.C. Vaz and J.M. Alexander, Phys. Rev. C18 (1978) 2152

1978VO06 C. Von Charzewski, V. Hnizdo and C. Toepffer, Nucl. Phys. A307 (1978) 309

1978VO13 C. von Charzewski, V. Hnizdo and C. Toepffer, S. Afr. J. Phys. 1 (1978) 222

1978WI1F Weiland and Highfall, Bull. Amer. Phys. Soc. 23 (1978) 1033

1978WO1C Wolf, Bull. Amer. Phys. Soc. 23 (1978) 1033

1978ZA04 P.C. Zalm and P.J. Brussaard, Z. Phys. A287 (1978) 265

1978ZA1D Zalm, Van Hienen and Glaudemans, Z. Phys. A287 (1978) 255

1979AB1H Abela et al., Conf. Proc. TRIUMF, Vancouver (1979) Paper 1B25

1979AL1J Alster and Warszawski, Phys. Rept. 52 (1979) 87

1979AL22 Y. Alhassid, R.D. Levine, J.S. Karp and S.G. Steadman, Phys. Rev. C20 (1979) 1789

1979AR1M Arima et al., AIP Conf. Proc. 54 (1979) 592

1979BA35 H. Bando, E.M. Krenciglowa and K. Ando, Nucl. Phys. A329 (1979) 109

1979BA52 C.N.M. Bakker and F.M. Kaspersen, Int. J. Appl. Radiat. Isotop. 30 (1979) 61

1979BE1X Berman, Suppl. Preprint UCRL-78482 (1979)

1979BE2L Benkoula et al., Proc. 3rd Symp. on Neutron Capture Gamma Rays, 1978 (1979) 371

1979BE59 G. Bertsch and R. Schaeffer, J. Phys. (Paris) 40 (1979) 1

1979BO22 V.I. Bogatin, O.V. Lozhkin and Y.P. Yakovlev, Nucl. Phys. A326 (1979) 508

1979BR04 H.S. Bradlow, W.D.M. Rae, P.S. Fisher, N.S. Godwin, G. Proudfoot and D. Sinclair, Nucl. Phys. A314 (1979) 207

1979BR17 B.A. Brown, S.E. Massen and P.E. Hodgson, Phys. Lett. B85 (1979) 167

1979BR30 B.A. Brown, S.E. Massen and P.E. Hodgson, J. Phys. (London) G5 (1979) 1655

1979BU12 B. Buck, A.C. Merchant and N. Rowley, Nucl. Phys. A327 (1979) 29

1979CH07 Y.-d. Chan, H. Bohn, R. Vandenbosch, R. Sielemann, J.G. Cramer, K.G. Bernhardt, H.C. Bhang and D.T.C. Chiang, Phys. Rev. Lett. 42 (1979) 687; Erratum Phys. Rev. Lett. 43 (1979) 1625

1979CH1T Chance and Harris, Astron. Astrophys. 74 (1979) 247

1979CHZL D.W.S. Chan and E. Sheldon, Bull. Amer. Phys. Soc. 24 (1979) 760, G4

1979CO09 A. Cortes and A.P. Zuker, Phys. Lett. B84 (1979) 25

1979CO10 M. Conze and P. Manakos, J. Phys. (London) G5 (1979) 671

1979CO1H Corfu et al., AIP Conf. Proc. 54 (1979) 528

1979CO1P Cowley, Mills and Heymann, S. African J. Phys. 2 (1979) 85

1979DA15 B.J. Dalton, W.J. Baldridge and J.P. Vary, Phys. Rev. C20 (1979) 1908

1979DAZK S. Davis, R. Malmin, J. Kolata, S. Tripathi, R. Luhn and P. DeYoung, Bull. Amer. Phys. Soc. 24 (1979) 842, FB3

1979DE18 B. Desplanques and J. Missimer, Phys. Lett. B84 (1979) 363

1979DE31 R.M.DeVries and J.C. Peng, Phys. Rev. Lett. 43 (1979) 1373

1979EN1F England et al., Nucl. Interactions, Canberra, Australia (1979) 470

1979FE06 M.P. Fewell, A.M. Baxter, D.C. Kean, R.H. Spear and T.H. Zabel, Nucl. Phys. A321 (1979) 457

1979FO17 H.T. Fortune, L. Bland, R. Middleton, W. Chung and B.H. Wildenthal, Phys. Lett. B87 (1979) 29

1979GAZV E.N. Gazis, A.C. Xenoulis, P. Kakanis, X. Aslanoglou and A.D. Panagiotou, Bull. Amer. Phys. Soc. 24 (1979) 695, KH10

1979GO1W P.R. Goode, B.R. Barrett and O. Portilho, Phys. Rev. C19 (1979) 542

1979GO1X A.A. Goy, G.M. Vagradov and R.R. Silbar, Phys. Lett. B80 (1979) 335

1979GR18 S.J. Greene, W.J. Braithwaite, D.B. Holtkamp, W.B. Cottingame, C.F. Moore, C.L. Morris, H.A. Thiessen, G.R. Burleson and G.S. Blanpied, Phys. Lett. B88 (1979) 62

1979GU1D Guzik, Bull. Amer. Phys. Soc. 24 (1979) 692

1979HA60 L. Hannappel, H. Henschel and H. Schneider, Nucl. Instrum. Meth. 167 (1979) 289

1979HAYV F. Haas, C. Beck, R.M. Freeman, B. Heusch and J.J. Kolata, Bull. Amer. Phys. Soc. 24 (1979) 851, GB4

1979HAYZ L.H. Harwood and G.M. Crawley, Bull. Amer. Phys. Soc. 24 (1979) 817, AC2

1979HE1D Hering et al., BNL-51115 (1979) 759

1979HE1F K.T. Hecht and W. Zahn, Nucl. Phys. A313 (1979) 77

1979HU1B M.S. Hussein, Phys. Rev. C19 (1979) 807

1979HW01 W-Y.P. Hwang, Phys. Rev. C20 (1979) 331

1979IN1A Ingram, AIP Conf. Proc. 54 (1979) 455

1979IV03 S. Iversen, H. Nann, A. Obst, K.K. Seth, N. Tanaka, C.L. Morris, H.A. Thiessen, K. Boyer, W. Cottingame, C.F. Moore et al., Phys. Lett. B82 (1979) 51

1979JA1M Jacobson, Jonsson and Kritiansson, Astrophys. Space Sci. 63 (1979) 215

1979JA22 L. Jarczyk, B. Kamys, J. Okolowicz, J. Sromicki, A. Strzalkowski, H. Witala, Z. Wrobel, M. Hugi, J. Lang, R. Muller et al., Nucl. Phys. A325 (1979) 510

1979JO08 R.R. Johnson, T. Masterson, B. Bassalleck, W. Gyles, T. Marks, K.L. Erdman, A.W. Thomas, D.R. Gill, E. Rost, J.J. Kraushaar et al., Phys. Rev. Lett. 43 (1979) 844

1979JU1D Jussernad, Compt. Rend. D288 (1979) 1027

1979KA07 S.B. Kaufman, M.W. Weisfield, E.P. Steinberg, B.D. Wilkins and D.J. Henderson, Phys. Rev. C19 (1979) 962

1979KE1B Kerkhove et al., Int. Conf. Nucl. Phys. with Electromag. Interact., Mainz (1979) 4.16

1979KI12 W.E. Kieser, R.E. Azuma, I. Berka, K.P. Jackson, A.B. McDonald, H.B. Mak, and W. McLatchie, Nucl. Phys. A327 (1979) 172

1979KI13 W.E. Kieser, R.E. Azuma and K.P. Jackson, Nucl. Phys. A331 (1979) 155

1979KN1F Knopfle, Proc. Mainz, 1979, Springer Lect. Notes 108 (1979) 311

1979KN1G Knupfer, Ender and Huber, Conf. Proc. TRIUMF, Vancouver (1979) Paper 5A13

1979KO07 W.K. Koo and L.J. Tassie, Nucl. Phys. A315 (1979) 21

1979KO20 D.G. Kovar, D.F. Geesaman, T.H. Braid, Y. Eisen, W. Henning, T.R. Ophel, M. Paul, K.E. Rehm, S.J. Sanders, P. Sperr et al., Phys. Rev. C20 (1979) 1305

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

1979KO28 W.K. Koo, Phys. Lett. B87 (1979) 307

1979KR07 S.J. Krieger and K.T.R. Davies, Phys. Rev. C20 (1979) 167

1979KU04 C.L. Kung, T.T.S. Kuo and K.F. Ratcliff, Phys. Rev. C19 (1979) 1063

1979LA16 S. Landowne and H.H. Wolter, Phys. Rev. Lett. 43 (1979) 1233

1979LA1H Lazareff, Audouze, Starrfield and Truran, Astrophys. J. 228 (1979) 875

1979LE1F Lee, Schramm, Wefel and Blake, Astrophys. J. 232 (1979) 854

1979LE1L Lewis and Perkins, IEEE Trans. on Nucl. Sci. 26 (1979) 1818

1979LE1Q Lee et al., AIP Conf. Proc. 54 (1979) 600, 603

1979LE1R M. LeMere, E.J. Kanellopoulos, W. Sunkel and Y.C. Tang, Phys. Lett. B87 (1979) 311

1979LOZK W.A. Lone and W.M. Inglis, Proc. Int. Symp. Neutron Capture Gamma Ray Spectroscopy and Related Topics, 3rd, BNL, Upton, NY, 1978; Eds., R.E. Chrien and W.R. Kane (1979) 678

1979LU09 C. Lunke, R. Corfu, J.-P. Egger, P. Gretillat, J. Piffaretti, E. Schwarz, J. Jansen, C. Perrin and B. Preedom, Helv. Phys. Acta 52 (1979) 417

1979MA1T Makowska-Rzeszutko, Nukleonika 24 (1979) 495

1979MA2Q Macarthur and Mak, IEEE Trans. on Nucl. Sci. 26 (1979) 1220

1979ME04 M.C. Mermaz, M.A.G. Fernandes, A. Greiner, B.T. Kim and N. Lisbona, Phys. Rev. C19 (1979) 794

1979ME12 M.C. Mermaz, A. Greiner, B.T. Kim, M.A.G. Fernandes, N. Lisbona, E. Muller, W. Chung and B.H. Wildenthal, Phys. Rev. C20 (1979) 2130

1979MI09 H. Miska, B. Norum, M.V. Hynes, W. Bertozzi, S. Kowalski, F.N. Rad, C.P. Sargent, T. Sasanuma and B.L. Berman, Phys. Lett. B83 (1979) 165

1979MO2C Morrison and Amos, AIP Conf. Proc. 54 (1979) 265

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

1979NA03 K. Nagatani and J.C. Peng, Phys. Rev. C19 (1979) 747

1979NA06 A. Nadasen, T.A. Carey, P.G. Roos, N.S. Chant, C.W. Wang and H.L. Chen, Phys. Rev. C19 (1979) 2099

1979NI1B Nishioka and Saito, Private Communication (1979)

1979OR01 M.E. Ortiz, A. Dacal, A. Menchaca-Rocha, M. Buenerd, D.L. Hendrie, J. Mahoney, C. Olmer and D.K. Scott, Phys. Lett. B84 (1979) 63

1979OS05 E. Oset and D. Strottman, Phys. Lett. B84 (1979) 396

1979PE1C Perroud, 1978 RPI Symp., Photopion Nucl. Phys. (1979) 69

1979PE1E Penzias, Rev. Mod. Phys. 51 (1979) 425

1979PI01 A.A. Pilt, M.A.M. Shahabuddin and J.A. Kuehner, Phys. Rev. C19 (1979) 20

1979PI10 W.T. Pinkston and P.J. Iano, Nucl. Phys. A330 (1979) 91

1979PO08 E.C. Pollacco, C. Garrett and D.C. Weisser, Phys. Rev. C19 (1979) 2073

1979PO1G Popa, Stud. Cerc. Fiz. 31 (1979) 137

1979RA10 Rae et al., Nucl. Phys. A319 (1979) 239

1979RA21 R. Rascher, W.F.J. Muller and K.P. Lieb, Phys. Rev. C20 (1979) 1028

1979RO1A Robert, Merlivat and Javoy, Nature 282 (1979) 785

1979SA27 G.R. Satchler, Nucl. Phys. A329 (1979) 233

1979SA31 T. Sakuda, S. Nagata and F. Nemoto, Prog. Theor. Phys. Suppl. 65 (1979) 111

1979SE04 F. Seiler and H.W. Roser, Nucl. Phys. A315 (1979) 45

1979SE08 K.K. Seth, S. Iversen, H. Nann, M. Kaletka, J. Hird and H.A. Thiessen, Phys. Rev. Lett. 43 (1979) 1574

1979ST21 E.J. Stephenson, B.P. Hichwa and J.D. Hutton, Nucl. Phys. A331 (1979) 269

1979SU1F Suzuki and Kubo, Tsukuba Symp. on Polarization Phenomena, Nov. 1979; Ed., K. Yagi (1979) 211

1979TH05 J.E.M. Thomson and M.N. Thompson, Nucl. Phys. A330 (1979) 66

1979TO1A Tonsfeldt, Clegg and Ludwig, Bull. Amer. Phys. Soc. 24 (1979) 652

1979TU1A Tucker, Kutner and Massano, Astrophys. J. 227 (1979) L143

1979TU1B Tungate and Fick, Microscopic Optical Potentials, Hamburg, Germany (1979) 404

1979VI05 A. Vidal-Quadras and M. Ortega, Nuovo Cim. A49 (1979) 235

1979VI09 J.B. Viano, A.J. Cole, N. Longequeue, J.J. Lucas, J. Menet, J.C. Saulnier and J.W. Sunier, Phys. Rev. C20 (1979) 551

1979WI1G Wieland, Highfall and King, IEEE Trans. on Nucl. Sci. 26 (1979) 1713

1979WI1Q Wildenthal and Chung, MSUCL-319 (Sept. 1979), Proc. Conf. on “The (p, n) Reaction and the Nucleon-Nucleon Force”, Colorado (1979)

1979WO04 J.G. Woodworth, K.G. McNeill, J.W. Jury, R.A. Alvarez, B.L. Berman, D.D. Paul and P. Meyer, Phys. Rev. C19 (1979) 1667

1979WO07 S.E. Woosley, W.A. Fowler, J.A. Holmes and B.A. Zimmerman, At. Data Nucl. Data Tables 22 (1978) 371

1979WU06 G. Wunner, Nucl. Phys. A318 (1979) 304

1979ZA07 J.G. Zabolitzk and, W. Ey, Nucl. Phys. A328 (1979) 507

1980AJ01 F. Ajzenberg-Selove and C.L. Busch, Nucl. Phys. A336 (1980) 1

1980AN17 E.J. Ansaldo, Phys. Rev. C22 (1980) 915

1980AN18 E.J. Ansaldo, C. Rangacharyulu, D. Bender, U. Kramer, A. Richter, E. Spamer and W. Knupfer, Phys. Lett. B95 (1980) 31

1980AN31 M.A. Ansari and M.L. Sergal, Lett. Nuovo Cim. 29 (1980) 350

1980AR1E J. Arvieux, Nucl. Phys. A335 (1980) 353

1980AS1A D. Ashery, Nucl. Phys. A335 (1980) 385

1980AY01 T. Aytimur and J.P. Svenne, Can. J. Phys. 58 (1980) 1026

1980BA1T Bar-Touv and Moalem, Proc. Int. Conf. on Nucl. Phys., Berkeley (1980) 782

1980BA2K Barashencov and Musulmanbecov, Z. Phys. A296 (1980) 371

1980BA36 G. Backenstoss, W. Kowald, I. Schwanner, L. Tauscher, H.J. Weyer, D. Gotta and R. Guigas, Phys. Lett. B95 (1980) 212

1980BE15 F.D. Becchetti, K.T. Hecht, J. Janecke, D. Overway and G. Kekelis, Nucl. Phys. A339 (1980) 132

1980BI11 P.G. Bizzeti, T.F. Fazzini, P.R. Maurenzig, A. Perego, G. Poggi, P. Sona and N. Taccetti, Lett. Nuovo Cim. 29 (1980) 167

1980BO21 K. Bodek, M. Hugi, L. Jarczyk, B. Kamys, J. Lang, R. Muller, M. Porebska, J. Sromicki, A. Strzalkowski, E. Ungricht et al., J. Phys. (London) G6 (1980) 1017

1980BR08 B.A. Brown and B.H. Wildenthal, Phys. Rev. C21 (1980) 2107

1980BR09 B.A. Brown, W. Chung and B.H. Wildenthal, Phys. Rev. C21 (1980) 2600

1980BR13 B.A. Brown, W. Chung and B.H. Wildenthal, Phys. Rev. C22 (1980) 774

1980BR21 B.A. Brown, W.A. Richter and N.S. Godwin, Phys. Rev. Lett. 45 (1980) 1681

1980CH1J Choudhury, Govil, Kapoor and Ramamurthy, Proc. Int. Conf. on Nucl. Phys., Berkeley (1980) 573

1980CL1B Clayton, Nukleonika 25 (1980) 1477, 1491

1980CO1U Corcalciuc, Stud. Cercet. Fiz. 32 (1980) 1135, 1166

1980DE05 J.M. Delbrouck-Habaru and G. Robaye, Nucl. Phys. A337 (1980) 107

1980DE1F B. Desplanques, Nucl. Phys. A335 (1980) 147

1980DE24 J.P. Dedonder, J.P. Maillet and C. Schmit, Ann. Phys. 127 (1980) 1

1980DO1E Dover and Gal, Proc. Int. Conf. on Nucl. Phys., Berkeley (1980) 795

1980EV1A Evans et al., Bull. Amer. Phys. Soc. 25 (1980) 745

1980FA06 E. Fabrici, S. Micheletti, M. Pignanelli, F.G. Resmini, R. De Leo, G. D'Erasmo, A. Pantaleo, J.L. Escudie and A. Tarrats, Phys. Rev. C21 (1980) 830

1980FA07 E. Fabrici, S. Micheletti, M. Pignanelli, F.G. Resmini, R. De Leo, G. D'Erasmo and A. Pantaleo, Phys. Rev. C21 (11980) 844

1980FR09 E. Friedman and A. Gal, Nucl. Phys. A345 (1980) 457

1980FU06 B.R. Fulton and T.M. Cormier, Phys. Lett. B97 (1980) 209

1980GE09 W.J. Gerace, M.M. Sternheim, K. Yoo and D.A. Sparrow, Phys. Rev. C22 (1980) 2497

1980GO01 F.L. Goodin and P.J. Ellis, Nucl. Phys. A334 (1980) 229

1980GR15 P. Grabmayr, J. Rapaport and R.W. Finlay, Nucl. Phys. A350 (1980) 167

1980HA14 K. Hatanaka, K. Imai, S. Kobayashi, T. Matsusue, M. Nakamura, K. Nisimura, T. Noro, H. Sakamoto, H. Shimizu and J. Shirai, Nucl. Phys. A340 (1980) 93

1980HA41 W.C. Haxton, B.F. Gibson and E.M. Henley, Phys. Rev. Lett. 45 (1980) 1677

1980HE06 J.C.P. Heggie, Z.E. Switkowski and G.J. Clark, Nucl. Instrum. Meth. Phys. Res. 168 (1980) 125

1980HU1D Hugg and Hanna, Proc. Int. Conf. on Nucl. Phys., Berkeley (1980) 891

1980HU1J Hugg and Hanna, Polarization, Santa Fe (1980) 294

1980JO06 M.B. Johnson, Phys. Rev. C22 (1980) 192

1980KA1L B. Karaoglu, T. Karapiperis and E.J. Moniz, Phys. Rev. C22 (1980) 1806

1980KE05 J. Keinonen, H.-B. Mak, P. Skensved, J.R. Leslie and W.M. McLatchie, Phys. Rev. C22 (1980) 351

1980KE1C Kelly et al., Bull. Amer. Phys. Soc. 25 (1980) 575

1980KO02 J.J. Kolata, R.M. Freeman, F. Hass, B. Heusch and A. Gallmann, Phys. Rev. C21 (1980) 579

1980KO1L Kostin, Koval, Kopanets and Tsytko, Ukr. Fiz. Zh. 25 (1980) 881

1980KRZX L. Kraus, I. Linck, A. Poves and J.C. Sens, Proc. Int. Conf. on Nucl. Phys., Berkeley (1980) 135

1980KU05 T.T.S. Kuo and E. Osnes, J. Phys. (London) G6 (1980) 335

1980KU1H Kudo and Tanaka, J. Chem. Phys. 72 (1980) 3049, 3052

1980LA1K Lass and Schweikert, Bull. Amer. Phys. Soc. 25 (1980) 783

1980LE04 T.-S.H. Lee and R.D. Lawson, Phys. Rev. C21 (1980) 679

1980LE11 S.M. Lee, T. Matsuse and A. Arima, Phys. Rev. Lett. 45 (1980) 165

1980LE21 M. Lemere, Y.C. Tang, E.J. Kanellopoulos and W. Sunkel, Nucl. Phys. A348 (1980) 321

1980LI1H Liu, We, Hwang and Li, Proc. Int. Conf. on Nucl. Phys., Berkeley (1980) 688

1980LI1L Liu et al., Phys. Energ. Fortis Phys. Nucl. (China) 4 (1980) 394

1980LO02 M. Lozano and G. Madurga, Phys. Lett. B90 (1980) 50

1980LO1B Lowry, Bennett and Krien, Bull. Amer. Phys. Soc. 25 (1980) 486

1980MA10 G. Mairle, K.T. Knopfle, H. Riedesel, G.J. Wagner, V. Bechtold and L. Friedrich, Nucl. Phys. A339 (1980) 61

1980MA18 C.P. Malta, J. Phys. (London) G6 (1980) 593

1980MA26 H.-B. Mak, G.T. Ewan, H.C. Evans, J.D. MacArthur, W. McLatchie and R.E. Azuma, Nucl. Phys. A343 (1980) 79

1980MC1G McCutcheon, Dickman, Shuter and Roger, Astrophys. J. 237 (1980) 9

1980MI1B Mikumo, UTTAC-28 (1979); NSSRO-26

1980MI1G D.J. Millener, Phys. Rev. C22 (1980) 1355

1980MO05 I. Morrison, Phys. Lett. B91 (1980) 4

1980NA10 I. Navon, E. Piasetzky, D. Ashery, A. Altman, G. Azuelos and F.W. Schleputz, Phys. Lett. B95 (1980) 365

1980NA14 F. Naulin, C. Detraz, M. Bernas, D. Guillemaud, E. Kashy, M. Langevin, F. Pougheon, P. Roussel and M. Roy-Stephan, J. Phys. Lett. 41 (1980) L79

1980NA1D Nann, Proc. Int. Conf. At. Masses and Fund. Constants; Eds., Nolen and Benenson (1980) 51

1980NE05 B. Neumann, H. Rebel, J. Buschmann, H.J. Gils, H. Klewe-Nebenius and S. Zagromski, Z. Phys. A296 (1980) 113

1980OK01 M. Oka and K. Kubodera, Phys. Lett. B90 (1980) 45

1980OLZW D.L. Olson, B.L. Berman, D.E. Greiner, H.H. Heckman, P.J. Lindstrom, G.D. Westfall and H.J. Crawford, Proc. Int. Conf. on Nucl. Phys., Berkeley (1980) 220

1980PE1F Penzias, Science 208 (1980) 663

1980PR09 G. Proudfoot, H.S. Bradlow, P.S. Fisher, N.S. Godwin, J. King, D. Sinclair and W.D.M. Rae, Nucl. Phys. A345 (1980) 278

1980PR1A Pruim and Knutson, Bull. Amer. Phys. Soc. 25 (1980) 555

1980PY01 R.E. Pywell, M.N. Thompson and B.L. Berman, Nucl. Instrum. Meth. Phys. Res. 178 (1980) 149

1980RA1F Racca et al., Bull. Amer. Phys. Soc. 25 (1980) 733

1980RE1B Read et al., Bull. Amer. Phys. Soc. 25 (1980) 592

1980RO19 N. Rowley and A.C. Merchant, Phys. Lett. B97 (1980) 341

1980SA04 A.N. Saharia and R.M. Woloshyn, Phys. Rev. C21 (1980) 1111

1980SA1L Sato et al., Proc. Int. Conf. on Nucl. Phys., Berkeley (1980) 536

1980SC24 I. Schwanner, R. Abela, G. Backenstoss, W. Kowald, P. Pavlopoulos, L. Tauscher, H.J. Weyer, P. Blum, M. Dorr, W. Fetscher et al., Phys. Lett. B96 (1980) 268

1980SH1K Shurpin, Kuo and Strottman, Proc. Int. Conf. on Nucl. Phys., Berkeley (1980) 20

1980SI1G Siegenthaler and Oeschger, Nature 285 (1980) 314

1980SK1A Skrzypczak et al., Proc. Int. Conf. on Nucl. Phys., Berkeley (1980) 575

1980SP1B Spulak, Astrophys. J. 235 (1980) 565

1980TA1L Tadic, Rept. Prog. Phys. 43 (1980) 67

1980TH01 H.A. Thiessen, Nucl. Phys. A335 (1980) 329

1980TR02 H.-J. Trost, A. Schwarz, U. Feindt, F.H. Heimlich, S. Heinzel, J. Hintze, F. Korber, R. Lekebusch, P. Lezoch, G. Mock et al., Nucl. Phys. A337 (1980) 377

1980VA03 R. Vandenbosch, Nucl. Phys. A339 (1980) 167

1980WA1M Wannier, Ann. Rev. Astro. Astrophys. 18 (1980) 399

1980WI09 J.P. Wieleczko, S. Harar, M. Conjeaud and F. Saint-Laurent, Phys. Lett. B93 (1980) 35

1980WI1K L. Winsberg, E.P. Steinberg, D. Henderson and A. Chrapkowski, Phys. Rev. C22 (1980) 2108

1980WI1L L. Winsberg, Phys. Rev. C22 (1980) 2123

1980YA08 M. Yagi and R. Amano, Int. J. Appl. Radiat. Isot. 31 (1980) 559

1980ZH01 M.V. Zhukov, D.H. Feng, Cheng-li Wu and J. Bang, Phys. Scr. 22 (1980) 426

1981AD01 E.G. Adelberger, C.D. Hoyle, H.E. Swanson and R.D. Von Lintig, Phys. Rev. Lett. 46 (1981) 695

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

1981AD1E Adelberger, Santa Fe 1980, AIP Conf. Proc. 69 (1981) 1367

1981AJ01 F. Ajzenberg-Selove, Nucl. Phys. A360 (1981) 1

1981AO01 K. Aoki and H. Horiuchi, Prog. Theor. Phys. 66 (1981) 1508

1981AR1D A. Arima, Nucl. Phys. A354 (1981) 19

1981AV02 I.K. Averyanov, A.I. Golubev and A.A. Sadovoy, Yad. Fiz. 33 (1981) 66

1981BA04 J. Bar-Touv and A. Moalem, Nucl. Phys. A351 (1981) 285

1981BA1G Basak et al., Santa Fe 1980, AIP Conf. Proc. 69 (1981) 593

1981BA1H Bart et al., Bull. Amer. Phys. Soc. 26 (1981) 605

1981BE2N W. Becker, W.H. Louisell, J.D. McCullen and M.O. Scully, Phys. Rev. Lett. 47 (1981) 1262

1981BE31 A.M. Bernstein, V.R. Brown and V.A. Madsen, Phys. Lett. B103 (1981) 255

1981BI03 M. Bini, P.G. Bizzeti and P. Sona, Phys. Rev. C23 (1981) 1265

1981BL1J Blake, Woosley, Weaver and Schramm, Astrophys. J. 428 (1981) 315

1981BOZY T.J. Bowles, J. Browne, P. Lisowski and M. Stelts, Bull. Amer. Phys. Soc. 26 (1981) 568, DI1

1981BU1B Burk and Stuiver, Science 211 (1981) 1417

1981CA09 O. Castanos and A. Frank, J. Phys. (London) G7 (1981) 1483

1981CA1E Carter et al., S. African J. Phys. 4 (1981) 13

1981CH24 H.-T. Chen, Phys. Rev. Lett. 47 (1981) 1382

1981CL1C Clement et al., Santa Fe 1980, AIP Conf. Proc. 69 (1981) 579

1981CO13 M.E. Cobern, L.C. Bland, H.T. Fortune, G.E. Moore, S. Mordechai and R. Middleton, Phys. Rev. C23 (1981) 2387

1981CO15 J. Cook and R.J. Griffiths, Nucl. Phys. A366 (1981) 27

1981CU07 A. Cunsolo, A. Foti, G. Imme, G. Pappalardo, G. Raciti and N. Saunier, Phys. Rev. C24 (1981) 476

1981DEZE L.C. Dennis, K.M. Abdo, A.D. Frawley and K.W. Kemper, Bull. Amer. Phys. Soc. 26 (1981) 1236, HE15

1981DEZW L.C. Dennis, K. Abdo, A.D. Frawley and K.W. Kemper, Bull. Amer. Phys. Soc. 26 (1981) 554, BI10

1981DI1C Divadeenam and Garg, Bull. Amer. Phys. Soc. 26 (1981) 1138

1981EL1D J.P. Elliot and J.A. Evans, Phys. Lett. B101 (1981) 216

1981EN1A Entezami, Dhuga, Karban, Nelson and Roman, Santa Fe 1980, AIP Conf. Proc. 69 (1981) 688

1981ER03 M. Erculisse, J. Phys. (London) G7 (1981) 951

1981FR17 E. Friedman, Phys. Lett. B104 (1981) 357

1981FR1C Frick et al., Santa Fe 1980, AIP Conf. Proc. 69 (1981) 473

1981GL1B Glashausser et al., Proc. Versailles Conf. (1981) 156

1981GO11 N.S. Godwin, W.D.M. Rae, B. Cooke, A. Etchegoyen, N.J. Eyre, P.S. Fisher, G. Proudfoot and D. Sinclair, Nucl. Phys. A363 (1981) 493

1981GOZY A. Gokmen, H. Breuer, B.G. Glagola, A.C. Mignerey, K. Kwiatkowski and V.E. Viola, Bull. Amer. Phys. Soc. 26 (1981) 580, EG9

1981GR06 S.M. Grimes and S.D. Bloom, Phys. Rev. C23 (1981) 1259

1981GR08 K. Grotowski, P. Belery, Th. Delbar, Y. El Masri, Gh. Gregoire, R. Janssens, J. Vervier, G. Paic, M. Albinska, J. Albinski et al., Phys. Rev. C23 (1981) 2513

1981GU1D Guzik, Astrophys. J. 244 (1981) 695

1981HA06 W.C. Haxton, Phys. Rev. Lett. 46 (1981) 698

1981HA18 F. Haas and Y. Abe, Phys. Rev. Lett. 46 (1981) 1667

1981HA1H Haeberli, Santa Fe 1980, AIP Conf. Proc. (1981) 1340

1981HA1Q Haxton, Proc. Versailles Conf. (1981) 481

1981HEZW B. Heusch, C. Beck, J.P. Coffin, P. Engelstein, R.M. Freeman, G. Guillaume, F. Haas and P. Wagner, Bull. Amer. Phys. Soc. 26 (1981) 1132, CB6

1981JA09 L. Jarczyk, B. Kamys, A. Magiera, J. Sromicki, A. Strzalkowski, G. Willim, Z. Wrobel, D. Balzer, K. Bodek, M. Hugi et al., Nucl. Phys. A369 (1981) 191

1981JAZV J. Janecke, E.H.L. Aarts, A.G. Drentje, Y. Iwasaki, R.V.F. Janssens and L.W. Put, Bull. Amer. Phys. Soc. 26 (1981) 1126, BD3

1981JO1D Jolivette, Bull. Amer. Phys. Soc. 26 (1981) 1126

1981KA1N Kaletka et al., Proc. Versailles Conf. (1981) 300

1981KA21 J.E. Kammeraad and L.D. Knutson, Nucl. Phys. A365 (1981) 237

1981KE04 J. Keinonen, H.-B. Mak, T.K. Alexander, G.C. Ball, W.G. Davies, J.S. Forster and I.V. Mitchell, Phys. Rev. C23 (1981) 2073

1981KE1B Kelly et al., Bull. Amer. Phys. Soc. 26 (1981) 606

1981KI04 Yu.V. Kirichenko, V.Yu. Gonchar, E.V. Inopin and V.N. Tarasov, Ukr. Fiz. Zh. 26 (181) 904

1981KR1K Kraus and Linck, LYCEN 8101 (1981)

1981LA16 K. Langanke, Phys. Lett. B104 (1981) 429

1981LA1G K. Langanke, R. Stademann and W. Timm, Phys. Rev. C24 (1981) 1023

1981LE1H Lewis et al., Santa Fe 1980, AIP Conf. Proc. 69 (1981) 590

1981LI04 G.-L. Li, C.-H. Li and T.-S.H. Lee, Phys. Lett. B99 (1981) 200

1981LI1J Liu, Bull. Amer. Phys. Soc. 26 (1981) 567

1981LI1L Liu, Proc. Versailles Conf. (191) 285

1981LI1M Liu and Li, Proc. Versailles Conf. (191) 286

1981LI1Q Li, Wu, Huang and Li, Phys. Energ. Fortis Phys. Nucl. (China) 5 (1981) 157

1981LI1W Liu, Wu, Huang and Li, Sci. Sin. 24 (1981) 789

1981LI23 P.W. Lisowski, R.C. Byrd, G. Mack, W. Tornow, R.L. Walter, T.B. Clegg and F.D. Santos, Phys. Rev. C24 (1981) 1852

1981MA14 G. Mairle, G.J. Wagner, K.T. Knopfle, Ken Pao Liu, H. Riedesel, V. Bechtold and L. Friedrich, Nucl. Phys. A363 (1981) 413

1981MA16 A. Malinovski, J. Coustham and H. Glattli, Nucl. Phys. A365 (1981) 103

1981MA26 V.S. Mathur and R. Prasad, J.Phys. (London) G7 (1981) 1455

1981MA27 M. May, H. Piekarz, R.E. Chrien, S. Chen, D. Maurizio, H. Palevsky, R. Sutter, Y.Xu, P. Barnes, B. Bassalleck et al., Phys. Rev. Lett. 47 (1981) 1106

1981ME1E Meyer and Elbaz, Santa Fe 1980, AIP Conf. Proc. 69 (1981) 1091

1981ME1F Meyer and Elbaz, Santa Fe 1980, AIP Conf. Proc. 69 (1981) 1083

1981MI09 G.A. Miller, Phys.Rev. C24 (1981) 221

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

1981NE09 A.V. Nero, E.G. Adelberger and F.S. Dietrich, Phys. Rev. C24 (1981) 1864

1981NI03 T. Nishi, I. Fujiwara, N. Imanishi, H. Moriyama, K. Otozai, R. Arakawa, S. Saito, T. Tsuneyoshi, N. Takahashi, S. Iwata et al., Nucl. Phys. A352 (1981) 461

1981NO1B Northcliffe, Cornelius, York and Hiebert, Santa Fe 1980, AIP Conf. Proc. 69 (1981) 1335

1981OS1D Osman and Youssef, Santa Fe 1980, AIP Conf. Proc. 69 (1981) 1094

1981OS1F Oset and Strottman, Proc. Versailles Conf. (1981) 287

1981PE1C F. Petrovich and W.G. Love, Nucl. Phys. A354 (1981) 499

1981PE1F Penzias, Astrophys. J. 249 (1981) 518

1981PI11 M. Pignanelli, H.V. von Geramb and R. de Leo, Phys. Rev. C24 (1981) 369

1981PO05 D. Pocanic, G. Vourvopoulos, X. Aslanoglou and E. Holub, J. Phys. (London) G7 (1981) 389

1981RAZN R.A. Racca, F.W. Prosser, Jr., K. Daneshvar, C.N. Davids and D.G. Kovar, Bull. Amer. Phys. Soc. 26 (1981) 1132, CB11

1981RI1A Richter, Nucl. Struct., NATO B67 (1981) 241

1981SC13 J. Schwenzel, K. Glasner, P. Niermann and E. Kuhlmann, Nucl. Phys. A367 (1981) 145

1981SEZR K.K. Seth, Proc. Int. Conf. on Nucl. Far from Stability, Helsingor, Denmark, Vol. 2 (1981) 655; CERN 81-09 (1981)

1981SH17 V.R. Shaginyan, Yad. Fiz. 33 (1981) 1473; Sov. J. Nucl. Phys. 33 (1981) 790

1981SI1B I. Sick, Nucl. Phys. A354 (1981) 37

1981SO03 H.M. Sommermann, H. Muther, K.C. Tam, T.T.S. Kuo and A. Faessler, Phys. Rev. C23 (1981) 1765

1981SP07 R.H. Spear, Phys. Rept. 73 (1981) 369

1981ST21 A.E. Stuchbery, C.G. Ryan and H.H. Bolotin, J. Phys. Soc. Jpn. 50 (1981) 2804

1981TA16 S.L. Tabor, L.C. Dennis, K.W. Kemper, J.D. Fox, K. Abdo, G. Neuschaefer, D.G. Kovar and H. Ernst, Phys. Rev. C24 (1981) 960

1981TH1B A.W. Thomas, Nucl. Phys. A354 (1981) 51

1981TO1G Tonsfeldt, Clegg, Ludwig and Wilkerson, Santa Fe 1980, AIP Conf. Proc. 691 (1981) 961

1981WA1R Waltham et al., Private Communication (1981)

1981WE1F Wefel, Schramm, Blake and Pridmore-Brown, Astrophys. J. 45 (1981) 565

1981WI1D M.E. Wiedenbeck and D.E. Greiner, Phys. Rev. Lett. 46 (1981) 682

1981WI1G Wilson, Langer and Goldsmith, Astrophys. J. 243 (1981) L47

1981WO1B Woosley and Weaver, Astrophys. J. 243 (1981) 651

1981WUZZ M.W. Wu, M.S. Chiou, N. Easwar and J.V. Maher, Bull. Amer. Phys. Soc. 26 (1981) 1222, FD10

1982AJ01 F. Ajzenberg-Selove, Nucl. Phys. A375 (1982) 1

1982AOZZ Y. Aoki, E.J. Ludwig, T.B. Clegg, R.E. Anderson, R.L. Varner and B.L. Burks, Bull. Amer. Phys. Soc. 27 (1982) 560, HXa4

1982AR1F Artemov et al., in Kiev (1982) 323

1982BA03 K. Bangert, U.E.P. Berg, G. Junghans, R. Stock and K. Wienhard, Nucl. Phys. A376 (1982) 15

1982BA06 G.C. Ball, T.K. Alexander, W.G. Davies, J.S. Forster and I.V. Mitchell, Nucl. Phys. A377 (1982) 268

1982BA1R P.D. Barnes, Nucl. Phys. A374 (1982) 415

1982BE1J W. Bertozzi, Nucl. Phys. A374 (1982) 109

1982CH05 J.L. Charvet, R. Dayras, J.M. Fieni, S. Joly and J.L. Uzureau, Nucl. Phys. A376 (1982) 292

1982DA07 C.H. Dasso, T.S. Dumitrescu and A. Vitturi, Nucl. Phys. A378 (1982) 100

1982DAZZ W.W. Daehnick, A.M. Hernandez, J.M. Niedra, A. El Ganayni and J.H. Chan, Bull. Amer. Phys. Soc. 27 (1982) 492, DXa3

1982DE1K D. Dehnhard, Nucl. Phys. A374 (1982) 377

1982FI1C E. Fiorini, Nucl. Phys. A374 (1982) 577

1982GA1D Gai et al., Europhys. Study Conf. on Nucl. Struct., Greece (1982)

1982GR02 S.J. Greene, D.B. Holtkamp, W.B. Cottingame, C.F. Moore, G.R. Burleson, C.L. Morris, H.A. Thiessen and H.T. Fortune, Phys. Rev. C25 (1982) 924

1982GR1F S.J. Greene, W.J. Braithwaite, D.B. Holtkamp, W.B. Cottingame, C.F. Moore, G.R. Burleson, G.S. Blanpied, A.J. Viescas, G.H. Daw, C.L. Morris et al., Phys. Rev. C25 (1982) 927

1982GRZZ S.J. Greene, W.B. Cottingame, G.R. Burleson, C.L. Morris, D.B. Holtkamp, L.C. Bland, H.T. Fortune, R. Gilman and C.F. Moore, Bull. Amer. Phys. Soc. 27 (1982) 467, BF6

1982IN1A C.H.Q. Ingram, Nucl. Phys. A374 (1982) 319

1982KI02 M.M. King Yen, S.T. Hsieh, H.C. Chiang and D.S. Chuu, J. Phys. (London) G8 (1982) 245

1982LA02 S. Landowne, R. Schlicher and H.H. Wolter, Nucl. Phys. A373 (1982) 141

1982LA04 K. Langanke, Nucl. Phys. A373 (1982) 493

1982LA26 J. Lange, K. Kumar and J.H. Hamilton, Rev. Mod. Phys. 54 (1982) 119

1982MA1H Mazitov, Radiok and Rasulov, in Kiev (1982) 309

1982NA03 R.C. Nayak, Phys. Rev. C25 (1982) 1034

1982NA04 F. Naulin, C. Detraz, M. Roy-Stephan, M. Bernas, J. de Boer, D. Guillemaud, M. Langevin, F. Pougheon and P. Roussel, Phys. Rev. C25 (1982) 1074

1982NO04 B.E. Norum, M.V. Hynes, H. Miska, W. Bertozzi, J. Kelly, S. Kowalski, F.N. Rad, C.P. Sargent, T. Sasanuma, W. Turchinetz et al., Phys. Rev. C25 (1982) 1778

1982OL01 J.W. Olness, E.K. Warburton, D.E. Alburger, C.J. Lister and D.J. Millener, Nucl. Phys. A373 (1982) 13

1982PI1B Piilonen and Calaprice, Bull. Amer. Phys. Soc. 27 (1982) 491

1982RI1B A. Richter, Nucl. Phys. A374 (1982) 177

1982SEZZ S.J. Seestrom-Morris, C.L. Morris, D. Dehnhard, C. Blilie, D. Gay, D.B. Holtkamp and H.T. Fortune, Bull. Amer. Phys. Soc. 27 (1982) 467, BF1

1982TH1C A.W. Thomas, Nucl. Phys. A374 (1982) 401

1982YA1A A.I. Yavin, Nucl. Phys. A374 (1982) 297

1982ZH1D Zhukov, Gomez and Bang, in Kiev (1982) 229