

Energy Levels of Light Nuclei $A = 18$

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Abstract: An evaluation of $A = 18-20$ was published in *Nuclear Physics A392* (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.

(References closed May 1, 1982)

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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 $^{16}\text{Be} + 2n$, $^{15}\text{Be} + 3n$, $^{14}\text{Be} + 4n$, $^{13}\text{Be} + 5n$, $^{12}\text{Be} + 6n$, $^{11}\text{Be} + 7n$ and $^{10}\text{Be} + 8n$ 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 $^{17}\text{B} + n$ by 1.4 MeV (1976JA23).

^{18}C

(Not illustrated)

The mass of ^{18}C has been determined in studies of the $^{18}\text{O}(\pi^-, \pi^+)^{18}\text{C}$ reaction at $E_\pi = 164$ MeV (1978SE07) and of the $^{48}\text{Ca}(^{18}\text{O}, ^{48}\text{Ti})^{18}\text{C}$ 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 $^{17}\text{C} + n$ and 4.94 MeV for $^{16}\text{C} + 2n$. [For masses of ^{16}C , ^{17}C see (1982AJ01)]. For the earlier work on ^{18}C see (1978AJ03). See also (1980NA1D, 1981SE1B) 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 $^{14}\text{C}(^{18}\text{O}, ^{14}\text{N})^{18}\text{N}$ and $^{18}\text{O}(t, ^3\text{He})^{18}\text{N}$ 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. $^{18}\text{N}(\beta^-)^{18}\text{O}$

$$Q_m = 14.03$$

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).

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

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 (1980KR1E; prelim.).

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

At $E(^{18}\text{O}) = 92.2$ MeV two groups are observed with differential cross sections of 16.5 and $3.3 \mu\text{b}/\text{sr}$ at $\theta_{\text{c.m.}} \approx 6^\circ$, 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).

$$4. \ ^{18}\text{O}(\pi^-, \gamma)^{18}\text{N} \quad Q_m = 125.53$$

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

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

See (1978AJ03).

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

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

GENERAL: (See also (1978AJ03).)

Shell model: (1977AN1P, 1977GR16, 1977SO1C, 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, 1979CH1X, 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, 1978WO1E, 1979CH1T, 1979GU1D, 1979JA1M, 1979LA1H, 1979LE1F, 1979PE1E, 1979RO1A, 1979TU1A, 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, 1980OL1C, 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, 1979MO2C, 1979OS05, 1979SE08, 1980AR1E, 1980AS1A, 1980BR08, 1980BR09, 1980DE24, 1980FR09, 1980GE09, 1980JO06, 1980KA1L, 1980LE04, 1980LI1H, 1980LI1L, 1980LU1D, 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 \pm 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 \pm keV)	$J^\pi; T$	τ_m^b or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
6.3513 \pm 0.6	(2 ⁻)	< 35 fsec	γ	3, 16, 23, 25, 35, 51
6.4044 \pm 1.2	3 ⁻	30 \pm 15 fsec	γ	3, 16, 35, 51, 54
6.88045 \pm 0.27	0 ⁻	< 25 fsec	γ	3, 16, 25, 35, 50, 51
7.1169 \pm 1.2	4 ⁺	< 25 fsec	γ, α	3, 8, 10, 11, 16, 18, 23, 28, 31, 35, 40, 41, 51
7.618 \pm 4	1 ⁻	$\Gamma < 2.5$	γ, α	3, 8, 10, 16, 35, 50, 51
7.77107 \pm 0.50	2 ⁻		γ	3, 16, 25, 50, 51
7.860 \pm 4	(4 ⁺)		γ	3, 8, 10, 11, 16, 23, 28, 35, 51
7.977 \pm 4	(3 ⁺ , 4 ⁻)		γ	3, 16, 23, 51
8.038 \pm 3	1 ⁻	< 2.5	γ, α	3, 8, 16, 51
8.126 \pm 3	5 ⁻		γ, α	3, 8, 10, 11, 16, 51
8.216 \pm 3	2 ⁺	1.0 \pm 0.8	γ, n, α	3, 8, 9, 16, 35, 51
8.287 \pm 3	3 ⁻	8 \pm 1	γ, n, α	3, 8, 9, 10, 11, 16, 18, 35, 51
8.411 \pm 8		8 \pm 6	n, α	9, 16, 51
8.521 \pm 6				16, 51
8.660 \pm 6				16, 51
8.817 \pm 12		70 \pm 12	n, α	8, 9, 35
8.956 \pm 4		43 \pm 3	n, α	8, 9, 35
(9.03)				8, 35
(9.10)				8, 35
9.362 \pm 6		27 \pm 15	n, α	8, 9, 11, 16, 35
9.414 \pm 18		\approx 120	n, α	8, 9, 11, 16, 35
9.48 \pm 24		\approx 65	n, α	8, 9, 16
9.673 \pm 7		60 \pm 30	n, α	8, 9, 16, 35
9.713 \pm 7				16, 35, 50
9.890 \pm 11		\approx 150	n, α	8, 9, 16, 35
10.119 \pm 10	3 ⁻	16 \pm 4	n, α	8, 9, 10, 16, 35
10.295 \pm 14	4 ⁺		n, α	8, 9, 10, 11, 16, 17, 35
10.396 \pm 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 \pm 15			n, α	8, 9, 16
10.82 \pm 20			n, α	8, 9
10.91 \pm 20			n, α	8, 9, 11
10.99 \pm 20			n, α	8, 9, 15
11.13 \pm 20			n, α	8, 9, 11, 15, 50
11.39 \pm 20	(2 ⁺)		n, α	8, 9, 10
11.41 \pm 20	(4 ⁺)		n, α	8, 9, 10
11.62 \pm 20	5 ⁻		n, α	8, 9, 10, 11, 35
11.69 \pm 20	6 ⁺		n, α	8, 9, 10, 11, 35
11.82 \pm 20	(3 ⁻)		n, α	8, 9, 15
12.04 \pm 20	(2 ⁺)		n, α	8, 9, 10
12.25 \pm 20	(1 ⁻)		n, α	8, 9, 10, 50
12.33 \pm 20	5 ⁻		n, α	8, 9, 10, 11
12.50 \pm 20	4 ⁺		n, α	8, 9
12.53 \pm 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 \pm 10	$T = 2$	≤ 30	γ	28
17.3	1 ⁻ , ($T = 2$)	600	γ , n, p	26
18.86 \pm 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 $^{18}\text{O}(e, e')$ (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, 1977SO1C, 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).

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

$^{18}\text{O}^*(1.98)$:

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

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

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

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

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

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

1. $^9\text{Be}(^9\text{Be}, ^9\text{Be})^9\text{Be}$

$$E_b = 23.4790$$

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_i^π	E_f (MeV)	Branch (%)	Comments
6.35	(2^-)	4.46	6 ± 2	$\delta = (0)$
		5.26 + 5.34	6 ± 2	
		1.98	32 ± 2	
		3.92	55 ± 2	
6.40	3^-	4.46	12 ± 2	$\delta = (0)$
		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	$\Gamma_\alpha\Gamma_\gamma/\Gamma = 0.34 \text{ eV}^d$
		1.98	54 ± 1	
		3.92	5 ± 1	
		4.46	12 ± 1	
		5.34	8 ± 1	
		6.20	7 ± 1	
		7.77	2^-	
7.86 ⁱ	(4^+)	4.46	11 ± 2	$\Gamma_\alpha\Gamma_\gamma/\Gamma = 0.89 \text{ eV}^d$
		5.10	36 ± 3^b	
		3.55	> 95	
7.98	$(3^+, 4^-)$	3.55	67 ± 2	$\Gamma_\alpha\Gamma_\gamma/\Gamma = 0.22 \text{ eV}^d$
		5.10	12 ± 2	
		5.38	21 ± 2	
		0	14 ± 1	
8.04 ⁱ	1^-	1.98	63 ± 1	$\Gamma_\alpha\Gamma_\gamma/\Gamma = 0.89 \text{ eV}^d$
		3.63	13 ± 1	
		4.46	2 ± 1	
		5.10	2 ± 1	
		5.26	6 ± 1	
8.13 ⁱ	5^-	3.55	94 ± 1	$\Gamma_\alpha\Gamma_\gamma/\Gamma = 0.22 \text{ eV}^d$

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

E_i (MeV)	J_i^π	E_f (MeV)	Branch (%)	Comments
8.22 ⁱ	2 ⁺	5.10	6 ± 2	
		1.98	22 ± 1	
		3.55	3 ± 1	
		3.92	1.0 ± 0.5	
		4.46	49 ± 1	
8.29 ⁱ	3 ⁻	5.10	25 ± 1	
		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 $^{18}\text{O}^*(0, 3.55)$ are < 1 and < 0.5% (1982OL01).

^h Transitions to $^{18}\text{O}^*(5.53, 6.20)$ 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) $^{11}\text{B}(^7\text{Li}, \text{p})^{17}\text{N}$ $Q_m = 8.417$ $E_b = 24.359$
 (b) $^{11}\text{B}(^7\text{Li}, \text{d})^{16}\text{N}$ $Q_m = 4.749$
 (c) $^{11}\text{B}(^7\text{Li}, \text{t})^{15}\text{N}$ $Q_m = 8.525$
 (d) $^{11}\text{B}(^7\text{Li}, \alpha)^{14}\text{C}$ $Q_m = 18.131$

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

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

Table 18.4: States of ^{18}O from $^{12}\text{C}(^7\text{Li}, \text{p})$ ^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. $^{12}\text{C}(^{20}\text{Ne}, ^{14}\text{O})^{18}\text{O}$ $Q_m = 14.2683$

See (1979OR01).

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

See (1978AJ03).

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

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

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

8. (a) $^{14}\text{C}(\alpha, \gamma)^{18}\text{O}$ $Q_m = 6.2279$
 (b) $^{14}\text{C}(\alpha, \alpha)^{14}\text{C}$ $E_b = 6.2279$

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 $^{18}\text{O}^*(7.12, 7.62, 8.04, 8.13)$, 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 $^{14}\text{C}(\alpha, \gamma)^{18}\text{O}$, $^{14}\text{C}(\alpha, n)^{17}\text{O}$ and $^{14}\text{C}(\alpha, \alpha)^{14}\text{C}$ ^a

E_α (MeV \pm keV)	Γ_{lab} (keV)	Particles out	$^{18}\text{O}^*$ (MeV)	J^π
1.140 \pm 2		γ	7.114	4 ⁺
1.787 \pm 4	< 3	γ	7.618	1 ⁻
2.090 \pm 5		γ	7.853	(4 ⁺ , 5 ⁻)
2.327 \pm 3	< 3	γ, α_0	8.038	1 ⁻
2.435 \pm 3		γ	8.122	5 ⁻
2.553 \pm 3	1.3 \pm 1	γ, n, α_0	8.213	2 ⁺
2.644 \pm 3	10 \pm 1	γ, n, α_0	8.284	3 ⁻
2.800 \pm 7	10 \pm 7	n	8.405	
3.330 \pm 12	90 \pm 15	n, α_0	8.817	
3.508 \pm 4	55 \pm 3	n, α_0	8.956 ^h	
4.030 \pm 15	35 \pm 20	n, (α_0)	9.362	
4.07 \pm 40	\approx 150	n, (α_0)	9.39	
4.17 \pm 40	\approx 70	n, (α_0)	9.47	
4.434 \pm 10	80 \pm 40	n, (α_0)	9.676	
4.70 \pm 40	\approx 200	n, (α_0)	9.88	
5.004 \pm 10	21 \pm 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 $^{14}\text{C}(\alpha, \gamma)^{18}\text{O}$, $^{14}\text{C}(\alpha, n)^{17}\text{O}$ and $^{14}\text{C}(\alpha, \alpha)^{14}\text{C}$ ^a
(continued)

E_α (MeV \pm keV)	Γ_{lab} (keV)	Particles out	$^{18}\text{O}^*$ (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; Γ_n , large.

^c Γ_α , small; Γ_n , small.

^d Γ_α , small; Γ_n , large.

^e Γ_α , large; Γ_n , small.

^f (1982GA1D; prelim.): $\theta_\alpha^2 = < 1, 0.8$ and 20%, respectively for $^{18}\text{O}^*(8.04, 8.21, 8.28)$. See also (1978AJ03).

^g $\pm 10 - 20$ keV for this and all higher resonances (G.E. Mitchell, private communication).

^h Two states with $E_x = 9.0$ to 9.2 MeV and $J^\pi = (2^+, 3^-)$ or $(4^+, 3^-)$ are reported by (1958WE29).

9. $^{14}\text{C}(\alpha, n)^{17}\text{O}$

$$Q_m = -1.8167$$

$$E_b = 6.2279$$

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. $^{14}\text{C}(^6\text{Li}, d)^{18}\text{O}$

$$Q_m = 4.7544$$

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

11. $^{14}\text{C}(^7\text{Li}, t)^{18}\text{O}$

$$Q_m = 3.761$$

At $E(^7\text{Li}) = 20.4$ 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 $^{18}\text{O}^*(0, 1.98, 7.12, 11.69)$ 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.).

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

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

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

See (1978AJ03).

$$14. \ (a) \ ^{15}\text{N}(\alpha, p)^{18}\text{O} \quad Q_m = -3.9796$$

$$(b) \ ^{15}\text{N}(^6\text{Li}, ^3\text{He})^{18}\text{O} \quad Q_m = 0.041$$

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

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

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

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

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 $^{18}\text{O}^*(5.34)$ [0_3^+] is largely $(s_{1/2})^2$ while $^{18}\text{O}^*(3.63)$ [0_2^+] has a dominantly collective nature as does $^{18}\text{O}^*(5.25)$ [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 $^{16}\text{O}(t, p)$ ^a

E_x (MeV \pm keV)	L	J^π	E_x (MeV \pm keV)	E_x (MeV \pm 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 $^{18}\text{O}^*(3.92, 5.01, 6.40, 7.77)$ 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.

$$17. \text{}^{16}\text{O}(\alpha, 2p)\text{}^{18}\text{O} \quad Q_m = -16.1071$$

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

$$\begin{aligned} 18. \text{(a)} \text{}^{16}\text{O}(\text{}^{10}\text{B}, \text{}^8\text{B})\text{}^{18}\text{O} & \quad Q_m = -14.824 \\ \text{(b)} \text{}^{16}\text{O}(\text{}^{12}\text{C}, \text{}^{10}\text{C})\text{}^{18}\text{O} & \quad Q_m = -19.6569 \\ \text{(c)} \text{}^{16}\text{O}(\text{}^{13}\text{C}, \text{}^{11}\text{C})\text{}^{18}\text{O} & \quad Q_m = -11.479 \\ \text{(d)} \text{}^{16}\text{O}(\text{}^{14}\text{C}, \text{}^{12}\text{C})\text{}^{18}\text{O} & \quad Q_m = -0.9341 \end{aligned}$$

At $E(^{10}\text{B}) = 100$ MeV, reaction (a) preferentially populates $^{18}\text{O}^*(3.55)$ [first $(d_{5/2})_{4^+}^2$ state]. $^{18}\text{O}^*(1.98, 5.26, 7.12, 8.0, 8.3, 9.1)$ are also populated (1978HA10). For reaction (b) see (1978AJ03). At $E(^{13}\text{C}) = 105$ MeV [reaction (c)] the angular distribution to $^{18}\text{O}^*(3.55)$ has been measured (1979RA10, 1980PR09). For reaction (d) see (1979HA1R).

$$19. \text{}^{17}\text{O}(\text{n}, \gamma)\text{}^{18}\text{O} \quad Q_m = 8.0446$$

The thermal capture cross section of ^{17}O is $538 \pm 65 \mu\text{b}$ (1979LOZK; prelim.).

$$20. \text{}^{17}\text{O}(\text{n}, \text{n})\text{}^{17}\text{O} \quad E_b = 8.0446$$

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

$$21. \text{}^{17}\text{O}(\text{n}, \text{p})\text{}^{17}\text{N} \quad Q_m = -7.898 \quad E_b = 8.0446$$

See (1978AJ03).

$$22. \text{}^{17}\text{O}(\text{n}, \alpha)\text{}^{14}\text{C} \quad Q_m = 1.8167 \quad E_b = 8.0446$$

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

$$23. \text{}^{17}\text{O}(\text{d}, \text{p})\text{}^{18}\text{O} \quad Q_m = 5.8199$$

Table 18.7: States of ^{18}O from $^{17}\text{O}(\text{d}, \text{p})$ ^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 (1977PE1G, 1978AJ03) and (1979SA31; theor.).

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

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

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

$$25. ^{18}\text{N}(\beta^-)^{18}\text{O} \quad Q_m = 14.03$$

Table 18.8: Branching in $^{18}\text{N}(\beta^-)^{18}\text{O}$ ^a

Decay to $^{18}\text{O}^*$ ^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 $^{18}\text{N}(\beta^-)^{18}\text{O}$ 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) $^{18}\text{O}(\gamma, n)^{17}\text{O}$ $Q_m = -8.0446$
 (b) $^{18}\text{O}(\gamma, 2n)^{16}\text{O}$ $Q_m = -12.1889$
 (c) $^{18}\text{O}(\gamma, p)^{17}\text{N}$ $Q_m = -15.942$
 (d) $^{18}\text{O}(\gamma, t)^{15}\text{N}$ $Q_m = -15.8345$
 (e) $^{18}\text{O}(\gamma, \alpha)^{14}\text{C}$ $Q_m = -6.2279$

The cross sections for the (γ, p) , (γ, n) , $(\gamma, 2n)$ 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 $(\gamma, 2n)$ cross section is a significant fraction of $\sigma(\gamma, \text{tot})$ and is even larger than $\sigma(\gamma, p)$. Above the GDR the partial cross sections decrease but the integrated $\sigma(\gamma, \text{tot})$ 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; $E_{\text{brems.}}$). 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. $^{18}\text{O}(\gamma, \gamma)^{18}\text{O}$

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

28. $^{18}\text{O}(e, e)^{18}\text{O}$

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 $^{18}\text{O}^*(1.98, 3.55, 3.63, 3.92, 5.10, 5.26, 5.34, 7.12, 7.86)$ [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 $^{18}\text{O}^*(3.63, 5.34)$, the 2^+ states $^{18}\text{O}^*(1.98, 3.92, 5.26)$ and the 4^+ states $^{18}\text{O}^*(3.55, 7.12, 7.86)$. (1982NO04) report transition charge density parameters for $^{18}\text{O}^*(1.98, 3.92, 5.26, 7.11)$ as well as $B(EL; 0_1^+ \rightarrow L^+)$. The $B(E2)$ are $44.8 \pm 1.3, 22.2 \pm 1.0$ and 28.3 ± 1.5 $e^2 \cdot \text{fm}^4$ for $^{18}\text{O}^*(1.98, 3.92, 5.26)$ and the $B(E4) = (9.04 \pm 0.90) \times 10^2$ and $(1.31 \pm 0.06) \times 10^4$ $e^2 \cdot \text{fm}^8$ for $^{18}\text{O}^*(3.55, 7.12)$ (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 . $B(M2)\uparrow = 58 \pm 8$ $\mu_k^2 \cdot \text{fm}^2$ and $B(M1)\uparrow = 0.28 \pm 0.04$ μ_k^2 for $^{18}\text{O}^*(16.38, 18.86)$. 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 $^{18}\text{O} + \gamma$

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. $^{18}\text{O}(\pi, \pi)^{18}\text{O}$

Angular distributions for the elastic scattering and the inelastic scattering to $^{18}\text{O}^*(1.98)$ have been studied at $E_{\pi^\pm} = 29.2$ MeV (1979JO08), 163 MeV (1978JA13; also to $^{18}\text{O}^*(5.10)$), 180 MeV (1978LU09) and 164 and 230 MeV (1978IV01, 1979IV03; also to $^{18}\text{O}^*(5.10)$). 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. $^{18}\text{O}(n, n)^{18}\text{O}$

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

31. $^{18}\text{O}(p, p)^{18}\text{O}$

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 $^{18}\text{O}^*(3.55, 5.09, 7.11)$ at 16.2 MeV]), (1980FA06, 1980FA07; 17.7 – 44.1 MeV; p_0), (1978NO1G, 1980KE1C, 1981KE1B; 135 MeV; all abstracts) and (1981GL1B; $E_{\bar{p}} = 800$ MeV; p_0, p_1, p_4, p_5, p_6 and p to $^{18}\text{O}^*(7.12)$).

At $E_p = 24.5$ MeV (1974ES02) have studied the angular distributions of the proton groups to $^{18}\text{O}^*(1.98, 3.55, 3.63, 3.92, 4.46, 5.10, 5.26, 5.53, 7.12)$: 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 $^{18}\text{O}^*(1.98, 5.10, 7.12)$. Such calculations also support evidence for a rotational band involving $^{18}\text{O}^*(0, 1.98, 7.12)$. The 3^- state at 5.10 MeV is strongly excited and collective in nature: $B(E3) = 1120 e^2 \cdot \text{fm}^6$. For $^{18}\text{O}^*(1.98, 3.92, 5.26)$, $B(E2) = 45, 8.3$ and $24 e^2 \cdot \text{fm}^4$ (1974ES02).

$^{18}\text{O}^*(1.98)$ has $|g| = 0.287 \pm 0.015$ [$\tau_m = 2.99 \pm 0.12$ psec] (1976AS04). $^{18}\text{O}^*(3.55)$ 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. $^{18}\text{O}(d, d)^{18}\text{O}$

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

33. $^{18}\text{O}(t, t)^{18}\text{O}$

The elastic scattering has been studied at $E_t = 6.4$ and 7.2 MeV (1964PU01).

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

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

35. $^{18}\text{O}(\alpha, \alpha)^{18}\text{O}$

Angular distributions of many α -groups have been measured in the range $E_\alpha = 21$ to 40.5 MeV: see (1978AJ03). The transitions to $^{18}\text{O}^*(4.46, 5.10)$ 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 $^{18}\text{O}^*(1.98, 3.55, 3.63, 3.92, 4.46, 5.10, 5.26, 5.34, 6.20, 6.40, 7.12, 7.62, 7.86, 8.22, 8.29, 8.82, 8.96, 9.03, 9.10, 9.36, 9.41, 9.68, 9.72 \pm 0.03, 9.88, 10.12, 10.29, 10.40, 11.62, 11.69)$. The levels at $E_x = 5.38, 8.48$ 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 $^{18}\text{O}^*(5.38, 5.53)$ (1971OL06).

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

36. (a) $^{18}\text{O}(^6\text{Li}, ^6\text{Li})^{18}\text{O}$

(b) $^{18}\text{O}(^7\text{Li}, ^7\text{Li})^{18}\text{O}$

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

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

See (1971KN05).

38. (a) $^{18}\text{O}(^{10}\text{B}, ^{10}\text{B})^{18}\text{O}$

(b) $^{18}\text{O}(^{11}\text{B}, ^{11}\text{B})^{18}\text{O}$

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

39. (a) $^{18}\text{O}(^{12}\text{C}, ^{12}\text{C})^{18}\text{O}$

(b) $^{18}\text{O}(^{13}\text{C}, ^{13}\text{C})^{18}\text{O}$

Elastic angular distributions have been studied at $E(^{18}\text{O}) = 32.3$ and 35 MeV (1978CH03) and 47.5, 55 and 57.5 MeV (1976WE05) for reaction (a) and at $E(^{18}\text{O}) = 31$ MeV for reaction (b) (1978CH03). Yields and fusion cross sections are reported by (1976SP07, 1978CH03, 1978CO07, 1978FR05, 1979CH07, 1979KO20, 1980WI09). See also (1979DAZK, 1979EN1F, 1979GA1H, 1981HE1J), (1978LE1T, 1978TS04) and (1978BI1G, 1978VA1A, 1979KR07, 1979NA03, 1980CH1J, 1980LE11, 1980LO02, 1980VA03, 1981HA18; theor.).

40. $^{18}\text{O}(^{16}\text{O}, ^{16}\text{O})^{18}\text{O}$

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

41. (a) $^{18}\text{O}(^{17}\text{O}, ^{17}\text{O})^{18}\text{O}$

(b) $^{18}\text{O}(^{18}\text{O}, ^{18}\text{O})^{18}\text{O}$

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

3.63, 4.46, 5.10, 7.12) are also populated: see (1978AJ03). For yield measurements [reaction (b)] see (1977KA21). See also (1979GA1H) and (1978CH10, 1978VO06, 1978VO13, 1981CA09, 1982LA04; theor.).

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

The elastic scattering has been studied at $E(^{19}\text{F}) = 27, 30$ and 33 MeV (1973GA14). See also (1979GA1H).

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

Angular distributions are reported at $E(^{18}\text{O}) = 29$ and 35 MeV to $^{18}\text{O}^*(0, 1.98)$ (1978CA07). For fusion measurements see (1978TA05, 1981RA1H). See also (1980RA1F).

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

For fusion measurements see (1977EI01, 1979RA21). See also (1980MI1B, 1980SA1L, 1981TA16, 1981WU1A), (1977SC1G) and (1978VA1A; theor.).

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

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, 1981WU1A). See also (1979SA27; theor.). For reaction (b) see (1982DA07, 1982LA02; theor.).

46. $^{18}\text{F}(\beta^+)^{18}\text{O}$ $Q_m = 1.6555$

See ^{18}F .

47. (a) $^{19}\text{F}(\gamma, p)^{18}\text{O}$ $Q_m = -7.9934$
 (b) $^{19}\text{F}(e, ep)^{18}\text{O}$ $Q_m = -7.9934$

In reaction (a) $^{18}\text{O}^*(1.98, 3.63)$ 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 .

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

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

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

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

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

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 $E_d = 12.4$ MeV (1981EN1A). See also (1978RO01).

$$51. \ ^{19}\text{F}(\text{t}, \alpha)^{18}\text{O} \quad Q_m = 11.8207$$

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 $0^+ \rightarrow 0^+$ transitions from $^{18}\text{O}^*(3.63, 5.34)$ 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)] $\langle M \rangle_\pi = 6.0 \pm 0.7 \text{ fm}^2$ and $\leq 4.5 \text{ fm}^2$. $^{18}\text{O}^*(5.34)$ appears to be the expected nearly spherical $(s_{1/2})^2$ state (1975SO05).

$$52. \ ^{19}\text{F}(\alpha, \alpha\text{p})^{18}\text{O} \quad Q_m = -7.9934$$

This reaction, leading to $^{18}\text{O}_{\text{g.s.}}$, 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 $^{19}\text{F}(t, \alpha\gamma)$ ^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 (± 20 keV).

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

See (1978AJ03).

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

At $E_d = 55$ MeV $^{18}\text{O}^*(1.98, 3.55, 5.10, 6.40)$ are preferentially populated (1981JA1E). See also (1978BE1H).

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

See (1978AJ03).

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

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, 1977SO1C, 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, 1978WO1E, 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, 1977SO1C, 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. $^{18}\text{F}(\beta^+)^{18}\text{O}$ $Q_m = 1.6555$

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 $^{18}\text{O}_{\text{g.s.}}$ is allowed indicates $J^\pi = 1^+$ for $^{18}\text{F}_{\text{g.s.}}$. The ratio $\epsilon_K/\beta^+ = 0.030 \pm 0.002$; see (1978AJ03). See also (1976BE1E, 1981BE2N, 1982PI1B) and (1980AF1A; theor.).

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

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

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

E_x (MeV \pm keV)	$J^\pi; T$	K^π	τ or $\Gamma_{\text{c.m.}}$ (keV)	Decay	Reactions
7.507 \pm 2	4 ⁻		12 \pm 2	p, α	39, 41
7.515 \pm 2			< 4	γ , p	37
7.530 \pm 2	2 ⁻ ; 1		16.5 \pm 3.0	γ , p, α	37, 39, 41
7.534 \pm 5			75	p, α	39, 41
7.556 \pm 2	(1 ⁻)		30	p	39
7.586 \pm 2			9 \pm 2	γ , p, α	37, 39, 41
7.687 \pm 2	3 ⁺ , 4 ⁺		36 \pm 4	p, α	39, 41
7.730 \pm 4	\geq 1		66 \pm 5	p, α	39, 41
7.764 \pm 4			70	p	39
7.879 \pm 3	\geq 2		20	p, α	39, 41
7.901 \pm 2	(2 ⁻)		38	p, α	10, 11, 41
7.943 \pm 12	(1 ⁺)		112	p, α	10, 11, 41
8.065 \pm 6	\geq 4		60	p, α	39, 41
8.116 \pm 8			96	p	39
8.211 \pm 2	2 ⁻		52	p, α	39, 41
8.240 \pm 2	4 ⁺		20	p	39
9.207 \pm 15 ^b	3, 4 ⁻ ; 0			p, d, α	24, 25, 27
9.50	2, 3 ⁺ ; 0			n, d, α	23, 27
9.58 \pm 20 ^c	6 ⁺	1 ⁺			14, 15
10.58 \pm 50					15
11.22 \pm 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 \pm 40					14, 15
15.09	4 ⁻ , 5 ⁺			d, α	27
15.34	5 ⁺ , 6 ⁻			d, α	27
15.79 \pm 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 \pm 120					15
(19.00 \pm 150)			(500 \pm 150)	γ , ^3He	17
20.1 \pm 200	(2 ⁻ ; 1)		1600 \pm 100	γ , ^3He	17
22.7 \pm 200	(2 ⁻ ; 1)		1200 \pm 100	γ , ^3He	17
(24.1 \pm 200)			(1400 \pm 300)	γ , ^3He	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 $^{14}\text{N} + \alpha$ and $^{16}\text{O} + \text{d}$, respectively. (1976CH24) reports 151 isospin mixed natural-parity states with $10.4 < E_x < 17.5$ MeV [$^{14}\text{N}(\alpha, \alpha_1)$] and (1973JO13) reports 138 such states with $9.2 < E_x < 19.4$ MeV [$^{16}\text{O}(\text{d}, \alpha_1)$] 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) $^{12}\text{C}(^6\text{Li}, \text{n})^{17}\text{F}$	$Q_m = 4.064$	$E_b = 13.215$
(b) $^{12}\text{C}(^6\text{Li}, \text{p})^{17}\text{O}$	$Q_m = 7.608$	
(c) $^{12}\text{C}(^6\text{Li}, \text{d})^{16}\text{O}$	$Q_m = 5.6885$	
(d) $^{12}\text{C}(^6\text{Li}, \text{t})^{15}\text{O}$	$Q_m = -3.718$	
(e) $^{12}\text{C}(^6\text{Li}, \alpha)^{14}\text{N}$	$Q_m = 8.7989$	
(f) $^{12}\text{C}(^6\text{Li}, ^6\text{Li})^{12}\text{C}$		

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; ^6Li elastic), (1978SO01; 9 to 14 MeV and 20 MeV; $\alpha_0, \alpha_1, \alpha_2$), (1980FU06; 20 to 36 MeV; ^6Li to $^{12}\text{C}^*(0, 4.43)$) and (1978CU03; 20 to 34 MeV; d to $^{16}\text{O}^*(0, 6.13, 6.92, 7.12, 8.87, 10.36, 11.09, 16.3)$).

The cross section for the isospin-forbidden α_1 group [to $^{14}\text{N}^*(2.31), 0^+, T = 1$] 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 ^6Li ions to $^{12}\text{C}^*(0, 4.43)$ 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 $E(^6\text{Li}) = 20$ MeV analyzing power measurements are reported for many deuteron and α groups and for elastically scattered ^6Li ions (1978MA13, 1979MA1T). Breakup processes have been studied by (1980NE05), cross sections at very high

energies by (1980SK1A), fusion by (1981DE1H, 1981DE2K). See also $^{16}\text{O}, ^{17}\text{O}$ in (1982AJ01), and $^{14}\text{N}, ^{15}\text{N}$ 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_i (MeV)	$J_i^\pi; T$	E_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	$\Gamma_\gamma = (4.6 \pm 2.2) \times 10^{-5} \text{ eV}$
		0.94	31 ± 1	$\Gamma_\gamma = (4.0 \pm 1.9) \times 10^{-5} \text{ eV}$
		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	$\delta = +(0.07 \pm 0.05)$
		1.04	34 ± 2	$\Gamma_\gamma = (5.7 \pm 2) \times 10^{-4} \text{ eV}$
		1.08	25 ± 2	$\Gamma_\gamma = (7.3 \pm 2.7) \times 10^{-4} \text{ eV}$
		1.70	2.0 ± 0.5	$\Gamma_\gamma = (4.8 \pm 1.8) \times 10^{-4} \text{ eV}$
		0	45 ± 5	$\delta = +(0.22 \pm 0.15)$
3.36 ^g	$3^+; 0$	0.94	9 ± 3	
		1.70	40 ± 4	
		2.10	< 3	
		2.52	6 ± 3	$\delta = -0.4_{-0.5}^{+0.3}$
3.72 ^h	$1^+; 0$	0	5 ± 2	
		1.04	91 ± 2	$\Gamma_\gamma = (1.3 \pm 0.2) \times 10^{-3} \text{ eV}$
		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)	$J_i^\pi; T$	E_f (MeV)	Branch (%)	
4.36 ^m	1^+	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	
4.40 ⁿ	$4^-; 0$	0.94	13 ± 4	$\delta = -(0.2 \pm 0.3)$
		1.12	60 ± 6	$\delta = -(0.2 \pm 0.2)$
4.65 ^o	$4^+; 1$	2.10	27 ± 3	
		0.94	17 ± 3	
4.75 ^p	$0^+; 1$	1.12	83 ± 3	$\delta = 0.15 \pm 0.15$
		0	92 ± 4	
4.86 ^q	$1^-; 0$	1.70	8 ± 4	
		1.04	65 ± 11	
		1.08	8 ± 6	
		3.06	23 ± 7	$\delta = -(0.4 \pm 0.4)$
4.96 ^r	$2^+; 1$	3.13	4 ± 3	
		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	$\Gamma_\gamma = 12 \pm 4 \text{ meV}^{\text{pp}}$
		3.36	5 ± 1	$\delta = 2.5 \pm 0.8$
		4.65	1.3 ± 0.3	
5.50 ^t	$3^{(-)}; 0$	3.06	100	$\Gamma_\gamma = 2.1 \pm 0.7 \text{ meV}^{\text{nn}}$
5.603 ^u	1^+	0	16.7 ± 2.3	
		1.04	3.8 ± 1.2	
		3.06	79.5 ± 5.9	$\Gamma_\gamma = 0.48 \pm 0.05 \text{ eV}^{\text{qq}}$
5.605 ^v	$1^-; 0+1$	0	6.7 ± 1.2	
		1.04	4.2 ± 0.8	
		1.08	54.3 ± 3.1	$\Gamma_\gamma = 0.87 \pm 0.07 \text{ eV}^{\text{qq}}$
		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	$\Gamma_\gamma = 0.46 \pm 0.06 \text{ eV}^{\text{qq}}$
		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)	$J_i^\pi; T$	E_f (MeV)) Branch (%)				
5.79 ^x	$2^-; 0$	3.13	28.5 ± 2.0	$\delta = +0.10 \pm 0.03$			
		0.94	40 ± 8				
		1.08	60 ± 8				
6.10 ^y	$4^-; 0$	0.94	4.9 ± 0.9	$\Gamma_\gamma = 51 \pm 10 \text{ meV}^{\text{nn}}$			
		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	$\Gamma_\gamma > 1.6 \text{ eV}$			
		1.70	12 ± 2				
		3.72	36 ± 3				
		4.36	2.1 ± 0.4				
6.16 ^{bb}	$3^+; 1$	5.603	0.19 ± 0.02	$\Gamma_\gamma = 0.96 \pm 0.26 \text{ eV}^{\text{nn}}$			
		0	0.2 ± 0.2				
		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	$\Gamma_\gamma = 0.80 \pm 0.11 \text{ eV}^{\text{nn}}$			
		2.10	71.5 ± 3.0				
		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 (%)		
6.26	$1^+; 0$	2.10	71.2 ± 3.0	$\Gamma_\gamma = 0.73 \pm 0.11 \text{ eV}^{\text{nn}}$	
		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		
		0	(100)		
6.28 ^{dd}	$2^+; 1$	0	0.3 ± 0.1	$\Gamma_\gamma = 1.8 \pm 0.5 \text{ eV}^{\text{nn}}$	
		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		
		0	4.0 ± 0.7		$\Gamma_\gamma = 0.17 \pm 0.04 \text{ eV}^{\text{nn}}$
		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				
6.31 ^{ee}	$3^+; 0$	3.84	4.6 ± 1.0	$\delta = -(0.01 \pm 0.14)$	
		4.12	2.4 ± 1.7		
		4.36	13.0 ± 1.5		
		0	1.5 ± 0.5		$\Gamma_\gamma = 0.44 \pm 0.18 \text{ eV}^{\text{nn}}$
		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		
6.39 ^{ff}	$2^+; 0 + 1$	0	13 ± 2	$\Gamma_\gamma = 74 \pm 21 \text{ meV}^{\text{nn}}$	
		0.94	33 ± 2		
		1.12	10 ± 2		
		1.70	4 ± 2		
		0			
6.48 ^{gs}	$3^+; 0$	0			
		0.94			
		1.12			
		1.70			
		0			

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

E_i (MeV)	$J_i^\pi; T$	E_f (MeV)	Branch (%)	
6.57 ^{hh}	$5^+; 0$	2.52	4 ± 2	$\Gamma_\gamma = 26 \pm 5 \text{ meV}^{\text{nn,oo}}$
		3.06	21 ± 3	
		3.79	4 ± 2	
		3.84	9 ± 2	
		4.96	2 ± 2	
		0.94	15.2 ± 1.6	
6.64 ⁱⁱ	$2^-; 1$	3.36	83 ± 3	$\Gamma_\gamma = 1.4 \pm 0.4 \text{ eV}^{\text{nn}}$
		5.30	2.3 ± 0.6	
		0.94	8.9 ± 0.6	
		2.10	58 ± 3	
		3.13	22.0 ± 1.3	
		3.72	0.9 ± 0.2	
		3.79	2.4 ± 0.2	
6.78 ^{jj}	$4^+; 0$	4.12	1.0 ± 0.3	$\Gamma_\gamma = 0.31 \pm 0.08 \text{ eV}^{\text{nn}}$ $\delta = -(0.35 \pm 0.18)$ $\delta = -(1.4 \pm 1.1)$ $\delta = 0.13 \pm 0.13$
		4.86	2.6 ± 0.2	
		5.50	4.0 ± 0.3	
		0.94	12.6 ± 0.9	
6.80 ^{kk}	$1^+, 2, 3^+; (0)$	1.12	25.2 ± 1.3	$\Gamma_\gamma = 0.31 \pm 0.08 \text{ eV}^{\text{nn}}$ $\delta = -(0.35 \pm 0.18)$ $\delta = -(1.4 \pm 1.1)$ $\delta = 0.13 \pm 0.13$
		4.65	62 ± 2	
		0	20 ± 2	
		0.94	20 ± 2	
		3.06	50 ± 3	
		3.84	3.0 ± 1.6	
6.88 ^{ll}	$3, 4^-; 0$	3.84	3.0 ± 1.6	$\Gamma_\gamma = 0.31 \pm 0.08 \text{ eV}^{\text{nn}}$ $\delta = -(0.35 \pm 0.18)$ $\delta = -(1.4 \pm 1.1)$ $\delta = 0.13 \pm 0.13$
		4.96	7.0 ± 1.7	
		2.10	9 ± 2	
7.34 ^{mm}	$1^-; 1$	4.65	91 ± 2	$\Gamma_\gamma = 0.31 \pm 0.08 \text{ eV}^{\text{nn}}$ $\delta = -(0.35 \pm 0.18)$ $\delta = -(1.4 \pm 1.1)$ $\delta = 0.13 \pm 0.13$
		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	$\Gamma_\gamma = 0.31 \pm 0.08 \text{ eV}^{\text{nn}}$ $\delta = -(0.35 \pm 0.18)$ $\delta = -(1.4 \pm 1.1)$ $\delta = 0.13 \pm 0.13$
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)	$J_i^\pi; T$	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 $^{18}\text{F}^*(1.04, 1.08)$ are < 0.1 and $< 0.2\%$.

^c Transitions to $^{18}\text{F}^*(1.04, 1.13, 1.70)$ are < 0.4 , < 2 and $< 0.2\%$.

^d Transitions to $^{18}\text{F}^*(1.04, 1.08, 2.10)$ are < 0.3 , < 0.3 and $< 0.2\%$.

^e Transitions to $^{18}\text{F}^*(1.08, 1.13, 1.70, 2.10, 2.53)$ are < 8 , < 14 , < 8 , < 5 and $< 5\%$.

^f Transitions to $^{18}\text{F}^*(0.94, 1.13, 2.10, 2.53)$ are < 0.6 , < 8 , < 3.0 , $< 0.3\%$.

^g Transitions to $^{18}\text{F}^*(1.04, 1.08, 1.12, 3.06)$ are < 5 , < 5 , < 3 and $< 5\%$.

^h Transitions to $^{18}\text{F}^*(0.94, 1.08, 1.12, 1.70, 2.10, 2.53, 3.13, 3.36)$ are < 2 , < 1 , < 10 , < 1 , < 1 , < 1 and $< 4\%$.

ⁱ Transitions to $^{18}\text{F}^*(0, 0.94, 1.12, 1.70, 3.13, 3.36)$ are < 1.5 , < 2.0 , < 1.0 , < 1.7 , < 0.9 and $< 1.8\%$.

^j Transitions to $^{18}\text{F}^*(1.04, 1.08, 2.10, 2.52, 3.13, 3.36)$ 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).

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

See (1972AJ02).

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

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

$$5. \text{(a) } {}^{12}\text{C}({}^{10}\text{B}, \alpha){}^{18}\text{F} \quad Q_m = 8.754$$

$$\text{(b) } {}^{12}\text{C}({}^{11}\text{B}, \alpha n){}^{18}\text{F} \quad Q_m = -2.701$$

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

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

See (1980KO02).

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

$^{18}\text{F}^*$ (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)
	<u>238 ± 4 nsec</u>	(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 $^{14}\text{N} + \alpha$ below $E_\alpha = 5 \text{ MeV}$ ^a

E_α (MeV \pm keV)	Particles out	$\Gamma_{\text{c.m.}}$ (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 \pm 3	γ		0.084 \pm 0.004	4 ⁺ ; 0	5.299
1.398 \pm 3	γ		0.022 \pm 0.003	3 ⁽⁻⁾ ; 0	5.503
1.527	γ, α_0		1.44 \pm 0.14	1 ⁺	5.603 ^d
1.529 \pm 2	γ, α_0	< 1.2	2.60 \pm 0.21	1 ⁻ ; 0 + 1	5.605 ^e
1.618 \pm 2	γ, α_0	< 0.8	1.4 \pm 0.2	1 ⁻ ; 0 + 1	5.674 ^f
1.765 \pm 4	γ		0.047 \pm 0.018	2 ⁻ ; 0	5.788
2.160 \pm 4	γ		0.20 \pm 0.04	4 ⁻ ; 0	6.096
2.166 \pm 7	γ, α_0		0.08 \pm 0.03	1, 2, 3 ⁽⁻⁾ ; 0	6.100
			^b		
2.348 \pm 3	γ, α_0	< 0.8		3 ⁻ ; 0 + 1	6.242 ^g
2.372 \pm 3	γ, α_0	< 3		1 ⁺ ; (0)	6.261 ^h
			^c		
2.438 \pm 4	γ		0.52 \pm 0.12	3 ⁺ ; 0	6.312
2.532 \pm 4	γ		1.6 \pm 0.4	2 ⁺ ; 0 + 1	6.385
	γ		0.16 \pm 0.06	3 ⁺ ; (0)	6.480
2.767 \pm 4	γ, α_0	(< 0.8)	0.29 \pm 0.06	5 ⁺ ; 0	6.568
2.870 \pm 4	γ, p_0	< 1.6	2.7 \pm 0.5	2 ⁻ ; 1	6.648
2.870 \pm 6	α_0	93 \pm 5	$\Gamma_\alpha/\Gamma = 0.85$	1 ⁻	6.648
			0.12 \pm 0.07	4 ⁺ ; 0	6.78
			< 0.2	1 ⁺ , 2, 3 ⁺ ; (0)	6.803
3.080 \pm 6	p_0, α_0	101 \pm 5		2 ⁻	6.811
3.576 \pm 4	α_0	< 4		(4 ⁺)	7.197
3.67	α_0	45 \pm 10		(1 ⁺)	7.27
3.72	p_0, α_0	53 \pm 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 $^{14}\text{N} + \alpha$ below $E_\alpha = 5 \text{ MeV}$ ^a (continued)

E_α (MeV \pm keV)	Particles out	$\Gamma_{\text{c.m.}}$ (keV)	$(2J + 1)\Gamma_\gamma\Gamma_\alpha/\Gamma$ (eV)	$J^\pi; T$	E_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 $^{14}\text{N}(\alpha, \alpha_1)$ are listed in Table 18.14 of (1978AJ03).

^b ≤ 0.07 for $^{18}\text{F}^*(6.11, 6.16)$ (1973RO03). See also (1978BE63).

^c ≤ 0.03 for $^{18}\text{F}^*(6.28)$ (1973RO03).

^d $\Gamma_\alpha = 42.8 \pm 1.6 \text{ eV}$, $\Gamma_\gamma = 0.485 \pm 0.046 \text{ eV}$, $l_\alpha = 0$ (1980MA26). See also Table 18.17.

^e $\Gamma_\alpha = 32.0 \pm 2.1 \text{ eV}$, $\Gamma_\gamma = 0.891 \pm 0.074 \text{ eV}$, $l_\alpha = 1$. ΔE_x for $^{18}\text{F}^*(5.603, 5.605)$ is $1.84 \pm 0.04 \text{ keV}$ (1980MA26). See also Table 18.17.

^f $\Gamma_\alpha = 130 \pm 5 \text{ eV}$, $\Gamma_\gamma = 1.4 \pm 0.3 \text{ eV}$, $l_\alpha = 1$ (1980MA26).

^g This resonance corresponds to two states at $E_x = 6240$ and 6242 keV . The lower member of the doublet (both of which have $J^\pi = 3^-$ and mixed isospin) has $\Gamma_\alpha = 133 \pm 4 \text{ eV}$, $\Gamma_\gamma = 0.80 \pm 0.11 \text{ eV}$; the higher has $\Gamma_\alpha = 137 \pm 4 \text{ eV}$, $\Gamma_\gamma = 0.73 \pm 0.11 \text{ eV}$ (1979KI12). See also (1978BE63).

^h $\Gamma_\alpha = 580 \pm 12 \text{ eV}$, $\Gamma_p = 25_{-25}^{+35} \text{ eV}$ (1979KI12).

$$7. \ ^{13}\text{C}(^{14}\text{N}, \ ^9\text{Be})^{18}\text{F} \quad Q_m = -6.232$$

See (1978PI1E).

$$8. \ ^{14}\text{N}(\alpha, \gamma)^{18}\text{F} \quad Q_m = 4.4159$$

A number of resonances have been observed for $E_\alpha < 3 \text{ MeV}$: 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 $^{14}\text{N}(\alpha, \alpha)$, $^{16}\text{O}(^3\text{He}, p)$, $^{17}\text{O}(p, \gamma)$ and $^{17}\text{O}(p, \alpha)$ [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_x , J^π and K^π assignments for ^{18}F states with $E_x < 6.9 \text{ MeV}$. 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, $S \approx 0.7 \text{ MeV} \cdot \text{b}$ (1972CO1C). See also (1978TA1U; astrophys.).

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

E_d (MeV \pm keV)	Particles out	$\Gamma_{\text{c.m.}}$ (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	$n, p_1, \alpha_0, \alpha_1$		$\geq 2; 0$	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	$\alpha_0, \alpha_2, \alpha_4$	60	$4, 5^+; 0$	12.06
5.17	α_0	55	$T = 0$	12.12

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

E_d (MeV \pm keV)	Particles out	$\Gamma_{\text{c.m.}}$ (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 $^{16}\text{O} + \text{d}$ ^a (continued)

E_d (MeV \pm keV)	Particles out	$\Gamma_{\text{c.m.}}$ (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 $^{16}\text{O} + \text{d}$ ^a (continued)

E_d (MeV \pm keV)	Particles out	$\Gamma_{\text{c.m.}}$ (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).

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

See (1978AJ03).

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

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

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

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

$^{16}\text{O}(d, \alpha_1)$ 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 $^{16}\text{O} + d$ at the same E_x relatively suppresses high- J states in the $^{16}\text{O} + d$ 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 $^{16}\text{O}(^3\text{He}, p\gamma)^{18}\text{F}$ ^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 $^{16}\text{O}(^3\text{He}, p\gamma)^{18}\text{F}$ ^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).

$$\begin{array}{lll}
 12. \text{ (a) } ^{14}\text{N}(\alpha, 2\alpha)^{10}\text{B} & Q_m = -11.6132 & E_b = 4.4159 \\
 \text{ (b) } ^{14}\text{N}(\alpha, ^6\text{Li})^{12}\text{C} & Q_m = -8.7989 &
 \end{array}$$

The total cross section for formation of ^{10}B and ^6Li 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, 1981GO1E). See also (1980BA2K; theor.).

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

Table 18.17: Excited states of ^{18}F from $^{17}\text{O}(\text{p}, \gamma)^{18}\text{F}$ (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. $^{14}\text{N}(^7\text{Li}, \text{t})^{18}\text{F}$ $Q_m = 1.949$

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 $^{18}\text{F}^*(1.70, 2.53, 3.36, 4.23, 5.30, 6.57)$ 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 $^{16}\text{O}(^3\text{He}, \text{p})^{18}\text{F}$ and $^{17}\text{O}(^3\text{He}, \text{d})^{18}\text{F}$) 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 $E_x = 9.58 \pm 0.02, 11.22 \pm 0.03$ 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 $^{18}\text{F}^*(1.70, 2.10, 2.52, 3.36, 4.40, 5.30, 6.57, 9.58, 11.22, 14.18)$.] See also (1979SA31; theor.).

15. (a) $^{14}\text{N}(^{11}\text{B}, ^7\text{Li})^{18}\text{F}$ $Q_m = -4.249$
 (b) $^{14}\text{N}(^{13}\text{C}, ^9\text{Be})^{18}\text{F}$ $Q_m = -6.2320$

Table 18.18: Resonances in $^{17}\text{O} + \text{p}$ ^a

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

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

E_p (keV)	Yield of ^b	$\Gamma_{\text{c.m.}}$ (keV)	$(2J + 1)\Gamma_p\Gamma_\alpha/\Gamma$ (keV)	$J^\pi; T$	E_x (MeV \pm keV)
1957 \pm 2	p ₀	6		1 ⁻	7.455
1983 \pm 2	$\gamma, \text{p}_1, \alpha_0$	12 \pm 3	1.5	(2)	7.480
(1990 \pm 2)	p ₀	32		(1 ⁻)	(7.486)
2012 \pm 2	p ₀ , α_0	12 \pm 2	7.2	4 ⁻	7.507
2020 \pm 2	γ	< 4			7.515
2036 \pm 2	$\gamma, \text{p}_0, \text{p}_1, \alpha_0$	16.5 \pm 3.0	5.5 ^e	2 ⁻ ; 1	7.530
2040 \pm 5	p ₁ , α_0	75			7.534
2064 \pm 2	p ₀	30		(1 ⁻)	7.556
2095 \pm 2	$\gamma, \text{p}_0, \text{p}_1, \alpha_0$	9 \pm 2	3.7 ^f	^g	7.586
2202 \pm 2	p ₀ , p ₁ , α_0	36 \pm 4	25.1	3 ⁺ , 4 ⁺ ^g	7.687
2248 \pm 4	p ₁ , α_0	66 \pm 5	28.2	≥ 1	7.730
2284 \pm 4	p ₁	70			7.764
2406 \pm 3	p ₁ , α_0	20	24.4	≥ 2	7.879
2429 \pm 2	α_0	38	42	(2 ⁻)	7.901
2473 \pm 12	α_0	112	80	(1 ⁺)	7.943
2603 \pm 6	p ₁ , α_0	60	11	≥ 4	8.065
E_p (keV)	Yield of ^b	$\Gamma_{\text{c.m.}}$ (keV)	$(2J + 1)\Gamma_p\Gamma_\alpha/\Gamma$ (eV)	$J^\pi; T$	E_x (MeV \pm keV)
2657 \pm 8	p ₁	96			8.116
2757 \pm 2	p ₀ , α_0	52	63	2 ⁻	8.211
2788 \pm 2	p ₀	20		4 ⁺	8.240
2928	α_0	≈ 50			8.371
3915 \pm 20	n	95			9.302
(4163 \pm 20)	n	19			(9.537)
4235 \pm 10	n	33			9.605
4330 \pm 10	n	33			9.694
4490 \pm 20	n	≈ 100			9.845
(4790 \pm 10)	n	28			(10.128)
4900 \pm 20	n	≈ 140			10.232

^a For references see table 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).

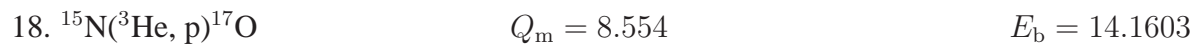
These reactions have been studied at $E(^{11}\text{B}) = 115$ MeV and $E(^{13}\text{C}) = 105$ MeV. Differential cross sections at three angles are reported for the transitions to $^{18}\text{F}^*(9.58, 10.57 \pm 0.07, 11.2)$ in reaction (a) and to $^{18}\text{F}^*(5.30, 6.57, 9.58, 10.60 \pm 0.08, 11.2)$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



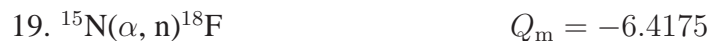
See (1977VO08).



Excitation functions have been measured for $E(^3\text{He}) = 2.5$ to 16 MeV for the γ_0 and $\gamma_{1 \rightarrow 4}$ yields. Resonances are observed corresponding to $E_x = (19.00 \pm 0.15)$ [$\gamma_{1 \rightarrow 4}$], 20.1 ± 0.2 [$\gamma_0, \gamma_{1 \rightarrow 4}$], 22.7 ± 0.2 [$\gamma_0, \gamma_{1 \rightarrow 4}$] and (24.1 ± 0.2) MeV [$\gamma_{1 \rightarrow 4}$], with $\Gamma_{\text{c.m.}} = 0.5 \pm 0.15, 1.6 \pm 0.1, 1.2 \pm 0.1$ and 1.4 ± 0.3 MeV, respectively. The γ_0 yield is dominated by $^{18}\text{F}^*(20.1)$ (1981WA1R) [see for $(2J + 1)\Gamma_{^3\text{He}}\Gamma_\gamma$ 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).



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



See (1978AJ03).

$$20. \text{}^{15}\text{N}(\text{}^6\text{Li}, \text{t})\text{}^{18}\text{F} \quad Q_{\text{m}} = -1.634$$

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

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

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

$$22. \text{}^{16}\text{O}(\text{d}, \gamma)\text{}^{18}\text{F} \quad Q_{\text{m}} = 7.5263$$

The capture cross section rises from $0.1 \mu\text{b}$ at $E_{\text{d}} = 0.4$ MeV to $25 \mu\text{b}$ 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).

$$23. \text{}^{16}\text{O}(\text{d}, \text{n})\text{}^{17}\text{F} \quad Q_{\text{m}} = -1.6243 \quad E_{\text{b}} = 7.5263$$

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 $E_{\text{d}} = 3$ to 15 MeV: see (1978AJ03) and at $E_{\text{d}} = 5$ to 15 MeV (1981LI23; \vec{n}_{0+1}). See also ^{17}F in (1982AJ01), (1980HU1J, 1980HU1D) and (1981NO1B).

$$24. \text{}^{16}\text{O}(\text{d}, \text{p})\text{}^{17}\text{O} \quad Q_{\text{m}} = 1.9197 \quad E_{\text{b}} = 7.5263$$

Excitation functions and polarization studies have been reported for several proton groups for $E_d = 0.3$ to 17 MeV: see (1978AJ03) and (1978RO1M; $E_{\bar{d}} = 14$ 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. $^{16}\text{O}(d, d)^{16}\text{O}$

$$E_b = 7.5263$$

The yield of elastically scattered deuterons and elastic polarization measurements have been reported for $E_d = 0.65$ to 56 MeV: see (1978AJ03) and (1982AOZZ; $E_d = 13.8$ to 16.5 MeV), (1981FR1C; TAP; $E_{\bar{d}} = 20$ MeV), (1981CL1C; VAP; $E_{\bar{d}} = 20.5$ MeV; also to $^{16}\text{O}^*(6.13)$), (1980MA10; VAP; $E_{\bar{d}} = 52$ MeV), (1980HA14; VAP; $E_{\bar{d}} = 56$ 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) $^{16}\text{O}(d, t)^{15}\text{O}$

$$Q_m = -9.4065$$

$$E_b = 7.5263$$

(b) $^{16}\text{O}(d, ^3\text{He})^{15}\text{N}$

$$Q_m = -6.6340$$

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

27. $^{16}\text{O}(d, \alpha)^{14}\text{N}$

$$Q_m = 3.1104$$

$$E_b = 7.5263$$

The yields of various groups of α -particles have been measured for $E_d \leq 20$ 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 $9.2 < E_x < 19.4$ 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 $E_x = 14$ MeV to ≈ 500 keV at $E_x = 20$ 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 $^{14}\text{N}(\alpha, \alpha_1)$ see Table 18.14 in (1978AJ03)].

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

28. $^{16}\text{O}(\text{d}, ^6\text{Li})^{12}\text{C}$

$$Q_{\text{m}} = -5.6885$$

$$E_{\text{b}} = 7.5263$$

See (1978AJ03).

29. $^{16}\text{O}(\text{t}, \text{n})^{18}\text{F}$

$$Q_{\text{m}} = 1.2690$$

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

30. $^{16}\text{O}(^3\text{He}, \text{p})^{18}\text{F}$

$$Q_{\text{m}} = 2.0328$$

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 τ_{m} measurements [see also Tables 18.12 and 18.13]. Studies of this reaction, together with the work on $^{14}\text{N}(\alpha, \gamma)$ and $^{17}\text{O}(\text{p}, \gamma)$, have defined the low-lying states of ^{18}F .

The g -factor of $^{18}\text{F}^*(0.94)$ [$J^\pi = 3^+$] is $+0.54 \pm 0.06$ (1981ST21), 0.58 ± 0.07 (1978GO1T). τ_{m} of $^{18}\text{F}^*(1.04) = 2.7 \pm 0.7$ 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 $^{18}\text{F}^*(1.08 \rightarrow \text{g.s.})$ decay leads to a value for the circular polarization of the $1.08 \rightarrow \text{g.s.}$ γ -ray [P_γ] [0^- ; $T = 0$ to 1^+ ; 0] = $\pm(5.8 \pm 0.4)$ keV $^{-1}\langle 1.04|V^{\text{PNC}}|1.08\rangle$ (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 $^{18}\text{F}^*(1.04, 1.08)$ [$J^\pi = 0^+, T = 1$; $J^\pi = 0^-, T = 1$, respectively] lies in testing the parity non-conserving (PNC) component of nuclear forces: see also (1980BI11), (1981HA1H) and (1980HA41; theor.). The magnetic moment of $^{18}\text{F}^*(1.13) = +2.855 \pm 0.030$ nm, in agreement with shell-model predictions for a $(1d_{5/2}^2)_{5^+}$ state: see (1978AJ03). See also (1979HA1M), (1977FI13, 1980HE06; applied) and ^{19}Ne .

31. $^{16}\text{O}(\alpha, \text{d})^{18}\text{F}$

$$Q_{\text{m}} = -16.3204$$

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

32. $^{16}\text{O}(^6\text{Li}, \alpha)^{18}\text{F}$

$$Q_{\text{m}} = 6.053$$

Angular distributions for α_0 are reported at $E(^6\text{Li}) = 5.5$ to 13.3 and 26 MeV: see (1978AJ03). At $E(^6\text{Li}) = 34$ MeV angular distributions are reported to $^{18}\text{F}^*(0, 0.94, 1.1$ [unres.]) and forward angle data has been obtained for $^{18}\text{F}^*(2.10, 3.72, 3.79, 3.84)$. The angular distributions for the first three groups are forward peaked and show little structure at back angles. $^{18}\text{F}^*(1.04, 3.06)$ 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.).

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

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

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

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

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

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

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

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

See (1978AJ03).

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

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

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: $^{18}\text{F}^*(5.603, 5.605, 5.668, 5.786)$ have $J^\pi = 1^+, 1^-, 1^-$ and 2^- . The 1^- states have mixed isospin. Astrophysical considerations are discussed in (1978AJ03) and (1975ZI1A, 1977RO1H, 1978RO1D).

$$38. \text{}^{17}\text{O}(\text{p}, \text{n})\text{}^{17}\text{F} \qquad Q_{\text{m}} = -3.544 \qquad E_{\text{b}} = 5.607$$

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

$$39. \text{}^{17}\text{O}(\text{p}, \text{p})\text{}^{17}\text{O} \qquad E_{\text{b}} = 5.607$$

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

$$40. \text{}^{17}\text{O}(\text{p}, \text{d})\text{}^{16}\text{O} \qquad Q_{\text{m}} = -1.920 \qquad E_{\text{b}} = 5.607$$

See (1978AJ03).

$$41. \text{}^{17}\text{O}(\text{p}, \alpha)\text{}^{14}\text{N} \qquad Q_{\text{m}} = 1.191 \qquad E_{\text{b}} = 5.607$$

The yield of α_0 shows a number of resonances for $E_{\text{p}} = 0.49$ to 3.0 MeV: see Table 18.18. The R -matrix fit of (1979KI13), obtained from data from $E_{\text{p}} = 400$ 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.).

$$42. \text{}^{17}\text{O}(\text{d}, \text{n})\text{}^{18}\text{F} \qquad Q_{\text{m}} = 3.382$$

See (1972AJ02).

$$43. \text{}^{17}\text{O}(\text{}^3\text{He}, \text{d})\text{}^{18}\text{F} \qquad Q_{\text{m}} = 0.113$$

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 $^{18}\text{F}^*(4.11)$ may be assigned $J^{\pi} = (2^+)$ or 3^+ . Since $l = 2$ for $^{18}\text{F}^*(4.65)$, $J^{\pi} \leq 5^+$, with 4^+ most likely (1969PO11). See also (1979SA31; theor.).

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

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

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

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 $^{18}\text{F}^*(1.04)$ [$J^\pi = 0^+$; $T = 1$] is $2.7_{-0.4}^{+0.6}$ fsec (1980KE05): see Table 18.13. See also ^{19}F .

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

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 $^{18}\text{F}^*(1.08, 1.12, 1.70, 2.10, 3.13, 3.36, 3.72, 3.79, 3.84, 4.12, 4.23, 4.36, 4.40, 4.65, 4.75)$. The angular distributions are consistent with the J^π assignments shown in Table 18.11, except for the distribution to $^{18}\text{F}^*(1.04)$ (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 $^{18}\text{F}^*(1.04)$ (1968HA30). At $E(^3\text{He}) = 33$ MeV the analyzing power angular distribution for t_0 has been measured by (1981BA1G).

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

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

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

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

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

Table 18.19: Branching in $^{18}\text{Ne}(\beta^+)^{18}\text{F}$ ^a

Decay to $^{18}\text{F}^*$ (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 $^{18}\text{F}^*(1.04)$.

^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 $^{18}\text{F}^*(0.94, 1.04, 1.08, 3.06, 3.13, 4.75)$ are reported by (1979TH05). See also (1978AJ03), (1980YA08; applied) and ^{19}F .

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

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

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

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).

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

Table 18.20: States of ^{18}F from $^{19}\text{F}(\text{p}, \text{d})$ ^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).

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

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

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

See (1972AJ02).

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

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

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

At $E_d = 11$ MeV α -groups are observed to many states of ${}^{18}\text{F}$ with $E_x < 7$ MeV. Weak or absent (each $\leq 0.3\%$ of the total yield at 30°) are the groups corresponding to ${}^{18}\text{F}^*(1.04, 3.06, 4.66, 4.74, 4.96)$: $T = 1$ 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 ${}^{18}\text{F}^*(2.10$ [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 ${}^{18}\text{F}^*(3.06)$ 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 $E_d = 10.25$ to 12.0 MeV leads to assignments of unnatural parity for ${}^{18}\text{F}^*(0, 0.94, 1.08 + 1.12, 1.70, 2.10, 3.36, 3.72, 4.12, 4.23, 4.36, 4.40, 5.603 + 5.605 + 5.67, 5.79, 6.10 + 6.10, 6.14 + 6.16, 6.31, 6.48)$ and to natural parity for ${}^{18}\text{F}^*(3.79, 3.84, 4.86)$: assignments of $J^\pi = 2^-, 1^+, 0^+, 1^-, 1^+, 3^+, 3^+$ are made for ${}^{18}\text{F}^*(4.23, 4.36, 4.75, 4.86, 5.603, 6.16, 6.48)$ [all $T = 0$ except ${}^{18}\text{F}^*(4.75)$] (1978DA02).

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

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

$$58. {}^{24}\text{Mg}({}^{12}\text{C}, {}^{18}\text{F}){}^{18}\text{F} \quad Q_m = -15.676$$

See (1978NO02).

¹⁸Ne
(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: (1978WO1E).

Complex reactions involving ¹⁸Ne: (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 ¹⁸Ne: (1977HA1Z, 1982ZH1D).

1. ¹⁸Ne(β^+)¹⁸F $Q_m = 4.447$

The half-life of ¹⁸Ne is 1672 ± 5 msec: see (1978AJ03). The decay is primarily to ¹⁸F*(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 ¹⁸F*(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 ¹⁸F*(1.04, 1.08) $0^+, 0^-$ doublet (1981AD01). [See also the discussion in (1981HA06)]. See also (1980LO1B, 1981BO1F) and (1978SZ03, 1979WI1Q, 1980OK01, 1981HA1Q; theor.).

2. ¹⁶O(³He, n)¹⁸Ne $Q_m = -3.196$

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

3. ¹⁶O(¹⁰B, ⁸Li)¹⁸Ne $Q_m = -18.951$

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

E_x (MeV \pm keV)	$J^\pi; T$	τ or $\Gamma_{\text{c.m.}}$ (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_i^π	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 $^{18}\text{Ne}^*(3.38)$ [$(d_{5/2})_{4^+}^2$ state] which is preferentially populated, has been studied by (1978HA10): $^{18}\text{Ne}^*(1.89)$ is also observed.

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

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

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

See (1978AJ03).

$$6. \ ^{18}\text{O}(\pi^+, \pi^-)^{18}\text{Ne} \quad Q_m = -6.101$$

Angular distributions of the transition to $^{18}\text{Ne}_{g.s.}$ have been studied at $E_{\pi^+} = 164$ MeV (1979GR18, 1979SE08, 1982GR1F; also to $^{18}\text{Ne}^*(1.89)$), and at 292 MeV (1982GR1F). The excitation function for production of $^{18}\text{Ne}^*(0, 1.89)$ have been measured by (1979GR18, 1982GR02, 1982GR1F) for $E_{\pi^+} = 80$ to 292 MeV. See also (1978AJ03), (1977PE12, 1978BU09, 1982GR1U) and the ‘‘GENERAL’’ section here.

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

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

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

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

B: $^{20}\text{Ne}(\text{p}, \text{t})^{18}\text{Ne}$: (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.

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