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Energy Levels of Light Nuclei
$A = 18$

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Abstract: An evaluation of $A = 18$–20 was published in *Nuclear Physics A*475 (1987), 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. Reference key numbers have been changed to the NNDC/TUNL format.

(References closed June 1, 1987)

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^{18}He

(Not illustrated)

Not observed: see (1982AV1A, 1983ANZQ; theor.).

^{18}Be

(Not illustrated)

^{18}Be has not been observed. It is predicted to have a mass excess of 78.43 MeV: see (1978AJ03). ^{18}Be is then unstable with respect to breakup into ^{16}Be + 2n, ^{15}Be + 3n, ^{14}Be + 4n, ^{13}Be + 5n, ^{12}Be + 6n, ^{11}Be + 7n and ^{10}Be + 8n by, respectively, 3.1, 3.0, 6.0, 3.1, 4.9, 1.8 and 1.3 MeV, using the masses for the residual nuclei adopted by (1985WA02, 1986AJ01, 1986AJ04). See also (1983ANZQ; theor.).

^{18}B

(Not illustrated)

^{18}B has not been observed in the bombardment of Ta by 44 MeV/A Ar ions (1985DE60, 1985LA03, 1986PO13) or in the bombardment of Be by 12 MeV/A ^{56}Fe ions (1984MU27). ^{18}B has been predicted to have a mass excess of 53.85 MeV. It would then be unstable with respect to ^{17}B + n by 1.8 MeV: see (1978AJ03, 1985WA02). ^{18}B is calculated to have $J^{\pi} = 4^-$ and to have excited states at 0.62, 0.86 and 1.59 MeV with $J^{\pi} = 1^-$, 2^- and 2^- (1985PO10). See also (1985AN1B) and (1983ANZQ; theor.).

^{18}C

(Fig. 4)

GENERAL: (See also (1978AJ03, 1983AJ01).)

See (1983ANZQ, 1983FR1A, 1983WI1A, 1984SA37, 1986AN07, 1986AV1B, 1986GU1D, 1987SA15).

Mass of ^{18}C: The atomic mass excess of ^{18}C is 24.923 ± 0.030 MeV, based on the Q-value of the ^{48}Ca(^{18}O, ^{18}C)^{48}Ti reaction. ^{18}C is then bound by 4.187 MeV with respect to breakup into ^{17}C + n (1982FI10). See also (1986PI09).

1. ^{18}C(β^-)^{18}N $\qquad Q_{\rm m} = 11.806$

The half-life of ^{18}C, $\tau_{1/2} = 66^{+25}_{-15}$ msec, $P_{\rm n} \approx 25\%$ (1987MU1J; prelim.). See also (1984KL06; theor.).

Table 18.1: Energy levels of ^{18}C

E_x in ^{18}C (MeV ± keV)	$J^\pi; T$	Decay	Reactions
0	$(0^+); 3$	(β^-)	2, 3
1.62 ± 20	$(2^+); 3$		2, 3

2. ^{18}O(π^-, π^+)^{18}C $\qquad Q_m = -25.705$

The angular distribution of the π^+ to the ground state of ^{18}C has been measured at $E_{\pi^-} = 164$ MeV by (1984GI10) [see also for excitation function at $\theta = 5°$ for $E_{\pi^-} \approx 140$ to 240 MeV]. There is also some indication of the population of an excited state at $E_x = 1.55$ MeV (1984GI10). See also (1983AJ01).

3. ^{48}Ca(^{18}O, ^{18}C)^{48}Ti $\qquad Q_m = -21.434$

$Q_0 = -21434 \pm 30$ keV (1982FI10).

At $E(^{18}\text{O}) = 112$ MeV the ground state and an excited state at 1.62 ± 0.02 MeV are observed by (1982FI10). See also (1983AJ01).

^{18}N

(Figs. 1 and 4)

GENERAL: (See also (1983AJ01).)

See (1981NAZQ, 1983ANZQ, 1983FR1A, 1983SH44, 1983WI1A, 1984AS1D, 1984HI1A, 1986AN07, 1986BI1A, 1986HA1B, 1986MA48, 1986ME1F, 1987RI03).

Mass of ^{18}N: The atomic mass excess derived from the Q-value of the ^{18}O(^{7}Li, ^{7}Be)^{18}N reaction is 13.117 ± 0.020 MeV (1983PU01). ^{18}N is then stable with respect to breakup into ^{17}N + n by 2.825 MeV. See (1983AJ01) for the earlier work.

1. ^{18}N(β^-)^{18}O $\qquad Q_m = 13.899$

The half-life of ^{18}N is 0.624 ± 0.012 sec (1982OL01). The decay branches are displayed in Table 18.9. The nature of the decay leads to $J^\pi = 1^-$ for the ^{18}N ground state (1982OL01). See also (1983SN03).

Table 18.2: Energy levels of ^{18}N

E_x (MeV ± keV)	$J^\pi; T$	$\tau_{1/2}$ (msec)	Decay	Reactions
0	$1^-; 2$	624 ± 12	β^-	1, 3, 4, 5, 6
0.121 ± 10	2^{-} [a]			3, 4, 6
0.575 ± 25	2^{-} [a]			3, 6, 7
0.747 ± 10	3^{-} [a]			6
[b]				
2.21				6
2.42				6

[a] Suggested by (1984BA24). See also (1982OL01).

[b] See (1984BA24) for a calculation suggesting additional states.

2. ^{14}C(^{7}Li, ^{3}He)^{18}N $\quad Q_m = -10.122$

The work described in (1983AJ01) has not been published.

3. ^{14}C(^{18}O, ^{14}N)^{18}N $\quad Q_m = -13.743$

At $E(^{18}\text{O}) = 92.2$ MeV groups are observed to the ground state of ^{18}N (unresolved) and to an excited state at $E_x = 575 \pm 25$ keV (1980NA14).

4. ^{18}O(π^-, π^0)^{18}N $\quad Q_m = -9.295$

See (1983AS01, 1984AS05).

5. ^{18}O(t, ^{3}He)^{18}N $\quad Q_m = -13.881$

See (1983AJ01).

6. ^{18}O(^{7}Li, ^{7}Be)^{18}N $\quad Q_m = -14.761$

$Q_0 = -14761 \pm 20$ keV (1983PU01).

At $E(^7\mathrm{Li}) = 52$ MeV, ^{7}Be groups are observed corresponding to the excitation of the states displayed in Table 18.2 (1983PU01).

7. ^{18}O(^{11}B, ^{11}C)^{18}N $\qquad Q_{\mathrm{m}} = -15.881$

See (1983PU01).

^{18}O

(Figs. 1 and 4)

GENERAL: (See also (1983AJ01).)

Shell model: (1978WI1B, 1982ZH01, 1983BR29, 1983WA17, 1983KI13, 1984AS07, 1984BA24, 1984CH1V, 1985LE1K, 1985SA29, 1986HAZY, 1986YU1B, 1987WA1H).

Cluster, collective and deformed models: (1983BE1W, 1983CL1B, 1983ME12, 1984AS04, 1984BA55, 1984GA1T, 1984SA37, 1985BA1A, 1985DE24, 1985RO1G, 1985SU10, 1986CA1T, 1986KA1D, 1986YU1B).

Special states: (1978WI1B, 1982BA62, 1982BE1Z, 1982ZH01, 1983BE1W, 1983BR29, 1983LI10, 1983ME12, 1983WA17, 1983KI13, 1984AS07, 1984BA24, 1984BA55, 1984CH1V, 1984GA1T, 1984GE1A, 1984HA14, 1984SA37, 1984ST1E, 1984WI17, 1985BR20, 1985CA1Q, 1985DE24, 1985LE1K, 1985LE1L, 1985MA1Q, 1985MA1R, 1985RO1G, 1985SA29, 1985SO12, 1985SU10, 1985YU1B, 1986AN10, 1986AN07, 1986CA1T, 1986CA27, 1986GU1A, 1986KA1D, 1986YU1B, 1987WA1H, 1987YA03).

Electromagnetic transitions and giant resonances: (1982AL30, 1982BA62, 1982BR24, 1982RI04, 1983BR29, 1983IS1F, 1983KA28, 1983KI13, 1984AS04, 1984AS07, 1984BA55, 1984BR1L, 1984GA1T, 1984HA14, 1984ST02, 1985AL21, 1985DE24, 1985LE1L, 1985SU10, 1985WI17, 1986AN10, 1986CA27, 1986ER1A, 1986HAZY).

Astrophysical questions: (1981WA1Q, 1982BU1A, 1982CA1A, 1982RO1A, 1982WI1B, 1982WO1A, 1983CO1K, 1984BL1J, 1984HA1R, 1984HA1Z, 1984LA1J, 1985HA1Z, 1985HA1R, 1986CO2C, 1986DO1L, 1986LA1C, 1986WI1L, 1987HA1C, 1987HA1D, 1987PR1A, 1987WI11).

Applications: (1982MA1Q, 1982PI1H, 1983AM1A, 1983AM1D, 1983GR1L, 1983KI1D, 1983KU1C, 1983LI1T, 1983TA1P, 1984LE1G, 1984SH2A, 1985WA1R, 1985YO1B, 1985ZA1A, 1986CO2B, 1986DR1E, 1986DU1Q, 1986EN1A, 1986HO1Q, 1986HO1L, 1986NI1C, 1986XU1C).

Complex reactions involving ^{18}O: (1981IC02, 1982MO1K, 1982SA1Q, 1983DE26, 1983EN04, 1983FR17, 1983FR1A, 1983GR10, 1983GR28, 1983LI10, 1983OL1A, 1983SA06, 1983VA23, 1983WI1A, 1984GR08, 1984HI1A, 1984HO23, 1984NA1D, 1985DE60, 1985GAZT, 1985HO05, 1985KAZQ, 1985MA1Q, 1985PO11, 1986AN1F, 1986HA1B, 1986IR01, 1986MA19, 1986ME06, 1986PO06, 1986SA30, 1986SC28, 1986SC29, 1986SO10, 1986VAZZ, 1987LI04, 1987RI03).

Muon capture: (1983GM1A, 1987SU06).

Pion capture and reactions (See also reaction 23): (1981SEZR, 1982BI08, 1982LI15, 1982LI1M, 1982LI1N, 1983AM1C, 1983AS01, 1983BE1W, 1983GE12, 1983HO02, 1983JO06, 1983LI08, 1983LI1U, 1983MA16, 1983ME1H, 1983OS1E, 1983RO07, 1983SE16, 1983ZE1C, 1984AL20, 1984AS05, 1984BL17, 1984GR27, 1984HU1C, 1984JO01, 1984KA26, 1984SC09, 1984TR15, 1985AL15, 1985BI01, 1985CA1Q, 1985CH23, 1985GI01, 1985GM01, 1985KE1A, 1985SE08, 1985SE21, 1986BA1C, 1986FO06, 1986GE06, 1986GM01, 1986RO03, 1986SCZX, 1986SI11, 1987TE01).

Table 18.3: Energy levels of ^{18}O [a]

E_{x} (MeV $\pm$ keV)	$J^{\pi}; T$	τ_{m} [b] or $\Gamma_{\mathrm{c.m.}}$ (keV)	Decay	Reactions
0	$0^{+}; 1$	—	stable	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48
1.98207 ± 0.09	2^{+}	$\tau_{\mathrm{m}}=2.80\pm0.07$ psec $g=-0.287\pm0.015$	γ	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 13, 15, 17, 18, 19, 22, 23, 24, 25, 26, 27, 29, 30, 36, 37, 39, 41, 42, 44, 45, 46, 47, 48
3.55484 ± 0.40	4^{+}	$\tau_{\mathrm{m}}=24.8\pm1.2$ psec $g=-0.62\pm0.10$	γ	2, 3, 6, 8, 9, 13, 14, 15, 17, 18, 19, 22, 25, 30, 36, 37, 47, 48
3.63376 ± 0.11	0^{+}	$\tau_{\mathrm{m}} = 1.38 \pm 0.16$ psec	γ	2, 3, 6, 8, 9, 13, 17, 19, 22, 25, 30, 36, 37, 46, 47, 48
3.92044 ± 0.14	2^{+}	26.5 ± 2.9 fsec	γ	2, 3, 6, 8, 9, 13, 17, 19, 22, 25, 30, 36, 47
4.45554 ± 0.10	1^{-}	65 ± 15 fsec	γ	2, 3, 6, 8, 9, 13, 17, 19, 25, 30, 36, 37, 46, 47
5.09778 ± 0.54	3^{-}	62 ± 25 fsec	γ	2, 3, 6, 8, 9, 13, 17, 19, 22, 23, 24, 25, 30, 36, 37, 42, 47, 48
5.2604 ± 1.2	2^{+}	10.1 ± 0.5 fsec	γ	2, 3, 6, 8, 9, 13, 15, 17, 22, 25, 30, 46, 47
5.3364 ± 0.6	0^{+}	200 ± 40 fsec	γ	2, 3, 8, 13, 17, 22, 30, 47
5.3778 ± 1.2	3^{+}	< 30 fsec	γ	2, 3, 13, 17, 47
5.53024 ± 0.29	2^{-}	< 25 fsec	γ	2, 3, 13, 19, 25, 30, 47
6.19822 ± 0.40	1^{-}	3.7 ± 0.6 fsec	γ	2, 3, 8, 13, 17, 19, 21, 30, 47
6.3513 ± 0.6	(2^{-})	< 35 fsec	γ	2, 3, 13, 17, 19, 30, 47, 48
6.4044 ± 1.2	3^{-}	30 ± 15 fsec	γ	2, 3, 13, 30, 47
6.88045 ± 0.27	0^{-}	< 25 fsec	γ	2, 3, 13, 19, 30, 46, 47

Table 18.3: Energy levels of ^{18}O [a] (continued)

E_x (MeV ± keV)	$J^\pi; T$	τ_m [b] or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
7.1169 ± 1.2	4^+	< 25 fsec	γ, α	2, 3, 6, 8, 9, 13, 15, 17, 22, 25, 30, 34, 36, 37, 47
7.619 ± 3	1^-	< 2.5		2, 3, 6, 8, 13, 30, 34, 36, 37, 47
7.77107 ± 0.50	2^-		γ	2, 3, 13, 19, 47
7.864 ± 5	5^-		γ	2, 3, 6, 8, 9, 13, 17, 22, 30, 34, 36, 37, 47, 48
7.977 ± 4	$(3^+, 4^-)$		γ	2, 3, 13, 17, 47
8.039 ± 2	1^-	< 2.5	γ, α	2, 3, 6, 7, 13, 14, 15, 34, 36, 37, 47
8.125 ± 2	5^-		γ, α	2, 3, 6, 8, 9, 13, 47
8.213 ± 4	2^+	1.0 ± 0.8	γ, n, α	2, 3, 6, 7, 13, 25, 30, 34, 36, 37, 47
8.282 ± 3	3^-	8 ± 1	γ, n, α	2, 3, 6, 7, 8, 9, 13, 30, 47
8.410 ± 8		8 ± 6	n, α	7, 13, 47
8.521 ± 6				13, 47
8.660 ± 6				13, 47
8.817 ± 12	(1^+)	70 ± 12	n, α	7, 25, 30
8.955 ± 4		43 ± 3	n, α	7, 13, 30
9.03				13, 17, 30
(9.10)				30
9.361 ± 6	(3^-)	27 ± 15	γ, n, α	7, 9, 13, 22, 30, 34, 36, 37
9.414 ± 18		≈ 120	n, α	7, 9, 13, 30
9.48 ± 24		≈ 65	n, α	7, 13
9.672 ± 7	(3^-)	60 ± 30	n, α	7, 13, 30, 34, 36, 37
9.713 ± 7				13, 30
9.890 ± 11		≈ 150	n, α	7, 13, 30
10.118 ± 10	3^-	16 ± 4	n, α	7, 8, 13, 30
10.295 ± 14	4^+		n, α	7, 8, 9, 13, 14, 30, 34, 36, 37
10.396 ± 9	3^-		n, α	7, 13, 30

Table 18.3: Energy levels of ^{18}O [a] (continued)

E_x (MeV ± keV)	$J^\pi; T$	τ_m [b] or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
10.595 ± 15			n, α	7, 13
10.82 ± 20			n, α	7
10.91 ± 20			n, α	7, 9
10.99 ± 20			n, α	7
11.13 ± 20			n, α	7, 9, 46
11.39 ± 20	(2^+)		n, α	7, 8
11.41 ± 20	(4^+)		n, α	7, 8
11.62 ± 20	5^-	76 ± 8	γ, n, α	7, 8, 9, 22, 30, 34, 36, 37
11.69 ± 20	6^+		n, α	7, 8, 9, 30
11.82 ± 20	(3^-)		n, α	7
12.04 ± 20	(2^+)	28 ± 6	γ, n, α	7, 8, 22
12.25 ± 20	(1^-)		n, α	7, 8
12.33 ± 20	5^-		n, α	7, 8, 9
12.50 ± 20	4^+		n, α	7, 34, 36, 37
12.53 ± 20	6^+		n, α	7, 8, 9, 34, 36, 37
13.1 [c]	1^-	700	γ, n	20
13.8	1^-	600	γ, n	20
14.7	1^-	800	γ, n	20
15.8	1^-	700	γ, n	20
16.210 ± 10	$1^{(-)}$		γ	22
16.315 ± 10	$(3, 2)^-$		γ	22
16.399 ± 5	2^-; 2	< 20	γ	22, 25
16.948 ± 10	$(3, 2)^-$		γ	22
17.025 ± 10	(> 2); 2	20 ± 6	γ	22
17.05	(7^-)	≈ 350		8
17.398 ± 10	1^-; (2)	600	γ, n, p	20, 22
17.450 ± 10	$(2, 1, 3)^-$		γ	22
17.5		≈ 150	γ	22
17.502 ± 10	$(1, 2, 3)^-$		γ	22
(17.6 ± 200)	(8^+)			8

Table 18.3: 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
17.635 ± 10			γ	22
18.049 ± 10			γ	22
18.2		≈ 150	γ	22
18.5		≈ 4300	γ	22
18.70 ± 20	$(4^-); 2$	< 20	γ	22
18.871 ± 5	$1^+; 2$		γ	22
18.927 ± 10	$(1, 2^+)$		γ	22
18.95	(7^-)	≈ 350		8
19.027 ± 10	$(1, 3)^-$		γ	22
19.150 ± 10	$(1^-, 2^+, 3^-)$		γ	22
19.24 ± 20	$(> 2); 2$	< 20	γ	22
19.4	$1^-; (2)$	900	γ, p	20
19.7		≈ 200	γ	22
20.2		≈ 180	γ	22
20.36 ± 20	$(4^-); 2$	< 20	γ	22
21.0	$1^-; (1)$	≈ 150	γ, n, p	20, 22
22.39 ± 40	(4^-)	74 ± 7	γ	22
22.7	1^-		γ, n, p	20
23.8	$1^-; (1)$	≈ 1500	γ, n, p	20, 22
27	$1^-; (2)$		γ, n, p	20
30			γ, n	20
36			γ	20

[a] See also Tables 18.4 and 18.11 here and 18.2 in (1983AJ01).

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

[c] For additional states with $12.9 \leq E_x \leq 23.1$ MeV see (1983CU03) [reaction 8].

K-mesons and other meson interactions: (1983MA1V, 1983TO21, 1986MO1Q, 1986MO1A).

Anti-proton interactions: (1983GR11, 1984GI11, 1984SU07, 1985DU05, 1985LI16, 1986DU10, 1986FR10, 1986RO23, 1987BA18, 1987SP05).

Hypernuclei: (1984AS1D, 1984MO1N, 1985YA1C, 1986MO1Q, 1986MO1A).

Other topics: (1978WI1B, 1981CL05, 1982CA12, 1982VE02, 1983AR1J, 1983BR29, 1983CL1B, 1983JO1C, 1983MA35, 1983SH32, 1983UE01, 1984WI17, 1985AL21, 1985AN28, 1985CH23, 1985MA56, 1985YU1B, 1986GU1A).

Ground and 1.98 MeV states of ^{18}*O:* (1978WI1B, 1982BA62, 1982CA12, 1982LO13, 1983ANZQ, 1983AR1J, 1984ANZW, 1984BA55, 1984FR13, 1984HA14, 1984ST1E, 1984WE04, 1985AN28, 1985BA1A, 1985DE24, 1986CA27, 1986RO03, 1987AB03, 1987SA15).

Isotopic abundance $= (0.200 \pm 0.012)$% (1984DE53).
$\langle r^2 \rangle^{1/2} = 2.784 \pm 0.020$ fm: see reaction 22.

^{18}*O*(1.98)*

g $= -0.287 \pm 0.015$ [see (1983AJ01)]
$Q = -4.2 \pm 0.8\ e \cdot$ fm^2 [weighted mean of -3.6 ± 0.9 and
$-\ 5.8 \pm 1.5\ e \cdot$ fm^2: see (1983GR28); see also (1983AJ01)].
B(E2; $0^+ \rightarrow 2^+$) $= 39.0 \pm 1.8\ e^2 \cdot$ fm^4 [(1979FE06, 1983GR10); see also (1983AJ01)];
$= 44.8 \pm 1.3\ e^2 \cdot$ fm^4 (1982NO04);
$= 47.6 \pm 1.0\ e^2 \cdot$ fm^4 (1982BA06); see also (1987RA01).

For a discussion of the hexadecapole deformation see (1983GR10). See also (1987RA01).

1. (a) ^{10}B(^{9}Be, p)^{18}O $\qquad Q_{\rm m} = 16.8917$
   (b) ^{11}B(^{9}Be, d)^{18}O $\qquad Q_{\rm m} = 7.6621$

See (1986CU02) for production cross sections of 1.98 MeV γ-rays.

2. ^{12}C(^{7}Li, p)^{18}O $\qquad Q_{\rm m} = 8.400$

Observed proton groups are displayed in Table 18.5. See also (1983AJ01, 1986SM01).

3. ^{13}C(^{6}Li, p)^{18}O $\qquad Q_{\rm m} = 10.704$

Angular distributions of proton groups have been measured to the states shown in Table 18.5 at E(^{6}Li) $= 28$ MeV (1986SM01). It is found that when $\sigma_{\rm tot}$ to a particular state in ^{18}O is large in this reaction, it is also large in the ^{12}C(^{7}Li, p) reaction. The relationship between the cross sections in this reaction and in reaction 1 depends on the parity of the final states (1986SM01).

Table 18.4: Radiative decays in ^{18}O [a]

E_i (MeV)	J_i^π	E_f (MeV)	Branch (%)	δ
1.98	2^+	0	100	
3.55	4^+	1.98	100	
3.63	0^+	0	0.30 ± 0.06	
		1.98	99.70 ± 0.06	
3.92 [b,c,d]	2^+	0	11.4 ± 0.5 [e]	
		1.98	88.6 ± 0.5	[f]
4.46 [b,c,d]	1^-	1.98	28.6 ± 1.1	[f]
		3.63	68.9 ± 0.7	
		3.92	2.5 ± 0.6	
5.10 [b,c,d]	3^-	1.98	76.3 ± 0.6	[f]
		3.55	5.8 ± 0.6	[f]
		3.92	17.9 ± 0.4	[f]
5.26 [b,d]	2^+	0	30.3 ± 0.9	[f]
		1.98	56.0 ± 1.0	0.15 ± 0.04
		3.55	1.1 ± 0.6	
		3.63	0.9 ± 0.6	
		3.92	8.7 ± 0.4	
		4.46	3.0 ± 0.3	
5.34	0^+	0	[g]	
		1.98	60 ± 2	
		4.46	40 ± 2	[f]
5.38	3^+	1.98	86.5 ± 2.2	[f]
		3.92	13.5 ± 2.2	[f]
5.53	2^-	1.98	49 ± 2	[f]
		3.92	24 ± 2	
		4.46	27 ± 2	[f]
6.20 [b,d]	1^-	0	88.7 ± 0.9	
		3.63	2.5 ± 0.3	
		4.46	4.1 ± 0.4	
		5.26	3.6 ± 0.4	
		5.34	1.1 ± 0.3	

Table 18.4: Radiative decays in ^{18}O [a] (continued)

E_i (MeV)	J_i^π	E_f (MeV)	Branch (%)	δ
6.35	(2^-)	1.98	32 ± 2	[f]
		3.92	55 ± 2	[f]
		4.46	12 ± 2	[f]
6.40 [b,d]	3^-	1.98	68.1 ± 1.8	[f]
		3.55	7.4 ± 1.2	
		3.92	6.3 ± 1.0	[f]
		4.46	2.8 ± 1.0	
		5.10	9.8 ± 0.9	
		5.26	5.6 ± 0.9	
6.88	0^-	4.46	100	[f]
7.12 [b,d,i]	4^+	1.98	27.0 ± 0.5	$-(0.052 \pm 0.035)$
		3.55	70.0 ± 6.0 [h]	
		3.92	1.8 ± 0.4	
		5.10	1.2 ± 0.3	
7.62 [i]	1^-	0	23 ± 2	
		1.98	62 ± 3 [j]	$-(0.027 \pm 0.008)$
		4.46	8 ± 1	$-(0.21 \pm 0.03)$
		5.34	6 ± 1	
		6.20	1 ± 1	
7.77	2^-	1.98	53 ± 3	
		4.46	11 ± 2	
		5.10	36 ± 3	
7.86 [i]	5^-	3.55	> 75	
7.98	$(3^+, 4^-)$	3.55	67 ± 2	
		5.10	12 ± 2	
		5.38	21 ± 2	
8.04 [i]	1^-	0	16 ± 1	
		1.98	70 ± 2 [k]	
		3.63	10 ± 1	
		5.26	4 ± 1	
8.13 [i]	5^-	3.55	99 ± 1 [l]	

Table 18.4: Radiative decays in ^{18}O [a] (continued)

E_i (MeV)	J_i^π	E_f (MeV)	Branch (%)	δ
		5.10	1 ± 1	
8.21 [i]	2^+	0	19 ± 4	
		1.98	29 ± 3	
		3.55	3 ± 1	
		3.92	3 ± 1	
		4.46	29 ± 3	
		5.10	17 ± 1	
8.28 [i]	3^-	3.55	61 ± 3	
		4.46	3 ± 3	
		5.26	36 ± 3	

[a] For references and additional information see Tables 18.3 in (1978AJ03, 1983AJ01). Upper limits for other transitions are not shown.

[b] M. Ruscev and M. Gai, private communication.

[c] Weighted means of results in Table 18.3 and in ref. [b].

[d] See also Table 3 in (1978AJ03).

[e] $\Gamma_\pi/\Gamma = (3.0 \pm 0.6) \times 10^{-3}$.

[f] δ is consistent with 0.

[g] $\Gamma_\pi/\Gamma \leq 2.3 \times 10^{-3}$.

[h] $\Gamma_\gamma/\Gamma_\alpha = 0.9 \pm 0.1$.

[i] Adopted by (1987GA15): see for upper limits for the branching ratio to other states.

[j] $\Gamma_\alpha\Gamma_\gamma/\Gamma = 0.34$ eV.

[k] $\Gamma_\alpha\Gamma_\gamma/\Gamma = 0.89$ eV.

[l] $\Gamma_\alpha\Gamma_\gamma/\Gamma = 0.22$ eV.

4. ^{13}C(^{9}Be, α)^{18}O $\qquad Q_m = 12.8300$

See (1983AJ01, 1983VO1A).

5. ^{13}C(^{17}O, ^{12}C)^{18}O $\qquad Q_m = 3.098$

See (1983AJ01) and (1984AB1A; theor.).

Table 18.5: States of ^{18}O from ^{12}C(^{7}Li, p) and ^{13}C(^{6}Li, p)

E_{x} (keV) [a]	σ_{tot} [b] (μb)	σ_{tot} [c] (μb)
0	41.7 ± 1.7	6.1 ± 0.3
1982.4 ± 4.2	243 ± 4	39 ± 1
$\equiv 3555.0$	429 ± 5	56 ± 1
3636.1 ± 3.5	58.5 ± 1.0	13 ± 1
3922.4 ± 3.1	209 ± 3	36 ± 1
4457.8 ± 3.0	164 ± 2	46 ± 1
5099.3 ± 3.8	387 ± 5	74 ± 1
5252.1 ± 4.9	353 ± 4	44 ± 1
5331.6 ± 3.8	217 ± 2	35 ± 1
5377.6 ± 3.6		
5532.2 ± 3.7	218 ± 3	45 ± 1
6194.9 ± 3.8	103 ± 2	37 ± 1
6351.1 ± 4.5 [d]	521 ± 4	131 ± 2
6402.1 ± 4.5		
6888.1 ± 6.1	33.8 ± 0.7	5.3 ± 0.4
7119.8 ± 5.1 [e]	892 ± 10	208 ± 2
7619.4 ± 5.0	124 ± 2	33 ± 1
7779.3 ± 4.8 [f]	262 ± 3	37 ± 1
7858.7 ± 4.9 [g]	487 ± 6	101 ± 1
7972.7 ± 4.8	380 ± 4	84 ± 1
8041.5 ± 5.0	80 ± 1	19 ± 1
8133.9 ± 5.3	500 ± 6	140 ± 2
8218.3 ± 5.2	508 ± 6	48 ± 1
8291.7 ± 5.6	368 ± 4	103 ± 2

[a] (1978FO29): ^{12}C(^{7}Li, p)^{18}O. See also Table 18.4 in (1983AJ01).

[b] σ_{tot} $(0 - 180°)$ from ^{12}C(^{7}Li, p) at $E(^{7}\mathrm{Li}) = 18.0$ MeV (1978FO29). Angular distributions were also measured at 16.0 MeV. The total cross sections generally agree with a $(2J + 1)$ relationship (1978FO29). For discussions of the deviations from this relationship see (1978FO29, 1984FO15).

[c] ^{13}C(^{6}Li, p)^{18}O at $E(^{6}\mathrm{Li}) = 28.0$ MeV (1986SM01).

[d] 2^{-} is suggested.

[e] May be an unresolved doublet.

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

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

Table 18.6: Resonances in ^{14}C(α, γ)^{18}O and ^{14}C(α, α)^{14}C [a]

E_α (MeV ±)	Γ_{lab} (keV)	Particles out	^{18}O* (MeV)	J^π
1.140 ± 2 [b]		γ	7.114	4^+
1.790 ± 2 [b]	< 3	γ	7.619	1^-
2.10 [b]		γ	7.86	5^-
2.330 ± 2 [b]	< 3	γ, α_0	8.039	1^-
2.440 ± 2 [b]		γ	8.125	5^-
2.554 ± 4 [b]	1.3 ± 1	γ, n, α_0	8.213	2^+
2.643 ± 3 [b]	10 ± 1	γ, n, α_0	8.282	3^-
2.800 ± 7	10 ± 7	n	8.404	
3.330 ± 12	90 ± 15	n, α_0	8.817	
3.508 ± 4	55 ± 3	n, α_0	8.955	
4.030 ± 15	35 ± 20	n, (α_0)	9.361	
4.07 ± 40	≈ 150	n, (α_0)	9.39	
4.17 ± 40	≈ 70	n, (α_0)	9.47	
4.434 ± 10	80 ± 40	n, (α_0)	9.675	
4.70 ± 40	≈ 200	n, (α_0)	9.88	
5.004 ± 10	21 ± 5	n, α_0	10.118	3^-
5.23 [c]	[d]	n, α_0	10.29	4^+
5.34	[d]	n, α_0	10.38	3^-
5.60	[e]	n, α_0	10.58	
5.90	[f]	n, α_0	10.82	
6.02	[f]	n, α_0	10.91	
6.13	[f]	n, α_0	10.99	
6.30	[e]	n, α_0	11.13	
6.64	[d]	n, α_0	11.39	(2^+)
6.67	[d]	n, α_0	11.41	(4^+)
6.93	[d]	n, α_0	11.62	5^-
7.03	[d]	n, α_0	11.69	6^+
7.19	[f]	n, α_0	11.82	(3^-)
7.47	[f]	n, α_0	12.04	(2^+)
7.75	[g]	n, α_0	12.25	$(0^+, 1^-)$
7.85	[d]	n, α_0	12.33	5^-

Table 18.6: Resonances in ^{14}C(α, γ)^{18}O and ^{14}C(α, α)^{14}C [a] (continued)

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

[a] See also Table 18.4. For references see Table 18.5 in (1978AJ03). I am grateful to E.K. Warburton for his comments.

[b] (1987GA15): $\Gamma_\gamma = 0.095 \pm 0.020$, 0.41 ± 0.08, 0.043 ± 0.009, 1.07 ± 0.22, 0.27 ± 0.05, 0.41 ± 0.09 and 0.49 ± 0.13 eV, respectively for ^{18}O*(7.11, 7.62, 7.86, 8.04, 8.13, 8.21, 8.28).

[c] ±10–20 keV for this and all higher resonances (G.E. Mitchell, private communication).

[d] Γ_α, large; $\Gamma_{\rm n}$, large.

[e] Γ_α, small; $\Gamma_{\rm n}$, small.

[f] Γ_α, small; $\Gamma_{\rm n}$, large.

[g] Γ_α, large; $\Gamma_{\rm n}$, small.

6. ^{14}C(α, γ)^{18}O $Q_{\rm m} = 6.2270$

Resonances in the yield of capture γ-rays are observed at $E_\alpha = 1.14$, 1.79, 2.09, 2.33, 2.44, 2.55 and 2.64 MeV: see Tables 18.6 here and 18.5 in (1978AJ03). Gamma-ray angular distribution and correlation measurements lead to $J^\pi = 4^+, 1^-, 1^-$ and 5^- for ^{18}O*(7.11, 7.62, 8.04, 8.13), as well as to J^π assignments for lower states involved in the cascade decay. See also (1982AL30, 1983GA02, 1985GA1J) and (1986HA2D; astrophysics).

7. (a) ^{14}C(α, α)^{14}C $E_{\rm b} = 6.2270$
(b) ^{14}C(α, n)^{17}O $Q_{\rm m} = -1.8172$

Observed anomalies in the scattering [reaction (a)] for $E_\alpha = 2$ to 8.2 MeV and the resonances in the relative neutron yield [reaction (b)] for $E_\alpha = 2.3$ to 8.5 MeV are displayed in Table 18.6. See also (1978AJ03) and (1985DE24, 1988UM1A; theor.).

8. (a) ^{14}C(^{6}Li, d)^{18}O $Q_{\rm m} = 4.752$
(b) ^{14}C(^{6}Li, dα)^{14}C $Q_{\rm m} = -1.4751$

At $E(^6\text{Li}) = 34$ MeV angular distributions have been measured for the deuteron groups to many states of ^{18}O (1981CU07) [see also (1983AJ01)] including ^{18}O*(17.6 ± 0.2) (1982CU01). $J^\pi = 4^+, 2^+, 2^+, (4^+)$ and (4^+) are suggested for ^{18}O*(7.86, 8.9, 12.04, 14.6, 17.0) (1981CU07). The 2^+, 4^+, 6^+ and 8^+ members of the $K^\pi = \text{O}_2^+$ rotational band based on ^{18}O*(3.62) are ^{18}O*(5.26, 7.12, 11.69, 17.6) (1981CU07, 1982CU01).

Angular correlations have been measured at $E(^6\text{Li}) = 34$ MeV; these lead to the assignment of $J^\pi = 8^+$ to ^{18}O*(17.6) (1982CU01) and to the assignment of $J^\pi = 4^+$, 5^-, 6^+, 7^- and 8^+ to sixteen states in ^{18}O with $11.4 \leq E_\text{x} \leq 23.1$ MeV (1983CU03) [see also for assignment of ^{18}O states to bands]. At $E(^6\text{Li}) = 32$ MeV (1983AR11) find that the strongest groups are those to (unresolved) structures at $E_\text{x} = 17.05$ and 18.95 MeV [each $\Gamma \approx 0.35$ MeV] dominated by $J^\pi = 7^-$. ^{18}O*(11.6, 12.6) with $J^\pi = (6^+, 5^-)$ and 5^- are also observed (1983AR11). [See, however, the density of states]. See also (1985KO1B; theor.).

9. ^{14}C(^{7}Li, t)^{18}O $\qquad Q_\text{m} = 3.759$

At $E(^7\text{Li}) = 20.4$ MeV, triton groups are observed corresponding to a number of states of ^{18}O with $E_\text{x} < 12.6$ MeV. Angular distributions were obtained for some of these, including ^{18}O*(0, 1.98, 7.12, 11.69) with $J^\pi = 0^+, 2^+, 4^+, 6^+$. The latter two are the most strongly populated in this reaction: they appear to be part of the ground-state rotational band: see (1972AJ02). See also (1983GA02, 1984RU1A).

10. ^{14}C(^{14}C, ^{10}Be)^{18}O $\qquad Q_\text{m} = -5.785$

See (1985KO04).

11. ^{14}C(^{16}O, ^{12}C)^{18}O $\qquad Q_\text{m} = -0.9349$

See (1978AJ03).

12. ^{15}N(^{13}C, ^{10}B)^{18}O $\qquad Q_\text{m} = -8.0421$

See (1983AJ01).

13. ^{16}O(t, p)^{18}O $\qquad Q_\text{m} = 3.7061$

Table 18.7: States in ^{18}O from ^{16}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 [e]	
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 Table 18.6 in (1978AJ03).

[b] Nominal energy.

[c] See, however, Table 18.9.

[d] Comparisons of E_x shown here with those displayed in Table 18.3 for ^{18}O*(3.92, 5.10, 6.40, 7.77) suggest that the uncertainty shown may be low: $\pm$ 6 keV was arbitrarily used in calculating the best value for E_x for this state in Table 18.3.

[e] This is the “average” of several unresolved levels. (1985FO11) state that the main components are at 8.96 and 9.03 MeV. [Comment: It is not clear whether these states are actually resolved.]

Proton groups corresponding to states of ^{18}O are displayed in Table 18.7 (1981CO13). 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 reaction 17, (1982AN12, 1985AN17) and (1985BA1A; theor.).

14. ^{16}O(α, 2p)^{18}O $\quad Q_{\rm m} = -16.1080$

At $E_\alpha = 65$ MeV, the angular distribution to ^{18}O*(3.55) [$J^\pi = 4^+$] has been studied. In addition ^{18}O*(8.04, 9.15, 10.3) are also populated: see (1983AJ01).

15. (a) ^{16}O(^{10}B, ^{8}B)^{18}O $\quad Q_{\rm m} = -14.824$
(b) ^{16}O(^{13}C, ^{11}C)^{18}O $\quad Q_{\rm m} = -11.480$

At $E(^{10}\text{B}) = 100$ MeV, ^{18}O*(3.55) [first $(\text{d}_{5/2})^2_{4^+}$ state] is preferentially populated. ^{18}O*(1.98, 5.26, 7.12, 8.0, 8.3, 9.1) are also observed. At $E(^{13}\text{C}) = 105$ MeV the angular distribution to ^{18}O*(3.55) has been measured. See (1983AJ01) and (1983OS07; theor.).

16. (a) ^{17}O(n, γ)^{18}O $\quad Q_{\rm m} = 8.0443$
(b) ^{17}O(n, n)^{17}O $\quad E_{\rm b} = 8.0443$
(c) ^{17}O(n, α)^{14}C $\quad Q_{\rm m} = 1.8172$

For reaction (a) see (1983AJ01). [The work reported there has not been published.] The scattering amplitude (bound) $a = 5.62 \pm 0.45$ fm, $\sigma_{\rm free} = 3.55 \pm 0.25$ b. The thermal cross section for reaction (c) is 235 ± 10 mb. See (1983AJ01) for references.

17. ^{17}O(d, p)^{18}O $\quad Q_{\rm m} = 5.8197$

Observed proton groups are displayed in Table 18.8. At $E_{\rm d} = 12$ MeV a strong, asymmetric peak is observed corresponding to $E_{\rm x} = 9.0$ MeV. On the basis of this work and the measurement of the cross section to a peak at about the same energy observed in the ^{16}O(t, p) reaction, (1985FO11) assign $J^\pi = 4^+$ and a (1d$_{5/2}$) (1d$_{3/2}$) configuration to ^{18}O*(9.0). Proton-γ coincidence measurements are shown in Table 18.4.

18. ^{17}O(^{12}C, ^{11}C)^{18}O $\quad Q_{\rm m} = -10.677$

Table 18.8: States of ^{18}O from ^{17}O(d, p) [a]

E_x (MeV ± keV) [b]	l_n [b]	J^π [b]	S [b]
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			
9.0 [c]		4^+	

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

[b] E_x values without uncertainties are nominal. J are consistent with l_n and are used to calculate S.

[c] (1985FO11). See text.

Table 18.9: Branching in ^{18}N(β^-)^{18}O [a]

Decay to ^{18}O* [b] (keV)	J^π	Branch (%)	$\log ft$ [c]
1982.05 ± 0.09 [d]	2^+	3.9 ± 1.5	6.73 ± 0.17
3554.13 ± 0.80	4^+	< 0.6	> 7.22
3633.70 ± 0.11	0^+	< 0.35	> 7.43
3920.42 ± 0.14	2^+	< 0.43	> 7.29
4455.52 ± 0.10	1^-	54.6 ± 1.1	5.107 ± 0.033
5097.60 ± 0.60	3^-	< 0.43	> 7.03
5530.17 ± 0.32	2^-	3.1 ± 0.4	6.10 ± 0.06
6198.22 ± 0.40	1^-	1.4 ± 0.2	6.28 ± 0.07
6349.76 ± 1.0	(2^-)	2.2 ± 0.3	6.04 ± 0.07
6880.45 ± 0.27	0^- [e]	14.8 ± 0.8	5.066 ± 0.040
7771.07 ± 0.50	2^- [e]	5.0 ± 0.5	5.26 ± 0.06

[a] (1982OL01).

[b] For γ-ray branchings see Table 18.4.

[c] It is estimated that (15 ± 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 13899 ± 20 keV for the ^{18}N(β^-)^{18}O Q-value (see also "mass of ^{18}N" in the "General" section of ^{18}N) and the $\tau_{1/2}$ value given in reaction 1 of ^{18}N, 624 ± 12 msec (1982OL01). I am indebted to Dr. E.K. Warburton for his calculations of the $\log ft$ values.

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

[e] See (1982OL01).

Angular distributions involving ^{18}O*(0, 1.98, 3.55) have been studied at $E(^{12}\mathrm{C}) = 115$ MeV: see (1983AJ01).

19. ^{18}N(β^-)^{18}O $\quad Q_\mathrm{m} = 13.899$

The transitions observed in the β^- decay are displayed in Table 18.9 (1982OL01).

20. (a) ^{18}O(γ, n)^{17}O $\quad Q_\mathrm{m} = -8.0443$
(b) ^{18}O(γ, 2n)^{16}O $\quad Q_\mathrm{m} = -12.1879$

(c) ^{18}O(γ, p)^{17}N $Q_{\rm m} = -15.942$
(d) ^{18}O(γ, t)^{15}N $Q_{\rm m} = -15.8336$
(e) ^{18}O(γ, α)^{14}C $Q_{\rm m} = -6.2270$

Table 18.10: Resonances in ^{18}O + γ

$E_{\rm x}$ (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 [c]	17.1		17.5	10.1 [b], 1.2 [e]	0.6
19.4 [c]		(19.1)	19.4	10.0 [b], 1.8 [e]	0.9
21.1 [d]		21.1	21.0	9.7 [b], 1.2 [e]	
22.6	(22.6)	22.7	22.7		
23.7 [d]	23.7	23.5	23.7	17.7 [b], 6.1 [e]	1.6
27 [c]	27		27–28		
30 [f]	30				
36 [f]					

[a] (1979WO04). See also Table 18.9 in (1983AJ01) and (1987JU07).
[b] $\sigma(\gamma, \rm n) + 2\sigma(\gamma, 2n)$.
[c] $T = 2$: see (1979WO04).
[d] $T = 1$: see (1979WO04).
[e] $\sigma(\gamma, \rm p)$.
[f] Weak and broad resonances: may indicate the presence of particle-hole states at these high energies.

The cross sections for the (γ, p), (γ, n), (γ, 2n) and (γ, tot) [tot = total absorption] have been measured with monoenergetic photons to 42 MeV: observed resonances are displayed in Table 18.10. All three of the partial cross sections have substantial strength in the giant resonance region; the (γ, 2n) cross section is a significant fraction of σ(γ, tot) and is even larger than σ(γ, 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 18.10. 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; $E_{\text{brems.}}$). The decay of the GDR to ^{14}C, ^{15}N, ^{16}O, ^{17}N and ^{17}O states has been studied: see (1983AJ01). Less than 20% of the decays of states with $14.5 < E_x < 20$ MeV goes via the n_0 channel (1987JU07). See (1978AJ03) for the earlier work, (1985SH1P), (1985PY01) and (1983KA28, 1984VA1G, 1985PY01, 1985VA1C; theor.).

21. $^{18}O(\gamma, \gamma)^{18}O$

The Γ_{γ_0} of ^{18}O*(6.20) is 0.18 ± 0.03 eV, assuming $\Gamma_{\gamma_0}/\Gamma = 0.88$; $E_x = 6202.7 \pm 0.8$ keV: see (1978AJ03).

22. $^{18}O(e, e)^{18}O$

The ^{18}O charge radius, $\langle r^2 \rangle^{1/2} = 2.784 \pm 0.020$ fm, based on studies of the elastic charge form factors for $E_e = 70$ to 370 MeV, the resulting determinations of the difference in the ^{18}O and ^{16}O radii, and the rms radius of ^{16}O: see (1983AJ01).

Inelastic scattering has been reported to many states of ^{18}O: see (1983AJ01) and Table 18.11 here (1982NO04, 1983BE36, 1986MA48). See also (1987DE43) and (1986GU05, 1986ST15, 1987MI1E; theor.).

Table 18.11: Some states of ^{18}O from ^{18}O(e, e′) [a]

E_x (MeV ± keV)	Γ (keV)	$J^\pi; T$	Mult.	Transition probability (in $e^2 \cdot \text{fm}^{2\lambda}$)
1.98 [b]		$2^+; 1$	C2	44.8 ± 1.3
3.55 [b]		$4^+; 1$	C4	$(9.04 \pm 0.90) \times 10^2$
3.92 [b]		$2^+; 1$	C2	22.2 ± 1.0
5.26 [b]		$2^+; 1$	C2	28.3 ± 1.5
7.12 [b]		$4^+; 1$	C4	$(1.31 \pm 0.06) \times 10^4$
9.36 ± 20 [c]	10 ± 7	$T = 1$		
11.65 ± 20 [c]	76 ± 8	$T = 1$		
12.06 ± 60 [c]	28 ± 6	$T = 1$		
16.210 ± 10 [d,e]		$1^{(-)}$		

Table 18.11: Some states of ^{18}O from ^{18}O(e, e′) [a] (continued)

	Γ (keV)	$J^\pi; T$	Mult.	Transition probability (in $e^2 \cdot \mathrm{fm}^{2\lambda}$)
16.315 ± 10 [d,e]		$(3, 2)^-$		
16.399 ± 5 [d,f]	< 20	$2^-; 2$ [g]	M2	$(64 \pm 8) \times 10^{-2}$
16.948 ± 10 [d,e]		$(3, 2)^-$		
17.025 ± 10 [d,e,f]	20 ± 6	$(> 2); 2$		
(17.35 ± 60) [f]	680 ± 250			
17.398 ± 10 [d,e]		$(2, 1, 3)^-$		
17.450 ± 10 [d,e]		$(2, 1, 3)^-$		
17.5 [d]	≈ 150			
17.502 ± 10 [d,e]		$(1, 2, 3)^-$		
17.635 ± 10 [d,e]				
18.049 ± 10 [d,e]		[d]		
18.2 [d]	≈ 150			
(18.48 ± 20) [f]	90 ± 34			
18.5 [d]	≈ 4300			
18.70 ± 20 [f]	< 20	$(4^-); 2$	M4	63 ± 8
18.871 ± 5 [d]		$1^+; 2$	M1	$(3.1 \pm 0.4) \times 10^{-2}$
18.927 [d,e]		$1; (2^+)$		
19.027 ± 10 [d,e]		$(1, 3)^-$		
19.150 ± 10 [d,e]		$1^-; (2^+, 3^-)$		
19.24 ± 20 [f]	< 20	$(> 2); 2$		
19.7 [d]	≈ 200			
20.2 [d]	≈ 180			
20.36 ± 20 [f]	< 20	$(4^-); 2$	M4	66 ± 6
21.0 [d]	≈ 150			
(21.43 ± 20) [f]	49 ± 37			
22.39 ± 40 [d,f]	74 ± 7	(4^-)	M4	400 ± 32
23.8 [d]	≈ 1300			

[a] Additional states have been excited: see reaction 28 in (1983AJ01). For ground state see text here.
[b] (1982NO04).
[c] Mark Manley, private communication.
[d] (1983BE36).
[e] Weakly excited.
[f] (1986MA48).
[g] See Fig. 4 (isobar diagram for $A = 18$) for missing $T = 2$ strength.

23. (a) ^{18}O($\pi^{\pm}$, $\pi^{\pm}$)^{18}O

(b) ^{18}O($\pi^{\pm}$, $\pi^{\pm}$p)^{17}N $\qquad Q_{\rm m} = -15.942$
(c) ^{18}O(π^{-}, π^{-}n)^{17}O $\qquad Q_{\rm m} = -8.0443$

Angular distributions for the scattering to ^{18}O*(0, 1.98, 5.10) have been reported at $E_{\pi^{\pm}} = 29.2$ to 230 MeV [see (1983AJ01)] and at 50 MeV (1984TA1A; ^{18}O*(0, 1.98)) at 140, 180 and 220 MeV (1984SE1A; ^{18}O*(1.98)), at 164 MeV (1987CH14; ^{18}O*(0, 1.98, 4.46, 5.10)) and at 180 MeV (1987MO07; ^{18}O*(1.98)). $\langle r_{\rm n}^2\rangle^{1/2} = 2.81 \pm 0.03$ fm, $\langle r_{\rm n}^2\rangle^{1/2} - \langle r_{\rm p}^2\rangle^{1/2} = 0.03 \pm 0.03$ fm: see (1983AJ01). For a discussion of the proton matter distribution in ^{18}O see (1985BA27). For total reaction cross sections at $E_{\pi} = 50$ and 65 MeV see (1986ME1C; prelim.). At $E_{\pi} = 165$ MeV, the cross section for reaction (c) is larger for ^{18}O than for ^{16}O while reaction (b) has a lower cross section (1982PI06). For the (π^{+}, 2p), (π^{+}, pn) and (π^{-}, pn) reactions at $E_{\pi} = 165$ MeV see (1984AL20, 1986AL22). See also the “General” section here.

24. ^{18}O(n, n)^{18}O

Angular distributions have been measured for $E_{\rm n} = 2.9$ to 24 MeV [see (1972AJ02, 1983AJ01)] and at $E_{\rm n} = 5.0$ to 7.5 MeV (1986KO10; $\rm n_0$, $\rm n_1$).

25. ^{18}O(p, p)^{18}O

Angular distributions have been measured for $E_{\rm p} = 0.84$ to 135 MeV [see (1978AJ03, 1983AJ01)], at $E_{\rm p} = 135$ MeV (1986KE05; $\rm p_1$) and at $E_{\vec{\rm p}} = 800$ MeV (1982GL08; p to ^{18}O*(0, 1.98, 7.12).

At $E_{\rm p} = 24.5$ MeV (1974ES02) have studied the angular distributions of the proton groups to ^{18}O*(1.98, 3.55, 3.63, 3.92, 4.46, 5.10, 5.26, 5.53, 7.12): a modified DWBA analysis leads to $J^{\pi} = 2^+, 4^+, 0^+, 2^+, 1^-, 3^-, 2^+, 2^-$ and 4^+ for these states. A coupled-channels calculation suggests $\beta_2 = 0.37\pm0.03, 0.56\pm0.06$ and 0.18 ± 0.04 for ^{18}O*(1.98, 5.10, 7.12). Such calculations also support evidence for a rotational band involving ^{18}O*(0, 1.98, 7.12). The 3^- state at 5.10 MeV is stongly excited and collective in nature: B(E3) $= 1120\ e^2 \cdot$ fm^6. For ^{18}O*(1.98, 3.92, 5.26), B(E2) $= 45$, 8.3 and 24 $e^2 \cdot$ fm^4 (1974ES02). The 800-MeV data indicates that ^{18}O*(7.12) can be described only if a large hexadecapole deformation is assumed (1982GL08). At $E_{\rm p} = 201$ MeV forward angle $\sigma(\theta)$ have been measured to ^{18}O*(8.21, 8.82, 16.40): it is proposed that ^{18}O*(8.82) has $J^\pi = 1^+$ and that additional 1^+ strength is located in a group centered at $E_{\rm x} \approx 10.1$ MeV as well as in the region $E_{\rm x} = 12.4$ to 15 MeV. The 1^+; $T = 2$ state ^{18}O*(18.87), reported in (e, e′), is not observed (1987DJ01).

^{18}O*(1.98) has $|{\rm g}| = 0.287 \pm 0.015$ [$\tau_{\rm m} = 2.99 \pm 0.12$ psec]. ^{18}O*(3.55) has $|{\rm g}| = 0.62 \pm 0.10$ suggesting a mainly $({\rm d}_{5/2})^2$ configuration for this state: see (1983AJ01). See also ^{19}F, (1983CE1A) and (1982KU04, 1982NA13, 1984PH02, 1986DE1G, 1986PE1E; theor.).

26. ^{18}O($\overline{\rm p}$, $\overline{\rm p}$)^{18}O

Angular distributions are reported with 178.4 MeV antiprotons to ^{18}O*(0, 1.98) (1986BR04, 1986LE13). For atomic effects see (1986KO22). See also (1984PO1A), (1985LI16; theor.) and the “General” section here.

27. ^{18}O(d, d)^{18}O

Angular distributions have been reported at $E_{\rm d} = 7.0$ to 15.0 MeV: see (1972AJ02, 1983AJ01). See also ^{20}F.

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

See (1972AJ02).

29. ^{18}O(^{3}He, ^{3}He)^{18}O

The elastic scattering has been studied at $E(^3{\rm He}) = 11.0$ to 41 MeV [see (1972AJ02, 1983AJ01)] and at 14 MeV (1982AB04), at 25 MeV (1982VE13) [the matter radius, $\langle r^2 \rangle_{\rm m}^{1/2} = 2.59 \pm 0.12$ fm] and at $E(^3{\rm He}) = 33$ MeV (1983LE03; also $A_{\rm y}$; and also to ^{18}O*(1.98)). See also (1985HA11, 1987CO07; theor.).

30. ^{18}O(α, α)^{18}O

Angular distributions of many α-groups have been measured in the range $E_\alpha = 21$ to 40.5 MeV [see (1978AJ03)], at 23.5 MeV (1984SA28; to ^{18}O*(1.98, $3.56 + 3.63$, 3.92, 4.45, $5.1 - 5.53$)) and at 54.1 MeV (1987AB03; g.s.). The transitions to ^{18}O*(4.46, 5.10) are $L = 1$ and 3, respectively, fixing $J^\pi = 1^-$ and 3^- for these states. Measurements of α-groups near $180°$ for $E_\alpha = 20.0$ to 23.4 MeV confirm assignments of natural parity for ^{18}O*(1.98, 3.55, 3.63, 3.92, 4.46, 5.10, 5.26, 5.34, 6.20, 6.40, 7.12, 7.62, 7.86, 8.22, 8.29, 8.82, 8.96, 9.03, 9.10, 9.36, 9.41, 9.67, 9.72 ± 0.03, 9.88, 10.12, 10.30, 10.40, 11.62, 11.69). [See, however, Table 18.3.] 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}O*(5.38, 5.53).

Alpha-gamma correlation measurements involving ^{18}O states below $E_x = 6.4$ MeV [see Table 18.4] lead to $J^\pi = 1^-$ and 3^- for ^{18}O*(6.20, 6.40). Other J^π values agree with previous assignments. The transitions $3.92 \to 1.98$ and $5.26 \to 1.98$ are almost pure M1. For τ_m measurements see Table 18.4 in (1978AJ03). For references see (1983AJ01). See also (1983WI12, 1984BR1P, 1984LA01, 1987AS01; theor.).

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

See (1972AJ02, 1983AJ01).

32. ^{18}O(^{9}Be, ^{9}Be)^{18}O

See (1972AJ02, 1983BI13, 1985BE1A) and (1984HA43; theor.).

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

An elastic angular distribution has been reported at $E(^{11}\text{B}) = 115$ MeV: see (1983AJ01). For reaction (a) see (1974AJ01).

34. (a) ^{18}O(^{12}C, ^{12}C)^{18}O
    (b) ^{18}O(^{13}C, ^{13}C)^{18}O
    (c) ^{18}O(^{14}C, ^{14}C)^{18}O
    (d) ^{18}O(^{12}C, α^{12}C)^{14}C $Q_m = -6.2270$

Elastic angular distributions have been studied at $E(^{18}\text{O}) = 32.3$ to 57.5 MeV for reaction (a) [as well as at $E(^{18}\text{O}) = 70$, 100 and 140 MeV (1982HE07)] and at $E(^{18}\text{O}) = 31$ MeV for reaction (b). Yields and fusion cross sections are reported by (1982BA49, 1982HE07, 1985BE40, 1985CA01, 1986GA13). See also (1983VO1B). For the earlier work see (1983AJ01). For reaction (c) see (1986STZY).

Angular correlations (reaction (d)) have been studied at $E(^{18}\text{O}) = 82$ MeV. ^{18}O*(7.10, 7.62, 7.86, 8.04, 8.22, 10.30, 11.59, 12.55) are observed: the first seven of these have $J^\pi = 4^+$, 1^-, 5^-, 1^-, 2^+, 4^+, 5^- (1984BH01, 1984RA07). In addition ^{18}O*(9.33, 9.65) are also populated [$\Gamma \approx 0.3$ MeV]: a possible interpretation of the data is that these two are 3^- states and that there is in addition a very wide (> 1 MeV) 2^+ state at ≈ 9.5 MeV (1984RA17). See also (1983CA1N), (1983BI13, 1984HA53) and (1982GI1C, 1982LO13, 1983CI08, 1983MA29, 1984FR1A, 1985CH1R, 1986HA13; theor.).

35. ^{18}O(^{15}N, ^{15}N)^{18}O

See (1983DU13).

36. ^{18}O(^{16}O, ^{16}O)^{18}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}O*(1.98, $3.55 + 3.63$, 3.92, 4.46, 5.10, 7.12). At $E(^{18}\text{O}) = 126$ MeV ^{18}O*(9.0) is relatively strongly populated. See (1983AJ01). For yields and fusion cross sections, including the effect of ^{18}O*(1.98), see (1985TH03, 1985WU03, 1986GA13, 1986TH01). See also (1983DU13), (1986BA69) and (1983SH04, 1985MA1T, 1986DAZS, 1986VI08, 1987LO01; theor.).

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

Angular distributions involving ^{18}O*(0, 1.98) are reported at $E(^{17}\text{O}) = 36$ MeV. Angular distributions [reaction (b)] have been studied at $E(^{18}\text{O}) = 20$ to 52 MeV. ^{18}O*($3.55 + 3.63$, 4.46, 5.10, 7.12) are also populated; see (1978AJ03, 1983AJ01). See also (1986GA13) and (1982CI1C, 1983DU13).

38. ^{18}O(^{19}F, ^{19}F)^{18}O

The elastic scattering has been studied at $E(^{19}\mathrm{F}) = 27$, 30 and 33 MeV: see (1983AJ01). See also (1986GA13) and (1982OH05; theor.).

39. (a) ^{18}O(^{24}Mg, ^{24}Mg)^{18}O
(b) ^{18}O(^{26}Mg, ^{26}Mg)^{18}O

Angular distributions are reported for reaction (a) at $E(^{18}\mathrm{O}) = 29$ and 35 MeV to ^{18}O*(0, 1.98). See (1983AJ01, 1983BI13) and (1982LO13, 1983CI08, 1984FR1A, 1985HU04, 1986HA13, 1986OS05; theor.).

40. ^{18}O(^{27}Al, ^{27}Al)^{18}O

The elastic angular distribution has been studied at $E(^{18}\mathrm{O}) = 100$ MeV (1981ME13). See also (1985DEZZ), (1983AJ01, 1983BI13) and (1982LO13, 1983CI08, 1984FR1A, 1985HU04; theor.).

41. ^{18}O(^{28}Si, ^{28}Si)^{18}O

Elastic angular distributions are reported at $E(^{18}\mathrm{O}) = 36$ to 56 MeV [see (1983AJ01)] and at 351.7 MeV (1984BUZX; also to ^{18}O*(1.98)). See also (1986BL08, 1986GA13), (1983BI13) and (1982LO13, 1983CI08, 1984FR1A, 1985HU04, 1986HOZF; theor.).

42. (a) ^{18}O(^{40}Ca, ^{40}Ca)^{18}O
(b) ^{18}O(^{44}Ca, ^{44}Ca)^{18}O
(c) ^{18}O(^{48}Ca, ^{48}Ca)^{18}O

Angular distributions have been measured at $E(^{18}\mathrm{O}) = 62.1$ MeV [reaction (a)] for the transitions to ^{18}O*(0, 1.98, 5.10) (1982RE14). For fusion study [reaction (b)] see (1984DE38). See also (1985DE38, 1986OS05, 1986RO12; theor.).

43. ^{18}F(β^+)^{18}O $\qquad Q_\mathrm{m} = 1.6554$

See ^{18}F.

Table 18.12: ^{18}O states from ^{19}F(t, $\alpha\gamma$) [a]

E_x (keV)	J^π	E_x (keV)	J^π
1982.16 ± 0.20		5530.5 ± 0.6	1, 2
3555.07 ± 0.45		6196.3 ± 1.2	1
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)
5098.5 ± 1.2		7116.9 ± 1.2	
5260.4 ± 1.2		7.75	$1 \rightarrow 4$
5336.4 ± 0.6		7.98	$1 \rightarrow 5$
5377.8 ± 1.2		[b]	

[a] (1973OL02): see Table 18.4 for branching ratios and Table 18.3 for τ_m. See also Table 18.10 in (1983AJ01).

[b] Alpha groups are also reported 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).

44. ^{19}F(γ, p)^{18}O $\qquad Q_m = -7.9942$

(1985KE03) have measured the yields of proton groups to ^{18}O*(0, 1.98) [and to unresolved states] for E_{bs} in the GDR range. See also (1978AJ03) and ^{19}F.

45. ^{19}F(n, d)^{18}O

Angular distributions have been measured at $E_n = 14$ to 14.4 MeV: see (1972AJ02). See also (1978AJ03) and ^{20}F.

46. ^{19}F(d, ^{3}He)^{18}O $\qquad Q_m = -2.5007$

Many states of ^{18}O ($E_x < 14.6$ MeV) have been populated in this reaction: see Table 18.8 in (1978AJ03). [*Comment:* Note, however, density of states.] Analyzing powers for the ground-state transition are reported at $E_{\vec{d}} = 12.4$ MeV (1983EN02). See also (1983KI13; theor.).

47. ^{19}F(t, α)^{18}O $Q_{\rm m} = 11.8198$

See Table 18.12.

48. ^{22}Ne(d, ^{6}Li)^{18}O $Q_{\rm m} = -8.194$

At $E_{\rm d} = 80$ MeV angular distributions have been measured for the ^{6}Li groups to the ground state of ^{18}O and to excited states at 1.98, 3.57, 5.10, 6.30, 7.8, 9.4 [± 0.04] MeV (1984OE02) [see also for $S_{\rm rel}$]. For earlier work see (1983AJ01).

^{18}F

(Figs. 2 and 4)

GENERAL: (See also (1983AJ01).)

Shell model: (1978WI1B, 1982ZH01, 1983BR29, 1983KI13, 1984MI1H, 1984MI17, 1985LE1K, 1986YU1B).

Cluster, collective and deformed models: (1983ME12, 1984QU1A, 1985BA1A, 1987ER05).

Special states: (1978WI1B, 1982ZH01, 1983BI1C, 1983BR29, 1983ME12, 1983KI13, 1984AD1E, 1984HA14, 1984HO1H, 1984MI1H, 1984MI17, 1985AD1A, 1985HA18, 1985LE1K, 1985MI10, 1985SO12, 1985YU1B, 1986AN07, 1986CA27, 1986HA1E, 1986HA1Q, 1986SI1K, 1986TO1D, 1986WI1P, 1986YU1B, 1987ER05).

Electromagnetic transitions: (1982RI04, 1983BR29, 1983KI13, 1984BI10, 1984HA14, 1984MI1H, 1984QU1A, 1985AD1A, 1986CA27, 1986SI1K, 1987ER05, 1987KI03).

Astrophysical questions: (1982WI1B).

Applications: (1982HI1H, 1982YA1C, 1984HI1D, 1984NI1C, 1985HU02, 1986HI1B, 1987HI1B).

Complex reactions involving ^{18}F: (1983DE26, 1983JA05, 1983OL1A, 1983WI1A, 1984GR08, 1984HI1A, 1984HO23, 1985BE40, 1985CU1C, 1985DR07, 1985GR1K, 1985PO11, 1986AV07, 1986BA3G, 1986GR1A, 1986HA1B, 1986HO27, 1986PO06, 1986SC28, 1986SC29, 1986VA23, 1987RI03, 1987RO10).

Pion capture and reactions (See also reaction 32.): (1982LI15, 1983HO02, 1986GE06, 1986NA1K).

Hypernuclei: (1984AS1D).

Other topics: (1978WI1B, 1983AD1B, 1983AG1C, 1983AR1J, 1983BI1C, 1983BR29, 1983SH32, 1984BI10, 1984HO1H, 1984MI1H, 1985AD1A, 1985AN28, 1985MI10, 1985YU1B, 1986LA29, 1986NA1K, 1986TO1D, 1987KI03).

Ground and 1.12 MeV states of ^{18}F: (1978WI1B, 1983ANZQ, 1983AR1J, 1984HA14, 1985AN28, 1985HA18, 1986CA27).

$$\mu_{1.12} = +2.86 \pm 0.03 \text{ nm [see (1983AJ01)]}$$

$$Q_{1.12} = 0.13 \pm 0.03 \text{ b [see (1983AJ01)].}$$

1. ^{18}F(β^+)^{18}O $\qquad Q_{\rm m} = 1.6554$

The positron decay is entirely to the ground state of ^{18}O [$J^\pi = 0^+$, $T = 1$]; the half-life is 109.77 ± 0.05 min [see Table 18.11 in (1972AJ02)]; $\log ft = 3.554$. The fact that the β^+ transition to ^{18}O$_{\rm g.s.}$ is allowed indicates $J^\pi = 1^+$ for ^{18}F$_{\rm g.s.}$. The ratio $\epsilon_{\rm K}/\beta^+ = 0.030 \pm 0.002$:

see (1978AJ03). See also (1985BR29), (1982KA1C; applications), (1985AR1A, 1985KL1A, 1986HE1C, 1987GOZX; astrophyics) and (1983CA03; theor.) [see for discussions of weak magnetism form factor and of search for heavy neutrinos].

Table 18.13: Energy levels of ^{18}F ^{a}

E_x (MeV $\pm$ keV)	$J^\pi; T$	K^π	τ or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
0	$1^+; 0$	0^+	$\tau_{1/2} = 109.77 \pm 0.05$ min	β^+	1, 4, 5, 6, 9, 10, 12, 13, 15, 21, 23, 24, 25, 29, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42
0.93720 ± 0.06	$3^+; 0$	0^+	$\tau_m = 67.6 \pm 2.5$ psec $g = +0.56 \pm 0.05$	γ	2, 6, 9, 10, 13, 21, 23, 25, 30, 34, 35, 37, 38, 39, 40, 42
1.04155 ± 0.08	$0^+; 1$		2.55 ± 0.45 fsec	γ	6, 9, 21, 25, 30, 33, 34, 36, 37, 38, 40, 41
1.08054 ± 0.12	$0^-; 0$	0^-	27.5 ± 1.9 fsec	γ	6, 9, 10, 21, 25, 34, 36, 37, 38, 39, 40, 42
1.12136 ± 0.15	$5^+; 0$	0^+	234 ± 10 nsec $\mu = +2.86 \pm 0.03$ nm $Q = 0.13 \pm 0.036$ b	γ	5, 6, 9, 10, 13, 14, 21, 22, 25, 30, 31, 34, 36, 38, 40, 42
1.70081 ± 0.18	$1^+; 0$	1^+	955 ± 27 fsec	γ	6, 10, 21, 25, 33, 34, 38, 40, 41, 42
2.10061 ± 0.10	$2^-; 0$	0^-	5.1 ± 0.5 psec	γ	6, 10, 13, 21, 23, 25, 34, 38, 40, 42
2.52335 ± 0.18	$2^+; 0$	1^+	590 ± 24 fsec	γ	6, 10, 21, 25, 30, 38, 40
3.06184 ± 0.18	$2^+; 1$		< 1.2 fsec	γ	6, 21, 25, 30, 34, 37, 38, 40, 41
3.13387 ± 0.15	$1^-; 0$	1^-	0.39 ± 0.02 psec	γ	6, 10, 21, 25, 34, 37, 38, 40
3.3582 ± 1.0	$3^+; 0$	1^+	0.44 ± 0.03 psec	γ	6, 10, 21, 34, 38, 40, 42
3.72419 ± 0.22	$1^+; 0$		$2.7^{+4.1}_{-2.7}$ fsec	γ	6, 10, 21, 23, 25, 33, 34, 38, 40, 42
3.79149 ± 0.22	$3^-; 0$	1^-	1.91 ± 0.13 psec	γ	5, 10, 21, 23, 25, 34, 38, 40, 42

Table 18.13: Energy levels of ^{18}F $^{\rm a}$ (continued)

$E_{\rm x}$ (MeV ± keV)	$J^\pi; T$	K^π	τ or $\Gamma_{\rm c.m.}$ (keV)	Decay	Reactions
3.83917 ± 0.22	$2^+; 0$		19.0 ± 2.7 fsec	γ	6, 10, 21, 23, 25, 30, 34, 38, 40, 42
4.11590 ± 0.25	$3^+; 0$		91 ± 22 fsec	γ	6, 10, 21, 23, 25, 30, 34, 38, 40, 42
4.2258 ± 0.7	$2^-; 0$	(1^-)	110 ± 15 fsec	γ	6, 10, 21, 23, 34, 38, 40, 42
4.36015 ± 0.26	$1^+; 0$		27 ± 10 fsec	γ	10, 21, 25, 33, 34, 38, 40, 42
4.3981 ± 0.7	$4^-; 0$	0^-	58 ± 12 fsec	γ	6, 10, 13, 14, 21, 34, 38, 40, 42
4.652 ± 2	$4^+; 1$		< 10 fsec	γ	6, 21, 24, 30, 34, 38, 40
4.753 ± 3	$0^+; 1$			γ	21, 34, 37, 38, 40, 42
4.8483 ± 0.5	$5^-; 0$	1^-	5.2 ± 0.9 psec	γ	5, 23
4.860 ± 2	$1^-; 0$		66 ± 18 fsec	γ, α	6, 21, 38, 40, 42
4.9636 ± 0.8	$2^+; 1$		< 4 fsec	γ	6, 21, 30, 38, 40
5.2976 ± 1.5	$4^+; 0$	1^+	30 ± 5 fsec	γ, α	6, 9, 10, 11, 21, 38, 40
5.502 ± 2	$3^{(-)}; 0$		63 ± 25 fsec	γ, α	6, 10, 21, 38, 40
5.60338 ± 0.27	1^+		15 ± 10 fsec	γ, α	6, 8, 25, 38, 40, 42
5.60486 ± 0.28	$1^-; 0+1$		$\Gamma < 1.2$ keV	γ, α	6, 8, 10, 21, 25, 38, 40, 42
5.673 ± 2	$1^-; 0+1$		< 0.8	γ, α	6, 8, 10, 21, 25, 38, 40, 42
5.786 ± 2.4	$2^-; 0$		$\tau_{\rm m} = 15 \pm 10$ fsec	γ, α	6, 21, 38, 40, 42
6.0964 ± 1.1	$4^-; 0$	1^-	$\Gamma = 0.24 \pm 0.03$	γ, p, α	6, 10, 21, 25, 29, 38, 40, 42
6.108 ± 3	$(1^+); 0$		0.034 ± 0.003	γ, p, α	6, 8, 21, 23, 29, 40, 42
6.13647 ± 0.33	$0^+; 1$		≤ 1	γ, p	21, 25, 27, 40, 42
6.1632 ± 0.9	$3^+; 1$		14 ± 0.5	γ, p, α	21, 25, 27, 29, 42
6.2404 ± 0.8	$3^-; 0+1$		0.19 ± 0.03	γ, p, α	6, 21, 25, 27, 29, 40
6.242 ± 3	$3^-; 0+1$		0.18 ± 0.04	γ, p, α	6, 8, 21, 25, 29, 40
6.262 ± 2.5	$1^+; 0$		0.60 ± 0.12	γ, p, α	6, 8, 10, 21, 29, 33, 40

Table 18.13: Energy levels of ^{18}F [a] (continued)

$E_{\rm x}$ (MeV $\pm$ keV)	$J^\pi; T$	K^π	τ or $\Gamma_{\rm c.m.}$ (keV)	Decay	Reactions
6.2832 ± 0.9	$2^+; 1$		10.0 ± 0.5	γ, p, α	21, 25, 27, 29
6.3105 ± 0.8	$3^+; 0$		0.95 ± 0.14	γ, p, α	6, 21, 25, 27, 29, 42
6.3855 ± 1.7	$2^+; 0 + 1$		0.49 ± 0.09	γ, p, α	6, 21, 25, 29, 40
6.4849 ± 1.5	$3^+; 0$		0.40 ± 0.10	γ, p, α	6, 21, 25, 29, 40, 42
6.5670 ± 1.5	$5^+; 0$	1^+	0.56 ± 0.13	γ, p, α	6, 8, 9, 10, 11, 21, 29, 40
6.633 ± 10	1		80 ± 2	p, α	29, 40
6.6437 ± 0.8	$2^-; 1$		0.60 ± 0.07	γ, p, α	6, 7, 21, 25, 29
6.647 ± 4	1^-		91 ± 4	p, α	8, 10, 29
6.777 ± 1.4	$4^+; 0$		9.2 ± 1.0	γ, p, α	21, 25, 27, 29, 40
6.8031 ± 1.5	1^+, 2, 3^+; 0		≤ 2	γ, p	10, 21, 25, 27, 40
6.809 ± 5	2^-		88 ± 2	p, α	7, 8, 29
6.811	(2^+)		3.0 ± 0.5	p, α	29
6.857 ± 10	(3^-)		5.0 ± 1.0	p, α	29, 40
6.8774 ± 1.7	3, 4^-; 0		≤ 2	γ, p, α	21, 25, 29
7.201 ± 2	(4^+); 0		6.5	p, α	8, 29, 40
7.247 ± 2	(1^+); 0		46.5	p, α	8, 29
7.291 ± 2	3^-		38	p, α	7, 8, 27, 29
7.315 ± 4	$(3^-$; 0)		52	p, α	29, 40
7.336 ± 2	$1^-; 1$		16 ± 2	γ, p	25, 27
7.406 ± 2	1^+		14.6 ± 1.4	p	27
7.447 ± 10			140	p, α	29
7.454 ± 2	1^-		6	p	27
7.478 ± 2	(2)		12 ± 3	γ, p, α	25, 27, 29
(7.485 ± 2)	(1^-)		32	p	27
7.506 ± 2	4^-		12 ± 2	p, α	27, 29
7.513 ± 2			< 4	γ, p	25
7.528 ± 2	$2^-; 1$		16.5 ± 3.0	γ, p, α	25, 27, 29
7.532 ± 5			75	p, α	27, 29
7.555 ± 2	(1^-)		30	p	27
7.584 ± 2			9 ± 2	γ, p, α	25, 27, 29
7.685 ± 2	3^+, 4^+		36 ± 4	p, α	27, 29
7.729 ± 4	≥ 1		66 ± 5	p, α	27, 29

Table 18.13: Energy levels of ^{18}F [a] (continued)

E_x (MeV ± keV)	$J^\pi; T$	K^π	τ or $\Gamma_{\mathrm{c.m.}}$ (keV)	Decay	Reactions
7.763 ± 4			70	p	27
7.878 ± 3	≥ 2		20	p, α	27, 29
7.899 ± 2	(2^-)		38	p, α	7, 8, 29
7.941 ± 12	(1^+)		112	p, α	7, 8, 29
8.064 ± 6	≥ 4		60	p, α	27, 29
8.115 ± 8			96	p	27
8.209 ± 2	2^-		52	p, α	27, 29
8.238 ± 2	4^+		20	p	27
9.207 ± 15 [b]	3, 4^-; 0			p, d, α	16, 17, 18
9.50	2, 3^+; 0			n, d, α	16, 18
9.58 ± 20 [c]	6^+	1^+		d, α	9, 10, 11, 22
10.58 ± 50					11
11.22 ± 30	7^+	1^+		d, α	9, 10, 11, 22
13.83	4^-, 5^+		60	d, α	18
14.02	4^-, 5^+		60	d, α	18
14.10	4^-, 5^+		60	d, α	18
14.18 ± 40	(8^+)	(1^+)		d, α	9, 10, 11
15.09	4^-, 5^+			d, α	18
15.34	5^+, 6^-			d, α	18
15.79 ± 100					11
16.07	4^-, 5^+		220	d, α	18
16.72	4^-, 5^+		60	d, α	18
17.43	4^-, 5^+, 6^-		70	d, α	18
18.62 ± 120					11
(19.00 ± 150)			(500 ± 150)	γ, ^{3}He	12
20.1 ± 200	$(2^-; 1)$		1600 ± 100	γ, ^{3}He	12
22.7 ± 200	$(2^-; 1)$		1200 ± 100	γ, ^{3}He	12
(24.1 ± 200)			(1400 ± 300)	γ, ^{3}He	12

[a] See also Table 18.14 for radiative transitions and 18.15 for τ_{m}.

[b] Uncertainty estimated by reviewer.

[c] For other states with $E_{\mathrm{x}} < 9.6$ MeV see footnote (e) in Table 18.17 of (1978AJ03) and Table 18.16 here. For other states with $10.0 < E_{\mathrm{x}} < 19.6$ MeV see Table 18.16 here, and Tables 18.14 and 18.16 in (1978AJ03). These two tables in (1978AJ03) display the states deduced from the yields of the isospin-forbidden α_1 groups in ^{14}N + α and ^{16}O + d, respectively. (1976CH24) reports 151 isospin mixed natural-parity states with $10.4 < E_{\mathrm{x}} < 17.5$ MeV [^{14}N(α, α_1)] and (1973JO13) reports 138 such states with $9.2 < E_{\mathrm{x}} < 19.4$ MeV [^{16}O(d, α_1)] of which 16 have $E_{\mathrm{x}} > 17.5$ MeV. In the region $10.4 < E_{\mathrm{x}} < 20.8$ MeV some 167 states with mixed isospin and natural parity have been reported. See also reaction 29.

2. (a) ^{10}B(^{9}Be, n)^{18}F $\quad Q_{\mathrm{m}} = 14.4539$
   (b) ^{11}B(^{9}Be, 2n)^{18}F $\quad Q_{\mathrm{m}} = 2.9998$

See (1986CU02) for production cross sections of 0.94 MeV γ-rays.

3. (a) ^{12}C(^{6}Li, d)^{16}O $\quad Q_{\mathrm{m}} = 5.6868 \quad E_{\mathrm{b}} = 13.212$
   (b) ^{12}C(^{6}Li, α)^{14}N $\quad Q_{\mathrm{m}} = 8.7972$
   (c) ^{12}C(^{6}Li, ^{6}Li)^{12}C

Cross sections for these and other charged particle channels have been measured for $E(^{6}\mathrm{Li}) = 1.9$ to 36 MeV [see (1978AJ03, 1983AJ01)].

The cross section for the isospin-forbidden α_1 group [to ^{14}N*(2.31), 0^+, $T = 1$] is 1 to 2% of the cross section to the allowed α_0 and α_2 groups for $E(^{6}\mathrm{Li}) = 3.2$ to 6 MeV while for 9 to 14 MeV it varies from 0.4 to 1.8%. At 20 MeV, the α_1 yield is 0.02% of the allowed yield. Structures are reported at $E(^{6}\mathrm{Li}) = 11.0$ 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. A resonance is also reported in the α_1 yield at $E(^{6}\mathrm{Li}) = 4.2$ MeV: $E_{\mathrm{x}} = 15.99 \pm 0.02$ MeV, $\Gamma_{\mathrm{c.m.}} = 290 \pm 30$ 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. Cross sections for populating ^{16}O*(8.87, 10.36, 11.08, 11.10) are reported by (1981GL02).

The excitation functions for the ^{6}Li ions to ^{12}C*(0, 4.43) shows a single isolated structure at $E(^{6}\mathrm{Li}) = 22.8$ 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. At $E(^{6}\vec{\mathrm{Li}}) = 20$ MeV analyzing power measurements are reported for many deuteron and α groups and for elastically scattered ^{6}Li ions. VAP measurements for elastic scattering are also reported at $E_{\vec{\mathrm{d}}} = 9.0$ and 19.2 MeV (1983RU09) and at 150 MeV (1986TA1B, 1986KA1C).

Table 18.14: Radiative decays in ^{18}F [a]

$E_{\rm i}$ (MeV)	$J^{\pi}_{\rm i}; T$	$E_{\rm f}$ (MeV)	Branch (%)	
0.94	$3^+; 0$	0	100	
1.04	$0^+; 1$	0	100	
1.08	$0^-; 0$	0	100	
1.12	$5^+; 0$	0.94	100	
1.70	$1^+; 0$	0	29.8 ± 1.3	
		1.04	70.2 ± 1.3	
2.10	$2^-; 0$	0	38 ± 1	$\Gamma_\gamma = (4.6 \pm 2.2) \times 10^{-5}$ eV
		0.94	31 ± 1	$\Gamma_\gamma = (4.0 \pm 1.9) \times 10^{-5}$ eV
		1.08	31 ± 1	
2.52	$2^+; 0$	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	$2^+; 1$	0	23.2 ± 0.8	
		0.94	76.7 ± 0.8	
		1.04	0.11 ± 0.03	
3.13	$1^-; 0$	0	39 ± 2	$\delta = +(0.07 \pm 0.05)$ $\Gamma_\gamma = (5.7 \pm 2) \times 10^{-4}$ eV
		1.04	34 ± 2	$\Gamma_\gamma = (7.3 \pm 2.7) \times 10^{-4}$ eV
		1.08	25 ± 2	$\Gamma_\gamma = (4.8 \pm 1.8) \times 10^{-4}$ eV
		1.70	2.0 ± 0.5	$\delta = +(0.22 \pm 0.15)$
3.36	$3^+; 0$	0	45 ± 5	
		0.94	9 ± 3	
		1.70	40 ± 4	
		2.10	< 3	
		2.52	6 ± 3	$\delta = -0.4^{+0.3}_{-0.5}$
3.72	$1^+; 0$	0	5 ± 2	
		1.04	91 ± 2	$\Gamma_\gamma = (1.3 \pm 0.2) \times 10^{-3}$ eV [c]
		3.06	4 ± 2	
3.79	$3^-; 0$	2.10	68 ± 4	$\delta = -(0.22 \pm 0.06)$
		2.52	2.2 ± 1.1	
		3.06	30 ± 3	$\delta = -(0.09 \pm 0.09)$

Table 18.14: Radiative decays in ^{18}F [a] (continued)

$E_{\rm i}$ (MeV)	$J^{\pi}_{\rm i}; T$	$E_{\rm f}$ (MeV)	Branch (%)	
3.84	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	3^+; 0	0	5 ± 3	
		3.06	95 ± 3	$\delta = +0.06 \pm 0.07$
4.23	2^-; 0	0	23 ± 2	$\delta = 0.15 \pm 0.15$
		0.94	49 ± 3	$\delta = 0.0 \pm 0.2$
		1.08	3.2 ± 1.0	
		1.70	9.3 ± 1.2	
		2.10	15 ± 5	
		3.13	0.9 ± 0.6	
4.36	1^+	3.06	100	
4.40	4^-; 0	0.94	13 ± 4	$\delta = -(0.2 \pm 0.3)$
		1.12	60 ± 6	$\delta = -(0.2 \pm 0.2)$
		2.10	27 ± 3	
4.65	4^+; 1	0.94	17 ± 3	
		1.12	83 ± 3	$\delta = 0.15 \pm 0.15$
4.75	0^+; 1	0	92 ± 4	
		1.70	8 ± 4	
4.85 [b]	5^-; 0	1.12	65 ± 4	
		3.79	35 ± 4	
4.86	1^-; 0	1.04	65 ± 11	
		1.08	8 ± 6	
		3.06	23 ± 7	$\delta = -(0.4 \pm 0.4)$
		3.13	4 ± 3	
4.96	2^+; 1	0	100	$\delta = 1.2 \pm 0.7$
5.30	4^+; 0	0.94	9 ± 2	$\delta = -(0.3 \pm 0.1)$
		1.12	7 ± 2	$\delta = -(1.1 \pm 0.5)$
		2.52	78 ± 3	$\Gamma_\gamma = 12 \pm 4$ meV [c]
		3.36	5 ± 1	$\delta = 2.5 \pm 0.8$

Table 18.14: Radiative decays in ^{18}F [a] (continued)

E_i (MeV)	$J^\pi_\mathrm{i}; T$	E_f (MeV)	Branch (%)	
		4.65	1.3 ± 0.3	
5.50	$3^{(-)}$; 0	3.06	100	$\Gamma_\gamma = 2.1 \pm 0.7$ meV [c]
5.603	1^+	0	16.7 ± 2.3	
		1.04	3.8 ± 1.2	
		3.06	79.5 ± 5.9	$\Gamma_\gamma = 0.48 \pm 0.05$ eV [c]
5.605	$1^-; 0+1$	0	6.7 ± 1.2	
		1.04	4.2 ± 0.8	
		1.08	54.3 ± 3.1	$\Gamma_\gamma = 0.87 \pm 0.07$ eV [c]
		3.06	2.6 ± 1.4	
		3.13	32.2 ± 2.5	$\delta = -0.05 \pm 0.02$
5.67	$1^-; 0+1$	0	6.2 ± 0.4	$\delta = -0.01 \pm 0.04$
		1.04	8.1 ± 0.7	
		1.08	52 ± 3	$\Gamma_\gamma = 0.46 \pm 0.06$ eV [c]
		1.70	0.8 ± 0.3	
		2.10	0.4 ± 0.2	
		3.06	4.0 ± 0.4	$\delta = 0.04 \pm 0.06$
		3.13	28.5 ± 2.0	$\delta = +0.10 \pm 0.03$
5.79	2^-; 0	0.94	40 ± 8	
		1.08	60 ± 8	
6.10	4^-; 0	0.94	4.9 ± 0.9	$\Gamma_\gamma = 51 \pm 10$ meV [c]
		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	(1^+); 0	0	24 ± 3	
		0.94	11 ± 3	
		2.10	20 ± 6	
		3.06	45 ± 5	
6.14	0^+; 1	0	50 ± 3	$\Gamma_\gamma > 1.6$ eV

Table 18.14: Radiative decays in ^{18}F [a] (continued)

E_i (MeV)	$J^\pi_\mathrm{i}; T$	E_f (MeV)	Branch (%)	
		1.70	12 ± 2	
		3.72	36 ± 3	
		4.36	2.1 ± 0.4	
		5.603	0.19 ± 0.02	
6.16	$3^+; 1$	0	0.2 ± 0.2	$\Gamma_\gamma = 0.96 \pm 0.26$ eV [c]
		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	
6.242	$3^-; 0 + 1$	0.94	4.6 ± 0.3	
		2.10	71.5 ± 3.0	$\Gamma_\gamma = 0.80 \pm 0.11$ eV [c]
		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	
6.241	$3^-; 0 + 1$	0.94	4.1 ± 0.3	
		2.10	71.2 ± 3.0	$\Gamma_\gamma = 0.73 \pm 0.11$ eV [c]
		3.36	0.8 ± 0.3	
		3.79	11.6 ± 0.6	
		3.84	0.9 ± 0.2	
		4.12	1.1 ± 0.4	
		4.23	8.2 ± 0.4	
		4.40	2.1 ± 0.3	
6.26	$1^+; 0$	0	(100)	

Table 18.14: Radiative decays in ^{18}F [a] (continued)

E_i (MeV)	$J^\pi_\mathrm{i}; T$	E_f (MeV)	Branch (%)	
6.28	$2^+; 1$	0	0.3 ± 0.1	$\Gamma_\gamma = 1.8 \pm 0.5$ eV [c]
		0.94	67 ± 3	
		1.04	1.3 ± 0.1	
		1.70	5.7 ± 0.6	
		2.10	1.2 ± 0.3	
		2.52	0.3 ± 0.2	
		3.13	0.7 ± 0.3	
		3.36	2.3 ± 0.3	
		3.72	1.4 ± 0.5	
		3.84	15.8 ± 1.4	
		4.12	3.9 ± 0.2	
		4.36	0.5 ± 0.4	
6.31	$3^+; 0$	0	4.0 ± 0.7	$\Gamma_\gamma = 0.17 \pm 0.04$ eV [c]
		0.94	10.6 ± 1.0	
		1.70	3.0 ± 0.8	
		2.52	4.0 ± 0.5	
		3.06	57 ± 3	$\delta = -(0.03 \pm 0.10)$
		3.72	1.4 ± 0.7	
		3.84	4.6 ± 1.0	
		4.12	2.4 ± 1.7	
		4.96	13.0 ± 1.5	$\delta = -(0.01 \pm 0.14)$
6.39	$2^+; 0+1$	0	1.5 ± 0.5	$\Gamma_\gamma = 0.44 \pm 0.18$ eV [c]
		0.94	75 ± 3	$\delta = -(0.25 \pm 0.10)$
		1.70	6.8 ± 1.7	
		3.84	14.1 ± 1.6	$\delta = 0.1 \pm 0.2$
		4.12	2.3 ± 0.5	
6.48	$3^+; 0$	0	13 ± 2	$\Gamma_\gamma = 74 \pm 21$ meV [c]
		0.94	33 ± 2	
		1.12	10 ± 2	
		1.70	4 ± 2	
		2.52	4 ± 2	

Table 18.14: Radiative decays in ^{18}F [a] (continued)

E_i (MeV)	$J^\pi_\mathrm{i}; T$	E_f (MeV)	Branch (%)	
		3.06	21 ± 3	
		3.79	4 ± 2	
		3.84	9 ± 2	
		4.96	2 ± 2	
6.57	5^+; 0	0.94	15.2 ± 1.6	
		3.36	83 ± 3	$\Gamma_\gamma = 26 \pm 5$ meV [c,d]
		5.30	2.3 ± 0.6	
6.64	2^-; 1	0.94	8.9 ± 0.6	$\Gamma_\gamma = 1.4 \pm 0.4$ eV [c]
		2.10	58 ± 3	
		3.13	22.0 ± 1.3	
		3.72	0.9 ± 0.2	
		3.79	2.4 ± 0.2	
		4.12	1.0 ± 0.3	
		4.86	2.6 ± 0.2	
		5.50	4.0 ± 0.3	
6.78	4^+; 0	0.94	12.6 ± 0.9	$\Gamma_\gamma = 0.31 \pm 0.08$ eV [c] $\delta = -(0.35 \pm 0.18)$
		1.12	25.2 ± 1.3	$\delta = -(1.4 \pm 1.1)$
		4.65	62 ± 2	$\delta = 0.13 \pm 0.13$
6.80	1^+, 2, 3^+; (0)	0	20 ± 2	
		0.94	20 ± 2	
		3.06	50 ± 3	
		3.84	3.0 ± 1.6	
		4.96	7.0 ± 1.7	
6.88	3, 4^-; 0	2.10	9 ± 2	
		4.65	91 ± 2	
7.34	1^-; 1	0	4 ± 0.5	
		1.08	54 ± 2	
		2.10	18 ± 1	
		3.06	1 ± 0.5	
		3.13	8 ± 0.5	

Table 18.14: Radiative decays in ^{18}F [a] (continued)

E_i (MeV)	$J^\pi_i; T$	E_f (MeV)	Branch (%)	
		4.23	15 ± 0.6	
7.48	(2)	0.94	100	
7.52		0.94	5 ± 4	
		2.10	7 ± 5	
		3.79	33 ± 5	
		4.40	55 ± 7	
7.53	2^-	0	10 ± 3	
		0.94	14 ± 6	
		2.10	50 ± 9	
		3.79	26 ± 7	
7.59		0	18 ± 7	
		0.94	14 ± 12	
		1.12	9 ± 7	
		4.65	59 ± 16	

[a] For earlier references see Tables 18.11 in (1978AJ03) and 18.12 in (1983AJ01). See these tables also for upper limits for transitions to other states.

[b] (1982FR15): see reactions 6 and 23.

[c] Γ_γ = total radiative width for this state.

[d] $\Gamma_\alpha = \Gamma \approx 560$ eV, $\Gamma_p < 4.5$ eV.

For fusion studies see (1982DE30, 1987PA12). For references to earlier work and for additional comments see (1978AJ03, 1983AJ01). See also (1980KR1F), (1984MU1D; theor.) and ^{12}C in (1985AJ01), ^{14}N in (1986AJ01) and ^{16}O in (1986AJ04).

4. ^{12}C(^{9}Be, t)^{18}F $\qquad Q_m = -4.4754$

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: see (1983AJ01). For excitation functions see (1982HU06, 1983JA09).

5. ^{12}C(^{11}B, αn)^{18}F $\qquad Q_m = -2.7015$

Table 18.15: Lifetime measurements of some ^{18}F states

^{18}F* (MeV)	$J^\pi; T$	τ_m	Refs.
0.94	$3^+; 0$	67.6 ± 2.5 psec	mean [a]
1.04	$0^+; 1$	2.7 ± 0.4 fsec	[b]
		$\underline{2.2 \pm 0.6}$ fsec	(1983CA21)
		2.55 ± 0.45 fsec	see (1983CA21) [c]
1.08	$0^-; 0$	27.5 ± 1.9 psec	mean [a]
1.12	$5^+; 0$	234 ± 10 nsec	mean [b]
1.70	$1^+; 0$	0.971 ± 0.30 psec	(1982BA40)
		$\underline{0.897 \pm 0.057}$ psec	(1983MO16) [d]
		0.955 ± 0.027 psec	mean
2.10	$2^-; 0$	5.12 ± 0.56 psec	(1982BA40)
		$\underline{4.93 \pm 0.78}$ psec	(1983MO16)
		5.06 ± 0.46 psec	mean
2.52	$2^+; 0$	0.605 ± 0.029 psec	(1982BA40)
		$\underline{0.554 \pm 0.045}$ psec	(1983MO16)
		0.590 ± 0.024 psec	mean
3.06	$2^+; 1$	< 1.2 fsec	(1982BA40) [a,e]
3.13	$1^-; 0$	0.403 ± 0.018 psec	(1982BA40)
		$\underline{0.343 \pm 0.022}$ psec	(1983MO16)
		0.39 ± 0.02 psec [A]	
3.36	$3^+; 0$	0.435 ± 0.041 psec	(1982BA40)
		$\underline{0.451 \pm 0.034}$ psec	(1983MO16)
		0.44 ± 0.03 psec [A]	
3.72	$1^+; 0$	4 ± 2 fsec	(1973RO04)
		$2.7^{+4.1}_{-2.7}$ fsec [A]	(1982BA40) [e]
3.79	$3^-; 0$	1.91 ± 0.17 psec	(1982BA40)
		$\underline{1.90 \pm 0.20}$ psec	(1983MO16)
		1.91 ± 0.13 psec	mean
3.84	$2^+; 0$	17.4 ± 3.6 fsec	(1982BA40)
		$\underline{21 \pm 4}$ fsec	(1983MO16)
		19.0 ± 2.7 fsec	mean
4.12	$3^+; 0$	91 ± 22 fsec	(1973RO06)

Table 18.15: Lifetime measurements of some ^{18}F states (continued)

^{18}F* (MeV)	$J^\pi; T$	τ_m	Refs.
4.23	2^-; 0	110 ± 15 fsec	(1973RO06)
4.36	1^+; 0	27 ± 10 fsec	(1973RO06)
4.40	4^-; 0	58 ± 12 fsec	(1973RO06)
4.65	4^+; 1	< 10 fsec	(1973RO06)
4.85	5^-; 0	5.2 ± 0.9 psec	(1982KO24)
4.86	1^-; 0	66 ± 18 fsec	(1973RO06)
4.96	2^+; 1	< 4 fsec	(1973RO06)
5.30	4^+; 0	30 ± 5 fsec	(1973RO05)
5.50	$3^{(-)}$; 0	63 ± 25 fsec	(1973RO06)
5.79	2^-; 0	15 ± 10 fsec	(1973RO06)

A = adopted.

[a] See Table 18.12 in (1978AJ03).

[b] See Table 18.13 in (1983AJ01).

[c] See also (1985KE1C).

[d] See also (1982MO09).

[e] See also (1983MO16).

$\tau_\text{m} = 5.2 \pm 0.9$ psec for ^{18}F*(4.85) [$5^-; T = 0$]. The E1 strength is $(3.4 \pm 0.6) \times 10^{-6}$ W.u. for the transition to ^{18}F*(1.12) [$5^+; T = 0$] and the E2 strength is 14.8 ± 2.6 W.u. for that to ^{18}F*(3.79) [3^-; 0]. The latter strength, which is that of a highly collective transition, corresponds to a quadrupole moment $Q_0 = 395 \pm 35$ mb and suggests that ^{18}F*(4.85) is the 5^- state of a (strongly decoupled) $K^\pi = 1^-$ band (1982KO24). See also Tables 18.14 and 18.15.

6. ^{14}N(α, γ)^{18}F $\qquad Q_\text{m} = 4.4152$

The non-resonant S-factor for this reaction, $S \approx 0.7$ MeV · b: see (1978AJ03). A number of resonances have been observed for $E_\alpha < 3$ MeV: see Table 18.16. Studies of these, principally by the Toronto and Queen's groups [see references in (1978AJ03, 1983AJ01)] in conjunction with work on ^{14}N(α, α), ^{16}O(^{3}He, p), ^{17}O(p, γ) and ^{17}O(p, α) [see Tables 18.18, 18.19, 18.20] have led to the determination of branching ratios, mixing ratios and widths (Table 18.14), lifetimes (Table 18.15) and the E_x, J^π and K^π assignments for ^{18}F states with $E_\text{x} < 6.9$ MeV. The reader is referred to the series of papers by the Toronto group for the most complete and definitive arguments on the parameters of the low-lying states of ^{18}F.

Table 18.16: Resonances in $^{14}\mathrm{N} + \alpha$ below $E_\alpha = 5$ MeV [a]

E_α (MeV ± keV)	Particles out	$\Gamma_{\mathrm{c.m.}}$ (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	4.850
0.698			$< 0.5 \times 10^{-4}$	2^+; 1	4.958
1.136 ± 3	γ		0.084 ± 0.004	4^+; 0	5.299
1.398 ± 3	γ		0.022 ± 0.003	$3^{(-)}$; 0	5.502
1.527	γ, α_0		1.44 ± 0.14	1^+	5.603 [e]
1.529 ± 2	γ, α_0	< 1.2	2.60 ± 0.21	$1^-; 0+1$	5.604 [f]
1.618 ± 2	γ, α_0	< 0.8	1.4 ± 0.2 [b]	$1^-; 0+1$	5.673 [g]
1.765 ± 4	γ		0.047 ± 0.018	2^-; 0	5.788
2.160 ± 4	γ		0.20 ± 0.04	4^-; 0	6.095
2.166 ± 7	γ, α_0		0.08 ± 0.03	1, 2, $3^{(-)}$; 0	6.100
			[c]		
2.348 ± 3	γ, α_0	< 0.8		$3^-; 0+1$	6.241 [h]
2.372 ± 3	γ, α_0	< 3		1^+; (0)	6.260 [i]
			[d]		
2.438 ± 4	γ		0.52 ± 0.12	3^+; 0	6.311
2.532 ± 4	γ		1.6 ± 0.4	$2^+; 0+1$	6.384
	γ		0.16 ± 0.06	3^+; (0)	6.480
2.767 ± 4	γ, α_0	(< 0.8)	0.29 ± 0.06	5^+; 0	6.567
2.870 ± 4	γ, p_0	< 1.6	2.7 ± 0.5	2^-; 1	6.647
2.870 ± 6	α_0	93 ± 5	$\Gamma_\alpha/\Gamma = 0.85$	1^-	6.647
			0.12 ± 0.07	4^+; 0	6.78
			< 0.2	1^+, 2, 3^+; (0)	6.803
3.080 ± 6	p_0, α_0	101 ± 5		2^-	6.810
3.576 ± 4	α_0	< 4		(4^+)	7.196
3.67	α_0	45 ± 10		(1^+)	7.27
3.72	p_0, α_0	53 ± 6		(3^-)	7.31
4.00	p_0, α_0	35		(3^-)	7.53
4.05	p_0, α_0	60			7.57
4.11	p_0, α_0	40			7.61

Table 18.16: Resonances in ^{14}N + α below $E_\alpha = 5$ MeV [a] (continued)

E_α (MeV ± 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}N(α, α_1) are listed in Table 18.14 of (1978AJ03).

[b] $\omega\gamma = 0.45 \pm 0.02$ (1982BE29).

[c] ≤ 0.07 for ^{18}F*(6.11, 6.16) (1973RO03).

[d] ≤ 0.03 for ^{18}F*(6.28) (1973RO03).

[e] $\Gamma_\alpha = 42.8 \pm 1.6$ eV, $\Gamma_\gamma = 0.485 \pm 0.046$ eV, $l_\alpha = 0$ (1980MA26). See also Table 18.19.

[f] $\Gamma_\alpha = 32.0 \pm 2.1$ eV, $\Gamma_\gamma = 0.891 \pm 0.074$ eV, $l_\alpha = 1$. ΔE_x for ^{18}F*(5.603, 5.605) is 1.84 ± 0.04 keV (1980MA26). See also Table 18.19.

[g] $\Gamma_\alpha = 130 \pm 5$ eV, $\Gamma_\gamma = 1.4 \pm 0.3$ eV, $l_\alpha = 1$ (1980MA26).

[h] 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 $\Gamma_\alpha = 133 \pm 4$ eV, $\Gamma_\gamma = 0.80 \pm 0.11$ eV; the higher has $\Gamma_\alpha = 137 \pm 4$ eV, $\Gamma_\gamma = 0.73 \pm 0.11$ eV (1979KI12).

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

No evidence is seen for the excitation of the (forbidden) state at $E_x = 4.753$ MeV [$J^\pi = 0^+$; $T = 1$] (1981LE1A, 1983LE08). See also (1985GO27; applications) and (1982BA1D, 1985AR1A, 1985KL1A, 1985MA1A, 1986HE1C, 1987GOZX; astrophysics).

7. ^{14}N(α, p)^{17}O $Q_m = -1.1914$ $E_b = 4.4152$

Observed resonances are displayed in Table 18.16. See also ^{17}O in (1986AJ04).

8. (a) ^{14}N(α, α)^{14}N $E_b = 4.4152$
(b) ^{14}N(α, 2α)^{10}B $Q_m = -11.6123$
(c) ^{14}N(α, ^{6}Li)^{12}C $Q_m = -8.7972$

Observed anomalies in the elastic scattering [reaction (a)] are exhibited in Table 18.16. Resonances in the α_1 isospin-forbidden yield are displayed in Table 18.14 of (1978AJ03). In the α_1 study, carried out for $E_\alpha = 7.6 \rightarrow 16.9$ MeV, a partial-wave analysis involving a method of removing ambiguities and parametrizing S-matrix elements gives the level parameters of 151 isospin mixed, natural-parity states in ^{18}F with $10.4 < E_x < 17.5$ MeV. Many of these states have also been reported in the ^{16}O(d, α_1) reaction [Table 18.16 of (1978AJ03)]. The argeement is best for low-lying 2^+ or 4^+ states, and is quite good for 3^- and 5^- states, while for high-J states the greater centrifugal barrier for ^{16}O + d at the same E_x relatively suppresses high-J states in the ^{16}O + d work. A study of the energy dependence of averaged intensities of the partial waves shows some indication that the lower partial waves reconserve isospin as E_x increases.

The total cross sections for formation of ^{10}B and ^{6}Li have been studied for $E_\alpha = 21$ to 42 MeV [see (1978AJ03)], as has the cross section for production of 1.64 and 2.31 MeV γ-rays from threshold to $E_\alpha = 26$ MeV [(1985DY05)]: see for astrophysical implications.] See also (1984RE14, 1986CO11) and (1986ALZZ; theor.).

9. (a) ^{14}N(^{6}Li, d)^{18}F $\quad Q_m = 2.940$
(b) ^{14}N(^{6}Li, dα)^{14}N $\quad Q_m = -1.4751$

At $E(^{6}\mathrm{Li}) = 36$ MeV angular distributions have been measured for the deuteron groups to ^{18}F*(5.34 [4^+], 6.56 [5^+], 9.58, 11.2, 14.1). Angular correlations lead to $J^\pi = 6^+$ and 8^+ for ^{18}F*(9.58, 14.1) and the data are consistent with $J^\pi = 7^+$ for ^{18}F*(11.2) (1983ET02). For the earlier work see (1978AJ03).

10. ^{14}N(^{7}Li, t)^{18}F $\quad Q_m = 1.947$

At $E(^{7}\mathrm{Li}) = 36$ MeV the $K^\pi = 1^+$ band 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 stongly populated. It is suggested that the first two are the 6^+ and 7^+ members of that band: see reaction 8. [Angular distributions are reported for ^{18}F*(1.70, 2.10, 2.52, 3.36, 4.40, 5.30, 6.57, 9.58, 11.22, 14.18).] See (1978AJ03) for the earlier work, and (1986NE1A; $E(^{14}\mathrm{N}) = 150$ MeV). See also (1986CO11; theor.).

11. (a) ^{14}N(^{11}B, ^{7}Li)^{18}F $\quad Q_m = -4.249$
(b) ^{14}N(^{13}C, ^{9}Be)^{18}F $\quad Q_m = -6.2324$

These reactions have been studied at $E(^{11}\mathrm{B}) = 115$ MeV and $E(^{13}\mathrm{C}) = 105$ MeV. Differential cross sections at three angles are reported for the transitions to ^{18}F*(9.58, 10.57 ± 0.07, 11.2) in reaction (a) and to ^{18}F*(5.30, 6.57, 9.58, 10.60 ± 0.08, 11.2) in reaction (b). In addition to these states ^{18}F*(14.18) is strongly excited in both reactions, and transitions to ^{18}F*(15.79 ± 0.10, 18.62 ± 0.12) are also reported: see (1983AJ01).

12. (a) ^{15}N(^{3}He, γ)^{18}F $\quad Q_{\rm m} = 14.1596$

(b) ^{15}N(^{3}He, α)^{14}N $\quad Q_{\rm m} = 9.7445$ $\quad E_{\rm b} = 14.1596$

Excitation functions have been measured for $E(^3{\rm He}) = 2.5$ to 16 MeV for the γ_0 and $\gamma_{1\to4}$ yields. Resonances are observed corresponding to $E_{\rm x} = (19.00 \pm 0.15)$ [$\gamma_{1\to4}$], 20.1 ± 0.2 [γ_0, $\gamma_{1\to4}$], 22.7 ± 0.2 [γ_0, $\gamma_{1\to4}$] and (24.1 ± 0.2) MeV [$\gamma_{1\to4}$], with $\Gamma_{\rm c.m.} = 0.5 \pm 0.15$, 1.6 ± 0.1, 1.2 ± 0.1 and 1.4 ± 0.3 MeV, respectively. The γ_0 yield is dominated by ^{18}F*(20.1) (1983WA05) [see for $(2J+1)\Gamma_{^3{\rm He}}\Gamma_\gamma$ values]. It is suggested that the structures decaying by γ_0 have $J^\pi = 2^-$ (and possibly $T = 1$) (1983WA05). For analyzing power measurements at $E(^3\vec{\rm He}) = 33$ MeV see (1986DR03).

13. ^{15}N(^{6}Li, t)^{18}F $\quad Q_{\rm m} = -1.636$

At $E(^6{\rm Li}) = 30$ MeV preferential excitation of odd-parity states of ^{18}F below $E_{\rm x} = 5$ MeV is reported. Angular distributions of the tritons to ^{18}F*(0, 0.94, 2.10, 4.40) [$J^\pi = 1^+, 3^+, 2^-, 4^-$] are all strongly forward peaked: see (1978AJ03).

14. (a) ^{15}N(^{11}B, ^{8}Li)^{18}F $\quad Q_{\rm m} = -13.049$

(b) ^{15}N(^{12}C, ^{9}Be)^{18}F $\quad Q_{\rm m} = -12.1194$

These reactions have been studied with $E(^{11}{\rm B}) = E(^{12}{\rm C}) = 115$ MeV. Reaction (a) is dominated by the transitions to ^{18}F*(1.12) [presumably the $J^\pi = 5^+$ state, although the group is unresolved] and to ^{18}F*(7.15, 9.45) [$J^\pi = (7^-)$ and (6^-)]. In reaction (b) no single state is strongly preferentially populated. Differential cross sections for ^{18}F*(4.40, 6.10, 7.15, 9.45) [$J^\pi = 4^-$, (5^-), (7^-), (6^-)], are fitted by FRDWBA: see (1983AJ01).

15. ^{16}O(d, γ)^{18}F $\quad Q_{\rm m} = 7.5256$

The capture cross section rises from 0.1 μb at $E_{\rm d} = 0.4$ MeV to 25 μb at 3.5 MeV: Γ_γ over this range is ≈ 2 eV: see (1972AJ02).

16. (a) ^{16}O(d, n)^{17}F $\quad Q_{\rm m} = -1.6241$ $\quad E_{\rm b} = 7.5256$

(b) ^{16}O(d, p)^{17}O $\quad Q_{\rm m} = 1.9191$

Excitation functions and polarization studies have been carried out to $E_{\rm d} = 17$ MeV [see (1978AJ03, 1983AJ01)] and at $E_{\rm d} \approx 5.6$ to 8.3 MeV (1985GR1B; p_0, p_3, p_4). Structures attributed to states in ^{18}F are displyed in Table 18.17. See also ^{17}O and ^{17}F in (1986AJ04), (1985JOZZ, 1986SE1B) and (1983DA31; applications).

Table 18.17: Maxima in the yields of $^{16}\mathrm{O} + \mathrm{d}$ [a]

E_{d} (MeV $\pm$ keV)	Particles out	$\Gamma_{\mathrm{c.m.}}$ (keV)	$J^{\pi}; T$	E_{x} (MeV)
0.895	p_1, α_0	210 ± 25		(8.320)
1.048	p_1, d_0, α_0	88 ± 10	1^+	8.456
1.199	α_0	230 ± 30		(8.590)
1.298	p_1, d_0, α_0	13 ± 3		(8.678)
1.325	d_0, α_0			(8.702)
1.482	α_0	40 ± 5		(8.842)
1.563	d_0, α_0	121 ± 15		(8.914)
1.616	α_0	19 ± 15		(8.961)
1.765	d_0, α_0	141 ± 10		(9.093)
1.885	p_0, p_1, d_0, α_0	108 ± 12	3, 4^-; 0	9.200
2.22	n_0, α_0		2, 3^+; 0	9.50
2.28	α_0		2, 3^+; 0	(9.55)
2.34	n_0, p_1			(9.60)
2.55	p_1			(9.79)
2.92	n, p_0, p_1			10.12
3.05	α_0		3, 4^-; 0	10.24
3.13	n, p_1, α_0, α_1		≥ 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		≥ 3; 0	11.79
4.93	α_0		5, 6^-; 0	11.90
5.05 ± 15	α_4	40		12.01
5.11	α_0, α_2, α_4	60	4, 5^+; 0	12.06
5.17	α_0	55	$T = 0$	12.12

Table 18.17: Maxima in the yields of ^{16}O + d [a] (continued)

$E_{\rm d}$ (MeV ± keV)	Particles out	$\Gamma_{\rm c.m.}$ (keV)	$J^\pi; T$	$E_{\rm x}$ (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	α_2, α_3, α_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	α_0, α_2, α_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	≥ 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	α_2, α_3, α_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		13.79
6.73	α_2	100		13.50
6.80	α_2, α_3	140		13.56
6.84	α_0, α_2, α_4	150		13.60
6.94	α_0, α_3	90		13.69
7.10	α_3, α_4	60	4^-, 5^+	13.83
7.27	α_3	150		13.98

Table 18.17: Maxima in the yields of ^{16}O + d [a] (continued)

E_d (MeV ± keV)	Particles out	$\Gamma_\mathrm{c.m.}$ (keV)	J^π; T	E_x (MeV)
7.31	α_2	60	4^-, 5^+	14.18
7.34	α_0, α_3, α_4	200		14.04
7.38	α_0, α_3	210		14.08
7.41	α_3	60	4^-, 5^+	14.02
7.49	α_0	220		14.18
7.58	α_0	200	≥ 4; 0	14.26
7.62	α_4	85		14.29
7.66	α_0, α_2, α_4	130	$T = 0$	14.33
7.67	α_0, α_2, α_3, α_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	α_0, α_2, α_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
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 18.17: Maxima in the yields of $^{16}\mathrm{O} + \mathrm{d}$ [a] (continued)

E_d (MeV $\pm$ keV)	Particles out	$\Gamma_\mathrm{c.m.}$ (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	α_0, α_3, α_4	200	5^+, 6^-	15.34
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
10.35	α_3	60	4^-, 5^+	16.72
11.15	α_3	70	4^-, 5^+, 6^-	17.43

[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).

17. ^{16}O(d, d)^{16}O $\qquad E_\mathrm{b} = 7.5256$

The yield of elastically scattered deuterons and elastic polarization measurements have been reported for $E_\mathrm{d} = 0.65$ to 56 MeV: see (1978AJ03, 1983AJ01). More recent measurements are those by (1985GR1B) [excitation functions for $E_\mathrm{d} \approx 5.6$ to 8.3 MeV] and the polarization studies at $E_{\vec{\mathrm{d}}} = 20.5$ MeV (1984FR14; TAP), 56 MeV (1986MA32; VAP, TAP) and 200, 400 and 700 MeV (1987NG01; VAP, TAP). See also (1982AO06, 1983AO03, 1986NG1B, 1986YA1R, 1987MA09; theor.) and ^{16}O in (1986AJ04).

18. ^{16}O(d, α)^{14}N $\qquad Q_\mathrm{m} = 3.1104 \qquad E_\mathrm{b} = 7.5256$

The yields of various groups of α-particles have been measured for $E_\mathrm{d} \leq 20$ MeV: see (1978AJ03, 1983AJ01). The yield curves have been fitted in terms of a large number of states in ^{18}F: see Tables 18.17 here, and 18.16 in (1978AJ03).

A detailed study by (1973JO13) of the isospin-forbidden α_1 yield, analyzed by S-matrix theory, identifies a large number of isospin mixed states in ^{18}F, possibly as many as 138 with $9.2 < E_\mathrm{x} < 19.4$ MeV. The reaction mechanism appears to be almost entirely compound nuclear. The isospin impurity, averaged over 1 MeV intervals, is $3-10\%$ for the above $E_{\rm x}$ range. The average coherence width increases from $\approx$ 100 keV at $E_{\rm x}$ = 14 MeV to $\approx$ 500 keV at $E_{\rm x}$ = 20 MeV. The level densities appear to be consistent with predictions of the Fermi-gas model (1973JO13). See also (1985JOZZ). [For mixed isospin states observed in ^{14}N(α, α_1) see Table 18.14 in (1978AJ03).] Polarization measurements are reported for $E_{\rm d} = 6.8$ to 16 MeV: see (1978AJ03, 1983AJ01).

19. ^{16}O(d, ^{6}Li)^{12}C $\quad Q_{\rm m} = -5.6868 \quad E_{\rm b} = 7.5256$

Polarization measurements for the transitions to ^{12}C*(0, 4.4) are reported at $E_{\vec{\rm d}} = 18$ and 22 MeV (1987TA07; VAP, TAP) and 51.7 MeV (1986YA12; VAP; also to ^{12}C*(14.1)).

20. ^{16}O(t, n)^{18}F $\quad Q_{\rm m} = 1.2690$

See (1987BO16; applied) and (1983AJ01).

21. ^{16}O(^{3}He, p)^{18}F $\quad Q_{\rm m} = 0.321$

Excitation energies derived from measurements of γ-rays are displayed in Table 18.18 together with l-assignments obtained from distorted-wave analyses, and J^π; T and K^π assignments from branching ratios, radiative widths, linear polarization, γ-ray angular distributions and $\tau_{\rm m}$ measurements [see also Tables 18.14 and 18.15]. Studies of this reaction, together with the work on ^{14}N(α, γ) and ^{17}O(p, γ), have defined the low-lying states of ^{18}F.

The g-factor of ^{18}F*(0.94) [$J^\pi = 3^+$] is $+(0.56 \pm 0.05)$: see (1983AJ01). The circular polarization of the 1.08 MeV → g.s. γ-ray, $P_\gamma = (-10 \pm 18) \times 10^{-4}$ (1982AH07), $(2.7 \pm 5.7) \times 10^{-4}$ (1985BI03), $(1.6 \pm 5.6) \times 10^{-4}$ (1985EV03), $(1.7 \pm 5.8) \times 10^{-4}$ (1987PA07). The weak pion-nucleon coupling constant deduced from the weighted average of all recent P_γ measurements [$(1.2 \pm 3.9) \times 10^{-4}$] is $(0.3^{+1.0}_{-0.3}) \times 10^{-7}$. Together with PNC matrix elements in other experiments this suggests that the isovector weak NN interaction may be strongly suppressed compared with the isoscalar weak NN interaction (1985EV03, 1987PA07). For a measurement of the ICC of the 0.94, 1.02, 1.04 and 1.08 MeV γ-rays see (1986KR04). See also (1978AJ03, 1983AJ01), (1984BE1A; applications), (1987ER05; theor.) and ^{19}Ne.

22. ^{16}O(α, d)^{18}F $\quad Q_{\rm m} = -16.3211$

Table 18.18: States in ^{18}F from ^{16}O(^{3}He, pγ)^{18}F [a]

E_x (keV) [b]	l [a]	$J^\pi; T$ [c]	K^π [c]
0	0	$1^+; 0$	0^+
937.1 ± 0.4	2	$3^+; 0$	0^+
1040.9 ± 0.5	0	$0^+; 1$	
1080.1 ± 0.5		$0^-; 0$	0^-
1119.0 ± 0.6	4	$5^+; 0$	0^+
1701.4 ± 0.7	0	$1^+; 0$	1^+
2099.9 ± 0.6		$2^-; 0$	0^-
2523.4 ± 0.7	2	$2^+; 0$	1^+
3061.2 ± 0.5	2	$2^+; 1$	
3132.8 ± 0.6		$1^-; 0$	1^-
3358.2 ± 1.0		$3^+; 0$	1^+
3725.4 ± 0.8		$1^+; 0$	
3790.6 ± 0.9		$3^-; 0$	1^-
3838.4 ± 0.7	2	$2^+; 0$	
4114.5 ± 0.9		$3^+; 0$	
4225.8 ± 0.7		$2^{(-)}; 0$	(1^-)
4361.0 ± 0.7		$1^{(+)}$	
4398.1 ± 0.7		$3^-, 4^-; 0$ [d]	(0^-)
4652 ± 2	4	$4^+; 1$	
4753 ± 3		$(0^+; 1)$	
4860 ± 2		$1^{(-)}; 0$	
4963.6 ± 0.8		$2^+; 1$	
5297.6 ± 1.5		4^+	1^+
5502 ± 2		$3^{(-)}; 0$	
5603 ± 2		$1^-; 0 + 1$	
5669 ± 2		$1^-; 0 + 1$	
5785 ± 3		$2^-; 0$	
6097.4 ± 1.4		$4^-; 0$	1^-
6108 ± 3		$1, 2, 3^{(-)}; 0$	
6138.3 ± 1.0		$0^+; 1$	
6164.0 ± 1.0		$3^+; 1$	

Table 18.18: States in ^{18}F from ^{16}O(^{3}He, pγ)^{18}F [a] (continued)

E_x (keV) [b]	l [a]	$J^\pi; T$ [c]	K^π [c]
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 [c]		$3^{(-)}$, 4^-; (0)	

[a] For earlier results derived from measurements of proton spectra and of γ-rays, see Table 18.18 in (1972AJ02). See also Tables 18.14 and 18.15 here.

[b] (1973RO03): γ-ray measurements.

[c] See Table 18.17 in (1978AJ03).

[d] See p. 179 of (1979KI12).

Angular distributions of the deuteron groups to ^{18}F*(1.12) [$J^\pi = 5^+$] have been studied at $E_\alpha = 28.0$ to 33.6 MeV: see (1983AJ01). At $E_\alpha = 65.3$ MeV a number of angular distributions are reported to ^{18}F states with $E_x \leq 11.4$ MeV: ^{18}F*(9.49, 10.54) are suggested to have $J^\pi = 6^-$ and 7^+ respectively (1986KA36). See, however, reactions 9 and 10.

23. ^{16}O(^{6}Li, α)^{18}F $\qquad Q_m = 6.050$

Angular distributions have been measured at $E(^6\text{Li}) = 5.5$ to 34 MeV [see (1983AJ01)] and at $E(^6\text{Li}) = 48$ MeV (1984CO05; α_0, α_1, α_4). (1982FR15) report the excitation of a state at $E_x = 4848.3 \pm 0.5$ keV which decays (35 ± 4)% to ^{18}F*(3.79) [$E_\gamma = 1056.8 \pm 0.4$ keV] and (65 ± 4)% to ^{18}F*(1.12). Alpha-γ angular correlations are consistent with $J^\pi = 5^-$, and $T = 0$ (1982FR15). See also (1986GL02) and (1986IC01; theor.).

24. (a) ^{16}O(^{11}B, ^{9}Be)^{18}F $\qquad Q_m = -8.290$
(b) ^{16}O(^{13}C, ^{11}B)^{18}F $\qquad Q_m = -11.153$
(c) ^{16}O(^{14}N, ^{12}C)^{18}F $\qquad Q_m = -2.7468$

Table 18.19: Excited states of ^{18}F from ^{17}O(p, γ)^{18}F [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
1121.36 ± 0.15	4115.90 ± 0.25
1700.81 ± 0.18	4360.15 ± 0.26
2100.61 ± 0.10	5603.38 ± 0.27
2523.35 ± 0.18	5604.86 ± 0.28
3061.84 ± 0.18	5668 ± 2
3133.87 ± 0.15	6136.47 ± 0.33

[a] See also Table 18.20 here, and Table 18.17 in (1983AJ01).

See (1983AJ01).

25. ^{17}O(p, γ)^{18}F $\quad Q_m = 5.6065$

Gamma-ray measurements lead to the very accurate E_x determinations for ^{18}F states below 6.2 MeV: see Table 18.19. Observed resonances are displayed in Table 18.20; branching ratios, radiative widths and multipole mixing ratios are shown in Table 18.14; and τ_m in Table 18.15.

The direct capture cross section has been studied for $E_p = 0.3$ to 1.9 MeV: ^{18}F*(5.603, 5.605, 5.668, 5.786) have $J^\pi = 1^+, 1^-, 1^-$ and 2^-. The 1^- states have mixed isospin. For astrophysical considerations see (1978AJ03, 1983AJ01) and (1982RO1A).

26. ^{17}O(p, n)^{17}F $\quad Q_m = -3.5432 \quad E_b = 5.6065$

Observed resonances are displayed in Table 18.20. Analyzing power measurements are reported at $E_{\vec{p}} = 135$ MeV (1983PUZZ; n_0).

27. ^{17}O(p, p)^{17}O $\quad E_b = 5.6065$

Table 18.20: Resonances in $^{17}\mathrm{O} + \mathrm{p}$ [a]

E_p (keV)	Yield of	$\Gamma_\mathrm{c.m.}$ (keV)	$(2J+1)\Gamma_\gamma\Gamma_\mathrm{p}/\Gamma$ (eV)	$J^\pi; T$	E_x (MeV ± keV)
517.0 ± 1.0	γ, α_0	0.24 ± 0.03	0.26 ± 0.05	$4^-; 0$	6.095
525	α_0	0.034 ± 0.003		(1^+)	6.102
561.2 ± 1.0	γ	≤ 1	2.2 ± 0.6	$0^+; 1$	6.136
587.1 ± 1.0	γ, p_0, α_0	14 ± 0.5	6.7 ± 1.8	$3^+; 1$	6.161
670.5 ± 1.0	γ, p_0, α_0	0.19 ± 0.03	(c)	$3^-; 0+1$	6.239
673.0	γ, α_0	0.18 ± 0.04	(c)	$3^-; 0+1$	6.242
690 ± 4	α_0	0.60 ± 0.12	≤ 0.02	$1^+; 0$	6.258
714.2 ± 1.0	γ, p_0, α_0	10.0 ± 0.5	9.1 ± 2.3	$2^+; 1$	6.281
741 ± 2	γ, p_0, α_0	0.95 ± 0.14	0.64 ± 0.17	$3^+; 0$	6.306
826 ± 2	γ, α_0	0.40 ± 0.09	0.60 ± 0.18	$2^+; 0+1$	6.386
926 ± 2	γ, α_0	0.40 ± 0.10	0.36 ± 0.15	$3^+; 0$	6.481
1015	α_0	0.56 ± 0.13	≤ 0.0023	$5^+; 0$	6.565
1090	α_0	80 ± 2		1	6.635
1098.9 ± 0.4	γ, α	0.60 ± 0.07	4.3 ± 1.2	$2^-; 1$	6.6439
1101 ± 4	α_0	89 ± 5			6.646
1240 ± 2 [b]	γ, p_0, α_0	9.2 ± 1.0	2.8 ± 0.7	$4^+; 0$	6.777
1270	γ, p_0	≤ 2	0.54 ± 0.20	$1^+, 2, 3^+; 0$	6.8031 ± 1.5
1274 ± 5	α_0	88 ± 2		2^-	6.809
1276	α_0	3.0 ± 0.5		(2^+)	6.811
1338	α_0	5.0 ± 1.0		(3^-)	6.870
1345 ± 3	γ, α_0	≤ 2	1.0 ± 0.4	$3, 4^-; 0$	6.876
1687.5 ± 1	α_0	6.5	3.9	$(4^+); 0$	7.199
1738 ± 2	α_0	46.5	8.8	$(1^+); 0$	7.247
1784 ± 2	p_0, α_0	38	47	3^-	7.291
1810 ± 4	α_0	52	8.5	$(3^-; 0)$	7.315
1832.5 ± 1	γ, p_0, p_1	16 ± 2	[d]	$1^-; 1$	7.336
1906 ± 2	p_0, p_1	14.6 ± 1.4		1^+	7.406
1950 ± 10	α_0	140	5.6		7.447
1957 ± 2	p_0	6		1^-	7.454
1983 ± 2	γ, p_1, α_0	12 ± 3	1.5	(2)	7.478
(1990 ± 2)	p_0	32		(1^-)	(7.485)
2012 ± 2	p_0, α_0	12 ± 2	7.2	4^-	7.506
2020 ± 2	γ	< 4			7.513

Table 18.20: Resonances in ^{17}O + p [a] (continued)

E_p (keV)	Yield of	$\Gamma_{c.m.}$ (keV)	$(2J+1)\Gamma_\gamma\Gamma_p/\Gamma$ (eV)	$J^\pi; T$	E_x (MeV ± keV)
2036 ± 2	γ, p_0, p_1, α_0	16.5 ± 3.0	5.5 [e]	$2^-; 1$	7.528
2040 ± 5	p_1, α_0	75			7.532
2064 ± 2	p_0	30		(1^-)	7.555
2095 ± 2	γ, p_0, p_1, α_0	9 ± 2	3.7 [f]	[g]	7.584
2202 ± 2	p_0, p_1, α_0	36 ± 4	25.1	$3^+, 4^+$ [g]	7.685
2248 ± 4	p_1, α_0	66 ± 5	28.2	≥ 1	7.729
2284 ± 4	p_1	70			7.763
2406 ± 3	p_1, α_0	20	24.4	≥ 2	7.878
2429 ± 2	α_0	38	42	(2^-)	7.899
2473 ± 12	α_0	112	80	(1^+)	7.941
2603 ± 6	p_1, α_0	60	11	≥ 4	8.064
2657 ± 2	p_1	96			8.115
2757 ± 8	p_0, α_0	52	63	2^-	8.209
2788 ± 2	p_0	20		4^+	8.238
2928	α_0	≈ 50			8.370
3915 ± 20	n	95			9.302
(4163 ± 20)	n	19			(9.536)
4235 ± 10	n	33			9.604
4330 ± 10	n	33			9.694
4490 ± 20	n	≈ 100			9.845
(4790 ± 10)	n	28			(10.128)
4900 ± 20	n	≈ 140			10.232

[a] For references see Tables 18.18 in (1978AJ03, 1983AJ01).

[b] See footnote [d] in Table 18.18 (1978AJ03).

[c] 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.

[d] $\Gamma_\gamma = 3.5 \pm 1.0$ eV.

[e] $\Gamma_\gamma = 0.44 \pm 0.10$ eV.

[f] $\Gamma_\gamma = 0.11 \pm 0.03$ eV.

[g] Assumed to be unresolved.

The elastic scattering has been studied for $E_p = 0.5$ to 13 MeV [see (1978AJ03, 1983AJ01)]: observed anomalies are displayed in Table 18.20. Analyzing powers have been measured at $E_{\vec{p}} = 89.7$ MeV (1985VO12; p_0).

28. ^{17}O(p, t)^{15}O $Q_\mathrm{m} = -11.3257$ $E_\mathrm{b} = 5.6065$

Analyzing powers have been reported at $E_{\vec{\mathrm{p}}} = 89.7$ MeV for the triton groups to a number of ^{15}O states (1985VO12).

29. ^{17}O(p, α)^{14}N $Q_\mathrm{m} = 1.1914$ $E_\mathrm{b} = 5.6065$

The yield of α_0 shows a number of resonances for $E_\mathrm{p} = 0.49$ to 3.0 MeV: see Table 18.20. The R-matrix fit of (1979KI13), obtained from data from $E_\mathrm{p} = 400$ 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 (1982RO1A, 1987RO25) and (1986BA89; theor.).

30. ^{17}O(^{3}He, d)^{18}F $Q_\mathrm{m} = 0.1130$

At $E(^3\mathrm{He}) = 15$ MeV DWBA analysis of angular distributions of deuteron groups corresponding to states of ^{18}F with $E_\mathrm{x} < 5$ MeV have led to J^π values and spectroscopic information: see (1972AJ02). See also (1987ER05; theor.).

31. ^{17}O(^{12}C, ^{11}B)^{18}F $Q_\mathrm{m} = -10.351$

See (1983AJ01).

32. ^{18}O(π^+, π^0)^{18}F $Q_\mathrm{m} = 2.949$

See (1983AS01, 1984AS05).

33. ^{18}O(p, n)^{18}F $Q_\mathrm{m} = -2.4387$

(1983AN05) have studied the distribution of Gamow-Teller (GT) strength. At $E_\mathrm{p} = 135$ MeV angular distributions have been studied to the 0^+ state at 1.04 MeV and to the 1^+ states ^{18}F*(0, 1.70, 3.72, 4.36, 6.26) as well as to possible 1^+; $T = 1$ groups at $E_\mathrm{x} = 9.9$ 10.9 and 11.9 MeV. 82% of the observed strength lies in the ground state group and 5.5% in the $(T = 1)$ states. The observed GT strength is $\approx \frac{2}{3}$ of that expected from the simple sum rule (1983AN05). See also (1985TAZY), (1985WA24), (1986MA1P, 1987HI1B; applied) and the earlier work in (1978AJ03).

Table 18.21: Branching in ^{18}Ne(β^+)^{18}F [a]

Decay to ^{18}F* (MeV)	$J^\pi; T$	E_{γ_0} (keV)	Branch (%) [b]	log f_0t [c]
0	$1^+; 0$		92.11 ± 0.21	3.096 ± 0.004
1.04 [d]	$0^+; 1$	1041.5 ± 0.3	7.70 ± 0.21	3.473 ± 0.013
1.08 [d]	$0^-; 0$	1080.76 ± 0.13 [b]	$(2.07 \pm 0.28) \times 10^{-3}$	7.012 ± 0.059
1.70	$1^+; 0$	1699.9 ± 0.3 [e]	0.188 ± 0.006	4.477 ± 0.015

[a] For the earlier work see Tables 18.19 in (1983AJ01) and 18.20 in (1978AJ03).

[b] (1983AD03). See also (1982HE04).

[c] Based on $\tau_{1/2} = 1672 \pm 8$ msec: see (1983AD03).

[d] The splitting of the 0^+ and 0^- states is 39.20 ± 0.11 keV (1983AD03).

[e] And 659.2 ± 0.3 keV for the γ-ray to ^{18}F*(1.04) (1982HE04).

34. ^{18}O(^{3}He, t)^{18}F $\qquad Q_m = -1.675$

At $E(^3\text{He}) = 16$ MeV, the triton spectrum is dominated by strong groups to ^{18}F*(0, 0.94) and to the 0^+ and 2^+, $T = 1$ states ^{18}F*(1.04, 3.06). Angular distributions have been studied to these and many other states at this energy and at $E(^3\text{He}) = 17.3$ MeV. At $E(^3\vec{\text{He}}) = 33$ MeV A_y measurements for t_0 have been reported. See (1983AJ01) for references.

35. ^{18}O(^{6}Li, ^{6}He)^{18}F $\qquad Q_m = -5.162$

See (1978AJ03).

36. ^{18}Ne(β^+)^{18}F $\qquad Q_m = 4.446$

The half-life of ^{18}Ne is 1672 ± 8 msec [see ^{18}Ne]. The decay is to ^{18}F*(0, 1.04, 1.08, 1.70): see Table 18.21.

37. ^{19}F(γ, n)^{18}F $\qquad Q_m = -10.4320$

Cross sections have been reported to 30 MeV for the transitions to ^{18}F*(0.94, 1.04, 1.08, 3.06, 3.13, 4.75): see (1983AJ01).

38. ^{19}F(p, d)^{18}F $Q_{\rm m} = -8.2074$

Angular distributions have been reported to many states of ^{18}F with $E_{\rm x} \lesssim 6$ MeV: see Table 18.20 in (1983AJ01). See also (1986VAZV [$E_{\rm p} = 18.6$ MeV; d$_0$, d$_2$]), (1983BEYY) and (1981CL05, 1983KI13; theor.).

39. ^{19}F(d, t)^{18}F $Q_{\rm m} = -4.1747$

See (1972AJ02, 1978AJ03).

40. ^{19}F(^{3}He, α)^{18}F $Q_{\rm m} = 10.1458$

See (1978AJ03).

41. ^{20}Ne(p, ^{3}He)^{18}F $Q_{\rm m} = -15.562$

See (1978AJ03).

42. ^{20}Ne(d, α)^{18}F $Q_{\rm m} = 2.7915$

At $E_{\rm d} = 11$ MeV α-groups are observed to many states of ^{18}F with $E_{\rm x} < 7$ MeV. Weak or absent (each ≤ 0.3% of the total yield at $30°$) are the groups corresponding to ^{18}F*(1.04, 3.06, 4.66, 4.74, 4.96): $T = 1$. Measurements of the TAP for $E_{\vec{\rm d}} = 10.25$ to 12.0 MeV leads to assignments of 2^-, 1^+, 0^+, 1^-, 1^+, 3^+, 3^+ to ^{18}F*(4.23, 4.36, 4.75, 4.86, 5.603, 6.16, 6.48). See (1972AJ02, 1978AJ03, 1983AJ01) for references and for other results and (1987HI1B; applications).

43. ^{21}Ne(p, α)^{18}F $Q_{\rm m} = -1.744$

See (1987GOZX).

44. ^{23}Na(d, ^{7}Li)^{18}F $Q_{\rm m} = -12.176$

See (1984NE1A).

^{18}Ne

(Figs. 3 and 4)

GENERAL: (See also (1983AJ01).)

Model calculations: (1982ZH01, 1983BR29, 1984SA37, 1985RO1G).

Special states: (1982ZH01, 1983BI1C, 1983BR29, 1984SA37, 1985RO1G, 1986AN10, 1986AN07).

Electromagnetic transitions: (1982BR24, 1982RI04, 1983BR29, 1985AL21, 1986AN10).

Astrophysical questions: (1982WI1B, 1987WI11).

Complex reactions involving ^{18}*Ne:* (1986HA1B).

Pion capture and reactions (See also reaction 4.): (1982AS1B, 1983HO02, 1983JO06, 1983LI08, 1983LI1U, 1983OS1E, 1984JO01, 1984KA26, 1985GM01, 1986BA1C, 1986FO06, 1986GE06).

Other topics: (1983BI1C, 1983BR29, 1983BR1E, 1985AL21, 1985AN28, 1986ST15).

Ground state of ^{18}*Ne:* (1983ANZQ, 1985AN28).

For B(E2) of ^{18}Ne*(1.89) and other parameters see (1987RA01) and Table 2 in the Introduction here.

1. ^{18}Ne(β^+)^{18}F $\qquad Q_{\rm m} = 4.446$

The half-life of ^{18}Ne is 1672 ± 8 msec: see (1978AJ03) and (1983AD03). The decay is primarily to ^{18}F*(0, 1.04, 1.70). In addition there is an extremely weak branch [$(2.07 \pm 0.28) \times 10^{-3}$%] to ^{18}F*(1.08) [$J^\pi = 0^-$; $T = 0$] (1983AD03): see Table 18.21 for the parameters of the decay. The parity mixing in the ^{18}F*(1.04, 1.08) $0^+ - 0^-$ doublet has been studied by (1983AD03). See also (1982HE04). For the earlier work see, in particular, (1981AD01, 1981HA06). See also (1983AD1C, 1983AD1B, 1983AD1D, 1984AD1E, 1985AD1A, 1985BR29) and (1984HA58, 1986BR1X, 1986HA1Q, 1986TO1D, 1987KI03; theor.).

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

See Table 18.24. See also (1983AJ01).

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

Table 18.22: Energy levels of ^{18}Ne [a]

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

[a] See also Table 18.23.

At $E(^{10}\text{B}) = 100$ MeV the angular distribution to ^{18}Ne*(3.38) [$(\text{d}_{5/2})^2_{4+}$ state] which is preferentially populated has been studied. ^{18}Ne*(1.89) is also observed. See (1983AJ01). See also (1983OS07; theor.).

4. $^{18}\text{O}(\pi^+, \pi^-)^{18}\text{Ne}$ $\qquad Q_m = -6.101$

Angular distributions have been studied at $E_{\pi^+} = 164$ and 292 MeV [see (1983AJ01)] and at 48.3 MeV (1985AL15; to $^{18}\text{Ne}_{\text{g.s.}}$) and 100 to 292 MeV (1985SE08; to $^{18}\text{Ne}_{\text{g.s.}}$). The excitation functions for production of ^{18}Ne*(0, 1.89) have been measured for $E_{\pi^+} = 80$ to 292 MeV: see (1983AJ01, 1985SE08). See also (1984BA1B, 1985GIZX, 1986ANZY), (1985GI01; theor.) and the "General" section here.

Table 18.23: Branching ratios and lifetimes of ^{18}Ne states [a]

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

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

[b] Ground state decay is $< 1\%$.

[c] Ground state decay is $< 5\%$.

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

5. ^{20}Ne(p, t)^{18}Ne $\qquad Q_\mathrm{m} = -20.026$

Observed triton groups are displayed in Table 18.24 as are J^π derived from DWBA analysis of angular distributions: The 0^+_3 state, identified at $E_\mathrm{x} = 4.59$ MeV, appears to have largely $\mathrm{s}^2_{1/2}$ configuration based on its large downward shift with respect to the analog state in ^{18}O (1981NE09).

^{18}Na
(not observed)

^{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 1.6 MeV: see (1978AJ03). See also (1986AN07) and (1983ANZQ; theor.).

^{18}Mg, etc.
(not observed)

See (1986AN07) and (1983ANZQ; theor.).

Table 18.24: States in ^{18}Ne from ^{16}O(^{3}He, n) and ^{20}Ne(p, t) [a]

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

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

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

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

[b] (1981NE09).

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

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