

Table 17.19 from (1982AJ01): States of  $^{17}\text{F}$  from  $^{14}\text{N}(^3\text{He}, \gamma)$  <sup>a</sup>

$E(^3\text{He})$ (MeV)	$\Gamma_{\text{c.m.}}$ (MeV)	Res. in	$(2J + 1)\Gamma_{^3\text{He}}\Gamma_{\gamma}$ (keV <sup>2</sup> )	$E_x$ (MeV)
(4.5) <sup>b</sup>	$1.0 \pm 0.3$	$\gamma_1, \alpha$ <sup>c</sup>	$32 \pm 20$	$(19.5 \pm 0.2)$
5.2	$1.07 \pm 0.16$	$\gamma_2$	$63 \pm 26$	$20.1 \pm 0.2$
(5.4) <sup>b</sup>	$1.2 \pm 0.4$	$\gamma_0$	$46 \pm 32$	$(20.2 \pm 0.3)$
5.6	$0.7 \pm 0.1$	$\gamma_1$	$33 \pm 11$	$20.4 \pm 0.1$
6.6	$0.9 \pm 0.1$	$\gamma_1$	$74 \pm 18$	$21.3 \pm 0.1$
(7.8) <sup>b</sup>	$2.0 \pm 0.5$	$\gamma_0$	$260 \pm 140$	$(22.2 \pm 0.3)$

<sup>a</sup> (1981WA1R). See also (1979CH2B, 1980CHZF). See, however, (1972MO39).

<sup>b</sup> Uncertain: J. Lowe, private communication.

<sup>c</sup> See reaction 6.

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# $^{17}\text{F}$ (1982AJ01)

Information on mass  
chains and nuclides

(See [Energy Level Diagrams](#) for  $^{17}\text{F}$ )

3	4
5	6
7	8
9	10
11	12
13	14
15	16
17	18
19	20

GENERAL: See ([1977AJ02](#)) and Table 17.18 [[Table of Energy Levels](#)] (in [PDF](#) or [PS](#)).

*Shell and cluster models:* ([1977DU04](#), [1977HA1Z](#), [1977PO16](#), [1978TH1A](#)).

*Special states:* ([1977HE18](#), [1978EN1D](#), [1980CH35](#), [1981TA09](#)).

*Electromagnetic transitions:* ([1976MC1G](#), [1977BR03](#), [1977HA1Z](#), [1977HO04](#), [1980CH35](#)).

*Complex reactions involving  $^{17}\text{F}$ :* ([1977AR06](#)).

*Astrophysical questions:* ([1977SI1D](#), [1978WO1E](#)).

*Reactions involving pions:* ([1981OS04](#), [1981PU1A](#)).

*Other topics:* ([1976SA1H](#), [1977BA3P](#), [1978EN1D](#), [1978SH1B](#), [1978SL1B](#), [1979BE1H](#), [1981TA09](#)).

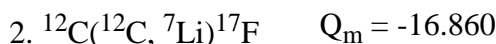
*Ground state of  $^{17}\text{F}$ :* ([1976JO1B](#), [1976MC1G](#), [1976SA1H](#), [1977AN12](#), [1977BR03](#), [1977DU04](#), [1977HA1Z](#), [1977KO28](#), [1977PO16](#), [1977SH13](#), [1978AR1R](#), [1978SL1B](#), [1980CH35](#), [1981TA09](#)).

$$\mu = 4.7223 \pm 0.0012 \text{ nm} \text{ ([1978LEZA](#))}.$$

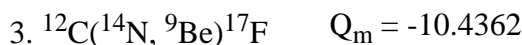
$$Q = 0.10 \pm 0.02 \text{ b} \text{ ([1974MI21](#))}.$$



Two recent measurements of the half-life of  $^{17}\text{F}$  are  $64.31 \pm 0.09$  sec ([1977AZ01](#)) and  $64.80 \pm 0.12$  sec ([1977AL20](#)): the weighted mean of these is  $64.49 \pm 0.16$  sec;  $\log ft = 3.36$ . Earlier values are listed in ([1971AJ02](#), [1977AJ02](#)). The upper limit for the  $\beta^+$  decay to  $^{17}\text{O}^*(0.87)$  is  $< 3.4 \times 10^{-4}$  per decay ([1969GA05](#)) [ $\log ft > 5.6$ ]. See also ([1978RA2A](#)) and ([1977AZ02](#), [1978BR1R](#), [1979BA08](#), [1979OS1E](#), [1979TO1B](#); theor.).



See ([1971AJ02](#)).



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Angular distributions are reported to  $^{17}\text{F}^*(0, 0.50)$  at  $E(^{14}\text{N}) = 53$  MeV ([1976ZE04](#)) and 78.8 MeV ([1977MO1A](#); unresolved).

$$4. \ ^{12}\text{C}(^{20}\text{Ne}, ^{15}\text{N})^{17}\text{F} \quad Q_m = -9.0962$$

See ([1979OR01](#)).

$$5. \ ^{14}\text{N}(^3\text{He}, \gamma)^{17}\text{F} \quad Q_m = 15.8431$$

Excitation functions for  $\gamma_0$ ,  $\gamma_1$ ,  $\gamma_2$  and  $\gamma_3$  have been studied for  $E(^3\text{He}) = 3$  to 19 MeV: observed resonances are displayed in Table 17.19 (in [PDF](#) or [PS](#)) ([1981WA1R](#)). [The earlier work by ([1973MO1C](#)), who studied the  $\gamma_{0+1}$  yield at  $90^\circ$ , indicated several sharp resonances].

$$6. \text{ (a) } ^{14}\text{N}(^3\text{He}, \text{n})^{16}\text{F} \quad Q_m = -0.969 \quad E_b = 15.8431$$

$$\text{(b) } ^{14}\text{N}(^3\text{He}, \text{p})^{16}\text{O} \quad Q_m = 15.2428$$

$$\text{(c) } ^{14}\text{N}(^3\text{He}, \text{d})^{15}\text{O} \quad Q_m = 1.8035$$

$$\text{(d) } ^{14}\text{N}(^3\text{He}, ^3\text{He})^{14}\text{N}$$

$$\text{(e) } ^{14}\text{N}(^3\text{He}, \alpha)^{13}\text{N} \quad Q_m = 10.024$$

Excitation functions for protons have been measured for  $E(^3\text{He}) = 2.5$  to 18 MeV [see ([1977AJ02](#))]: some large structures are observed. The polarization of the  $p_0$  group has been studied at  $E(^3\text{He}) = 9.8$  MeV. The elastic scattering of  $^3\text{He}$  (reaction (d)) and the yield of  $\alpha$ -particles (reaction (e)), studied in the ranges  $E(^3\text{He}) = 4$  to 7 MeV and 2.5 to 8.5 MeV, respectively, show some evidence of structures ([1970KN01](#), [1973MO1C](#)): see the discussion in ([1977AJ02](#)). See also [16O](#) and [16F](#) here, and [13N](#), [14N](#) and [15O](#) in ([1981AJ01](#)).

$$7. \ ^{14}\text{N}(\alpha, \text{n})^{17}\text{F} \quad Q_m = -4.7347$$

See [18F](#) in ([1978AJ03](#)).

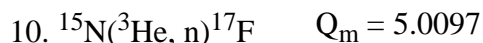
$$8. \ ^{14}\text{N}(^6\text{Li}, \text{t})^{17}\text{F} \quad Q_m = 0.049$$

At  $E(^6\text{Li}) = 18$  MeV  $^{17}\text{F}^*(3.86, 5.22 \pm 0.01, 5.67 + 5.68)$  are strongly excited.  $J^\pi = 9/2^-$  is suggested for  $^{17}\text{F}^*(5.22)$  ([1973BI01](#)). See also ([1977MA2G](#)).

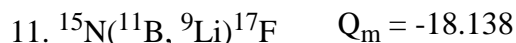
$$9. \ ^{14}\text{N}(^{10}\text{B}, ^7\text{Li})^{17}\text{F} \quad Q_m = -1.945$$



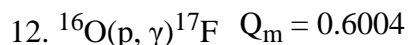
See ([1977AJ02](#)).



Angular distributions have been reported to most of the states of  $^{17}\text{F}$  with  $E_x < 8.1$  MeV at  $E(^3\text{He}) = 3.8$  and 4.8 MeV: see ([1977AJ02](#)). Neutron groups have also been reported to  $^{17}\text{F}$  states at  $E_x = 11.195 \pm 0.007$ ,  $12.540 \pm 0.010$  and  $13.059$  MeV, with  $\Gamma < 20$ ,  $< 25$  and  $< 25$  keV, respectively. Angular distributions at  $E(^3\text{He}) = 10.36$  and 11.88 MeV lead to  $J^\pi = 1/2^-$  for  $^{17}\text{F}^*(11.20)$  [ $L = 0$ ],  $3/2^-$  or  $5/2^-$  for  $^{17}\text{F}^*(12.54)$  and  $(3/2^-, 5/2^-)$  for  $^{17}\text{F}^*(13.06)$ . These three states are probably the first three  $T = 3/2$  states in  $^{17}\text{F}$  ([1969AD02](#)). The branching ratios for transitions to  $^{16}\text{O}^*(0, 6.05, 6.13)$  for  $^{17}\text{F}^*(11.20)$  and for the analog  $T = 3/2$  state in  $^{17}\text{O}$  are displayed in Table 17.11 (in [PDF](#) or [PS](#)): the ratios of the reduced widths are quite different in the two mirror nuclei ([1970MC02](#), [1973AD02](#)).



At  $E(^{11}\text{B}) = 115$  MeV  $^{17}\text{F}^*(0, 5.22)$  are strongly populated ([1979RA10](#)).



$$Q_0 = 600.35 \pm 0.28 \text{ keV} \quad (\text{a href="#">1976RO1T).$$

At low energies the direct capture to  $^{17}\text{F}^*(0, 0.50)$  is observed: see ([1971AJ02](#), [1977AJ02](#)). Extrapolation of cross-section data leads to  $S(0) \approx 8 \text{ keV} \cdot \text{b}$ : see ([1977AJ02](#)). In addition to two  $T = 1/2$  resonances, five resonances corresponding to  $T = 3/2$  states are observed in the  $\gamma_1$  and  $\gamma_0 + \gamma_1$  yields: see Table 17.20 (in [PDF](#) or [PS](#)) for the reported parameters. The lowest  $T = 3/2$  states of even parity at  $E_x = 13.27$  and  $14.02$  MeV [ $J^\pi = (1/2^+)$  and  $5/2^+$ ] (see Table 17.21 (in [PDF](#) or [PS](#))) are not observed here:  $\Gamma_\gamma \leq 7$  and  $\leq 11.8$  eV, respectively ([1975HA06](#)). The (E1) values for the  $T = 3/2$  states are in good agreement with shell model 2p-1h calculations using realistic Kuo-Brown interaction matrix elements ([1975HA06](#)).

The  $(\gamma_0 + \gamma_1)$  yield at  $90^\circ$  has been studied for  $E_p = 15.75$  to 31.66 MeV: it shows the giant dipole resonance centered at  $E_x = 22$  MeV with a width of  $\approx 5$  MeV and a pigmy resonance centered at 17.5 MeV. The integrated strength of the, mainly  $T = 1/2$ , giant resonance is  $10 \text{ MeV} \cdot \text{mb}$ : the observed strength distribution is on good agreement with odd parity 2p-1h, 1p excitation calculations. The pigmy resonance is due to  $f_{7/2} \rightarrow d_{5/2}$ : the main  $f_{7/2}$  strength lies in two states at  $E_x = 16.9$  and 18.0 MeV ([1975HA07](#)). See also ([1979BL1F](#)), ([1981CA1D](#)), ([1975ZI1A](#); astrophys.) and ([1977AL18](#); theor.).



$$(c) \ ^{16}\text{O}(p, pn)^{15}\text{O} \quad Q_m = -15.6639$$

$$(d) \ ^{16}\text{O}(p, p\alpha)^{12}\text{C} \quad Q_m = -7.1620$$

Yield curves for elastic protons, protons scattered to  $^{16}\text{O}^*(6.05, 6.13, 6.92, 7.12, 8.87)$  and for  $\gamma$ -rays from  $^{16}\text{O}^*(6.13, 6.92)$  have been studied at many energies up to  $E_p = 46$  MeV: see Table 17.19 (in [PDF](#) or [PS](#)) in ([1971AJ02](#)) and ([1977AJ02](#)) for the earlier work and ([1981KR1B](#);  $E_{p\text{-bar}} = 8.5$  to 10.6 MeV;  $p_0$ ), ([1979DA11](#);  $E_{p\text{-bar}} \approx 14.4$  MeV;  $p_0$ ). The observed resonances are displayed in Table 17.21 (in [PDF](#) or [PS](#)).

Polarization results have been reported at  $E_p = 3.47$  to 49.4 MeV [see ([1977AJ02](#))] and at  $E_p = 40$  MeV ([1978MO14](#);  $p_5$ ), 42.5, 44.0 and 49.3 MeV ([1977PE09](#);  $p_5$ ), 65 MeV ([1979SA38](#), [1981SA1F](#);  $p_0$ ), 135 MeV ([1980KE14](#);  $p_2, p_4$ ), 800 MeV ([1979AD03](#), [1979GL1C](#);  $p_0, p_{1+2}, p_3, p_4, p_5$ ) and 1 GeV ([1978AL1G](#), [1978AL1X](#), [1980AL09](#)). For total reaction cross sections see ([1979DE31](#), [1981DY03](#)). See also ([1977AJ02](#)).

Polarization in quasi-elastic scattering (reaction (b)) has been studied at  $E_p = 200$  MeV by ([1976KI10](#), [1980KI06](#)) and 635 MeV ([1977NA29](#), [1978NA18](#)). For reactions (c) and (d) see ([1977AJ02](#)). For reaction (d) see ([1981DY03](#)). For spallation measurements see ([1976IN04](#), [1977MO1C](#)) and ([1979VD02](#)). For antiproton scattering see ([1981AU01](#); theor.).

See also  $^{16}\text{O}$  and ([1978GO05](#), [1978SA33](#), [1979WI1N](#), [1979WI1P](#), [1980LE28](#)), ([1979RA1C](#); astrophys.), ([1977PL1A](#), [1979DE1P](#), [1979VO08](#), [1980MC1C](#), [1980WH1A](#), [1981RA1B](#)) and ([1976JE1A](#), [1976LE26](#), [1977KO2G](#), [1977PH02](#), [1978AB08](#), [1978AL07](#), [1978BI1L](#), [1978BR28](#), [1978GR1D](#), [1978PH01](#), [1978RE1G](#), [1978SC14](#), [1978WU03](#), [1979BI1C](#), [1979CH2C](#), [1979ER02](#), [1979KO01](#), [1979MA48](#), [1979PH05](#), [1979RA27](#), [1980AU09](#), [1980AY01](#), [1980DE2F](#), [1980DM1A](#), [1980MA28](#), [1980MA06](#), [1980RA1B](#), [1981DE2J](#); theor.).

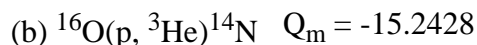
$$14. \ ^{16}\text{O}(p, n)^{16}\text{F} \quad Q_m = -16.211 \quad E_b = 0.6004$$

For analyzing power measurements see ([1981MA1F](#), [1981MA1J](#);  $E_{\text{pol. } p} = 135$  MeV). See also  $^{16}\text{F}$ .

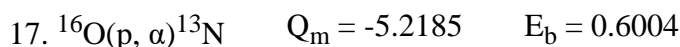
$$15. \ ^{16}\text{O}(p, d)^{15}\text{O} \quad Q_m = -13.4392 \quad E_b = 0.6004$$

The excitation function for  $d_0$  ( $\theta = 70^\circ$ ) has been measured for  $E_p = 21$  to 38.5 MeV. A strong resonance is observed at  $E_p = 24$  MeV: see Table 17.21 (in [PDF](#) or [PS](#)). Polarization measurements are reported at  $E_p = 65$  MeV ([1981HO1L](#);  $d_0$ ), 30.3 MeV [see ([1977AJ02](#))] and  $E_{\text{pol. } p} = 200$  MeV ([1981LI1B](#)). See also  $^{15}\text{O}$  in ([1981AJ01](#)) and ([1979CA1A](#)).

$$16. (a) \ ^{16}\text{O}(p, t)^{14}\text{O} \quad Q_m = -20.4062 \quad E_b = 0.6004$$



The excitation function ( $\theta = 70^\circ$ ) for tritons has been measured for  $E_p = 32$  to  $39.5$  MeV: no structure is observed [see (1977AJ02)]. Differential cross sections and analyzing powers have been studied at  $E_p = 43.8$  MeV for the transitions to  $^{14}\text{O}^*(0, 5.17, 6.29, 6.59, 7.78, 9.72)$  and  $^{14}\text{N}^*(0, 2.31, 3.95, 5.11, 7.03, 9.17)$ : attempts to fit the analyzing powers with zero-range DWBA were only successful for the first pair of analog states [ $^{14}\text{O}_{\text{g.s.}}$ ,  $^{14}\text{N}^*(2.31)$ ] (1974MA12). For other polarization measurements see (1977AJ02). See also  $^{14}\text{N}$  and  $^{14}\text{O}$  in (1981AJ01) and (1977HA1P).

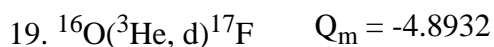


Excitation functions of various  $\alpha$ -groups and activation functions have been measured from threshold to  $E_p = 44$  MeV: see Table 17.19 (in PDF or PS) in (1971AJ02) and (1977AJ02) for the earlier work and (1977GR17; 6.6 to 10.4 MeV;  $\sigma_\pi$ ). Observed resonances are displayed in Table 17.21 (in PDF or PS). Some broad structures have been reported above  $E_p \approx 15$  MeV; particularly strong peaks appear at  $E_p \approx 22$  and  $25.5$  MeV: see (1977AJ02).

This reaction is involved in explosive burning in stars: see (1977AJ02) for earlier work and (1977GR17;  $S_0 = 4 \pm 3$  b at  $E_p(\text{cm}) = 6.5$  MeV). See also (1977CL1F).



Slow neutron thresholds have been observed corresponding to the ground and first excited states of  $^{17}\text{F}$ : see (1971AJ02). The  $E_x$  of  $^{17}\text{F}^*(0.50)$  is  $495.33 \pm 0.10$  keV (1966AL10; from  $\gamma$ -measurement);  $\tau_m = 407 \pm 9$  psec (1964BE15). Neutron groups have been observed corresponding to  $^{17}\text{F}^*(0, 0.50, 3.10, 3.86, 4.70)$ . Angular measurements have been obtained for the  $n_0$  and  $n_1$  groups ( $l_p = 2$  and  $0$ , respectively:  $J^\pi = 5/2^+$  and  $1/2^+$ ) for  $E_d \leq 12$  MeV: see Table 17.21 (in PDF or PS) in (1971AJ02) and (1972AN21;  $E_d = 3.10, 3.40$  and  $3.66$  MeV). For polarization measurements see  $^{18}\text{F}$  in (1983AJ01). See also (1980HU1J) and (1977AJ02).



At  $E(^3\text{He}) = 18$  MeV, angular distributions of the deuterons to  $^{17}\text{F}^*(0, 0.50, 3.104 \pm 0.003, 3.857 \pm 0.004)$  have been measured. The spectroscopic factors for  $^{17}\text{F}^*(0, 0.50)$  are  $0.94$  and  $0.83$ . Two-step processes appear to be involved in the excitation of  $^{17}\text{F}^*(3.10, 3.86)$  (1975FO16). Angular distributions have also been measured at  $E(^3\text{He}) = 30$  MeV (1977KO2H; to  $^{17}\text{F}^*(5.1, 5.7)$ ) and at  $E(\text{pol. } ^3\text{He}) = 33$  MeV (1980LU03, 1981RO1H;  $d_0, d_1$ ). See also  $^{19}\text{Ne}$  in (1983AJ01) and (1977CO1Z;

theor.).

$$20. \text{}^{16}\text{O}(\alpha, t)\text{}^{17}\text{F} \quad Q_m = -19.2137$$

See ([1971AJ02](#), [1977AJ02](#)).

$$21. \text{}^{16}\text{O}({}^7\text{Li}, {}^6\text{He})\text{}^{17}\text{F} \quad Q_m = -9.374$$

The angular distribution involving  ${}^{17}\text{F}_{\text{g.s.}}$  has been measured at  $E({}^7\text{Li}) = 36$  MeV ([1973SC26](#)).

$$22. \text{(a)} \text{}^{16}\text{O}({}^{10}\text{B}, {}^9\text{Be})\text{}^{17}\text{F} \quad Q_m = -5.985$$

$$\text{(b)} \text{}^{16}\text{O}({}^{11}\text{B}, {}^{10}\text{Be})\text{}^{17}\text{F} \quad Q_m = -10.628$$

Angular distributions have been measured at  $E({}^{10}\text{B}) = 100$  MeV for the transitions to  ${}^{17}\text{F}^*(0 + 0.50, 5.1, 8.1)$ , ([1975NA15](#)), and at  $E({}^{11}\text{B}) = 115$  MeV for the transition to  ${}^{17}\text{F}_{\text{g.s.}}$  ([1979RA10](#)).

$$23. \text{(a)} \text{}^{16}\text{O}({}^{12}\text{C}, {}^{11}\text{B})\text{}^{17}\text{F} \quad Q_m = -15.3566$$

$$\text{(b)} \text{}^{16}\text{O}({}^{13}\text{C}, {}^{12}\text{B})\text{}^{17}\text{F} \quad Q_m = -16.933$$

Angular distributions have been measured at  $E({}^{12}\text{C}) = 76.8$  MeV ([1977MO1A](#), [1979MO14](#);  ${}^{17}\text{F}^*(0, 0.5)$ ) and at  $E({}^{13}\text{C}) = 105$  MeV ([1979RA10](#);  ${}^{17}\text{F}_{\text{g.s.}}$ ).

$$24. \text{}^{16}\text{O}({}^{14}\text{N}, {}^{13}\text{C})\text{}^{17}\text{F} \quad Q_m = -6.9503$$

Angular distributions involving  ${}^{17}\text{F}^*(0, 0.5)$  have been measured at  $E({}^{14}\text{N}) = 76.2$  MeV ([1977MO1A](#), [1979MO14](#)) and 155 MeV ([1975NA15](#), [1976NA09](#)).

$$25. \text{}^{16}\text{O}({}^{16}\text{O}, {}^{15}\text{N})\text{}^{17}\text{F} \quad Q_m = -11.5272$$

Angular distributions involving  ${}^{17}\text{F}^*(0 + 0.5)$  have been measured at  $E({}^{16}\text{O}) = 95.2$  MeV ([1977MO1A](#), [1979MO14](#)).

$$26. \text{}^{17}\text{O}(\text{p}, \text{n})\text{}^{17}\text{F} \quad Q_m = -3.544$$

Angular distributions of the  $n_0$  and  $n_1$  groups have been obtained for  $E_p = 6.95$  to 13.50 MeV ( $n_0$ ) and 6.95 to 12.45 MeV ( $n_1$ ). There appears to be collective enhancement in the  $L = 2$  transition to  ${}^{17}\text{F}^*(0.5)$ . A large spin-flip term in the effective two-body force is necessary to account for the strength of the ground state

transition ([1969AN06](#)). See also [<sup>18</sup>F in \(1983AJ01\)](#).

$$27. \text{}^{17}\text{O}(\text{}^3\text{He}, \text{t})\text{}^{17}\text{F} \quad Q_m = -2.780$$

Angular distributions have been studied for  $t_0$  and  $t_1$  at  $E(^3\text{He}) = 17.3$  MeV [see ([1977AJ02](#))] and for  $t_0$  at  $E(\text{pol. } ^3\text{He}) = 33$  MeV ([1981BA1G](#)).

$$28. \text{}^{17}\text{Ne}(\beta^+)\text{}^{17}\text{F} \quad Q_m = 14.53$$

See [<sup>17</sup>Ne](#).

$$29. \text{}^{19}\text{F}(\gamma, 2\text{n})\text{}^{17}\text{F} \quad Q_m = -19.582$$

See [<sup>19</sup>F in \(1983AJ01\)](#).

$$30. \text{}^{19}\text{F}(\text{p}, \text{t})\text{}^{17}\text{F} \quad Q_m = -11.100$$

Angular distributions have been measured for the  $t_0 \rightarrow t_3$  groups at  $E_p = 22.8, 42.4$  and 45 MeV: see ([1977AJ02](#)).

$$31. \text{}^{20}\text{Ne}(\text{p}, \alpha)\text{}^{17}\text{F} \quad Q_m = -4.1306$$

See ([1977GR17](#), [1980KO1Q](#)) and ([1977AJ02](#)).

$$32. \text{(a) } \text{}^{20}\text{Ne}(\text{}^3\text{He}, \text{}^6\text{Li})\text{}^{17}\text{F} \quad Q_m = -8.151$$

$$\text{(b) } \text{}^{22}\text{Ne}(\text{}^3\text{He}, \text{}^8\text{Li})\text{}^{17}\text{F} \quad Q_m = -15.993$$

At  $E(^3\text{He}) = 75$  and 88 MeV  $^{17}\text{F}^*(0, 0.5)$  have been populated in both reactions ([1978KE06](#)).

