

¹⁶⁰Gd(d,t),(pol d,t) 2004Gr26,1967Tj01,1976Pe02

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	C. W. Reich	NDS 113, 157 (2012)	31-Dec-2010

Additional information 1.

Data are from primarily from the (d,t) study of 2004Gr26, with relevant comments to data from 1967Tj01 and 1976Pe02.

Other measurements: 1967Ja03, 1973Ma43, and 1975Ja18. Other analyses, especially including the influence of Coriolis mixing on the calculated cross sections: 1969Ka24, 1970Ka47, 1972Ja16, 1973Ga12, 1975Ja19, 1978Pe05, and 1980Pe07.

Configuration assignments are the dominant ones from nuclear-model calculations reported in 2004Gr26. For further details for some specific cases, see the Adopted Values.

2004Gr26: E(d)=22 MeV. Polarized d beam. Enriched (98.2% in ¹⁶⁰Gd) target of Gd₂O₃ of thickness 125 μg/cm² evaporated onto a 14-μg/cm²-thick C backing. t measured using a Q3d magnetic spectrograph, FWHM≈7 keV, with a cathode strip detector. Reaction products measured with a vector-polarized (70% 10 transverse to the beam direction) beam at laboratory angles of 12, 16, 20, 25, 30 and 35°. Angular distributions measured for levels above 650 keV. Also, the (d,t) reaction was measured using an unpolarized d beam, E(d)=25 MeV, at laboratory angles of 8, 40, 45, and 50°. DWBA analysis. Nuclear-model calculations of the configurational makeup of the levels.

1976Pe02: E(d)=17 MeV, measured angular distribution of t in split-pole spectrograph with FWHM≈7 keV.

1967Tj01: E(d)=12 MeV, t measured in magnetic spectrometer with FWHM≈9 keV, cross section measured at 60°, 90°, and 125°. Conf assignments are the dominant ones. For more details for specific cases, see the Adopted Levels data set.

¹⁵⁹Gd Levels

E(level) ^{†‡}	J ^π #	L&	S ^{bc}	Comments
0.0 ^e	3/2 ^{-@}	1	511 ^d	
51.0 ^e 8	5/2 ^{-@}		22 ^d	
66.2 ^f 9	5/2 ^{+@}		6 ^d	
119.2 ^f 9	7/2 ^{+@}	4	63 ^d	E(level): Level not reported in earlier (d,t) studies.
122.1 ^e 6	7/2 ^{-@}	3	672 ^d	
145.4 ^g 6	5/2 ^{-@}	3	106 ^d	
184.4 ^f 6	9/2 ^{+@}	4	307 ^d	
212.3 ^e 6	9/2 ^{-@}	5	55 ^d	
227.8 ^g 5	7/2 ^{-@}	3	252 ^d	
273.7 ^f 9	11/2 ^{+@}	6	6 ^d	
324.9 ^e 6	11/2 ^{-@}	5	18 ^d	part of a doublet peak reported at 330 keV by 1967Tj01.
330.6 ^g 8	9/2 ^{-@}	5	22 ^d	part of a doublet peak reported at 330 keV by 1967Tj01.
372.6 ^f 6	13/2 ^{+@}	6	121 ^d	
456.4 ^g 6	11/2 ^{-@}	5	26 ^d	
508.1 ^h 6	1/2 ^{-@}	1	251 ^d	
558.2 ^h 10	3/2 ^{-@}	1	23 ^d	
588.6 ^h 7	5/2 ^{-@}	3	63 ^d	
602.2 ^q 13	3/2 ^{+@}	2	9 ^d	E(level): possibly the same as the 598 and 602 levels reported by 1967Tj01 and 1976Pe02, respectively.
633.4 7	@	4	4 ^d	J ^π : Assigned as 7/2 ⁺ by 2004Gr26 and interpreted as the ν7/2[33] bandhead.
646.5 ^q 10	5/2 ^{+@}	2	7 ^d	E(level): Level may be the same as the 642 level reported by 1976Pe02.
684.1 ⁱ 27	(11/2 ⁻)	(5) ^a	188	
705.3 ^h 4	7/2 ⁻	3	42	
744.1 ^j 3	3/2 ⁺	2	1367	
781.3 ^k 25	1/2 ⁺	0	454	
800.4 ^j 6	3/2 ⁺ ,5/2 ⁺	2	50	
819.4 ^k 7	3/2 ⁺ ,5/2 ⁺	2	10	

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$^{160}\text{Gd}(\text{d,t}),(\text{pol d,t})$ [2004Gr26,1967Tj01,1976Pe02](#) (continued) ^{159}Gd Levels (continued)

E(level) ^{†‡}	J ^π #	L&	S ^{bc}	Comments
858.8 ^k 6	3/2 ⁺	2	39	
876.6 ^j 5	(7/2 ⁺ ,9/2 ⁺)	4 ^a	47	
926.6 4	7/2 ⁻	3	24	
938.7 7			12 ^d	
948.8 ^l 5	7/2 ⁻	3	19	
962.4 6	3/2 ⁺	2	11	
973.9 ^o 9	1/2 ⁺	0	1341	
1001.56 ^o 24	3/2 ⁺	2	276	
1014.9 8	1/2 ⁺	0	3	
1043.2 ^l 6			3 ^d	From (d,p), level is assigned as the 9/2 ⁻ member of ν5/2[512].
1059.3 ^o 5	5/2 ⁺	2	101	
1079.9 4	1/2 ⁻	1	80	
1110.56 ^m 27	3/2 ⁻	1	105	
1120.3 ^o 5	7/2 ⁺	4	23	
1128.8 5	3/2 ⁺	2	71	
1134.9 ^r 6	(7/2 ⁻)	(3) ^a	25	
1139.81 ⁿ 27	1/2 ⁻	1	95	
1146.04 ⁿ 25	3/2 ⁻	1	335	
1159.90 28	5/2 ⁺	2	207	
1170.9 4	1/2 ⁺	0	26	
1178.6 ^m 5	5/2 ⁻	3	16	
1190.5 6	5/2 ⁺	2	18	
1202.6 5	9/2 ⁺	4	57	
1216.9 8	1/2 ⁻	1	2	
1229.1 ^o 6	9/2 ⁺	4	7	
1239.5 ^m 4	(7/2 ⁻)	3 ^a	90	
1253.1 ⁿ 5	5/2 ⁻	3	10	
1284.1 4	3/2 ⁻	1	58	
1296.4 6	3/2 ⁻	1	7	
1303.2 ⁿ 5	7/2 ⁻	3	16	
1315.8 4	1/2 ⁺	0	4	
1325.1 4	5/2 ⁻ ,7/2 ⁻	3	3	
1343.54 28	5/2 ⁻	3	100	
1356.6 9	(3/2 ⁺)	(2) ^a	5	
1365.9 ^m 6	9/2 ⁻	5	15	
1373.0 8	9/2 ⁻	5	6	
1379.2 10	1/2 ⁺	0	5	
1392.3 6	(1/2 ⁺)	(0) ^a	18	
1406.9 10	5/2 ⁻	3	2	
1414.8 5	5/2 ⁺	2	25	
1419.4 6	9/2 ⁺	4	30	
1429.5 5	5/2 ⁺	2	101	
1442.8 ⁿ 5	(9/2 ⁻)	(5) ^a	26	
1454.4 9	1/2 ⁺	0	7	
1468.9 7	(1/2 ⁺)	(0) ^a	3	
1478.2 3	3/2 ⁺	2	5	
1488.2 5	7/2 ⁺	4	17	
1493.8 10	5/2 ⁻ ,7/2 ⁻	3	3	
1508.4 5	5/2 ⁺	2	37	
1519.9 6	(1/2 ⁻)	(1) ^a	7	
1532.4 ^p 4	7/2 ⁺	4	12	
1541.0 5	5/2 ⁺	2	29	
1548.5 9	(3/2 ⁺)	(2) ^a	2	

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$^{160}\text{Gd}(\text{d,t}),(\text{pol d,t})$ **2004Gr26,1967Tj01,1976Pe02 (continued)** ^{159}Gd Levels (continued)

E(level) ^{†‡}	J ^π #	L&	S ^{bc}	Comments
1561.3 5	3/2 ⁻	1	16	
1571.4 4	1/2 ⁺	0	100	
1580.2 7	5/2 ⁺	2	54	
1592.5 9	5/2 ⁺	2	8	
1603.1 4	3/2 ⁻	1	15	J ^π : Assigned as the 3/2 ⁻ member of the ν1/2 ⁻ [510] band by 2004Gr26.
1611.1 8	5/2 ⁻	3	2	
1622.3 4	(11/2 ⁻)	(5) ^a	16	J ^π : Assigned as the 11/2 ⁻ member of the ν9/2 ⁻ [514] band by 2004Gr26.
1631.4 ^p 5	(9/2 ⁺)	(4) ^a	9	
1637.9 ^s 7	(3/2 ⁻)	(1) ^a	6	
1644.1 8	5/2 ⁻	3	4	
1656.2 6	3/2 ⁺	2	35	
1668.4 7	5/2 ⁺	2	25	
1672.9 7	(7/2 ⁺)	(4) ^a	4	
1682.9 6	5/2 ⁻ ,7/2 ⁻	3	1	
1690.8 6	5/2 ⁺	2	22	
1702.8 5	7/2 ⁻	3	12	J ^π : 2004Gr26 report J ^π =7/2 ⁻ in their table (table iii) of (d,p) and (d,t) data and in their Summary Level Scheme (their table iv). However, in their discussion of band and conf assignments, they (tentatively) assign this as the 5/2 ⁻ member of the ν3/2[512] band. The evaluator has not adopted this latter choice.
1713.0 15	(5/2 ⁺)	(2) ^a	2	
1719.5 12	(3/2 ⁺)	(2) ^a	2	
1729.7 7	5/2 ⁻	3	3	
1745.9 9	(5/2 ⁺)	(2) ^a	2	
1753.6 12	1/2 ⁺	0	3	
1759.8 8	3/2 ⁻	1	1	
1773.8 7	3/2 ⁻	1	5	
1783.8 7	(7/2 ⁻)	(3) ^a	6	
1792.0 9	(1/2 ⁺)	(0) ^a	2	
1807.2 ^s 10	7/2 ⁻	3	4	
1813.4 7	3/2 ⁺	2	25	
1823.8 18	1/2 ⁻	1	2	
1830.8 4	3/2 ⁺	2	5	
1840.0 8	1/2 ⁺	0	90	
1850.8 19	1/2 ⁺	0	4	
1859.4 17	5/2 ⁻	3	3	
1868.2 8	3/2 ⁺ ,5/2 ⁺	2	17	
1874.2 10	5/2 ⁺	2	12	
1883.5 8	(1/2 ⁻)	(1) ^a	18	
1891.4 23	3/2 ⁺ ,5/2 ⁺	2	3	
1899.5 10	3/2 ⁺ ,5/2 ⁺	2	8	
1908.5 9	5/2 ⁺	2	10	
1917.5 7	3/2 ⁺	2	12	
1925.9 15	(1/2 ⁻ ,3/2 ⁻)	(1) ^a	5	
1930.6 14	5/2 ⁻	3	3	
1938.4 7	(7/2 ⁺)	4 ^a	7	
1946.1 8	1/2 ⁻	1	6	
1954.6 5	3/2 ⁻	1	7	
1964.6 ^f 3	5/2 ⁺	2	405	
1972.5 8	5/2 ⁺	2	30	
1980.3 10	1/2 ⁺	0	26	
1989.2 19	3/2 ⁻	1	6	
1997.3 7	1/2 ⁺	0	71	
2006.5 14	5/2 ⁻	3	12	
2012.9 14	3/2 ⁻	1	5	
2032.7 5	5/2 ⁺	2	73	

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$^{160}\text{Gd}(\text{d,t}),(\text{pol d,t})$ **2004Gr26,1967Tj01,1976Pe02 (continued)** ^{159}Gd Levels (continued)

E(level) ^{†‡}	J ^π #	L&	S ^{bc}	Comments
2039.3 5	3/2 ⁺	2	59	
2044.5 15	5/2 ⁻	3	17	
2051.9 9	1/2 ⁺	0	16	
2073.7 6	1/2 ⁻ ,3/2 ⁻	1	21	
2081.9 8	1/2 ⁺	0	14	
2092.7 8	5/2 ⁺	2	76	
2105.1 6	3/2 ⁺	2	31	
2115.1 10	3/2 ⁻	1	21	
2125.8 14	3/2 ⁻	1	6	
2136.0 7	3/2 ⁺ ,5/2 ⁺	2	15	
2149.9 9	5/2 ⁺	2	25	
2162.0 20	5/2 ⁺	2	24	
2169.0 20	3/2 ⁺	2	16	
2176.0 20	(5/2 ⁺)	(2) ^a	8	
2186.0 20	5/2 ⁺	2	11	
2194.5 11	3/2 ⁺	2	22	
2203.1 11	3/2 ⁺	2	22	
2212.8 9	5/2 ⁺	2	23	
2221.7 10	5/2 ⁻	3	8	
2233.1 12	3/2 ⁻	1	5	
2242.3 7	5/2 ⁺	2	93	
2252.8 16	5/2 ⁺	2	32	
2260.2 8	3/2 ⁺	2	12	
2271.9 21	5/2 ⁺	2	8	
2284.5 15	3/2 ⁺	2	11	
2297.3 12	3/2 ⁺	2	15	
2306.0 20	3/2 ⁺	2	7	
2316.6 12	1/2 ⁻ ,3/2 ⁻	1	21	J ^π : Listed as 3/2 ⁻ ,5/2 ⁻ by 2004Gr26 in their table (table iii) of (d,p) and (d,t) data, but as 1/2 ⁻ ,3/2 ⁻ elsewhere in their paper.
2560				Level reported by 1976Pe02 only. 2004Gr26 report levels only up to 2316.6 keV.

[†] Average of values from 2004Gr26 over all the spectra, unless noted otherwise. A systematic error of 0.2 keV is included. For levels below 650 keV, the values are from the data at $\theta=20^\circ$ with the unpolarized beam.

[‡] Above ≈ 1.9 MeV, the association of previously reported (d,t) peaks with those of 2004Gr26 is problematic.

L and J^π assignments are from 2004Gr26, based on angular distributions and analyzing power in (pol d,t), unless otherwise noted. These assignments are consistent with those in the Adopted Levels. Conf assignments are also based on the agreement between the measured cross sections for individual levels within a band and those expected for the proposed Nilsson orbital (the 'fingerprint').

@ As reported by 2004Gr26, in their Summary Table (table iv). These authors do not list this value in their summary of their (d,t) data (their table iii).

& Values inferred by the evaluator from the J^π values given by 2004Gr26. These authors do not explicitly list L values. They are consistent with the adopted information and with those previously given by 1976Pe02, when the respective levels are seen in both reactions.

^a The angular distribution of the tritons from this level could not be satisfactorily described by the DWBA calculations.

^b Label= $d\sigma/d\Omega(\mu\text{b/sr})$.

^c Values at 30° , unless noted otherwise.

^d From data at $\theta_{\text{lab}}=20^\circ$ with an unpolarized d beam.

^e Band(A): $\nu 3/2[521]$ band (g.s. band).

^f Band(B): $\nu 5/2[642]$ band.

^g Band(C): $\nu 5/2[523]$ band.

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 $^{160}\text{Gd}(\text{d,t}),(\text{pol d,t})$ [2004Gr26](#),[1967Tj01](#),[1976Pe02](#) (continued)

 ^{159}Gd Levels (continued)

- h* Band(D): $\nu 1/2[521]$ band.
i Band(E): $\nu 11/2[505]$ bandhead.
j Band(F): $\nu 3/2[402]$ band.
k Band(G): $\nu 1/2[660]$ band, mixed with $\nu 1/2[400]$ and the K-2 γ -vibration based on $\nu 5/2[642]$.
l Band(H): $\nu 5/2[512]$ band.
m Band(I): $\nu 3/2[532]$ band.
n Band(J): $\nu 1/2[530]$ band.
o Band(K): $\nu 1/2[400]$, mixed with $\nu 1/2[660]$.
p Band(L): $\nu 7/2[404]$ band.
q Band(M): $\nu 3/2^+[651]$ band.
r Band(N): $\nu 7/2^- [514]$ bandhead.
s Band(O): $\nu 3/2^- [512]$ band. Conf and band tentatively proposed by [2004Gr26](#).
t Band(P): $\nu 5/2^+ [402]$ bandhead. Conf tentatively proposed by [2004Gr26](#) but not adopted by the evaluator.

$^{160}\text{Gd}(\text{d,t}),(\text{pol d,t})$ 2004Gr26,1967Tj01,1976Pe02

					Band(F): v3/2[402] band
					<u>(7/2⁺,9/2⁺)</u> 876.6
					<u>3/2⁺,5/2⁺</u> 800.4
					<u>3/2⁺</u> 744.1
			Band(D): v1/2[521] band		Band(E): v11/2[505] bandhead
			<u>7/2⁻</u> 705.3		<u>(11/2⁻)</u> 684.1
			<u>5/2⁻</u> 588.6		
			<u>3/2⁻</u> 558.2		
			<u>1/2⁻</u> 508.1		
			Band(C): v5/2[523] band		
			<u>11/2⁻</u> 456.4		
			Band(B): v5/2[642] band		
Band(A): v3/2[521] band (g.s. band)	<u>13/2⁺</u> 372.6				
<u>11/2⁻</u> 324.9		<u>9/2⁻</u> 330.6			
	<u>11/2⁺</u> 273.7				
<u>9/2⁻</u> 212.3		<u>7/2⁻</u> 227.8			
	<u>9/2⁺</u> 184.4				
<u>7/2⁻</u> 122.1	<u>7/2⁺</u> 119.2	<u>5/2⁻</u> 145.4			
<u>5/2⁻</u> 51.0	<u>5/2⁺</u> 66.2				
<u>3/2⁻</u> 0.0					

$^{160}\text{Gd}(\text{d,t}),(\text{pol d,t})$ 2004Gr26,1967Tj01,1976Pe02 (continued)Band(L): $\nu 7/2[404]$ band(9/2⁺) 1631.47/2⁺ 1532.4Band(J): $\nu 1/2[530]$ band(9/2⁻) 1442.8Band(I): $\nu 3/2[532]$ band9/2⁻ 1365.97/2⁻ 1303.2Band(K): $\nu 1/2[400]$,
mixed with $\nu 1/2[660]$ 5/2⁻ 1253.1(7/2⁻) 1239.59/2⁺ 1229.15/2⁻ 1178.63/2⁻ 1146.04
1/2⁻ 1139.813/2⁻ 1110.567/2⁺ 1120.3Band(H): $\nu 5/2[512]$ band1043.25/2⁺ 1059.33/2⁺ 1001.56Band(G): $\nu 1/2[660]$ band,
mixed with $\nu 1/2[400]$
and the K=2 γ -vibration
based on $\nu 5/2[642]$ 7/2⁻ 948.81/2⁺ 973.93/2⁺ 858.83/2⁺, 5/2⁺ 819.41/2⁺ 781.3

