

¹⁸⁶W(d,p),¹⁸⁶W(pol d,p) 2008Bo26,1997Bo14,1972Ca01

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	M. S. Basunia	NDS 110, 999 (2009)	1-Nov-2008

Other measurements: 1973Ca09 and 1965Er03.

2008Bo26: ¹⁸⁶W(d,p), ¹⁸⁶W(Pol d,P); 99.8% enriched ¹⁸⁶W; for ¹⁸⁶W(d,p) E=22 MeV; Q3d spectrograph, position sensitive cathode strip detector; reaction product measured at 10°, 13°, 16°, 20°, 30°, 40°; another measurement with E=18 at 40°. For ¹⁸⁶W(Pol d,P) E=18 MeV; charged particle measured at 3° interval between 11° to 26° and then 5° interval between 30° to 50°.

Reported differential cross section, deduced level energy, l value, spectroscopic strengths, analyzing power, etc.

1997Bo14: ¹⁸⁶W(d,p), Target: 99.8% enriched ¹⁸⁶W; Projectile: d, E=24 and 28 MeV; spectra at 30° and 50° scattering angles were measured with a position sensitive cathode strip detector with single strip readout; Measured: relative intensities, deduced level energies, l values, and J^π.

1972Ca01: ¹⁸⁶W(d,p), Target: ¹⁸⁶W, Projectile: d, E=12.08 MeV, Cross sections were measured at θ=60°, 90°, and 125°.

1973Ca09: ¹⁸⁶W(Pol d,P), Target:¹⁸⁶W; Projectile: Pol d, E=12.08- and 15.0-MeV. Experimental resolution is 25-35 keV FWHM;

Data were taken at seven angles in the range of 30°–125°, Deduced level energy and assigned J^π on the basis of vector-analyzing power.

Q(d,p)=3236 5 (1965Er03), Q(d,p)=3240 10. Other: 1963Is01.

¹⁸⁷W Levels

E(level) [†]	J ^π #	dσ/dω(μb/sr) ^d	L ^a	S	Comments
0 ^f	3/2 ⁻	51 2	1	0.012	E(level): -0.1 keV 5 in 1997Bo14 and 0.3 keV 2 in 2008Bo26. dσ/dω(μb/sr)=86 3 (10°) and 40 2 (30°).
77.1 ^{‡f} 2	5/2 ⁻ @	469 11	3	0.14	dσ/dω(μb/sr)=452 7 (10°) and 238 18 (30°) (2008Bo26).
145.9 ^g 2	1/2 ⁻	12 1	1	0.006	dσ/dω(μb/sr)=18 2 (10°) and 2.3 5(30°).
200.7 ^f 4	7/2 ⁻	≈9	3		dσ/dω(μb/sr)=8 5 (10°) and 9 5 (30°).
204.8 ^{‡g} 2	3/2 ⁻ @	412 11	1	0.098	dσ/dω(μb/sr)=205 10 (10°) and 261 6 (30°).
303.1 ^{‡g} 2	5/2 ⁻	54 2	3	0.014	dσ/dω(μb/sr)=42 2 (10°) and 26 2 (30°).
330.9 ^f 2	9/2 ⁻	13 1	(5) ^{bc}	0.02	dσ/dω(μb/sr)=11 1 (10°) and 10 1 (30°).
350.4 ^{‡h} 2	7/2 ⁻	497 10	3	0.086	J ^π : Bandhead of 7/2 ⁻ [503] based on the half-life of 5 ns and on the large cross section in the (d,p) reaction. dσ/dω(μb/sr)=449 6 (10°) and 246 5 (30°).
364.1 ^l 4	9/2 ⁻	63 3	5 ^b	0.097	dσ/dω(μb/sr)=38 3 (10°) and 64 3 (30°).
410.4 ^m 5	11/2 ⁺	0.9 3	(6)		dσ/dω(μb/sr)=1.5 6 (30°). J ^π : On the basis of population-depopulation data of ¹⁸⁶ W(n,γ) reaction (2008Bo26), please also see J ^π comments at adopted level.
432.1 ^{‡g} 3	7/2 ⁻	141 3	3	0.028	dσ/dω(μb/sr)=88 3 (10°) and 76 3 (30°).
510.0 ^f 5	(11/2 ⁻)	1.2 3			
522.3 ^h 2	9/2 ⁻	2.6 4	(5) ^c	0.008	J ^π : On the basis of population-depopulation data of ¹⁸⁶ W(n,γ) reaction (2008Bo26). dσ/dω(μb/sr)=2.7 6 (10°) and 4.3 6 (30°).
574.6 ^l 3	(11/2 ⁻)	2.1 5	(5) ^c	0.002	dσ/dω(μb/sr)=2.3 5 (13°) and 2.6 5 (30°).
597.7 ^m 2	13/2 ⁺	31 2	6	0.057	J ^π : Based on the definite angular distributions, confirmed by DWBA calculation (2008Bo26). Earlier assignment was 9/2 ⁻ (1997Bo14). dσ/dω(μb/sr)=15 1 (10°) and 38 2 (30°).
640.4 ^{‡n} 2	5/2 ⁻ @	230 5	3	0.056	dσ/dω(μb/sr)=216 16 (10°) and 112 3 (30°).
728.3 ^h 2	(11/2 ⁻)	5 1			J ^π : Revised by 2008Bo26 instead of 5/2 (1997Bo14) from absence of depopulating γ-rays from this level. dσ/dω(μb/sr)=16 2 (10°) and 3.7 7 (30°).
762.4 3	1/2 ⁻	1.2 4	(1)	≈0.001	dσ/dω(μb/sr)=2.4 9 (10°) and 2.7 7 (30°).
776.1 ⁿ 2	7/2 ⁻	18 3	(3)	0.003	dσ/dω(μb/sr)=25 6 (13°) and 11 2 (30°).
782.2 ^{‡o} 1	1/2 ⁻ @	337 6	1	0.17	dσ/dω(μb/sr)=441 8 (13°) and 269 5 (30°).

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$^{186}\text{W}(\text{d,p}), ^{186}\text{W}(\text{pol d,p})$ **2008Bo26,1997Bo14,1972Ca01** (continued) ^{187}W Levels (continued)

E(level) [†]	J ^π #	dσ/dω(μb/sr) ^d	L ^a	S	Comments
797.0 ^g 4	(11/2 ⁻)				dσ/dω(μb/sr)=8 1 (13°) and 5 1 (30°). Flat angular distribution.
811.1 ^m 5	(15/2 ⁺)	10 3			dσ/dω(μb/sr)=12 4 (30°).
816.1 ^q 1	3/2 ⁻ @	427 7	1	0.10	dσ/dω(μb/sr)=428 11 (13°) and 345 7 (30°).
852.1 ^r 3	3/2 ⁻	132 4	1	0.032	dσ/dω(μb/sr)=200 6 (10°) and 107 4 (30°).
863.3 3	5/2 ⁻ , (3/2 ⁻)	57 3	3+(1)	0.013	dσ/dω(μb/sr)=53 4 (10°) and 34 4 (30°).
892.0 ^s 4	3/2 ⁻	34 2	1	0.008	dσ/dω(μb/sr)=69 3 (10°) and 35 2 (30°).
914.2 ^q 2	5/2 ⁻	13 1	3	0.0024	dσ/dω(μb/sr)=10 1 (10°) and 5.1 8 (30°).
933 1					E(level): Contaminated by ^{185}W (2008Bo26). dσ/dω(μb/sr) 1≈(30°).
959.9 ^r 2	5/2 ⁻	48 5	3	0.010	dσ/dω(μb/sr)=29 2 (10°) and 29 2 (30°).
971.5 ^s 3	5/2 ⁻		3	0.0016	dσ/dω(μb/sr)=5.4 9 (10°) and 5.1 8 (30°).
978.9 ^f 1	3/2 ⁻		1	0.014 3	dσ/dω(μb/sr)=85 3 (10°), 60 3 (16°) and 45 2 (30°).
988.9 2	3/2 ⁻		1	0.003	dσ/dω(μb/sr)=15 1 (10°), 12 2 (16°) and 5.9 8 (30°).
999.6 2					dσ/dω(μb/sr)=9 1 (10°), 8 1 (16°) and 7 1 (30°).
1018.8 9	3/2 ⁻				dσ/dω(μb/sr)=1.9 6 (13°).
1033.5 2					dσ/dω(μb/sr)=9 1 (10°), 8 1 (16°) and 7.6 8 (30°).
1056.8 ^q 4	(7/2 ⁻)			≈0.0006	dσ/dω(μb/sr)=4 1 (10°), 4 1 (16°) and 2.8 7 (30°).
1070.0 2	(7/2 ⁻)&	99 5	3	0.015	dσ/dω(μb/sr)=85 3 (10°) and 62 2 (30°).
1085.8 ^f 2	(5/2 ⁻)	48 3	3	≈0.01	dσ/dω(μb/sr)=49 3 (10°) and 27 2 (30°).
1104.9 3		2.5 9			dσ/dω(μb/sr)=1.8 6 (10°) and 2.8 7 (30°).
1114.2 ^r 2	(7/2 ⁻)	15 2	(3)	≈0.002	L: (≥5) in 1972Ca01. dσ/dω(μb/sr)=10 1 (10°) and 8 1 (30°).
1138.0 2	5/2	34 2	2,(3)	0.003	L,J ^π : L=1 in 1972Ca01; J on the basis of (n,γ) population-depopulation data (2008Bo26). dσ/dω(μb/sr)=39 2 (10°) and 21 2 (30°).
1187.5 4		5 2			dσ/dω(μb/sr)=4 2 (30°).
1192.5 2		19 2			E(level): 1196 6 in 1972Ca01.
1199.2 6		4.6 8			dσ/dω(μb/sr)=28 2 (10°) and 9 2 (30°).
1207.7 6					dσ/dω(μb/sr)=12 2 (10°).
1217.5 3	3/2 ⁻	5.4 6	1	0.001	J ^π : On the basis of (n,γ) population-depopulation data (2008Bo26). dσ/dω(μb/sr)=11 1 (10°) and 3.9 8 (30°).
1226.1 9		3 1			
1234.2 ⁱ 1	7/2 ⁻ &	122 3	3	0.018	dσ/dω(μb/sr)=101 3 (10°) and 81 3 (30°).
1268.4 2	5/2 ⁻	41 2	3	0.009	L,J ^π : L≥5 in 1972Ca01; J ^π on the basis of (n,γ) population-depopulation data (2008Bo26). dσ/dω(μb/sr)=38 2 (10°) and 25 2 (30°).
1287.5 6					dσ/dω(μb/sr)=5.7 9 (16°).
1307.0 2	5/2	24 3	(3)	0.0064	dσ/dω(μb/sr)=28 3 (10°).
1312.6 ^u 1	3/2 ⁻	367 7	1	0.079	J ^π : On the basis of l=1 shaped angular distributions and analyzing powers. dσ/dω(μb/sr)=524 7 (10°) and 193 10 (30°).
1347.6 ^p 1	1/2 ⁻	154 4	1	0.069	dσ/dω(μb/sr)=223 5 (10°) and 99 6 (30°). J ^π : On the basis of l=1 shaped angular distributions and analyzing powers.
1359.3 ^j 1	7/2 ⁻ &	289 5	3	0.039	dσ/dω(μb/sr)=223 5 (10°) and 181 7 (30°).
1374.1 2	(3/2 ⁺)	25 2	(2)	0.003	dσ/dω(μb/sr)=24 2 (10°) and 8 1 (30°). J ^π : On the basis of (n,γ) population-depopulation data (2008Bo26).
1384.1 ^v 1	3/2 ⁻	155 4	1	0.038	dσ/dω(μb/sr)=227 6 (10°) and 123 6 (30°).
1415.5 ^p 1	3/2 ⁻	117 5	1	0.023	dσ/dω(μb/sr)=153 5 (10°) and 81 10 (30°).

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$^{186}\text{W}(\text{d,p}), ^{186}\text{W}(\text{pol d,p})$ **2008Bo26,1997Bo14,1972Ca01** (continued) ^{187}W Levels (continued)

E(level) [†]	J ^π #	dσ/dω(μb/sr) ^d	L ^a	S	Comments
1424.6 ^k 1	7/2 ⁻ &	443 9	3	0.057	dσ/dω(μb/sr)=354 7 (10°) and 264 18 (30°).
1432.1 4		13 6			
1450.8 2	1/2,(3/2)	8 2	(1)		dσ/dω(μb/sr)=6 2 (10°).
1477.2 ^v 5	5/2 ⁻	90 3	3	0.024	dσ/dω(μb/sr)=101 3 (10°) and 51 3 (30°).
1486.9 5	3/2 ⁻	17 2	1	0.0037	dσ/dω(μb/sr)=18 2 (10°) and 11 2 (30°).
1492.2 8		9 2			
1502.1 2	3/2 ⁺	8 2	2	0.0014	E(level): 1494 6 (1972Ca01). L,J ^π : L=1 in 1972Ca01; J ^π based on the basis of (n,γ) population-depopulation. dσ/dω(μb/sr)=9 1 (10°) and 4 1 (30°). dσ/dω(μb/sr)=8 2 (30°).
1527.6 ^p 4	(5/2 ⁻)	14 5	3	≈0.003	
1534.0 ^y 1	5/2 ⁺	495 8	1	0.046	L,J ^π : L=1 by 1973Ca09; J ^π =(3/2 ⁻) in (Pol d,P) from vector analyzing power analyses (1973Ca09). However, from moderately large (d,p) cross sections and definite analyzing powers, 2008Bo26 assigned J ^π =5/2 ⁺ and a configuration of i _{13/2} +g _{9/2} . dσ/dω(μb/sr)=665 18 (13°) and 317 6 (30°). dσ/dω(μb/sr)=4.4 9 (30°). dσ/dω(μb/sr)=37 2 (30°). dσ/dω(μb/sr)=11 3 (30°).
1555 1		6 1			
1564.5 2	1/2 ⁻ ,3/2 ⁻	50 2	1		
1583.5 3		13 6			
1588.9 ^z 2	5/2 ⁺	244 8	2	0.024	L,J ^π : L=1 by 1972Ca01; However, from moderately large (d,p) cross sections and definite analyzing powers, 2008Bo26 assigned J ^π =5/2 ⁺ and a configuration of i _{13/2} +g _{9/2} . dσ/dω(μb/sr)=295 6 (10°) and 144 5 (30°). L: From 1972Ca01. dσ/dω(μb/sr)=34 3 (10°) and 50 3 (30°). dσ/dω(μb/sr)=7 2 (10°). dσ/dω(μb/sr)=13 2 (10°) and 5 1 (30°). L: From 1972Ca01. dσ/dω(μb/sr)=20 2 (10°) and 15 2 (30°). dσ/dω(μb/sr)=8 2 (10°) and 4 1 (30°). dσ/dω(μb/sr)=4 1 (10°). dσ/dω(μb/sr)=2≈(10°).
1600.4 2	(1/2 ⁻ ,3/2 ⁻)	59 4	(1)		
1611.3 8	3/2 ⁺	4 2	(2)	0.001	
1620.0 2	3/2 ⁻	10 2	(1)	0.002	
1633.4 2		26 3	(3)		
1648.2 4	5/2 ⁺			0.0004	
1657.1 3		≈7			
1667.0 4		≈7			
1674.7 4	3/2 ⁽⁻⁾		1	0.003	L,S: L from 1972Ca01; upper limit of S is given (2008Bo26). dσ/dω(μb/sr)=15 3 (10°), 21 3 (16°) and 10 1 (30°). dσ/dω(μb/sr)=21 3 (10°), 25 2 (16°) and 10 1 (30°). dσ/dω(μb/sr)=25 3 (10°), 19 2 (16°) and 9 2 (30°). E(level): Possible doublet (2008Bo26). E(level): Possible doublet (2008Bo26). dσ/dω(μb/sr)=10 2 (10°) and 5 1 (30°).
1686.4 3		≈5			
1693.4 3	3/2 ⁺		(2)	0.002	
1708.0 5					
1712.7 2					
1718.6 2	7/2 ⁻		3	0.018	dσ/dω(μb/sr)=29 3 (10°), 25 5 (16°) and 14 2 (30°). dσ/dω(μb/sr)=126 5 (10°), 131 5 (16°) and 99 3 (30°).
1729.4 2	1/2,3/2		1,2	0.008,0.006	dσ/dω(μb/sr)=45 3 (10°), 46 3 (16°) and 19 2 (30°). dσ/dω(μb/sr)=15 3 (10°), 12 4 (16°) and 7 2 (30°).
1744.0 4					
1748.5 3		43 4	1,2		dσ/dω(μb/sr)=43 4 (10°) and 32 3 (30°).
1771.2 3	1/2 ⁻ ,3/2 ⁻	22 2	1		dσ/dω(μb/sr)=36 2 (10°) and 21 2 (30°).
1783.7 3		30 2	1,(3)		dσ/dω(μb/sr)=30 2 (10°) and 16 2 (30°).
1806.6 3		18 2			dσ/dω(μb/sr)=16 2 (10°) and 13 2 (30°).
1816.6 4	3/2 ⁽⁻⁾	22 2		0.004	dσ/dω(μb/sr)=21 2 (10°) and 20 2 (30°).
1824.5 4	3/2 ⁻	51 2	1	0.013	dσ/dω(μb/sr)=75 3 (10°) and 41 2 (30°).
1837.5 3		12 2	(3)		dσ/dω(μb/sr)=10 2 (10°) and 9 2 (30°).
1845.5 4	1/2 ⁻ ,3/2	11 2		(1,2)	dσ/dω(μb/sr)=9 2 (10°) and 13 2 (30°).
1857.6 5	1/2,3/2	11 1	(0,1)		dσ/dω(μb/sr)=17 2 (10°) and 8 1 (30°).

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$^{186}\text{W}(\text{d,p}), ^{186}\text{W}(\text{pol d,p})$ **2008Bo26,1997Bo14,1972Ca01** (continued) ^{187}W Levels (continued)

E(level) [†]	J ^π #	dσ/dω(μb/sr) ^d	L ^a	S	Comments
1872.1 4		21 2	1,(2,3)		dσ/dω(μb/sr)=24 3 (10°) and 11 6 (30°).
1876.2 5		6 2			dσ/dω(μb/sr)=6 2 (10°) and ≈4 (30°).
1888.9 5					dσ/dω(μb/sr)=3 1 (10°) and 5 1 (30°).
1905.7 ^w 4	3/2 ⁻	63 3	1	0.015	dσ/dω(μb/sr)=89 3 (10°) and 37 3 (30°).
1916.3 4	(5/2 ⁺)	75 3	(1),2,(3)	≈0.007	dσ/dω(μb/sr)=99 3 (10°).
1930.8 4	1/2 ⁻ ,3/2 ⁻	16 2	1		dσ/dω(μb/sr)=20 2 (10°).
1941.1 6		34 4	(1)		dσ/dω(μb/sr)=57 3 (10°) and 39 13 (30°) (unresolved).
1946.8 8		8 3			dσ/dω(μb/sr)=8 2 (10°).
1955.6 6	(1/2 ⁻),3/2 ⁻	13 2	1	0.003	dσ/dω(μb/sr)=24 2 (10°).
1966.0 6		17 2	(1,2)		dσ/dω(μb/sr)=26 2 (10°) and 16 8 (30°).
1979.1 5	3/2 ⁺	17 2	(2)	0.002	dσ/dω(μb/sr)=24 2 (10°) and 20 8 (30°).
1992.1 9		15 2			
1997.7 ^x 9	3/2 ⁻	13 2			
2008.9 4		32 7			
2017.7 4		82 9			
2027.5 9		19 3			
2038.6 5		31 6			
2043.9 5	1/2 ⁻ ,3/2 ⁻	32 5			
2060.4 7	1/2,3/2	23 5			dσ/dω(μb/sr)=13 3 (30°).
2072.5 4	1/2,3/2	32 5			dσ/dω(μb/sr)=16 3 (30°).
2092.3 6		17 4			dσ/dω(μb/sr)=17 5 (30°).
2099.7 5		35 6			dσ/dω(μb/sr)=17 3 (30°).
2125.9 8		5 ^e 2			
2141.7 8		8 ^e 2			
2181.5 9		8 ^e 2			
2230.8 11		15 ^e 3			
2243.1 12		10 ^e 2			
2254.3 13		22 ^e 3			
2265.3 13		7 ^e 2			

[†] From **2008Bo26**, except otherwise noted. Proposed levels 752-, 1147-, 1251-, 1511- and 1541-keV (**1997Bo14**) are not observed in the revised experiment and concluded as non existing (**2008Bo26**).

[‡] Also reported in the $^{186}\text{W}(\text{Pol d,P})$ study (**1973Ca09**).

From L values and band assignments along with the $^{186}\text{W}(\text{n},\gamma)^{187}\text{W}$ reaction study in **2008Bo26**.

@ From $^{186}\text{W}(\text{Pol d,P})$, deduced by **1973Ca09** on the basis of vector-analyzing power (normalized to 0, 77, and 205 levels), angular distributions, and previous evidence from (d,p) and (n,γ) data. DWBA analysis was performed.

& On the basis of l=3 shaped angular distributions and analyzing powers.

^a From **2008Bo26**, except otherwise noted. The L values are extracted by **2008Bo26** from DWBA calculation and angular distribution. In **1972Ca01** L value was extracted from cross-section ratios at θ=60°, 90°, and 125°. In **1997Bo14**, L values are assigned from the average intensity ratio at 28 MeV (measured by **1997Bo14**) to the 12 MeV at 60° (measured by **1972Ca01**). The L values of **2008Bo26**, **1997Bo14**, **1972Ca01** are mostly consistent and the differences are noted, if any.

^b From **2008Bo26**. L≥5 is predicted by **1972Ca01**.

^c Anomalous angular distribution reported by **2008Bo26**.

^d From **2008Bo26** at 20°. dσ/dω(μb/sr) of 10° and 30° is given in the comments section.

^e Revised data of 28 MeV measurements by **1997Bo14**.

^f 3/2[512].

^g 1/2[510].

^h 7/2[503] (1).

ⁱ 7/2[503] (2).

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${}^{186}\text{W}(\text{d,p}), {}^{186}\text{W}(\text{pol d,p})$ [2008Bo26,1997Bo14,1972Ca01](#) (continued)

${}^{187}\text{W}$ Levels (continued)

- j* 7/2[503] (3).
- k* 7/2[503] (4).
- l* 9/2[505].
- m* 11/2[615].
- n* 5/2[503].
- o* 1/2[501] (1).
- p* 1/2[501] (2).
- q* 3/2[501] (1).
- r* 3/2[501] (2).
- s* 3/2[501] (3).
- t* 3/2[501] (4).
- u* 3/2[501] (5).
- v* 3/2[501] (6).
- w* 3/2[501] (7).
- x* 3/2[501] (9).
- y* $i_{13/2}+g_{9/2}$ (1).
- z* $i_{13/2}+g_{9/2}$ (2).