CLASSIFICATION OF ELECTROMAGNETIC RADIATION

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Basic Conversions:
$c = \lambda\nu = \nu/k$
$\nu = c/\lambda = ck$
$\lambda = c/\nu = 1/k$
$k = \nu/c = 1/\lambda$
c = speed of light = 2.99792458×10^8 m/s

Frequency (ν)	Wavelength (λ)	Wave number (k)	Names of bands	Approximate photon energies
3×10^0 — 3×10^1 Hz 3 — 30 Hz	10^8 — 10^7 m 100 — 10 Mm	10^{-8} — 10^{-7} m^{-1} 10 — 100 Gm^{-1}	ELF-(ELF 1), ITU band no. 1	
3×10^1 — 3×10^2 Hz 30 — 300 Hz	10^7 — 10^6 m 10 — 1 Mm	10^{-7} — 10^{-6} m^{-1} 100 Gm^{-1} — 1Mm^{-1}	SLF-(ELF 2), ITU band no. 2, megameter waves	
3×10^2 — 3×10^3 Hz 300 Hz — 3 kHz	10^6 — 10^5 m 1 Mm — 100 km	10^{-6} — 10^{-5} m^{-1} 1 — 10 Mm^{-1}	ULF-(ELF 3), ITU band no. 3	
3×10^3 — 3×10^4 Hz 3 — 30 kHz	10^5 — 10^4 m 100 — 10 km	10^{-5} — 10^{-4} m^{-1} 10 — 100 Mm^{-1}	VLF, ITU band no. 4, myriameter waves	
3×10^4 — 3×10^5 Hz 30 — 300 kHz	10^4 — 10^3 m 10 — 1 km	10^{-4} — 10^{-3} m^{-1} 100 Mm^{-1} — 1 km^{-1}	LF, ITU band no. 5, kilometer waves	
3×10^5 — 3×10^6 Hz 300 kHz — 3 MHz	10^3 —10^2 m 1 km — 100 m	10^{-3} — 10^{-2} m^{-1} 1 — 10 km^{-1}	MF, ITU band no. 6, hectometer waves	
3×10^6 — 3×10^7 Hz 3 — 30 MHz	10^2 — 10^1 m 100 — 10 m	10^{-2} — 10^{-1} m^{-1} 10 — 100 km^{-1}	HF, ITU band no. 7, decameter waves	
3×10^7 — 3×10^8 Hz 30 — 300 MHz	10^1 — 10^0 m 10 — 1 m	10^{-1} — 10^0 m^{-1} 100 km^{-1} — 1 mm^{-1}	VHF, ITU band no. 8, meter waves	
3×10^8 — 3×10^9 Hz 300 MHz — 3 GHz	10^0 — 10^{-1} 1 m — 100 mm	10^0 — 10^1 m^{-1} 1 — 10 m^{-1}	UHF, ITU band no. 9, decimeter waves[a]	
3×10^9 — 3×10^{10} Hz 3 — 30 GHz	10^{-1} — 10^{-2} 100 —10 mm	10^1 — 10^2 m^{-1} 10 — 100 m^{-1}	SHF, ITU band no. 10, centimeter waves[a]	
3×10^{10} — 3×10^{11} Hz 30 — 300 GHz	10^{-2} — 10^{-3} m 10 —1 mm	10^2 — 10^3 m^{-1} 100 m^{-1} — 1 mm^{-1} (1 — 10 cm^{-1})	EHF, ITU band no. 11, millimeter waves	
3×10^{11} — 3×10^{12} Hz 300 GHz — 3 THz	10^{-3} — 10^{-4} 1 mm — 100 μm	10^3 — 10^4 m^{-1} (1 — 10 mm^{-1}) (10 — 100 cm^{-1})	Part of micrometer waves, includes part of far or thermal infrared; ITU band no. 12	
3×10^{12} — 3×10^{13} Hz 3 — 30 THz	10^{-4} — 10^{-5} 100 — 10 μm	10^4 — 10^5 m^{-1} 10 — 100 mm^{-1} (100 — 1000 cm^{-1})	Part of micrometer waves includes part of far (thermal) infrared	
3×10^{13} — 3×10^{14} Hz 30 — 300 THz	10^{-5} — 10^{-6} m 10 — 1 μm (100,000 — 10,000 Å)	10^5 — 10^6 m^{-1} 100 mm^{-1} — 1μm^{-1}	Part of μm waves, part of infrared	(1.6 — 16) × 10^{-20} joule {0.1 — 1 eV}
3×10^{14} — 3×10^{15} Hz 300 THz — 3 PHz	10^{-6} — 10^{-7}m 1 μm — 100 m (10,000 — 1000 Å)	10^6 — 10^7 m^{-1} 1 — 10 μm^{-1}	Near infrared, visible, near ultraviolet	(1.6 — 16) × 10^{-19} joule {1 — 10 eV}
3×10^{15} — 3×10^{16} Hz 3 — 30 PHz	10^{-7} — 10^{-8}m 100 — 10 nm (1000 — 100 Å)	10^7 — 10^8 m^{-1} 10 — 100 μm^{-1}	Part of vacuum ultraviolet	(1.6 — 16) × 10^{-18} joule {10 — 100 eV}
3×10^{16} — 3×10^{17} Hz 30 — 300 PHz	10^{-8} — 10^{-9} m 10 —1 nm (100 — 10 Å)	10^8 — 10^9 m^{-1} 100 μm^{-1} — 1 nm^{-1}	Part of soft X-rays	(1.6 — 16) × 10^{-17} joule {100 — 1000 eV}
3×10^{17} — 3×10^{18} Hz 300 PHz — 3 Ehz	10^{-9} — 10^{-10} m 1 nm — 100 pm (10 — 1 Å)	10^9 — 10^{10} m^{-1} 1 — 10 nm^{-1}	Part of soft X-rays	(1.6 — 16) × 10^{-16} joule {1 — 10 keV}
3×10^{18} — 3×10^{19} Hz 3 — 30 Ehz	10^{-10} — 10^{-11} m 100 — 10 pm (1 — 0.1 Å)	10^{10} — 10^{11} m^{-1} 10 — 100 nm^{-1}	Hard X-rays and part of soft γ-rays	(1.6 — 16) × 10^{-15} joule {10 — 100 keV}
3×10^{19} — 3×10^{20} Hz 30 — 300 Ehz	10^{-11} — 10^{-12} m 10 — 1 pm (0.1 — 0.01 Å)	10^{11} — 10^{12} m^{-1} 100 nm^{-1} — 1 pm^{-1}	Part of soft and part of hard γ-rays (limit at 510 keV)	(1.6 — 16) × 10^{-14} joule {100 keV — 1 MeV}
3×10^{20} — 3×10^{21} Hz 300 — 3000 EHz	10^{-12} — 10^{-13} m 1 pm — 100 fm (0.01 — 0.001 Å)	10^{12} — 10^{13} m^{-1} 1 — 10 pm^{-1}	Part of hard γ-rays and part of "cosmic" γ-rays	(1.6 — 16) × 10^{-13} joule {1 — 10 MeV}
3×10^{21} — 3×10^{22} Hz 3000 — 30,000 EHz	10^{-13} — 10^{-14} m 100 — 10 fm (0.001 — 0.0001 Å)	10^{13} — 10^{14} m^{-1} 10 — 100 pm^{-1}	γ-rays produced by cosmic rays	(1.6 — 16) × 10^{-12} joule {10 — 100 MeV}

Note: Abbreviations used in this table: Å— ångstrom (1 Å=10^{-10} m); EHz—exahertz (10^{18} hertz); EHF—extremely high frequency; ELF— extremely low frequency; eV—electron volt (1 eV = 1.60218×10^{-19} joule); fm—femtometer (10^{-15} m); GHz—gigahertz (10^{9} hertz); Gm—gigameter (10^{9} m); HF—high frequency; Hz—hertz (s^{-1}); ITU—International Telecommunications Union; keV— kiloelectron volt (10^{3} eV); km—kilometer (10^{3} m); LF—low frequency; m—meter; MeV— megaelectron volt (10^{6} eV); MF—medium frequency; MHz—megahertz (10^{6} hertz); Mm—megameter (10^{6} meter); mm—millimeter (10^{-3} meter); µm—micrometer (10^{-6} meter); nm—nanometer (10^{-9}meter); PHz—petahertz (10^{15} hertz); pm—picometer (10^{-12} meter); SHF—super high frequency; SLF—super low frequency; THz—terahertz; UHF— ultra high frequency; ULF—ultra low frequency; VHF—very high frequency; VLF—very low frequency.

[a] Also called "microwaves"; not to be confused with "micrometer waves".

LETTER DESIGNATIONS OF MICROWAVE BANDS

Frequency (GHz)	Wavelength (cm)	Wavenumber (cm^{-1})	Band
1—2	30—15	0.033—0.067	L-Band
1—4	15—7.5	0.067—0.133	S-Band
4—8	7.5—3.7	0.133—0.267	C-Band
8—12	3.7—2.5	0.267—0.4	X-Band
12—18	2.5—1.7	0.4—0.6	Ku-Band
18—27	1.7—1.1	0.6—0.9	K-Band
27—40	1.1—0.75	0.9—1.33	Ka-Band

BLACK BODY RADIATION

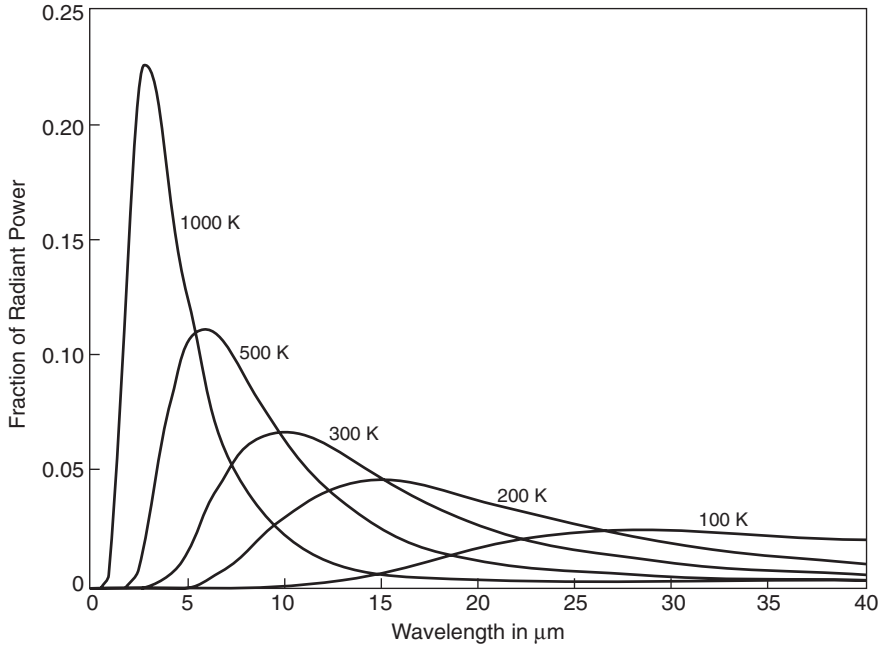
The total power radiated from an ideal black body and the wavelength corresponding to maximum power are given here as a function of absolute temperature. Constants used in the calculation are taken from the table "Fundamental Physical Constants" in Section 1. The radiated power in a band $\Delta\lambda$ at λ_{max} may be calculated from:

$$P_{max} = 0.657548\ (\Delta\lambda/\lambda_{max})\ P_{tot}$$

T/K	P_{tot}	λ_{max}/μm	T/K	P_{tot}	λ_{max}/μm	T/K	P_{tot}	λ_{max}/μm
50	0.354 W/m²	57.955	740	17.004	3.916	1520	302.689	1.906
100	5.671	28.978	750	17.942	3.864	1540	318.937	1.882
150	28.707	19.318	760	18.918	3.813	1560	335.831	1.858
200	90.728	14.489	770	19.934	3.763	1580	353.387	1.834
250	221.504	11.591	780	20.989	3.715	1600	371.623	1.811
273	314.973	10.614	790	22.087	3.668	1620	390.555	1.789
280	348.541	10.349	800	23.226	3.622	1640	410.202	1.767
290	401.064	9.992	810	24.410	3.577	1660	430.581	1.746
300	459.311	9.659	820	25.638	3.534	1680	451.710	1.725
310	523.684	9.348	830	26.911	3.491	1700	473.607	1.705
320	594.596	9.055	840	28.232	3.450	1720	496.290	1.685
330	672.478	8.781	850	29.600	3.409	1740	519.779	1.665
340	757.771	8.523	860	31.018	3.369	1760	544.093	1.646
350	850.931	8.279	870	32.486	3.331	1780	569.249	1.628
360	952.428	8.049	880	34.006	3.293	1800	595.267	1.610
370	1.063 kW/m²	7.832	890	35.578	3.256	1820	622.168	1.592
380	1.182	7.626	900	37.204	3.220	1840	649.970	1.575
390	1.312	7.430	910	38.886	3.184	1860	678.694	1.558
400	1.452	7.244	920	40.623	3.150	1880	708.359	1.541
410	1.602	7.068	930	42.418	3.116	1900	738.987	1.525
420	1.764	6.899	940	44.272	3.083	1920	770.597	1.509
430	1.939	6.739	950	46.187	3.050	1940	803.210	1.494
440	2.125	6.586	960	48.162	3.018	1960	836.848	1.478
450	2.325	6.439	970	50.201	2.987	1980	871.531	1.464
460	2.539	6.299	980	52.303	2.957	2000	907.282	1.449
470	2.767	6.165	990	54.471	2.927	2020	944.121	1.435
480	3.010	6.037	1000	56.705	2.898	2040	982.071	1.420
490	3.269	5.914	1020	61.379	2.841	2060	1.021 MW/m²	1.407
500	3.544	5.796	1040	66.337	2.786	2080	1.061	1.393
510	3.836	5.682	1060	71.589	2.734	2100	1.103	1.380
520	4.146	5.573	1080	77.147	2.683	2120	1.145	1.367
530	4.474	5.467	1100	83.022	2.634	2140	1.189	1.354
540	4.822	5.366	1120	89.227	2.587	2160	1.234	1.342
550	5.189	5.269	1140	95.773	2.542	2180	1.281	1.329
560	5.577	5.175	1160	102.672	2.498	2200	1.328	1.317
570	5.986	5.084	1180	109.939	2.456	2220	1.377	1.305
580	6.417	4.996	1200	117.584	2.415	2240	1.428	1.294
590	6.871	4.911	1220	125.621	2.375	2260	1.479	1.282
600	7.349	4.830	1240	134.063	2.337	2280	1.532	1.271
610	7.851	4.750	1260	142.924	2.300	2300	1.587	1.260
620	8.379	4.674	1280	152.217	2.264	2320	1.643	1.249
630	8.933	4.600	1300	161.955	2.229	2340	1.700	1.238
640	9.514	4.528	1320	172.154	2.195	2360	1.759	1.228
650	10.122	4.458	1340	182.827	2.163	2380	1.819	1.218
660	10.760	4.391	1360	193.989	2.131	2400	1.881	1.207
670	11.427	4.325	1380	205.655	2.100	2420	1.945	1.197
680	12.124	4.261	1400	217.838	2.070	2440	2.010	1.188
690	12.853	4.200	1420	230.556	2.041	2460	2.077	1.178
700	13.615	4.140	1440	243.822	2.012	2480	2.145	1.168
710	14.410	4.081	1460	257.652	1.985	2500	2.215	1.159
720	15.239	4.025	1480	272.063	1.958	2550	2.398	1.136
730	16.103	3.970	1500	287.070	1.932	2600	2.591	1.115

T/K	P_{tot}	λ_{max}/μm	T/K	P_{tot}	λ_{max}/μm	T/K	P_{tot}	λ_{max}/μm
2650	2.796	1.093	3600	9.524	0.805	5100	38.362	0.568
2700	3.014	1.073	3650	10.065	0.794	5200	41.461	0.557
2750	3.243	1.054	3700	10.627	0.783	5300	44.743	0.547
2800	3.485	1.035	3750	11.214	0.773	5400	48.217	0.537
2850	3.741	1.017	3800	11.824	0.763	5500	51.889	0.527
2900	4.011	0.999	3850	12.458	0.753	5600	55.767	0.517
2950	4.294	0.982	3900	13.118	0.743	5700	59.858	0.508
3000	4.593	0.966	3950	13.804	0.734	5800	64.170	0.500
3050	4.907	0.950	4000	14.517	0.724	5900	68.712	0.491
3100	5.237	0.935	4100	16.024	0.707	6000	73.490	0.483
3150	5.583	0.920	4200	17.645	0.690	6500	101.222	0.446
3200	5.946	0.906	4300	19.386	0.674	7000	136.149	0.414
3250	6.326	0.892	4400	21.254	0.659	7500	179.418	0.386
3300	6.725	0.878	4500	23.253	0.644	8000	232.264	0.362
3350	7.142	0.865	4600	25.389	0.630	8500	296.004	0.341
3400	7.578	0.852	4700	27.670	0.617	9000	372.042	0.322
3450	8.033	0.840	4800	30.101	0.604	9500	461.867	0.305
3500	8.509	0.828	4900	32.689	0.591	10000	567.051	0.290
3550	9.006	0.816	5000	35.441	0.580			

The curves below show, for various temperatures, the fraction of radiant power as a function of wavelength. The function plotted is $P_\lambda/\Delta\lambda\, P_{tot}$, where P_λ is the power at wavelength λ in a small interval Δλ (in μm), and P_{tot} is the total power.

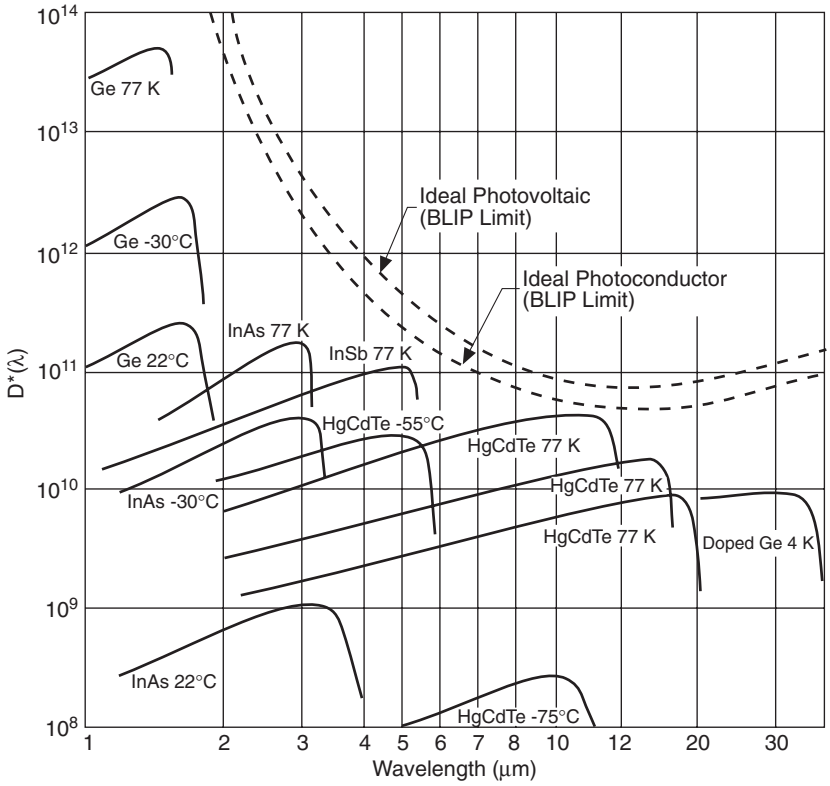


CHARACTERISTICS OF INFRARED DETECTORS

This graph summarizes the wavelength response of some semiconductors used as detectors for infrared radiation. The quantity $D^*(\lambda)$ is the signal to noise ratio for an incident radiant power density of 1 W/cm^2 and a bandwidth of 1 Hz (60° field of view). The Ge, InAs, and InSb detectors are photovoltaics, while the HgCdTe series are photoconductive devices. The cutoff wavelength of the latter can be varied by adjusting the relative amounts of Hg, Cd, and Te (three examples are shown at 77 K). The graph also shows the theoretical background limited sensitivity for ideal detectors which introduce no intrinsic noise.

Reference

Infrared Detectors 1995, EG&G Judson, Montgomeryville, PA.



REFRACTIVE INDEX AND TRANSMITTANCE OF REPRESENTATIVE GLASSES

Typical values of the index of refraction and internal transmittance (fraction of light transmitted through a one centimeter thickness) are tabulated here for selected types of glasses, as well as for synthetic fused (vitreous) silica. Nominal compositions are given in the first part of the table. The second part gives the index of refraction, relative to air, and the internal transmittance for representative samples of each glass at wavelengths in the infrared, visible, and near-ultraviolet regions. It should be emphasized that wide variation of these parameters may be found among subtypes of each glass. More detailed data may be found in Reference 3.

Assuming that the Lambert-Beer Law is followed, the transmittance of a glass plate of thickness d (in centimeters) can be obtained by raising the transmittance value in the table to the power d.

References

1. Weber, M. J., *CRC Handbook of Laser Science and Technology*, Vol. IV, Part 2, CRC Press, Boca Raton, FL ,1988.
2. Gray, D. E., Ed., *American Institute of Physics Handbook, Third Edition*, McGraw Hill, New York, 1972.
3. *Schott Optical Glass*, Schott Glass Technologies, Inc., 400 York Ave., Duryea, PA 18642.
4. Kaye, G. W. C., and Laby, T. H., *Tables of Physical and Chemical Constants, 15th Edition*, Longman, London, 1986.

		Composition in percent by mass									
Type	**Name**	**SiO_2**	**B_2O_3**	**Al_2O_3**	**Na_2O**	**K_2O**	**CaO**	**BaO**	**ZnO**	**PbO**	**P_2O_5**
PK	Phosphate crown		3	10		12	5				70
PSK	Dense phosphate crown		3	5			4	28			60
BK	Borosilicate crown	70	10		8	8	1	3			
K	Crown	74			9	11	6				
ZK	Zinc crown	71			17				12		
BaK	Barium crown	60	3		3	10		19	5		
SK	Dense crown	39	15	5				41			
KF	Crown flint	67		2	16				3	12	
BaLF	Barium light flint	51			6	5		20	14	4	
SSK	Extra dense crown	35	10	5				42	8		
LLF	Extra light flint	63			5	8				24	
BaF	Barium flint	46				8		16	8	22	
LF	Light flint	53			5	8				34	
F	Flint	47			2	7				44	
BaSF	Dense barium flint	43			1	7		11	5	33	
SF	Dense flint	33				5				62	
KzFS	Short flint										
SiO_2	Fused silica	100									

	Index of refraction				Transmittance of 1 cm plate			
Type	**1.060 µm**	**546.1 nm**	**365.0 nm**	**312.6 nm**	**1.060 µm**	**546.1 nm**	**365.0 nm**	**310 nm**
PK	1.51519	1.52736	1.54503	1.5574	0.997	0.998	0.987	0.46
PSK	1.54154	1.55440	1.57342	1.5868	0.996	0.998	0.984	0.46
BK	1.50669	1.51872	1.53627	1.5486	0.999	0.998	0.987	0.35
K	1.50091	1.51314	1.53189	1.5454	0.998	0.998	0.988	0.40
ZK	1.52220	1.53534	1.55588	1.5708	0.996	0.998	0.976	0.27
BaK	1.55695	1.57124	1.59407	1.6108	0.998	0.997	0.986	0.28
SK	1.59490	1.60994	1.63398		0.998	0.998	0.959	0.28
KF	1.50586	1.51978	1.54251	1.5600	0.998	0.996	0.989	0.49
BaLF	1.57579	1.59166	1.61804		0.996	0.998	0.933	0.010
SSK	1.60402	1.61993	1.64595		0.999	0.998	0.915	0.010
LaK	1.69710	1.71616	1.74573		0.999	0.998	0.882	0.17
LLF	1.52775	1.54344	1.57038		0.998	0.997	0.990	0.32
BaF	1.56873	1.58565	1.61524		0.999	0.997	0.992	0.004
LF	1.56594	1.58482	1.61926		0.999	0.998	0.981	0.008
F	1.58636	1.60718	1.64606		0.997	0.998	0.959	
BaSF	1.60889	1.62987	1.66926		0.999	0.998	0.857	
SF	1.71350	1.74620	1.8145		0.998	0.997	0.650	
KzFS	1.59680	1.61639	1.64849	1.6739		0.998	0.672	0.012
SiO_2	1.44968	1.46008	1.47435[a]	1.53430[b]				

[a] At 366.3 nm.

[b] At 213.9 nm.

INDEX OF REFRACTION OF WATER

This table gives the index of refraction of liquid water at atmospheric pressure, relative to a vacuum, at several temperatures and wavelengths. It is generated from the formulation in Reference 1, which covers a wide range of temperature, pressure, and wavelength. The wavelengths listed here correspond to prominent lines of cadmium (226.50 and 361.05 nm), potassium (404.41 nm), sodium (589.00 nm), Ne (632.80 nm, from a helium - neon laser), and mercury (1.01398 μm).

References

1. Schiebener, P., Straub, J., Levelt Sengers, J. M. H., and Gallagher, J. S., *J. Phys. Chem. Ref. Data*, 19, 677, 1990; 19, 1617, 1990.
2. Marsh, K. N., Editor, *Recommended Reference Materials for the Realization of Physicochemical Properties*, Blackwell Scientific Publications, Oxford, 1987.

t/°C	226.50 nm	361.05 nm	404.41 nm	589.00 nm	632.80 nm	1.01398 μm
0	1.39450	1.34896	1.34415	1.33432	1.33306	1.32612
10	1.39422	1.34870	1.34389	1.33408	1.33282	1.32591
20	1.39336	1.34795	1.34315	1.33336	1.33211	1.32524
30	1.39208	1.34682	1.34205	1.33230	1.33105	1.32424
40	1.39046	1.34540	1.34065	1.33095	1.32972	1.32296
50	1.38854	1.34373	1.33901	1.32937	1.32814	1.32145
60	1.38636	1.34184	1.33714	1.32757	1.32636	1.31974
70	1.38395	1.33974	1.33508	1.32559	1.32438	1.31784
80	1.38132	1.33746	1.33284	1.32342	1.32223	1.31576
90	1.37849	1.33501	1.33042	1.32109	1.31991	1.31353
100	1.37547	1.33239	1.32784	1.31861	1.31744	1.31114

INDEX OF REFRACTION OF LIQUIDS FOR CALIBRATION PURPOSES

This table gives the index of refraction of six liquids which are available in highly pure form and whose index of refraction has been accurately measured as a function of wavelength and temperature. They are therefore useful for calibration of refractometers. The estimated uncertainty in the values is:

2,2,4-Trimethylpentane	±0.00003
Hexadecane	±0.00008
trans-Bicyclo[4.0.0]decane	±0.00008
1-Methylnaphthalene	±0.00008
Toluene	±0.00003
Methylcyclohexane	±0.00003

Full details are given in the references. This table is reprinted from Reference 1 by permission of the International Union of Pure and Applied Chemistry.

References

1. Marsh, K. N., Editor, *Recommended Reference Materials for the Realization of Physicochemical Properties*, Blackwell Scientific Publications, Oxford, 1987.
2. Tilton, L. W., *J. Opt. Soc. Am.*, 32, 71, 1941.

λ	2,2,4-Trimethylpentane			Hexadecane		
nm	20°C	25°C	30°C	20°C	25°C	30°C
667.81	1.38916	1.38670	1.38424	1.43204	1.43001	1.42798
656.28	1.38945	1.38698	1.38452	1.43235	1.43032	1.42829
589.26	1.39145	1.38898	1.38650	1.43453	1.43250	1.43047
546.07	1.39316	1.39068	1.38820	1.43640	1.43436	1.43232
501.57	1.39544	1.39294	1.39044	1.43888	1.43684	1.43480
486.13	1.39639	1.39389	1.39138	1.43993	1.43788	1.43583
435.83	1.40029	1.39776	1.39523	1.44419	1.44213	1.44007

λ	*trans*-Bicyclo[4.4.0]decane			1-Methylnaphthalene		
nm	20°C	25°C	30°C	20°C	25°C	30°C
667.81	1.46654	1.46438	1.46222	1.60828	1.60592	1.60360
656.28	1.46688	1.46472	1.46256	1.60940	1.60703	1.60471
589.26	1.46932	1.46715	1.46498	1.61755	1.61512	1.61278
546.07	1.47141	1.46923	1.46705	1.62488	1.62240	1.62005
501.57	1.47420	1.47200	1.46980	1.63513	1.63259	1.63022
486.13	1.47535	1.47315	1.47095	1.63958	1.63701	1.63463
435.83	1.48011	1.47789	1.47567		1.65627	1.65386

λ	Toluene			Methylcyclohexane		
nm	20°C	25°C	30°C	20°C	25°C	30°C
667.81	1.49180	1.48903	1.48619	1.42064	1.41812	1.41560
656.28	1.49243	1.48966	1.48682	1.42094	1.41842	1.41591
589.26	1.49693	1.49413	1.49126	1.42312	1.42058	1.41806
546.07	1.50086	1.49803	1.49514	1.42497	1.42243	1.41989
501.57	1.50620	1.50334	1.50041	1.42744	1.42488	1.42233
486.13	1.50847	1.50559	1.50265	1.42847	1.42590	1.42334
435.83	1.51800	1.51506	1.51206	1.43269	1.43010	1.42752

INDEX OF REFRACTION OF AIR

This is a table of the index of refraction n of dry air at 15°C and a pressure of 101.325 kPa and containing 0.045% by volume of carbon dioxide ("standard air"). The index of refraction is defined by $n = \lambda_{vac}/\lambda_{air}$ where λ is the wavelength of the radiation. The index is calculated from the expression

$$(n-1) \times 10^8 = 8342.54 + 2406147(130 - \sigma^2)^{-1} + 15998(38.9 - \sigma^2)^{-1}$$

where $\sigma = 1/\lambda_{vac}$ and λ_{vac} has units of μm. The equation is valid for λ_{vac} from 200 nm to 2 μm. The table also gives the correction $(n-1)\lambda_{air}$ which must be added to the wavelength in air to obtain λ_{vac}.

If the air is at a temperature t in °C (ITS-90) and a pressure p in pascals, a value of $(n - 1)$ from this table should be multiplied by

$$p[1 + p(60.1 - 0.972t) \times 10^{-10}]/96095.43(1 + 0.003661t)$$

References

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λ_{vac}	$(n-1) \times 10^8$	$\lambda_{vac} - \lambda_{air}$	λ_{vac}	$(n-1) \times 10^8$	$\lambda_{vac} - \lambda_{air}$	λ_{vac}	$(n-1) \times 10^8$	$\lambda_{vac} - \lambda_{air}$
200 nm	32409	0.06480 nm	540	27804	0.15010	880	27462	0.24160
210	31748	0.06665	550	27784	0.15277	890	27458	0.24431
220	31226	0.06868	560	27765	0.15544	900	27454	0.24701
230	30801	0.07082	570	27747	0.15811	910	27449	0.24972
240	30447	0.07305	580	27730	0.16079	920	27445	0.25243
250	30148	0.07535	590	27714	0.16347	930	27441	0.25513
260	29892	0.07769	600	27698	0.16614	940	27437	0.25784
270	29670	0.08009	610	27684	0.16882	950	27434	0.26055
280	29477	0.08251	620	27670	0.17151	960	27430	0.26326
290	29307	0.08497	630	27657	0.17419	970	27427	0.26597
300	29157	0.08745	640	27644	0.17688	980	27423	0.26868
310	29023	0.08995	650	27632	0.17956	990	27420	0.27138
320	28904	0.09247	660	27621	0.18225			
330	28796	0.09500	670	27610	0.18494	1.00 μm	27417	0.0002741
340	28700	0.09755	680	27600	0.18763	1.05	27402	0.0002876
350	28612	0.10011	690	27590	0.19032	1.10	27390	0.0003012
360	28532	0.10269	700	27581	0.19301	1.15	27379	0.0003148
370	28460	0.10527	710	27572	0.19570	1.20	27370	0.0003283
380	28393	0.10786	720	27563	0.19840	1.25	27361	0.0003419
390	28332	0.11046	730	27555	0.20109	1.30	27354	0.0003555
400	28276	0.11307	740	27547	0.20379	1.35	27347	0.0003691
410	28224	0.11569	750	27539	0.20649	1.40	27341	0.0003827
420	28177	0.11831	760	27532	0.20918	1.45	27336	0.0003963
430	28132	0.12094	770	27525	0.21188	1.50	27331	0.0004099
440	28091	0.12357	780	27518	0.21458	1.55	27327	0.0004234
450	28053	0.12620	790	27511	0.21728	1.60	27323	0.0004370
460	28018	0.12885	800	27505	0.21998	1.65	27319	0.0004506
470	27985	0.13149	810	27499	0.22268	1.70	27316	0.0004642
480	27954	0.13414	820	27493	0.22538	1.75	27313	0.0004778
490	27925	0.13679	830	27488	0.22808	1.80	27310	0.0004914
500	27897	0.13945	840	27482	0.23079	1.85	27307	0.0005050
510	27872	0.14211	850	27477	0.23349	1.90	27305	0.0005187
520	27848	0.14477	860	27472	0.23619	1.95	27303	0.0005323
530	27825	0.14743	870	27467	0.23890	2.00	27301	0.0005459

CHARACTERISTICS OF LASER SOURCES

William F. Krupke

Light Amplification by Stimulated Emission of Radiation was first demonstrated by Maiman in 1960, the result of a population inversion produced between energy levels of chromium ions in a ruby crystal when irradiated with a xenon flashlamp. Since then population inversions and coherent emission have been generated in literally thousands of substances (neutral and ionized gases, liquids, and solids) using a variety of incoherent excitation techniques (optical pumping, electrical discharges, gas-dynamic flow, electron-beams, chemical reactions, nuclear decay).

The extrema of laser output parameters which have been demonstrated to date and the laser media used are summarized in Table 1. Note that the extreme power and energy parameters listed in this table were attained with laser *systems* rather than with simple laser oscillators.

Laser sources are commonly classified in terms of the state-of-matter of the active medium: gas, liquid, and solid. Each of these classes is further subdivided into one or more types as shown in Table 2. A well-known representative example of each type of laser is also given in Table 2 together with its nominal operation wavelength and the methods by which it is pumped.

The various lasers together cover a wide spectral range from the far ultraviolet to the far infrared. The particular wavelength of emission (usually a narrow line) is presented for some six dozen lasers in Figures 1A and 1B.

By suitably designing the excitation source and/or by controlling the laser resonator structure, laser systems can provide continuous or pulsed radiation as shown in Table 3.

Besides the method of excitation and the temporal behavior of a laser, there are many other parameters that characterize its operation and efficiency, as shown in Tables 4 and 5.

Although many lasers only emit in one or more narrow spectral "lines", an increasing number of lasers can be tuned by changing the composition or the pressure of the medium, or by varying the wavelength of the pump bands. The spectral regions in which these tunable lasers operate are presented in Figure 2.

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TABLE 1. Extrema of Output Parameters of Laser Devices or Systems

Parameter	Value	Laser medium
Peak power	1×10^{14} W(collimated)	Nd:glass
Peak power density	10^{18} W/cm^2 (focused)	Nd:glass
Pulse energy	$>10^5$ J	CO_2, Nd:glass
Average power	10^5 W	CO_2
Pulse duration	3×10^{-15} s continuous wave (cw)	Rh6G dye; various gases, liquids, solids
Wavelength	60 nm ↔ 385 μm	Many required
Efficiency (nonlaser pumped)	70%	CO
Beam quality	Diffraction limited	Various gases, liquids, solids
Spectral linewidth	20 Hz (for 10^{-1} s)	Neon-helium
Spatial coherence	10 m	Ruby

TABLE 2. Classes, Types, and Representative Examples of Laser Sources

Class	Type (characteristic)	Representative example	Nominal operating wavelength (nm)	Method(s) of excitation
Gas	Atom, neutral (electronic transition)	Neon-Helium (Ne-He)	633	Glow discharge
	Atom, ionic (electronic transition)	Argon (Ar^+)	488	Arc discharge
	Molecule, neutral (electronic transition)	Krypton fluoride (KrF)	248	Glow discharge; e-beam
	Molecule, neutral (vibrational transition)	Carbon dioxide (CO_2)	10600	Glow discharge; gasdynamic flow
	Molecule, neutral (rotational transition)	Methyl fluoride (CH_3F)	496000	Laser pumping
	Molecule, ionic (electronic transition)	Nitrogen ion (N_2^+)	420	E-beam
Liquid	Organic solvent (dye-chromophore)	Rhodamine dye (Rh6G)	580–610	Flashlamp; laser pumping
	Organic solvent (rare earth chelate)	Europium:TTF	612	Flashlamp
	Inorganic solvent (trivalent rare earth ion)	Neodymium:$POCl_4$	1060	Flashlamp
Solid	Insulator, crystal (impurity)	Neodymium:YAG	1064	Flashlamp, arc lamp
	Insulator, crystal (stoichiometric)	Neodymium:UP(NdP_5O_{14})	1052	Flashlamp
	Insulator, crystal (color center)	F_2^-:LiF	1120	Laser pumping
	Insulator, amorphous (impurity)	Neodymium:glass	1061	Flashlamp
	Semiconductor (p-n junction)	GaAs	820	Injection current
	Semiconductor (electron-hole plasma)	GaAs	890	E- beam, laser pumping

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TABLE 3. Temporal Characteristics of Lasers and Laser Systems

Form	Technique	Pulse width range (s)
Continuous wave	Excitation is continuous; resonator Q is held constant at some moderate value	∞
Pulsed	Excitation is pulsed; resonator Q is held constant at some moderate value	$10^{-8} – 10^{-3}$
Q-Switched	Excitation is continuous or pulsed; resonator Q is switched from a very low value to a moderate value	$10^{-8} – 10^{-6}$
Cavity dumped	Excitation is continuous or pulsed; resonator Q is switched from a very high value to a low value	$10^{-7} – 10^{-5}$
Mode locked	Excitation is continuous or pulsed; phase or loss of the resonator modes is modulated at a rate related to the resonator transit time	$10^{-12} – 10^{-9}$

TABLE 4. Properties and Performance of Some Continuous Wave (CW) Lasers

		Gas			Liquid	Solid	
Parameter	**Unit**	**Neon helium**	**Argon ion**	**Carbon dioxide**	**Rhodamine 6G dye**	**Nd:YAG**	**GaAs**
Excitation method		DC discharge	DC discharge	DC discharge	Ar^+ laser pump	Krypton arc lamp	DC injection
Gain medium composition		Neon:helium	Argon	CO_2:N_2:He	Rh 6G:H_2O	Nd:YAG	p:n:GaAs
Gain medium density	Torr	0.1:1.0	0.4	0.4:0.8:5.0			
	ions/cm^3				2(18):2(22)	1.5(20):2(22)	2(19):3(18):3(22)
Wavelength	nm	633	488	10600	590	1064	810
Laser cross-section	cm^{-2}	3(-13)	1.6(-12)	1.5(-16)	1.8(-16)	7(-19)	~6(-15)
Radiative lifetime (upper level)	s	~1(-7)	7.5(-9)	4(-3)	6.5(-9)	2.6(-4)	~1(-9)
Decay lifetime (upper level)	s	~1(-7)	~5.0(-9)	~4(-3)	6.0(-9)	2.3(-4)	~1(-9)
Gain bandwidth	nm	2(-3)	5(-3)	1.6(-2)	80	0.5	10
Type, gain saturation		Inhomogeneous	Inhomogeneous	Homogeneous	Homogeneous	Homogeneous	Homogeneous
Homogeneous saturation flux	W cm^{-2}			~20	3(5)	2.3(3)	~2(4)
Decay lifetime (lower level)	s	~ 1(-8)	~4(-10)	~5(-6)	<1(-12)	< 1(-7)	<1(-12)
Inversion density	cm^{-3}	~ 1(9)	2(10)	2(15)	2(16)	6(16)	1(16)
Small signal gain coefficient	cm^{-1}	~ 1(-3)	~3(-2)	1(-2)	4	5(-2)	40
Pump power density	W cm^{-3}	3	900	0.15	1(6)	150	7(7)
Output power density	W cm^{-3}	2.6(-3)	~1	2(-2)	3(5)	95	5(6)
Laser size (diameter: length)	cm:cm	0.5:100	0.3:100	5.0:600	1(-3):0.3	0.6:10	5(-4):7(-3);2(-2)[a]
Excitation current/ voltage	A/V	3(-2):2(3)	30:300	0.1:1.5(4)		90:125	1.0/1.7
Excitation current density	A cm^{-2}	0.15	600	6(-3)		140	4.5(3)
Excitation power	W	60	9(3)	1.5(3)	4	1.1(4)	1.7
Output power	W	0.06	10	240	0.3	300	0.12
Efficiency	%	0.1	0.1	13	7	2.6	7

[a] Junction thickness:width:length.
[b] Pressure dependent.

TABLE 5. Properties and Performance of Some Pulsed Lasers

		Gas				Liquid	Solid	
Parameter	**Unit**	**Carbon dioxide**		**Krypton fluoride**		**Rhodamine 6G**	**Nd:YAG**	**Nd:glass**
Excitation method		TEA-discharge	E- beam/sust.	Glow discharge	E-beam	Xenon flashlamp	Xenon flashlamp	Xenon flashlamp
Gain medium composition		CO_2:N_2:He	CO_2:N_2:He	He:Kr:F_2	Ar:Kr:F_2	Rh6G:alcohol	Nd:YAG	Nd:Glass
Gain medium density	torr	100:50:600	240:240:320	1070:70:3	1235:52:3			–
	ions/cm^3					1(18):1.5(22)	1.5(20):1(22)	3(20):2(22)
Wavelength	nm	10600	10600	249	249	590	1064	1061
Laser cross-section	cm^{-2}	2(-18)	2(-18)	2(-16)	2(-16)	1.8(-16)	7(-19)	2.8(-20)
Radiative lifetime (upper level)	s	4(-3)	4(-3)	7(-9)	7(-9)	6.5(-9)	2.6(-4)	4.1(-4)
Decay lifetime (upper level)	s	~1(-4)	5(-5)	2(-9)	3(-9)	6.0(-9)	2.3(-4)	3.7(-4)
Gain bandwidth	nm	1	1	2	2	80	0.5	26
Homogeneous saturation fluence	J/cm^2	0.2	0.2	4(-3)	4(-3)	2(-3)	0.6	~5
Decay lifetime (lower level)	s	5(-8)[a]	1(-8)[a]	< 1(-12)	<1(-12)	<1(-12)	<1(-7)	<1(-8)
Inversion density	cm^{-3}	3(17)	6(17)	4(14)	2(14)	2(16)	4(17)	3(18)
Small signal gain coefficient	cm^{-1}	2(-2)	4(-2)	8–92)	4(-2)	4	0.3	8(-2)
Medium excitation energy density	J/cm^3	0.1	0.36	0.15	0.13	2.8	0.15	0.6
Output energy density	J/cm^3	2(-2)	1.8(-2)	1.5(-3)	1.2(-2)	0.85	5(-2)	2(-2)
Laser dimensions	cm: cm: cm	4.5:4.5:87	10:10:100	1.5:4.5:100	8.5:10:100	1.2:25	0.6:7.5	0.6:8.3
Excitation current/voltage	A/V	6(4)/3.3(3)	2.4(4)/4(4)	2.5(4)/1.5(5)	1.2(4)/2.5(5)	2(5)/2.5(4)		
Excitation current density	A cm^2	8.5	22	170	11.5	2.6(3)		
Excitation peak power	W	2(8)	9(8)	4(9)	3(9)	5.4(9)	4(4)	9(4)
Output pulse energy	J	35	180	1	102	32	0.1	1.0
Output pulse length	s	1(-6)	4(-6)	2.5(-8)	6(-7)	3.2(-6)	2(-8)	1(-4)
Output pulse power	W	3.5(7)	4(7)	4(7)	2(8)	1(7)	5(6)	1(4)
Efficiency	%	17	5	1	10[b]	0.2	1.5	3.7

[a] Pressure dependent.
[b] Intrinsic efficiency ≡ energy output/energy deposited in gas.

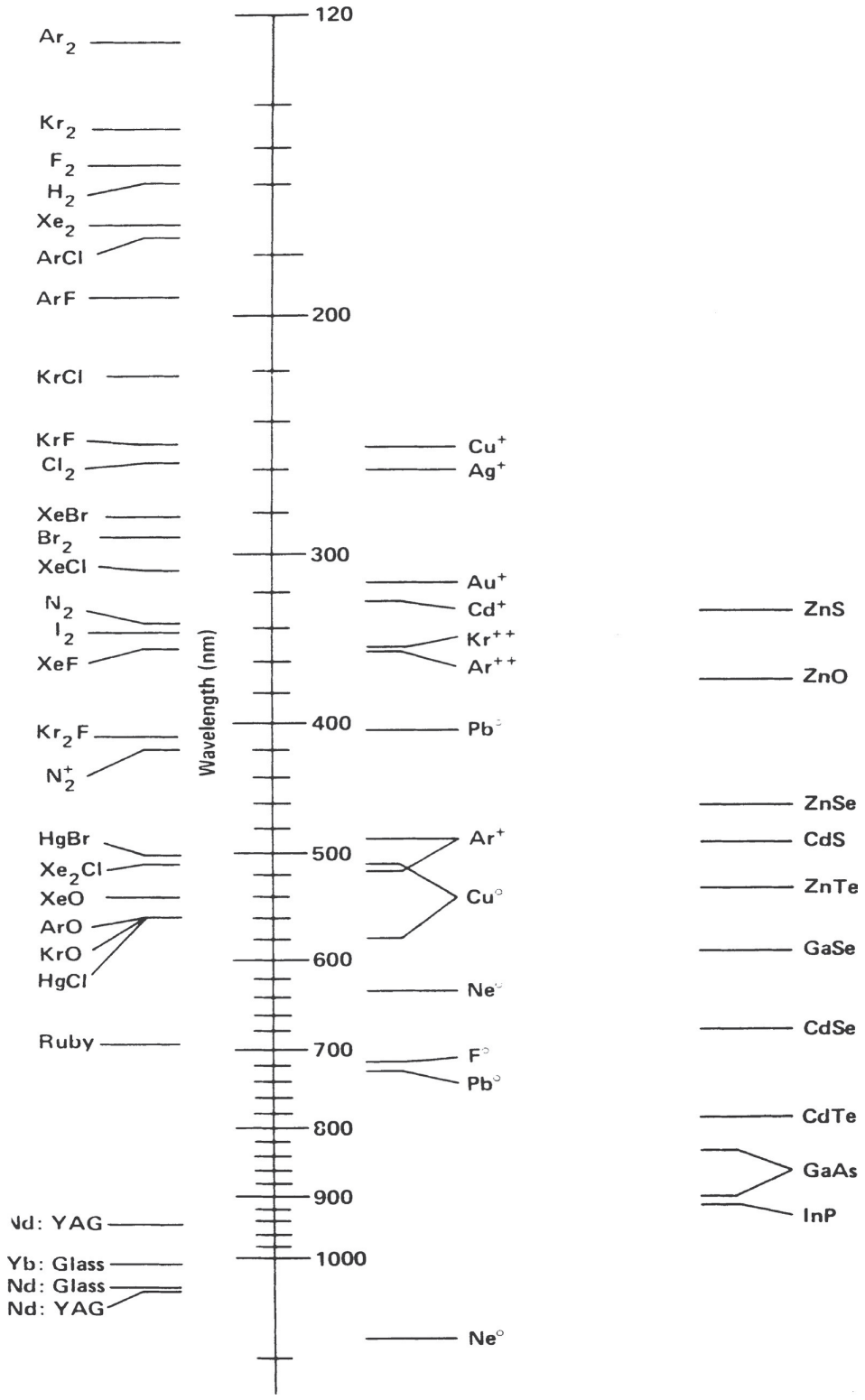

FIGURE 1A. Wavelengths of lasers operating in the 120 to 1200 nm spectral region.

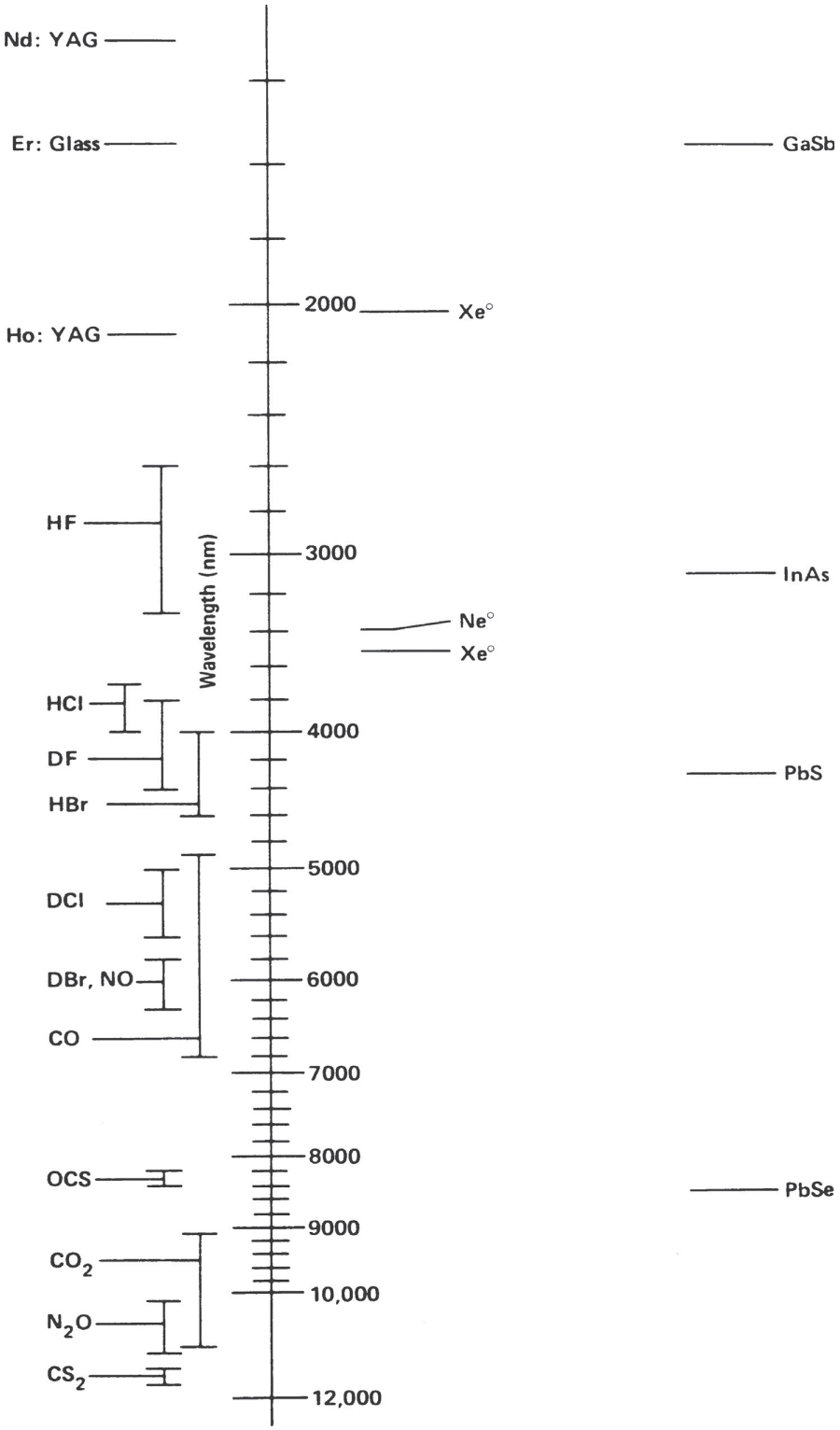

FIGURE 1B. Wavelength of lasers operating in the 1300 to 12,000 nm spectral region.

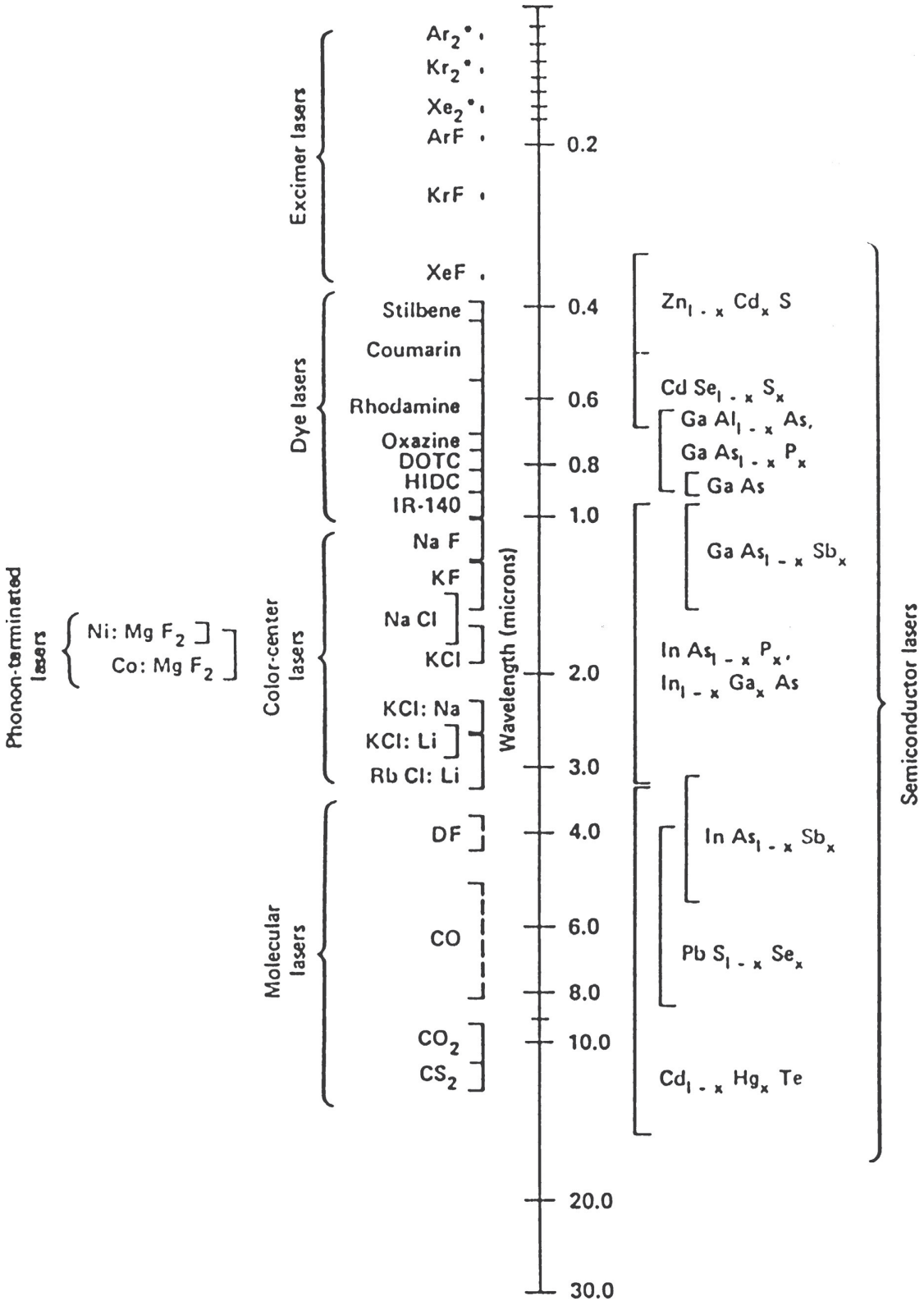

FIGURE 2. Spectral tuning ranges of various types of tunable lasers.

INFRARED LASER FREQUENCIES

Arthur Maki

The CO_2 laser has been the subject of a number of very accurate frequency measurements. Most of the earlier measurements are given by Bradley et al.[1] That analysis was based on a single absolute frequency measurement and many laser frequency differences. New measurements of the methane frequency[2-4] have made it necessary to slightly revise that single absolute frequency measurement. In addition, there have been several other absolute frequency measurements[5-7] that have been used here to improve the accuracy of the present tables. New frequency difference measurements have also been added to the database used for the present tables.[8]

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Frequencies for the $00^{\circ}1\text{-}(10^{\circ}0,02^{\circ}0)_{I}$ and $00^{\circ}1\text{-}(10^{\circ}0,02^{\circ}0)_{II}$ Bands of $^{12}C^{16}O_2$ with the Estimated 2-σ Uncertainties

Line	Band I frequency (MHz)	Uncertainty (MHz)	Line	Band II frequency (MHz)	Uncertainty (MHz)
P(70)	26721305.4647	0.1680	P(70)	29789856.3783	0.0308
P(68)	26794232.6712	0.1217	P(68)	29861850.7690	0.0192
P(66)	26866318.8073	0.0867	P(66)	29933216.1760	0.0122
P(64)	26937571.7234	0.0606	P(64)	30003944.2861	0.0086
P(62)	27007998.9216	0.0415	P(62)	30074026.9127	0.0072
P(60)	27077607.5643	0.0279	P(60)	30143456.0039	0.0066
P(58)	27146404.4834	0.0185	P(58)	30212223.6504	0.0061
P(56)	27214396.1873	0.0121	P(56)	30280322.0930	0.0055
P(54)	27281588.8696	0.0081	P(54)	30347743.7306	0.0049
P(52)	27347988.4161	0.0057	P(52)	30414481.1273	0.0044
P(50)	27413600.4119	0.0043	P(50)	30480527.0196	0.0041
P(48)	27478430.1487	0.0036	P(48)	30545874.3239	0.0039
P(46)	27542482.6310	0.0032	P(46)	30610516.1429	0.0039
P(44)	27605762.5826	0.0030	P(44)	30674445.7724	0.0039
P(42)	27668274.4525	0.0028	P(42)	30737656.7080	0.0039
P(40)	27730022.4206	0.0027	P(40)	30800142.6511	0.0039
P(38)	27791010.4036	0.0026	P(38)	30861897.5150	0.0038
P(36)	27851242.0594	0.0025	P(36)	30922915.4310	0.0037
P(34)	27910720.7927	0.0024	P(34)	30983190.7534	0.0037
P(32)	27969449.7593	0.0023	P(32)	31042718.0652	0.0037
P(30)	28027431.8708	0.0022	P(30)	31101492.1833	0.0036
P(28)	28084669.7981	0.0021	P(28)	31159508.1631	0.0037
P(26)	28141165.9762	0.0020	P(26)	31216761.3029	0.0037
P(24)	28196922.6067	0.0019	P(24)	31273247.1487	0.0037
P(22)	28251941.6622	0.0017	P(22)	31328961.4978	0.0037
P(20)	28306224.8888	0.0016	P(20)	31383900.4028	0.0037
P(18)	28359773.8090	0.0014	P(18)	31438060.1749	0.0037
P(16)	28412589.7245	0.0012	P(16)	31491437.3872	0.0036
P(14)	28464673.7184	0.0011	P(14)	31544028.8776	0.0036
P(12)	28516026.6574	0.0009	P(12)	31595831.7516	0.0036
P(10)	28566649.1935	0.0008	P(10)	31646843.3843	0.0035
P(8)	28616541.7661	0.0008	P(8)	31697061.4225	0.0035
P(6)	28665704.6027	0.0008	P(6)	31746483.7868	0.0035
P(4)	28714137.7205	0.0008	P(4)	31795108.6724	0.0035
P(2)	28761840.9272	0.0008	P(2)	31842934.5511	0.0035
R(0)	28832026.2198	0.0008	R(0)	31913172.5691	0.0035
R(2)	28877902.4382	0.0007	R(2)	31958996.0621	0.0034
R(4)	28923046.4303	0.0006	R(4)	32004017.3822	0.0034

Line	Band I frequency (MHz)	Uncertainty (MHz)	Line	Band II frequency (MHz)	Uncertainty (MHz)
R(6)	28967457.0657	0.0005	R(6)	32048236.2498	0.0034
R(8)	29011133.0054	0.0003	R(8)	32091652.6619	0.0034
R(10)	29054072.7010	0.0001	R(10)	32134266.8917	0.0034
R(12)	29096274.3935	0.0003	R(12)	32176079.4878	0.0034
R(14)	29137736.1129	0.0005	R(14)	32217091.2721	0.0035
R(16)	29178455.6759	0.0007	R(16)	32257303.3386	0.0036
R(18)	29218430.6852	0.0009	R(18)	32296717.0510	0.0037
R(20)	29257658.5269	0.0010	R(20)	32335334.0408	0.0038
R(22)	29296136.3689	0.0011	R(22)	32373156.2044	0.0039
R(24)	29333861.1583	0.0012	R(24)	32410185.7003	0.0041
R(26)	29370829.6191	0.0011	R(26)	32446424.9459	0.0042
R(28)	29407038.2491	0.0011	R(28)	32481876.6140	0.0042
R(30)	29442483.3168	0.0011	R(30)	32516543.6293	0.0042
R(32)	29477160.8582	0.0012	R(32)	32550429.1641	0.0042
R(34)	29511066.6733	0.0013	R(34)	32583536.6340	0.0042
R(36)	29544196.3221	0.0015	R(36)	32615869.6937	0.0041
R(38)	29576545.1205	0.0017	R(38)	32647432.2320	0.0040
R(40)	29608108.1360	0.0019	R(40)	32678228.3665	0.0039
R(42)	29638880.1831	0.0022	R(42)	32708262.4386	0.0038
R(44)	29668855.8183	0.0024	R(44)	32737539.0081	0.0039
R(46)	29698029.3350	0.0027	R(46)	32766062.8469	0.0041
R(48)	29726394.7582	0.0032	R(48)	32793838.9334	0.0045
R(50)	29753945.8385	0.0037	R(50)	32820872.4463	0.0055
R(52)	29780676.0464	0.0042	R(52)	32847168.7576	0.0071
R(54)	29806578.5659	0.0047	R(54)	32872733.4269	0.0099
R(56)	29831646.2878	0.0052	R(56)	32897572.1935	0.0141
R(58)	29855871.8032	0.0058	R(58)	32921690.9701	0.0202
R(60)	29879247.3960	0.0074	R(60)	32945095.8355	0.0288
R(62)	29901765.0357	0.0113	R(62)	32967793.0268	0.0407
R(64)	29923416.3695	0.0186	R(64)	32989788.9322	0.0567
R(66)	29944192.7145	0.0302	R(66)	33011090.0831	0.0780
R(68)	29964085.0488	0.0475	R(68)	33031703.1467	0.1060
R(70)	29983084.0036	0.0720	R(70)	33051634.9172	0.1423

Frequencies for the $00^{\circ}1\text{-}(10^{\circ}0,02^{\circ}0)_{I}$ and $00^{\circ}1\text{-}(10^{\circ}0,02^{\circ}0)_{II}$ Bands of $^{13}C^{16}O_2$ with the Estimated 2-σ Uncertainties

P(66)	25523832.1808	0.7836	P(66)	28512082.5283	1.2894
P(64)	25590013.4703	0.5415	P(64)	28585121.9396	0.9194
P(62)	25655543.6502	0.3629	P(62)	28657449.4180	0.6420
P(60)	25720428.2487	0.2339	P(60)	28729056.6374	0.4375
P(58)	25784672.4840	0.1430	P(58)	28799935.4147	0.2897
P(56)	25848281.2771	0.0810	P(56)	28870077.7187	0.1853
P(54)	25911259.2627	0.0405	P(54)	28939475.6771	0.1135
P(52)	25973610.8005	0.0157	P(52)	29008121.5846	0.0659
P(50)	26035339.9857	0.0045	P(50)	29076007.9109	0.0357
P(48)	26096450.6582	0.0079	P(48)	29143127.3077	0.0180
P(46)	26156946.4123	0.0101	P(46)	29209472.6164	0.0090
P(44)	26216830.6053	0.0101	P(44)	29275036.8754	0.0058
P(42)	26276106.3655	0.0090	P(42)	29339813.3270	0.0050
P(40)	26334776.6003	0.0077	P(40)	29403795.4243	0.0044
P(38)	26392844.0030	0.0068	P(38)	29466976.8383	0.0037
P(36)	26450311.0599	0.0063	P(36)	29529351.4635	0.0032
P(34)	26507180.0565	0.0061	P(34)	29590913.4252	0.0029
P(32)	26563453.0836	0.0060	P(32)	29651657.0844	0.0028
P(30)	26619132.0428	0.0058	P(30)	29711577.0447	0.0028
P(28)	26674218.6515	0.0055	P(28)	29770668.1566	0.0031
P(26)	26728714.4479	0.0054	P(26)	29828925.5239	0.0035
P(24)	26782620.7952	0.0054	P(24)	29886344.5074	0.0041
P(22)	26835938.8858	0.0054	P(22)	29942920.7308	0.0046
P(20)	26888669.7451	0.0055	P(20)	29998650.0838	0.0051
P(18)	26940814.2347	0.0055	P(18)	30053528.7271	0.0054

Line	Band I frequency (MHz)	Uncertainty (MHz)	Line	Band II frequency (MHz)	Uncertainty (MHz)
P(16)	26992373.0555	0.0055	P(16)	30107553.0955	0.0055
P(14)	27043346.7508	0.0054	P(14)	30160719.9016	0.0055
P(12)	27093735.7083	0.0052	P(12)	30213026.1388	0.0054
P(10)	27143540.1624	0.0051	P(10)	30264469.0839	0.0054
P(8)	27192760.1962	0.0049	P(8)	30315046.2994	0.0054
P(6)	27241395.7431	0.0048	P(6)	30364755.6359	0.0055
P(4)	27289446.5880	0.0047	P(4)	30413595.2335	0.0056
P(2)	27336912.3682	0.0046	P(2)	30461563.5231	0.0057
R(0)	27407012.8882	0.0045	P(0)	30531879.5415	0.0057
R(2)	27453013.4589	0.0043	P(2)	30577664.6138	0.0056
R(4)	27498426.5430	0.0040	P(4)	30622575.1885	0.0054
R(6)	27543251.1200	0.0037	P(6)	30666611.0128	0.0051
R(8)	27587486.0225	0.0034	P(8)	30709772.1257	0.0047
R(10)	27631129.9356	0.0031	P(10)	30752058.8571	0.0045
R(12)	27674181.3963	0.0029	P(12)	30793471.8269	0.0044
R(14)	27716638.7917	0.0029	P(14)	30834011.9425	0.0043
R(16)	27758500.3577	0.0029	P(16)	30873680.3976	0.0044
R(18)	27799764.1770	0.0029	P(18)	30912478.6694	0.0044
R(20)	27840428.1773	0.0030	P(20)	30950408.5159	0.0044
R(22)	27880490.1283	0.0029	P(22)	30987471.9732	0.0043
R(24)	27919947.6395	0.0029	P(24)	31023671.3517	0.0042
R(26)	27958798.1567	0.0028	P(26)	31059009.2327	0.0042
R(28)	27997038.9591	0.0028	P(28)	31093488.4642	0.0042
R(30)	28034667.1551	0.0027	P(30)	31127112.1569	0.0043
R(32)	28071679.6785	0.0027	P(32)	31159883.6793	0.0045
R(34)	28108073.2842	0.0026	P(34)	31191806.6529	0.0046
R(36)	28143844.5432	0.0026	P(36)	31222884.9469	0.0048
R(38)	28178989.8377	0.0026	P(38)	31253122.6730	0.0053
R(40)	28213505.3554	0.0028	P(40)	31282524.1795	0.0061
R(42)	28247387.0838	0.0033	P(42)	31311094.0452	0.0077
R(44)	28280630.8035	0.0046	P(44)	31338837.0736	0.0108
R(46)	28313232.0818	0.0083	P(46)	31365758.2858	0.0173
R(48)	28345186.2652	0.0161	P(48)	31391862.9147	0.0295
R(50)	28376488.4720	0.0301	P(50)	31417156.3972	0.0505
R(52)	28407133.5839	0.0531	P(52)	31441644.3679	0.0845
R(54)	28437116.2372	0.0887	P(54)	31465332.6516	0.1366
R(56)	28466430.8141	0.1419	P(56)	31488227.2557	0.2138
R(58)	28495071.4324	0.2188	P(58)	31510334.3631	0.3247
R(60)	28523031.9357	0.3271	P(60)	31531660.3243	0.4800
R(62)	28550305.8819	0.4763	P(62)	31552211.6497	0.6932
R(64)	28576886.5323	0.6781	P(64)	31571995.0017	0.9805
R(66)	28602766.8393	0.9467	P(66)	31591017.1868	1.3619

Frequencies for the 00°1-(10°0,02°0)$_{I}$ and 00°1-(10°0,02°0)$_{II}$ Bands of $^{12}C^{18}O_2$ with the Estimated 2-σ Uncertainties

P(70)	27045326.3119	0.4540	P(70)	30695237.5856	0.0858
P(68)	27114914.0922	0.3324	P(68)	30755520.2231	0.0570
P(66)	27183635.7945	0.2392	P(66)	30815311.4928	0.0364
P(64)	27251496.4118	0.1688	P(64)	30874607.2084	0.0223
P(62)	27318500.7361	0.1165	P(62)	30933403.2309	0.0131
P(60)	27384653.3618	0.0783	P(60)	30991695.4724	0.0075
P(58)	27449958.6881	0.0510	P(58)	31049479.9009	0.0049
P(56)	27514420.9224	0.0319	P(56)	31106752.5446	0.0041
P(54)	27578044.0828	0.0191	P(54)	31163509.4964	0.0040
P(52)	27640832.0010	0.0108	P(52)	31219746.9183	0.0040
P(50)	27702788.3248	0.0059	P(50)	31275461.0455	0.0039
P(48)	27763916.5206	0.0035	P(48)	31330648.1908	0.0039
P(46)	27824219.8762	0.0028	P(46)	31385304.7490	0.0039
P(44)	27883701.5029	0.0026	P(44)	31439427.2006	0.0039
P(42)	27942364.3379	0.0025	P(42)	31493012.1163	0.0038
P(40)	28000211.1464	0.0024	P(40)	31546056.1605	0.0038

Line	Band I frequency (MHz)	Uncertainty (MHz)	Line	Band II frequency (MHz)	Uncertainty (MHz)
P(38)	28057244.5242	0.0022	P(38)	31598556.0954	0.0037
P(36)	28113466.8992	0.0021	P(36)	31650508.7847	0.0037
P(34)	28168880.5335	0.0020	P(34)	31701911.1970	0.0037
P(32)	28223487.5256	0.0019	P(32)	31752760.4093	0.0037
P(30)	28277289.8118	0.0017	P(30)	31803053.6105	0.0037
P(28)	28330289.1679	0.0016	P(28)	31852788.1043	0.0038
P(26)	28382487.2111	0.0015	P(26)	31901961.3125	0.0038
P(24)	28433885.4012	0.0013	P(24)	31950570.7773	0.0038
P(22)	28484485.0420	0.0012	P(22)	31998614.1649	0.0038
P(20)	28534287.2828	0.0011	P(20)	32046089.2669	0.0037
P(18)	28583293.1193	0.0010	P(18)	32092994.0036	0.0037
P(16)	28631503.3952	0.0010	P(16)	32139326.4254	0.0036
P(14)	28678918.8025	0.0009	P(14)	32185084.7154	0.0036
P(12)	28725539.8830	0.0010	P(12)	32230267.1907	0.0036
P(10)	28771367.0288	0.0010	P(10)	32274872.3041	0.0037
P(8)	28816400.4829	0.0010	P(8)	32318898.6455	0.0038
P(6)	28860640.3403	0.0011	P(6)	32362344.9434	0.0039
P(4)	28904086.5477	0.0011	P(4)	32405210.0652	0.0041
P(2)	28946738.9048	0.0011	P(2)	32447493.0185	0.0041
R(0)	29009228.1702	0.0010	P(0)	32509824.0580	0.0042
R(2)	29049894.0586	0.0010	P(2)	32550648.1723	0.0042
R(4)	29089764.2368	0.0009	P(4)	32590887.7542	0.0042
R(6)	29128837.8426	0.0008	P(6)	32630542.4457	0.0041
R(8)	29167113.8668	0.0008	P(8)	32669612.0295	0.0041
R(10)	29204591.1529	0.0009	P(10)	32708096.4282	0.0040
R(12)	29241268.3964	0.0010	P(12)	32745995.7040	0.0040
R(14)	29277144.1444	0.0011	P(14)	32783310.0573	0.0040
R(16)	29312216.7955	0.0012	P(16)	32820039.8258	0.0040
R(18)	29346484.5984	0.0012	P(18)	32856185.4827	0.0040
R(20)	29379945.6517	0.0013	P(20)	32891747.6358	0.0040
R(22)	29412597.9024	0.0013	P(22)	32926727.0254	0.0040
R(24)	29444439.1458	0.0013	P(24)	32961124.5220	0.0040
R(26)	29475467.0236	0.0014	P(26)	32994941.1249	0.0040
R(28)	29505679.0230	0.0015	P(28)	33028177.9594	0.0040
R(30)	29535072.4755	0.0016	P(30)	33060836.2743	0.0040
R(32)	29563644.5557	0.0018	P(32)	33092917.4394	0.0041
R(34)	29591392.2794	0.0020	P(34)	33124422.9429	0.0043
R(36)	29618312.5023	0.0023	P(36)	33155354.3878	0.0046
R(38)	29644401.9182	0.0028	P(38)	33185713.4894	0.0049
R(40)	29669657.0575	0.0036	P(40)	33215502.0716	0.0056
R(42)	29694074.2853	0.0053	P(42)	33244722.0637	0.0068
R(44)	29717649.7992	0.0082	P(44)	33273375.4969	0.0092
R(46)	29740379.6276	0.0128	P(46)	33301464.5003	0.0134
R(48)	29762259.6274	0.0200	P(48)	33328991.2976	0.0199
R(50)	29783285.4820	0.0307	P(50)	33355958.2027	0.0294
R(52)	29803452.6988	0.0461	P(52)	33382367.6161	0.0427
R(54)	29822756.6072	0.0681	P(54)	33408222.0209	0.0607
R(56)	29841192.3558	0.0985	P(56)	33433523.9780	0.0848
R(58)	29858754.9100	0.1401	P(58)	33458276.1228	0.1165
R(60)	29875439.0495	0.1960	P(60)	33482481.1601	0.1576
R(62)	29891239.3658	0.2702	P(62)	33506141.8605	0.2104
R(64)	29906150.2589	0.3673	P(64)	33529261.0556	0.2775
R(66)	29920165.9352	0.4930	P(66)	33551841.6335	0.3621
R(68)	29933280.4042	0.6540	P(68)	33573886.5352	0.4679
R(70)	29945487.4756	0.8581	P(70)	33595398.7493	0.5992

Frequencies for the 00°1-(10°0,02°0)$_I$ and 00°1-(10°0,02°0)$_{II}$ Bands of $^{13}C^{18}O_2$ with the Estimated 2-σ Uncertainties

P(70)	25967863.7652	1.1146	P(70)	28960476.2278	0.4069
P(68)	26033448.2798	0.8152	P(68)	29022326.9578	0.2861
P(66)	26098273.9159	0.5860	P(66)	29083661.3546	0.1961

Line	Band I frequency (MHz)	Uncertainty (MHz)	Line	Band II frequency (MHz)	Uncertainty (MHz)
P(64)	26162346.4813	0.4129	P(64)	29144473.5795	0.1303
P(62)	26225671.5466	0.2844	P(62)	29204757.8761	0.0833
P(60)	26288254.4494	0.1906	P(60)	29264508.5768	0.0507
P(58)	26350100.2984	0.1237	P(58)	29323720.1086	0.0290
P(56)	26411213.9778	0.0772	P(56)	29382386.9988	0.0152
P(54)	26471600.1504	0.0459	P(54)	29440503.8809	0.0073
P(52)	26531263.2618	0.0258	P(52)	29498065.4997	0.0038
P(50)	26590207.5442	0.0138	P(50)	29555066.7172	0.0032
P(48)	26648437.0195	0.0077	P(48)	29611502.5178	0.0031
P(46)	26705955.5026	0.0057	P(46)	29667368.0132	0.0031
P(44)	26762766.6051	0.0055	P(44)	29722658.4475	0.0034
P(42)	26818873.7378	0.0055	P(42)	29777369.2022	0.0039
P(40)	26874280.1143	0.0056	P(40)	29831495.8006	0.0044
P(38)	26928988.7531	0.0056	P(38)	29885033.9125	0.0049
P(36)	26983002.4809	0.0056	P(36)	29937979.3584	0.0053
P(34)	27036323.9351	0.0055	P(34)	29990328.1139	0.0054
P(32)	27088955.5657	0.0054	P(32)	30042076.3132	0.0055
P(30)	27140899.6384	0.0051	P(30)	30093220.2534	0.0055
P(28)	27192158.2363	0.0049	P(28)	30143756.3978	0.0054
P(26)	27242733.2620	0.0047	P(26)	30193681.3793	0.0053
P(24)	27292626.4396	0.0044	P(24)	30242992.0038	0.0052
P(22)	27341839.3165	0.0042	P(22)	30291685.2529	0.0051
P(20)	27390373.2651	0.0040	P(20)	30339758.2870	0.0049
P(18)	27438229.4843	0.0037	P(18)	30387208.4477	0.0048
P(16)	27485409.0008	0.0035	P(16)	30434033.2603	0.0046
P(14)	27531912.6704	0.0033	P(14)	30480230.4356	0.0045
P(12)	27577741.1795	0.0031	P(12)	30525797.8725	0.0044
P(10)	27622895.0455	0.0031	P(10)	30570733.6593	0.0043
P(8)	27667374.6182	0.0031	P(8)	30615036.0750	0.0043
P(6)	27711180.0803	0.0033	P(6)	30658703.5912	0.0044
P(4)	27754311.4480	0.0034	P(4)	30701734.8727	0.0045
P(2)	27796768.5718	0.0036	P(2)	30744128.7785	0.0045
R(0)	27859189.3155	0.0036	P(0)	30806522.5414	0.0045
R(2)	27899959.0889	0.0035	P(2)	30847319.2956	0.0044
R(4)	27940052.7921	0.0033	P(4)	30887476.2168	0.0043
R(6)	27979469.5315	0.0031	P(6)	30926993.0424	0.0042
R(8)	28018208.2478	0.0028	P(8)	30965869.7046	0.0041
R(10)	28056267.7161	0.0026	P(10)	31004106.3298	0.0040
R(12)	28093646.5448	0.0025	P(12)	31041703.2379	0.0040
R(14)	28130343.1757	0.0025	P(14)	31078660.9408	0.0040
R(16)	28166355.8825	0.0025	P(16)	31114980.1420	0.0040
R(18)	28201682.7706	0.0025	P(18)	31150661.7340	0.0041
R(20)	28236321.7757	0.0025	P(20)	31185706.7976	0.0042
R(22)	28270270.6628	0.0024	P(22)	31220116.5992	0.0043
R(24)	28303527.0249	0.0024	P(24)	31253892.5891	0.0043
R(26)	28336088.2817	0.0023	P(26)	31287036.3991	0.0044
R(28)	28367951.6781	0.0024	P(28)	31319549.8396	0.0043
R(30)	28399114.2823	0.0025	P(30)	31351434.8973	0.0043
R(32)	28429572.9843	0.0026	P(32)	31382693.7318	0.0042
R(34)	28459324.4940	0.0028	P(34)	31413328.6728	0.0042
R(36)	28488365.3390	0.0029	P(36)	31443342.2165	0.0041
R(38)	28516691.8625	0.0029	P(38)	31472737.0219	0.0040
R(40)	28544300.2211	0.0031	P(40)	31501515.9074	0.0039
R(42)	28571186.3823	0.0032	P(42)	31529681.8467	0.0040
R(44)	28597346.1222	0.0032	P(44)	31557237.9646	0.0042
R(46)	28622775.0223	0.0038	P(46)	31584187.5329	0.0046
R(48)	28647468.4672	0.0071	P(48)	31610533.9656	0.0057
R(50)	28671421.6417	0.0148	P(50)	31636280.8146	0.0088
R(52)	28694629.5272	0.0286	P(52)	31661431.7650	0.0151
R(54)	28717086.8993	0.0510	P(54)	31685990.6298	0.0261
R(56)	28738788.3239	0.0852	P(56)	31709961.3449	0.0434

Line	Band I frequency (MHz)	Uncertainty (MHz)	Line	Band II frequency (MHz)	Uncertainty (MHz)
R(58)	28759728.1540	0.1355	P(58)	31733347.9642	0.0693
R(60)	28779900.5263	0.2075	P(60)	31756154.6537	0.1068
R(62)	28799299.3572	0.3078	P(62)	31778385.6867	0.1594
R(64)	28817918.3393	0.4447	P(64)	31800045.4375	0.2317
R(66)	28835750.9374	0.6283	P(66)	31821138.3761	0.3291
R(68)	28852790.3843	0.8707	P(68)	31841669.0622	0.4581
R(70)	28869029.6768	1.1863	P(70)	31861642.1394	0.6268

Frequencies for the $01^{1e}1\text{-}(11^{1e}0,03^{1e}0)_I$ and $01^{1e}1\text{-}(11^{1e}0,03^{1e}0)_{II}$ Bands of $^{12}C^{16}O_2$ with the Estimated 2-σ Uncertainties

P(59)	26125213.2723	1.6633	P(59)	30427055.2899	0.1962
P(57)	26191576.6703	1.0880	P(57)	30494640.3229	0.1332
P(55)	26257240.7898	0.6844	P(55)	30561557.5929	0.0865
P(53)	26322208.2302	0.4094	P(53)	30627802.0344	0.0530
P(51)	26386481.4313	0.2286	P(51)	30693368.7014	0.0306
P(49)	26450062.6783	0.1155	P(49)	30758252.7710	0.0175
P(47)	26512954.1076	0.0498	P(47)	30822449.5469	0.0123
P(45)	26575157.7109	0.0191	P(45)	30885954.4624	0.0114
P(43)	26636675.3402	0.0160	P(43)	30948763.0834	0.0109
P(41)	26697508.7115	0.0182	P(41)	31010871.1119	0.0100
P(39)	26757659.4084	0.0177	P(39)	31072274.3882	0.0091
P(37)	26817128.8857	0.0160	P(37)	31132968.8940	0.0091
P(35)	26875918.4726	0.0144	P(35)	31192950.7549	0.0102
P(33)	26934029.3751	0.0131	P(33)	31252216.2430	0.0118
P(31)	26991462.6787	0.0119	P(31)	31310761.7788	0.0134
P(29)	27048219.3509	0.0106	P(29)	31368583.9339	0.0147
P(27)	27104300.2431	0.0096	P(27)	31425679.4328	0.0155
P(25)	27159706.0925	0.0093	P(25)	31482045.1550	0.0157
P(23)	27214437.5237	0.0097	P(23)	31537678.1367	0.0154
P(21)	27268495.0505	0.0104	P(21)	31592575.5725	0.0147
P(19)	27321879.0769	0.0108	P(19)	31646734.8172	0.0137
P(17)	27374589.8987	0.0108	P(17)	31700153.3868	0.0127
P(15)	27426627.7040	0.0104	P(15)	31752828.9602	0.0119
P(13)	27477992.5747	0.0098	P(13)	31804759.3803	0.0113
P(11)	27528684.4867	0.0096	P(11)	31855942.6551	0.0113
P(9)	27578703.3113	0.0101	P(9)	31906376.9582	0.0116
P(7)	27628048.8151	0.0113	P(7)	31956060.6304	0.0122
P(5)	27676720.6609	0.0127	P(5)	32004992.1796	0.0129
P(3)	27724718.4080	0.0141	P(3)	32053170.2819	0.0136
R(1)	27841759.7696	0.0152	P(1)	32170312.0391	0.0149
R(3)	27887393.2105	0.0146	P(3)	32215845.0845	0.0151
R(5)	27932349.2934	0.0135	P(5)	32260620.8121	0.0152
R(7)	27976627.0108	0.0124	P(7)	32304638.8261	0.0152
R(9)	28020225.2521	0.0115	P(9)	32347898.8990	0.0150
R(11)	28063142.8031	0.0110	P(11)	32390400.9714	0.0148
R(13)	28105378.3457	0.0109	P(13)	32432145.1513	0.0145
R(15)	28146930.4576	0.0109	P(15)	32473131.7137	0.0142
R(17)	28187797.6116	0.0107	P(17)	32513361.0997	0.0140
R(19)	28227978.1750	0.0103	P(19)	32552833.9153	0.0140
R(21)	28267470.4088	0.0099	P(21)	32591550.9309	0.0141
R(23)	28306272.4666	0.0099	P(23)	32629513.0796	0.0143
R(25)	28344382.3939	0.0107	P(25)	32666721.4564	0.0144
R(27)	28381798.1267	0.0122	P(27)	32703177.3164	0.0142
R(29)	28418517.4902	0.0141	P(29)	32738882.0732	0.0136
R(31)	28454538.1976	0.0165	P(31)	32773837.2976	0.0136
R(33)	28489857.8477	0.0213	P(33)	32808044.7156	0.0174
R(35)	28524473.9240	0.0312	P(35)	32841506.2063	0.0279
R(37)	28558383.7917	0.0486	P(37)	32874223.8000	0.0462
R(39)	28591584.6963	0.0754	P(39)	32906199.6761	0.0735
R(41)	28624073.7602	0.1131	P(41)	32937436.1606	0.1114
R(43)	28655847.9806	0.1644	P(43)	32967935.7238	0.1624
R(45)	28686904.2261	0.2328	P(45)	32997700.9775	0.2292

Line	Band I frequency (MHz)	Uncertainty (MHz)	Line	Band II frequency (MHz)	Uncertainty (MHz)
R(47)	28717239.2334	0.3239	P(47)	33026734.6728	0.3151
R(49)	28746849.6038	0.4465	P(49)	33055039.6965	0.4238
R(51)	28775731.7988	0.6142	P(51)	33082619.0689	0.5595
R(53)	28803882.1361	0.8465	P(53)	33109475.9403	0.7272

Frequencies for the $01^{1f}1\text{-}(11^{1f}0,03^{1f}0)_I$ and $01^{1f}1\text{-}(11^{1f}0,03^{1f}0)_{II}$ Bands of $^{12}C^{16}O_2$ with the Estimated 2-σ Uncertainties

P(60)	26051570.0104	4.4521	P(60)	30355115.0204	0.2752
P(58)	26120964.4932	3.0629	P(58)	30425283.5969	0.1926
P(56)	26189552.8496	2.0516	P(56)	30494732.8293	0.1301
P(54)	26257339.6006	1.3305	P(54)	30563455.6325	0.0840
P(52)	26324329.0344	0.8289	P(52)	30631445.1076	0.0512
P(50)	26390525.2136	0.4901	P(50)	30698694.5456	0.0292
P(48)	26455931.9824	0.2698	P(48)	30765197.4310	0.0163
P(46)	26520552.9722	0.1334	P(46)	30830947.4444	0.0111
P(44)	26584391.6075	0.0551	P(44)	30895938.4662	0.0104
P(42)	26647451.1105	0.0181	P(42)	30960164.5794	0.0105
P(40)	26709734.5057	0.0151	P(40)	31023620.0723	0.0105
P(38)	26771244.6242	0.0174	P(38)	31086299.4415	0.0107
P(36)	26831984.1067	0.0157	P(36)	31148197.3941	0.0114
P(34)	26891955.4069	0.0126	P(34)	31209308.8510	0.0126
P(32)	26951160.7945	0.0105	P(32)	31269628.9481	0.0138
P(30)	27009602.3576	0.0096	P(30)	31329153.0395	0.0147
P(28)	27067282.0045	0.0092	P(28)	31387876.6994	0.0151
P(26)	27124201.4662	0.0090	P(26)	31445795.7236	0.0149
P(24)	27180362.2977	0.0089	P(24)	31502906.1318	0.0141
P(22)	27235765.8792	0.0090	P(22)	31559204.1695	0.0128
P(20)	27290413.4182	0.0093	P(20)	31614686.3091	0.0113
P(18)	27344305.9494	0.0096	P(18)	31669349.2515	0.0098
P(16)	27397444.3368	0.0097	P(16)	31723189.9280	0.0086
P(14)	27449829.2733	0.0096	P(14)	31776205.5007	0.0081
P(12)	27501461.2824	0.0096	P(12)	31828393.3642	0.0085
P(10)	27552340.7179	0.0101	P(10)	31879751.1463	0.0095
P(8)	27602467.7649	0.0111	P(8)	31930276.7092	0.0107
P(6)	27651842.4399	0.0125	P(6)	31979968.1497	0.0120
P(4)	27700464.5912	0.0139	P(4)	32028823.8002	0.0131
P(2)	27748333.8988	0.0148	P(2)	32076842.2290	0.0139
R(2)	27864709.8633	0.0146	P(2)	32193218.1935	0.0150
R(4)	27909939.2762	0.0135	P(4)	32238298.4853	0.0151
R(6)	27954412.3294	0.0122	P(6)	32282538.0393	0.0153
R(8)	27998127.7801	0.0112	P(8)	32325936.7244	0.0153
R(10)	28041084.2173	0.0107	P(10)	32368494.6458	0.0154
R(12)	28083280.0620	0.0108	P(12)	32410212.1438	0.0155
R(14)	28124713.5668	0.0110	P(14)	32451089.7941	0.0155
R(16)	28165382.8151	0.0112	P(16)	32491128.4063	0.0154
R(18)	28205285.7213	0.0111	P(18)	32530329.0234	0.0152
R(20)	28244420.0302	0.0110	P(20)	32568692.9211	0.0149
R(22)	28282783.3158	0.0114	P(22)	32606221.6061	0.0147
R(24)	28320372.9812	0.0129	P(24)	32642916.8154	0.0144
R(26)	28357186.2574	0.0149	P(26)	32678780.5147	0.0140
R(28)	28393220.2023	0.0168	P(28)	32713814.8971	0.0133
R(30)	28428471.6994	0.0175	P(30)	32748022.3813	0.0120
R(32)	28462937.4565	0.0165	P(32)	32781405.6101	0.0106
R(34)	28496614.0042	0.0142	P(34)	32813967.4482	0.0122
R(36)	28529497.6934	0.0163	P(36)	32845710.9809	0.0212
R(38)	28561584.6939	0.0309	P(38)	32876639.5111	0.0385
R(40)	28592870.9914	0.0593	P(40)	32906756.5580	0.0646
R(42)	28623352.3850	0.1054	P(42)	32936065.8540	0.1015
R(44)	28653024.4839	0.1779	P(44)	32964571.3426	0.1518
R(46)	28681882.7038	0.2907	P(46)	32992277.1760	0.2184
R(48)	28709922.2632	0.4635	P(48)	33019187.7118	0.3048
R(50)	28737138.1785	0.7231	P(50)	33045307.5105	0.4152

INFRARED AND FAR-INFRARED ABSORPTION FREQUENCY STANDARDS

Arthur Maki

Aside from the CO_2 laser transitions, the absorption spectrum of CO has been more accurately and thoroughly measured than any other spectrum. A bibliography of earlier measurements on CO is given by Maki and Wells,[1] and the present tables were calculated from the measurements referred to in that work. In addition, some new and very accurate frequency measurements[2,3] have been made and were incorporated in the present tables. The frequencies of the rotational transitions of HF and HCl were calculated from constants obtained from fitting the measurements of Evenson et al.[4,5] and Jennings and Wells.[6]

A new report on infrared wavenumber standards from the International Union of Pure and Applied Chemistry, Commission on Molecular Structure and Spectroscopy, may be found in Reference 7.

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Wavenumbers for the $\nu = 1 - 0$ Band of CO

Wavenumber (unc)*/cm^{-1}	Transition	Wavenumber (unc)/cm^{-1}	Transition
		2147.081132(01)	R(0)
2139.426071(01)	P(1)	2150.856006(01)	R(1)
2135.546178(01)	P(2)	2154.595581(01)	R(2)
2131.631574(01)	P(3)	2158.299710(01)	R(3)
2127.682404(01)	P(4)	2161.968245(01)	R(4)
2123.698816(01)	P(5)	2165.601041(01)	R(5)
2119.680957(01)	P(6)	2169.197949(01)	R(6)
2115.628973(01)	P(7)	2172.758824(01)	R(7)
2111.543012(01)	P(8)	2176.283519(01)	R(8)
2107.423221(01)	P(9)	2179.771887(01)	R(9)
2103.269746(01)	P(10)	2183.223782(01)	R(10)
2099.082734(01)	P(11)	2186.639057(01)	R(11)
2094.862333(01)	P(12)	2190.017565(01)	R(12)
2090.608688(01)	P(13)	2193.359161(01)	R(13)
2086.321947(01)	P(14)	2196.663698(01)	R(14)
2082.002256(01)	P(15)	2199.931030(01)	R(15)
2077.649762(01)	P(16)	2203.161010(01)	R(16)
2073.264612(01)	P(17)	2206.353492(01)	R(17)
2068.846952(01)	P(18)	2209.508331(02)	R(18)
2064.396929(01)	P(19)	2212.625379(02)	R(19)
2059.914688(02)	P(20)	2215.704492(02)	R(20)
2055.400377(02)	P(21)	2218.745522(02)	R(21)
2050.854140(02)	P(22)	2221.748326(03)	R(22)
2046.276126(03)	P(23)	2224.712755(03)	R(23)
2041.666479(03)	P(24)	2227.638666(03)	R(24)
2037.025345(03)	P(25)	2230.525912(04)	R(25)
2032.352870(04)	P(26)	2233.374349(04)	R(26)
2027.649200(04)	P(27)	2236.183829(04)	R(27)
2022.914480(04)	P(28)	2238.954210(05)	R(28)
2018.148857(05)	P(29)	2241.685344(05)	R(29)
2013.352474(05)	P(30)	2244.377088(06)	R(30)
2008.525477(06)	P(31)	2247.029296(07)	R(31)
2003.668012(06)	P(32)	2249.641824(08)	R(32)
1998.780224(07)	P(33)	2252.214527(10)	R(33)
1993.862257(09)	P(34)	2254.747262(14)	R(34)
1988.914257(11)	P(35)	2257.239883(18)	R(35)
1983.936367(14)	P(36)	2259.692248(24)	R(36)
1978.928733(18)	P(37)	2262.104213(33)	R(37)
1973.891500(25)	P(38)	2264.475634(45)	R(38)

Wavenumbers for the $\nu = 1 - 0$ Band of CO

Wavenumber (unc)*/cm^{-1}	Transition	Wavenumber (unc)/cm^{-1}	Transition
1968.824811(34)	P(39)	2266.806368(61)	R(39)
1963.728813(46)	P(40)	2269.096273(81)	R(40)
1958.603648(61)	P(41)	2271.345206(106)	R(41)
1953.449462(82)	P(42)	2273.553027(139)	R(42)

* The uncertainty in the last digits (twice the standard error) is given in parentheses.

Wavenumbers for the $\nu = 2 - 0$ Band of CO

Wavenumber (unc)*/cm^{-1}	Transition	Wavenumber (unc)/cm^{-1}	Transition
		4263.837198(02)	R(0)
4256.217140(02)	P(1)	4267.542066(02)	R(1)
4252.302244(02)	P(2)	4271.176630(02)	R(2)
4248.317633(02)	P(3)	4274.740746(02)	R(3)
4244.263453(02)	P(4)	4278.234264(02)	R(4)
4240.139852(02)	P(5)	4281.657039(02)	R(5)
4235.946975(02)	P(6)	4285.008924(02)	R(6)
4231.684972(02)	P(7)	4288.289772(02)	R(7)
4227.353987(02)	P(8)	4291.499437(02)	R(8)
4222.954169(02)	P(9)	4294.637773(02)	R(9)
4218.485665(02)	P(10)	4297.704631(02)	R(10)
4213.948620(02)	P(11)	4300.699868(02)	R(11)
4209.343182(02)	P(12)	4303.623334(02)	R(12)
4204.669499(02)	P(13)	4306.474886(02)	R(13)
4199.927716(02)	P(14)	4309.254375(02)	R(14)
4195.117980(02)	P(15)	4311.961657(02)	R(15)
4190.240439(02)	P(16)	4314.596584(02)	R(16)
4185.295239(02)	P(17)	4317.159011(02)	R(17)
4180.282526(02)	P(18)	4319.648791(02)	R(18)
4175.202447(02)	P(19)	4322.065779(03)	R(19)
4170.055149(03)	P(20)	4324.409829(03)	R(20)
4164.840777(03)	P(21)	4326.680794(03)	R(21)
4159.559478(03)	P(22)	4328.878530(03)	R(22)
4154.211398(03)	P(23)	4331.002889(04)	R(23)
4148.796683(04)	P(24)	4333.053728(04)	R(24)
4143.315479(04)	P(25)	4335.030899(05)	R(25)
4137.767932(04)	P(26)	4336.934259(06)	R(26)
4132.154187(05)	P(27)	4338.763661(07)	R(27)
4126.474391(06)	P(28)	4340.518961(09)	R(28)
4120.728689(07)	P(29)	4342.200014(11)	R(29)
4114.917226(09)	P(30)	4343.806675(16)	R(30)
4109.040148(12)	P(31)	4345.338799(21)	R(31)
4103.097600(16)	P(32)	4346.796243(29)	R(32)
4097.089728(21)	P(33)	4348.178862(40)	R(33)
4091.016676(29)	P(34)	4349.486513(54)	R(34)
4084.878591(40)	P(35)	4350.719052(73)	R(35)
4078.675618(54)	P(36)	4351.876336(96)	R(36)
4072.407901(73)	P(37)	4352.958224(127)	R(37)
4066.075588(97)	P(38)	4353.964572(166)	R(38)
4059.678822(127)	P(39)	4354.895240(214)	R(39)

* The uncertainty in the last digits (twice the standard error) is given in parentheses.

Wavenumbers for the $\nu = 3 - 0$ Band of CO

Wavenumber (unc)*/cm^{-1}	Transition	Wavenumber (unc)/cm^{-1}	Transition
		6354.179057(13)	R(0)
6346.594000(13)	P(1)	6357.813923(13)	R(1)
6342.644103(13)	P(2)	6361.343487(13)	R(2)
6338.589491(13)	P(3)	6364.767599(13)	R(3)
6334.430309(13)	P(4)	6368.086115(13)	R(4)

Wavenumbers for the $\nu = 3 - 0$ Band of CO

Wavenumber (unc)*/cm^{-1}	Transition	Wavenumber (unc)/cm^{-1}	Transition
6330.166705(13)	P(5)	6371.298887(13)	R(5)
6325.798826(13)	P(6)	6374.405768(12)	R(6)
6321.326819(13)	P(7)	6377.406611(12)	R(7)
6316.750831(12)	P(8)	6380.301271(12)	R(8)
6312.071008(12)	P(9)	6383.089600(12)	R(9)
6307.287498(12)	P(10)	6385.771452(12)	R(10)
6302.400447(12)	P(11)	6388.346680(13)	R(11)
6297.410003(12)	P(12)	6390.815139(13)	R(12)
6292.316311(13)	P(13)	6393.176681(13)	R(13)
6287.119520(13)	P(14)	6395.431160(13)	R(14)
6281.819775(13)	P(15)	6397.578430(13)	R(15)
6276.417224(13)	P(16)	6399.618344(13)	R(16)
6270.912012(13)	P(17)	6401.550757(13)	R(17)
6265.304287(13)	P(18)	6403.375523(13)	R(18)
6259.594194(13)	P(19)	6405.092495(14)	R(19)
6253.781880(13)	P(20)	6406.701527(14)	R(20)
6247.867492(14)	P(21)	6408.202474(14)	R(21)
6241.851176(14)	P(22)	6409.595189(15)	R(22)
6235.733077(14)	P(23)	6410.879527(15)	R(23)
6229.513342(15)	P(24)	6412.055343(16)	R(24)
6223.192117(15)	P(25)	6413.122491(17)	R(25)
6216.769547(16)	P(26)	6414.080825(19)	R(26)
6210.245778(17)	P(27)	6414.930201(23)	R(27)
6203.620957(19)	P(28)	6415.670474(28)	R(28)
6196.895229(23)	P(29)	6416.301500(37)	R(29)
6190.068739(28)	P(30)	6416.823133(50)	R(30)
6183.141633(37)	P(31)	6417.235231(67)	R(31)
6176.114058(50)	P(32)	6417.537649(90)	R(32)
6168.986159(67)	P(33)		
6161.758082(90)	P(34)		

* The uncertainty in the last digits (twice the standard error) is given in parentheses.

Frequencies and Wavenumbers for the Rotational Lines of CO

Frequency/MHz	Uncertainty*/MHz	J'	J''	Wavenumber/cm^{-1}	Uncertainty*/cm^{-1}
115271.2029	0.0004	1	0	3.84503345	0.00000001
230538.0016	0.0008	2	1	7.68991999	0.00000003
345795.9923	0.0012	3	2	11.53451273	0.00000004
461040.7712	0.0016	4	3	15.37866477	0.00000005
576267.9350	0.0019	5	4	19.22222923	0.00000006
691473.0809	0.0021	6	5	23.06505926	0.00000007
806651.8065	0.0023	7	6	26.90700800	0.00000008
921799.7104	0.0025	8	7	30.74792863	0.00000008
1036912.3919	0.0027	9	8	34.58767438	0.00000009
1151985.4515	0.0029	10	9	38.42609848	0.00000010
1267014.4906	0.0031	11	10	42.26305422	0.00000010
1381995.1119	0.0034	12	11	46.09839491	0.00000011
1496922.9195	0.0038	13	12	49.93197392	0.00000013
1611793.5189	0.0042	14	13	53.76364468	0.00000014
1726602.5173	0.0047	15	14	57.59326065	0.00000016
1841345.5237	0.0052	16	15	61.42067535	0.00000017
1956018.1486	0.0057	17	16	65.24574239	0.00000019
2070616.0050	0.0061	18	17	69.06831542	0.00000020
2185134.7075	0.0065	19	18	72.88824816	0.00000022
2299569.8733	0.0069	20	19	76.70539441	0.00000023
2413917.1217	0.0071	21	20	80.51960806	0.00000024
2528172.0747	0.0073	22	21	84.33074306	0.00000024
2642330.3567	0.0074	23	22	88.13865346	0.00000025
2756387.5949	0.0075	24	23	91.94319341	0.00000025

Frequencies and Wavenumbers for the Rotational Lines of CO

Frequency/MHz	Uncertainty*/MHz	J'	J''	Wavenumber/cm^{-1}	Uncertainty*/cm^{-1}
2870339.4194	0.0077	25	24	95.74421713	0.00000026
2984181.4631	0.0080	26	25	99.54157896	0.00000027
3097909.3621	0.0085	27	26	103.33513334	0.00000028
3211518.7558	0.0090	28	27	107.12473480	0.00000030
3325005.2869	0.0096	29	28	110.91023800	0.00000032
3438364.6013	0.0102	30	29	114.69149772	0.00000034
3551592.3489	0.0107	31	30	118.46836884	0.00000036
3664684.1829	0.0111	32	31	122.24070637	0.00000037
3777635.7608	0.0118	33	32	126.00836545	0.00000039
3890442.7435	0.0137	34	33	129.77120137	0.00000046
4003100.7965	0.0179	35	34	133.52906952	0.00000060
4115605.5892	0.0254	36	35	137.28182546	0.00000085
4227952.7954	0.0370	37	36	141.02932487	0.00000123
4340138.0932	0.0531	38	37	144.77142361	0.00000177
4452157.1657	0.0746	39	38	148.50797766	0.00000249
4564005.7001	0.1025	40	39	152.23884318	0.00000342

* The uncertainty given is twice the standard error.

Frequencies and Wavenumbers for the Rotational Lines of HF

Frequency/MHz	Uncertainty*/MHz	J'	J''	Wavenumber/cm^{-1}	Uncertainty*/cm^{-1}
1232476.21	0.12	1	0	41.110981	0.000004
2463428.09	0.19	2	1	82.171116	0.000006
3691334.81	0.25	3	2	123.129676	0.000008
4914682.58	0.51	4	3	163.936165	0.000017
6131968.11	1.10	5	4	204.540439	0.000037
7341702.00	2.00	6	5	244.892818	0.000067
8542412.1	3.21	7	6	284.944197	0.000107
9732646.8	4.72	8	7	324.646153	0.000157
10910978.2	6.51	9	8	363.951056	0.000217
12076004.8	8.55	10	9	402.81216	0.000285
13226355.2	10.81	11	10	441.18372	0.000361
14360689.8	13.25	12	11	479.02105	0.00044
15477704.4	15.86	13	12	516.28065	0.00053
16576131.8	18.61	14	13	552.92024	0.00062
17654744.4	21.48	15	14	588.89888	0.00072
18712356.5	24.44	16	15	624.17703	0.00082
19747825.6	27.43	17	16	658.71656	0.00092
20760054.3	30.32	18	17	692.4809	0.00101
21747991.7	32.91	19	18	725.4349	0.00110
22710634.7	34.94	20	19	757.5452	0.00117
23647028.7	36.08	21	20	788.7800	0.00120
24556268.8	35.93	22	21	819.1090	0.00120
25437499.9	34.12	23	22	848.5037	0.00114
26289917.4	30.32	24	23	876.9373	0.00101
27112767.2	24.41	25	24	904.38457	0.00081
27905345.6	16.88	26	25	930.82214	0.00056
28666999.3	10.80	27	26	956.22817	0.00036
29397124.8	14.65	28	27	980.58253	0.00049
30095168.2	24.62	29	28	1003.86676	0.00082
30760624.2	33.36	30	29	1026.0640	0.00111
31393035.7	36.17	31	30	1047.1590	0.00121

* The uncertainty given is twice the standard error.

Frequencies and Wavenumbers for the Rotational Lines of $H^{35}Cl$

Frequency/MHz	Uncertainty*/MHz	J'	J''	Wavenumber/cm^{-1}	Uncertainty*/cm^{-1}
1876226.517	0.065	3	2	62.584180	0.000002
2499864.439	0.066	4	3	83.386502	0.000002
3121986.563	0.064	5	4	104.138262	0.000002
3742216.601	0.076	6	5	124.826909	0.000003
4360180.042	0.098	7	6	145.439951	0.000003
4975504.51	0.11	8	7	165.964966	0.000004
5587820.10	0.12	9	8	186.389615	0.000004
6196759.76	0.22	10	9	206.701656	0.000007
6801959.63	0.50	11	10	226.888951	0.000017
7403059.41	1.02	12	11	246.939481	0.000034
7999702.7	1.8	13	12	266.841359	0.000062
8591537.3	3.1	14	13	286.582837	0.000103
9178215.8	4.8	15	14	306.152324	0.000161

* The uncertainty given is twice the standard error.

Frequencies and Wavenumbers for the Rotational Lines of $H^{37}Cl$

Frequency/MHz	Uncertainty*/MHz	J'	J''	Wavenumber/cm^{-1}	Uncertainty*/cm^{-1}
1873410.72	0.05	3	2	62.490255	0.000002
2496115.33	0.05	4	3	83.261445	0.000002
3117308.69	0.05	5	4	103.982225	0.000002
3736615.64	0.06	6	5	124.640082	0.000002
4353662.84	0.08	7	6	145.222561	0.000003
4968079.04	0.09	8	7	165.717279	0.000003
5579495.53	0.10	9	8	186.111938	0.000003
6187546.42	0.19	10	9	206.394332	0.000006
6791869.04	0.45	11	10	226.552365	0.000015
7392104.3	0.9	12	11	246.574057	0.000030
7987896.9	1.6	13	12	266.447561	0.000054
8578896.1	2.7	14	13	286.161170	0.000089

* The uncertainty given is twice the standard error.

SENSITIVITY OF THE HUMAN EYE TO LIGHT OF DIFFERENT WAVELENGTHS

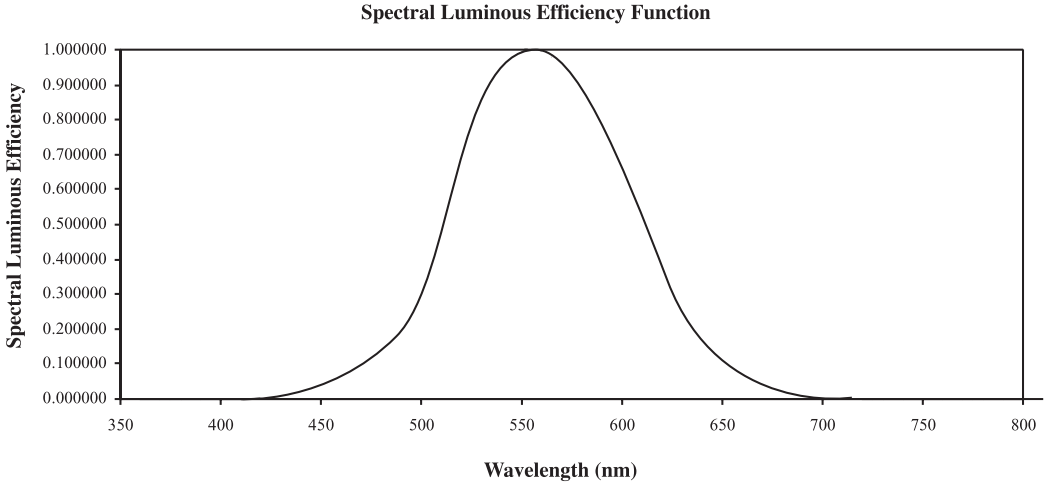
The human eye responds to electromagnetic radiation in the wavelength range from about 360 nm (violet) to 820 nm (red), with a peak sensitivity near 555 nm. While the detailed shape of this response curve depends on the individual person, studies on representative samples of human subjects have led to adoption of a standard function relating the perceived brightness (luminous flux) to the actual power of the spectral radiation. This function is referred to as $V(\lambda)$, the photopic spectral luminous efficiency function, and it plays an important role in photometry.

The function $V(\lambda)$, as adopted by the International Commission on Illumination (CIE) is tabulated and plotted below.

References

1. *The Basis for Physical Photometry*, CIE Publication #18.2, 1983.
2. *CIE Standard Colorimetric Observers*, ISO/CIE #10527, 1991.
3. *Kaye and Laby Tables of Physical and Chemical Constants, Sixteenth Edition*, Longman Group Ltd., Harlow, Essex, 1995.

λ/nm	$V(\lambda)$	λ/nm	$V(\lambda)$	λ/nm	$V(\lambda)$
360	0.000004	520	0.710000	670	0.032000
370	0.000012	530	0.862000	680	0.017000
380	0.000039	540	0.954000	690	0.008210
390	0.000120	550	0.994950	700	0.004102
400	0.000396	555	1.000000	710	0.002091
410	0.001210	560	0.995000	720	0.001047
420	0.004000	570	0.952000	730	0.000520
430	0.011600	580	0.870000	740	0.000249
440	0.023000	590	0.757000	750	0.000120
450	0.038000	600	0.631000	760	0.000060
460	0.060000	610	0.503000	770	0.000030
470	0.090980	620	0.381000	780	0.000015
480	0.139020	630	0.265000	790	0.000007
490	0.208020	640	0.175000	800	0.000004
500	0.323000	650	0.107000	810	0.000002
510	0.503000	660	0.061000	820	0.000001



INDEX OF REFRACTION OF INORGANIC CRYSTALS

This table lists the index of refraction of selected crystalline inorganic compounds. When, available, values are give as a function of wavelength in the range from the ultraviolet to the far infrared region. For each compound a value at 589 nm, the wavelength of the principal sodium line, is given. The data have been taken from the references indicated; in many cases, data from a reference have been refitted to generate the index of refraction at the wavelengths used in this table. All values refer to ambient temperature. Entries marked by * are based on extrapolation beyond the range of available experimental data.

Compounds belonging to the cubic crystal system have only a single refractive index value, but other systems are anisotropic, so that the crystal is characterized by two or three unique indexes. Hexagonal, rhombohedral, and tetragonal crystals have two unique indexes which are traditionally labeled n_o and n_e for "ordinary ray" and "extraordinary ray". Orthorhombic, monoclinic, and triclinic crystals are characterized by three indexes which are here called n_x, n_y, and n_z. The table indicates the crystal system for each entry in order to identify the material uniquely.

The refractive index and other optical properties for metals, semiconductors, and certain other compounds can be found in the tables "Optical Properties of Selected Elements" and "Optical Properties of Selected Inorganic and Organic Solids" in Section 12 of this *Handbook*.

References

1. Li, H. H., "Refractive Index of Alkali Halides and its Wavelength and Temperature Derivatives", *J. Phys. Chem. Ref. Data* 5, 329, 1976.
2. Li, H. H., "Refractive Index of Alkaline Earth Halides and its Wavelength and Temperature Derivatives", *J. Phys. Chem. Ref. Data* 9, 161, 1980.
3. Li, H. H., "Refractive Index of ZnS, ZnSe, and ZnTe and its Wavelength and Temperature Derivatives", *J. Phys. Chem. Ref. Data* 13, 103, 1984.
4. Shannon, R. D., Shannon, R. C., Medenbach, O., and Fischer, R. X., "Refractive Index and Dispersion of Fluorides and Oxides", *J. Phys. Chem. Ref. Data* 31, 931, 2002.
5. Gray, D. E., ed., *American Institute of Physics Handbook*, Sec. 6b, p. **6**-12, McGraw-Hill, New York, 1972.
6. Landolt-Börnstein Numerical Data and Functional Relationships in Science and *Technology*, III/11, Elastic, Piezoelectric, Pyroelectric, Piezooptic, Electrooptic Constants, and Nonlinear Dielectric Susceptibilities of Crystals, Springer-Verlag, Berlin, 1979.
7. Landolt-Börnstein Numerical Data and Functional Relationships in Science and *Technology*, III/30A, High Frequency Properties of Dielectric Crystals. Piezooptic and Electrooptic Constants, Springer-Verlag, Berlin, 1996.
8. Weber, M. J., *CRC Handbook of Laser Science and Technology*, Vol. IV. Optical Materials. Part 2: Properties, CRC Press, Boca Raton, FL, 1986.

Compound	Crystal system	Ray	Index of Refraction at the Indicated Wavelength								Ref.
			300 nm	589 nm	750 nm	1 μm	2 μm	5 μm	10 μm	20 μm	
AgCl	cub	n		2.0668	2.0401	2.0224	2.0062	1.9975	1.9803	1.9069	5
$AlPO_4$	rhomb	n_o		1.5247	1.5203	1.5161	1.5034				6
	rhomb	n_e		1.5338	1.5290	1.5245	1.5116				6
Al_2O_3	hex	n_o		1.7673							4
	hex	n_e		1.7598							4
As_2O_3[a]	cub	n		1.7537							4
BaF_2	cub	n	1.5010	1.4744	1.4712	1.4686	1.4647	1.4511	1.4014		2
BaO	cub	n		1.9841							4
$BaSO_4$	orth	n_x		1.6362							4
	orth	n_y		1.6374							4
	orth	n_z		1.6480							4
$BaTiO_3$	tetr	n_o		2.4405							4
	tetr	n_e		2.3831							4
$BaWO_4$	tetr	n_o		1.8426							4
	tetr	n_e		1.8405							4
BeO	hex	n_o		1.7184							4
	hex	n_e		1.7342							4
$BeSO_4 \cdot 4H_2O$	tetr	n_o		1.4713							4
	tetr	n_e		1.4328							4
$CaCO_3$[b]	hex	n_o	1.7216	1.6584	1.6503	1.6436	1.6249				5
	hex	n_e	1.5145	1.4864	1.4828	1.4801	1.4753				5
CaF_2	cub	n	1.4540	1.4338	1.4311	1.4289	1.4239	1.3990	1.299		2
CaO	cub	n		1.8396							4
$CaSO_4$	orth	n_x		1.5698							4
	orth	n_y		1.5755							4
	orth	n_z		1.6137							4
$CaSO_4 \cdot 2H_2O$	monocl	n_x		1.5207							4
	monocl	n_y		1.5227							4
	monocl	n_z		1.5304							4
$CaWO_4$	tetr	n_o		1.9195							4
	tetr	n_e		1.9355							4
CdS	hex	n_o		2.507	2.390	2.334					5

Compound	Crystal system	Ray	Index of Refraction at the Indicated Wavelength								Ref.
			300 nm	589 nm	750 nm	1 μm	2 μm	5 μm	10 μm	20 μm	
	hex	n_e		2.525	2.409	2.352					5
CdSe	hex	n_o			2.68*	2.5502	2.4682	2.4483	2.4331		7
	hex	n_e			2.69*	2.5696	2.4873	2.4676	2.4514		7
CdTe	cub	n							2.6724	2.6302	7
CeF_3	hex	n_o		1.6183							4
	hex	n_e		1.6113							4
CsBr	cub	n	1.8047	1.6974	1.6861	1.6784	1.6711	1.6678	1.6630	1.6439	1
CsCl	cub	n	1.712	1.640	1.631	1.626	1.620	1.616	1.606	1.563	1
$CsClO_4$	orth	n_x		1.4752							4
	orth	n_y		1.4788							4
	orth	n_z		1.4804							4
CsF	cub	n	1.506	1.477	1.474	1.472	1.469*	1.461*	1.436*	1.32*	1
CsI	cub	n	1.9790	1.7873	1.7694	1.7576	1.7465	1.7428	1.7396	1.7280	1
Cs_2SO_4	orth	n_x		1.5598							4
	orth	n_y		1.5644							4
	orth	n_z		1.5662							4
CuBr	cub	n		2.117							7
CuCl	cub	n		1.9727	1.9391				1.9245		7
$CuSO_4 \cdot 5H_2O$	tricl	n_x		1.5140							4
	tricl	n_y		1.5367							4
	tricl	n_z		1.5436							4
Dy_2O_3	cub	n		1.9757							4
FeF_2	tetr	n_o		1.514							4
	tetr	n_e		1.524							4
Gd_2O_3	cub	n		1.96							4
HgS	rhomb	n_o		2.9413	2.7770	2.7120	2.6305		2.6018		6
	rhomb	n_e		3.3072	3.0896	3.0050	2.8776		2.8522		6
KBr	cub	n	1.6482	1.5598	1.5498	1.5444	1.5383	1.5345	1.5264	1.4924	1
KCl	cub	n	1.5455	1.4902	1.4840	1.4798	1.4753	1.4704	1.4564	1.3946	1
$KClO_4$	orth	n_x		1.4730							4
	orth	n_y		1.4736							4
	orth	n_z		1.4768							4
KF	cub	n	1.380	1.362	1.360	1.358	1.355	1.344	1.304*	1.09*	1
KH_2AsO_4	tetr	n_o		1.5674							7
	tetr	n_e		1.5179							7
KH_2PO_4	tetr	n_o	1.5450	1.5093	1.5030	1.4957					5
	tetr	n_e	1.4977	1.4682	1.4641	1.4606					5
KI	cub	n	1.834*	1.665	1.650	1.640	1.631	1.627	1.620	1.593	1
KIO_3	tricl	n_x		1.6959							7
	tricl	n_y		1.8317							7
	tricl	n_z		1.8343							7
KIO_4	tetr	n_o		1.6205							4
	tetr	n_e		1.6476							4
$KNbO_3$	orth	n_x		2.2480	2.3395	2.2612					7
	orth	n_y		2.3464	2.2959	2.2622					7
	orth	n_x		2.1803	2.1457	2.1288					7
K_2SO_4	orth	n_x		1.4934							4
	orth	n_y		1.4947							4
	orth	n_z		1.4973							4
LaF_3	hex	n_o		1.605							4
	hex	n_e		1.599							4
LiBr	cub	n	1.810	1.783	1.781	1.778	1.774*	1.756*	1.68*	1.33*	1
LiCl	cub	n	1.677	1.662	1.660	1.658	1.654*	1.62*	1.53*		1
$LiClO_4 \cdot 3H_2O$	hex	n_o		1.4832							4
	hex	n_e		1.4384							4
LiF	cub	n	1.4087	1.3921	1.3895	1.3871	1.3786	1.3266	1.1005		1
LiI	cub	n	1.979	1.955	1.952	1.950	1.948*	1.940*	1.91*	1.77*	1
$LiIO_3$	hex	n_o		1.8875	1.8713	1.8589	1.8410				6
	hex	n_e		1.7400	1.7268	1.7179	1.7062				6
$LiNbO_3$	rhomb	n_o		2.3007	2.2632	2.2370					7

Compound	Crystal system	Ray	Index of Refraction at the Indicated Wavelength								Ref.
			300 nm	589 nm	750 nm	1 μm	2 μm	5 μm	10 μm	20 μm	
	rhomb	n_e		2.2116	2.1804	2.1567					7
$LiTaO_3$	rhomb	n_o		2.1864	2.1590	2.1391	2.1066				7
	rhomb	n_e		2.1908	2.1634	2.1432	2.1115				7
$Li_2SO_4 \cdot H_2O$	monocl	n_x		1.4615							4
	monocl	n_y		1.4765							4
	monocl	n_z		1.4863							4
Lu_2O_3	cub	n		1.9349							4
MgF_2	tetr	n_o	1.3930	1.3776	1.375	1.373	1.368	1.34	1.21		2
	tetr	n_e	1.4055	1.3894	1.387	1.385	1.379	1.34	1.21		2
MgO	cub	n		1.7355	1.7283	1.7228	1.7084	1.6361			5
$MgSO_4 \cdot 7H_2O$	orth	n_x		1.4326							4
	orth	n_y		1.4555							4
	orth	n_z		1.4607							4
MnF_2	tetr	n_o		1.472							4
	tetr	n_e		1.501							4
$NH_4H_2AsO_4$	tetr	n_o	1.6401	1.5777	1.5704	1.5583					7
	tetr	n_e	1.5754	1.5232	1.5179	1.5101					7
$NH_4H_2PO_4$	tetr	n_o	1.5668	1.5247	1.5187	1.5084					7
	tetr	n_e	1.5137	1.4797	1.4754	1.4694					7
NaBr	cub	n	1.748	1.642	1.631	1.623	1.616	1.609	1.593*	1.520*	1
$NaBrO_3$	cub	n		1.6168							4
NaCl	cub	n	1.6066	1.5441	1.5369	1.5320	1.5265	1.5188	1.4947	1.382*	1
$NaClO_3$	cub	n		1.5151							7
NaF	cub	n	1.3424	1.3252	1.3231	1.3214	1.3179	1.3017	1.2400		1
$NaH_2PO_4 \cdot 2H_2O$	orth	n_x		1.4400							7
	orth	n_y		1.4628							7
	orth	n_z		1.4814							7
NaI	cub	n	1.93*	1.774	1.758	1.74	1.73*	1.73*	1.71*	1.66*	1
$NaNO_2$	orth	n_x		1.6547							7
	orth	n_y		1.3455							7
	orth	n_z		1.4125							7
$NaNO_3$	rhomb	n_o		1.5840							5
	rhomb	n_e		1.3340							5
$Na_2HPO_4 \cdot 7H_2O$	monocl	n_x		1.4411							4
	monocl	n_y		1.4423							4
	monocl	n_z		1.4525							4
Na_2SO_4	orth	n_x		1.4669							4
	orth	n_y		1.4730							4
	orth	n_z		1.4809							4
NdF_3	hex	n_o		1.6191							4
	hex	n_e		1.6132							4
Nd_2O_3	cub	n		1.92							4
NiF_2	tetr	n_o		1.526							4
	tetr	n_e		1.561							4
$NiSO_4 \cdot 6H_2O$	tetr	n_o		1.5107							4
	tetr	n_e		1.4870							4
PbF_2	cub	n	1.94*	1.767	1.754	1.745	1.73	1.70	1.66	1.32	5
$PbSO_4$	orth	n_x		1.8780							4
	orth	n_y		1.8834							4
	orth	n_z		1.8945							4
PrF_3	hex	n_o		1.6207							4
	hex	n_e		1.6146							4
RbBr	cub	n	1.639	1.553	1.544	1.538	1.532	1.530	1.525	1.505*	1
RbCl	cub	n	1.549	1.493	1.487	1.483	1.479	1.475	1.465	1.424*	1
$RbClO_4$	orth	n_x		1.4691							4
	orth	n_y		1.4701							4
	orth	n_z		1.4732							4
RbF	cub	n	1.428*	1.397	1.394	1.391	1.388	1.379	1.346	1.19*	1
RbH_2AsO_4	tetr	n_o	1.6183	1.5603	1.5538	1.5432					7
	tetr	n_e	1.5718	1.5232	1.5184	1.5121					7

Compound	Crystal system	Ray	Index of Refraction at the Indicated Wavelength								Ref.
			300 nm	589 nm	750 nm	1 μm	2 μm	5 μm	10 μm	20 μm	
RbH_2PO_4	tetr	n_o	1.5434	1.5078	1.5021	1.4941					7
	tetr	n_e	1.5106	1.4791	1.4754	1.4704					7
RbI	cub	n	1.808	1.647	1.633	1.623	1.615	1.612	1.608	1.595	1
Rb_2SO_4	orth	n_x		1.5131							4
	orth	n_y		1.5133							4
	orth	n_z		1.5144							4
Sb_2O_3[c]	cub	n		2.8017							4
Sc_2O_3	cub	n		1.9943							4
SiO_2[d]	hex	n_o	1.5733	1.5442	1.5394	1.5350	1.5209				5
	hex	n_e	1.5882	1.5534	1.5484	1.5438	1.5291				5
SnO_2	tetr	n_o		1.993							4
	tetr	n_e		2.088							4
SrF_2	cub	n	1.459	1.4380	1.435	1.433	1.429	1.412	1.35		2
SrO	cub	n		1.8710							4
$SrSO_4$	orth	n_x		1.6214							4
	orth	n_y		1.6231							4
	orth	n_z		1.6303							4
$SrTiO_3$	cub	n		2.4082	2.3525	2.3160	2.2676	2.1205			5
$SrWO_4$	tetr	n_o		1.8618							4
	tetr	n_e		1.8719							4
TbF_3	hex	n_o		1.6034							4
	hex	n_e		1.5603							4
TeO_2	tetr	n_o		2.2738		2.2080					7
	tetr	n_e		2.4295		2.3520					7
ThO_2	cub	n		2.1113							4
TiO_2[e]	tetr	n_o		2.612	2.533	2.485	2.399	2.220			5
	tetr	n_e		2.910	2.805	2.748					5
	tetr	n_o		2.562							4
	tetr	n_e		2.489							4
TlBr	cub	n		2.418	2.350	2.289	2.103	1.984	2.339	2.322	5
TlCl	cub	n		2.247	2.198	2.145	1.986	1.891	2.193		5
$TlClO_4$	orth	n_x		1.6427							4
	orth	n_y		1.6446							4
	orth	n_z		1.6542							4
Tl_2SO_4	orth	n_x		1.8604							4
	orth	n_y		1.8676							4
	orth	n_z		1.8857							4
Y_2O_3	cub	n		1.930							4
Yb_2O_3	cub	n		1.9468							4
ZnF_2	tetr	n_o		1.495							4
	tetr	n_e		1.525							4
ZnO	hex	n_o		2.0036	1.9662	1.9435	1.9197				7
	hex	n_e		2.0199	1.9821	1.9589	1.9330				7
ZnS[f]	cub	n		2.3691	2.3232	2.2932	2.2633				7
ZnS[g]	hex	n_o		2.372	2.331	2.303	2.26	2.25	2.20		3,5
	hex	n_e		2.368	2.327	2.301					5
ZnSe	cub	n		2.6222	2.5384	2.4888	2.4462	2.4296	2.4065		3
ZnTe	cub	n		3.060	2.880	2.789	2.719	2.698	2.684		3
$ZrSiO_4$[h]	tetr	n_o		1.9255							4
	tetr	n_e		1.9843							4

* Provisional value based on extrapolation beyond the range of experimental data.

[a] Arsenolite
[b] Calcite
[c] Senarmontite
[d] α-Quartz
[e] Rutile
[f] Sphalerite
[g] Wurtzite
[h] Zircon

PROTON AFFINITIES

Proton affinity is a useful parameter for describing gas phase ion-molecule reactions in fields such as atmospheric chemistry, plasma chemistry, mass spectrometry, and astrophysics. The proton affinity E_{pa} (often designated in the literature as PA) of a molecular species M is defined as the negative of the enthalpy change for the gas phase reaction

$$M + H^+ \rightarrow MH^+.$$

A closely related quantity is the gas phase basicity $\Delta_{base}G°$ (often designated as GB), which is the negative of the Gibbs energy change for the same reaction. Thus the two are related by

$$\Delta_{base}G° = E_{pa} + T\Delta S,$$

where T is the temperature and ΔS is the entropy change in the reaction (which can be calculated if the molecular structure of M and M^+ is known).

Direct measurement of the proton affinity is possible for only a few molecules, mainly olefins and carbonyl compounds. However, these measurements have been used to establish a scale of E_{pa} values that permits proton affinities to be determined for many other molecules, including unstable species and reaction intermediates. The basis for this scale is described by Hunter and Lias in Reference 1.

The E_{pa} and $\Delta_{base}G°$ values at a temperature of 298 K are tabulated below for selected molecules. Many values are given to one decimal place, but the majority are not accurate to better than one or two kilojoules per mole. The methods of measurement are described in Reference 1, which contains a much more extensive and detailed tabulation.

Compounds are listed by molecular formula in the Hill order, but with all compounds that do not contain carbon appearing before those that do contain carbon.

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Molecular formula	Name	E_{pa} kJ/mol	$\Delta_{base}G°$ kJ/mol	Notes
Ar	Argon	369.2	346.3	
AsF_3	Arsenic(III) fluoride	636.7	604.2	
AsH_3	Arsine	747.9	712.0	
BHO_2	Metaboric acid	763.0	730.5	
BH_3O_3	Boric acid	728.1	698.4	
B_2H_6	Diborane	615	586.0	
$B_3H_6N_3$	Borazine	802.5	772.8	
B_4H_{10}	Tetraborane(10)	605	572.5	
B_5H_9	Pentaborane(9)	699.4	666.9	
BaO	Barium oxide	1215.4	1187.6	
Br	Bromine (atomic)	554.4	531.2	
BrH	Hydrogen bromide	584.2	557.7	
BrLi	Lithium bromide	819	792.5	
CaO	Calcium oxide	1190.6	1162.3	
Cl	Chlorine (atomic)	513.6	490.1	
ClH	Hydrogen chloride	556.9	530.1	
ClLi	Lithium chloride	827	800.5	
Co	Cobalt	742.7	719.8	
Cr	Chromium	791.3	768.4	
CsHO	Cesium hydroxide	1117.9	1092.2	
Cs_2O	Cesium oxide	1442.9	1412.2	
Cu	Copper	655.3	632.4	
F	Fluorine (atomic)	340.1	315.1	
FH	Hydrogen fluoride	484	456.7	
FO	Fluorine oxide	508.7	482.2	
F_2	Fluorine	332	305.5	
F_2O_2S	Sulfuryl fluoride	605.5	580.5	

Molecular formula	Name	E_{pa} kJ/mol	$\Delta_{base}G°$ kJ/mol	Notes
F_3N	Nitrogen trifluoride	568.4	538.6	
F_3OP	Phosphoryl fluoride	694.0	664.2	
F_3P	Phosphorus(III) fluoride	695.3	662.8	
F_4Si	Tetrafluorosilane	502.9	476.6	
F_6S	Sulfur hexafluoride	575.3	550.7	
Fe	Iron	754	731.1	
FeO	Iron(II) oxide	907	880.5	
GeH_4	Germane	713.4	687.1	
HI	Hydrogen iodide	627.5	601.3	
HKO	Potassium hydroxide	1101.8	1075.4	
HLi	Lithium hydride	1021.7	996.4	
HLiO	Lithium hydroxide	1000.1	972.1	
HNO_3	Nitric acid	751.4	731.5	
HN_3	Hydrazoic acid	756.0	723.5	
HNa	Sodium hydride	1095	1070.6	
HNaO	Sodium hydroxide	1071.8	1044.8	
HO	Hydroxyl	593.2	564.0	
HO_2	Hydroperoxy	660	627.5	
HP	Phosphorus monohydride	670.3	639.6	
H_2	Hydrogen	422.3	394.7	
$H_2N_2O_2$	Nitramide	757.4	725.0	
H_2O	Water	691	660.0	
H_2O_2	Hydrogen peroxide	674.5	643.8	
H_2O_4S	Sulfuric acid	717	681	Ref. 3
H_2P	Phosphino	709.2	675.7	
H_2S	Hydrogen sulfide	705	673.8	
H_2Se	Hydrogen selenide	707.8	676.4	
H_2Si	Silylene	839.2	804.1	
H_2Te	Hydrogen telluride	735.9	704.5	
H_3N	Ammonia	853.6	819.0	
H_3P	Phosphine	785	750.9	
H_4N_2	Hydrazine	853.2	822.4	
H_4Si	Silane	639.7	613.4	
H_6OSi_2	Disiloxane	749	718.3	
He	Helium	177.8	148.5	
I	Iodine (atomic)	608.2	583.5	
K_2O	Potassium oxide	1342.5	1311.8	
Kr	Krypton	424.6	402.4	
La	Lanthanum	1013	991.9	
Li_2	Dilithium	1162	1133.1	
Li_2O	Lithium oxide	1206	1175.3	
Lu	Lutetium	992	970.6	
Mg	Magnesium	819.6	797.3	
MgO	Magnesium oxide	988	959.4	
Mg_2	Dimagnesium	919	886.5	
Mn	Manganese	797.3	774.4	
N	Nitrogen (atomic)	342.2	318.7	
NO	Nitric oxide	531.8	505.3	
NO_2	Nitrogen dioxide	591.0	560.3	
NP	Phosphorus nitride	789.4	757.0	
N_2	Nitrogen	493.8	464.5	
N_2O	Nitrous oxide	549.8	523.3	Protonation at N
N_2O	Nitrous oxide	575.2	548.7	Protonation at O
Na_2	Disodium	1146.8	1118.2	
Na_2O	Sodium oxide	1375.9	1345.2	
Ne	Neon	198.8	174.4	
Ni	Nickel	737	714.1	
O	Oxygen (atomic)	485.2	459.6	
OP	Phosphorus monoxide	682	649.5	
OSi	Silicon monoxide	777.8	750.4	Protonation at O

Molecular formula	Name	E_{pa} kJ/mol	$\Delta_{base}G°$ kJ/mol	Notes
OSi	Silicon monoxide	533	500.5	Protonation at Si
OSr	Strontium oxide	1209	1180.7	
O_2	Oxygen	421	396.3	
O_2S	Sulfur dioxide	672.3	643.3	
O_3	Ozone	625.5	595.9	
O_3S	Sulfur trioxide	588.3	560.3	
O_4Os	Osmium(VIII) oxide	676.9	650.6	
P	Phosphorus	626.8	604.8	
Pd	Palladium	696	673.4	
Rh	Rhodium	768	745.4	
Ru	Ruthenium	774	751.4	
S	Sulfur	664.3	640.2	
SSi	Silicon monosulfide	627	596.6	Protonation at Si
SSi	Silicon monosulfide	683	660.2	Protonation at S
Sc	Scandium	914	892.0	
Si	Silicon	837	814.1	
Ti	Titanium	876	853.7	
U	Uranium	995.2	973.2	
V	Vanadium	859.4	836.8	
Xe	Xenon	499.6	478.1	
Y	Yttrium	967	945.9	
Zn	Zinc	608.6	586.0	
$CBrF_3$	Bromotrifluoromethane	580.0	550.3	
CBrN	Cyanogen bromide	749.8	719.2	
$CClF_3$	Chlorotrifluoromethane	571.3	541.5	
CClN	Cyanogen chloride	722.1	691.5	
CCl_2	Dichloromethylene	861	828.5	
CCl_2S	Carbonothioic dichloride	752.5	721.8	
CFN	Cyanogen fluoride	632	601.3	
CF_2	Difluoromethylene	765	732.5	
CF_2O	Carbonyl fluoride	666.7	637.0	
CF_3I	Trifluoroiodomethane	628.0	598.2	
CF_3NO	Trifluoronitrosomethane	703.3	670.8	
CF_4	Tetrafluoromethane	529.3	503.7	
CHCl	Chloromethylene	874.1	839.9	
CHF	Fluoromethylene	797.9	763.8	
CHF_3	Trifluoromethane	619.5	589.7	
CHF_3O_3S	Trifluoromethanesulfonic acid	699.4	666.9	
CHN	Hydrogen cyanide	712.9	681.6	
CHN	Hydrogen isocyanide	772.3	739.8	
CHNO	Isocyanic acid (HNCO)	753	718.8	
CHNO	Fulminic acid	758	725.5	
CHO	Oxomethyl (HCO)	636	601.8	
CHO_2	Formyloxyl	623.4	590.9	
CH_2F_2	Difluoromethane	620.5	589.7	
CH_2N_2	Diazomethane	858.9	826.7	
CH_2N_2	Cyanamide	805.6	774.9	
CH_2O	Formaldehyde	712.9	683.3	
CH_2O_2	Formic acid	742.0	710.3	
CH_2S	Thioformaldehyde	759.7	730.5	
CH_2Se	Selenoformaldehyde	764.0	734.9	
CH_3Br	Bromomethane	664.2	638.0	
CH_3Cl	Chloromethane	647.3	621.1	
CH_3F	Fluoromethane	598.9	571.5	
CH_3I	Iodomethane	691.7	665.5	
CH_3NO	Formamide	822.2	791.2	
CH_3NO_2	Nitromethane	754.6	721.6	
CH_3NO_2	Methyl nitrite	798.9	766.4	
CH_3NO_3	Methyl nitrate	733.6	714.8	
CH_3N_3	Methyl azide	833	800.5	

Molecular formula	Name	E_{pa} kJ/mol	$\Delta_{base}G°$ kJ/mol	Notes
CH_4	Methane	543.5	520.6	
CH_4N	Methylamidogen	832.8	801.6	
CH_4N_2O	Urea	873.5	841.6	Protonation at O; Ref. 8
CH_4N_2S	Thiourea	893.7	863.9	
CH_4O	Methanol	754.3	724.5	
CH_4O_3S	Methanesulfonic acid	761.3	728.9	
CH_4S	Methanethiol	773.4	742	
CH_5N	Methylamine	899.0	864.5	
CH_5NO	*O*-Methylhydroxylamine	844.8	812.3	
CH_5N_3	Guanidine	986.3	949.4	
CH_5P	Methylphosphine	851.5	817.6	
CH_6N_2	Methylhydrazine	898.8	866.4	
CN	Cyanide	>595	>564	Protonation at N
CNS	Thiocyanate	751	718.5	
CO	Carbon monoxide	594	562.8	Protonation at C
CO	Carbon monoxide	426.3	402.2	Protonation at O
COS	Carbon oxysulfide	628.5	602.6	Protonation at S
COSe	Carbon oxyselenide	670	644.1	Protonation at Se
CO_2	Carbon dioxide	540.5	515.8	
CS	Carbon monosulfide	791.5	760	
CS_2	Carbon disulfide	681.9	657.7	
CSe	Carbon monoselenide	831.8	800.2	Protonation at C
CSe_2	Carbon diselenide	725	700.9	
C_2ClF_3O	Trifluoroacetyl chloride	681.6	649.8	
C_2Cl_3N	Trichloroacetonitrile	723.2	692.6	
C_2F_3N	Trifluoroacetonitrile	688.4	657.7	
C_2H	Ethynyl	753	720.8	
C_2HCl_3O	Trichloroacetaldehyde	722.3	690.5	
$C_2HCl_3O_2$	Trichloroacetic acid	770.0	739.1	
C_2HF	Fluoroacetylene	686	661.3	
C_2HF_3	Trifluoroethene	699.4	666.9	
$C_2HF_3O_2$	Trifluoroacetic acid	711.7	680.7	
C_2H_2	Acetylene	641.4	616.7	
C_2H_2ClN	Chloroacetonitrile	745.7	715.1	
$C_2H_2F_2$	1,1-Difluoroethene	734	705.1	
$C_2H_2F_2$	*trans*-1,2-Difluoroethene	688.6	657.9	
C_2H_2O	Ketene	825.3	793.6	
$C_2H_3ClO_2$	Chloroacetic acid	765.4	734.5	
$C_2H_3Cl_3O$	2,2,2-Trichloroethanol	729.3	698.9	
C_2H_3F	Fluoroethene	729	700.1	
$C_2H_3FO_2$	Fluoroacetic acid	765.4	734.5	
$C_2H_3F_3O$	2,2,2-Trifluoroethanol	700.2	669.9	
$C_2H_3F_3O$	Methyl trifluoromethyl ether	719.2	690.0	
C_2H_3N	Acetonitrile	779.2	748	
C_2H_3N	Isocyanomethane	839.1	806.6	
C_2H_3NO	Methyl isocyanate	764.4	732.0	
C_2H_3NS	Methyl thiocyanate	796.7	766.1	
C_2H_3NS	Methyl isothiocyanate	799.2	766.7	
$C_2H_3N_3$	1*H*-1,2,3-Triazole	879.3	847.4	
$C_2H_3N_3$	1*H*-1,2,4-Triazole	886.0	855.9	
C_2H_4	Ethylene	680.5	651.5	
$C_2H_4F_2O$	2,2-Difluoroethanol	727.4	697.0	
$C_2H_4F_3N$	2,2,2-Trifluoroethylamine	846.8	812.9	
$C_2H_4N_2$	Aminoacetonitrile	824.9	791.0	
C_2H_4O	Acetaldehyde	768.5	736.5	
C_2H_4O	Oxirane	774.2	745.3	
$C_2H_4O_2$	Acetic acid	783.7	752.8	
$C_2H_4O_2$	Methyl formate	782.5	751.5	
C_2H_4S	Thiirane	807.4	777.6	
C_2H_5Br	Bromoethane	696.2	669.7	

Molecular formula	Name	E_{pa} kJ/mol	$\Delta_{base}G°$ kJ/mol	Notes
C_2H_5BrO	2-Bromoethanol	766.1	735.7	
C_2H_5Cl	Chloroethane	693.4	666.9	
C_2H_5ClO	2-Chloroethanol	766.1	735.7	
C_2H_5F	Fluoroethane	683.4	655.8	
C_2H_5FO	2-Fluoroethanol	715.6	685.2	
C_2H_5I	Iodoethane	724.8	698.3	
C_2H_5N	Ethenamine	898.9	866.5	
C_2H_5N	Ethyleneimine	905.5	872.5	
C_2H_5NO	Acetamide	863.6	832.6	
C_2H_5NO	*N*-Methylformamide	851.3	820.3	
$C_2H_5NO_2$	Nitroethane	765.7	733.2	
$C_2H_5NO_2$	Ethyl nitrite	818.9	786.4	
$C_2H_5NO_2$	Glycine	886.5	852.2	
$C_2H_5NO_2$	Acetohydroxamic acid	854.0	823.0	
C_2H_5NS	Thioacetamide	884.6	852.8	
C_2H_6	Ethane	596.3	569.9	
C_2H_6Hg	Dimethyl mercury	771.6	740.8	
$C_2H_6N_2$	Ethanimidamide	970.7	938.2	
$C_2H_6N_2$	trans-Dimethyldiazene	865.1	834.4	
$C_2H_6N_2O$	2-Aminoacetamide		882.3	
$C_2H_6N_2O_2$	*N*-Methyl-*N*-nitromethanamine	828.3	795.8	
C_2H_6O	Ethanol	776.4	746	
C_2H_6O	Dimethyl ether	792	764.5	
C_2H_6OS	Dimethyl sulfoxide	884.4	853.7	
$C_2H_6O_2$	1,2-Ethanediol	815.9	773.6	
C_2H_6S	Ethanethiol	789.6	758.4	
C_2H_6S	Dimethyl sulfide	830.9	801.2	
$C_2H_6S_2$	Dimethyl disulfide	815.3	782.8	
C_2H_7N	Ethylamine	912.0	878	
C_2H_7N	Dimethylamine	929.5	896.5	
C_2H_7NO	Ethanolamine	930.3	896.8	
$C_2H_7O_3P$	Dimethyl hydrogen phosphite	894.8	862.4	
C_2H_7P	Dimethylphosphine	912.0	877.9	
$C_2H_8N_2$	1,2-Ethanediamine	951.6	912.5	
$C_2H_8N_2$	1,1-Dimethylhydrazine	927.1	894.7	
C_2N_2	Cyanogen	674.7	645.8	
C_2O	Dicarbon monoxide	774.7	747.0	
C_3	Carbon trimer	767.0	736.3	
C_3F_6O	Perfluoroacetone	670.4	639.7	
C_3HN	Cyanoacetylene	751.2	720.5	
$C_3H_2F_6O$	1,1,1,3,3,3-Hexafluoro-2-propanol	686.6	656.2	
$C_3H_2N_2$	Malononitrile	723.0	694.1	
C_3H_3	2-Propynyl	741	708.5	
$C_3H_3Cl_3O$	1,1,1-Trichloro-2-propanone	768.3	736.3	
$C_3H_3F_3O$	1,1,1-Trifluoroacetone	723.9	692.0	
$C_3H_3F_3O_2$	Methyl trifluoroacetate	740.5	709.6	
C_3H_3N	Acrylonitrile	784.7	753.7	
C_3H_3NO	Oxazole	876.4	844.5	
C_3H_3NO	Isoxazole	848.6	816.8	
C_3H_3NO	2-Oxopropanenitrile	746.9	716.2	
C_3H_3NS	Thiazole	904	872.1	
$C_3H_3N_3$	1,3,5-Triazine	848.8	819.6	
C_3H_4	Allene	775.3	745.8	
C_3H_4	Propyne	748.2	723.0	
C_3H_4	Cyclopropene	818.5	787.8	
C_3H_4ClN	3-Chloropropanenitrile	773.1	742.4	
$C_3H_4N_2$	1*H*-Pyrazole	894.1	860.5	
$C_3H_4N_2$	Imidazole	942.8	909.2	
$C_3H_4N_2S$	2-Thiazolamine	930.6	898.7	
C_3H_4O	Acrolein	797.0	765.1	

Molecular formula	Name	E_{pa} kJ/mol	$\Delta_{base}G°$ kJ/mol	Notes
C_3H_4O	1-Propen-1-one	834.1	803.4	
$C_3H_4O_3$	Ethylene carbonate	814.2	784.4	
C_3H_5	Allyl	736	707.4	
C_3H_5	Cyclopropyl	738.9	702.0	
$C_3H_5ClO_2$	Ethyl chloroformate	764.8	733.8	
C_3H_5FO	1-Fluoro-2-propanone	795.4	763.5	
$C_3H_5F_3O$	2,2,2-Trifluoroethyl methyl ether	747.6	718.4	
C_3H_5N	Propanenitrile	794.1	763.0	
C_3H_5N	2-Propyn-1-amine	887.4	853.5	
C_3H_5N	Ethyl isocyanide	851.3	818.9	
C_3H_5NO	Acrylamide	870.7	839.8	
C_3H_5NO	Methoxyacetonitrile	758.1	727.4	
C_3H_5NO	2-Azetidinone	852.6	821.7	
C_3H_5NS	(Methylthio)acetonitrile	784.8	754.1	
$C_3H_5N_3$	1*H*-Pyrazol-3-amine	921.5	889.6	
$C_3H_5N_3$	1*H*-Pyrazol-4-amine	907.6	874.0	
C_3H_6	Propene	741.6		Ref. 5
C_3H_6	Cyclopropane	750.3	722.2	
$C_3H_6N_2$	3-Aminopropanenitrile	866.4	832.5	
$C_3H_6N_2$	Dimethylcyanamide	852.1	821.4	
$C_3H_6N_2S$	2-Imidazolidinethione	921.9	891.2	
C_3H_6O	Methyl vinyl ether	859.2	830.3	
C_3H_6O	Propanal	786.0	754.0	
C_3H_6O	Acetone	812	782.1	
C_3H_6O	Oxetane	801.3	773.9	
$C_3H_6O_2$	Propanoic acid	797.2	766.2	
$C_3H_6O_2$	Ethyl formate	799.4	768.4	
$C_3H_6O_2$	Methyl acetate	821.6	790.7	
$C_3H_6O_3$	Dimethyl carbonate	830.2	799.2	
C_3H_6S	(Methylthio)ethene	858.2	829.3	
C_3H_6S	Thietane	834.8	805.0	
C_3H_6S	Methylthiirane	833.3	801.5	
C_3H_7N	Allylamine	909.5	875.5	
C_3H_7N	Cyclopropylamine	904.7	869.9	
C_3H_7N	Azetidine	943.4	908.6	
C_3H_7N	1-Methylaziridine	934.8	904.1	
C_3H_7N	Propyleneimine	925.1	892.1	
C_3H_7NO	*N*,*N*-Dimethylformamide	887.5	856.6	
C_3H_7NO	*N*-Methylacetamide	888.5	857.6	
C_3H_7NO	Propanamide	876.2	845.3	
$C_3H_7NO_2$	Isopropyl nitrite	845.5	813.0	
$C_3H_7NO_2$	*L*-Alanine	901.6	867.7	
$C_3H_7NO_2$	Sarcosine	921.2	888.7	
$C_3H_7NO_2S$	*L*-Cysteine	903.2	869.3	
$C_3H_7NO_3$	*L*-Serine	914.6	880.7	
C_3H_8	Propane	625.7	607.8	
$C_3H_8N_2O$	*N*,*N*'-Dimethylurea	903.3	873.5	
$C_3H_8N_2S$	*N*,*N*'-Dimethylthiourea	926.0	895.1	
C_3H_8O	1-Propanol	786.5	756.1	
C_3H_8O	2-Propanol	793.0	762.6	
C_3H_8O	Ethyl methyl ether	808.6	781.2	
$C_3H_8O_2$	1,3-Propanediol	876.2	825.9	
$C_3H_8O_2$	2-Methoxyethanol	768.8	729.8	
$C_3H_8O_3$	Glycerol	874.8	820	
C_3H_8S	1-Propanethiol	794.9	763.6	
C_3H_8S	2-Propanethiol	803.6	772.3	
C_3H_8S	Ethyl methyl sulfide	846.5	815.3	
C_3H_9As	Trimethylarsine	897.3	864.9	
$C_3H_9BO_3$	Trimethyl borate	815.8	783.4	
C_3H_9N	Propylamine	917.8	883.9	

Molecular formula	Name	E_{pa} kJ/mol	$\Delta_{base}G°$ kJ/mol	Notes
C_3H_9N	Isopropylamine	923.8	889.0	
C_3H_9N	Ethylmethylamine	942.2	909.2	
C_3H_9N	Trimethylamine	948.9	918.1	
C_3H_9NO	2-Methoxyethylamine	928.6	894.6	
C_3H_9NO	Trimethylamine oxide	983.2	953.5	
C_3H_9NO	3-Amino-1-propanol	962.5	917.3	
$C_3H_9O_3P$	Trimethyl phosphite	929.7	899.9	
$C_3H_9O_4P$	Trimethyl phosphate	890.6	860.8	
C_3H_9P	Trimethylphosphine	958.8	926.3	
$C_3H_{10}N_2$	1,3-Propanediamine	987.0	940.0	
$C_3H_{10}OSi$	Trimethylsilanol	814.0	781.5	
C_4F_8	Perfluorocyclobutane	>544		Ref. 6
C_4H_2	1,3-Butadiyne	737.2	712.8	
$C_4H_4F_6O$	Bis(2,2,2-trifluoroethyl) ether	702.3	674.9	
$C_4H_4N_2$	Pyrazine	877.1	847.0	
$C_4H_4N_2$	Pyrimidine	885.8	855.7	
$C_4H_4N_2$	Pyridazine	907.2	877.1	
$C_4H_4N_2O_2$	Uracil	872.7	841.7	
$C_4H_4N_2S_2$	2,4(1*H*,3*H*)-Pyrimidinedithione	911.4	880.5	
C_4H_4O	Furan	812	781	Ref. 10
$C_4H_4O_3$	Succinic anhydride	797		Ref. 9
C_4H_4S	Thiophene	815.0	784.3	
$C_4H_5Cl_3O_2$	Ethyl trichloroacetate	790.4	759.4	
$C_4H_5F_3O_2$	Ethyl trifluoroacetate	758.8	727.9	
C_4H_5N	Pyrrole	875.4	843.8	
C_4H_5N	Cyclopropanecarbonitrile	808.2	777.5	
$C_4H_5NO_2$	Ethyl cyanoformate	745.7	714.7	
C_4H_5NS	2-Methylthiazole	930.6	898.7	
$C_4H_5N_3O$	Cytosine	949.9	918	
C_4H_6	1,2-Butadiene	778.9	749.8	
C_4H_6	1,3-Butadiene	783.4	757.6	
C_4H_6	2-Butyne	775.8	745.1	
C_4H_6	Cyclobutene	784.4	753.6	
$C_4H_6F_3NO$	2,2,2-Trifluoro-*N*,*N*-dimethylacetamide	849.0	818.0	
$C_4H_6N_2$	1-Methylimidazol	959.6	927.7	
$C_4H_6N_2$	2-Methyl-1*H*-imidazole	963.4	929.6	
$C_4H_6N_2$	4-Methyl-1*H*-imidazole	952.8	920.9	
$C_4H_6N_2$	1-Methyl-1*H*-pyrazole	912.0	880.1	
$C_4H_6N_2$	3-Methyl-1*H*-pyrazole	906.0	874.2	
$C_4H_6N_2$	4-Methyl-1*H*-pyrazole	906.8	873.4	
C_4H_6O	2-Methylpropenal	808.7	776.8	
C_4H_6O	3-Buten-2-one	834.7	802.8	
C_4H_6O	Cyclobutanone	802.5	772.7	
C_4H_6O	2,3-Dihydrofuran	866.9	834.4	
C_4H_6O	2,5-Dihydrofuran	823.4	796	
$C_4H_6O_2$	*trans*-2-Butenoic acid	824.0	793	
$C_4H_6O_2$	Methacrylic acid	816.7	785.7	
$C_4H_6O_2$	Cyclopropanecarboxylic acid	821.4	790.4	
$C_4H_6O_2$	Vinyl acetate	813.9	782.9	
$C_4H_6O_2$	Methyl acrylate	825.8	794.8	
$C_4H_6O_2$	2,3-Butanedione	801.9	770.1	
$C_4H_6O_2$	γ-Butyrolactone	840.0	808.1	
$C_4H_6O_2$	2,3-Dihydro-1,4-dioxin	823.5	792.8	
$C_4H_6O_3$	Acetic anhydride	844		Ref. 9
C_4H_7	2-Methylallyl	778	747.3	
C_4H_7N	Butanenitrile	798.4	767.7	
C_4H_7N	2-Methylpropanenitrile	803.6	772.8	
C_4H_7N	1-Isocyanopropane	856.8	824.3	
C_4H_7NO	2-Butenamide	887.1	856.1	

Molecular formula	Name	E_{pa} kJ/mol	$\Delta_{base}G°$ kJ/mol	Notes
C_4H_7NO	2-Methyl-2-propenamide	880.4	849.4	
$C_4H_7NO_4$	*L*-Aspartic acid	908.9	875	
C_4H_8	*trans*-2-Butene	747	719.9	
C_4H_8	Isobutene	802.1	775.6	
$C_4H_8N_2$	(Dimethylamino)acetonitrile	884.5	853.7	
$C_4H_8N_2O_3$	*L*-Asparagine	929	891.5	
$C_4H_8N_2O_3$	*N*-Glycylglycine		882	
C_4H_8O	Ethyl vinyl ether	870.1	840.4	
C_4H_8O	2-Methoxy-1-propene	894.9	866.1	
C_4H_8O	Butanal	792.7	760.8	
C_4H_8O	Isobutanal	797.3	765.5	
C_4H_8O	2-Butanone	827.3	795.5	
C_4H_8O	Tetrahydrofuran	822.1	794.7	
$C_4H_8O_2$	Propyl formate	804.9	773.9	
$C_4H_8O_2$	Isopropyl formate	811.3	780.3	
$C_4H_8O_2$	Ethyl acetate	835.7	804.7	
$C_4H_8O_2$	Methyl propanoate	830.2	799.2	
$C_4H_8O_2$	1,3-Dioxane	825.4	796.2	
$C_4H_8O_2$	1,4-Dioxane	797.4	770.0	
$C_4H_8O_3$	Ethyl methyl carbonate	842.7	810.8	
C_4H_8S	Tetrahydrothiophene	849.1	819.3	
C_4H_9N	Pyrrolidine	948.3	915.3	
C_4H_9NO	*N*-Methylpropanamide	920.4	889.4	
C_4H_9NO	2-Methylpropanamide	878.6	846.7	
C_4H_9NO	*N*-Ethylacetamide	898.0	867.0	
C_4H_9NO	*N,N*-Dimethylacetamide	908.0	877.0	
C_4H_9NO	Morpholine	924.3	891.2	
$C_4H_9NO_2$	*tert*-Butyl nitrite	863.9	831.4	
$C_4H_9NO_2$	Ethyl *N*-methylcarbamate	888.8	857.8	
$C_4H_9NO_3$	*L*-Threonine	922.5	888.5	
C_4H_9NS	*N,N*-Dimethylthioacetamide	925.3	894.4	
C_4H_{10}	Isobutane	677.8	671.3	
$C_4H_{10}N_2$	Piperazine	943.7	914.7	
$C_4H_{10}N_2$	3-Ethyl-3-methyldiaziridine	903.8	871.3	
$C_4H_{10}O$	1-Butanol	789.2	758.9	
$C_4H_{10}O$	2-Butanol	815.7	784.6	
$C_4H_{10}O$	2-Methyl-1-propanol	793.7	762.2	
$C_4H_{10}O$	2-Methyl-2-propanol	802.6	772.2	
$C_4H_{10}O$	Diethyl ether	828.4	801	
$C_4H_{10}O$	Methyl propyl ether	814.9	785.7	
$C_4H_{10}O$	Isopropyl methyl ether	826.3	797.1	
$C_4H_{10}O_2$	1,4-Butanediol	915.6	854.9	
$C_4H_{10}O_2$	1,2-Dimethoxyethane	858.0	820.2	
$C_4H_{10}O_3$	1,2,4-Butanetriol	905.9	841	
$C_4H_{10}S$	1-Butanethiol	801.7	770.5	
$C_4H_{10}S$	2-Methyl-1-propanethiol	802.6	771.4	
$C_4H_{10}S$	2-Methyl-2-propanethiol	816.4	785.1	
$C_4H_{10}S$	Diethyl sulfide	856.7	827.0	
$C_4H_{11}N$	Butylamine	921.5	886.6	
$C_4H_{11}N$	*tert*-Butylamine	934.1	899.9	
$C_4H_{11}N$	Isobutylamine	924.8	890.8	
$C_4H_{11}N$	Diethylamine	952.4	919.4	
$C_4H_{11}N$	Isopropylmethylamine	952.4	919.4	
$C_4H_{11}N$	Ethyldimethylamine	960.1	929.1	
$C_4H_{11}NO$	*N*-Ethyl-*N*-hydroxyethanamine	914.7	882.2	
$C_4H_{11}NO$	4-Amino-1-butanol	984.5	932.1	
$C_4H_{11}NO_2$	Diethanolamine	953	920	
$C_4H_{12}N_2$	1,4-Butanediamine	1005.6	954.3	
$C_4H_{12}N_2$	*N,N'*-Dimethyl-1,2-ethanediamine	989.2	946.9	
$C_4H_{12}Sn$	Tetramethylstannane	823.7	797.4	

Molecular formula	Name	E_{pa} kJ/mol	$\Delta_{base}G°$ kJ/mol	Notes
$C_4H_{14}OSi_2$	1,1,3,3-Tetramethyldisiloxane	845.3	814.6	
C_4NiO_4	Nickel carbonyl	742.3	716.0	
C_5F_5N	Perfluoropyridine	764.9	733.0	
C_5FeO_5	Iron pentacarbonyl	833.0	798.5	
$C_5H_3ClN_4$	6-Chloro-1*H*-purine	873.6	841.7	
C_5H_4BrN	2-Bromopyridine	904.8	873.0	
C_5H_4BrN	3-Bromopyridine	910.0	878.2	
C_5H_4BrN	4-Bromopyridine	917.8	886.0	
C_5H_4ClN	2-Chloropyridine	900.9	869	
C_5H_4ClN	3-Chloropyridine	903.4	871.5	
C_5H_4ClN	4-Chloropyridine	916.1	884.2	
C_5H_4FN	3-Fluoropyridine	902.0	870.1	
C_5H_4FN	2-Fluoropyridine	884.6	852.7	
$C_5H_4N_2O_2$	4-Nitropyridine	874.3	842.5	
$C_5H_4N_2O_3$	4-Nitropyridine 1-oxide	868.0	837.3	
$C_5H_4N_4$	1*H*-Purine	920.1	888.2	
$C_5H_4N_4O$	Hypoxanthine	912.3	880.5	
C_5H_5	Cyclopentadienyl	831.5	799.1	
C_5H_5N	Pyridine	930	898.1	
C_5H_5NO	3-Pyridinol	929.5	897.7	
C_5H_5NO	Pyridine-1-oxide	923.6	892.9	
$C_5H_5N_5$	Adenine	942.8	912.5	
$C_5H_5N_5O$	Guanine	959.5	927.6	
C_5H_6	1,3-Cyclopentadiene	821.6	798.4	
$C_5H_6N_2$	2-Pyridinamine	947.2	915.3	
$C_5H_6N_2$	3-Pyridinamine	954.4	922.6	
$C_5H_6N_2$	4-Pyridinamine	979.7	947.8	
$C_5H_6N_2O_2$	Thymine	880.9	850.0	
C_5H_6O	2-Methylfuran	865.9	833.5	
C_5H_6O	3-Methylfuran	854.0	821.5	
$C_5H_6O_3$	Glutaric anhydride	816		Ref. 9
$C_5H_6O_3$	3-Methylsuccinic anhydride	807		Ref. 9
C_5H_6S	2-Methylthiophene	859.0	826.5	
$C_5H_7F_3O_2$	Propyl trifluoroacetate	763.9	732.9	
C_5H_8	*trans*-1,3-Pentadiene	834.1	804.4	
C_5H_8	2-Methyl-1,3-butadiene	826.4	797.6	
C_5H_8	2-Pentyne	810.2	778.0	
C_5H_8	3-Methyl-1-butyne	814.9	787.8	
C_5H_8	Cyclopentene	766.3	733.8	
C_5H_8	1-Methylcyclobutene	841.5	807.3	
C_5H_8	Vinylcyclopropane	816.3	787.5	
C_5H_8	3,3-Dimethylcyclopropene	847.8	817.1	
$C_5H_8N_2$	1,3-Dimethyl-1*H*-pyrazole	933.9	902.3	
$C_5H_8N_2$	1,4-Dimethyl-1*H*-imidazole	976.7	944.9	
$C_5H_8N_2$	1,5-Dimethyl-1*H*-pyrazole	934.3	902.8	
$C_5H_8N_2$	3,4-Dimethyl-1*H*-pyrazole	927.3	895.4	
$C_5H_8N_2$	3,5-Dimethyl-1*H*-pyrazole	933.5	900.1	
$C_5H_8N_2$	1,2-Dimethyl-1*H*-imidazole	984.7	952.6	
$C_5H_8N_2$	1,5-Dimethyl-1*H*-imidazole	977.6	945.8	
C_5H_8O	*trans*-2-Pentenal	839.0	807.2	
C_5H_8O	3-Methyl-2-butenal	856.9	825.0	
C_5H_8O	3-Methyl-3-buten-2-one	843.1	811.3	
C_5H_8O	Cyclopropyl methyl ketone	854.9	823	
C_5H_8O	Cyclopentanone	823.7	794.0	
C_5H_8O	3,4-Dihydro-2H-pyran	865.8	833.4	
$C_5H_8O_2$	3-Methyl-2-butenoic acid	822.9	791.9	
$C_5H_8O_2$	*cis*-2-Methyl-2-butenoic acid	822.5	791.5	
$C_5H_8O_2$	Cyclobutanecarboxylic acid	817.4	786.4	
$C_5H_8O_2$	Methyl trans-2-butenoate	851.3	820.4	
$C_5H_8O_2$	Methyl methacrylate	831.4	800.5	

Molecular formula	Name	E_{pa} kJ/mol	$\Delta_{base}G°$ kJ/mol	Notes
$C_5H_8O_2$	Methyl cyclopropanecarboxylate	842.1	811.2	
$C_5H_8O_2$	2,4-Pentanedione	873.5	836.8	
C_5H_9N	2-Isocyano-2-methylpropane	870.7	838.3	
C_5H_9N	3-(Dimethylamino)-1-propyne	940.3	909.5	
C_5H_9N	Pentanenitrile	802.4	771.7	
C_5H_9N	2,2-Dimethylpropanenitrile	810.9	780.2	
C_5H_9NO	3-Ethoxypropanenitrile	807.2	776.5	
C_5H_9NO	*N,N*-Dimethyl-2-propenamide	904.3	873.4	
C_5H_9NO	*N*-Methyl-2-pyrrolidone	923.5	891.6	
$C_5H_9NO_2$	*L*-Proline	920.5	886.0	
$C_5H_9NO_4$	*L*-Glutamic acid	913.0	879.1	
$C_5H_9N_3$	Histamine	999.8	961.9	
C_5H_{10}	2-Methyl-2-butene	808.8	779.9	
$C_5H_{10}N_2O$	1,3-Dimethyl-2-imidazolidinone	918.4	886.0	
$C_5H_{10}N_2O_3$	*L*-Glutamine	937.8	900	
$C_5H_{10}O$	Allyl ethyl ether	833.7	804.5	
$C_5H_{10}O$	Pentanal	796.6	764.8	
$C_5H_{10}O$	2-Pentanone	832.7	800.9	
$C_5H_{10}O$	3-Pentanone	836.8	807	
$C_5H_{10}O$	3-Methyl-2-butanone	836.3	804.4	
$C_5H_{10}O$	Tetrahydropyran	822.8	795.4	
$C_5H_{10}O$	2-Methyltetrahydrofuran	840.8	811.6	
$C_5H_{10}O_2$	Butyl formate	806.0	775	
$C_5H_{10}O_2$	Propyl acetate	836.6	805.6	
$C_5H_{10}O_2$	Isopropyl acetate	836.6	805.6	
$C_5H_{10}O_2$	Methyl butanoate	836.4	805.4	
$C_5H_{10}O_2$	Methyl isobutanoate	836.6	805.7	
$C_5H_{10}O_2$	*cis*-1,2-Cyclopentanediol	885.6	853.1	
$C_5H_{10}S$	Thiacyclohexane	855.8	826.0	
$C_5H_{11}N$	Allyldimethylamine	957.8	926.8	
$C_5H_{11}N$	Piperidine	954.0	921	
$C_5H_{11}N$	*N*-Methylpyrrolidine	965.6	934.8	
$C_5H_{11}NO$	2,2-Dimethylpropanamide	889.0	857.2	
$C_5H_{11}NO_2$	*L*-Valine	910.6	876.7	
$C_5H_{11}NO_2S$	*L*-Methionine	935.4	901.5	
$C_5H_{12}N_2O$	Tetramethylurea	930.6	899.6	
$C_5H_{12}N_2S$	Tetramethylthiourea	947.6	916.6	
$C_5H_{12}O$	2,2-Dimethyl-1-propanol	795.5	765.2	
$C_5H_{12}O$	Butyl methyl ether	820.3	791.2	
$C_5H_{12}O$	Methyl tert-butyl ether	841.6	812.4	
$C_5H_{12}O$	Ethyl isopropyl ether	842.7	813.5	
$C_5H_{12}S$	2,2-Dimethyl-1-propanethiol	809.5	778.2	
$C_5H_{12}Si$	Vinyltrimethylsilane	833	804.1	
$C_5H_{13}N$	Pentylamine	923.5	889.5	
$C_5H_{13}N$	2-Methyl-2-butanamine	937.8	903.6	
$C_5H_{13}N$	2,2-Dimethylpropylamine	928.3	894.0	
$C_5H_{13}N$	Ethylisopropylamine	960.0	926.7	
$C_5H_{13}N$	*N,N*-Dimethyl-1-propanamine	962.8	931.9	
$C_5H_{13}N$	Diethylmethylamine	971.0	940.0	
$C_5H_{13}N_3$	1,1,3,3-Tetramethylguanidine	1031.6	997.4	
$C_5H_{14}N_2$	*N,N,N',N'*-Tetramethylmethanediamine	952.2	919.8	
$C_5H_{14}N_2$	*N,N*-Dimethyl-1,3-propanediamine	1025.0	975.3	
$C_5H_{14}N_2$	1,5-Pentanediamine	999.6	946.2	
C_6CrO_6	Chromium carbonyl	739.2	714.6	
C_6F_6	Hexafluorobenzene	648.0	624.4	
C_6HF_5	Pentafluorobenzene	690.4	662.7	
$C_6H_2F_4$	1,2,3,4-Tetrafluorobenzene	700.4	672.7	
$C_6H_2F_4$	1,2,3,5-Tetrafluorobenzene	747.3	719.6	
$C_6H_2F_4$	1,2,4,5-Tetrafluorobenzene	746.5	718.8	
$C_6H_3F_3$	1,2,3-Trifluorobenzene	724.3	696.6	

Molecular formula	Name	E_{pa} kJ/mol	$\Delta_{base}G°$ kJ/mol	Notes
$C_6H_3F_3$	1,2,4-Trifluorobenzene	729.5	699.4	
$C_6H_3F_3$	1,3,5-Trifluorobenzene	741.9	715.4	
C_6H_4	Benzyne	841	808.5	
$C_6H_4F_2$	*o*-Difluorobenzene	731.2	703.5	
$C_6H_4F_2$	*m*-Difluorobenzene	749.7	722	
$C_6H_4F_2$	*p*-Difluorobenzene	718.7	692.8	
$C_6H_4N_2$	2-Pyridinecarbonitrile	872.9	841	
$C_6H_4N_2$	3-Pyridinecarbonitrile	877.0	845.1	
$C_6H_4N_2$	4-Pyridinecarbonitrile	880.6	848.8	
$C_6H_4O_2$	*p*-Benzoquinone	799.1	769.3	
C_6H_5	Phenyl	884	851.5	
C_6H_5Br	Bromobenzene	754.1	725.8	
C_6H_5Cl	Chlorobenzene	753.1	724.6	
C_6H_5F	Fluorobenzene	755.9	726.6	
C_6H_5NO	Nitrosobenzene	854.3	823.6	
C_6H_5NO	4-Pyridinecarboxaldehyde	904.6	872.8	
$C_6H_5NO_2$	Nitrobenzene	800.3	769.5	
$C_6H_5N_3$	Azidobenzene	820	787.5	
C_6H_5O	Phenoxy	873.2		Ref. 4
C_6H_6	Benzene	750.4	725.4	
C_6H_6BrN	3-Bromoaniline	873.2	841.4	
C_6H_6ClN	3-Chloroaniline	868.1	836.3	
C_6H_6ClN	4-Chloroaniline	873.8	842.0	
C_6H_6ClN	2-Chloro-4-methylpyridine	921.2	889.4	
C_6H_6ClN	2-Chloro-6-methylpyridine	908.0	876.2	
C_6H_6ClNO	2-Chloro-6-methoxypyridine	909.9	878.0	
C_6H_6FN	3-Fluoroaniline	867.3	835.5	
C_6H_6FN	4-Fluoroaniline	871.5	839.7	
C_6H_6IN	3-Iodoaniline	878.7	846.8	
C_6H_6N	Anilino	949.8	917.4	
$C_6H_6N_2O$	3-Pyridinecarboxamide	918.3	886.4	
$C_6H_6N_2O_2$	4-Nitroaniline	866.0	834.2	
$C_6H_6N_4$	6-Methyl-1*H*-purine	939.2	907.3	
C_6H_6O	Bis(2-propynyl) ether	783.9	756.5	
C_6H_6O	Phenol	817.3	786.3	
C_6H_7N	Bis(2-propynyl)amine	910.0	876.9	
C_6H_7N	Aniline	882.5	850.6	
C_6H_7N	2-Methylpyridine	949.1	917.3	
C_6H_7N	3-Methylpyridine	943.4	911.6	
C_6H_7N	4-Methylpyridine	947.2	915.3	
C_6H_7NO	1-Methyl-2(1*H*)-pyridinone	925.8	894.8	
C_6H_7NO	2-Aminophenol	898.8	866.9	
C_6H_7NO	3-Aminophenol	898.8	866.9	
C_6H_7NO	2-Methoxypyridine	934.7	902.8	
C_6H_7NO	3-Methoxypyridine	942.7	910.9	
C_6H_7NO	4-Methoxypyridine	961.7	929.8	
C_6H_7NO	3-Methylpyridine-1-oxide	935.2	902.8	
C_6H_8	1,3-Cyclohexadiene	837	804.5	
C_6H_8	1,4-Cyclohexadiene	837	808.0	
$C_6H_8N_2$	1,2-Benzenediamine	896.5	865.8	
$C_6H_8N_2$	1,3-Benzenediamine	929.9	899.2	
$C_6H_8N_2$	1,4-Benzenediamine	905.9	874.0	
$C_6H_8N_2O$	Bis(2-cyanoethyl) ether	813.8	786.4	
C_6H_8O	2,4-Dimethylfuran	894.7	862.3	
C_6H_8O	2,5-Dimethylfuran	865.9	835.2	
C_6H_8O	3,4-Dimethylfuran	869.0	838.3	
$C_6H_8O_2$	1,3-Cyclohexanedione	881.2	849.4	
$C_6H_8O_2$	1,4-Cyclohexanedione	812.5	782.7	
$C_6H_8O_2$	1,2-Cyclohexanedione	849.6	818.9	
$C_6H_8O_3$	4-Methylglutaric anhydride	820		Ref. 9

Molecular formula	Name	E_{pa} kJ/mol	$\Delta_{base}G°$ kJ/mol	Notes
$C_6H_9F_3O_2$	Butyl trifluoroacetate	764.8	733.8	
C_6H_9N	2,5-Dimethylpyrrole	918.7	887.1	
$C_6H_9N_3O_2$	*L*-Histidine	988	950.2	
C_6H_{10}	Methylenecyclopentane	832.4	803.5	
C_6H_{10}	(1-Methylvinyl)cyclopropane	871.6	842.7	
C_6H_{10}	2-Methyl-1,3-pentadiene	864.9	836	
C_6H_{10}	3-Methyl-1,3-pentadiene	852.3	823.4	
C_6H_{10}	2,3-Dimethyl-1,3-butadiene	835.0	807.8	
C_6H_{10}	1-Hexyne	799.8	774.8	
C_6H_{10}	2-Hexyne	806.1	781.1	
C_6H_{10}	Cyclohexene	784.5	752.0	
C_6H_{10}	1-Methylcyclopentene	816.5	787.1	
$C_6H_{10}N_2$	1,3,5-Trimethyl-1*H*-pyrazole	949.3	917.4	
$C_6H_{10}N_2$	3,4,5-Trimethyl-1*H*-pyrazole	949.3	916.0	
$C_6H_{10}O$	7-Oxabicyclo[2.2.1]heptane	844.2	816.8	
$C_6H_{10}O$	7-Oxabicyclo[4.1.0]heptane	848.1	815.6	
$C_6H_{10}O$	*trans*-3-Hexen-2-one	865.6	833.8	
$C_6H_{10}O$	Diallyl ether	827.4	800.0	
$C_6H_{10}O$	Cyclohexanone	841.0	811.2	
$C_6H_{10}O$	Mesityl oxide	878.7	846.9	
$C_6H_{10}O_2$	Cyclopentanecarboxylic acid	817.4	786.4	
$C_6H_{10}O_2$	2,5-Hexanedione	892.0	851.8	
$C_6H_{11}N$	*N*-Allyl-2-propen-1-amine	949.3	916.3	
$C_6H_{11}NO$	1-Methyl-2-piperidinone	924.4	892.6	
$C_6H_{11}N_3O_4$	*N*-(*N*-Glycylglycyl)glycine	966.8	916.8	
C_6H_{12}	1-Hexene	805.2	776.3	
C_6H_{12}	2-Methyl-2-pentene	812	783.1	
C_6H_{12}	2,3-Dimethyl-2-butene	813.9	785.9	
C_6H_{12}	Cyclohexane	686.9	666.9	
$C_6H_{12}N_2$	Triethylenediamine	963.4	934.6	
$C_6H_{12}N_2O_3$	*N*-*L*-Alanyl-*L*-alanine		905.6	
$C_6H_{12}O$	Oxepane	834.2	806.8	
$C_6H_{12}O$	3-Hexanone	843.2	811.3	
$C_6H_{12}O$	3,3-Dimethyl-2-butanone	840.1	808.2	
$C_6H_{12}O_2$	*cis*-1,3-Cyclohexanediol	882.2	849.7	
$C_6H_{12}O_2$	*trans*-1,3-Cyclohexanediol	828.6	797.9	
$C_6H_{12}O_2$	Methyl 2,2-dimethylpropanoate	845.2	814.2	
$C_6H_{12}O_2$	Diacetone alcohol	822.9	791.1	
$C_6H_{12}O_6$	α-*D*-Glucose		778.9	
$C_6H_{12}O_6$	β-*D*-Glucose		778.9	
$C_6H_{13}N$	*N*,*N*,2-Trimethylpropenylamine	967.0	934.5	
$C_6H_{13}N$	Cyclohexylamine	934.4	899.6	
$C_6H_{13}N$	1-Methylpiperidine	971.1	940.1	
$C_6H_{13}N$	Hexahydro-1*H*-azepine	956.7	923.5	
$C_6H_{13}NO$	*N*,*N*-Dimethylbutanamide	921.7	890.8	
$C_6H_{13}NO$	*N*,*N*-Diethylacetamide	925.4	894.4	
$C_6H_{13}NO_2$	*L*-Leucine	914.6	880.6	
$C_6H_{13}NO_2$	*L*-Isoleucine	917.4	883.5	
$C_6H_{14}N_2O_2$	*L*-Lysine	996	951.0	
$C_6H_{14}N_4O_2$	*L*-Arginine	1051.0	1006.6	
$C_6H_{14}O$	Dipropyl ether	837.9	810.5	
$C_6H_{14}O$	Diisopropyl ether	855.5	828.1	
$C_6H_{14}O$	*tert*-Butyl ethyl ether	856.0	826.9	
$C_6H_{14}O_3$	Diethylene glycol dimethyl ether	918.8	870.9	
$C_6H_{14}S$	Dipropyl sulfide	864.7	834.9	
$C_6H_{14}S$	Diisopropyl sulfide	876.4	846.6	
$C_6H_{15}N$	Butyldimethylamine	969.2	938.2	
$C_6H_{15}N$	Isobutyldimethylamine	968.7	937.8	
$C_6H_{15}N$	Hexylamine	927.5	893.5	
$C_6H_{15}N$	Dipropylamine	962.3	929.3	

Molecular formula	Name	E_{pa} kJ/mol	$\Delta_{base}G°$ kJ/mol	Notes
$C_6H_{15}N$	Diisopropylamine	971.9	938.6	
$C_6H_{15}N$	Triethylamine	981.8	951	
$C_6H_{15}NO$	6-Amino-1-hexanol	969.0	915.7	
$C_6H_{15}OP$	Triethylphosphine oxide	936.6	906.8	
$C_6H_{15}O_4P$	Triethyl phosphate	909.3	879.6	
$C_6H_{15}P$	Triethylphosphine	984.5	952.0	
$C_6H_{16}N_2$	1,6-Hexanediamine	999.5	946.2	
$C_6H_{16}N_2$	*N,N,N',N'*-Tetramethyl-1,2-ethanediamine	1012.8	970.6	
$C_6H_{16}OSi$	Triethylsilanol	822.1	794.8	
$C_6H_{18}N_3OP$	Hexamethylphosphoric triamide	958.6	928.7	
$C_6H_{18}N_3P$	Hexamethylphosphorous triamide	930.1	897.7	
$C_6H_{18}OSi_2$	Hexamethyldisiloxane	846.4	816.2	
C_6MoO_6	Molybdenum hexacarbonyl	762.6	738.1	
C_6O_6W	Tungsten carbonyl	758.0	733.4	
$C_7H_4N_2O_2$	3-Nitrobenzonitrile	781.4	750.7	
$C_7H_4N_2O_2$	4-Nitrobenzonitrile	775.7	745.1	
C_7H_5ClO	3-Chlorobenzaldehyde	813.0	781.1	
C_7H_5ClO	4-Chlorobenzaldehyde	831.3	799.4	
C_7H_5FO	3-Fluorobenzaldehyde	814.3	782.5	
C_7H_5FO	4-Fluorobenzaldehyde	827.1	795.3	
C_7H_5N	Benzonitrile	811.5	780.9	
C_7H_5N	Isocyanobenzene	868.4	836.0	
C_7H_5NO	Benzoxazole	891.6	859.8	
$C_7H_5NO_3$	4-Nitrobenzaldehyde	795.1	763.2	
C_7H_6ClNO	3-Chlorobenzamide	877.2	846.3	
C_7H_6ClNO	4-Chlorobenzamide	877.2	846.3	
C_7H_6F	*m*-Fluorobenzyl	836.5	804	
C_7H_6FNO	3-Fluorobenzamide	877.2	846.3	
C_7H_6FNO	4-Fluorobenzamide	877.2	846.3	
$C_7H_6F_3N$	3-(Trifluoromethyl)aniline	856.9	825.1	
$C_7H_6N_2$	1*H*-Benzimidazole	953.8	920.5	
$C_7H_6N_2$	1*H*-Indazole	900.8	868.9	
$C_7H_6N_2$	3-Aminobenzonitrile	842.3	810.4	
$C_7H_6N_2$	1*H*-Pyrrolo[2,3-b]pyridine	940.2	908.3	
$C_7H_6N_2O_3$	4-Nitrobenzamide	845.3	814.4	
$C_7H_6N_2O_3$	3-Nitrobenzamide	854.2	823.2	
C_7H_6O	Benzaldehyde	834.0	802.1	
C_7H_6O	2,4,6-Cycloheptatrien-1-one	920.8	891.0	
$C_7H_6O_2$	Benzoic acid	821.1	790.1	
C_7H_7	Benzyl	831.4	800.7	
C_7H_7Br	2-Bromotoluene	775.3	745.8	
C_7H_7Br	3-Bromotoluene	782.0	752.5	
C_7H_7Br	4-Bromotoluene	775.3	745.8	
C_7H_7Cl	2-Chlorotoluene	790.5	761.1	
C_7H_7Cl	3-Chlorotoluene	783.9	754.5	
C_7H_7Cl	4-Chlorotoluene	762.9	735.2	
C_7H_7F	2-Fluorotoluene	773.3	743.8	
C_7H_7F	3-Fluorotoluene	785.4	756.0	
C_7H_7F	4-Fluorotoluene	763.8	736.1	
C_7H_7I	1-Iodo-2-methylbenzene	780.3	750.8	
C_7H_7N	4-Vinylpyridine	944.1	912.3	
C_7H_7NO	1-(3-Pyridinyl)ethanone	916.2	884.3	
C_7H_7NO	1-(4-Pyridinyl)ethanone	914.7	882.9	
C_7H_7NO	4-Aminobenzaldehyde	910.4	878.6	
C_7H_7NO	Benzamide	892.1	861.2	
$C_7H_7NO_2$	Methyl 3-pyridinecarboxylate	925.6	893.8	
$C_7H_7NO_2$	Methyl 4-pyridinecarboxylate	926.6	894.7	
$C_7H_7NO_2$	Aniline-2-carboxylic acid	901.5	869.0	
$C_7H_7NO_2$	Aniline-3-carboxylic acid	864.7	832.3	

Molecular formula	Name	E_{pa} kJ/mol	$\Delta_{base}G°$ kJ/mol	Notes
$C_7H_7NO_2$	Aniline-4-carboxylic acid	864.7	832.3	
$C_7H_7NO_2$	4-Nitrotoluene	815.2	782.7	
$C_7H_7NO_3$	4-Nitrobenzenemethanol	810.5	778.0	
$C_7H_7N_3$	1-Methyl-1*H*-benzotriazole	931.2	898.7	
C_7H_7O	2-Methylphenoxy	874.5	842	
C_7H_8	Toluene	784.0	756.3	
C_7H_8	2,5-Norbornadiene	849.3	820.3	
$C_7H_8N_2O$	4-Aminobenzamide	927.9	896.9	
$C_7H_8N_2O$	3-Aminobenzamide	900.9	869.9	
$C_7H_8N_2O_2$	*N*-Methyl-4-nitroaniline	891.6	865.1	
C_7H_8O	*o*-Cresol	832	800	Ref. 10
C_7H_8O	*m*-Cresol	841	809	Ref. 10
C_7H_8O	*p*-Cresol	814	782	Ref. 10
C_7H_8O	Benzyl alcohol	778.3	748.0	
C_7H_8O	Anisole	839.6	807.2	
$C_7H_8O_2$	2,6-Dimethyl-4*H*-pyran-4-one	941.5	907.3	
$C_7H_8O_2S$	Methyl phenyl sulfone	812.7	780.3	
C_7H_8S	(Methylthio)benzene	872.6	843.7	
C_7H_9N	Benzylamine	913.3	879.4	
C_7H_9N	2-Methylaniline	890.9	859.1	
C_7H_9N	3-Methylaniline	895.8	864.0	
C_7H_9N	4-Methylaniline	896.7	864.8	
C_7H_9N	*N*-Methylaniline	916.6	890.1	
C_7H_9N	2-Ethylpyridine	952.4	920.6	
C_7H_9N	3-Ethylpyridine	947.4	915.5	
C_7H_9N	4-Ethylpyridine	951.1	919.2	
C_7H_9N	2,3-Dimethylpyridine	958.9	927.0	
C_7H_9N	2,4-Dimethylpyridine	962.9	930.8	
C_7H_9N	2,5-Dimethylpyridine	958.8	926.9	
C_7H_9N	2,6-Dimethylpyridine	963.0	931.1	
C_7H_9N	3,4-Dimethylpyridine	957.3	925.5	
C_7H_9N	3,5-Dimethylpyridine	955.4	923.5	
C_7H_9NO	2-Methoxyaniline	905.2	873.3	
C_7H_9NO	3-Methoxyaniline	913.0	881.1	
C_7H_9NO	4-Methoxyaniline	900.3	868.5	
C_7H_{10}	Bicyclo[2.2.1]hept-2-ene	836.5	804.0	
$C_7H_{10}N_2$	*N*,*N*-Dimethyl-2-pyridinamine	968.2	941.6	
$C_7H_{10}N_2$	*N*,*N*-Dimethyl-4-pyridinamine	997.6	971.1	
$C_7H_{10}O$	Dicyclopropyl ketone	880.4	850.6	
$C_7H_{10}O$	Bicyclo[2.2.1]heptan-2-one	847.4	815.5	
$C_7H_{11}N$	Cyclohexanecarbonitrile	815.0	784.4	
C_7H_{12}	2,4-Dimethyl-1,3-pentadiene	886.5	857.6	
C_7H_{12}	1-Methylcyclohexene	825.1	792.6	
C_7H_{12}	1,2-Dimethylcyclopentene	822.6	791.9	
$C_7H_{12}N_2$	2,3,4,6,7,8-Hexahydropyrrolo[1,2-a]pyrimidine	1038.3	1005.9	
$C_7H_{12}O$	Cycloheptanone	845.6	815.9	
$C_7H_{12}O$	4-Methylcyclohexanone	844.9	813.0	
$C_7H_{12}O_2$	Cyclohexanecarboxylic acid	823.8	792.8	
$C_7H_{13}N$	1-Azabicyclo[2.2.2]octane	983.3	952.5	
C_7H_{14}	2,4-Dimethyl-2-pentene	812	783.1	
$C_7H_{14}O$	Methoxycyclohexane	840.5	811.3	
$C_7H_{14}O$	4-Heptanone	845.0	815.3	
$C_7H_{14}O$	2,4-Dimethyl-3-pentanone	850.3	820.5	
$C_7H_{14}O$	Cyclohexanemethanol	802.1	771.7	
$C_7H_{15}N$	Cyclohexanemethanamine	926.6	895.8	
$C_7H_{16}O$	*tert*-Butyl isopropyl ether	870.7	841.5	
$C_7H_{17}N$	Heptylamine	923.2	889.3	
$C_7H_{17}N$	Methyldipropylamine	983.5	950.9	
$C_7H_{17}N$	Diethylpropylamine	978.8	947.9	

Molecular formula	Name	E_{pa} kJ/mol	$\Delta_{base}G°$ kJ/mol	Notes
$C_7H_{18}N_2$	1,7-Heptanediamine	998.5	944.9	
$C_7H_{18}N_2$	*N,N,N',N'*-Tetramethyl-1,3-propanediamine	1035.2	985.4	
$C_8H_4F_3N$	3-(Trifluoromethyl)benzonitrile	791.4	760.8	
$C_8H_4F_3N$	4-(Trifluoromethyl)benzonitrile	787.2	758.3	
$C_8H_4N_2$	*m*-Dicyanobenzene	779.3	750.4	
$C_8H_4N_2$	*p*-Dicyanobenzene	779.0	751.8	
C_8H_5Cl	1-Chloro-4-ethynylbenzene	832.4	801.7	
$C_8H_5Cl_3O$	2,2,2-Trichloro-1-phenylethanone	818.9	787.0	
$C_8H_5F_3O$	2,2,2-Trifluoro-1-phenylethanone	799.2	767.4	
$C_8H_5F_3O$	4-(Trifluoromethyl)benzaldehyde	805.6	773.8	
C_8H_5NO	4-Formylbenzonitrile	796.9	766.3	
C_8H_6	Phenylacetylene	832.0	801.3	
C_8H_6ClN	4-(Chloromethyl)benzonitrile	812.8	782.1	
C_8H_6ClN	3-(Chloromethyl)benzonitrile	811.2	780.6	
$C_8H_6N_2$	Quinoxaline	903.8	873.7	
$C_8H_6N_2$	Cinnoline	936.3	904.4	
C_8H_7Br	1-Bromo-4-vinylbenzene	838.7	809.8	
C_8H_7Br	1-Bromo-3-vinylbenzene	822.4	793.5	
C_8H_7ClO	1-(3-Chlorophenyl)ethanone	846.9	815.1	
C_8H_7ClO	1-(4-Chlorophenyl)ethanone	856.6	824.8	
$C_8H_7ClO_2$	Methyl 4-chlorobenzoate	842.1	811.1	
$C_8H_7ClO_2$	Methyl 3-chlorobenzoate	835.4	804.4	
C_8H_7FO	1-(4-Fluorophenyl)ethanone	858.6	826.8	
C_8H_7N	Benzeneacetonitrile	805.5	774.8	
C_8H_7N	1*H*-Indole	933.4	901.9	
$C_8H_7NO_3$	1-(4-Nitrophenyl)ethanone	824.3	792.5	
$C_8H_7NO_3$	1-(3-Nitrophenyl)ethanone	826.0	794.1	
$C_8H_7NO_4$	Methyl 3-nitrobenzoate	815.7	784.7	
$C_8H_7NO_4$	Methyl 4-nitrobenzoate	813.2	782.3	
C_8H_8	Styrene	839.5	809.2	
$C_8H_8N_2$	1-Methyl-1*H*-benzimidazole	967.0	935.2	
$C_8H_8N_2$	2-Methyl-2*H*-indazole	941.4	909.6	
$C_8H_8N_2$	1-Methyl-1*H*-indazole	922.4	890.5	
C_8H_8O	3-Methylbenzaldehyde	840.0	808.1	
C_8H_8O	4-Methylbenzaldehyde	851.8	820.0	
C_8H_8O	Acetophenone	861.1	829.3	
$C_8H_8O_2$	*o*-Toluic acid	838.8	807.8	
$C_8H_8O_2$	*m*-Toluic acid	829.8	798.8	
$C_8H_8O_2$	*p*-Toluic acid	836.7	805.7	
$C_8H_8O_2$	Methyl benzoate	850.5	819.5	
$C_8H_8O_2$	3-Methoxybenzaldehyde	844.1	812.2	
$C_8H_8O_2$	4-Methoxybenzaldehyde	881.1	849.3	
$C_8H_8O_2$	1-(3-Hydroxyphenyl)ethanone	863.6	831.8	
$C_8H_8O_2$	1-(4-Hydroxyphenyl)ethanone	883.7	851.9	
$C_8H_8O_3$	Methyl 4-hydroxybenzoate	863.4	832.5	
$C_8H_8O_3$	Methyl 3-hydroxybenzoate	850.0	819.1	
C_8H_9N	2,3-Dihydro-1*H*-indole	957.1	926.3	
C_8H_9NO	3-Methylbenzamide	900.9	869.9	
C_8H_9NO	4-Methylbenzamide	900.9	869.9	
C_8H_9NO	1-(4-Aminophenyl)ethanone	908.8	877.0	
$C_8H_9NO_2$	3-Methoxybenzamide	900.9	869.9	
$C_8H_9NO_2$	2,4-Dimethyl-1-nitrobenzene	831.0	798.5	
$C_8H_9NO_2$	Methyl 4-aminobenzoate	883.9	853.0	
$C_8H_9NO_2$	4-Methoxybenzamide	900.3	869.4	
C_8H_{10}	Ethylbenzene	788.0	760.3	
C_8H_{10}	*o*-Xylene	796.0	768.3	
C_8H_{10}	*m*-Xylene	812.1	786.2	
C_8H_{10}	*p*-Xylene	794.4	766.8	
$C_8H_{10}ClN$	4-Chloro-*N,N*-dimethylaniline	922.9	896.4	

Molecular formula	Name	E_{pa} kJ/mol	$\Delta_{base}G°$ kJ/mol	Notes
$C_8H_{10}N_2O_2$	*N,N*-Dimethyl-4-nitroaniline	896.7	870.2	
$C_8H_{10}N_2O_2$	*N,N*-Dimethyl-3-nitroaniline	894.1	867.6	
$C_8H_{10}O$	Benzyl methyl ether	816.7	787.5	
$C_8H_{10}O$	2-Methylanisole	850	818	Ref. 10
$C_8H_{10}O$	3-Methylanisole	860	828	Ref. 10
$C_8H_{10}O$	4-Methylanisole	841	809	Ref. 10
$C_8H_{11}N$	4-Isopropylpyridine	955.7	923.8	
$C_8H_{11}N$	3-Ethylaniline	897.9	866.1	
$C_8H_{11}N$	*N*-Ethylaniline	924.8	892.9	
$C_8H_{11}N$	*N,N*-Dimethylaniline	941.1	909.2	
$C_8H_{11}N$	2,6-Dimethylaniline	901.7	869.8	
$C_8H_{11}N$	Benzeneethanamine	936.2	902.3	
$C_8H_{11}N$	2-Propylpyridine	955.7	923.8	
C_8H_{12}	2-Methyl-2-norbornene	845	812.5	
$C_8H_{12}N_2$	*N,N*-Dimethyl-1,4-benzenediamine	955.0	928.4	
$C_8H_{12}N_2O_2$	Ethyl 1,5-dimethyl-1*H*-pyrazole-3-carboxylate	933.4	901.5	
$C_8H_{14}O$	Cyclooctanone	849.4	819.6	
$C_8H_{14}O$	1-Cyclohexylethanone	841.4	809.5	
$C_8H_{14}O_2$	Methyl cyclohexanecarboxylate	846.2	815.3	
$C_8H_{16}O$	2,2,4-Trimethyl-3-pentanone	856.9	825.0	
$C_8H_{17}N$	Cyclohexyldimethylamine	983.6	952.6	
$C_8H_{18}O$	Dibutyl ether	845.7	818.3	
$C_8H_{18}O$	Di-*sec*-butyl ether	865.9	838.5	
$C_8H_{18}O$	Di-*tert*-butyl ether	887.4	860.0	
$C_8H_{18}O_4$	Triethylene glycol dimethyl ether	946.6	892.4	
$C_8H_{18}O_5$	Tetraethylene glycol		>910	
$C_8H_{18}S$	Dibutyl sulfide	871.8	842.1	
$C_8H_{18}S$	Di-*tert*-butyl sulfide	893.8	864.0	
$C_8H_{19}N$	*N*-Ethyl-*N*-isopropyl-2-propanamine	994.3	963.5	
$C_8H_{19}N$	Octylamine	928.9	895.0	
$C_8H_{19}N$	Dibutylamine	968.5	935.3	
$C_8H_{19}N$	Di-*sec*-butylamine	980.7	947.5	
$C_8H_{19}N$	Diisobutylamine	958.1	925.1	
$C_8H_{20}N_2$	*N,N,N',N'*-Tetramethyl-1,4-butanediamine	1046.3	992.7	
$C_8H_{20}N_2$	Tetraethylhydrazine	964.3	935.3	
$C_9H_7MnO_3$	Manganese 2-methylcyclopentadienyl tricarbonyl	833.8	801.3	
C_9H_7N	Quinoline	953.2	921.4	
C_9H_7N	Isoquinoline	951.7	919.9	
C_9H_7NO	4-Acetylbenzonitrile	826.8	795.0	
C_9H_8	Indene	848.8	819.6	
C_9H_8O	2-Methylbenzofuran	859.6	827.2	
$C_9H_8O_3$	Methyl 4-formylbenzoate	832.9	801.9	
C_9H_9Cl	1-Chloro-4-isopropenylbenzene	854.3	825.4	
$C_9H_9ClO_2$	3-Chloro-4-methoxyacetophenone	883.7	851.9	
C_9H_{10}	2-Methylstyrene	855.2	826.3	
C_9H_{10}	3-Methylstyrene	849.4	820.5	
C_9H_{10}	4-Methylstyrene	861.7	832.8	
C_9H_{10}	*cis*-1-Propenylbenzene	836.4	807.5	
C_9H_{10}	*trans*-1-Propenylbenzene	834.2	805.3	
C_9H_{10}	Isopropenylbenzene	864.2	835.3	
C_9H_{10}	Cyclopropylbenzene	834.9	802.4	
$C_9H_{10}N_2$	4-(Dimethylamino)benzonitrile	889.1	862.6	
$C_9H_{10}O$	1-(3-Methylphenyl)ethanone	868.2	836.4	
$C_9H_{10}O$	1-Phenyl-1-propanone	867.4	835.6	
$C_9H_{10}O$	1-Phenyl-2-propanone	842.6	810.8	
$C_9H_{10}O$	4-Methylacetophenone	875.5	843.6	
$C_9H_{10}OS$	4-Acetylthioanisole	888.2	856.3	
$C_9H_{10}O_2$	Methyl 2-methylbenzoate	858.3	827.3	

Molecular formula	Name	E_{pa} kJ/mol	$\Delta_{base}G°$ kJ/mol	Notes
$C_9H_{10}O_2$	Methyl 3-methylbenzoate	857.7	826.8	
$C_9H_{10}O_2$	1-(3-Methoxyphenyl)ethanone	871.2	839.3	
$C_9H_{10}O_2$	Methyl 4-methylbenzoate	861.5	830.6	
$C_9H_{10}O_2$	4-Acetylanisole	895.6	863.7	
$C_9H_{10}O_3$	Methyl 4-methoxybenzoate	870.6	839.6	
$C_9H_{10}O_3$	Methyl 3-methoxybenzoate	856.7	825.8	
$C_9H_{11}N$	5,6,7,8-Tetrahydroquinoline	966.0	934.1	
$C_9H_{11}N$	5,6,7,8-Tetrahydroisoquinoline	966.6	934.7	
$C_9H_{11}NO$	4-(Dimethylamino)benzaldehyde	924.8	898.3	
$C_9H_{11}NO$	*N,N*-Dimethylbenzamide	932.7	901.8	
$C_9H_{11}NO_2$	1,3,5-Trimethyl-2-nitrobenzene	823.8	793.1	
$C_9H_{11}NO_2$	*L*-Phenylalanine	922.9	888.9	
$C_9H_{11}NO_3$	*L*-Tyrosine	926	892.1	
C_9H_{12}	Propylbenzene	790.1	762.4	
C_9H_{12}	Isopropylbenzene	791.6	763.9	
C_9H_{12}	1,3,5-Trimethylbenzene	836.2	808.6	
$C_9H_{12}N_2$	3-(2-Pyrrolidinyl)pyridine, (*S*)-	964.0	931.0	
$C_9H_{12}N_2O_6$	Uridine	947.6	916.6	
$C_9H_{12}O_3$	1,3,5-Trimethoxybenzene	926.7	898.2	
$C_9H_{13}N$	*N*-Ethyl-*N*-methylaniline	939.0	912.4	
$C_9H_{13}N$	2,6-Diethylpyridine	972.3	940.4	
$C_9H_{13}N$	4-*tert*-Butylpyridine	957.7	925.8	
$C_9H_{13}N$	2-*tert*-Butylpyridine	961.7	929.8	
$C_9H_{13}N$	2-Methyl-*N,N*-dimethylaniline	951.8	925.3	
$C_9H_{13}N$	3-Methyl-*N,N*-dimethylaniline	942.1	915.7	
$C_9H_{13}N$	4-Methyl-*N,N*-dimethylaniline	950.0	918.1	
$C_9H_{13}N$	*N,N*-Dimethylbenzylamine	968.4	937.4	
$C_9H_{13}NO$	4-Methoxy-*N,N*-dimethylaniline	949.1	922.4	
$C_9H_{13}N_3O_5$	Cytidine	982.5	950.0	
$C_9H_{14}O$	Isophorone	893.5	861.6	
$C_9H_{15}N$	*N,N*-Diallyl-2-propen-1-amine	972.3	941.3	
$C_9H_{15}N$	*N*-(1-Cyclopenten-1-yl)pyrrolidine	1019.2	988.4	
$C_9H_{16}O$	Cyclononanone	852.6	822.8	
$C_9H_{17}N_3O_4$	*N*-(*N*-*L*-Alanyl-*L*-alanyl)-*L*-alanine		924.1	
$C_9H_{18}O$	5-Nonanone	853.7	821.9	
$C_9H_{18}O$	Di-*tert*-butyl ketone	861.3	831.5	
$C_9H_{19}N$	1-Isobutylpiperidine	974.5	943.5	
$C_9H_{19}N$	2,2,6,6-Tetramethylpiperidine	987.0	953.9	
$C_9H_{21}N$	Tripropylamine	991.0	960.1	
$C_{10}H_8$	Naphthalene	802.9	779.4	
$C_{10}H_8$	Azulene	925.2	896	
$C_{10}H_8N_2$	2,2'-Bipyridine	965		Ref. 7
$C_{10}H_9N$	1-Naphthylamine	907.0	875.1	
$C_{10}H_{10}Fe$	Ferrocene	863.6	841.3	
$C_{10}H_{10}N_2$	1,8-Naphthalenediamine	944.5	912.1	
$C_{10}H_{10}N_2$	1-Methyl-3-phenyl-1*H*-pyrazole	932.6	900.8	
$C_{10}H_{10}N_2$	1-Methyl-5-phenyl-1*H*-pyrazole	932.4	900.5	
$C_{10}H_{10}Ni$	Nickelocene	935.7	907.3	
$C_{10}H_{10}O_2$	1,4-Diacetylbenzene	850.8	821.0	
$C_{10}H_{10}O_2$	1,3-Diacetylbenzene	852.0	822.3	
$C_{10}H_{10}O_3$	4-Acetylphenyl acetate	853.2	821.3	
$C_{10}H_{10}O_4$	Dimethyl isophthalate	843.5	814.3	
$C_{10}H_{10}O_4$	Dimethyl terephthalate	843.2	812.3	
$C_{10}H_{10}Ru$	Ruthenocene	899.1	876.8	
$C_{10}H_{12}$	1-Methyl-3-(1-methylvinyl)benzene	867.6	838.7	
$C_{10}H_{12}$	1-Methyl-4-(1-methylvinyl)benzene	881.8	852.9	
$C_{10}H_{12}$	1-Methyl-2-(1-methylvinyl)benzene	857.8	828.9	
$C_{10}H_{12}$	1,2,3,4-Tetrahydronaphthalene	809.7	782.1	
$C_{10}H_{12}O$	1-(2,4-Dimethylphenyl)ethanone	882.6	850.8	
$C_{10}H_{12}O$	1-(2,5-Dimethylphenyl)ethanone	873.5	841.6	

Molecular formula	Name	E_{pa} kJ/mol	$\Delta_{base}G°$ kJ/mol	Notes
$C_{10}H_{12}O$	1-(3,4-Dimethylphenyl)ethanone	882.8	851.0	
$C_{10}H_{12}O_2$	Methyl 2,5-dimethylbenzoate	864.7	833.7	
$C_{10}H_{12}O_2$	Methyl 2,4-dimethylbenzoate	868.2	837.2	
$C_{10}H_{12}O_2$	Methyl 3,5-dimethylbenzoate	864.3	833.4	
$C_{10}H_{13}N$	1-Phenylpyrrolidine	941.6	915.1	
$C_{10}H_{13}NO$	4'-(Dimethylamino)acetophenone	932.8	906.3	
$C_{10}H_{13}NO$	*N,N*,3-Trimethylbenzamide	927.0	896.0	
$C_{10}H_{13}NO$	*N,N*,4-Trimethylbenzamide	927.0	896.0	
$C_{10}H_{13}NO$	1-[3-(Dimethylamino)phenyl]ethanone	928.0	901.5	
$C_{10}H_{13}N_5O_3$	2'-Deoxyadenosine	991.5	959.1	
$C_{10}H_{13}N_5O_4$	Adenosine	989.3	956.8	
$C_{10}H_{13}N_5O_5$	Guanosine	993.4	960.9	
$C_{10}H_{14}$	Butylbenzene	791.9	764.2	
$C_{10}H_{14}$	1,2,3,5-Tetramethylbenzene	845.6	816.5	
$C_{10}H_{14}ClN$	4-Chloro-*N,N*-diethylaniline	931.0	899.2	
$C_{10}H_{14}N_2$	*L*-Nicotine	963.4	932.6	
$C_{10}H_{14}N_2O$	*N,N*-Diethyl-3-pyridinecarboxamide	940.9	909.0	
$C_{10}H_{14}N_2O_5$	Thymidine	948.3	915.9	
$C_{10}H_{15}N$	*N,N*,2,6-Tetramethylaniline	954.1	923.2	
$C_{10}H_{15}N$	*N,N*,3,5-Tetramethylaniline	956.1	924.3	
$C_{10}H_{15}N$	*N,N*-Diethylaniline	959.8	927.9	
$C_{10}H_{16}N_2$	*N,N,N',N'*-Tetramethyl-1,2-benzenediamine	982.6	950.2	
$C_{10}H_{17}N$	Tricyclo[3.3.1.1^{3,7}]decan-1-amine	948.8	916.3	
$C_{10}H_{22}O$	Dipentyl ether	852.7	825.3	
$C_{10}H_{22}O_5$	Tetraethylene glycol dimethyl ether	953.8	897.8	
$C_{10}H_{23}N$	Decylamine	930.4	896.5	
$C_{10}H_{24}N_2$	*N,N,N',N'*-Tetramethyl-1,6-hexanediamine	1035.8	982.2	
$C_{11}H_9N$	4-Phenylpyridine	939.7	907.8	
$C_{11}H_{10}$	1-Methylnaphthalene	834.8	805.3	
$C_{11}H_{10}$	2-Methylnaphthalene	831.9	802.4	
$C_{11}H_{12}N_2O_2$	*L*-Tryptophan	948.9	915	
$C_{11}H_{14}O_2$	Methyl 2,4,6-trimethylbenzoate	866.3	835.3	
$C_{11}H_{15}N$	1-Phenylpiperidine	952.9	926.4	
$C_{11}H_{15}N$	Tricyclo[3.3.1.1^{3,7}]decane-1-carbonitrile	834.4	803.8	
$C_{11}H_{16}$	Pentamethylbenzene	850.7	823.5	
$C_{11}H_{17}N$	*N,N*-Diethyl-4-methylaniline	962.8	931.0	
$C_{11}H_{17}N$	2-Hexylpyridine	963.6	931.7	
$C_{11}H_{18}O$	1,4,7,7-Tetramethylbicyclo[2.2.1]heptan-2-one	863.3	831.4	
$C_{11}H_{24}O_4$	2,6,10,14-Tetraoxapentadecane		895.1	
$C_{12}H_8N_2$	Phenazine	938.4	908.3	
$C_{12}H_9NO$	Phenyl-3-pyridinylmethanone	934.1	902.3	
$C_{12}H_{10}$	Acenaphthene	851.7	821.0	
$C_{12}H_{10}$	Biphenyl	813.6	782.9	
$C_{12}H_{16}O$	1-(4-tert-Butylphenyl)ethanone	882.5	850.6	
$C_{12}H_{18}$	Hexamethylbenzene	860.6	836.0	
$C_{12}H_{18}O$	1-Tricyclo[3.3.1.1^{3,7}]dec-1-ylethanone	864.9	833.1	
$C_{12}H_{19}N$	*N,N*-Dipropylaniline	963.0	931.1	
$C_{12}H_{20}O$	2,5-Di-*tert*-butylfuran	894.7	863.9	
$C_{12}H_{27}N$	Tributylamine	998.5	967.6	
$C_{13}H_9N$	Acridine	972.6	940.7	
$C_{13}H_{10}$	9*H*-Fluorene	831.5	803.8	
$C_{13}H_{10}O$	Benzophenone	882.3	852.5	
$C_{13}H_{12}$	2-Methylbiphenyl	815.9	783.4	
$C_{13}H_{12}$	3-Methylbiphenyl	828.0	795.5	
$C_{13}H_{12}$	4-Methylbiphenyl	817.9	785.4	
$C_{13}H_{12}$	Diphenylmethane	802.0	769.5	
$C_{13}H_{13}P$	Methyldiphenylphosphine	972.1	939.7	

Molecular formula	Name	E_{pa} kJ/mol	$\Delta_{base}G°$ kJ/mol	Notes
$C_{13}H_{21}N$	2,6-Di-*tert*-butylpyridine	982.9	951	
$C_{13}H_{21}N$	2,4-Di-*tert*-butylpyridine	983.8	952.0	
$C_{13}H_{21}NO$	*N,N*-Dimethyltricyclo[3.3.1.1^{3,7}]decane-1-carboxamide	949.4	917.6	
$C_{14}H_{10}$	Anthracene	877.3	846.6	
$C_{14}H_{10}$	Phenanthrene	825.7	795.0	
$C_{14}H_{12}$	1,1-Diphenylethene	885.7	856.9	
$C_{14}H_{14}$	1,2-Diphenylethane	801.8	774.1	
$C_{14}H_{18}$	1,2,3,4,5,6,7,8-Octahydroanthracene	845.4	814.7	
$C_{14}H_{18}$	1,2,3,4,5,6,7,8-Octahydrophenanthrene	846.2	815.5	
$C_{14}H_{23}N$	4-Octylaniline	894.5	862	
$C_{15}H_{12}$	2-Methylanthracene	887.5	855.1	
$C_{15}H_{12}$	9-Methylanthracene	896.5	865.8	
$C_{15}H_{12}N_2$	3,5-Diphenyl-1*H*-pyrazole	946.3	912.7	
$C_{15}H_{16}$	1,3-Diphenylpropane	820.1	787.6	
$C_{15}H_{18}$	1,4-Dimethyl-7-isopropylazulene	983.1	950.6	
$C_{15}H_{24}$	1,3-Di-*tert*-butyl-5-methylbenzene	853.7	826.0	
$C_{16}H_{10}$	Fluoranthene	828.6	800.9	
$C_{16}H_{10}$	Pyrene	869.2	840.1	
$C_{16}H_{18}$	1,4-Diphenylbutane	822.0	779.8	
$C_{17}H_{20}$	1,5-Diphenylpentane	824.7	782.4	
$C_{18}H_{12}$	Chrysene	840.9	810.1	
$C_{18}H_{12}$	Naphthacene	905.5	876.5	
$C_{18}H_{12}$	Triphenylene	819.2	791.2	
$C_{18}H_{15}As$	Triphenylarsine	908.9	876.4	
$C_{18}H_{15}AsO$	Triphenylarsine oxide	906.2	876.4	
$C_{18}H_{15}N$	Triphenylamine	908.9	876.4	
$C_{18}H_{15}OP$	Triphenylphosphine oxide	906.2	876.4	
$C_{18}H_{15}P$	Triphenylphosphine	972.8	940.4	
$C_{18}H_{15}PS$	Triphenylphosphine sulfide	906.2	876.4	
$C_{18}H_{15}Sb$	Triphenylstibine	845.5	813.1	
$C_{18}H_{22}$	1,6-Diphenylhexane	826.1	783.8	
$C_{18}H_{30}$	1,3,5-Tri-*tert*-butylbenzene	848.8	822.3	
$C_{20}H_{12}$	Perylene	888.6	859.6	
$C_{22}H_{12}$	Benzo[ghi]perylene	876.0	845.2	
$C_{22}H_{14}$	Picene	851.3	820.6	
$C_{24}H_{12}$	Coronene	861.3	835.0	
C_{60}	Carbon (fullerene-C_{60})		827.5	
C_{70}	Carbon (fullerene-C_{70})		827.5	

SUMMARY TABLES OF PARTICLE PROPERTIES

Extracted from the Particle Listings of the
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GAUGE AND HIGGS BOSONS

γ

$I(J^{PC}) = 0\Gamma1(1^{--})$

Mass $m < 2 \times 10^{-16}$ eV
Charge $q < 5 \times 10^{-30}$ e
Mean life τ = Stable

g or gluon

$I(J^{P}) = 0(1^{-})$

Mass $m = 0$ [a]
SU(3) color octet

W

$J = 1$

Charge $= \pm 1$ e
Mass $m = 80.41 \pm 0.10$ GeV
$m_Z - m_W = 10.78 \pm 0.10$ GeV
$m_{W^+} - m_{W^-} = -0.2 \pm 0.6$ GeV
Full width $\Gamma = 2.06 \pm 0.06$ GeV

W^- modes are charge conjugates of the modes below.

W^+ DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\ell^+\nu$	[b]	(10.74±0.33) %		–
$e^+\nu$		(10.9 ±0.4) %		40205
$\mu^+\nu$		(10.2 ±0.5) %		40205
$\tau^+\nu$		(11.3 ±0.8) %		40185
hadrons		(67.8 ±1.0) %		–
$\pi^+\gamma$		$< 2.2 \times 10^{-4}$	95%	40205

Z

$J = 1$

Charge $= 0$
Mass $m = 91.187 \pm 0.007$ GeV [c]
Full width $\Gamma = 2.490 \pm 0.007$ GeV
$\Gamma(\ell^+\ell^-) = 83.83 \pm 0.27$ MeV [b]
Γ(invisible) $= 498.3 \pm 4.2$ MeV [d]
Γ(hadrons) $= 1740.7 \pm 5.9$ MeV
$\Gamma(\mu^+\mu^-)/\Gamma(e^+e^-) = 1.000 \pm 0.005$
$\Gamma(\tau^+\tau^-)/\Gamma(e^+e^-) = 0.998 \pm 0.005$ [e]

Average charged multiplicity

$\langle N_{charged} \rangle = 21.00 \pm 0.13$

Couplings to leptons

$g_V^\ell = -0.0377 \pm 0.0007$
$g_A^\ell = -0.5008 \pm 0.0008$
$g^{\nu e} = 0.53 \pm 0.09$
$g^{\nu\mu} = 0.502 \pm 0.017$

Asymmetry parameters [f]

$A_e = 0.1519 \pm 0.0034$
$A_\mu = 0.102 \pm 0.034$
$A_\tau = 0.143 \pm 0.008$
$A_c = 0.59 \pm 0.19$
$A_b = 0.89 \pm 0.11$

Charge asymmetry (%) at Z pole

$A_{FB}^{(0\ell)} = 1.59 \pm 0.18$
$A_{FB}^{(0u)} = 4.0 \pm 7.3$
$A_{FB}^{(0s)} = 9.9 \pm 3.1$ (S = 1.2)
$A_{FB}^{(0c)} = 7.32 \pm 0.58$
$A_{FB}^{(0b)} = 10.02 \pm 0.28$

Z DECAY MODES		Fraction (Γ_i/Γ)	Confidence level		p (MeV/c)
e^+e^-		(3.366±0.008) %			45594
$\mu^+\mu^-$		(3.367±0.013) %			45593
$\tau^+\tau^-$		(3.360±0.015) %			45559
$\ell^+\ell^-$	[b]	(3.366±0.006) %			–
invisible		(20.01 ±0.16) %			–
hadrons		(69.90 ±0.15) %			–
$(u\bar{u}+c\bar{c})/2$		(10.1 ±1.1) %			–
$(d\bar{d}+s\bar{s}+b\bar{b})/3$		(16.6 ±0.6) %			–
$c\bar{c}$		(12.4 ±0.6) %			–
$b\bar{b}$		(15.16 ±0.09) %			–
ggg		< 1.1 %		95%	–
$\pi^0\gamma$		$< 5.2 \times 10^{-5}$		95%	45593
$\eta\gamma$		$< 5.1 \times 10^{-5}$		95%	45592
$\omega\gamma$		$< 6.5 \times 10^{-4}$		95%	45590
$\eta'(958)\gamma$		$< 4.2 \times 10^{-5}$		95%	45588
$\gamma\gamma$		$< 5.2 \times 10^{-5}$		95%	45594
$\gamma\gamma\gamma$		$< 1.0 \times 10^{-5}$		95%	45594
$\pi^\pm W^\mp$	[g]	$< 7 \times 10^{-5}$		95%	10139
$\rho^\pm W^\mp$	[g]	$< 8.3 \times 10^{-5}$		95%	10114
$J/\psi(1S)$X		(3.66 ±0.23) $\times 10^{-3}$			–
$\psi(2S)$X		(1.60 ±0.29) $\times 10^{-3}$			–
$\chi_{c1}(1P)$X		(2.9 ±0.7) $\times 10^{-3}$			–
$\chi_{c2}(1P)$X		$< 3.2 \times 10^{-3}$		90%	–
$\Upsilon(1S)$ X + $\Upsilon(2S)$ X + $\Upsilon(3S)$ X		(1.0 ±0.5) $\times 10^{-4}$			–
$\Upsilon(1S)$X		$< 5.5 \times 10^{-5}$		95%	–
$\Upsilon(2S)$X		$< 1.39 \times 10^{-4}$		95%	–
$\Upsilon(3S)$X		$< 9.4 \times 10^{-5}$		95%	–
$(D^0/\bar{D}^0)$ X		(20.7 ±2.0) %			–
$D^\pm$X		(12.2 ±1.7) %			–
$D^*(2010)^\pm$X	[g]	(11.4 ±1.3) %			–
B_s^0X		seen			–
anomalous γ+ hadrons	[h]	$< 3.2 \times 10^{-3}$		95%	–
$e^+e^-\gamma$	[h]	$< 5.2 \times 10^{-4}$		95%	45594
$\mu^+\mu^-\gamma$	[h]	$< 5.6 \times 10^{-4}$		95%	45593
$\tau^+\tau^-\gamma$	[h]	$< 7.3 \times 10^{-4}$		95%	45559
$\ell^+\ell^-\gamma\gamma$	[i]	$< 6.8 \times 10^{-6}$		95%	–
$q\bar{q}\gamma\gamma$	[i]	$< 5.5 \times 10^{-6}$		95%	–

$\nu\bar{\nu}\gamma\gamma$			[*i*] < 3.1	$\times 10^{-6}$	95%	45594
$e^{\pm}\mu^{\mp}$		*LF*	[*g*] < 1.7	$\times 10^{-6}$	95%	45593
$e^{\pm}\tau^{\mp}$		*LF*	[*g*] < 9.8	$\times 10^{-6}$	95%	45576
$\mu^{\pm}\tau^{\mp}$		*LF*	[*g*] < 1.2	$\times 10^{-5}$	95%	45576

Higgs Bosons — H^0 and $H^{\pm}$, Searches for

H^0 Mass $m >$ 77.5 GeV CL = 95%

H_1^0 in Supersymmetric Models ($m_{H_1^0} < m_{H_2^0}$)

Mass $m >$ 62.5 GeV CL = 95%

A^0 Pseudoscalar Higgs Boson in Supersymmetric Models [*j*]

Mass $m >$ 62.5 GeV CL = 95% $\tan\beta > 1$

$H^{\pm}$ Mass $m >$ 54.5 GeV CL = 95%

See the Particle Listings for a Note giving details of Higgs Bosons.

Heavy Bosons Other Than Higgs Bosons, Searches for

Additional *W* Bosons

W_R — right-handed W

Mass $m >$ 549 GeV

(assuming light right-handed neutrino)

W' with standard couplings decaying to $e\nu$ / $\mu\nu$

Mass $m >$ 720 GeV CL = 95%

Additional *Z* Bosons

Z'_{SM} with standard couplings

Mass $m >$ 690 GeV CL = 95% ($p\bar{p}$ direct search)

Mass $m >$ 779 GeV CL = 95% (electroweak fit)

Z_{LR} of $SU(2)_L \times SU(2)_R \times U(1)$ (with $g_L = g_R$)

Mass $m >$ 630 GeV CL = 95% ($p\bar{p}$ direct search)

Mass $m >$ 389 GeV CL = 95% (electroweak fit)

Z_χ of $SO(10) \rightarrow SU(5) \times U(1)_\chi$ (coupling constant derived from G.U.T.)

Mass $m >$ 595 GeV CL = 95% ($p\bar{p}$ direct search)

Mass $m >$ 321 GeV CL = 95% (electroweak fit)

Z_ψ of $E_6 \rightarrow SO(10) \times U(1)_\psi$ (coupling constant derived from G.U.T.)

Mass $m >$ 590 GeV CL = 95% ($p\bar{p}$ direct search)

Mass $m >$ 160 GeV CL = 95% (electroweak fit)

Z_η of $E_6 \rightarrow SU(3) \times SU(2) \times U(1) \times U(1)_\eta$ (coupling constant derived from G.U.T.); charges are $Q_\eta = \sqrt{3/8}Q_\chi - \sqrt{5/8}Q_\psi$)

Mass $m >$ 620 GeV CL = 95% ($p\bar{p}$ direct search)

Mass $m >$ 182 GeV CL = 95% (electroweak fit)

Scalar Leptoquarks

Mass $m >$ 225 GeV CL = 95% (1st generation, pair prod.)

Mass $m >$ 237 GeV CL = 95% (1st gener., single prod.)

Mass $m >$ 119 GeV CL = 95% (2nd gener., pair prod.)

Mass $m >$ 73 GeV CL = 95% (2nd gener., single prod.)

Mass $m >$ 99 GeV CL = 95% (3rd gener., pair prod.)

(See the Particle Listings for assumptions on leptoquark quantum numbers and branching fractions.)

Axions (A^0) and Other Very Light Bosons, Searches for

The standard Peccei-Quinn axion is ruled out. Variants with reduced couplings or much smaller masses are constrained by various data. The Particle Listings in the full *Review* contain a Note discussing axion searches.

The best limit for the half-life of neutrinoless double beta decay with Majoron emission is $> 7.2 \times 10^{24}$ years (CL = 90%).

NOTES

In this Summary Table:

When a quantity has "(S = ...)" to its right, the error on the quantity has been enlarged by the "scale factor" S, defined as $S = \sqrt{\chi^2/(N-1)}$, where N is the number of measurements used in calculating the quantity. We do this when S > 1, which often indicates that the measurements are inconsistent. When S > 1.25, we also show in the Particle Listings an ideogram of the measurements. For more about S, see the Introduction.

A decay momentum p is given for each decay mode. For a 2-body decay, p is the momentum of each decay product in the rest frame of the decaying particle. For a 3-or-more-body decay, p is the largest momentum any of the products can have in this frame.

[*a*] Theoretical value. A mass as large as a few MeV may not be precluded.

[*b*] ℓ indicates each type of lepton (e, μ, and τ), not sum over them.

[*c*] The Z-boson mass listed here corresponds to a Breit-Wigner resonance parameter. It lies approximately 34 MeV above the real part of the position of the pole (in the energy-squared plane) in the Z-boson propagator.

[*d*] This partial width takes into account Z decays into $\nu\bar{\nu}$ and any other possible undetected modes.

[*e*] This ratio has not been corrected for the τ mass.

[*f*] Here $A \equiv 2g_V g_A/(g_V^2+g_A^2)$.

[*g*] The value is for the sum of the charge states of particle/antiparticle states indicated.

[*h*] See the Z Particle Listings for the γ energy range used in this measurement.

[*i*] For $m_{\gamma\gamma} = (60 \pm 5)$ GeV.

[*j*] The limits assume no invisible decays.

LEPTON SUMMARY TABLE

LEPTONS

e

$J = \frac{1}{2}$

Mass $m = 0.51099907 \pm 0.00000015$ MeV [a]
$= (5.485799111 \pm 0.000000012) \times 10^{-4}$ u
$(m_{e^+} - m_{e^-})/m < 4 \times 10^{-8}$, CL = 90%
$|q_{e^+} + q_{e^-}|/e < 4 \times 10^{-8}$
Magnetic moment $\mu = 1.001159652193 \pm 0.000000000010\ \mu_B$
$(g_{e^+} - g_{e^-}) / g_{\text{average}} = (-0.5 \pm 2.1) \times 10^{-12}$
Electric dipole moment $d = (0.18 \pm 0.16) \times 10^{-26}$ $e$cm
Mean life $\tau > 4.3 \times 10^{23}$ yr, CL = 68% [b]

μ

$J = \frac{1}{2}$

Mass $m = 105.658389 \pm 0.000034$ MeV [c]
$= 0.113428913 \pm 0.000000017$ u
Mean life $\tau = (2.19703 \pm 0.00004) \times 10^{-6}$ s
$\tau_{\mu^+}/\tau_{\mu^-} = 1.00002 \pm 0.00008$
$c\tau = 658.654$ m
Magnetic moment $\mu = 1.0011659230 \pm 0.0000000084\ e\hbar/2m_\mu$
$(g_{\mu^+} - g_{\mu^-}) / g_{\text{average}} = (-2.6 \pm 1.6) \times 10^{-8}$
Electric dipole moment $d = (3.7 \pm 3.4) \times 10^{-19}$ $e$cm

Decay parameters [d]

$\rho = 0.7518 \pm 0.0026$
$\eta = -0.007 \pm 0.013$
$\delta = 0.749 \pm 0.004$
$\xi P_\mu = 1.003 \pm 0.008$ [e]
$\xi P_\mu \delta/\rho > 0.99682$, CL = 90% [e]
$\xi' = 1.00 \pm 0.04$
$\xi'' = 0.7 \pm 0.4$
$\alpha/A = (0 \pm 4) \times 10^{-3}$
$\alpha'/A = (0 \pm 4) \times 10^{-3}$
$\beta/A = (4 \pm 6) \times 10^{-3}$
$\beta'/A = (2 \pm 6) \times 10^{-3}$
$\bar{\eta} = 0.02 \pm 0.08$

μ^+ modes are charge conjugates of the modes below.

μ^- DECAY MODES		Fraction (Γ_j/Γ)		Confidence level	p (MeV/c)
$e^-\bar{\nu}_e\nu_\mu$		$\approx 100\%$			53
$e^-\bar{\nu}_e\nu_\mu\gamma$	[f]	(1.4±0.4) %			53
$e^-\bar{\nu}_e\nu_\mu e^+e^-$	[g]	$(3.4 \pm 0.4) \times 10^{-5}$			53
Lepton Family number (LF) violating modes					
$e^-\nu_e\bar{\nu}_\mu$	LF	[h] < 1.2	%	90%	53
$e^-\gamma$	LF	< 4.9	$\times 10^{-11}$	90%	53
$e^-e^+e^-$	LF	< 1.0	$\times 10^{-12}$	90%	53
$e^-2\gamma$	LF	< 7.2	$\times 10^{-11}$	90%	53

τ

$J = \frac{1}{2}$

Mass $m = 1777.05^{+0.29}_{-0.26}$ MeV
Mean life $\tau = (290.0 \pm 1.2) \times 10^{-15}$ s
$c\tau = 86.93\ \mu$m
Magnetic moment anomaly > -0.052 and < 0.058, CL = 95%
Electric dipole moment $d > -3.1$ and $< 3.1 \times 10^{-16}$ $e$cm, CL = 95%

Weak dipole moment

$\text{Re}(d_\tau^W) < 0.56 \times 10^{-17}$ $e$cm, CL = 95%
$\text{Im}(d_\tau^W) < 1.5 \times 10^{-17}$ $e$cm, CL = 95%

Weak anomalous magnetic dipole moment

$\text{Re}(\alpha_\tau^W) < 4.5 \times 10^{-3}$, CL = 90%
$\text{Im}(\alpha_\tau^W) < 9.9 \times 10^{-3}$, CL = 90%

Decay parameters

See the τ Particle Listings for a note concerning τ-decay parameters.

$\rho^\tau(e \text{ or } \mu) = 0.748 \pm 0.010$
$\rho^\tau(e) = 0.745 \pm 0.012$
$\rho^\tau(\mu) = 0.741 \pm 0.030$
$\xi^\tau(e \text{ or } \mu) = 1.01 \pm 0.04$
$\xi^\tau(e) = 0.98 \pm 0.05$
$\xi^\tau(\mu) = 1.07 \pm 0.08$
$\eta^\tau(e \text{ or } \mu) = 0.01 \pm 0.07$
$\eta^\tau(\mu) = -0.10 \pm 0.18$
$(\delta\xi)^\tau(e \text{ or } \mu) = 0.749 \pm 0.026$
$(\delta\xi)^\tau(e) = 0.733 \pm 0.033$
$(\delta\xi)^\tau(\mu) = 0.78 \pm 0.05$
$\xi^\tau(\pi) = 0.99 \pm 0.05$
$\xi^\tau(\rho) = 0.996 \pm 0.010$
$\xi^\tau(a_1) = 1.02 \pm 0.04$
$\xi^\tau(\text{all hadronic modes}) = 0.997 \pm 0.009$

τ^+ modes are charge conjugates of the modes below. "$h^\pm$" stands for $\pi^\pm$ or $K^\pm$. "ℓ" stands for e or μ. "Neutral" means neutral hadron whose decay products include γ's and/or π^0's.

τ^- DECAY MODES		Fraction (Γ_j/Γ)	Scale factor/ Confidence level	p (MeV/c)
Modes with one charged particle				
particle$^- \geq 0$ neutrals $\geq 0K_L^0\nu_\tau$ ("1-prong")		(84.71± 0.13) %	S=1.2	–
particle$^- \geq 0$ neutrals $\geq 0K^0\nu_\tau$		(85.30± 0.13) %	S=1.2	–
$\mu^-\bar{\nu}_\mu\nu_\tau$	[f]	(17.37± 0.09) %		885
$\mu^-\bar{\nu}_\mu\nu_\tau\gamma$	[g]	$(3.0 \pm 0.6) \times 10^{-3}$		–
$e^-\bar{\nu}_e\nu_\tau$	[f]	(17.81± 0.07) %		889
$h^- \geq 0$ neutrals $\geq 0K_L^0\ \nu_\tau$		(49.52± 0.16) %	S=1.2	–
$h^- \geq 0K_L^0\ \nu_\tau$		(12.32± 0.12) %	S=1.5	–
$h^-\nu_\tau$		(11.79± 0.12) %	S=1.5	–
$\pi^-\nu_\tau$	[f]	(11.08± 0.13) %	S=1.4	883
$K^-\nu_\tau$	[f]	$(7.1 \pm 0.5) \times 10^{-3}$		820
$h^- \geq 1$ neutralsν_τ		(36.91± 0.17) %	S=1.2	–
$h^-\pi^0\nu_\tau$		(25.84± 0.14) %	S=1.1	–
$\pi^-\pi^0\nu_\tau$	[f]	(25.32± 0.15) %	S=1.1	878
$\pi^-\pi^0$non-$\rho(770)\nu_\tau$		$(3.0 \pm 3.2) \times 10^{-3}$		878
$K^-\pi^0\nu_\tau$	[f]	$(5.2 \pm 0.5) \times 10^{-3}$		814
$h^- \geq 2\pi^0\nu_\tau$		(10.79± 0.16) %	S=1.2	–
$h^-2\pi^0\nu_\tau$		(9.39± 0.14) %	S=1.2	–
$h^-2\pi^0\nu_\tau$(ex.K^0)		(9.23± 0.14) %	S=1.2	–
$\pi^-2\pi^0\nu_\tau$(ex.K^0)	[f]	(9.15± 0.15) %	S=1.2	862
$K^-2\pi^0\nu_\tau$(ex.K^0)	[f]	$(8.0 \pm 2.7) \times 10^{-4}$		796
$h^- \geq 3\pi^0\nu_\tau$		(1.40± 0.11) %	S=1.1	–
$h^-3\pi^0\nu_\tau$		(1.23± 0.10) %	S=1.1	–
$\pi^-3\pi^0\nu_\tau$(ex.K^0)	[f]	(1.11± 0.14) %		836
$K^-3\pi^0\nu_\tau$(ex.K^0)	[f]	$(4.3\ ^{+0.0}_{-2.9}) \times 10^{-4}$		766
$h^-4\pi^0\nu_\tau$(ex.K^0)		$(1.7 \pm 0.6) \times 10^{-3}$		–
$h^-4\pi^0\nu_\tau$(ex.K^0,η)	[f]	$(1.1 \pm 0.6) \times 10^{-3}$		–
$K^- \geq 0\pi^0\ \geq 0K^0\ \nu_\tau$		(1.66± 0.10) %		–
$K^- \geq 1$ (π^0 or K^0) ν_τ		$(9.5 \pm 1.0) \times 10^{-3}$		–
Modes with K^0's				
K^0(particles)$^-\nu_\tau$		(1.66± 0.09) %	S=1.4	–
$h^-\overline{K}^0 \geq 0$ neutrals $\geq 0K_L^0\nu_\tau$		(1.62± 0.09) %	S=1.4	–
$h^-\overline{K}^0\nu_\tau$		$(9.9 \pm 0.8) \times 10^{-3}$	S=1.5	–
$\pi^-\overline{K}^0\nu_\tau$	[f]	$(8.3 \pm 0.8) \times 10^{-3}$	S=1.4	812
$\pi^-\overline{K}^0$ (non-$K^*(892)^-$)ν_τ		$< 1.7 \times 10^{-3}$	CL=95%	812
$K^-K^0\nu_\tau$	[f]	$(1.59 \pm 0.24) \times 10^{-3}$		737
$h^-\overline{K}^0\pi^0\nu_\tau$		$(5.5 \pm 0.5) \times 10^{-3}$		–
$\pi^-\overline{K}^0\pi^0\nu_\tau$	[f]	$(3.9 \pm 0.5) \times 10^{-3}$		794
$\overline{K}^0\rho^-\nu_\tau$		$(1.9 \pm 0.7) \times 10^{-3}$		–
$K^-K^0\pi^0\nu_\tau$	[f]	$(1.51 \pm 0.29) \times 10^{-3}$		685
$\pi^-\overline{K}^0\pi^0\pi^0\nu_\tau$		$(6 \pm 4) \times 10^{-4}$		–
$K^-K^0\pi^0\pi^0\nu_\tau$		$< 3.9 \times 10^{-4}$	CL=95%	–
$\pi^-K^0\overline{K}^0\nu_\tau$	[f]	$(1.21 \pm 0.21) \times 10^{-3}$	S=1.2	682

$\pi^- K^0_S K^0_S \nu_\tau$		$(3.0 \pm 0.5) \times 10^{-4}$		S=1.2	–
$\pi^- K^0_S K^0_L \nu_\tau$		$(6.0 \pm 1.0) \times 10^{-4}$		S=1.2	–
$\pi^- K^0_S K^0_S \pi^0 \nu_\tau$		$< 2.0 \times 10^{-4}$		CL=95%	–
$\pi^- K^0_S K^0_L \pi^0 \nu_\tau$		$(3.1 \pm 1.2) \times 10^{-4}$			–
$K^- K^0 \geq 0$ neutrals ν_τ		$(3.1 \pm 0.4) \times 10^{-3}$			–
$K^0 h^+ h^- h^- \geq 0$ neutrals ν_τ		$< 1.7 \times 10^{-3}$		CL=95%	–
$K^0 h^+ h^- h^- \nu_\tau$		$(2.3 \pm 2.0) \times 10^{-4}$			–
Modes with three charged particles					
$h^- h^- h^+ \geq 0$neut. ν_τ ("3-prong")		(15.18± 0.13) %		S=1.2	–
$h^- h^- h^+ \geq 0$ neutrals ν_τ (ex. $K^0_S \to \pi^+\pi^-$)		(14.60± 0.13) %		S=1.2	–
$\pi^- \pi^+ \pi^- \geq 0$ neutrals ν_τ		(14.60± 0.14) %			–
$h^- h^- h^+ \nu_\tau$		(9.96± 0.10) %		S=1.1	–
$h^- h^- h^+ \nu_\tau$ (ex.K^0)		(9.62± 0.10) %		S=1.1	–
$h^- h^- h^+ \nu_\tau$ (ex.K^0,ω)		(9.57± 0.10) %		S=1.1	–
$\pi^- \pi^+ \pi^- \nu_\tau$		(9.56± 0.11) %		S=1.1	–
$\pi^- \pi^+ \pi^- \nu_\tau$ (ex.K^0)		(9.52± 0.11) %		S=1.1	–
$\pi^- \pi^+ \pi^- \nu_\tau$ (ex.K^0,ω)	[l]	(9.23± 0.11) %		S=1.1	–
$h^- h^- h^+ \geq 1$ neutrals ν_τ		(5.18± 0.11) %		S=1.2	–
$h^- h^- h^+ \geq 1$ neutrals ν_τ (ex. $K^0_S \to \pi^+\pi^-$)		(4.98± 0.11) %		S=1.2	–
$h^- h^- h^+ \pi^0 \nu_\tau$		(4.50± 0.09) %		S=1.1	–
$h^- h^- h^+ \pi^0 \nu_\tau$ (ex.K^0)		(4.31± 0.09) %		S=1.1	–
$h^- h^- h^+ \pi^0 \nu_\tau$ (ex. K^0, ω)		(2.59± 0.09) %			–
$\pi^- \pi^+ \pi^- \pi^0 \nu_\tau$		(4.35± 0.10) %			–
$\pi^- \pi^+ \pi^- \pi^0 \nu_\tau$ (ex.K^0)		(4.22± 0.10) %			–
$\pi^- \pi^+ \pi^- \pi^0 \nu_\tau$ (ex.K^0,ω)	[l]	(2.49± 0.10) %			–
$h^- (\rho\pi)^0 \nu_\tau$		(2.88± 0.35) %			–
$(a_1(1260)\, h)^- \nu_\tau$		< 2.0	%	CL=95%	–
$h^- \rho\pi^0 \nu_\tau$		(1.35± 0.20) %			–
$h^- \rho^+ h^- \nu_\tau$		$(4.5 \pm 2.2) \times 10^{-3}$			–
$h^- \rho^- h^+ \nu_\tau$		(1.17± 0.23) %			–
$h^- h^- h^+ 2\pi^0 \nu_\tau$		$(5.4 \pm 0.4) \times 10^{-3}$			–
$h^- h^- h^+ 2\pi^0 \nu_\tau$ (ex.K^0)		$(5.3 \pm 0.4) \times 10^{-3}$			–
$h^- h^- h^+ 2\pi^0 \nu_\tau$ (ex.K^0,ω,η)	[l]	$(1.1 \pm 0.4) \times 10^{-3}$			–
$h^- h^- h^+ \geq 3\pi^0 \nu_\tau$	[l]	$(1.4 \pm {}^{0.9}_{0.7}) \times 10^{-3}$		S=1.5	–
$h^- h^- h^+ 3\pi^0 \nu_\tau$		$(2.9 \pm 0.8) \times 10^{-4}$			–
$K^- h^+ h^- \geq 0$ neutrals ν_τ		$(5.4 \pm 0.7) \times 10^{-3}$		S=1.1	–
$K^- \pi^+ \pi^- \geq 0$ neutrals ν_τ		$(3.1 \pm 0.6) \times 10^{-3}$		S=1.1	–
$K^- \pi^+ \pi^- \nu_\tau$		$(2.3 \pm 0.4) \times 10^{-3}$			–
$K^- \pi^+ \pi^- \nu_\tau$ (ex.K^0)	[l]	$(1.8 \pm 0.5) \times 10^{-3}$			–
$K^- \pi^+ \pi^- \pi^0 \nu_\tau$		$(8 \pm 4) \times 10^{-4}$			–
$K^- \pi^+ \pi^- \pi^0 \nu_\tau$ (ex.K^0)	[l]	$(2.4 \pm {}^{4.3}_{1.6}) \times 10^{-4}$			–
$K^- \pi^+ K^- \geq 0$ neut. ν_τ		$< 9 \times 10^{-4}$		CL=95%	–
$K^- K^+ \pi^- \geq 0$ neut. ν_τ		$(2.3 \pm 0.4) \times 10^{-3}$			–
$K^- K^+ \pi^- \nu_\tau$	[l]	$(1.61\pm 0.26) \times 10^{-3}$			685
$K^- K^+ \pi^- \pi^0 \nu_\tau$	[l]	$(6.9 \pm 3.0) \times 10^{-4}$			–
$K^- K^+ K^- \geq 0$ neut. ν_τ		$< 2.1 \times 10^{-3}$		CL=95%	–
$K^- K^+ K^- \nu_\tau$		$< 1.9 \times 10^{-4}$		CL=90%	–
$\pi^- K^+ \pi^- \geq 0$ neut. ν_τ		$< 2.5 \times 10^{-3}$		CL=95%	–
$e^- e^- e^+ \overline{\nu}_e \nu_\tau$		$(2.8 \pm 1.5) \times 10^{-5}$			889
$\mu^- e^- e^+ \overline{\nu}_\mu \nu_\tau$		$< 3.6 \times 10^{-5}$		CL=90%	885
Modes with five charged particles					
$3h^- 2h^+ \geq 0$ neutrals ν_τ (ex. $K^0_S \to \pi^-\pi^+$) ("5-prong")		$(9.7 \pm 0.7) \times 10^{-4}$			–
$3h^- 2h^+ \nu_\tau$ (ex.K^0)	[l]	$(7.5 \pm 0.7) \times 10^{-4}$			–
$3h^- 2h^+ \pi^0 \nu_\tau$ (ex.K^0)	[l]	$(2.2 \pm 0.5) \times 10^{-4}$			–
$3h^- 2h^+ 2\pi^0 \nu_\tau$		$< 1.1 \times 10^{-4}$		CL=90%	–
Miscellaneous other allowed modes					
$(5\pi)^- \nu_\tau$		$(7.4 \pm 0.7) \times 10^{-3}$			–
$4h^- 3h^+ \geq 0$ neutrals ν_τ ("7-prong")		$< 2.4 \times 10^{-6}$		CL=90%	–
$K^*(892)^- \geq 0 (h^0 \neq K^0_S) \nu_\tau$		(1.94± 0.31) %			–
$K^*(892)^- \geq 0$ neutrals ν_τ		(1.33± 0.13) %			–
$K^*(892)^- \nu_\tau$		(1.28± 0.08) %			665
$K^*(892)^0 K^- \geq 0$ neutrals ν_τ		$(3.2 \pm 1.4) \times 10^{-3}$			–
$K^*(892)^0 K^- \nu_\tau$		$(2.1 \pm 0.4) \times 10^{-3}$			539
$\overline{K}^*(892)^0 \pi^- \geq 0$ neutrals ν_τ		$(3.8 \pm 1.7) \times 10^{-3}$			–
$\overline{K}^*(892)^0 \pi^- \nu_\tau$		$(2.2 \pm 0.5) \times 10^{-3}$			653
$(\overline{K}^*(892)\pi)^- \nu_\tau \to \pi^- \overline{K}^0 \pi^0 \nu_\tau$		$(1.1 \pm 0.5) \times 10^{-3}$			–
$K_1(1270)^- \nu_\tau$		$(4 \pm 4) \times 10^{-3}$			433
$K_1(1400)^- \nu_\tau$		$(8 \pm 4) \times 10^{-3}$			335
$K^*_2(1430)^- \nu_\tau$		$< 3 \times 10^{-3}$		CL=95%	317
$\eta\pi^- \nu_\tau$		$< 1.4 \times 10^{-4}$		CL=95%	798
$\eta\pi^- \pi^0 \nu_\tau$	[l]	$(1.74\pm 0.24) \times 10^{-3}$			778
$\eta\pi^- \pi^0 \pi^0 \nu_\tau$		$(1.4 \pm 0.7) \times 10^{-4}$			746
$\eta K^- \nu_\tau$		$(2.7 \pm 0.6) \times 10^{-4}$			720
$\eta\pi^+ \pi^- \pi^- \geq 0$ neutrals ν_τ		$< 3 \times 10^{-3}$		CL=90%	–
$\eta\pi^- \pi^+ \pi^- \nu_\tau$		$(3.4 \pm 0.8) \times 10^{-4}$			–
$\eta a_1(1260)^- \nu_\tau \to \eta\pi^- \rho^0 \nu_\tau$		$< 3.9 \times 10^{-4}$		CL=90%	–
$\eta\eta\pi^- \nu_\tau$		$< 1.1 \times 10^{-4}$		CL=90%	637
$\eta\eta\pi^- \pi^0 \nu_\tau$		$< 2.0 \times 10^{-4}$		CL=95%	559
$\eta'(958)\pi^- \nu_\tau$		$< 7.4 \times 10^{-5}$		CL=90%	–
$\eta'(958)\pi^- \pi^0 \nu_\tau$		$< 8.0 \times 10^{-5}$		CL=90%	–
$\phi\pi^- \nu_\tau$		$< 2.0 \times 10^{-4}$		CL=90%	585
$\phi K^- \nu_\tau$		$< 6.7 \times 10^{-5}$		CL=90%	–
$f_1(1285)\pi^- \nu_\tau$		$(5.8 \pm 2.3) \times 10^{-4}$			–
$f_1(1285)\pi^- \nu_\tau \to \eta\pi^-\pi^+\pi^-\nu_\tau$		$(1.9 \pm 0.7) \times 10^{-4}$			–
$h^- \omega \geq 0$ neutrals ν_τ		(2.36± 0.08) %			–
$h^- \omega \nu_\tau$	[l]	(1.93± 0.06) %			–
$h^- \omega \pi^0 \nu_\tau$	[l]	$(4.3 \pm 0.5) \times 10^{-3}$			–
$h^- \omega 2\pi^0 \nu_\tau$		$(1.9 \pm 0.8) \times 10^{-4}$			–

Lepton Family number (LF), Lepton number (L), or Baryon number (B) violating modes (In the modes below, ℓ means a sum over e and μ modes)

L means lepton number violation (*e.g.* $\tau^- \to e^+\pi^-\pi^-$). Following common usage Γ LF means lepton family violation *and not* lepton number violation (*e.g.* $\tau^- \to e^-\pi^+\pi^-$). B means baryon number violation.

$e^- \gamma$	LF	$< 2.7 \times 10^{-6}$		CL=90%	888
$\mu^- \gamma$	LF	$< 3.0 \times 10^{-6}$		CL=90%	885
$e^- \pi^0$	LF	$< 3.7 \times 10^{-6}$		CL=90%	883
$\mu^- \pi^0$	LF	$< 4.0 \times 10^{-6}$		CL=90%	880
$e^- K^0$	LF	$< 1.3 \times 10^{-3}$		CL=90%	819
$\mu^- K^0$	LF	$< 1.0 \times 10^{-3}$		CL=90%	815
$e^- \eta$	LF	$< 8.2 \times 10^{-6}$		CL=90%	804
$\mu^- \eta$	LF	$< 9.6 \times 10^{-6}$		CL=90%	800
$e^- \rho^0$	LF	$< 2.0 \times 10^{-6}$		CL=90%	722
$\mu^- \rho^0$	LF	$< 6.3 \times 10^{-6}$		CL=90%	718
$e^- K^*(892)^0$	LF	$< 5.1 \times 10^{-6}$		CL=90%	663
$\mu^- K^*(892)^0$	LF	$< 7.5 \times 10^{-6}$		CL=90%	657
$e^- \overline{K}^*(892)^0$	LF	$< 7.4 \times 10^{-6}$		CL=90%	663
$\mu^- \overline{K}^*(892)^0$	LF	$< 7.5 \times 10^{-6}$		CL=90%	657
$e^- \phi$	LF	$< 6.9 \times 10^{-6}$		CL=90%	596
$\mu^- \phi$	LF	$< 7.0 \times 10^{-6}$		CL=90%	590
$\pi^- \gamma$	L	$< 2.8 \times 10^{-4}$		CL=90%	883
$\pi^- \pi^0$	L	$< 3.7 \times 10^{-4}$		CL=90%	878
$e^- e^+ e^-$	LF	$< 2.9 \times 10^{-6}$		CL=90%	888
$e^- \mu^+ \mu^-$	LF	$< 1.8 \times 10^{-6}$		CL=90%	882
$e^+ \mu^- \mu^-$	LF	$< 1.5 \times 10^{-6}$		CL=90%	882
$\mu^- e^+ e^-$	LF	$< 1.7 \times 10^{-6}$		CL=90%	885
$\mu^+ e^- e^-$	LF	$< 1.5 \times 10^{-6}$		CL=90%	885
$\mu^- \mu^+ \mu^-$	LF	$< 1.9 \times 10^{-6}$		CL=90%	873
$e^- \pi^+ \pi^-$	LF	$< 2.2 \times 10^{-6}$		CL=90%	877
$e^+ \pi^- \pi^-$	L	$< 1.9 \times 10^{-6}$		CL=90%	877
$\mu^- \pi^+ \pi^-$	LF	$< 8.2 \times 10^{-6}$		CL=90%	866
$\mu^+ \pi^- \pi^-$	L	$< 3.4 \times 10^{-6}$		CL=90%	866
$e^- \pi^+ K^-$	LF	$< 6.4 \times 10^{-6}$		CL=90%	814
$e^- \pi^- K^+$	LF	$< 3.8 \times 10^{-6}$		CL=90%	814
$e^+ \pi^- K^-$	L	$< 2.1 \times 10^{-6}$		CL=90%	814
$e^- K^+ K^-$	LF	$< 6.0 \times 10^{-6}$		CL=90%	739
$e^+ K^- K^-$	L	$< 3.8 \times 10^{-6}$		CL=90%	739
$\mu^- \pi^+ K^-$	LF	$< 7.5 \times 10^{-6}$		CL=90%	800
$\mu^- \pi^- K^+$	LF	$< 7.4 \times 10^{-6}$		CL=90%	800
$\mu^+ \pi^- K^-$	L	$< 7.0 \times 10^{-6}$		CL=90%	800
$\mu^- K^+ K^-$	LF	$< 1.5 \times 10^{-5}$		CL=90%	699
$\mu^+ K^- K^-$	L	$< 6.0 \times 10^{-6}$		CL=90%	699
$e^- \pi^0 \pi^0$	LF	$< 6.5 \times 10^{-6}$		CL=90%	878
$\mu^- \pi^0 \pi^0$	LF	$< 1.4 \times 10^{-5}$		CL=90%	867
$e^- \eta\eta$	LF	$< 3.5 \times 10^{-5}$		CL=90%	700
$\mu^- \eta\eta$	LF	$< 6.0 \times 10^{-5}$		CL=90%	654
$e^- \pi^0 \eta$	LF	$< 2.4 \times 10^{-5}$		CL=90%	798
$\mu^- \pi^0 \eta$	LF	$< 2.2 \times 10^{-5}$		CL=90%	784
$\overline{p}\gamma$	LB	$< 2.9 \times 10^{-4}$		CL=90%	641
$\overline{p}\pi^0$	LB	$< 6.6 \times 10^{-4}$		CL=90%	632
$\overline{p}\eta$	LB	$< 1.30 \times 10^{-3}$		CL=90%	476
e^- light boson	LF	$< 2.7 \times 10^{-3}$		CL=95%	–
μ^- light boson	LF	$< 5 \times 10^{-3}$		CL=95%	–

Heavy Charged Lepton Searches

$L^\pm$ – charged lepton

Mass $m > 80.2$ GeV, CL = 95% $m_\nu \approx 0$

$L^\pm$ – stable charged heavy lepton

Mass $m > 84.2$ GeV, CL = 95%

Neutrinos

See the Particle Listings for a Note "Neutrino Mass" giving details of neutrinos, masses, mixing, and the status of experimental searches.

ν_e $J = \frac{1}{2}$

Mass m: Unexplained effects have resulted in significantly negative m^2 in the new, precise tritium beta decay experiments. It is felt that a real neutrino mass as large as 10–15 eV would cause observable spectral distortions even in the presence of the end-point count excesses.

Mean life/mass, $\tau/m_{\nu_e} > 7 \times 10^9$ s/eV (solar)

Mean life/mass, $\tau/m_{\nu_e} > 300$ s/eV, CL = 90% (reactor)

Magnetic moment $\mu < 1.8 \times 10^{-10}\ \mu_B$, CL = 90%

ν_μ $J = \frac{1}{2}$

Mass $m < 0.17$ MeV, CL = 90%

Mean life/mass, $\tau/m_{\nu_\mu} > 15.4$ s/eV, CL = 90%

Magnetic moment $\mu < 7.4 \times 10^{-10}\ \mu_B$, CL = 90%

ν_τ $J = \frac{1}{2}$

Mass $m < 18.2$ MeV, CL = 95%

Magnetic moment $\mu < 5.4 \times 10^{-7}\ \mu_B$, CL = 90%

Electric dipole moment $d < 5.2 \times 10^{-17}\ e$cm, CL = 95%

Number of Light Neutrino Types

(including ν_e, ν_μ, and ν_τ)

Number $N = 2.994 \pm 0.012$ (Standard Model fits to LEP data)

Number $N = 3.07 \pm 0.12$ (Direct measurement of invisible Z width)

Massive Neutrinos and Lepton Mixing, Searches for

For excited leptons, see Compositeness Limits below.

See the Particle Listings for a Note "Neutrino Mass" giving details of neutrinos, masses, mixing, and the status of experimental searches.

While no direct, uncontested evidence for massive neutrinos or lepton mixing has been obtained, suggestive evidence has come from solar neutrino observations, from anomalies in the relative fractions of ν_e and ν_μ observed in energetic cosmic-ray air showers, and possibly from a $\overline{\nu}_e$ appearance experiment at Los Alamos. Sample limits are:

Stable Neutral Heavy Lepton Mass Limits

Mass $m > 45.0$ GeV, CL = 95% (Dirac)

Mass $m > 39.5$ GeV, CL = 95% (Majorana)

Neutral Heavy Lepton Mass Limits

Mass $m > 69.0$ GeV, CL = 95% (Dirac ν_L coupling to e, μ, τ with $|U_{\ell j}|^2 > 10^{-12}$)

Mass $m > 58.2$ GeV, CL = 95% (Majorana ν_L coupling to e, μ, τ with $|U_{\ell j}|^2 > 10^{-12}$)

Solar Neutrinos

Detectors using gallium ($E_\nu \gtrsim 0.2$ MeV), chlorine ($E_\nu \gtrsim 0.8$ MeV), and Čerenkov effect in water ($E_\nu \gtrsim 7$ MeV) measure significantly lower neutrino rates than are predicted from solar models. The deficit in the solar neutrino flux compared with solar model calculations could be explained by oscillations with $\Delta m^2 \leq 10^{-5}$ eV^2 causing the disappearance of ν_e.

Atmospheric Neutrinos

Underground detectors observing neutrinos produced by cosmic rays in the atmosphere have measured a ν_μ/ν_e ratio much less than expected and also a deficiency of upward going ν_μ compared to downward. This could be explained by oscillations leading to the disappearance of ν_μ with $\Delta m^2 \approx 10^{-3}$ to 10^{-2} eV^2.

ν oscillation: $\overline{\nu}_e \not\to \overline{\nu}_e$ (θ = mixing angle)

$\Delta m^2 < 9 \times 10^{-4}$ eV^2, CL = 90% (if $\sin^2 2\theta = 1$)

$\sin^2 2\theta < 0.02$, CL = 90% (if $\Delta(m^2)$ is large)

ν oscillation: $\nu_\mu\ (\overline{\nu}_\mu) \to \nu_e\ (\overline{\nu}_e)$ (any combination)

$\Delta m^2 < 0.075$ eV^2, CL = 90% (if $\sin^2 2\theta = 1$)

$\sin^2 2\theta < 1.8 \times 10^{-3}$, CL = 90% (if $\Delta(m^2)$ is large)

NOTES

In this Summary Table:

When a quantity has "(S = ...)" to its right, the error on the quantity has been enlarged by the "scale factor" S, defined as $S = \sqrt{\chi^2/(N-1)}$, where N is the number of measurements used in calculating the quantity. We do this when S > 1, which often indicates that the measurements are inconsistent. When S > 1.25, we also show in the Particle Listings an ideogram of the measurements. For more about S, see the Introduction.

A decay momentum p is given for each decay mode. For a 2-body decay, p is the momentum of each decay product in the rest frame of the decaying particle. For a 3-or-more-body decay, p is the largest momentum any of the products can have in this frame.

[a] The uncertainty in the electron mass in unified atomic mass units (u) is ten times smaller than that given by the 1986 CODATA adjustment, quoted in the Table of Physical Constants (Section 1). The conversion to MeV via the factor 931.49432(28) MeV/u is more uncertain because of the electron charge uncertainty. Our value in MeV differs slightly from the 1986 CODATA result.

[b] This is the best "electron disappearance" limit. The best limit for the mode $e^- \to \nu\gamma$ is $> 2.35 \times 10^{25}$ yr (CL=68%).

[c] The muon mass is most precisely known in u (unified atomic mass units). The conversion factor to MeV via the factor 931.49432(28) MeV/u is more uncertain because of the electron charge uncertainty.

[d] See the "Note on Muon Decay Parameters" in the μ Particle Listings for definitions and details.

[e] P_μ is the longitudinal polarization of the muon from pion decay. In standard $V-A$ theory, $P_\mu = 1$ and $\rho = \delta = 3/4$.

[f] This only includes events with the γ energy > 10 MeV. Since the $e^-\overline{\nu}_e\nu_\mu$ and $e^-\overline{\nu}_e\nu_\mu\gamma$ modes cannot be clearly separated, we regard the latter mode as a subset of the former.

[g] See the μ Particle Listings for the energy limits used in this measurement.

[h] A test of additive vs. multiplicative lepton family number conservation.

[i] Basis mode for the τ.

QUARK SUMMARY TABLE

QUARKS

The *u*-, *d*-, and *s*-quark masses are estimates of so-called "current-quark masses," in a mass-independent subtraction scheme such as $\overline{\text{MS}}$ at a scale $\mu \approx 2$ GeV. The *c*- and *b*-quark masses are estimated from charmonium, bottomonium, *D*, and *B* masses. They are the "running" masses in the $\overline{\text{MS}}$ scheme. These can be different from the heavy quark masses obtained in potential models.

u

$I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$

Mass $m = 1.5$ to 5 MeV [a] Charge $= \frac{2}{3}\ e$ $I_z = +\frac{1}{2}$

$m_u/m_d = 0.20$ to 0.70

d

$I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$

Mass $m = 3$ to 9 MeV [a] Charge $= -\frac{1}{3}\ e$ $I_z = -\frac{1}{2}$

$m_s/m_d = 17$ to 25

$\overline{m} = (m_u + m_d)/2 = 2$ to 6 MeV

s

$I(J^P) = 0(\frac{1}{2}^+)$

Mass $m = 60$ to 170 MeV [a] Charge $= -\frac{1}{3}\ e$ Strangeness $= -1$

$(m_s - (m_u + m_d)/2)/(m_d - m_u) = 34$ to 51

c

$I(J^P) = 0(\frac{1}{2}^+)$

Mass $m = 1.1$ to 1.4 GeV Charge $= \frac{2}{3}\ e$ Charm $= +1$

b

$I(J^P) = 0(\frac{1}{2}^+)$

Mass $m = 4.1$ to 4.4 GeV Charge $= -\frac{1}{3}\ e$ Bottom $= -1$

t

$I(J^P) = 0(\frac{1}{2}^+)$

Charge $= \frac{2}{3}\ e$ Top $= +1$

Mass $m = 173.8 \pm 5.2$ GeV (direct observation of top events)

Mass $m = 170 \pm 7\ (+14)$ GeV (Standard Model electroweak fit, assuming $M_H = M_Z$. Number in parentheses is shift from changing M_H to 300 GeV.

b′ (4th Generation) Quark, Searches for

Mass $m >$ 128 GeV, CL = 95% ($p\bar{p}$, charged current decays)

Mass $m >$ 46.0 GeV, CL = 95% (e^+e^-, all decays)

Free Quark Searches

All searches since 1977 have had negative results.

NOTES

[a] The ratios m_u/m_d and m_s/m_d are extracted from pion and kaon masses using chiral symmetry. The estimates of *u* and *d* masses are not without controversy and remain under active investigation. Within the literature there are even suggestions that the *u* quark could be essentially massless. The *s*-quark mass is estimated from SU(3) splittings in hadron masses.

LIGHT UNFLAVORED MESONS
($S = C = B = 0$)

For $I = 1$ (π, b_1, ρ, a_1): $u\bar{d}$, $(u\bar{u}-d\bar{d})/\sqrt{2}$, $d\bar{u}$;
for $I = 0$ (η, η', h_1, h_1', ω, ϕ, f_1, f_1'): $c_1(u\bar{u}+d\bar{d}) + c_2(s\bar{s})$

$\pi^\pm$

$I^G(J^P) = 1^-(0^-)$

Mass $m = 139.56995 \pm 0.00035$ MeV
Mean life $\tau = (2.6033 \pm 0.0005) \times 10^{-8}$ s (S = 1.2)
$c\tau = 7.8045$ m

$\pi^\pm \to \ell^\pm \nu\gamma$ form factors [a]

$F_V = 0.017 \pm 0.008$
$F_A = 0.0116 \pm 0.0016$ (S = 1.3)
$R = 0.059^{+0.009}_{-0.008}$

π^- modes are charge conjugates of the modes below.

π^+ DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\mu^+\nu_\mu$		[b] (99.98770±0.00004) %		30
$\mu^+\nu_\mu\gamma$		[c] (1.24 ±0.25) $\times 10^{-4}$		30
$e^+\nu_e$		[b] (1.230 ±0.004) $\times 10^{-4}$		70
$e^+\nu_e\gamma$		[c] (1.61 ±0.23) $\times 10^{-7}$		70
$e^+\nu_e\pi^0$		(1.025 ±0.034) $\times 10^{-8}$		4
$e^+\nu_e e^+e^-$		(3.2 ±0.5) $\times 10^{-9}$		70
$e^+\nu_e\nu\bar{\nu}$		< 5 $\times 10^{-6}$	90%	70
Lepton Family number (LF) or Lepton number (L) violating modes				
$\mu^+\bar{\nu}_e$	L	[d] < 1.5 $\times 10^{-3}$	90%	30
$\mu^+\nu_e$	LF	[d] < 8.0 $\times 10^{-3}$	90%	30
$\mu^-e^+e^+\nu$	LF	< 1.6 $\times 10^{-6}$	90%	30

π^0

$I^G(J^{PC}) = 1^-(0^{-+})$

Mass $m = 134.9764 \pm 0.0006$ MeV
$m_{\pi^\pm} - m_{\pi^0} = 4.5936 \pm 0.0005$ MeV
Mean life $\tau = (8.4 \pm 0.6) \times 10^{-17}$ s (S = 3.0)
$c\tau = 25.1$ nm

π^0 DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
2γ		(98.798±0.032) %	S=1.1	67
$e^+e^-\gamma$		(1.198±0.032) %	S=1.1	67
γpositronium		(1.82 ±0.29) $\times 10^{-9}$		67
$e^+e^+e^-e^-$		(3.14 ±0.30) $\times 10^{-5}$		67
e^+e^-		(7.5 ±2.0) $\times 10^{-8}$		67
4γ		< 2 $\times 10^{-8}$	CL=90%	67
$\nu\bar{\nu}$		[e] < 8.3 $\times 10^{-7}$	CL=90%	67
$\nu_e\bar{\nu}_e$		< 1.7 $\times 10^{-6}$	CL=90%	67
$\nu_\mu\bar{\nu}_\mu$		< 3.1 $\times 10^{-6}$	CL=90%	67
$\nu_\tau\bar{\nu}_\tau$		< 2.1 $\times 10^{-6}$	CL=90%	67
Charge conjugation (C) or Lepton Family number (LF) violating modes				
3γ	C	< 3.1 $\times 10^{-8}$	CL=90%	67
$\mu^+e^- + e^-\mu^+$	LF	< 1.72 $\times 10^{-8}$	CL=90%	26

η

$I^G(J^{PC}) = 0^+(0^{-+})$

Mass $m = 547.30 \pm 0.12$ MeV
Full width $\Gamma = 1.18 \pm 0.11$ keV [f] (S = 1.8)

G-nonconserving decay parameters

$\pi^+\pi^-\pi^0$ Left-right asymmetry = $(0.09 \pm 0.17) \times 10^{-2}$
$\pi^+\pi^-\pi^0$ Sextant asymmetry = $(0.18 \pm 0.16) \times 10^{-2}$
$\pi^+\pi^-\pi^0$ Quadrant asymmetry = $(-0.17 \pm 0.17) \times 10^{-2}$
$\pi^+\pi^-\gamma$ Left-right asymmetry = $(0.9 \pm 0.4) \times 10^{-2}$
$\pi^+\pi^-\gamma$ β (D-wave) = 0.05 ± 0.06 (S = 1.5)

Dalitz plot parameter

$\pi^0\pi^0\pi^0$ $\alpha = -0.039 \pm 0.015$

η DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Neutral modes				
neutral modes		(71.5 ±0.6) %	S=1.4	–
2γ	[f]	(39.21±0.34) %	S=1.4	274
$3\pi^0$		(32.2 ±0.4) %	S=1.3	178
$\pi^0 2\gamma$		(7.1 ±1.4) $\times 10^{-4}$		257
other neutral modes		< 2.8 %	CL=90%	–
Charged modes				
charged modes		(28.5 ±0.6) %	S=1.4	–
$\pi^+\pi^-\pi^0$		(23.1 ±0.5) %	S=1.4	173
$\pi^+\pi^-\gamma$		(4.77±0.13) %	S=1.3	235
$e^+e^-\gamma$		(4.9 ±1.1) $\times 10^{-3}$		274
$\mu^+\mu^-\gamma$		(3.1 ±0.4) $\times 10^{-4}$		252
e^+e^-		< 7.7 $\times 10^{-5}$	CL=90%	274
$\mu^+\mu^-$		(5.8 ±0.8) $\times 10^{-6}$		252
$\pi^+\pi^-e^+e^-$		(1.3 $^{+1.2}_{-0.8}$) $\times 10^{-3}$		235
$\pi^+\pi^-2\gamma$		< 2.1 $\times 10^{-3}$		235
$\pi^+\pi^-\pi^0\gamma$		< 6 $\times 10^{-4}$	CL=90%	173
$\pi^0\mu^+\mu^-\gamma$		< 3 $\times 10^{-6}$	CL=90%	210
Charge conjugation (C)Γ Parity (P)Γ Charge conjugation × Parity (CP)Γ or Lepton Family number (LF) violating modes				
$\pi^+\pi^-$	$PTCP$	< 9 $\times 10^{-4}$	CL=90%	235
3γ	C	< 5 $\times 10^{-4}$	CL=95%	274
$\pi^0e^+e^-$	C	[g] < 4 $\times 10^{-5}$	CL=90%	257
$\pi^0\mu^+\mu^-$	C	[g] < 5 $\times 10^{-6}$	CL=90%	210
$\mu^+e^- + \mu^-e^+$	LF	< 6 $\times 10^{-6}$	CL=90%	263

$f_0(400\text{–}1200)$ [h] or σ

$I^G(J^{PC}) = 0^+(0^{++})$

Mass $m = (400\text{–}1200)$ MeV
Full width $\Gamma = (600\text{–}1000)$ MeV

$f_0(400\text{–}1200)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\pi\pi$	dominant	–
$\gamma\gamma$	seen	–

$\rho(770)$ [l]

$I^G(J^{PC}) = 1^+(1^{--})$

Mass $m = 770.0 \pm 0.8$ MeV (S = 1.8)
Full width $\Gamma = 150.7 \pm 1.1$ MeV
$\Gamma_{ee} = 6.77 \pm 0.32$ keV

$\rho(770)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\pi\pi$	~ 100 %		358
$\rho(770)^{\pm}$ decays			
$\pi^{\pm}\gamma$	$(4.5 \pm 0.5) \times 10^{-4}$	S=2.2	372
$\pi^{\pm}\eta$	$< 6 \times 10^{-3}$	CL=84%	146
$\pi^{\pm}\pi^+\pi^-\pi^0$	$< 2.0 \times 10^{-3}$	CL=84%	249
$\rho(770)^0$ decays			
$\pi^+\pi^-\gamma$	$(9.9 \pm 1.6) \times 10^{-3}$		358
$\pi^0\gamma$	$(6.8 \pm 1.7) \times 10^{-4}$		372
$\eta\gamma$	$(2.4 \, {}^{+0.8}_{-0.9}) \times 10^{-4}$	S=1.6	189
$\mu^+\mu^-$	[j] $(4.60 \pm 0.28) \times 10^{-5}$		369
e^+e^-	[j] $(4.49 \pm 0.22) \times 10^{-5}$		384
$\pi^+\pi^-\pi^0$	$< 1.2 \times 10^{-4}$	CL=90%	319
$\pi^+\pi^-\pi^+\pi^-$	$< 2 \times 10^{-4}$	CL=90%	246
$\pi^+\pi^-\pi^0\pi^0$	$< 4 \times 10^{-5}$	CL=90%	252

$\omega(782)$

$I^G(J^{PC}) = 0^-(1^{--})$

Mass $m = 781.94 \pm 0.12$ MeV (S = 1.5)
Full width $\Gamma = 8.41 \pm 0.09$ MeV
$\Gamma_{ee} = 0.60 \pm 0.02$ keV

$\omega(782)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\pi^+\pi^-\pi^0$	(88.8 ± 0.7) %		327
$\pi^0\gamma$	(8.5 ± 0.5) %		379
$\pi^+\pi^-$	(2.21 ± 0.30) %		365
neutrals (excluding $\pi^0\gamma$)	$(5.3 \, {}^{+8.7}_{-3.5}) \times 10^{-3}$		–
$\eta\gamma$	$(6.5 \pm 1.0) \times 10^{-4}$		199
$\pi^0 e^+e^-$	$(5.9 \pm 1.9) \times 10^{-4}$		379
$\pi^0\mu^+\mu^-$	$(9.6 \pm 2.3) \times 10^{-5}$		349
e^+e^-	$(7.07 \pm 0.19) \times 10^{-5}$	S=1.1	391
$\pi^+\pi^-\pi^0\pi^0$	< 2 %	CL=90%	261
$\pi^+\pi^-\gamma$	$< 3.6 \times 10^{-3}$	CL=95%	365
$\pi^+\pi^-\pi^+\pi^-$	$< 1 \times 10^{-3}$	CL=90%	256
$\pi^0\pi^0\gamma$	$(7.2 \pm 2.5) \times 10^{-5}$		367
$\mu^+\mu^-$	$< 1.8 \times 10^{-4}$	CL=90%	376
3γ	$< 1.9 \times 10^{-4}$	CL=95%	391
Charge conjugation (C) violating modes			
$\eta\pi^0$	C $< 1 \times 10^{-3}$	CL=90%	162
$3\pi^0$	C $< 3 \times 10^{-4}$	CL=90%	329

$\eta'(958)$

$I^G(J^{PC}) = 0^+(0^{-+})$

Mass $m = 957.78 \pm 0.14$ MeV
Full width $\Gamma = 0.203 \pm 0.016$ MeV (S = 1.3)

$\eta'(958)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\pi^+\pi^-\eta$	(43.8 ± 1.5) %	S=1.1	232
$\rho^0\gamma$(including non-resonant $\pi^+\pi^-\gamma$)	(30.2 ± 1.3) %	S=1.1	169
$\pi^0\pi^0\eta$	(20.7 ± 1.3) %	S=1.2	239
$\omega\gamma$	(3.01 ± 0.30) %		160
$\gamma\gamma$	(2.11 ± 0.13) %	S=1.2	479
$3\pi^0$	$(1.54 \pm 0.26) \times 10^{-3}$		430
$\mu^+\mu^-\gamma$	$(1.03 \pm 0.26) \times 10^{-4}$		467
$\pi^+\pi^-\pi^0$	< 5 %	CL=90%	427
$\pi^0\rho^0$	< 4 %	CL=90%	118
$\pi^+\pi^+\pi^-\pi^-$	< 1 %	CL=90%	372
$\pi^+\pi^+\pi^-\pi^-$ neutrals	< 1 %	CL=95%	–
$\pi^+\pi^+\pi^-\pi^-\pi^0$	< 1 %	CL=90%	298
6π	< 1 %	CL=90%	189
$\pi^+\pi^-e^+e^-$	$< 6 \times 10^{-3}$	CL=90%	458
$\pi^0\gamma\gamma$	$< 8 \times 10^{-4}$	CL=90%	469
$4\pi^0$	$< 5 \times 10^{-4}$	CL=90%	379
e^+e^-	$< 2.1 \times 10^{-7}$	CL=90%	479
Charge conjugation (C) or Parity (P) violating modes			
$\pi^+\pi^-$	$PTCP$ < 2 %	CL=90%	458
$\pi^0\pi^0$	$PTCP$ $< 9 \times 10^{-4}$	CL=90%	459
$\pi^0 e^+e^-$	C [g] < 1.3 %	CL=90%	469
ηe^+e^-	C [g] < 1.1 %	CL=90%	322
3γ	C $< 1.0 \times 10^{-4}$	CL=90%	479
$\mu^+\mu^-\pi^0$	C [g] $< 6.0 \times 10^{-5}$	CL=90%	445
$\mu^+\mu^-\eta$	C [g] $< 1.5 \times 10^{-5}$	CL=90%	274

$f_0(980)$ [k]

$I^G(J^{PC}) = 0^+(0^{++})$

Mass $m = 980 \pm 10$ MeV
Full width $\Gamma = 40$ to 100 MeV

$f_0(980)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\pi\pi$	dominant		470
$K\overline{K}$	seen		–
$\gamma\gamma$	$(1.19 \pm 0.33) \times 10^{-5}$		490
e^+e^-	$< 3 \times 10^{-7}$	90%	490

$a_0(980)$ [k]

$I^G(J^{PC}) = 1^-(0^{++})$

Mass $m = 983.4 \pm 0.9$ MeV
Full width $\Gamma = 50$ to 100 MeV

$a_0(980)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\eta\pi$	dominant	321
$K\overline{K}$	seen	–
$\gamma\gamma$	seen	492

$\phi(1020)$

$I^G(J^{PC}) = 0^-(1^{--})$

Mass $m = 1019.413 \pm 0.008$ MeV
Full width $\Gamma = 4.43 \pm 0.05$ MeV

$\phi(1020)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
K^+K^-	(49.1 ± 0.8) %	S=1.3	127
$K_L^0K_S^0$	(34.1 ± 0.6) %	S=1.2	110
$\rho\pi + \pi^+\pi^-\pi^0$	(15.5 ± 0.7) %	S=1.5	–
$\eta\gamma$	(1.26 ± 0.06) %	S=1.1	363
$\pi^0\gamma$	$(1.31 \pm 0.13) \times 10^{-3}$		501
e^+e^-	$(2.99 \pm 0.08) \times 10^{-4}$	S=1.2	510
$\mu^+\mu^-$	$(2.5 \pm 0.4) \times 10^{-4}$		499
ηe^+e^-	$(1.3 \, {}^{+0.8}_{-0.6}) \times 10^{-4}$		363
$\pi^+\pi^-$	$(8 \, {}^{+5}_{-4}) \times 10^{-5}$	S=1.5	490
$\omega\gamma$	< 5 %	CL=84%	210
$\rho\gamma$	$< 7 \times 10^{-4}$	CL=90%	219
$\pi^+\pi^-\gamma$	$< 3 \times 10^{-5}$	CL=90%	490
$f_0(980)\gamma$	$< 1 \times 10^{-4}$	CL=90%	39
$\pi^0\pi^0\gamma$	$< 1 \times 10^{-3}$	CL=90%	492
$\pi^+\pi^-\pi^+\pi^-$	$< 8.7 \times 10^{-4}$	CL=90%	410
$\pi^+\pi^+\pi^-\pi^-\pi^0$	$< 1.5 \times 10^{-4}$	CL=95%	341
$\pi^0 e^+e^-$	$< 1.2 \times 10^{-4}$	CL=90%	501
$\pi^0\eta\gamma$	$< 2.5 \times 10^{-3}$	CL=90%	346
$a_0(980)\gamma$	$< 5 \times 10^{-3}$	CL=90%	36
$\eta'(958)\gamma$	$(1.2 \, {}^{+0.7}_{-0.5}) \times 10^{-4}$		–
$\mu^+\mu^-\gamma$	$(2.3 \pm 1.0) \times 10^{-5}$		–

$h_1(1170)$

$I^G(J^{PC}) = 0^-(1^{+-})$

Mass $m = 1170 \pm 20$ MeV
Full width $\Gamma = 360 \pm 40$ MeV

$h_1(1170)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\rho\pi$	seen	310

$b_1(1235)$ $I^G(J^{PC}) = 1^+(1^{+-})$

Mass $m = 1229.5 \pm 3.2$ MeV (S = 1.6)
Full width $\Gamma = 142 \pm 9$ MeV (S = 1.2)

$b_1(1235)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\omega\pi$	dominant		348
[D/S amplitude ratio $= 0.29 \pm 0.04$]			
$\pi^\pm\gamma$	$(1.6\pm0.4)\times10^{-3}$		608
$\eta\rho$	seen		–
$\pi^+\pi^+\pi^-\pi^0$	< 50 %	84%	536
$(K\overline{K})^\pm\pi^0$	< 8 %	90%	248
$K^0_S K^0_L\pi^\pm$	< 6 %	90%	238
$K^0_S K^0_S\pi^\pm$	< 2 %	90%	238
$\phi\pi$	< 1.5 %	84%	146

$a_1(1260)$ [l] $I^G(J^{PC}) = 1^-(1^{++})$

Mass $m = 1230 \pm 40$ MeV [m]
Full width $\Gamma = 250$ to 600 MeV

$a_1(1260)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\rho\pi$	dominant	356
[D/S amplitude ratio $= -0.100 \pm 0.028$]		
$\pi\gamma$	seen	607
$\pi(\pi\pi)_{S\text{-wave}}$	possibly seen	575

$f_2(1270)$ $I^G(J^{PC}) = 0^+(2^{++})$

Mass $m = 1275.0 \pm 1.2$ MeV
Full width $\Gamma = 185.5^{+3.8}_{-2.7}$ MeV (S = 1.5)

$f_2(1270)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\pi\pi$	$(84.6\ ^{+2.5}_{-1.3})$ %	S=1.3	622
$\pi^+\pi^-2\pi^0$	$(7.2\ ^{+1.5}_{-2.7})$ %	S=1.3	562
$K\overline{K}$	$(4.6\ \pm0.4)$ %	S=2.8	403
$2\pi^+2\pi^-$	$(2.8\ \pm0.4)$ %	S=1.2	559
$\eta\eta$	$(4.5\ \pm1.0)\times10^{-3}$	S=2.4	327
$4\pi^0$	$(3.0\ \pm1.0)\times10^{-3}$		564
$\gamma\gamma$	$(1.32^{+0.17}_{-0.16})\times10^{-5}$		637
$\eta\pi\pi$	$< 8 \times10^{-3}$	CL=95%	475
$K^0K^-\pi^+$ + c.c.	$< 3.4 \times10^{-3}$	CL=95%	293
e^+e^-	$< 9 \times10^{-9}$	CL=90%	637

$f_1(1285)$ $I^G(J^{PC}) = 0^+(1^{++})$

Mass $m = 1281.9 \pm 0.6$ MeV (S = 1.7)
Full width $\Gamma = 24.0 \pm 1.2$ MeV (S = 1.4)

$(4\pi = \rho(\pi\pi)_{P\text{wave}})$

$f_1(1285)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
4π	$(35\ \pm4\ )$ %	S=1.6	563
$\pi^0\pi^0\pi^+\pi^-$	(23.5 ± 3.0) %	S=1.6	566
$2\pi^+2\pi^-$	(11.7 ± 1.5) %	S=1.6	563
$\rho^0\pi^+\pi^-$	(11.7 ± 1.5) %	S=1.6	340
$4\pi^0$	$< 7 \times10^{-4}$	CL=90%	568
$\eta\pi\pi$	$(50\ \pm18\ )$ %		479
$a_0(980)\pi$ [ignoring $a_0(980) \to K\overline{K}$]	$(34\ \pm8\ )$ %	S=1.2	234
$\eta\pi\pi$ [excluding $a_0(980)\pi$]	$(15\ \pm7\ )$ %	S=1.1	–
$K\overline{K}\pi$	(9.6 ± 1.2) %	S=1.5	308
$K\overline{K}^*(892)$	not seen		–
$\gamma\rho^0$	(5.4 ± 1.2) %	S=2.3	410
$\phi\gamma$	$(7.9\pm3.0)\times10^{-4}$		236

$\eta(1295)$ $I^G(J^{PC}) = 0^+(0^{-+})$

Mass $m = 1297.0 \pm 2.8$ MeV
Full width $\Gamma = 53 \pm 6$ MeV

$\eta(1295)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\eta\pi^+\pi^-$	seen	488
$a_0(980)\pi$	seen	245
$\eta\pi^0\pi^0$	seen	–
$\eta(\pi\pi)_{S\text{-wave}}$	seen	–

$\pi(1300)$ $I^G(J^{PC}) = 1^-(0^{-+})$

Mass $m = 1300 \pm 100$ MeV [m]
Full width $\Gamma = 200$ to 600 MeV

$\pi(1300)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\rho\pi$	seen	406
$\pi(\pi\pi)_{S\text{-wave}}$	seen	–

$a_2(1320)$ $I^G(J^{PC}) = 1^-(2^{++})$

Mass $m = 1318.1 \pm 0.6$ MeV (S = 1.1)
Full width $\Gamma = 107 \pm 5$ MeV [m] ($K^\pm K^0_S$ and $\eta\pi$ modes)

$a_2(1320)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\rho\pi$	(70.1 ± 2.7) %	S=1.2	419
$\eta\pi$	(14.5 ± 1.2) %		535
$\omega\pi\pi$	(10.6 ± 3.2) %	S=1.3	362
$K\overline{K}$	(4.9 ± 0.8) %		437
$\eta'(958)\pi$	$(5.3\pm0.9)\times10^{-3}$		287
$\pi^\pm\gamma$	$(2.8\pm0.6)\times10^{-3}$		652
$\gamma\gamma$	$(9.4\pm0.7)\times10^{-6}$		659
$\pi^+\pi^-\pi^-$	< 8 %	CL=90%	621
e^+e^-	$< 2.3 \times10^{-7}$	CL=90%	659

$f_0(1370)$ [k] $I^G(J^{PC}) = 0^+(0^{++})$

Mass $m = 1200$ to 1500 MeV
Full width $\Gamma = 200$ to 500 MeV

$f_0(1370)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\pi\pi$	seen	–
4π	seen	–
$4\pi^0$	seen	–
$2\pi^+2\pi^-$	seen	–
$\pi^+\pi^-2\pi^0$	seen	–
$2(\pi\pi)_{S\text{-wave}}$	seen	–
$\eta\eta$	seen	–
$K\overline{K}$	seen	–
$\gamma\gamma$	seen	–
e^+e^-	not seen	–

$f_1(1420)$ [n] $I^G(J^{PC}) = 0^+(1^{++})$

Mass $m = 1426.2 \pm 1.2$ MeV (S = 1.3)
Full width $\Gamma = 55.0 \pm 3.0$ MeV

$f_1(1420)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\overline{K}\pi$	dominant	439
$K\overline{K}^*(892)$ + c.c.	dominant	155
$\eta\pi\pi$	possibly seen	571

$\omega(1420)$ [o] $I^G(J^{PC}) = 0^-(1^{--})$

Mass $m = 1419 \pm 31$ MeV
Full width $\Gamma = 174 \pm 60$ MeV

$\omega(1420)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\rho\pi$	dominant	488

$\eta(1440)$ [p]

$I^G(J^{PC}) = 0^+(0^{-+})$

Mass $m = 1400$ - 1470 MeV [m]
Full width $\Gamma = 50$ - 80 MeV [m]

$\eta(1440)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\overline{K}\pi$	seen	–
$K\overline{K}^*(892)+$ c.c.	seen	–
$\eta\pi\pi$	seen	–
$a_0(980)\pi$	seen	–
$\eta(\pi\pi)$ s-wave	seen	–
4π	seen	–

$a_0(1450)$

$I^G(J^{PC}) = 1^-(0^{++})$

Mass $m = 1474 \pm 19$ MeV
Full width $\Gamma = 265 \pm 13$ MeV

$a_0(1450)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\pi\eta$	seen	613
$\pi\eta'(958)$	seen	392
$K\overline{K}$	seen	530

$\rho(1450)$ [q]

$I^G(J^{PC}) = 1^+(1^{--})$

Mass $m = 1465 \pm 25$ MeV [m]
Full width $\Gamma = 310 \pm 60$ MeV [m]

$\rho(1450)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\pi\pi$	seen		719
4π	seen		665
$\omega\pi$	<2.0 %	95%	512
e^+e^-	seen		732
$\eta\rho$	<4 %		317
$\phi\pi$	<1 %		358
$K\overline{K}$	$<1.6\times10^{-3}$	95%	541

$f_0(1500)$ [r]

$I^G(J^{PC}) = 0^+(0^{++})$

Mass $m = 1500 \pm 10$ MeV (S = 1.3)
Full width $\Gamma = 112 \pm 10$ MeV

$f_0(1500)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\eta\eta'(958)$	seen	–
$\eta\eta$	seen	513
4π	seen	–
$4\pi^0$	seen	690
$2\pi^+2\pi^-$	seen	686
2π	seen	–
$\pi^+\pi^-$	seen	737
$2\pi^0$	seen	738
$K\overline{K}$	seen	563

$f_2'(1525)$

$I^G(J^{PC}) = 0^+(2^{++})$

Mass $m = 1525 \pm 5$ MeV [m]
Full width $\Gamma = 76 \pm 10$ MeV [m]

$f_2'(1525)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\overline{K}$	(88.8 ±3.1) %	581
$\eta\eta$	(10.3 ±3.1) %	531
$\pi\pi$	(8.2 ±1.5) $\times10^{-3}$	750
$\gamma\gamma$	(1.32±0.21) $\times10^{-6}$	763

$\omega(1600)$ [s]

$I^G(J^{PC}) = 0^-(1^{--})$

Mass $m = 1649 \pm 24$ MeV (S = 2.3)
Full width $\Gamma = 220 \pm 35$ MeV (S = 1.6)

$\omega(1600)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\rho\pi$	seen	637
$\omega\pi\pi$	seen	601
e^+e^-	seen	824

$\omega_3(1670)$

$I^G(J^{PC}) = 0^-(3^{--})$

Mass $m = 1667 \pm 4$ MeV
Full width $\Gamma = 168 \pm 10$ MeV [m]

$\omega_3(1670)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\rho\pi$	seen	647
$\omega\pi\pi$	seen	614
$b_1(1235)\pi$	possibly seen	359

$\pi_2(1670)$

$I^G(J^{PC}) = 1^-(2^{-+})$

Mass $m = 1670 \pm 20$ MeV [m]
Full width $\Gamma = 258 \pm 18$ MeV [m] (S = 1.7)

$\pi_2(1670)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
3π	(95.8±1.4) %	806
$f_2(1270)\pi$	(56.2±3.2) %	325
$\rho\pi$	(31 ±4) %	649
$f_0(1370)\pi$	(8.7±3.4) %	–
$K\overline{K}^*(892)+$ c.c.	(4.2±1.4) %	453

$\phi(1680)$

$I^G(J^{PC}) = 0^-(1^{--})$

Mass $m = 1680 \pm 20$ MeV [m]
Full width $\Gamma = 150 \pm 50$ MeV [m]

$\phi(1680)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\overline{K}^*(892)+$ c.c.	dominant	463
$K^0_SK\pi$	seen	620
$K\overline{K}$	seen	681
e^+e^-	seen	840
$\omega\pi\pi$	not seen	622

$\rho_3(1690)$

$I^G(J^{PC}) = 1^+(3^{--})$

J^P from the 2π and $K\overline{K}$ modes.
Mass $m = 1691 \pm 5$ MeV [m]
Full width $\Gamma = 160 \pm 10$ MeV [m] (S = 1.5)

$\rho_3(1690)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor	p (MeV/c)
4π	(71.1 ± 1.9) %		788
$\pi^\pm\pi^+\pi^-\pi^0$	(67 ±22) %		788
$\omega\pi$	(16 ± 6) %		656
$\pi\pi$	(23.6 ± 1.3) %		834
$K\overline{K}\pi$	(3.8 ± 1.2) %		628
$K\overline{K}$	(1.58± 0.26) %	1.2	686
$\eta\pi^+\pi^-$	seen		728

$\rho(1700)$ [q]

$I^G(J^{PC}) = 1^+(1^{--})$

Mass $m = 1700 \pm 20$ MeV [m] ($\eta\rho^0$ and $\pi^+\pi^-$ modes)
Full width $\Gamma = 240 \pm 60$ MeV [m] ($\eta\rho^0$ and $\pi^+\pi^-$ modes)

$\rho(1700)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\rho\pi\pi$	dominant	640
$2(\pi^+\pi^-)$	large	792
$\rho^0\pi^+\pi^-$	large	640
$\rho^\pm\pi^\mp\pi^0$	large	642
$\pi^+\pi^-$	seen	838
$\pi^-\pi^0$	seen	839
$K\overline{K}^*(892)+$ c.c.	seen	479
$\eta\rho$	seen	533
$K\overline{K}$	seen	692
e^+e^-	seen	850
$\pi^0\omega$	seen	662

$f_J(1710)$ [t]

$I^G(J^{PC}) = 0^+(\text{even}^{++})$

Mass $m = 1712 \pm 5$ MeV (S = 1.1)
Full width $\Gamma = 133 \pm 14$ MeV (S = 1.2)

$f_J(1710)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\overline{K}$	seen	690
$\eta\eta$	seen	648
$\pi\pi$	seen	837

$\pi(1800)$

$I^G(J^{PC}) = 1^-(0^{-+})$

Mass $m = 1801 \pm 13$ MeV (S = 1.9)
Full width $\Gamma = 210 \pm 15$ MeV

$\pi(1800)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\pi^+\pi^-\pi^-$	seen	–
$f_0(980)\pi^-$	seen	623
$f_0(1370)\pi^-$	seen	–
$\rho\pi^-$	not seen	728
$\eta\eta\pi^-$	seen	–
$a_0(980)\eta$	seen	459
$f_0(1500)\pi^-$	seen	240
$\eta\eta'(958)\pi^-$	seen	–
$K_0^*(1430)K^-$	seen	–
$K^*(892)K^-$	not seen	560

$\phi_3(1850)$

$I^G(J^{PC}) = 0^-(3^{--})$

Mass $m = 1854 \pm 7$ MeV
Full width $\Gamma = 87^{+28}_{-23}$ MeV (S = 1.2)

$\phi_3(1850)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\overline{K}$	seen	785
$K\overline{K}^*(892)+$ c.c.	seen	602

$f_2(2010)$

$I^G(J^{PC}) = 0^+(2^{++})$

Seen by one group only.
Mass $m = 2011^{+60}_{-80}$ MeV
Full width $\Gamma = 202 \pm 60$ MeV

$f_2(2010)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\phi\phi$	seen	–

$a_4(2040)$

$I^G(J^{PC}) = 1^-(4^{++})$

Mass $m = 2020 \pm 16$ MeV
Full width $\Gamma = 387 \pm 70$ MeV

$a_4(2040)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\overline{K}$	seen	892
$\pi^+\pi^-\pi^0$	seen	–
$\eta\pi^0$	seen	941

$f_4(2050)$

$I^G(J^{PC}) = 0^+(4^{++})$

Mass $m = 2044 \pm 11$ MeV (S = 1.4)
Full width $\Gamma = 208 \pm 13$ MeV (S = 1.2)

$f_4(2050)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\omega\omega$	(26 ±6) %	658
$\pi\pi$	(17.0±1.5) %	1012
$K\overline{K}$	$(6.8^{+3.4}_{-1.8}) \times 10^{-3}$	895
$\eta\eta$	(2.1±0.8) $\times 10^{-3}$	863
$4\pi^0$	< 1.2 %	977

$f_2(2300)$

$I^G(J^{PC}) = 0^+(2^{++})$

Mass $m = 2297 \pm 28$ MeV
Full width $\Gamma = 149 \pm 40$ MeV

$f_2(2300)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\phi\phi$	seen	529

$f_2(2340)$

$I^G(J^{PC}) = 0^+(2^{++})$

Mass $m = 2339 \pm 60$ MeV
Full width $\Gamma = 319^{+80}_{-70}$ MeV

$f_2(2340)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\phi\phi$	seen	573

STRANGE MESONS
($S = \pm 1$, $C = B = 0$)

$K^+ = u\bar{s}$, $K^0 = d\bar{s}$, $\overline{K}^0 = \bar{d}s$, $K^- = \bar{u}s$, similarly for K^*'s

$K^\pm$

$I(J^P) = \frac{1}{2}(0^-)$

Mass $m = 493.677 \pm 0.016$ MeV [u] (S = 2.8)
Mean life $\tau = (1.2386 \pm 0.0024) \times 10^{-8}$ s (S = 2.0)
$c\tau = 3.713$ m

Slope parameter g [v]

(See Particle Listings for quadratic coefficients)
$K^+ \to \pi^+\pi^+\pi^- = -0.2154 \pm 0.0035$ (S = 1.4)
$K^- \to \pi^-\pi^-\pi^+ = -0.217 \pm 0.007$ (S = 2.5)
$K^\pm \to \pi^\pm\pi^0\pi^0 = 0.594 \pm 0.019$ (S = 1.3)

$K^\pm$ decay form factors [a,w]
K^+_{e3} $\lambda_+ = 0.0286 \pm 0.0022$
$K^+_{\mu 3}$ $\lambda_+ = 0.032 \pm 0.008$ (S = 1.6)
$K^+_{\mu 3}$ $\lambda_0 = 0.006 \pm 0.007$ (S = 1.6)
K^+_{e3} $|f_S/f_+| = 0.084 \pm 0.023$ (S = 1.2)
K^+_{e3} $|f_T/f_+| = 0.38 \pm 0.11$ (S = 1.1)
$K^+_{\mu 3}$ $|f_T/f_+| = 0.02 \pm 0.12$
$K^+ \to e^+\nu_e\gamma$ $|F_A + F_V| = 0.148 \pm 0.010$
$K^+ \to \mu^+\nu_\mu\gamma$ $|F_A + F_V| < 0.23$ Γ CL = 90%
$K^+ \to e^+\nu_e\gamma$ $|F_A - F_V| < 0.49$
$K^+ \to \mu^+\nu_\mu\gamma$ $|F_A - F_V| = -2.2$ to 0.3

K^- modes are charge conjugates of the modes below.

K^+ DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\mu^+\nu_\mu$		(63.51±0.18) %	S=1.3	236
$e^+\nu_e$		(1.55±0.07) × 10^{-5}		247
$\pi^+\pi^0$		(21.16±0.14) %	S=1.1	205
$\pi^+\pi^+\pi^-$		(5.59±0.05) %	S=1.8	125
$\pi^+\pi^0\pi^0$		(1.73±0.04) %	S=1.2	133
$\pi^0\mu^+\nu_\mu$		(3.18±0.08) %	S=1.5	215
Called $K^+_{\mu 3}$.				
$\pi^0 e^+\nu_e$		(4.82±0.06) %	S=1.3	228
Called K^+_{e3}.				
$\pi^0\pi^0 e^+\nu_e$		(2.1 ±0.4) × 10^{-5}		206
$\pi^+\pi^- e^+\nu_e$		(3.91±0.17) × 10^{-5}		203
$\pi^+\pi^-\mu^+\nu_\mu$		(1.4 ±0.9) × 10^{-5}		151
$\pi^0\pi^0\pi^0 e^+\nu_e$		< 3.5 × 10^{-6}	CL=90%	135
$\pi^+\gamma\gamma$	[x]	(1.10±0.32) × 10^{-6}		227
$\pi^+ 3\gamma$	[x]	< 1.0 × 10^{-4}	CL=90%	227
$\mu^+\nu_\mu\nu\overline{\nu}$		< 6.0 × 10^{-6}	CL=90%	236
$e^+\nu_e\nu\overline{\nu}$		< 6 × 10^{-5}	CL=90%	247
$\mu^+\nu_\mu e^+ e^-$		(1.3 ±0.4) × 10^{-7}		236
$e^+\nu_e e^+ e^-$		(3.0 $^{+3.0}_{-1.5}$) × 10^{-8}		247
$\mu^+\nu_\mu\mu^+\mu^-$		< 4.1 × 10^{-7}	CL=90%	185
$\mu^+\nu_\mu\gamma$	[x,y]	(5.50±0.28) × 10^{-3}		236
$\pi^+\pi^0\gamma$	[x,y]	(2.75±0.15) × 10^{-4}		205
$\pi^+\pi^0\gamma$(DE)	[x,z]	(1.8 ±0.4) × 10^{-5}		205
$\pi^+\pi^+\pi^-\gamma$	[x,y]	(1.04±0.31) × 10^{-4}		125
$\pi^+\pi^0\pi^0\gamma$	[x,y]	(7.5 $^{+5.5}_{-3.0}$) × 10^{-6}		133
$\pi^0\mu^+\nu_\mu\gamma$	[x,y]	< 6.1 × 10^{-5}	CL=90%	215
$\pi^0 e^+\nu_e\gamma$	[x,y]	(2.62±0.20) × 10^{-4}		228
$\pi^0 e^+\nu_e\gamma$(SD)	[aa]	< 5.3 × 10^{-5}	CL=90%	228
$\pi^0\pi^0 e^+\nu_e\gamma$		< 5 × 10^{-6}	CL=90%	206

Lepton Family number (LF) Lepton number (L) $\Delta S = \Delta Q$ (SQ) violating modes or $\Delta S = 1$ weak neutral current ($S1$) modes

$\pi^+\pi^+ e^-\overline{\nu}_e$	SQ	< 1.2	× 10^{-8}	CL=90%	203
$\pi^+\pi^+\mu^-\overline{\nu}_\mu$	SQ	< 3.0	× 10^{-6}	CL=95%	151
$\pi^+ e^+ e^-$	$S1$	(2.74±0.23)	× 10^{-7}		227
$\pi^+\mu^+\mu^-$	$S1$	(5.0 ±1.0)	× 10^{-8}		172
$\pi^+\nu\overline{\nu}$	$S1$	(4.2 $^{+9.7}_{-3.5}$)	× 10^{-10}		227
$\mu^- \nu e^+ e^+$	LF	< 2.0	× 10^{-8}	CL=90%	236
$\mu^+\nu_e$	LF [d]	< 4	× 10^{-3}	CL=90%	236
$\pi^+\mu^+ e^-$	LF	< 2.1	× 10^{-10}	CL=90%	214
$\pi^+\mu^- e^+$	LF	< 7	× 10^{-9}	CL=90%	214
$\pi^-\mu^+ e^+$	L	< 7	× 10^{-9}	CL=90%	214
$\pi^- e^+ e^+$	L	< 1.0	× 10^{-8}	CL=90%	227
$\pi^-\mu^+\mu^+$	L [d]	< 1.5	× 10^{-4}	CL=90%	172
$\mu^+\overline{\nu}_e$	L [d]	< 3.3	× 10^{-3}	CL=90%	236
$\pi^0 e^+\overline{\nu}_e$	L	< 3	× 10^{-3}	CL=90%	228

K^0

$I(J^P) = \frac{1}{2}(0^-)$

50% K_S + 50% K_L
Mass $m = 497.672 \pm 0.031$ MeV
$m_{K^0} - m_{K^\pm} = 3.995 \pm 0.034$ MeV (S = 1.1)
$|m_{K^0} - m_{\overline{K}^0}| / m_{\text{average}} < 10^{-18}$ [bb]

K^0_S

$I(J^P) = \frac{1}{2}(0^-)$

Mean life $\tau = (0.8934 \pm 0.0008) \times 10^{-10}$ s
$c\tau = 2.6762$ cm

CP-violation parameters [cc]
Im(η_{+-0}) $= -0.002 \pm 0.008$
Im(η_{000})^2 < 0.1 Γ CL = 90%

K^0_S DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\pi^+\pi^-$		(68.61±0.28) %	S=1.2	206
$\pi^0\pi^0$		(31.39±0.28) %	S=1.2	209
$\pi^+\pi^-\gamma$	[y,dd]	(1.78±0.05) × 10^{-3}		206
$\gamma\gamma$		(2.4 ±0.9) × 10^{-6}		249
$\pi^+\pi^-\pi^0$		(3.4 $^{+1.1}_{-0.9}$) × 10^{-7}		133
$3\pi^0$		< 3.7 × 10^{-5}	CL=90%	139
$\pi^\pm e^\mp\nu$	[ee]	(6.70±0.07) × 10^{-4}	S=1.1	229
$\pi^\pm\mu^\mp\nu$	[ee]	(4.69±0.06) × 10^{-4}	S=1.1	216
$\Delta S = 1$ weak neutral current ($S1$) modes				
$\mu^+\mu^-$	$S1$	< 3.2 × 10^{-7}	CL=90%	225
$e^+ e^-$	$S1$	< 1.4 × 10^{-7}	CL=90%	249
$\pi^0 e^+ e^-$	$S1$	< 1.1 × 10^{-6}	CL=90%	231

K^0_L

$I(J^P) = \frac{1}{2}(0^-)$

$m_{K_L} - m_{K_S} = (0.5301 \pm 0.0014) \times 10^{10}\ \hbar\ \text{s}^{-1}$
$= (3.489 \pm 0.009) \times 10^{-12}$ MeV
Mean life $\tau = (5.17 \pm 0.04) \times 10^{-8}$ s (S = 1.1)
$c\tau = 15.51$ m

Slope parameter g [v]

(See Particle Listings for quadratic coefficients)
$K^0_L \to \pi^+\pi^-\pi^0 = 0.670 \pm 0.014$ (S = 1.6)

K_L decay form factors [w]
K^0_{e3} $\lambda_+ = 0.0300 \pm 0.0016$ (S = 1.2)
$K^0_{\mu 3}$ $\lambda_+ = 0.034 \pm 0.005$ (S = 2.3)
$K^0_{\mu 3}$ $\lambda_0 = 0.025 \pm 0.006$ (S = 2.3)
K^0_{e3} $|f_S/f_+| < 0.04$ Γ CL = 68%
K^0_{e3} $|f_T/f_+| < 0.23$ Γ CL = 68%
$K^0_{\mu 3}$ $|f_T/f_+| = 0.12 \pm 0.12$
$K_L \to e^+ e^-\gamma$: $\alpha_{K^*} = -0.28 \pm 0.08$

***CP*-violation parameters** [α]

$\delta = (0.327 \pm 0.012)\%$
$|\eta_{00}| = (2.275 \pm 0.019) \times 10^{-3}$ (S = 1.1)
$|\eta_{+-}| = (2.285 \pm 0.019) \times 10^{-3}$
$|\eta_{00}/\eta_{+-}| = 0.9956 \pm 0.0023$ [ff] (S = 1.8)
$\epsilon'/\epsilon = (1.5 \pm 0.8) \times 10^{-3}$ [ff] (S = 1.8)
$\phi_{+-} = (43.5 \pm 0.6)^\circ$
$\phi_{00} = (43.4 \pm 1.0)^\circ$
$\phi_{00} - \phi_{+-} = (-0.1 \pm 0.8)^\circ$
j for $K_L^0 \to \pi^+\pi^-\pi^0 = 0.0011 \pm 0.0008$
$|\eta_{+-\gamma}| = (2.35 \pm 0.07) \times 10^{-3}$
$\phi_{+-\gamma} = (44 \pm 4)^\circ$
$|\epsilon'_{+-\gamma}|/\epsilon < 0.3$ CL = 90%

$\Delta S = -\Delta Q$ in $K^0_{\ell 3}$ decay

Re $x = 0.006 \pm 0.018$ (S = 1.3)
Im $x = -0.003 \pm 0.026$ (S = 1.2)

***CPT*-violation parameters**

Re $\Delta = 0.018 \pm 0.020$
Im $\Delta = 0.02 \pm 0.04$

K_L^0 DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$3\pi^0$		(21.12 ±0.27) %	S=1.1	139
$\pi^+\pi^-\pi^0$		(12.56 ±0.20) %	S=1.7	133
$\pi^\pm\mu^\mp\nu$ Called $K^0_{\mu 3}$.	[gg]	(27.17 ±0.25) %	S=1.1	216
$\pi^\pm e^\mp\nu_e$ Called K^0_{e3}.	[gg]	(38.78 ±0.27) %	S=1.1	229
2γ		(5.92 ±0.15) $\times 10^{-4}$		249
3γ		< 2.4 $\times 10^{-7}$	CL=90%	249
$\pi^0 2\gamma$	[hh]	(1.70 ±0.28) $\times 10^{-6}$		231
$\pi^0\pi^\pm e^\mp\nu$	[gg]	(5.18 ±0.29) $\times 10^{-5}$		207
$(\pi\mu\text{atom})\nu$		(1.06 ±0.11) $\times 10^{-7}$		–
$\pi^\pm e^\mp\nu_e\gamma$	[½gg,hh]	(3.62 $^{+0.26}_{-0.21}$) $\times 10^{-3}$		229
$\pi^+\pi^-\gamma$	[½hh]	(4.61 ±0.14) $\times 10^{-5}$		206
$\pi^0\pi^0\gamma$		< 5.6 $\times 10^{-6}$		209
Charge conjugation × Parity (*CP*, *CPV*) or Lepton Family number (*LF*) violating modes or $\Delta S = 1$ weak neutral current (*S1*) modes				
$\pi^+\pi^-$	*CPV*	(2.067±0.035) $\times 10^{-3}$	S=1.1	206
$\pi^0\pi^0$	*CPV*	(9.36 ±0.20) $\times 10^{-4}$		209
$\mu^+\mu^-$	*S1*	(7.2 ±0.5) $\times 10^{-9}$	S=1.4	225
$\mu^+\mu^-\gamma$	*S1*	(3.25 ±0.28) $\times 10^{-7}$		225
e^+e^-	*S1*	< 4.1 $\times 10^{-11}$	CL=90%	249
$e^+e^-\gamma$	*S1*	(9.1 ±0.5) $\times 10^{-6}$		249
$e^+e^-\gamma\gamma$	*S1* [hh]	(6.5 ±1.2) $\times 10^{-7}$		249
$\pi^+\pi^-e^+e^-$	*S1* [hh]	< 4.6 $\times 10^{-7}$	CL=90%	206
$\mu^+\mu^-e^+e^-$	*S1*	(2.9 $^{+6.7}_{-2.4}$) $\times 10^{-9}$		225
$e^+e^-e^+e^-$	*S1*	(4.1 ±0.8) $\times 10^{-8}$	S=1.2	249
$\pi^0\mu^+\mu^-$	*CPTS1* [ii]	< 5.1 $\times 10^{-9}$	CL=90%	177
$\pi^0 e^+e^-$	*CPTS1* [ii]	< 4.3 $\times 10^{-9}$	CL=90%	231
$\pi^0\nu\bar{\nu}$	*CPTS1* [jj]	< 5.8 $\times 10^{-5}$	CL=90%	231
$e^\pm\mu^\mp$	*LF* [gg]	< 3.3 $\times 10^{-11}$	CL=90%	238
$e^\pm e^\pm\mu^\mp\mu^\mp$	*LF* [gg]	< 6.1 $\times 10^{-9}$	CL=90%	–

$K^*(892)$

$I(J^P) = \frac{1}{2}(1^-)$

$K^*(892)^\pm$ mass $m = 891.66 \pm 0.26$ MeV
$K^*(892)^0$ mass $m = 896.10 \pm 0.28$ MeV (S = 1.4)
$K^*(892)^\pm$ full width $\Gamma = 50.8 \pm 0.9$ MeV
$K^*(892)^0$ full width $\Gamma = 50.5 \pm 0.6$ MeV (S = 1.1)

$K^*(892)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$K\pi$	~ 100 %		291
$K^0\gamma$	(2.30±0.20) $\times 10^{-3}$		310
$K^\pm\gamma$	(9.9 ±0.9) $\times 10^{-4}$		309
$K\pi\pi$	< 7 $\times 10^{-4}$	95%	224

$K_1(1270)$

$I(J^P) = \frac{1}{2}(1^+)$

Mass $m = 1273 \pm 7$ MeV [m]
Full width $\Gamma = 90 \pm 20$ MeV [m]

$K_1(1270)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\rho$	(42 ±6) %	76
$K_0^*(1430)\pi$	(28 ±4) %	–
$K^*(892)\pi$	(16 ±5) %	301
$K\omega$	(11.0±2.0) %	–
$K f_0(1370)$	(3.0±2.0) %	–

$K_1(1400)$

$I(J^P) = \frac{1}{2}(1^+)$

Mass $m = 1402 \pm 7$ MeV
Full width $\Gamma = 174 \pm 13$ MeV (S = 1.6)

$K_1(1400)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K^*(892)\pi$	(94 ±6) %	401
$K\rho$	(3.0±3.0) %	298
$K f_0(1370)$	(2.0±2.0) %	–
$K\omega$	(1.0±1.0) %	285
$K_0^*(1430)\pi$	not seen	–

$K^*(1410)$

$I(J^P) = \frac{1}{2}(1^-)$

Mass $m = 1414 \pm 15$ MeV (S = 1.3)
Full width $\Gamma = 232 + 21$ MeV (S = 1.1)

$K^*(1410)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$K^*(892)\pi$	> 40 %	95%	408
$K\pi$	(6.6±1.3) %		611
$K\rho$	< 7 %	95%	309

$K_0^*(1430)$ [kk]

$I(J^P) = \frac{1}{2}(0^+)$

Mass $m = 1429 \pm 6$ MeV
Full width $\Gamma = 287 \pm 23$ MeV

$K_0^*(1430)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\pi$	(93±10) %	621

$K_2^*(1430)$

$I(J^P) = \frac{1}{2}(2^+)$

$K_2^*(1430)^\pm$ mass $m = 1425.6 \pm 1.5$ MeV (S = 1.1)
$K_2^*(1430)^0$ mass $m = 1432.4 \pm 1.3$ MeV
$K_2^*(1430)^\pm$ full width $\Gamma = 98.5 \pm 2.7$ MeV (S = 1.1)
$K_2^*(1430)^0$ full width $\Gamma = 109 \pm 5$ MeV (S = 1.9)

$K_2^*(1430)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$K\pi$	(49.9±1.2) %		622
$K^*(892)\pi$	(24.7±1.5) %		423
$K^*(892)\pi\pi$	(13.4±2.2) %		375
$K\rho$	(8.7±0.8) %	S=1.2	331
$K\omega$	(2.9±0.8) %		319
$K^+\gamma$	(2.4±0.5) $\times 10^{-3}$	S=1.1	627
$K\eta$	(1.5$^{+3.4}_{-1.0}$) $\times 10^{-3}$	S=1.3	492
$K\omega\pi$	< 7.2 $\times 10^{-4}$	CL=95%	110
$K^0\gamma$	< 9 $\times 10^{-4}$	CL=90%	631

$K^*(1680)$ $I(J^P) = \frac{1}{2}(1^-)$

Mass $m = 1717 \pm 27$ MeV (S = 1.4)
Full width $\Gamma = 322 \pm 110$ MeV (S = 4.2)

$K^*(1680)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\pi$	(38.7±2.5) %	779
$K\rho$	$(31.4^{+4.7}_{-2.1})$ %	571
$K^*(892)\pi$	$(29.9^{+2.2}_{-4.7})$ %	615

$K_2(1770)$ [l] $I(J^P) = \frac{1}{2}(2^-)$

Mass $m = 1773 \pm 8$ MeV
Full width $\Gamma = 186 \pm 14$ MeV

$K_2(1770)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\pi\pi$		–
$K_2^*(1430)\pi$	dominant	287
$K^*(892)\pi$	seen	653
$Kf_2(1270)$	seen	–
$K\phi$	seen	441
$K\omega$	seen	608

$K_3^*(1780)$ $I(J^P) = \frac{1}{2}(3^-)$

Mass $m = 1776 \pm 7$ MeV (S = 1.1)
Full width $\Gamma = 159 \pm 21$ MeV (S = 1.3)

$K_3^*(1780)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$K\rho$	(31 ± 9) %		612
$K^*(892)\pi$	(20 ± 5) %		651
$K\pi$	(18.8± 1.0) %		810
$K\eta$	(30 ±13) %		715
$K_2^*(1430)\pi$	< 16 %	95%	284

$K_2(1820)$ [mm] $I(J^P) = \frac{1}{2}(2^-)$

Mass $m = 1816 \pm 13$ MeV
Full width $\Gamma = 276 \pm 35$ MeV

$K_2(1820)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K_2^*(1430)\pi$	seen	325
$K^*(892)\pi$	seen	680
$Kf_2(1270)$	seen	186
$K\omega$	seen	638

$K_4^*(2045)$ $I(J^P) = \frac{1}{2}(4^+)$

Mass $m = 2045 \pm 9$ MeV (S = 1.1)
Full width $\Gamma = 198 \pm 30$ MeV

$K_4^*(2045)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\pi$	(9.9±1.2) %	958
$K^*(892)\pi\pi$	(9 ±5) %	800
$K^*(892)\pi\pi\pi$	(7 ±5) %	764
$\rho K\pi$	(5.7±3.2) %	742
$\omega K\pi$	(5.0±3.0) %	736
$\phi K\pi$	(2.8±1.4) %	591
$\phi K^*(892)$	(1.4±0.7) %	363

CHARMED MESONS ($C = \pm 1$)

$D^+ = c\bar{d}$ $D^0 = c\bar{u}$ $\bar{D}^0 = \bar{c}u$ $D^- = \bar{c}d$ similarly for D^*'s

$D^\pm$ $I(J^P) = \frac{1}{2}(0^-)$

Mass $m = 1869.3 \pm 0.5$ MeV (S = 1.1)
Mean life $\tau = (1.057 \pm 0.015) \times 10^{-12}$ s
$c\tau = 317$ μm

CP-violation decay-rate asymmetries

$A_{CP}(K^+K^-\pi^\pm) = -0.017 \pm 0.027$
$A_{CP}(K^\pm K^{*0}) = -0.02 \pm 0.05$
$A_{CP}(\phi\pi^\pm) = -0.014 \pm 0.033$
$A_{CP}(\pi^+\pi^-\pi^\pm) = -0.02 \pm 0.04$

$D^+ \to \bar{K}^*(892)^0\ell^+\nu_\ell$ form factors

$r_2 = 0.72 \pm 0.09$
$r_V = 1.85 \pm 0.12$
$\Gamma_L/\Gamma_T = 1.23 \pm 0.13$
$\Gamma_+/\Gamma_- = 0.16 \pm 0.04$

D^- modes are charge conjugates of the modes below.

D^+ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Inclusive modes			
e^+ anything	(17.2 ±1.9) %		–
K^- anything	(24.2 ±2.8) %	S=1.4	–
$\bar{K}^0$ anything + K^0 anything	(59 ±7) %		–
K^+ anything	(5.8 ±1.4) %		–
η anything	[mm] < 13 %	CL=90%	–
Leptonic and semileptonic modes			
$\mu^+\nu_\mu$	< 7.2 $\times 10^{-4}$	CL=90%	932
$\bar{K}^0\ell^+\nu_\ell$	[oo] (6.8 ±0.8) %		868
$\bar{K}^0e^+\nu_e$	(6.7 ±0.9) %		868
$\bar{K}^0\mu^+\nu_\mu$	$(7.0 \pm^{3.0}_{2.0})$ %		865
$K^-\pi^+e^+\nu_e$	$(4.1 \pm^{0.9}_{0.7})$ %		863
$\bar{K}^*(892)^0e^+\nu_e$ × B($\bar{K}^{*0} \to K^-\pi^+$)	(3.2 ±0.33) %		720
$K^-\pi^+e^+\nu_e$ nonresonant	< 7 $\times 10^{-3}$	CL=90%	863
$K^-\pi^+\mu^+\nu_\mu$	(3.2 ±0.4) %	S=1.1	851
$\bar{K}^*(892)^0\mu^+\nu_\mu$ × B($\bar{K}^{*0} \to K^-\pi^+$)	(2.9 ±0.4) %		715
$K^-\pi^+\mu^+\nu_\mu$ nonresonant	(2.7 ±1.1) $\times 10^{-3}$		851
$(\bar{K}^*(892)\pi)^0e^+\nu_e$	< 1.2 %	CL=90%	714
$(\bar{K}\pi\pi)^0e^+\nu_e$ non-$\bar{K}^*(892)$	< 9 $\times 10^{-3}$	CL=90%	846
$K^-\pi^+\pi^0\mu^+\nu_\mu$	< 1.4 $\times 10^{-3}$	CL=90%	825
$\pi^0\ell^+\nu_\ell$	[pp] (3.1 ±1.5) $\times 10^{-3}$		930
Fractions of some of the following modes with resonances have already appeared above as submodes of particular charged-particle modes.			
$\bar{K}^*(892)^0\ell^+\nu_\ell$	[oo] (4.7 ±0.4) %		720
$\bar{K}^*(892)^0e^+\nu_e$	(4.8 ±0.5) %		720
$\bar{K}^*(892)^0\mu^+\nu_\mu$	(4.4 ±0.6) %	S=1.1	715
$\rho^0e^+\nu_e$	(2.2 ±0.8) $\times 10^{-3}$		776
$\rho^0\mu^+\nu_\mu$	(2.7 ±0.7) $\times 10^{-3}$		772
$\phi e^+\nu_e$	< 2.09 %	CL=90%	657
$\phi\mu^+\nu_\mu$	< 3.72 %	CL=90%	651
$\eta\ell^+\nu_\ell$	< 5 $\times 10^{-3}$	CL=90%	–
$\eta'(958)\mu^+\nu_\mu$	< 9 $\times 10^{-3}$	CL=90%	684
Hadronic modes with a $\bar{K}$ or $\bar{K}K\bar{K}$			
$\bar{K}^0\pi^+$	(2.89±0.26) %	S=1.1	862
$K^-\pi^+\pi^+$	[qq] (9.0 ±0.6) %		845
$\bar{K}^*(892)^0\pi^+$ × B($\bar{K}^{*0} \to K^-\pi^+$)	(1.27±0.13) %		712
$\bar{K}_0^*(1430)^0\pi^+$ × B($\bar{K}_0^*(1430)^0 \to K^-\pi^+$)	(2.3 ±0.3) %		368
$\bar{K}^*(1680)^0\pi^+$ × B($\bar{K}^*(1680)^0 \to K^-\pi^+$)	(3.7 ±0.8) $\times 10^{-3}$		65
$K^-\pi^+\pi^+$ nonresonant	(8.5 ±0.8) %		845
$\bar{K}^0\pi^+\pi^0$	[qq] (9.7 ±3.0) %	S=1.1	845

$\overline{K}^0\rho^+$		(6.6 ±2.5) %			680
$\overline{K}^*(892)^0\pi^+$		(6.3 ±0.4) $\times 10^{-3}$			712
$\times$ B($\overline{K}^{*0} \to \overline{K}^0\pi^0$)					
$\overline{K}^0\pi^+\pi^0$ nonresonant		(1.3 ±1.1) %			845
$K^-\pi^+\pi^+\pi^0$	[qq]	(6.4 ±1.1) %			816
$\overline{K}^*(892)^0\rho^+$ total		(1.4 ±0.9) %			423
$\times$ B($\overline{K}^{*0} \to K^-\pi^+$)					
$\overline{K}_1(1400)^0\pi^+$		(2.2 ±0.6) %			390
$\times$ B($\overline{K}_1(1400)^0 \to K^-\pi^+\pi^0$)					
$K^-\rho^+\pi^+$ total		(3.1 ±1.1) %			616
$K^-\rho^+\pi^+$ 3-body		(1.1 ±0.4) %			616
$\overline{K}^*(892)^0\pi^+\pi^0$ total		(4.5 ±0.9) %			687
$\times$ B($\overline{K}^{*0} \to K^-\pi^+$)					
$\overline{K}^*(892)^0\pi^+\pi^0$ 3-body		(2.8 ±0.9) %			687
$\times$ B($\overline{K}^{*0} \to K^-\pi^+$)					
$K^*(892)^-\pi^+\pi^+$ 3-body		(7 ±3) $\times 10^{-3}$			688
$\times$ B($K^{*-} \to K^-\pi^0$)					
$K^-\pi^+\pi^+\pi^0$ nonresonant	[rr]	(1.2 ±0.6) %			816
$\overline{K}^0\pi^+\pi^+\pi^-$	[qq]	(7.0 ±0.9) %			814
$\overline{K}^0a_1(1260)^+$		(4.0 ±0.9) %			328
$\times$ B($a_1(1260)^+ \to \pi^+\pi^+\pi^-$)					
$\overline{K}_1(1400)^0\pi^+$		(2.2 ±0.6) %			390
$\times$ B($\overline{K}_1(1400)^0 \to \overline{K}^0\pi^+\pi^-$)					
$K^*(892)^-\pi^+\pi^+$ 3-body		(1.4 ±0.6) %			688
$\times$ B($K^{*-} \to \overline{K}^0\pi^-$)					
$\overline{K}^0\rho^0\pi^+$ total		(4.2 ±0.9) %			614
$\overline{K}^0\rho^0\pi^+$ 3-body		(5 ±5) $\times 10^{-3}$			614
$\overline{K}^0\pi^+\pi^+\pi^-$ nonresonant		(8 ±4) $\times 10^{-3}$			814
$K^-\pi^+\pi^+\pi^+\pi^-$	[qq]	(7.2 ±1.0) $\times 10^{-3}$			772
$\overline{K}^*(892)^0\pi^+\pi^+\pi^-$		(5.4 ±2.3) $\times 10^{-3}$			642
$\times$ B($\overline{K}^{*0} \to K^-\pi^+$)					
$\overline{K}^*(892)^0\rho^0\pi^+$		(1.9 $^{+1.1}_{-1.0}$) $\times 10^{-3}$			242
$\times$ B($\overline{K}^{*0} \to K^-\pi^+$)					
$\overline{K}^*(892)^0\pi^+\pi^+\pi^-$ no-ρ		(2.9 ±1.1) $\times 10^{-3}$			642
$\times$ B($\overline{K}^{*0} \to K^-\pi^+$)					
$K^-\rho^0\pi^+\pi^+$		(3.1 ±0.9) $\times 10^{-3}$			529
$K^-\pi^+\pi^+\pi^+\pi^-$ nonresonant		< 2.3	$\times 10^{-3}$	CL=90%	772
$K^-\pi^+\pi^+\pi^0\pi^0$		(2.2 $^{+5.0}_{-0.9}$) %			775
$\overline{K}^0\pi^+\pi^+\pi^-\pi^0$		(5.4 $^{+3.0}_{-1.4}$) %			773
$\overline{K}^0\pi^+\pi^+\pi^+\pi^-\pi^-$		(8 ±7) $\times 10^{-4}$			714
$K^-\pi^+\pi^+\pi^+\pi^-\pi^0$		(2.0 ±1.8) $\times 10^{-3}$			718
$\overline{K}^0K^0K^+$		(1.8 ±0.8) %			545

Fractions of some of the following modes with resonances have already appeared above as submodes of particular charged-particle modes.

$\overline{K}^0\rho^+$		(6.6 ±2.5) %			680
$\overline{K}^0a_1(1260)^+$		(8.0 ±1.7) %			328
$\overline{K}^0a_2(1320)^+$		< 3	$\times 10^{-3}$	CL=90%	199
$\overline{K}^*(892)^0\pi^+$		(1.90±0.19) %			712
$\overline{K}^*(892)^0\rho^+$ total	[rr]	(2.1 ±1.3) %			423
$\overline{K}^*(892)^0\rho^+$ S-wave	[rr]	(1.6 ±1.6) %			423
$\overline{K}^*(892)^0\rho^+$ P-wave		< 1	$\times 10^{-3}$	CL=90%	423
$\overline{K}^*(892)^0\rho^+$ D-wave		(10 ±7) $\times 10^{-3}$			423
$\overline{K}^*(892)^0\rho^+$ D-wave longitudinal		< 7	$\times 10^{-3}$	CL=90%	423
$\overline{K}_1(1270)^0\pi^+$		< 7	$\times 10^{-3}$	CL=90%	487
$\overline{K}_1(1400)^0\pi^+$		(4.9 ±1.2) %			390
$\overline{K}^*(1410)^0\pi^+$		< 7	$\times 10^{-3}$	CL=90%	382
$\overline{K}_0^*(1430)^0\pi^+$		(3.7 ±0.4) %			368
$\overline{K}^*(1680)^0\pi^+$		(1.43±0.30) %			65
$\overline{K}^*(892)^0\pi^+\pi^0$ total		(6.7 ±1.4) %			687
$\overline{K}^*(892)^0\pi^+\pi^0$ 3-body	[rr]	(4.2 ±1.4) %			687
$K^*(892)^-\pi^+\pi^+$ 3-body		(2.0 ±0.9) %			688
$K^-\rho^+\pi^+$ total		(3.1 ±1.1) %			616
$K^-\rho^+\pi^+$ 3-body		(1.1 ±0.4) %			616
$\overline{K}^0\rho^0\pi^+$ total		(4.2 ±0.9) %		CL=90%	614
$\overline{K}^0\rho^0\pi^+$ 3-body		(5 ±5) $\times 10^{-3}$			614
$\overline{K}^0f_0(980)\pi^+$		< 5	$\times 10^{-3}$	CL=90%	461
$\overline{K}^*(892)^0\pi^+\pi^+\pi^-$		(8.1 ±3.4) $\times 10^{-3}$		S=1.7	642
$\overline{K}^*(892)^0\rho^0\pi^+$		(2.9 $^{+1.7}_{-1.5}$) $\times 10^{-3}$		S=1.8	242
$\overline{K}^*(892)^0\pi^+\pi^+\pi^-$ no-ρ		(4.3 ±1.7) $\times 10^{-3}$			642
$K^-\rho^0\pi^+\pi^+$		(3.1 ±0.9) $\times 10^{-3}$			529

Pionic modes

$\pi^+\pi^0$		(2.5 ±0.7) $\times 10^{-3}$			925
$\pi^+\pi^+\pi^-$		(3.6 ±0.4) $\times 10^{-3}$			908
$\rho^0\pi^+$		(1.05±0.31) $\times 10^{-3}$			769
$\pi^+\pi^+\pi^-$ nonresonant		(2.2 ±0.4) $\times 10^{-3}$			908
$\pi^+\pi^+\pi^-\pi^0$		(1.9 $^{+1.5}_{-1.2}$) %			882
$\eta\pi^+ \times$ B($\eta \to \pi^+\pi^-\pi^0$)		(1.7 ±0.6) $\times 10^{-3}$			848
$\omega\pi^+ \times$ B($\omega \to \pi^+\pi^-\pi^0$)		< 6	$\times 10^{-3}$	CL=90%	764
$\pi^+\pi^+\pi^+\pi^-\pi^-$		(2.1 ±0.4) $\times 10^{-3}$			845
$\pi^+\pi^+\pi^+\pi^-\pi^-\pi^0$		(2.9 $^{+2.9}_{-2.0}$) $\times 10^{-3}$			799

Fractions of some of the following modes with resonances have already appeared above as submodes of particular charged-particle modes.

$\eta\pi^+$		(7.5 ±2.5) $\times 10^{-3}$			848
$\rho^0\pi^+$		(1.05±0.31) $\times 10^{-3}$			769
$\omega\pi^+$		< 7	$\times 10^{-3}$	CL=90%	764
$\eta\rho^+$		< 1.2	%	CL=90%	658
$\eta'(958)\pi^+$		< 9	$\times 10^{-3}$	CL=90%	680
$\eta'(958)\rho^+$		< 1.5	%	CL=90%	355

Hadronic modes with a $K\overline{K}$ pair

$K^+\overline{K}^0$		(7.4 ±1.0) $\times 10^{-3}$			792
$K^+K^-\pi^+$	[qq]	(8.8 ±0.8) $\times 10^{-3}$			744
$\phi\pi^+ \times$ B($\phi \to K^+K^-$)		(3.0 ±0.3) $\times 10^{-3}$			647
$K^+\overline{K}^*(892)^0$		(2.8 ±0.4) $\times 10^{-3}$			610
$\times$ B($\overline{K}^{*0} \to K^-\pi^+$)					
$K^+K^-\pi^+$ nonresonant		(4.5 ±0.9) $\times 10^{-3}$			744
$K^0\overline{K}^0\pi^+$		—			741
$K^*(892)^+\overline{K}^0$		(2.1 ±1.0) %			611
$\times$ B($K^{*+} \to K^0\pi^+$)					
$K^+K^-\pi^+\pi^0$		—			682
$\phi\pi^+\pi^0 \times$ B($\phi \to K^+K^-$)		(1.1 ±0.5) %			619
$\phi\rho^+ \times$ B($\phi \to K^+K^-$)		< 7	$\times 10^{-3}$	CL=90%	268
$K^+K^-\pi^+\pi^0$ non-ϕ		(1.5 $^{+0.7}_{-0.6}$) %			682
$K^+\overline{K}^0\pi^+\pi^-$		< 2	%	CL=90%	678
$K^0K^-\pi^+\pi^+$		(1.0 ±0.6) %			678
$K^*(892)^+\overline{K}^*(892)^0$		(1.2 ±0.5) %			273
$\times$ B^2($K^{*+} \to K^0\pi^+$)					
$K^0K^-\pi^+\pi^+$ non-$K^{*+}\overline{K}^{*0}$		< 7.9	$\times 10^{-3}$	CL=90%	678
$K^+K^-\pi^+\pi^+\pi^-$		—			600
$\phi\pi^+\pi^+\pi^-$		< 1	$\times 10^{-3}$	CL=90%	565
$\times$ B($\phi \to K^+K^-$)					
$K^+K^-\pi^+\pi^+\pi^-$ nonresonant		< 3	%	CL=90%	600

Fractions of the following modes with resonances have already appeared above as submodes of particular charged-particle modes.

$\phi\pi^+$		(6.1 ±0.6) $\times 10^{-3}$			647
$\phi\pi^+\pi^0$		(2.3 ±1.0) %			619
$\phi\rho^+$		< 1.4	%	CL=90%	268
$\phi\pi^+\pi^+\pi^-$		< 2	$\times 10^{-3}$	CL=90%	565
$K^+\overline{K}^*(892)^0$		(4.2 ±0.5) $\times 10^{-3}$			610
$K^*(892)^+\overline{K}^0$		(3.2 ±1.5) %			611
$K^*(892)^+\overline{K}^*(892)^0$		(2.6 ±1.1) %			273

Doubly Cabibbo suppressed (DC) modes or $\Delta C = 1$ weak neutral current ($C1$) modes or Lepton Family number (LF) or Lepton number (L) violating modes

$K^+\pi^+\pi^-$	DC	(6.8 ±1.5) $\times 10^{-4}$			845
$K^+\rho^0$	DC	(2.5 ±1.2) $\times 10^{-4}$			681
$K^*(892)^0\pi^+$	DC	(3.6 ±1.6) $\times 10^{-4}$			712
$K^+\pi^+\pi^-$ nonresonant	DC	(2.4 ±1.2) $\times 10^{-4}$			845
$K^+K^+K^-$	DC	< 1.4	$\times 10^{-4}$	CL=90%	550
ϕK^+	DC	< 1.3	$\times 10^{-4}$	CL=90%	527
$\pi^+e^+e^-$	$C1$	< 6.6	$\times 10^{-5}$	CL=90%	929
$\pi^+\mu^+\mu^-$	$C1$	< 1.8	$\times 10^{-5}$	CL=90%	917
$\rho^+\mu^+\mu^-$	$C1$	< 5.6	$\times 10^{-4}$	CL=90%	759
$K^+e^+e^-$	[ss]	< 2.0	$\times 10^{-4}$	CL=90%	869
$K^+\mu^+\mu^-$	[ss]	< 9.7	$\times 10^{-5}$	CL=90%	856
$\pi^+e^+\mu^-$	LF	< 1.1	$\times 10^{-4}$	CL=90%	926
$\pi^+e^-\mu^+$	LF	< 1.3	$\times 10^{-4}$	CL=90%	926
$K^+e^+\mu^-$	LF	< 1.3	$\times 10^{-4}$	CL=90%	866

$K^+e^-\mu^+$	LF	$<$ 1.2	$\times10^{-4}$	CL=90%	866
$\pi^-e^+e^+$	L	$<$ 1.1	$\times10^{-4}$	CL=90%	929
$\pi^-\mu^+\mu^+$	L	$<$ 8.7	$\times10^{-5}$	CL=90%	917
$\pi^-e^+\mu^+$	L	$<$ 1.1	$\times10^{-4}$	CL=90%	926
$\rho^-\mu^+\mu^+$	L	$<$ 5.6	$\times10^{-4}$	CL=90%	759
$K^-e^+e^+$	L	$<$ 1.2	$\times10^{-4}$	CL=90%	869
$K^-\mu^+\mu^+$	L	$<$ 1.2	$\times10^{-4}$	CL=90%	856
$K^-e^+\mu^+$	L	$<$ 1.3	$\times10^{-4}$	CL=90%	866
$K^*(892)^-\mu^+\mu^+$	L	$<$ 8.5	$\times10^{-4}$	CL=90%	703

D^0

$I(J^P) = \frac{1}{2}(0^-)$

Mass $m = 1864.6 \pm 0.5$ MeV (S = 1.1)
$m_{D^\pm} - m_{D^0} = 4.76 \pm 0.10$ MeV (S = 1.1)
Mean life $\tau = (0.415 \pm 0.004) \times 10^{-12}$ s
$c\tau = 124.4\ \mu$m
$|m_{D_1^0} - m_{D_2^0}| < 24 \times 10^{10}\ \hbar\ \mathrm{s}^{-1}$ CL = 90% [tt]
$|\Gamma_{D_1^0} - \Gamma_{D_2^0}|/\Gamma_{D^0} < 0.20$ CL = 90% [tt]
$\Gamma(K^+\ell^-\overline{\nu}_\ell$ (via $\overline{D}^0$))/$\Gamma(K^-\ell^+\nu_\ell) < 0.005$ CL = 90%
$\frac{\Gamma(K^-\pi^-\text{ or }K^-\pi^-\pi^+\pi^-(\text{via}\overline{D}^0))}{\Gamma(K^-\pi^-\text{ or }K^-\pi^-\pi^+\pi^-)} < 0.0085$ (or < 0.0037) CL = 90% [uu]

CP-violation decay-rate asymmetries

$A_{CP}(K^+K^-) = 0.026 \pm 0.035$
$A_{CP}(\pi^+\pi^-) = -0.05 \pm 0.08$
$A_{CP}(K^0_S\phi) = -0.03 \pm 0.09$
$A_{CP}(K^0_S\pi^0) = -0.018 \pm 0.030$

$\overline{D}^0$ modes are charge conjugates of the modes below.

D^0 DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Inclusive modes				
e^+ anything		(6.75 ±0.29) %		–
μ^+ anything		(6.6 ±0.8) %		–
K^- anything		(53 ±4) %	S=1.3	–
$\overline{K}^0$ anything + K^0 anything		(42 ±5) %		–
K^+ anything		(3.4 $^{+0.6}_{-0.4}$) %		–
η anything	[nn]	$<$ 13 %	CL=90%	–
Semileptonic modes				
$K^-\ell^+\nu_\ell$	[oo]	(3.50±0.17) %	S=1.3	867
$K^-e^+\nu_e$		(3.66±0.18) %		867
$K^-\mu^+\nu_\mu$		(3.23±0.17) %		863
$K^-\pi^0e^+\nu_e$		(1.6 $^{+1.3}_{-0.5}$) %		861
$\overline{K}^0\pi^-e^+\nu_e$		(2.8 $^{+1.7}_{-0.9}$) %		860
$\overline{K}^*(892)^-e^+\nu_e$ × B($K^{*-}\to\overline{K}^0\pi^-$)		(1.35±0.22) %		719
$K^*(892)^-\ell^+\nu_\ell$		—		–
$\overline{K}^*(892)^0\pi^-e^+\nu_e$		—		708
$K^-\pi^+\pi^-\mu^+\nu_\mu$		$<$ 1.2 $\times10^{-3}$	CL=90%	821
$(\overline{K}^*(892)\pi)^-\mu^+\nu_\mu$		$<$ 1.4 $\times10^{-3}$	CL=90%	693
$\pi^-e^+\nu_e$		(3.7 ±0.6) $\times10^{-3}$		927

A fraction of the following resonance mode has already appeared above as a submode of a charged-particle mode.

$K^*(892)^-e^+\nu_e$		(2.02±0.33) %		719
Hadronic modes with a $\overline{K}$ or $K\overline{K}$				
$K^-\pi^+$		(3.85±0.09) %		861
$\overline{K}^0\pi^0$		(2.12±0.21) %	S=1.1	860
$\overline{K}^0\pi^+\pi^-$	[qq]	(5.4 ±0.4) %	S=1.2	842
$\overline{K}^0\rho^0$		(1.21±0.17) %		676
$\overline{K}^0f_0(980)$ × B($f_0\to\pi^+\pi^-$)		(3.0 ±0.8) $\times10^{-3}$		549
$\overline{K}^0f_2(1270)$ × B($f_2\to\pi^+\pi^-$)		(2.4 ±0.9) $\times10^{-3}$		263
$\overline{K}^0f_0(1370)$ × B($f_0\to\pi^+\pi^-$)		(4.3 ±1.3) $\times10^{-3}$		–
$K^*(892)^-\pi^+$ × B($K^{*-}\to\overline{K}^0\pi^-$)		(3.4 ±0.3) %		711
$K_0^*(1430)^-\pi^+$ × B($K_0^*(1430)^-\to\overline{K}^0\pi^-$)		(6.4 ±1.6) $\times10^{-3}$		364
$\overline{K}^0\pi^+\pi^-$ nonresonant		(1.47±0.24) %		842
$K^-\pi^+\pi^0$	[qq]	(13.9 ±0.9) %	S=1.3	844
$K^-\rho^+$		(10.8 ±1.0) %		678
$K^*(892)^-\pi^+$ × B($K^{*-}\to K^-\pi^0$)		(1.7 ±0.2) %		711
$\overline{K}^*(892)^0\pi^0$ × B($\overline{K}^{*0}\to K^-\pi^+$)		(2.1 ±0.3) %		709
$K^-\pi^+\pi^0$ nonresonant		(6.9 ±2.5) $\times10^{-3}$		844
$\overline{K}^0\pi^0\pi^0$		—		843
$\overline{K}^*(892)^0\pi^0$ × B($\overline{K}^{*0}\to\overline{K}^0\pi^0$)		(1.1 ±0.2) %		709
$\overline{K}^0\pi^0\pi^0$ nonresonant		(7.9 ±2.1) $\times10^{-3}$		843
$K^-\pi^+\pi^+\pi^-$	[qq]	(7.6 ±0.4) %	S=1.1	812
$K^-\pi^+\rho^0$ total		(6.3 ±0.4) %		612
$K^-\pi^+\rho^0$ 3-body		(4.8 ±2.1) $\times10^{-3}$		612
$\overline{K}^*(892)^0\rho^0$ × B($\overline{K}^{*0}\to K^-\pi^+$)		(9.8 ±2.2) $\times10^{-3}$		418
$K^-a_1(1260)^+$ × B($a_1(1260)^+\to\pi^+\pi^+\pi^-$)		(3.6 ±0.6) %		327
$\overline{K}^*(892)^0\pi^+\pi^-$ total × B($\overline{K}^{*0}\to K^-\pi^+$)		(1.5 ±0.4) %		683
$\overline{K}^*(892)^0\pi^+\pi^-$ 3-body × B($\overline{K}^{*0}\to K^-\pi^+$)		(9.5 ±2.1) $\times10^{-3}$		683
$K_1(1270)^-\pi^+$ × B($K_1(1270)^-\to K^-\pi^+\pi^-$)	[rr]	(3.6 ±1.0) $\times10^{-3}$		483
$K^-\pi^+\pi^+\pi^-$ nonresonant		(1.76±0.25) %		812
$\overline{K}^0\pi^+\pi^-\pi^0$	[qq]	(10.0 ±1.2) %		812
$\overline{K}^0\eta$ × B($\eta\to\pi^+\pi^-\pi^0$)		(1.6 ±0.3) $\times10^{-3}$		772
$\overline{K}^0\omega$ × B($\omega\to\pi^+\pi^-\pi^0$)		(1.9 ±0.4) %		670
$K^*(892)^-\rho^+$ × B($K^{*-}\to\overline{K}^0\pi^-$)		(4.1 ±1.6) %		422
$\overline{K}^*(892)^0\rho^0$ × B($\overline{K}^{*0}\to\overline{K}^0\pi^0$)		(4.9 ±1.1) $\times10^{-3}$		418
$K_1(1270)^-\pi^+$ × B($K_1(1270)^-\to\overline{K}^0\pi^-\pi^0$)	[rr]	(5.1 ±1.4) $\times10^{-3}$		483
$\overline{K}^*(892)^0\pi^+\pi^-$ 3-body × B($\overline{K}^{*0}\to\overline{K}^0\pi^0$)		(4.8 ±1.1) $\times10^{-3}$		683
$\overline{K}^0\pi^+\pi^-\pi^0$ nonresonant		(2.1 ±2.1) %		812
$K^-\pi^+\pi^0\pi^0$		(15 ±5) %		815
$K^-\pi^+\pi^+\pi^-\pi^0$		(4.1 ±0.4) %		771
$\overline{K}^*(892)^0\pi^+\pi^-\pi^0$ × B($\overline{K}^{*0}\to K^-\pi^+$)		(1.2 ±0.6) %		641
$\overline{K}^*(892)^0\eta$ × B($\overline{K}^{*0}\to K^-\pi^+$) × B($\eta\to\pi^+\pi^-\pi^0$)		(2.9 ±0.8) $\times10^{-3}$		580
$K^-\pi^+\omega$ × B($\omega\to\pi^+\pi^-\pi^0$)		(2.7 ±0.5) %		605
$\overline{K}^*(892)^0\omega$ × B($\overline{K}^{*0}\to K^-\pi^+$) × B($\omega\to\pi^+\pi^-\pi^0$)		(7 ±3) $\times10^{-3}$		406
$\overline{K}^0\pi^+\pi^+\pi^-\pi^-$		(5.8 ±1.6) $\times10^{-3}$		768
$\overline{K}^0\pi^+\pi^-\pi^0\pi^0(\pi^0)$		(10.6 $^{+7.3}_{-3.0}$) %		771
$\overline{K}^0K^+K^-$		(9.4 ±1.0) $\times10^{-3}$		544
$\overline{K}^0\phi$ × B($\phi\to K^+K^-$)		(4.3 ±0.5) $\times10^{-3}$		520
$\overline{K}^0K^+K^-$ non-ϕ		(5.1 ±0.8) $\times10^{-3}$		544
$K^0_SK^0_SK^0_S$		(8.4 ±1.5) $\times10^{-4}$		538
$K^+K^-K^-\pi^+$		(2.1 ±0.5) $\times10^{-4}$		434
$K^+K^-\overline{K}^0\pi^0$		(7.2 $^{+4.8}_{-3.5}$) $\times10^{-3}$		435

Fractions of many of the following modes with resonances have already appeared above as submodes of particular charged-particle modes. (Modes for which there are only upper limits and $\overline{K}^*(892)\rho$ submodes only appear below.)

$\overline{K}^0\eta$		(7.1 ±1.0) $\times10^{-3}$		772
$\overline{K}^0\rho^0$		(1.21±0.17) %		676
$K^-\rho^+$		(10.8 ±1.0) %	S=1.2	678
$\overline{K}^0\omega$		(2.1 ±0.4) %		670
$\overline{K}^0\eta'(958)$		(1.72±0.26) %		565
$\overline{K}^0f_0(980)$		(5.7 ±1.6) $\times10^{-3}$		549
$\overline{K}^0\phi$		(8.6 ±1.0) $\times10^{-3}$		520
$K^-a_1(1260)^+$		(7.3 ±1.1) %		327
$\overline{K}^0a_1(1260)^0$		$<$ 1.9 %	CL=90%	322
$\overline{K}^0f_2(1270)$		(4.2 ±1.5) $\times10^{-3}$		263
$K^-a_2(1320)^+$		$<$ 2 $\times10^{-3}$	CL=90%	197
$\overline{K}^0f_0(1370)$		(7.0 ±2.1) $\times10^{-3}$		–
$K^*(892)^-\pi^+$		(5.1 ±0.4) %	S=1.2	711
$\overline{K}^*(892)^0\pi^0$		(3.2 ±0.4) %		709
$\overline{K}^*(892)^0\pi^+\pi^-$ total		(2.3 ±0.5) %		683
$\overline{K}^*(892)^0\pi^+\pi^-$ 3-body		(1.43±0.32) %		683

$K^-\pi^+\rho^0$ total	(6.3 ±0.4) %			612
$K^-\pi^+\rho^0$ 3-body	(4.8 ±2.1) $\times 10^{-3}$			612
$\overline{K}^*(892)^0\rho^0$	(1.47±0.33) %			418
$\overline{K}^*(892)^0\rho^0$ transverse	(1.5 ±0.5) %			418
$\overline{K}^*(892)^0\rho^0$ S-wave	(2.8 ±0.6) %			418
$\overline{K}^*(892)^0\rho^0$ S-wave long.	< 3	$\times 10^{-3}$	CL=90%	418
$\overline{K}^*(892)^0\rho^0$ P-wave	< 3	$\times 10^{-3}$	CL=90%	418
$\overline{K}^*(892)^0\rho^0$ D-wave	(1.9 ±0.6) %			418
$K^*(892)^-\rho^+$	(6.1 ±2.4) %			422
$K^*(892)^-\rho^+$ longitudinal	(2.9 ±1.2) %			422
$K^*(892)^-\rho^+$ transverse	(3.2 ±1.8) %			422
$K^*(892)^-\rho^+$ P-wave	< 1.5	%	CL=90%	422
$K^-\pi^+ f_0(980)$	< 1.1	%	CL=90%	459
$\overline{K}^*(892)^0 f_0(980)$	< 7	$\times 10^{-3}$	CL=90%	–
$K_1(1270)^-\pi^+$	[n] (1.06±0.29) %			483
$K_1(1400)^-\pi^+$	< 1.2	%	CL=90%	386
$\overline{K}_1(1400)^0\pi^0$	< 3.7	%	CL=90%	387
$K^*(1410)^-\pi^+$	< 1.2	%	CL=90%	378
$K_0^*(1430)^-\pi^+$	(1.04±0.26) %			364
$K_2^*(1430)^-\pi^+$	< 8	$\times 10^{-3}$	CL=90%	367
$\overline{K}_2^*(1430)^0\pi^0$	< 4	$\times 10^{-3}$	CL=90%	363
$\overline{K}^*(892)^0\pi^+\pi^-\pi^0$	(1.8 ±0.9) %			641
$\overline{K}^*(892)^0\eta$	(1.9 ±0.5) %			580
$K^-\pi^+\omega$	(3.0 ±0.6) %			605
$\overline{K}^*(892)^0\omega$	(1.1 ±0.5) %			406
$K^-\pi^+\eta'(958)$	(7.0 ±1.8) $\times 10^{-3}$			479
$\overline{K}^*(892)^0\eta'(958)$	< 1.1	$\times 10^{-3}$	CL=90%	99

Pionic modes

$\pi^+\pi^-$	(1.53±0.09) $\times 10^{-3}$			922
$\pi^0\pi^0$	(8.5 ±2.2) $\times 10^{-4}$			922
$\pi^+\pi^-\pi^0$	(1.6 ±1.1) %		S=2.7	907
$\pi^+\pi^+\pi^-\pi^-$	(7.4 ±0.6) $\times 10^{-3}$			879
$\pi^+\pi^+\pi^-\pi^-\pi^0$	(1.9 ±0.4) %			844
$\pi^+\pi^+\pi^+\pi^-\pi^-\pi^-$	(4.0 ±3.0) $\times 10^{-4}$			795

Hadronic modes with a $K\overline{K}$ pair

K^+K^-	(4.27±0.16) $\times 10^{-3}$			791
$K^0\overline{K}^0$	(6.5 ±1.8) $\times 10^{-4}$		S=1.2	788
$K^0K^-\pi^+$	(6.4 ±1.0) $\times 10^{-3}$		S=1.1	739
$\overline{K}^*(892)^0K^0$ $\times$ B($\overline{K}^{*0}\to K^-\pi^+$)	< 1.1	$\times 10^{-3}$	CL=90%	605
$K^*(892)^+K^-$ $\times$ B($K^{*+}\to K^0\pi^+$)	(2.3 ±0.5) $\times 10^{-3}$			610
$K^0K^-\pi^+$ nonresonant	(2.3 ±2.3) $\times 10^{-3}$			739
$\overline{K}^0K^+\pi^-$	(5.0 ±1.0) $\times 10^{-3}$			739
$K^*(892)^0\overline{K}^0$ $\times$ B($K^{*0}\to K^+\pi^-$)	< 5	$\times 10^{-4}$	CL=90%	605
$K^*(892)^-K^+$ $\times$ B($K^{*-}\to \overline{K}^0\pi^-$)	(1.2 ±0.7) $\times 10^{-3}$			610
$\overline{K}^0K^+\pi^-$ nonresonant	(3.9 $^{+2.3}_{-1.9}$) $\times 10^{-3}$			739
$K^+K^-\pi^0$	(1.3 ±0.4) $\times 10^{-3}$			742
$K_S^0K_S^0\pi^0$	< 5.9	$\times 10^{-4}$		739
$K^+K^-\pi^+\pi^-$	[w] (2.52±0.24) $\times 10^{-3}$			676
$\phi\pi^+\pi^-\times$ B($\phi\to K^+K^-$)	(5.3 ±1.4) $\times 10^{-4}$			614
$\phi\rho^0\times$ B($\phi\to K^+K^-$)	(3.0 ±1.6) $\times 10^{-4}$			260
$K^+K^-\rho^0$ 3-body	(9.1 ±2.3) $\times 10^{-4}$			309
$K^*(892)^0K^-\pi^+$+c.c. $\times$ B($K^{*0}\to K^+\pi^-$)	[ww] < 5	$\times 10^{-4}$		528
$K^*(892)^0\overline{K}^*(892)^0$ $\times$ B^2($K^{*0}\to K^+\pi^-$)	(6 ±2) $\times 10^{-4}$			257
$K^+K^-\pi^+\pi^-$ non-ϕ	—			676
$K^+K^-\pi^+\pi^-$ nonresonant	< 8	$\times 10^{-4}$	CL=90%	676
$K^0\overline{K}^0\pi^+\pi^-$	(6.9 ±2.7) $\times 10^{-3}$			673
$K^+K^-\pi^+\pi^-\pi^0$	(3.1 ±2.0) $\times 10^{-3}$			600

Fractions of most of the following modes with resonances have already appeared above as submodes of particular charged-particle modes.

$\overline{K}^*(892)^0K^0$	< 1.6	$\times 10^{-3}$	CL=90%	605
$K^*(892)^+K^-$	(3.5 ±0.8) $\times 10^{-3}$			610
$K^*(892)^0\overline{K}^0$	< 8	$\times 10^{-4}$	CL=90%	605
$K^*(892)^-K^+$	(1.8 ±1.0) $\times 10^{-3}$			610
$\phi\pi^0$	< 1.4	$\times 10^{-3}$	CL=90%	644
$\phi\eta$	< 2.8	$\times 10^{-3}$	CL=90%	489
$\phi\omega$	< 2.1	$\times 10^{-3}$	CL=90%	239
$\phi\pi^+\pi^-$	(1.08±0.29) $\times 10^{-3}$			614
$\phi\rho^0$	(6 ±3) $\times 10^{-4}$			260
$\phi\pi^+\pi^-$ 3-body	(7 ±5) $\times 10^{-4}$			614
$K^*(892)^0K^-\pi^+$ + c.c.	[ww] < 8	$\times 10^{-4}$	CL=90%	–
$K^*(892)^0\overline{K}^*(892)^0$	(1.4 ±0.5) $\times 10^{-3}$			257

Doubly Cabibbo suppressed (DC) modes
$\Delta C = 2$ forbidden via mixing ($C2M$) modes
$\Delta C = 1$ weak neutral current ($C1$) modes or Lepton Family number (LF) violating modes

$K^+\ell^-\overline{\nu}_\ell$(via $\overline{D}^0$)	$C2M$	< 1.7	$\times 10^{-4}$	CL=90%	–
$K^+\pi^-$ or $K^+\pi^-\pi^+\pi^-$(via $\overline{D}^0$)	$C2M$	< 1.0	$\times 10^{-3}$	CL=90%	–
$K^+\pi^-$	DC	(2.8 ±0.9) $\times 10^{-4}$			861
$K^+\pi^-$(via $\overline{D}^0$)		< 1.9	$\times 10^{-4}$	CL=90%	861
$K^+\pi^-\pi^+\pi^-$	DC	(1.9 ±2.7) $\times 10^{-4}$			812
$K^+\pi^-\pi^+\pi^-$(via $\overline{D}^0$)		< 4	$\times 10^{-4}$	CL=90%	812
μ^- anything (via $\overline{D}^0$)		< 4	$\times 10^{-4}$	CL=90%	–
e^+e^-	$C1$	< 1.3	$\times 10^{-5}$	CL=90%	932
$\mu^+\mu^-$	$C1$	< 4.1	$\times 10^{-6}$	CL=90%	926
$\pi^0e^+e^-$	$C1$	< 4.5	$\times 10^{-5}$	CL=90%	927
$\pi^0\mu^+\mu^-$	$C1$	< 1.8	$\times 10^{-4}$	CL=90%	915
ηe^+e^-	$C1$	< 1.1	$\times 10^{-4}$	CL=90%	852
$\eta\mu^+\mu^-$	$C1$	< 5.3	$\times 10^{-4}$	CL=90%	838
$\rho^0e^+e^-$	$C1$	< 1.0	$\times 10^{-4}$	CL=90%	773
$\rho^0\mu^+\mu^-$	$C1$	< 2.3	$\times 10^{-4}$	CL=90%	756
ωe^+e^-	$C1$	< 1.8	$\times 10^{-4}$	CL=90%	768
$\omega\mu^+\mu^-$	$C1$	< 8.3	$\times 10^{-4}$	CL=90%	751
ϕe^+e^-	$C1$	< 5.2	$\times 10^{-5}$	CL=90%	654
$\phi\mu^+\mu^-$	$C1$	< 4.1	$\times 10^{-4}$	CL=90%	631
$\overline{K}^0e^+e^-$		[ss] < 1.1	$\times 10^{-4}$	CL=90%	866
$\overline{K}^0\mu^+\mu^-$		[ss] < 2.6	$\times 10^{-4}$	CL=90%	852
$\overline{K}^*(892)^0e^+e^-$		[ss] < 1.4	$\times 10^{-4}$	CL=90%	717
$\overline{K}^*(892)^0\mu^+\mu^-$		[ss] < 1.18	$\times 10^{-3}$	CL=90%	698
$\pi^+\pi^-\pi^0\mu^+\mu^-$	$C1$	< 8.1	$\times 10^{-4}$	CL=90%	863
$\mu^\pm e^\mp$	LF	[gg] < 1.9	$\times 10^{-5}$	CL=90%	929
$\pi^0e^\pm\mu^\mp$	LF	[gg] < 8.6	$\times 10^{-5}$	CL=90%	924
$\eta e^\pm\mu^\mp$	LF	[gg] < 1.0	$\times 10^{-4}$	CL=90%	848
$\rho^0e^\pm\mu^\mp$	LF	[gg] < 4.9	$\times 10^{-5}$	CL=90%	769
$\omega e^\pm\mu^\mp$	LF	[gg] < 1.2	$\times 10^{-4}$	CL=90%	764
$\phi e^\pm\mu^\mp$	LF	[gg] < 3.4	$\times 10^{-5}$	CL=90%	648
$\overline{K}^0e^\pm\mu^\mp$	LF	[gg] < 1.0	$\times 10^{-4}$	CL=90%	862
$\overline{K}^*(892)^0e^\pm\mu^\mp$	LF	[gg] < 1.0	$\times 10^{-4}$	CL=90%	712

$D^*(2007)^0$

$I(J^P) = \frac{1}{2}(1^-)$
I, J, P need confirmation.

Mass $m = 2006.7 \pm 0.5$ MeV (S = 1.1)
$m_{D^{*0}} - m_{D^0} = 142.12 \pm 0.07$ MeV
Full width Γ < 2.1 MeV, CL = 90%

$\overline{D}^*(2007)^0$ modes are charge conjugates of modes below.

$D^*(2007)^0$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$D^0\pi^0$	(61.9±2.9) %	43
$D^0\gamma$	(38.1±2.9) %	137

$D^*(2010)^\pm$

$I(J^P) = \frac{1}{2}(1^-)$
I, J, P need confirmation.

Mass $m = 2010.0 \pm 0.5$ MeV (S = 1.1)
$m_{D^*(2010)^-} - m_{D^-} = 140.64 \pm 0.10$ MeV (S = 1.1)
$m_{D^*(2010)^-} - m_{D^0} = 145.397 \pm 0.030$ MeV
Full width Γ < 0.131 MeV, CL = 90%

$D^*(2010)^-$ modes are charge conjugates of the modes below.

$D^*(2010)^\pm$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$D^0\pi^+$	(68.3±1.4) %	39
$D^+\pi^0$	(30.6±2.5) %	38
$D^+\gamma$	(1.1$^{+2.1}_{-0.7}$) %	136

$D_1(2420)^0$

$I(J^P) = \frac{1}{2}(1^+)$
I, J, P need confirmation.

Mass $m = 2422.2 \pm 1.8$ MeV (S = 1.2)
Full width $\Gamma = 18.9^{+4.6}_{-3.5}$ MeV

$\overline{D}_1(2420)^0$ modes are charge conjugates of modes below.

$D_1(2420)^0$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$D^*(2010)^+\pi^-$	seen	355
$D^+\pi^-$	not seen	474

$D_2^*(2460)^0$

$I(J^P) = \frac{1}{2}(2^+)$

$J^P = 2^+$ assignment strongly favored (ALBRECHT 89B).

Mass $m = 2458.9 \pm 2.0$ MeV (S = 1.2)
Full width $\Gamma = 23 \pm 5$ MeV

$\overline{D}_2^*(2460)^0$ modes are charge conjugates of modes below.

$D_2^*(2460)^0$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$D^+\pi^-$	seen	503
$D^*(2010)^+\pi^-$	seen	387

$D_2^*(2460)^\pm$

$I(J^P) = \frac{1}{2}(2^+)$

$J^P = 2^+$ assignment strongly favored (ALBRECHT 89B).

Mass $m - 2459 \pm 4$ MeV (S − 1.7)
$m_{D_2^*(2460)^\pm} - m_{D_2^*(2460)^0} = 0.9 \pm 3.3$ MeV (S = 1.1)
Full width $\Gamma = 25^{+8}_{-7}$ MeV

$D_2^*(2460)^-$ modes are charge conjugates of modes below.

$D_2^*(2460)^\pm$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$D^0\pi^+$	seen	508
$D^{*0}\pi^+$	seen	390

CHARMED, STRANGE MESONS ($C = S = \pm 1$)

$D_s^+ = c\bar{s}$, $D_s^- = \bar{c}s$ similarly for D_s^{*}'s

$D_s^\pm$ was $F^\pm$

$I(J^P) = 0(0^-)$

Mass $m = 1968.5 \pm 0.6$ MeV (S = 1.1)
$m_{D_s^\pm} - m_{D^\pm} = 99.2 \pm 0.5$ MeV (S = 1.1)
Mean life $\tau = (0.467 \pm 0.017) \times 10^{-12}$ s
$c\tau = 140\ \mu$m

D_s^+ form factors

$r_2 = 1.6 \pm 0.4$
$r_V = 1.5 \pm 0.5$
$\Gamma_L/\Gamma_T = 0.72 \pm 0.18$

Branching fractions for modes with a resonance in the final state include all the decay modes of the resonance. D_s^- modes are charge conjugates of the modes below.

D_s^+ DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Inclusive modes				
K^- anything		(13 $^{+14}_{-12}$) %		–
$\overline{K}^0$ anything + K^0 anything		(39 ±28) %		–
K^+ anything		(20 $^{+18}_{-14}$) %		–
non-$K\overline{K}$ anything		(64 ±17) %		–
e^+ anything		(8 $^{+\ 6}_{-\ 5}$) %		–
ϕ anything		(18 $^{+15}_{-10}$) %		–
Leptonic and semileptonic modes				
$\mu^+\nu_\mu$		(4.0 $\pm$ 2.2 / 2.0) $\times 10^{-3}$	S=1.4	981
$\tau^+\nu_\tau$		(7 ± 4) %		182
$\phi\ell^+\nu_\ell$	[xx]	(2.0 ± 0.5) %		–
$\eta\ell^+\nu_\ell$ + $\eta'(958)\ell^+\nu_\ell$	[xx]	(3.4 ± 1.0) %		–
$\eta\ell^+\nu_\ell$		(2.5 ± 0.7) %		–
$\eta'(958)\ell^+\nu_\ell$		(8.8 ± 3.4) $\times 10^{-3}$		–
Hadronic modes with a $K\overline{K}$ pair (including from a ϕ)				
$K^+\overline{K}^0$		(3.6 ± 1.1) %		850
$K^+K^-\pi^+$	[qq]	(4.4 ± 1.2) %	S=1.1	805
$\phi\pi^+$	[yy]	(3.6 ± 0.9) %		712
$K^+\overline{K}^*(892)^0$	[yy]	(3.3 ± 0.9) %		682
$f_0(980)\pi^+$	[yy]	(1.8 ± 0.8) %	S=1.3	732
$K^+\overline{K}_0^*(1430)^0$	[yy]	(7 ± 4) $\times 10^{-3}$		186
$f_J(1710)\pi^+ \to K^+K^-\pi^+$	[zz]	(1.5 ± 1.9) $\times 10^{-3}$		204
$K^+K^-\pi^+$ nonresonant		(9 ± 4) $\times 10^{-3}$		805
$K^0\overline{K}^0\pi^+$		—		802
$K^*(892)^+\overline{K}^0$	[yy]	(4.3 ± 1.4) %		683
$K^+K^-\pi^+\pi^0$		—		748
$\phi\pi^+\pi^0$	[yy]	(9 ± 5) %		687
$\phi\rho^+$	[yy]	(6.7 ± 2.3) %		407
$\phi\pi^+\pi^0$ 3-body	[yy]	< 2.6 %	CL=90%	687
$K^+K^-\pi^+\pi^0$ non-ϕ		< 9 %	CL=90%	748
$K^+\overline{K}^0\pi^+\pi^-$		< 2.8 %	CL=90%	744
$K^0K^-\pi^+\pi^+$		(4.3 ± 1.5) %		744
$K^*(892)^+\overline{K}^*(892)^0$	[yy]	(5.8 ± 2.5) %		412
$K^0K^-\pi^+\pi^+$ non-$K^{*+}\overline{K}^{*0}$		< 2.9 %	CL=90%	744
$K^+K^-\pi^+\pi^+\pi^-$		(8.3 ± 3.3) $\times 10^{-3}$		673
$\phi\pi^+\pi^+\pi^-$	[yy]	(1.18± 0.35) %		640
$K^+K^-\pi^+\pi^+\pi^-$ non-ϕ		(3.0 $\pm$ 3.0 / 2.0) $\times 10^{-3}$		673
Hadronic modes without K's				
$\pi^+\pi^+\pi^-$		(1.0 ± 0.4) %	S=1.2	959
$\rho^0\pi^+$		< 8 $\times 10^{-4}$	CL=90%	827
$f_0(980)\pi^+$	[yy]	(1.8 ± 0.8) %	S=1.7	732
$f_2(1270)\pi^+$	[yy]	(2.3 ± 1.3) $\times 10^{-3}$		559
$f_0(1500)\pi^+ \to \pi^+\pi^-\pi^+$	[aaa]	(2.8 ± 1.6) $\times 10^{-3}$		391
$\pi^+\pi^+\pi^-$ nonresonant		< 2.8 $\times 10^{-3}$	CL=90%	959
$\pi^+\pi^+\pi^-\pi^0$		< 12 %	CL=90%	935
$\eta\pi^+$	[yy]	(2.0 ± 0.6) %		902

$\omega\pi^+$		[yy]	$(3.1 \pm 1.4) \times 10^{-3}$		822
$\pi^+\pi^+\pi^+\pi^-\pi^-$			$(6.9 \pm 3.0) \times 10^{-3}$		899
$\pi^+\pi^+\pi^-\pi^0\pi^0$			—		902
$\eta\rho^+$		[yy]	(10.3 ± 3.2) %		727
$\eta\pi^+\pi^0$ 3-body		[yy]	< 3.0 %	CL=90%	886
$\pi^+\pi^+\pi^+\pi^-\pi^-\pi^0$			(4.9 ± 3.2) %		856
$\eta'(958)\pi^+$		[yy]	(4.9 ± 1.8) %		743
$\pi^+\pi^+\pi^+\pi^-\pi^-\pi^0\pi^0$			—		803
$\eta'(958)\rho^+$		[yy]	(12 ± 4) %		470
$\eta'(958)\pi^+\pi^0$ 3-body		[yy]	< 3.1 %	CL=90%	720
Modes with one or three K's					
$K^0\pi^+$			$< 8 \times 10^{-3}$	CL=90%	916
$K^+\pi^+\pi^-$			(1.0 ± 0.4) %		900
$K^+\rho^0$			$< 2.9 \times 10^{-3}$	CL=90%	747
$K^*(892)^0\pi^+$		[yy]	$(6.5 \pm 2.8) \times 10^{-3}$		773
$K^+K^+K^-$			$< 6 \times 10^{-4}$	CL=90%	628
ϕK^+		[yy]	$< 5 \times 10^{-4}$	CL=90%	607
$\Delta C = 1$ weak neutral current ($C1$) modes or Lepton number (L) violating modes					
$\pi^+\mu^+\mu^-$		[ss]	$< 4.3 \times 10^{-4}$	CL=90%	968
$K^+\mu^+\mu^-$	$C1$		$< 5.9 \times 10^{-4}$	CL=90%	909
$K^*(892)^+\mu^+\mu^-$	$C1$		$< 1.4 \times 10^{-3}$	CL=90%	765
$\pi^-\mu^+\mu^+$	L		$< 4.3 \times 10^{-4}$	CL=90%	968
$K^-\mu^+\mu^+$	L		$< 5.9 \times 10^{-4}$	CL=90%	909
$K^*(892)^-\mu^+\mu^+$	L		$< 1.4 \times 10^{-3}$	CL=90%	765

$D_s^{*\pm}$ $I(J^P) = 0(?^?)$

J^P is natural, width and decay modes consistent with 1^-.

Mass $m = 2112.4 \pm 0.7$ MeV (S = 1.1)

$m_{D_s^{*\pm}} - m_{D_s^{\pm}} = 143.8 \pm 0.4$ MeV

Full width $\Gamma < 1.9$ MeV, CL = 90%

D_s^{*-} modes are charge conjugates of the modes below.

D_s^{*+} DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$D_s^+\gamma$	(94.2±2.5) %	139
$D_s^+\pi^0$	(5.8±2.5) %	48

$D_{s1}(2536)^{\pm}$ $I(J^P) = 0(1^+)$

J, P need confirmation.

Mass $m = 2535.35 \pm 0.34 \pm 0.5$ MeV

Full width $\Gamma < 2.3$ MeV, CL = 90%

$D_{s1}(2536)^-$ modes are charge conjugates of the modes below.

$D_{s1}(2536)^+$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$D^*(2010)^+K^0$	seen	150
$D^*(2007)^0K^+$	seen	169
D^+K^0	not seen	382
D^0K^+	not seen	392
$D_s^{*+}\gamma$	possibly seen	389

$D_{sJ}(2573)^{\pm}$ $I(J^P) = 0(?^?)$

J^P is natural, width and decay modes consistent with 2^+.

Mass $m = 2573.5 \pm 1.7$ MeV

Full width $\Gamma = 15^{+5}_{-4}$ MeV

$D_{sJ}(2573)^-$ modes are charge conjugates of the modes below.

$D_{sJ}(2573)^+$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
D^0K^+	seen	436
$D^*(2007)^0K^+$	not seen	245

BOTTOM MESONS ($B = \pm 1$)

$B^+ = u\bar{b}$, $B^0 = d\bar{b}$, $\overline{B}^0 = \bar{d}b$, $B^- = \bar{u}b$, similarly for B^*'s

B-particle organization

Many measurements of B decays involve admixtures of B hadrons. Previously we arbitrarily included such admixtures in the $B^{\pm}$ section, but because of their importance we have created two new sections: "$B^{\pm}/B^0$ Admixture" for $\Upsilon(4S)$ results and "$B^{\pm}/B^0/B_s^0$/b-baryon Admixture" for results at higher energies. Most inclusive decay branching fractions are found in the Admixture sections. B^0-$\overline{B}^0$ mixing data are found in the B^0 section, while B_s^0-$\overline{B}_s^0$ mixing data and B-$\overline{B}$ mixing data for a B^0/B_s^0 admixture are found in the B_s^0 section. CP-violation data are found in the B^0 section. b-baryons are found near the end of the Baryon section.

The organization of the B sections is now as follows, where bullets indicate particle sections and brackets indicate reviews.

[Production and Decay of b-flavored Hadrons]

[Semileptonic Decays of B Mesons]

- $B^{\pm}$
  - mass, mean life
  - branching fractions
- B^0
  - mass, mean life
  - branching fractions
  - polarization in B^0 decay
  - B^0-$\overline{B}^0$ mixing
  - [B^0-$\overline{B}^0$ Mixing and CP Violation in B Decay]
  - CP violation
- $B^{\pm}$ B^0 Admixtures
  - branching fractions
- $B^{\pm}/B^0/B_s^0$/b-baryon Admixtures
  - mean life
  - production fractions
  - branching fractions
- B^*
  - mass
- B_s^0
  - mass, mean life
  - branching fractions
  - polarization in B_s^0 decay
  - B_s^0-$\overline{B}_s^0$ mixing
  - B-$\overline{B}$ mixing (admixture of B^0, B_s^0)

At end of Baryon Listings:

- Λ_b
  - mass, mean life
  - branching fractions
- b-baryon Admixture
  - mean life
  - branching fractions

$B^\pm$ $I(J^P) = \frac{1}{2}(0^-)$

I, *J*, *P* need confirmation. Quantum numbers shown are quark-model predictions.

Mass $m_{B^\pm} = 5278.9 \pm 1.8$ MeV
Mean life $\tau_{B^\pm} = (1.65 \pm 0.04) \times 10^{-12}$ s
$c\tau = 495\ \mu$m

B^- modes are charge conjugates of the modes below. Modes which do not identify the charge state of the B are listed in the $B^\pm/B^0$ ADMIXTURE section.

The branching fractions listed below assume 50% $B^0\overline{B}{}^0$ and 50% B^+B^- production at the $\Upsilon(4S)$. We have attempted to bring older measurements up to date by rescaling their assumed $\Upsilon(4S)$ production ratio to 50:50 and their assumed D, D_s, D^*, and ψ branching ratios to current values whenever this would affect our averages and best limits significantly.

Indentation is used to indicate a subchannel of a previous reaction. All resonant subchannels have been corrected for resonance branching fractions to the final state so the sum of the subchannel branching fractions can exceed that of the final state.

B^+ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Semileptonic and leptonic modes			
$\ell^+\nu_\ell$ anything	[pp] (10.3 ±0.9) %		–
$\overline{D}{}^0\ell^+\nu_\ell$	[pp] (1.86±0.33) %		–
$\overline{D}{}^*(2007)^0\ell^+\nu_\ell$	[pp] (5.3 ±0.8) %		–
$\pi^0 e^+\nu_e$	< 2.2	$\times 10^{-3}$ CL=90%	2638
$\omega\ell^+\nu_\ell$	[pp] < 2.1	$\times 10^{-4}$ CL=90%	–
$\rho^0\ell^+\nu_\ell$	[pp] < 2.1	$\times 10^{-4}$ CL=90%	–
$e^+\nu_e$	< 1.5	$\times 10^{-5}$ CL=90%	2639
$\mu^+\nu_\mu$	< 2.1	$\times 10^{-5}$ CL=90%	2638
$\tau^+\nu_\tau$	< 5.7	$\times 10^{-4}$ CL=90%	2340
$e^+\nu_e\gamma$	< 2.0	$\times 10^{-4}$ CL=90%	–
$\mu^+\nu_\mu\gamma$	< 5.2	$\times 10^{-5}$ CL=90%	–
$D\overline{D}{}^*\Gamma$ or D_s modes			
$\overline{D}{}^0\pi^+$	(5.3 ±0.5)	$\times 10^{-3}$	2308
$\overline{D}{}^0\rho^+$	(1.34±0.18) %		2238
$\overline{D}{}^0\pi^+\pi^+\pi^-$	(1.1 ±0.4) %		2289
$\overline{D}{}^0\pi^+\pi^+\pi^-$ nonresonant	(5 ±4)	$\times 10^{-3}$	2289
$\overline{D}{}^0\pi^+\rho^0$	(4.2 ±3.0)	$\times 10^{-3}$	2209
$\overline{D}{}^0 a_1(1260)^+$	(5 ±4)	$\times 10^{-3}$	2123
$D^*(2010)^-\pi^+\pi^+$	(2.1 ±0.6)	$\times 10^{-3}$	2247
$D^-\pi^+\pi^+$	< 1.4	$\times 10^{-3}$ CL=90%	2299
$\overline{D}{}^*(2007)^0\pi^+$	(4.6 ±0.4)	$\times 10^{-3}$	2256
$D^*(2010)^+\pi^0$	< 1.7	$\times 10^{-4}$ CL=90%	2254
$\overline{D}{}^*(2007)^0\rho^+$	(1.55±0.31) %		2183
$\overline{D}{}^*(2007)^0\pi^+\pi^+\pi^-$	(9.4 ±2.6)	$\times 10^{-3}$	2236
$\overline{D}{}^*(2007)^0 a_1(1260)^+$	(1.9 ±0.5) %		2062
$D^*(2010)^-\pi^+\pi^+\pi^0$	(1.5 ±0.7) %		2235
$D^*(2010)^-\pi^+\pi^+\pi^+\pi^-$	< 1 %	CL=90%	2217
$\overline{D}{}_1^*(2420)^0\pi^+$	(1.5 ±0.6)	$\times 10^{-3}$ S=1.3	2081
$\overline{D}{}_1^*(2420)^0\rho^+$	< 1.4	$\times 10^{-3}$ CL=90%	1997
$\overline{D}{}_2^*(2460)^0\pi^+$	< 1.3	$\times 10^{-3}$ CL=90%	2064
$\overline{D}{}_2^*(2460)^0\rho^+$	< 4.7	$\times 10^{-3}$ CL=90%	1979
$\overline{D}{}^0 D_s^+$	(1.3 ±0.4) %		1815
$\overline{D}{}^0 D_s^{*+}$	(9 ±4)	$\times 10^{-3}$	1734
$\overline{D}{}^*(2007)^0 D_s^+$	(1.2 ±0.5) %		1737
$\overline{D}{}^*(2007)^0 D_s^{*+}$	(2.7 ±1.0) %		1650
$D_s^+\pi^0$	< 2.0	$\times 10^{-4}$ CL=90%	2270
$D_s^{*+}\pi^0$	< 3.3	$\times 10^{-4}$ CL=90%	2214
$D_s^+\eta$	< 5	$\times 10^{-4}$ CL=90%	2235
$D_s^{*+}\eta$	< 8	$\times 10^{-4}$ CL=90%	2177
$D_s^+\rho^0$	< 4	$\times 10^{-4}$ CL=90%	2198
$D_s^{*+}\rho^0$	< 5	$\times 10^{-4}$ CL=90%	2139
$D_s^+\omega$	< 5	$\times 10^{-4}$ CL=90%	2195
$D_s^{*+}\omega$	< 7	$\times 10^{-4}$ CL=90%	2136
$D_s^+ a_1(1260)^0$	< 2.2	$\times 10^{-3}$ CL=90%	2079
$D_s^{*+} a_1(1260)^0$	< 1.6	$\times 10^{-3}$ CL=90%	2014
$D_s^+\phi$	< 3.2	$\times 10^{-4}$ CL=90%	2141
$D_s^{*+}\phi$	< 4	$\times 10^{-4}$ CL=90%	2079
$D_s^+\overline{K}{}^0$	< 1.1	$\times 10^{-3}$ CL=90%	2241
$D_s^{*+}\overline{K}{}^0$	< 1.1	$\times 10^{-3}$ CL=90%	2184
$D_s^+\overline{K}{}^*(892)^0$	< 5	$\times 10^{-4}$ CL=90%	2171
$D_s^{*+}\overline{K}{}^*(892)^0$	< 4	$\times 10^{-4}$ CL=90%	2110
$D_s^-\pi^+K^+$	< 8	$\times 10^{-4}$ CL=90%	2222
$D_s^{*-}\pi^+K^+$	< 1.2	$\times 10^{-3}$ CL=90%	2164
$D_s^-\pi^+K^*(892)^+$	< 6	$\times 10^{-3}$ CL=90%	2137
$D_s^{*-}\pi^+K^*(892)^+$	< 8	$\times 10^{-3}$ CL=90%	2075
Charmonium modes			
$J/\psi(1S)K^+$	(9.9 ±1.0)	$\times 10^{-4}$	1683
$J/\psi(1S)K^+\pi^+\pi^-$	(1.4 ±0.6)	$\times 10^{-3}$	1612
$J/\psi(1S)K^*(892)^+$	(1.47±0.27)	$\times 10^{-3}$	1571
$J/\psi(1S)\pi^+$	(5.0 ±1.5)	$\times 10^{-5}$	1727
$J/\psi(1S)\rho^+$	< 7.7	$\times 10^{-4}$ CL=90%	1613
$J/\psi(1S)a_1(1260)^+$	< 1.2	$\times 10^{-3}$ CL=90%	1414
$\psi(2S)K^+$	(6.9 ±3.1)	$\times 10^{-4}$ S=1.3	1284
$\psi(2S)K^*(892)^+$	< 3.0	$\times 10^{-3}$ CL=90%	1115
$\psi(2S)K^+\pi^+\pi^-$	(1.9 ±1.2)	$\times 10^{-3}$	909
$\chi_{c1}(1P)K^+$	(1.0 ±0.4)	$\times 10^{-3}$	1411
$\chi_{c1}(1P)K^*(892)^+$	< 2.1	$\times 10^{-3}$ CL=90%	1265
K or K^* modes			
$K^0\pi^+$	(2.3 ±1.1)	$\times 10^{-5}$	2614
$K^+\pi^0$	< 1.6	$\times 10^{-5}$ CL=90%	2615
$\eta' K^+$	(6.5 ±1.7)	$\times 10^{-5}$	2528
$\eta' K^*(892)^+$	< 1.3	$\times 10^{-4}$ CL=90%	2472
ηK^+	< 1.4	$\times 10^{-5}$ CL=90%	2587
$\eta K^*(892)^+$	< 3.0	$\times 10^{-5}$ CL=90%	2534
$K^*(892)^0\pi^+$	< 4.1	$\times 10^{-5}$ CL=90%	2561
$K^*(892)^+\pi^0$	< 9.9	$\times 10^{-5}$ CL=90%	2562
$K^+\pi^-\pi^+$ nonresonant	< 2.8	$\times 10^{-5}$ CL=90%	2609
$K^-\pi^+\pi^+$ nonresonant	< 5.6	$\times 10^{-5}$ CL=90%	–
$K_1(1400)^0\pi^+$	< 2.6	$\times 10^{-3}$ CL=90%	2451
$K_2^*(1430)^0\pi^+$	< 6.8	$\times 10^{-4}$ CL=90%	2443
$K^+\rho^0$	< 1.9	$\times 10^{-5}$ CL=90%	2559
$K^0\rho^+$	< 4.8	$\times 10^{-5}$ CL=90%	2559
$K^*(892)^+\pi^+\pi^-$	< 1.1	$\times 10^{-3}$ CL=90%	2556
$K^*(892)^+\rho^0$	< 9.0	$\times 10^{-4}$ CL=90%	2505
$K_1(1400)^+\rho^0$	< 7.8	$\times 10^{-4}$ CL=90%	2389
$K_2^*(1430)^+\rho^0$	< 1.5	$\times 10^{-3}$ CL=90%	2382
$K^+\overline{K}{}^0$	< 2.1	$\times 10^{-5}$ CL=90%	2592
$K^+K^-\pi^+$ nonresonant	< 7.5	$\times 10^{-5}$ CL=90%	–
$K^+K^-K^+$	< 2.0	$\times 10^{-4}$ CL=90%	2522
$K^+\phi$	< 1.2	$\times 10^{-5}$ CL=90%	2516
$K^+K^-K^+$ nonresonant	< 3.8	$\times 10^{-5}$ CL=90%	2516
$K^*(892)^+K^+K^-$	< 1.6	$\times 10^{-3}$ CL=90%	2466
$K^*(892)^+\phi$	< 7.0	$\times 10^{-5}$ CL=90%	2460
$K_1(1400)^+\phi$	< 1.1	$\times 10^{-3}$ CL=90%	2339
$K_2^*(1430)^+\phi$	< 3.4	$\times 10^{-3}$ CL=90%	2332
$K^+ f_0(980)$	< 8	$\times 10^{-5}$ CL=90%	2524
$K^*(892)^+\gamma$	(5.7 ±3.3)	$\times 10^{-5}$	2564
$K_1(1270)^+\gamma$	< 7.3	$\times 10^{-3}$ CL=90%	2486
$K_1(1400)^+\gamma$	< 2.2	$\times 10^{-3}$ CL=90%	2453
$K_2^*(1430)^+\gamma$	< 1.4	$\times 10^{-3}$ CL=90%	2447
$K^*(1680)^+\gamma$	< 1.9	$\times 10^{-3}$ CL=90%	2361
$K_3^*(1780)^+\gamma$	< 5.5	$\times 10^{-3}$ CL=90%	2343
$K_4^*(2045)^+\gamma$	< 9.9	$\times 10^{-3}$ CL=90%	2243
Light unflavored meson modes			
$\pi^+\pi^0$	< 2.0	$\times 10^{-5}$ CL=90%	2636
$\pi^+\pi^+\pi^-$	< 1.3	$\times 10^{-4}$ CL=90%	2630
$\rho^0\pi^+$	< 4.3	$\times 10^{-5}$ CL=90%	2582
$\pi^+ f_0(980)$	< 1.4	$\times 10^{-4}$ CL=90%	2547
$\pi^+ f_2(1270)$	< 2.4	$\times 10^{-4}$ CL=90%	2483
$\pi^+\pi^-\pi^+$ nonresonant	< 4.1	$\times 10^{-5}$ CL=90%	–
$\pi^+\pi^0\pi^0$	< 8.9	$\times 10^{-4}$ CL=90%	2631
$\rho^+\pi^0$	< 7.7	$\times 10^{-5}$ CL=90%	2582
$\pi^+\pi^-\pi^+\pi^0$	< 4.0	$\times 10^{-3}$ CL=90%	2621
$\rho^+\rho^0$	< 1.0	$\times 10^{-3}$ CL=90%	2525
$a_1(1260)^+\pi^0$	< 1.7	$\times 10^{-3}$ CL=90%	2494
$a_1(1260)^0\pi^+$	< 9.0	$\times 10^{-4}$ CL=90%	2494
$\omega\pi^+$	< 4.0	$\times 10^{-4}$ CL=90%	2580

$\eta\pi^+$	<	1.5	$\times 10^{-5}$	CL=90%	2609
$\eta'\pi^+$	<	3.1	$\times 10^{-5}$	CL=90%	2550
$\eta'\rho^+$	<	4.7	$\times 10^{-5}$	CL=90%	2493
$\eta\rho^+$	<	3.2	$\times 10^{-5}$	CL=90%	2554
$\pi^+\pi^+\pi^+\pi^-\pi^-$	<	8.6	$\times 10^{-4}$	CL=90%	2608
$\rho^0 a_1(1260)^+$	<	6.2	$\times 10^{-4}$	CL=90%	2434
$\rho^0 a_2(1320)^+$	<	7.2	$\times 10^{-4}$	CL=90%	2411
$\pi^+\pi^+\pi^+\pi^-\pi^-\pi^0$	<	6.3	$\times 10^{-3}$	CL=90%	2592
$a_1(1260)^+ a_1(1260)^0$	<	1.3	%	CL=90%	2335
Baryon modes					
$p\bar{p}\pi^+$	<	1.6	$\times 10^{-4}$	CL=90%	2439
$p\bar{p}\pi^+$ nonresonant	<	5.3	$\times 10^{-5}$	CL=90%	–
$p\bar{p}\pi^+\pi^+\pi^-$	<	5.2	$\times 10^{-4}$	CL=90%	2369
$p\bar{p}K^+$ nonresonant	<	8.9	$\times 10^{-5}$	CL=90%	–
$p\bar{\Lambda}$	<	6	$\times 10^{-5}$	CL=90%	2430
$p\bar{\Lambda}\pi^+\pi^-$	<	2.0	$\times 10^{-4}$	CL=90%	2367
$\bar{\Delta}^0 p$	<	3.8	$\times 10^{-4}$	CL=90%	2402
$\Delta^{++}\bar{p}$	<	1.5	$\times 10^{-4}$	CL=90%	2402
$\Lambda_c^- p\pi^+$		(6.2 ±2.7)	$\times 10^{-4}$		–
$\Lambda_c^- p\pi^+\pi^0$	<	3.12	$\times 10^{-3}$	CL=90%	–
$\Lambda_c^- p\pi^+\pi^+\pi^-$	<	1.46	$\times 10^{-3}$	CL=90%	–
$\Lambda_c^- p\pi^+\pi^+\pi^-\pi^0$	<	1.34	%	CL=90%	–
Lepton Family number (LF) or Lepton number (L) violating modes, or $\Delta B = 1$ weak neutral current ($B1$) modes					
$\pi^+ e^+ e^-$	$B1$	<	3.9	$\times 10^{-3}$	CL=90%	2638
$\pi^+\mu^+\mu^-$	$B1$	<	9.1	$\times 10^{-3}$	CL=90%	2633
$K^+ e^+ e^-$	$B1$	<	6	$\times 10^{-5}$	CL=90%	2616
$K^+\mu^+\mu^-$	$B1$	<	1.0	$\times 10^{-5}$	CL=90%	2612
$K^*(892)^+ e^+ e^-$	$B1$	<	6.9	$\times 10^{-4}$	CL=90%	2564
$K^*(892)^+\mu^+\mu^-$	$B1$	<	1.2	$\times 10^{-3}$	CL=90%	2560
$\pi^+ e^+\mu^-$	LF	<	6.4	$\times 10^{-3}$	CL=90%	2637
$\pi^+ e^-\mu^+$	LF	<	6.4	$\times 10^{-3}$	CL=90%	2637
$K^+ e^+\mu^-$	LF	<	6.4	$\times 10^{-3}$	CL=90%	2615
$K^+ e^-\mu^+$	LF	<	6.4	$\times 10^{-3}$	CL=90%	2615
$\pi^- e^+ e^+$	L	<	3.9	$\times 10^{-3}$	CL=90%	2638
$\pi^-\mu^+\mu^+$	L	<	9.1	$\times 10^{-3}$	CL=90%	2633
$\pi^- e^+\mu^+$	LF	<	6.4	$\times 10^{-3}$	CL=90%	2637
$K^- e^+ e^+$	L	<	3.9	$\times 10^{-3}$	CL=90%	2616
$K^-\mu^+\mu^+$	L	<	9.1	$\times 10^{-3}$	CL=90%	2612
$K^- e^+\mu^+$	LF	<	6.4	$\times 10^{-3}$	CL=90%	2615

B^0

$I(J^P) = \frac{1}{2}(0^-)$

I, J, P need confirmation. Quantum numbers shown are quark-model predictions.

Mass $m_{B^0} = 5279.2 \pm 1.8$ MeV
$m_{B^0} - m_{B^\pm} = 0.35 \pm 0.29$ MeV (S = 1.1)
Mean life $\tau_{B^0} = (1.56 \pm 0.04) \times 10^{-12}$ s
$c\tau = 468\ \mu$m
$\tau_{B^-}/\tau_{B^0} = 1.02 \pm 0.04$ (average of direct and inferred)
$\tau_{B^-}/\tau_{B^0} = 1.04 \pm 0.04$ (direct measurements)
$\tau_{B^-}/\tau_{B^0} = 0.95^{+0.15}_{-0.12}$ (inferred from branching fractions)

B^0-$\bar{B}^0$ mixing parameters

$\chi_d = 0.172 \pm 0.010$
$\Delta m_{B^0} = m_{B^0_H} - m_{B^0_L} = (0.464 \pm 0.018) \times 10^{12}\ \hbar\ \mathrm{s}^{-1}$
$x_d = \Delta m_{B^0}/\Gamma_{B^0} = 0.723 \pm 0.032$

CP violation parameters

$|\mathrm{Re}(\epsilon_{B^0})| = 0.002 \pm 0.008$

$\bar{B}^0$ modes are charge conjugates of the modes below. Reactions indicate the weak decay vertex and do not include mixing. Modes which do not identify the charge state of the B are listed in the $B^\pm/B^0$ ADMIXTURE section.

The branching fractions listed below assume 50% $B^0\bar{B}^0$ and 50% B^+B^- production at the $\Upsilon(4S)$. We have attempted to bring older measurements up to date by rescaling their assumed $\Upsilon(4S)$ production ratio to 50:50 and their assumed $D/D_s/D^*$ and ψ branching ratios to current values whenever this would affect our averages and best limits significantly.

Indentation is used to indicate a subchannel of a previous reaction. All resonant subchannels have been corrected for resonance branching fractions to the final state so the sum of the subchannel branching fractions can exceed that of the final state.

B^0 DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\ell^+\nu_\ell$ anything	[pp]	(10.5 ± 0.8) %		–
$D^-\ell^+\nu_\ell$	[pp]	(2.00± 0.25) %		–
$D^*(2010)^-\ell^+\nu_\ell$	[pp]	(4.60± 0.27) %		–
$\rho^-\ell^+\nu_\ell$	[pp]	(2.5 $^{+\ 0.8}_{-\ 1.0}$) $\times 10^{-4}$		–
$\pi^-\ell^+\nu_\ell$		(1.8 ± 0.6) $\times 10^{-4}$		–
Inclusive modes				
K^+ anything		(78 ±80) %		–
$D\bar{D}^*\Gamma$ or D_s modes				
$D^-\pi^+$		(3.0 ± 0.4) $\times 10^{-3}$		2306
$D^-\rho^+$		(7.9 ± 1.4) $\times 10^{-3}$		2236
$\bar{D}^0\pi^+\pi^-$	<	1.6 $\times 10^{-3}$	CL=90%	2301
$D^*(2010)^-\pi^+$		(2.76± 0.21) $\times 10^{-3}$		2254
$D^-\pi^+\pi^+\pi^-$		(8.0 ± 2.5) $\times 10^{-3}$		2287
($D^-\pi^+\pi^+\pi^-$) nonresonant		(3.9 ± 1.9) $\times 10^{-3}$		2287
$D^-\pi^+\rho^0$		(1.1 ± 1.0) $\times 10^{-3}$		2207
$D^- a_1(1260)^+$		(6.0 ± 3.3) $\times 10^{-3}$		2121
$D^*(2010)^-\pi^+\pi^0$		(1.5 ± 0.5) %		2247
$D^*(2010)^-\rho^+$		(6.7 ± 3.3) $\times 10^{-3}$		2181
$D^*(2010)^-\pi^+\pi^+\pi^-$		(7.6 ± 1.7) $\times 10^{-3}$	S=1.3	2235
($D^*(2010)^-\pi^+\pi^+\pi^-$) nonresonant		(0.0 ± 2.5) $\times 10^{-3}$		2235
$D^*(2010)^-\pi^+\rho^0$		(5.7 ± 3.1) $\times 10^{-3}$		2151
$D^*(2010)^- a_1(1260)^+$		(1.30± 0.27) %		2061
$D^*(2010)^-\pi^+\pi^+\pi^-\pi^0$		(3.4 ± 1.8) %		2218
$\bar{D}_2^*(2460)^-\pi^+$	<	2.2 $\times 10^{-3}$	CL=90%	2064
$\bar{D}_2^*(2460)^-\rho^+$	<	4.9 $\times 10^{-3}$	CL=90%	1979
$D^- D_s^+$		(8.0 ± 3.0) $\times 10^{-3}$		1812
$D^*(2010)^- D_s^+$		(9.6 ± 3.4) $\times 10^{-3}$		1735
$D^- D_s^{*+}$		(1.0 ± 0.5) %		1731
$D^*(2010)^- D_s^{*+}$		(2.0 ± 0.7) %		1649
$D_s^+\pi^-$	<	2.8 $\times 10^{-4}$	CL=90%	2270
$D_s^{*+}\pi^-$	<	5 $\times 10^{-4}$	CL=90%	2214
$D_s^+\rho^-$	<	7 $\times 10^{-4}$	CL=90%	2198
$D_s^{*+}\rho^-$	<	8 $\times 10^{-4}$	CL=90%	2139
$D_s^+ a_1(1260)^-$	<	2.6 $\times 10^{-3}$	CL=90%	2079
$D_s^{*+} a_1(1260)^-$	<	2.2 $\times 10^{-3}$	CL=90%	2014
$D_s^- K^+$	<	2.4 $\times 10^{-4}$	CL=90%	2242
$D_s^{*-} K^+$	<	1.7 $\times 10^{-4}$	CL=90%	2185
$D_s^- K^*(892)^+$	<	9.9 $\times 10^{-4}$	CL=90%	2172
$D_s^{*-} K^*(892)^+$	<	1.1 $\times 10^{-3}$	CL=90%	2112
$D_s^- \pi^+ K^0$	<	5 $\times 10^{-3}$	CL=90%	2221
$D_s^{*-}\pi^+ K^0$	<	3.1 $\times 10^{-3}$	CL=90%	2164
$D_s^-\pi^+ K^*(892)^0$	<	4 $\times 10^{-3}$	CL=90%	2136
$D_s^{*-}\pi^+ K^*(892)^0$	<	2.0 $\times 10^{-3}$	CL=90%	2074
$\bar{D}^0\pi^0$	<	1.2 $\times 10^{-4}$	CL=90%	2308
$\bar{D}^0\rho^0$	<	3.9 $\times 10^{-4}$	CL=90%	2238
$\bar{D}^0\eta$	<	1.3 $\times 10^{-4}$	CL=90%	2274
$\bar{D}^0\eta'$	<	9.4 $\times 10^{-4}$	CL=90%	2198
$\bar{D}^0\omega$	<	5.1 $\times 10^{-4}$	CL=90%	2235
$\bar{D}^*(2007)^0\pi^0$	<	4.4 $\times 10^{-4}$	CL=90%	2256
$\bar{D}^*(2007)^0\rho^0$	<	5.6 $\times 10^{-4}$	CL=90%	2183
$\bar{D}^*(2007)^0\eta$	<	2.6 $\times 10^{-4}$	CL=90%	2220
$\bar{D}^*(2007)^0\eta'$	<	1.4 $\times 10^{-3}$	CL=90%	2141
$\bar{D}^*(2007)^0\omega$	<	7.4 $\times 10^{-4}$	CL=90%	2180
$D^*(2010)^+ D^*(2010)^-$	<	2.2 $\times 10^{-3}$	CL=90%	1711
$D^*(2010)^+ D^-$	<	1.8 $\times 10^{-3}$	CL=90%	1790
$D^+ D^*(2010)^-$	<	1.2 $\times 10^{-3}$	CL=90%	1790
Charmonium modes				
$J/\psi(1S)K^0$		(8.9 ± 1.2) $\times 10^{-4}$		1683
$J/\psi(1S)K^+\pi^-$		(1.1 ± 0.6) $\times 10^{-3}$		1652
$J/\psi(1S)K^*(892)^0$		(1.35± 0.18) $\times 10^{-3}$		1570
$J/\psi(1S)\pi^0$	<	5.8 $\times 10^{-5}$	CL=90%	1728
$J/\psi(1S)\eta$	<	1.2 $\times 10^{-3}$	CL=90%	1672
$J/\psi(1S)\rho^0$	<	2.5 $\times 10^{-4}$	CL=90%	1614

$J/\psi(1S)\omega$		< 2.7	$\times 10^{-4}$	CL=90%	1609
$\psi(2S)K^0$		< 8	$\times 10^{-4}$	CL=90%	1283
$\psi(2S)K^+\pi^-$		< 1	$\times 10^{-3}$	CL=90%	1238
$\psi(2S)K^*(892)^0$		$(1.4 \pm 0.9) \times 10^{-3}$			1113
$\chi_{c1}(1P)K^0$		< 2.7	$\times 10^{-3}$	CL=90%	1411
$\chi_{c1}(1P)K^*(892)^0$		< 2.1	$\times 10^{-3}$	CL=90%	1263

K or K^* modes

$K^+\pi^-$		$(1.5^{+0.5}_{-0.4}) \times 10^{-5}$			2615
$K^0\pi^0$		< 4.1	$\times 10^{-5}$	CL=90%	2614
$\eta' K^0$		$(4.7^{+2.8}_{-2.2}) \times 10^{-5}$			2528
$\eta' K^*(892)^0$		< 3.9	$\times 10^{-5}$	CL=90%	2472
$\eta K^*(892)^0$		< 3.0	$\times 10^{-5}$	CL=90%	2534
ηK^0		< 3.3	$\times 10^{-5}$	CL=90%	2593
K^+K^-		< 4.3	$\times 10^{-6}$	CL=90%	2593
$K^0\overline{K}^0$		< 1.7	$\times 10^{-5}$	CL=90%	2592
$K^+\rho^-$		< 3.5	$\times 10^{-5}$	CL=90%	2559
$K^0\rho^0$		< 3.9	$\times 10^{-5}$	CL=90%	2559
$K^0 f_0(980)$		< 3.6	$\times 10^{-4}$	CL=90%	2523
$K^*(892)^+\pi^-$		< 7.2	$\times 10^{-5}$	CL=90%	2562
$K^*(892)^0\pi^0$		< 2.8	$\times 10^{-5}$	CL=90%	2562
$K_2^*(1430)^+\pi^-$		< 2.6	$\times 10^{-3}$	CL=90%	2445
$K^0K^+K^-$		< 1.3	$\times 10^{-3}$	CL=90%	2522
$K^0\phi$		< 8.8	$\times 10^{-5}$	CL=90%	2516
$K^-\pi^+\pi^+\pi^-$	[*bbb*]	< 2.3	$\times 10^{-4}$	CL=90%	2600
$K^*(892)^0\pi^+\pi^-$		< 1.4	$\times 10^{-3}$	CL=90%	2556
$K^*(892)^0\rho^0$		< 4.6	$\times 10^{-4}$	CL=90%	2504
$K^*(892)^0 f_0(980)$		< 1.7	$\times 10^{-4}$	CL=90%	2467
$K_1(1400)^+\pi^-$		< 1.1	$\times 10^{-3}$	CL=90%	2451
$K^-a_1(1260)^+$	[*bbb*]	< 2.3	$\times 10^{-4}$	CL=90%	2471
$K^*(892)^0K^+K^-$		< 6.1	$\times 10^{-4}$	CL=90%	2466
$K^*(892)^0\phi$		< 4.3	$\times 10^{-5}$	CL=90%	2459
$K_1(1400)^0\rho^0$		< 3.0	$\times 10^{-3}$	CL=90%	2389
$K_1(1400)^0\phi$		< 5.0	$\times 10^{-3}$	CL=90%	2339
$K_2^*(1430)^0\rho^0$		< 1.1	$\times 10^{-3}$	CL=90%	2380
$K_2^*(1430)^0\phi$		< 1.4	$\times 10^{-3}$	CL=90%	2330
$K^*(892)^0\gamma$		$(4.0 \pm 1.9) \times 10^{-5}$			2564
$K_1(1270)^0\gamma$		< 7.0	$\times 10^{-3}$	CL=90%	2486
$K_1(1400)^0\gamma$		< 4.3	$\times 10^{-3}$	CL=90%	2453
$K_2^*(1430)^0\gamma$		< 4.0	$\times 10^{-4}$	CL=90%	2445
$K^*(1680)^0\gamma$		< 2.0	$\times 10^{-3}$	CL=90%	2361
$K_3^*(1780)^0\gamma$		< 1.0	%	CL=90%	2343
$K_4^*(2045)^0\gamma$		< 4.3	$\times 10^{-3}$	CL=90%	2244
$\phi\phi$		< 3.9	$\times 10^{-5}$	CL=90%	2435

Light unflavored meson modes

$\pi^+\pi^-$		< 1.5	$\times 10^{-5}$	CL=90%	2636
$\pi^0\pi^0$		< 9.3	$\times 10^{-6}$	CL=90%	2636
$\eta\pi^0$		< 8	$\times 10^{-6}$	CL=90%	2609
$\eta\eta$		< 1.8	$\times 10^{-5}$	CL=90%	2582
$\eta'\pi^0$		< 1.1	$\times 10^{-5}$	CL=90%	2551
$\eta'\eta'$		< 4.7	$\times 10^{-5}$	CL=90%	2460
$\eta'\eta$		< 2.7	$\times 10^{-5}$	CL=90%	2522
$\eta'\rho^0$		< 2.3	$\times 10^{-5}$	CL=90%	2493
$\eta\rho^0$		< 1.3	$\times 10^{-5}$	CL=90%	2554
$\pi^+\pi^-\pi^0$		< 7.2	$\times 10^{-4}$	CL=90%	2631
$\rho^0\pi^0$		< 2.4	$\times 10^{-5}$	CL=90%	2582
$\rho^\mp\pi^\pm$	[*gg*]	< 8.8	$\times 10^{-5}$	CL=90%	2582
$\pi^+\pi^-\pi^+\pi^-$		< 2.3	$\times 10^{-4}$	CL=90%	2621
$\rho^0\rho^0$		< 2.8	$\times 10^{-4}$	CL=90%	2525
$a_1(1260)^\mp\pi^\pm$	[*gg*]	< 4.9	$\times 10^{-4}$	CL=90%	2494
$a_2(1320)^\mp\pi^\pm$	[*gg*]	< 3.0	$\times 10^{-4}$	CL=90%	2473
$\pi^+\pi^-\pi^0\pi^0$		< 3.1	$\times 10^{-3}$	CL=90%	2622
$\rho^+\rho^-$		< 2.2	$\times 10^{-3}$	CL=90%	2525
$a_1(1260)^0\pi^0$		< 1.1	$\times 10^{-3}$	CL=90%	2494
$\omega\pi^0$		< 4.6	$\times 10^{-4}$	CL=90%	2580
$\pi^+\pi^+\pi^-\pi^-\pi^0$		< 9.0	$\times 10^{-3}$	CL=90%	2609
$a_1(1260)^+\rho^-$		< 3.4	$\times 10^{-3}$	CL=90%	2434
$a_1(1260)^0\rho^0$		< 2.4	$\times 10^{-3}$	CL=90%	2434
$\pi^+\pi^+\pi^+\pi^-\pi^-\pi^-$		< 3.0	$\times 10^{-3}$	CL=90%	2592
$a_1(1260)^+a_1(1260)^-$		< 2.8	$\times 10^{-3}$	CL=90%	2336
$\pi^+\pi^+\pi^+\pi^-\pi^-\pi^-\pi^0$		< 1.1	%	CL=90%	2572

Baryon modes

$p\overline{p}$		< 1.8	$\times 10^{-5}$	CL=90%	2467
$p\overline{p}\pi^+\pi^-$		< 2.5	$\times 10^{-4}$	CL=90%	2406
$p\overline{\Lambda}\pi^-$		< 1.8	$\times 10^{-4}$	CL=90%	2401
$\Delta^0\overline{\Delta}^0$		< 1.5	$\times 10^{-3}$	CL=90%	2334
$\Delta^{++}\Delta^{--}$		< 1.1	$\times 10^{-4}$	CL=90%	2334
$\overline{\Sigma}_c^{--}\Delta^{++}$		< 1.0	$\times 10^{-3}$	CL=90%	1839
$\Lambda_c^-p\pi^+\pi^-$		$(1.3 \pm 0.6) \times 10^{-3}$			–
Λ_c^-p		< 2.1	$\times 10^{-4}$	CL=90%	2021
$\Lambda_c^-p\pi^0$		< 5.9	$\times 10^{-4}$	CL=90%	–
$\Lambda_c^-p\pi^+\pi^-\pi^0$		< 5.07	$\times 10^{-3}$	CL=90%	–
$\Lambda_c^-p\pi^+\pi^-\pi^+\pi^-$		< 2.74	$\times 10^{-3}$	CL=90%	–

Lepton Family number (LF) violating modes or $\Delta B = 1$ weak neutral current ($B1$) modes

$\gamma\gamma$	$B1$		< 3.9	$\times 10^{-5}$	CL=90%	2640
e^+e^-	$B1$		< 5.9	$\times 10^{-6}$	CL=90%	2640
$\mu^+\mu^-$	$B1$		< 6.8	$\times 10^{-7}$	CL=90%	2637
$K^0e^+e^-$	$B1$		< 3.0	$\times 10^{-4}$	CL=90%	2616
$K^0\mu^+\mu^-$	$B1$		< 3.6	$\times 10^{-4}$	CL=90%	2612
$K^*(892)^0e^+e^-$	$B1$		< 2.9	$\times 10^{-4}$	CL=90%	2564
$K^*(892)^0\mu^+\mu^-$	$B1$		< 2.3	$\times 10^{-5}$	CL=90%	2559
$K^*(892)^0\nu\overline{\nu}$	$B1$		< 1.0	$\times 10^{-3}$	CL=90%	2244
$e^\pm\mu^\mp$	LF	[*gg*]	< 5.9	$\times 10^{-6}$	CL=90%	2639
$e^\pm\tau^\mp$	LF	[*gg*]	< 5.3	$\times 10^{-4}$	CL=90%	2341
$\mu^\pm\tau^\mp$	LF	[*gg*]	< 8.3	$\times 10^{-4}$	CL=90%	2339

$B^\pm/B^0$ ADMIXTURE

The branching fraction measurements are for an admixture of B mesons at the $\Upsilon(4S)$. The values quoted assume that $B(\Upsilon(4S) \to B\overline{B}) = 100\%$.

For inclusive branching fractions[*e.g.*, $B \to D^\pm$ anything]the treatment of multiple D's in the final state must be defined. One possiblity would be to count the number of events with one-or-more D's and divide by the total number of B's. Another possibility would be to count the total number of D's and divide by the total number of B's[which is the definition of average multiplicity. The two definitions are identical when only one of the specified particles is allowed in the final state. Even though the "one-or-more" definition seems sensible]for practical reasons inclusive branching fractions are almost always measured using the multiplicity definition. For heavy final state particles[authors call their results inclusive branching fractions while for light particles some authors call their results multiplicities. In the B sections]we list all results as inclusive branching fractions[adopting a multiplicity definition. This means that inclusive branching fractions can exceed 100% and that inclusive partial widths can exceed total widths]just as inclusive cross sections can exceed total cross sections.

$\overline{B}$ modes are charge conjugates of the modes below. Reactions indicate the weak decay vertex and do not include mixing.

***B* DECAY MODES**	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Semileptonic and leptonic modes			
$B \to e^+\nu_e$ anything	[*ccc*] $(10.41 \pm 0.29)\%$	S=1.2	–
$B \to \overline{p}e^+\nu_e$ anything	$< 1.6 \times 10^{-3}$	CL=90%	–
$B \to \mu^+\nu_\mu$ anything	[*ccc*] $(10.3 \pm 0.5)\%$		–
$B \to \ell^+\nu_\ell$ anything	[*pp,ccc*] $(10.45 \pm 0.21)\%$		–
$B \to D^-\ell^+\nu_\ell$ anything	[*pp*] $(2.7 \pm 0.8)\%$		–
$B \to \overline{D}^0\ell^+\nu_\ell$ anything	[*pp*] $(7.0 \pm 1.4)\%$		–
$B \to \overline{D}^{**}\ell^+\nu_\ell$	[*pp,ddd*] $(2.7 \pm 0.7)\%$		–
$B \to \overline{D}_1(2420)\ell^+\nu_\ell$ anything	$(7.4 \pm 1.6) \times 10^{-3}$		–
$B \to D\pi\ell^+\nu_\ell$ anything + $D^*\pi\ell^+\nu_\ell$ anything	$(2.3 \pm 0.4)\%$		–
$B \to \overline{D}_2^*(2460)\ell^+\nu_\ell$ anything	$< 6.5 \times 10^{-3}$	CL=95%	–
$B \to D^{*-}\pi^+\ell^+\nu_\ell$ anything	$(1.00 \pm 0.34)\%$		–
$B \to D_s^-\ell^+\nu_\ell$ anything	[*pp*] $< 9 \times 10^{-3}$	CL=90%	–
$B \to D_s^-\ell^+\nu_\ell K^+$ anything	[*pp*] $< 6 \times 10^{-3}$	CL=90%	–
$B \to D_s^-\ell^+\nu_\ell K^0$ anything	[*pp*] $< 9 \times 10^{-3}$	CL=90%	–
$B \to K^+\ell^+\nu_\ell$ anything	[*pp*] $(6.0 \pm 0.5)\%$		–
$B \to K^-\ell^+\nu_\ell$ anything	[*pp*] $(10 \pm 4) \times 10^{-3}$		–
$B \to K^0/\overline{K}^0\ell^+\nu_\ell$ anything	[*pp*] $(4.4 \pm 0.5)\%$		–

$D\ell D^*\ell$ or D_s modes						
$B \to D^\pm$ anything		(24.1 ±1.9) %				–
$B \to D^0/\overline{D}{}^0$ anything		(63.1 ±2.9) %			S=1.1	–
$B \to D^*(2010)^\pm$ anything		(22.7 ±1.6) %				–
$B \to D^*(2007)^0$ anything		(26.0 ±2.7) %				–
$B \to D_s^\pm$ anything	[gg]	(10.0 ±2.5) %				–
$b \to c\overline{c}s$		(22 ±4) %				–
$B \to D_s D\ell D_s^* D\ell D_s D^*\ell$ or $D_s^* D^*$	[gg]	(4.9 ±1.3) %				–
$B \to D^*(2010)\gamma$		< 1.1		$\times 10^{-3}$	CL=90%	–
$B \to D_s^+\pi^-\ell D_s^{*+}\pi^-\ell$ $D_s^+\rho^-\ell D_s^{*+}\rho^-\ell D_s^+\pi^0\ell$ $D_s^{*+}\pi^0\ell D_s^+\eta\ell D_s^{*+}\eta\ell$ $D_s^+\rho^0\ell D_s^{*+}\rho^0\ell D_s^+\omega\ell$ $D_s^{*+}\omega$	[gg]	< 5		$\times 10^{-4}$	CL=90%	–
$B \to D_{s1}(2536)^+$ anything		< 9.5		$\times 10^{-3}$	CL=90%	–
Charmonium modes						
$B \to J/\psi(1S)$ anything		(1.13±0.06) %				–
$B \to J/\psi(1S)$ (direct) anything		(8.0 ±0.8) $\times 10^{-3}$				–
$B \to \psi(2S)$ anything		(3.5 ±0.5) $\times 10^{-3}$				–
$B \to \chi_{c1}(1P)$ anything		(4.2 ±0.7) $\times 10^{-3}$				–
$B \to \chi_{c1}(1P)$ (direct) anything		(3.7 ±0.7) $\times 10^{-3}$				–
$B \to \chi_{c2}(1P)$ anything		< 3.8		$\times 10^{-3}$	CL=90%	–
$B \to \eta_c(1S)$ anything		< 9		$\times 10^{-3}$	CL=90%	–
K or K^* modes						
$B \to K^\pm$ anything	[gg]	(78.9 ±2.5) %				–
$B \to K^+$ anything		(66 ±5) %				–
$B \to K^-$ anything		(13 ±4) %				–
$B \to K^0/\overline{K}{}^0$ anything	[gg]	(64 ±4) %				–
$B \to K^*(892)^\pm$ anything		(18 ±6) %				–
$B \to K^*(892)^0/\overline{K}{}^*(892)^0$ anything	[gg]	(14.6 ±2.6) %				–
$B \to K_1(1400)\gamma$		< 4.1		$\times 10^{-4}$	CL=90%	–
$B \to K_2^*(1430)\gamma$		< 8.3		$\times 10^{-4}$	CL=90%	–
$B \to K_2(1770)\gamma$		< 1.2		$\times 10^{-3}$	CL=90%	–
$B \to K_3^*(1780)\gamma$		< 3.0		$\times 10^{-3}$	CL=90%	–
$B \to K_4^*(2045)\gamma$		< 1.0		$\times 10^{-3}$	CL=90%	–
$B \to \overline{b} \to \overline{s}\gamma$		(2.3 ±0.7) $\times 10^{-4}$				–
$B \to \overline{b} \to \overline{s}$gluon		< 6.8		%	CL=90%	–
Light unflavored meson modes						
$B \to \pi^\pm$ anything	[gg,eee]	(359 ±7) %				–
$B \to \eta$ anything		(17.6 ±1.6) %				–
$B \to \rho^0$ anything		(21 ±5) %				–
$B \to \omega$ anything		< 81		%	CL=90%	–
$B \to \phi$ anything		(3.5 ±0.7) %			S=1.8	–
Baryon modes						
$B \to \Lambda_c^\pm$ anything		(6.4 ±1.1) %				–
$B \to \Lambda_c^- e^+$ anything		< 3.2		$\times 10^{-3}$	CL=90%	–
$B \to \Lambda_c^- p$ anything		(3.6 ±0.7) %				–
$B \to \Lambda_c^- p e^+ \nu_e$		< 1.5		$\times 10^{-3}$	CL=90%	–
$B \to \overline{\Sigma}_c^{--}$ anything		(4.2 ±2.4) $\times 10^{-3}$				–
$B \to \overline{\Sigma}_c^-$ anything		< 9.6		$\times 10^{-3}$	CL=90%	–
$B \to \overline{\Sigma}_c^0$ anything		(4.6 ±2.4) $\times 10^{-3}$				–
$B \to \overline{\Sigma}_c^0 N (N = p$ or $n)$		< 1.5		$\times 10^{-3}$	CL=90%	–
$B \to \Xi_c^0$ anything $\times$ B($\Xi_c^0 \to \Xi^-\pi^+$)		(1.4 ±0.5) $\times 10^{-4}$				–
$B \to \Xi_c^+$ anything $\times$ B($\Xi_c^+ \to \Xi^-\pi^+\pi^+$)		(4.5 $^{+1.3}_{-1.2}$) $\times 10^{-4}$				–
$B \to p/\overline{p}$ anything	[gg]	(8.0 ±0.4) %				–
$B \to p/\overline{p}$ (direct) anything	[gg]	(5.5 ±0.5) %				–
$B \to \Lambda/\overline{\Lambda}$ anything	[gg]	(4.0 ±0.5) %				–
$B \to \Xi^-/\overline{\Xi}^+$ anything	[gg]	(2.7 ±0.6) $\times 10^{-3}$				–
$B \to$ baryons anything		(6.8 ±0.6) %				–
$B \to p\overline{p}$ anything		(2.47±0.23) %				–
$B \to \Lambda\overline{p}/\overline{\Lambda}p$ anything	[gg]	(2.5 ±0.4) %				–
$B \to \Lambda\overline{\Lambda}$ anything		< 5		$\times 10^{-3}$	CL=90%	–

Lepton Family number (LF) violating modes or $\Delta B = 1$ weak neutral current ($B1$) modes						
$B \to e^+ e^- s$	$B1$	< 5.7		$\times 10^{-5}$	CL=90%	–
$B \to \mu^+ \mu^- s$	$B1$	< 5.8		$\times 10^{-5}$	CL=90%	–
$B \to e^\pm \mu^\mp s$	LF	< 2.2		$\times 10^{-5}$	CL=90%	–

$B^\pm/B^0/B_s^0$/b-baryon ADMIXTURE

These measurements are for an admixture of bottom particles at high energy (LEP, Tevatron, $S\overline{p}pS$).

Mean life $\tau = (1.564 \pm 0.014) \times 10^{-12}$ s

Mean life $\tau = (1.72 \pm 0.10) \times 10^{-12}$ s Charged b-hadron admixture

Mean life $\tau = (1.58 \pm 0.14) \times 10^{-12}$ s Neutral b-hadron admixture

$\tau_{\text{charged } b\text{-hadron}}/\tau_{\text{neutral } b\text{-hadron}} = 1.09 \pm 0.13$

The branching fraction measurements are for an admixture of B mesons and baryons at energies above the $\Upsilon(4S)$. Only the highest energy results (LEP, Tevatron, $S\overline{p}pS$) are used in the branching fraction averages. The production fractions give our best current estimate of the admixture at LEP.

For inclusive branching fractions, *e.g.*, $B \to D^\pm$ anything, the treatment of multiple D's in the final state must be defined. One possiblity would be to count the number of events with one-or-more D's and divide by the total number of B's. Another possibility would be to count the total number of D's and divide by the total number of B's, which is the definition of average multiplicity. The two definitions are identical when only one of the specified particles is allowed in the final state. Even though the "one-or-more" definition seems sensible, for practical reasons inclusive branching fractions are almost always measured using the multiplicity definition. For heavy final state particles, authors call their results inclusive branching fractions while for light particles some authors call their results multiplicities. In the B sections, we list all results as inclusive branching fractions, adopting a multiplicity definition. This means that inclusive branching fractions can exceed 100% and that inclusive partial widths can exceed total widths, just as inclusive cross sections can exceed total cross sections.

The modes below are listed for a $\overline{b}$ initial state. b modes are their charge conjugates. Reactions indicate the weak decay vertex and do not include mixing.

$\overline{b}$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)

PRODUCTION FRACTIONS

The production fractions for weakly decaying b-hadrons at the Z have been calculated from the best values of mean lives, mixing parameters, and branching fractions in this edition by the LEP B Oscillation Working Group as described in the note "Production and Decay of b-Flavored Hadrons" in the $B^\pm$ Particle Listings. Values assume

$$B(\overline{b} \to B^+) = B(\overline{b} \to B^0)$$
$$B(\overline{b} \to B^+) + B(\overline{b} \to B^0) + B(\overline{b} \to B_s^0) + B(b \to \Lambda_b) = 100\ \%.$$

The notation for production fractions varies in the literature (f_{B^0}, $f(b \to \overline{B}^0)$, Br($b \to \overline{B}^0$)). We use our own branching fraction notation here, $B(\overline{b} \to B^0)$.

B^+		(39.7 $^{+\ 1.8}_{-\ 2.2}$) %	–
B^0		(39.7 $^{+\ 1.8}_{-\ 2.2}$) %	–
B_s^0		(10.5 $^{+\ 1.8}_{-\ 1.7}$) %	–
Λ_b		(10.1 $^{+\ 3.9}_{-\ 3.1}$) %	–

DECAY MODES

Semileptonic and leptonic modes

ν anything		(23.1 ± 1.5) %	–
$\ell^+\nu_\ell$ anything	[pp,ccc]	(10.99± 0.23) %	–
$e^+\nu_e$ anything	[ccc]	(10.9 ± 0.5) %	–
$\mu^+\nu_\mu$ anything	[ccc]	(10.8 ± 0.5) %	–
$D^-\ell^+\nu_\ell$ anything	[pp]	(2.02± 0.29) %	–
$\overline{D}{}^0\ell^+\nu_\ell$ anything	[pp]	(6.5 ± 0.6) %	–
$D^{*-}\ell^+\nu_\ell$ anything	[pp]	(2.76± 0.29) %	–
$\overline{D}{}_J^0\ell^+\nu_\ell$ anything	[pp,fff]	seen	–
$D_J^-\ell^+\nu_\ell$ anything	[pp,fff]	seen	–
$\overline{D}{}_2^*(2460)^0\ell^+\nu_\ell$ anything		seen	–
$D_2^*(2460)^-\ell^+\nu_\ell$ anything		seen	–
$\tau^+\nu_\tau$ anything		(2.6 ± 0.4) %	–
$\overline{c} \to \ell^-\overline{\nu}_\ell$ anything	[pp]	(7.8 ± 0.6) %	–

Charmed meson and baryon modes					
$\overline{D}^0$ anything		(60.1 ± 3.2) %			–
D^- anything		(23.7 ± 2.3) %			–
$\overline{D}_s$ anything		(18 ± 5) %			–
Λ_c anything		(9.7 ± 2.9) %			–
$\overline{c}/c$ anything	[eee]	(117 ± 4) %			–
Charmonium modes					
$J/\psi(1S)$ anything		(1.16± 0.10) %			–
$\psi(2S)$ anything		(4.8 ± 2.4)	$\times 10^{-3}$		–
$\chi_{c1}(1P)$ anything		(1.8 ± 0.5) %			–
K* or *K* **modes**					
$\overline{s}\gamma$		< 5.4	$\times 10^{-4}$	90%	–
$K^\pm$ anything		(88 ±19) %			–
K^0_S anything		(29.0 ± 2.9) %			–
Pion modes					
π^0 anything	[eee]	(278 ±60) %			–
Baryon modes					
$p/\overline{p}$ anything		(14 ± 6) %			–
Other modes					
charged anything	[eee]	(497 ± 7) %			–
hadron$^+$ hadron$^-$		(1.7 $^{+\ 1.0}_{-\ 0.7}$)	$\times 10^{-5}$		–
charmless		(7 ±21)	$\times 10^{-3}$		–
Baryon modes					
$\Lambda/\overline{\Lambda}$ anything		(5.9 ± 0.6) %			–
$\Delta B = 1$ weak neutral current ($B1$) modes					
$\mu^+\mu^-$ anything	*B1*	< 3.2	$\times 10^{-4}$	90%	–

B^*

$I(J^P) = \frac{1}{2}(1^-)$

*I*Γ *J*Γ *P* need confirmation. Quantum numbers shown are quark-model predictions.

Mass $m_{B^*} = 5324.9 \pm 1.8$ MeV

$m_{B^*} - m_B = 45.78 \pm 0.35$ MeV

B* **DECAY MODES**	Fraction (Γ_i/Γ)	*p* (MeV/*c*)
$B\gamma$	dominant	46

BOTTOM, STRANGE MESONS ($B = \pm 1, S = \mp 1$)

$B^0_s = s\overline{b}$ Γ $\overline{B}^0_s = \overline{s}b$ Γ similarly for B^{*0}_s's

B^0_s

$I(J^P) = 0(0^-)$

*I*Γ *J*Γ *P* need confirmation. Quantum numbers shown are quark-model predictions.

Mass $m_{B^0_s} = 5369.3 \pm 2.0$ MeV

Mean life $\tau = (1.54 \pm 0.07) \times 10^{-12}$ s

$c\tau = 462\ \mu$m

B^0_s-$\overline{B}^0_s$ mixing parameters

χ_B at high energy $= f_d\chi_d + f_s\chi_s = 0.118 \pm 0.006$

$\Delta m_{B^0_s} = m_{B^0_{sH}} - m_{B^0_{sL}} > 9.1 \times 10^{12}\ \hbar\ \text{s}^{-1}$ Γ CL = 95%

$x_s - \Delta m_{B^0_s}/\Gamma_{B^0_s} > 14.0$ Γ CL = 95%

$\chi_s > 0.4975$ Γ CL = 95%

These branching fractions all scale with B($\overline{b} \to B^0_s$) Γ the LEP B^0_s production fraction. The first four were evaluated using B($\overline{b} \to B^0_s$) = $(10.5^{+1.8}_{-1.7})$% and the rest assume B($\overline{b} \to B^0_s$) = 12%.

The branching fraction B($B^0_s \to D^-_s \ell^+ \nu_\ell$ anything) is not a pure measurement since the measured product branching fraction B($\overline{b} \to B^0_s$) × B($B^0_s \to D^-_s \ell^+ \nu_\ell$ anything) was used to determine B($\overline{b} \to B^0_s$) Γ as described in the note on "Production and Decay of *b*-Flavored Hadrons."

***B*^0_s DECAY MODES**		Fraction (Γ_i/Γ)		Confidence level	*p* (MeV/*c*)
D^-_s anything		(92 ±33) %			–
$D^-_s \ell^+ \nu_\ell$ anything	[ggg]	(8.1 ± 2.5) %			–
$D^-_s \pi^+$		< 13	%		2321
$J/\psi(1S)\phi$		(9.3 ± 3.3)	$\times 10^{-4}$		1590
$J/\psi(1S)\pi^0$		< 1.2	$\times 10^{-3}$	90%	1788
$J/\psi(1S)\eta$		< 3.8	$\times 10^{-3}$	90%	1735
$\psi(2S)\phi$		seen			1122
$\pi^+\pi^-$		< 1.7	$\times 10^{-4}$	90%	1122
$\pi^0\pi^0$		< 2.1	$\times 10^{-4}$	90%	2861
$\eta\pi^0$		< 1.0	$\times 10^{-3}$	90%	2655
$\eta\eta$		< 1.5	$\times 10^{-3}$	90%	2628
π^+K^-		< 2.1	$\times 10^{-4}$	90%	2660
K^+K^-		< 5.9	$\times 10^{-5}$	90%	2639
$p\overline{p}$		< 5.9	$\times 10^{-5}$	90%	2515
$\gamma\gamma$		< 1.48	$\times 10^{-4}$	90%	2685
$\phi\gamma$		< 7	$\times 10^{-4}$	90%	2588
Lepton Family number (LF) violating modes or $\Delta B = 1$ weak neutral current ($B1$) modes					
$\mu^+\mu^-$	*B1*	< 2.0	$\times 10^{-6}$	90%	2682
e^+e^-	*B1*	< 5.4	$\times 10^{-5}$	90%	2864
$e^\pm\mu^\mp$	*LF*	[gg] < 4.1	$\times 10^{-5}$	90%	2864
$\phi\nu\overline{\nu}$	*B1*	< 5.4	$\times 10^{-3}$	90%	–

$c\bar{c}$ MESONS

$\eta_c(1S)$ $I^G(J^{PC}) = 0^+(0^{-+})$

Mass $m = 2979.8 \pm 2.1$ MeV (S = 2.1)
Full width $\Gamma = 13.2^{+3.8}_{-3.2}$ MeV

$\eta_c(1S)$ DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
Decays involving hadronic resonances				
$\eta'(958)\pi\pi$		(4.1 ±1.7) %		1319
$\rho\rho$		(2.6 ±0.9) %		1275
$K^*(892)^0 K^-\pi^+ +$ c.c.		(2.0 ±0.7) %		1273
$K^*(892)\overline{K}^*(892)$		(8.5 ±3.1) $\times 10^{-3}$		1193
$\phi\phi$		(7.1 ±2.8) $\times 10^{-3}$		1086
$a_0(980)\pi$		< 2 %	90%	1323
$a_2(1320)\pi$		< 2 %	90%	1193
$K^*(892)\overline{K} +$ c.c.		< 1.28 %	90%	1307
$f_2(1270)\eta$		< 1.1 %	90%	1142
$\omega\omega$		< 3.1 $\times 10^{-3}$	90%	1268
Decays into stable hadrons				
$K\overline{K}\pi$		(5.5 ±1.7) %		1378
$\eta\pi\pi$		(4.9 ±1.8) %		1425
$\pi^+\pi^- K^+ K^-$		(2.0 $^{+0.7}_{-0.6}$) %		1342
$2(K^+K^-)$		(2.1 ±1.2) %		1053
$2(\pi^+\pi^-)$		(1.2 ±0.4) %		1457
$p\overline{p}$		(1.2 ±0.4) $\times 10^{-3}$		1157
$K\overline{K}\eta$		< 3.1 %	90%	1262
$\pi^+\pi^- p\overline{p}$		< 1.2 %	90%	1023
$\Lambda\overline{\Lambda}$		< 2 $\times 10^{-3}$	90%	987
Radiative decays				
$\gamma\gamma$		(3.0 ±1.2) $\times 10^{-4}$		1489

$J/\psi(1S)$ $I^G(J^{PC}) = 0^-(1^{--})$

Mass $m = 3096.88 \pm 0.04$ MeV
Full width $\Gamma = 87 \pm 5$ keV
$\Gamma_{ee} = 5.26 \pm 0.37$ keV (Assuming $\Gamma_{ee} = \Gamma_{\mu\mu}$)

$J/\psi(1S)$ DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
hadrons		(87.7 ±0.5) %		–
virtual $\gamma \to$ hadrons		(17.0 ±2.0) %		–
e^+e^-		(6.02±0.19) %		1548
$\mu^+\mu^-$		(6.01±0.19) %		1545
Decays involving hadronic resonances				
$\rho\pi$		(1.27±0.09) %		1449
$\rho^0\pi^0$		(4.2 ±0.5) $\times 10^{-3}$		1449
$a_2(1320)\rho$		(1.09±0.22) %		1125
$\omega\pi^+\pi^+\pi^-\pi^-$		(8.5 ±3.4) $\times 10^{-3}$		1392
$\omega\pi^+\pi^-$		(7.2 ±1.0) $\times 10^{-3}$		1435
$\omega f_2(1270)$		(4.3 ±0.6) $\times 10^{-3}$		1143
$K^*(892)^0\overline{K}_2^*(1430)^0 +$ c.c.		(6.7 ±2.6) $\times 10^{-3}$		1005
$\omega K^*(892)\overline{K} +$ c.c.		(5.3 ±2.0) $\times 10^{-3}$		1098
$K^+\overline{K}^*(892)^- +$ c.c.		(5.0 ±0.4) $\times 10^{-3}$		1373
$K^0\overline{K}^*(892)^0 +$ c.c.		(4.2 ±0.4) $\times 10^{-3}$		1371
$\omega\pi^0\pi^0$		(3.4 ±0.8) $\times 10^{-3}$		1436
$b_1(1235)^\pm\pi^\mp$	[gg]	(3.0 ±0.5) $\times 10^{-3}$		1299
$\omega K^\pm K_S^0\pi^\mp$	[gg]	(3.0 ±0.7) $\times 10^{-3}$		1210
$b_1(1235)^0\pi^0$		(2.3 ±0.6) $\times 10^{-3}$		1299
$\phi K^*(892)\overline{K} +$ c.c.		(2.04±0.28) $\times 10^{-3}$		969
$\omega K\overline{K}$		(1.9 ±0.4) $\times 10^{-3}$		1268
$\omega f_J(1710) \to \omega K\overline{K}$		(4.8 ±1.1) $\times 10^{-4}$		878
$\phi 2(\pi^+\pi^-)$		(1.60±0.32) $\times 10^{-3}$		1318
$\Delta(1232)^{++}\overline{p}\pi^-$		(1.6 ±0.5) $\times 10^{-3}$		1030
$\omega\eta$		(1.58±0.16) $\times 10^{-3}$		1394
$\phi K\overline{K}$		(1.48±0.22) $\times 10^{-3}$		1179
$\phi f_J(1710) \to \phi K\overline{K}$		(3.6 ±0.6) $\times 10^{-4}$		875
$p\overline{p}\omega$		(1.30±0.25) $\times 10^{-3}$	S=1.3	769
$\Delta(1232)^{++}\overline{\Delta}(1232)^{--}$		(1.10±0.29) $\times 10^{-3}$		938
$\Sigma(1385)^-\overline{\Sigma}(1385)^+$ (or c.c.)	[gg]	(1.03±0.13) $\times 10^{-3}$		692
$p\overline{p}\eta'(958)$		(9 ±4) $\times 10^{-4}$	S=1.7	596
$\phi f_2'(1525)$		(8 ±4) $\times 10^{-4}$	S=2.7	871
$\phi\pi^+\pi^-$		(8.0 ±1.2) $\times 10^{-4}$		1365
$\phi K^\pm K_S^0\pi^\mp$	[gg]	(7.2 ±0.9) $\times 10^{-4}$		1114
$\omega f_1(1420)$		(6.8 ±2.4) $\times 10^{-4}$		1062
$\phi\eta$		(6.5 ±0.7) $\times 10^{-4}$		1320
$\Xi(1530)^-\overline{\Xi}^+$		(5.9 ±1.5) $\times 10^{-4}$		597
$pK^-\overline{\Sigma}(1385)^0$		(5.1 ±3.2) $\times 10^{-4}$		645
$\omega\pi^0$		(4.2 ±0.6) $\times 10^{-4}$	S=1.4	1447
$\phi\eta'(958)$		(3.3 ±0.4) $\times 10^{-4}$		1192
$\phi f_0(980)$		(3.2 ±0.9) $\times 10^{-4}$	S=1.9	1182
$\Xi(1530)^0\overline{\Xi}^0$		(3.2 ±1.4) $\times 10^{-4}$		608
$\Sigma(1385)^-\overline{\Sigma}^+$ (or c.c.)	[gg]	(3.1 ±0.5) $\times 10^{-4}$		857
$\phi f_1(1285)$		(2.6 ±0.5) $\times 10^{-4}$	S=1.1	1032
$\rho\eta$		(1.93±0.23) $\times 10^{-4}$		1398
$\omega\eta'(958)$		(1.67±0.25) $\times 10^{-4}$		1279
$\omega f_0(980)$		(1.4 ±0.5) $\times 10^{-4}$		1271
$\rho\eta'(958)$		(1.05±0.18) $\times 10^{-4}$		1283
$p\overline{p}\phi$		(4.5 ±1.5) $\times 10^{-5}$		527
$a_2(1320)^\pm\pi^\mp$	[gg]	< 4.3 $\times 10^{-3}$	CL=90%	1263
$K\overline{K}_2^*(1430) +$ c.c.		< 4.0 $\times 10^{-3}$	CL=90%	1159
$K_2^*(1430)^0\overline{K}_2^*(1430)^0$		< 2.9 $\times 10^{-3}$	CL=90%	588
$K^*(892)^0\overline{K}^*(892)^0$		< 5 $\times 10^{-4}$	CL=90%	1263
$\phi f_2(1270)$		< 3.7 $\times 10^{-4}$	CL=90%	1036
$p\overline{p}\rho$		< 3.1 $\times 10^{-4}$	CL=90%	779
$\phi\eta(1440) \to \phi\eta\pi\pi$		< 2.5 $\times 10^{-4}$	CL=90%	946
$\omega f_2'(1525)$		< 2.2 $\times 10^{-4}$	CL=90%	1003
$\Sigma(1385)^0\overline{\Lambda}$		< 2 $\times 10^{-4}$	CL=90%	911
$\Delta(1232)^+\overline{p}$		< 1 $\times 10^{-4}$	CL=90%	1100
$\Sigma^0\overline{\Lambda}$		< 9 $\times 10^{-5}$	CL=90%	1032
$\phi\pi^0$		< 6.8 $\times 10^{-6}$	CL=90%	1377
Decays into stable hadrons				
$2(\pi^+\pi^-)\pi^0$		(3.37±0.26) %		1496
$3(\pi^+\pi^-)\pi^0$		(2.9 ±0.6) %		1433
$\pi^+\pi^-\pi^0$		(1.50±0.20) %		1533
$\pi^+\pi^-\pi^0 K^+K^-$		(1.20±0.30) %		1368
$4(\pi^+\pi^-)\pi^0$		(9.0 ±3.0) $\times 10^{-3}$		1345
$\pi^+\pi^- K^+K^-$		(7.2 ±2.3) $\times 10^{-3}$		1407
$K\overline{K}\pi$		(6.1 ±1.0) $\times 10^{-3}$		1440
$p\overline{p}\pi^+\pi^-$		(6.0 ±0.5) $\times 10^{-3}$	S=1.3	1107
$2(\pi^+\pi^-)$		(4.0 ±1.0) $\times 10^{-3}$		1517
$3(\pi^+\pi^-)$		(4.0 ±2.0) $\times 10^{-3}$		1466
$n\overline{n}\pi^+\pi^-$		(4 ±4) $\times 10^{-3}$		1106
$\Sigma^0\overline{\Sigma}^0$		(1.27±0.17) $\times 10^{-3}$		992
$2(\pi^+\pi^-)K^+K^-$		(3.1 ±1.3) $\times 10^{-3}$		1320
$p\overline{p}\pi^+\pi^-\pi^0$	[hhh]	(2.3 ±0.9) $\times 10^{-3}$	S=1.9	1033
$p\overline{p}$		(2.14±0.10) $\times 10^{-3}$		1232
$p\overline{p}\eta$		(2.09±0.18) $\times 10^{-3}$		948
$p\overline{n}\pi^-$		(2.00±0.10) $\times 10^{-3}$		1174
$n\overline{n}$		(1.9 ±0.5) $\times 10^{-3}$		1231
$\Xi^-\overline{\Xi}$		(1.8 ±0.4) $\times 10^{-3}$	S=1.8	818
$\Lambda\overline{\Lambda}$		(1.35±0.14) $\times 10^{-3}$	S=1.2	1074
$p\overline{p}\pi^0$		(1.09±0.09) $\times 10^{-3}$		1176
$\Lambda\overline{\Sigma}^-\pi^+$ (or c.c.)	[gg]	(1.06±0.12) $\times 10^{-3}$		945
$pK^-\overline{\Lambda}$		(8.9 ±1.6) $\times 10^{-4}$		876
$2(K^+K^-)$		(7.0 ±3.0) $\times 10^{-4}$		1131
$pK^-\overline{\Sigma}^0$		(2.9 ±0.8) $\times 10^{-4}$		820
K^+K^-		(2.37±0.31) $\times 10^{-4}$		1468
$\Lambda\overline{\Lambda}\pi^0$		(2.2 ±0.7) $\times 10^{-4}$		998
$\pi^+\pi^-$		(1.47±0.23) $\times 10^{-4}$		1542
$K_S^0K_L^0$		(1.08±0.14) $\times 10^{-4}$		1466
$\Lambda\overline{\Sigma} +$ c.c.		< 1.5 $\times 10^{-4}$	CL=90%	1032
$K_S^0K_S^0$		< 5.2 $\times 10^{-6}$	CL=90%	1466
Radiative decays				
$\gamma\eta_c(1S)$		(1.3 ±0.4) %		116
$\gamma\pi^+\pi^-2\pi^0$		(8.3 ±3.1) $\times 10^{-3}$		1518
$\gamma\eta\pi\pi$		(6.1 ±1.0) $\times 10^{-3}$		1487
$\gamma\eta(1440) \to \gamma K\overline{K}\pi$	[p]	(9.1 ±1.8) $\times 10^{-4}$		1223
$\gamma\eta(1440) \to \gamma\gamma\rho^0$		(6.4 ±1.4) $\times 10^{-5}$		1223
$\gamma\eta(1440) \to \gamma\eta\pi^+\pi^-$		(3.4 ±0.7) $\times 10^{-4}$		–
$\gamma\rho\rho$		(4.5 ±0.8) $\times 10^{-3}$		1343
$\gamma\eta'(958)$		(4.31±0.30) $\times 10^{-3}$		1400
$\gamma 2\pi^+2\pi^-$		(2.8 ±0.5) $\times 10^{-3}$	S=1.9	1517
$\gamma f_4(2050)$		(2.7 ±0.7) $\times 10^{-3}$		874
$\gamma\omega\omega$		(1.59±0.33) $\times 10^{-3}$		1337
$\gamma\eta(1440) \to \gamma\rho^0\rho^0$		(1.7 ±0.4) $\times 10^{-3}$	S=1.3	1223
$\gamma f_2(1270)$		(1.38±0.14) $\times 10^{-3}$		1286
$\gamma f_J(1710) \to \gamma K\overline{K}$		(8.5 $^{+1.2}_{-0.9}$) $\times 10^{-4}$	S=1.2	1075

$\gamma\eta$	(8.6 ±0.8) × 10^{-4}			1500
$\gamma f_1(1420) \rightarrow \gamma K\overline{K}\pi$	(8.3 ±1.5) × 10^{-4}			1220
$\gamma f_1(1285)$	(6.5 ±1.0) × 10^{-4}			1283
$\gamma f_2'(1525)$	(4.7 $^{+0.7}_{-0.5}$) × 10^{-4}			1173
$\gamma\phi\phi$	(4.0 ±1.2) × 10^{-4}		S=2.1	1166
$\gamma p\overline{p}$	(3.8 ±1.0) × 10^{-4}			1232
$\gamma\eta(2225)$	(2.9 ±0.6) × 10^{-4}			834
$\gamma\eta(1760) \rightarrow \gamma\rho^0\rho^0$	(1.3 ±0.9) × 10^{-4}			1048
$\gamma\pi^0$	(3.9 ±1.3) × 10^{-5}			1546
$\gamma p\overline{p}\pi^+\pi^-$	< 7.9	× 10^{-4}	CL=90%	1107
$\gamma\gamma$	< 5	× 10^{-4}	CL=90%	1548
$\gamma\Lambda\overline{\Lambda}$	< 1.3	× 10^{-4}	CL=90%	1074
3γ	< 5.5	× 10^{-5}	CL=90%	1548
$\gamma f_J(2220)$	> 2.50	× 10^{-3}	CL=99.9%	–
$\gamma f_0(1500)$	(5.7 ±0.8) × 10^{-4}			1184
γe^+e^-	(8.8 ±1.4) × 10^{-3}			–

$\chi_{c0}(1P)$

$I^G(J^{PC}) = 0^+(0^{++})$

Mass $m = 3417.3 \pm 2.8$ MeV
Full width $\Gamma = 14 \pm 5$ MeV

$\chi_{c0}(1P)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
Hadronic decays			
$2(\pi^+\pi^-)$	(3.7±0.7) %		1679
$\pi^+\pi^-K^+K^-$	(3.0±0.7) %		1580
$\rho^0\pi^+\pi^-$	(1.6±0.5) %		1608
$3(\pi^+\pi^-)$	(1.5±0.5) %		1633
$K^+\overline{K}^*(892)^0\pi^- +$ c.c.	(1.2±0.4) %		1522
$\pi^+\pi^-$	(7.5±2.1) × 10^{-3}		1702
K^+K^-	(7.1±2.4) × 10^{-3}		1635
$\pi^+\pi^-p\overline{p}$	(5.0±2.0) × 10^{-3}		1320
$p\overline{p}$	< 9.0 × 10^{-4}	90%	1427
Radiative decays			
$\gamma J/\psi(1S)$	(6.6±1.8) × 10^{-3}		303
$\gamma\gamma$	< 5 × 10^{-4}	95%	1708

$\chi_{c1}(1P)$

$I^G(J^{PC}) = 0^+(1^{++})$

Mass $m = 3510.53 \pm 0.12$ MeV
Full width $\Gamma = 0.88 \pm 0.14$ MeV

$\chi_{c1}(1P)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
Hadronic decays		
$3(\pi^+\pi^-)$	(2.2±0.8) %	1683
$2(\pi^+\pi^-)$	(1.6±0.5) %	1727
$\pi^+\pi^-K^+K^-$	(9 ±4) × 10^{-3}	1632
$\rho^0\pi^+\pi^-$	(3.9±3.5) × 10^{-3}	1659
$K^+\overline{K}^*(892)^0\pi^- +$ c.c.	(3.2±2.1) × 10^{-3}	1576
$\pi^+\pi^-p\overline{p}$	(1.4±0.9) × 10^{-3}	1381
$p\overline{p}$	(8.6±1.2) × 10^{-5}	1483
$\pi^+\pi^- + K^+K^-$	< 2.1 × 10^{-3}	–
Radiative decays		
$\gamma J/\psi(1S)$	(27.3±1.6) %	389

$\chi_{c2}(1P)$

$I^G(J^{PC}) = 0^+(2^{++})$

Mass $m = 3556.17 \pm 0.13$ MeV
Full width $\Gamma = 2.00 \pm 0.18$ MeV

$\chi_{c2}(1P)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
Hadronic decays			
$2(\pi^+\pi^-)$	(2.2±0.5) %		1751
$\pi^+\pi^-K^+K^-$	(1.9±0.5) %		1656
$3(\pi^+\pi^-)$	(1.2±0.8) %		1707
$\rho^0\pi^+\pi^-$	(7 ±4) × 10^{-3}		1683
$K^+\overline{K}^*(892)^0\pi^- +$ c.c.	(4.8±2.8) × 10^{-3}		1601
$\pi^+\pi^-p\overline{p}$	(3.3±1.3) × 10^{-3}		1410
$\pi^+\pi^-$	(1.9±1.0) × 10^{-3}		1773
K^+K^-	(1.5±1.1) × 10^{-3}		1708
$p\overline{p}$	(10.0±1.0) × 10^{-5}		1510
$J/\psi(1S)\pi^+\pi^-\pi^0$	< 1.5 %	90%	185
Radiative decays			
$\gamma J/\psi(1S)$	(13.5±1.1) %		430
$\gamma\gamma$	(1.6±0.5) × 10^{-4}		1778

$\psi(2S)$

$I^G(J^{PC}) = 0^-(1^{--})$

Mass $m = 3686.00 \pm 0.09$ MeV
Full width $\Gamma = 277 \pm 31$ keV (S = 1.1)
$\Gamma_{ee} = 2.14 \pm 0.21$ keV (Assuming $\Gamma_{ee} = \Gamma_{\mu\mu}$)

$\psi(2S)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
hadrons	(98.10±0.30) %		–
virtual $\gamma \rightarrow$ hadrons	(2.9 ±0.4) %		–
e^+e^-	(8.5 ±0.7) × 10^{-3}		1843
$\mu^+\mu^-$	(7.7 ±1.7) × 10^{-3}		1840
Decays into $J/\psi(1S)$ and anything			
$J/\psi(1S)$ anything	(54.2 ±3.0) %		–
$J/\psi(1S)$ neutrals	(22.8 ±1.7) %		–
$J/\psi(1S)\pi^+\pi^-$	(30.2 ±1.9) %		477
$J/\psi(1S)\pi^0\pi^0$	(17.9 ±1.8) %		481
$J/\psi(1S)\eta$	(2.7 ±0.4) %	S=1.7	200
$J/\psi(1S)\pi^0$	(9.7 ±2.1) × 10^{-4}		527
$J/\psi(1S)\mu^+\mu^-$	(10.0 ±3.3) × 10^{-3}		–
Hadronic decays			
$3(\pi^+\pi^-)\pi^0$	(3.5 ±1.6) × 10^{-3}		1746
$2(\pi^+\pi^-)\pi^0$	(3.0 ±0.8) × 10^{-3}		1799
$\pi^+\pi^-K^+K^-$	(1.6 ±0.4) × 10^{-3}		1726
$\pi^+\pi^-p\overline{p}$	(8.0 ±2.0) × 10^{-4}		1491
$K^+\overline{K}^*(892)^0\pi^- +$ c.c.	(6.7 ±2.5) × 10^{-4}		1673
$2(\pi^+\pi^-)$	(4.5 ±1.0) × 10^{-4}		1817
$\rho^0\pi^+\pi^-$	(4.2 ±1.5) × 10^{-4}		1751
$p\overline{p}$	(1.9 ±0.5) × 10^{-4}		1586
$3(\pi^+\pi^-)$	(1.5 ±1.0) × 10^{-4}		1774
$p\overline{p}\pi^0$	(1.4 ±0.5) × 10^{-4}		1543
K^+K^-	(1.0 ±0.7) × 10^{-4}		1776
$\pi^+\pi^-\pi^0$	(9 ±5) × 10^{-5}		1830
$\rho\pi$	< 8.3 × 10^{-5}	CL=90%	1760
$\pi^+\pi^-$	(8 ±5) × 10^{-5}		1838
$\Lambda\overline{\Lambda}$	< 4 × 10^{-4}	CL=90%	1467
$\Xi^-\overline{\Xi}^+$	< 2 × 10^{-4}	CL=90%	1285
$K^+K^-\pi^0$	< 2.96 × 10^{-5}	CL=90%	1754
$K^+\overline{K}^*(892)^- +$ c.c.	< 5.4 × 10^{-5}	CL=90%	1698
Radiative decays			
$\gamma\chi_{c0}(1P)$	(9.3 ±0.9) %		261
$\gamma\chi_{c1}(1P)$	(8.7 ±0.8) %		171
$\gamma\chi_{c2}(1P)$	(7.8 ±0.8) %		127
$\gamma\eta_c(1S)$	(2.8 ±0.6) × 10^{-3}		639
$\gamma\eta'(958)$	< 1.1 × 10^{-3}	CL=90%	1719
$\gamma\gamma$	< 1.6 × 10^{-4}	CL=90%	1843
$\gamma\eta(1440) \rightarrow \gamma K\overline{K}\pi$	< 1.2 × 10^{-4}	CL=90%	1569

$\psi(3770)$

$I^G(J^{PC}) = ?^?(1^{--})$

Mass $m = 3769.9 \pm 2.5$ MeV (S = 1.8)
Full width $\Gamma = 23.6 \pm 2.7$ MeV (S = 1.1)
$\Gamma_{ee} = 0.26 \pm 0.04$ keV (S = 1.2)

$\psi(3770)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor	p (MeV/c)
$D\overline{D}$	dominant		242
e^+e^-	(1.12±0.17) × 10^{-5}	1.2	1885

$\psi(4040)$ [iii]

$I^G(J^{PC}) = ?^?(1^{--})$

Mass $m = 4040 \pm 10$ MeV
Full width $\Gamma = 52 \pm 10$ MeV
$\Gamma_{ee} = 0.75 \pm 0.15$ keV

$\psi(4040)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
e^+e^-	(1.4±0.4) × 10^{-5}	2020
$D^0\overline{D}^0$	seen	777
$D^*(2007)^0\overline{D}^0 +$ c.c.	seen	578
$D^*(2007)^0\overline{D}^*(2007)^0$	seen	232

$\psi(4160)$ [iii] $I^G(J^{PC}) = ?^?(1^{--})$

Mass $m = 4159 \pm 20$ MeV
Full width $\Gamma = 78 \pm 20$ MeV
$\Gamma_{ee} = 0.77 \pm 0.23$ keV

$\psi(4160)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
e^+e^-	$(10\pm4)\times10^{-6}$	2079

$\psi(4415)$ [iii] $I^G(J^{PC}) = ?^?(1^{--})$

Mass $m = 4415 \pm 6$ MeV
Full width $\Gamma = 43 \pm 15$ MeV (S = 1.8)
$\Gamma_{ee} = 0.47 \pm 0.10$ keV

$\psi(4415)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
hadrons	dominant	–
e^+e^-	$(1.1\pm0.4)\times10^{-5}$	2207

$b\bar{b}$ MESONS

$\Upsilon(1S)$ $I^G(J^{PC}) = 0^-(1^{--})$

Mass $m = 9460.37 \pm 0.21$ MeV (S = 2.7)
Full width $\Gamma = 52.5 \pm 1.8$ keV
$\Gamma_{ee} = 1.32 \pm 0.05$ keV

$\Upsilon(1S)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\tau^+\tau^-$	$(2.67^{+0.14}_{-0.16})$ %		4384
e^+e^-	(2.52 ± 0.17) %		4730
$\mu^+\mu^-$	(2.48 ± 0.07) %	S=1.1	4729
Hadronic decays			
$J/\psi(1S)$anything	$(1.1\ \pm0.4\ )\times10^{-3}$		4223
$\rho\pi$	$< 2 \times10^{-4}$	CL=90%	4698
$\pi^+\pi^-$	$< 5 \times10^{-4}$	CL=90%	4728
K^+K^-	$< 5 \times10^{-4}$	CL=90%	4704
$p\bar{p}$	$< 5 \times10^{-4}$	CL=90%	4636
Radiative decays			
$\gamma 2h^+2h^-$	$(7.0\ \pm1.5\ )\times10^{-4}$		4720
$\gamma 3h^+3h^-$	$(5.4\ \pm2.0\ )\times10^{-4}$		4703
$\gamma 4h^+4h^-$	$(7.4\ \pm3.5\ )\times10^{-4}$		4679
$\gamma\pi^+\pi^-K^+K^-$	$(2.9\ \pm0.9\ )\times10^{-4}$		4686
$\gamma 2\pi^+2\pi^-$	$(2.5\ \pm0.9\ )\times10^{-4}$		4720
$\gamma 3\pi^+3\pi^-$	$(2.5\ \pm1.2\ )\times10^{-4}$		4703
$\gamma 2\pi^+2\pi^-K^+K^-$	$(2.4\ \pm1.2\ )\times10^{-4}$		4658
$\gamma\pi^+\pi^-p\bar{p}$	$(1.5\ \pm0.6\ )\times10^{-4}$		4604
$\gamma 2\pi^+2\pi^-p\bar{p}$	$(4\ \ \pm6\ \ )\times10^{-5}$		4563
$\gamma 2K^+2K^-$	$(2.0\ \pm2.0\ )\times10^{-5}$		4601
$\gamma\eta'(958)$	$< 1.3 \times10^{-3}$	CL=90%	4682
$\gamma\eta$	$< 3.5 \times10^{-4}$	CL=90%	4714
$\gamma f_2'(1525)$	$< 1.4 \times10^{-4}$	CL=90%	4607
$\gamma f_2(1270)$	$< 1.3 \times10^{-4}$	CL=90%	4644
$\gamma\eta(1440)$	$< 8.2 \times10^{-5}$	CL=90%	4624
$\gamma f_J(1710) \to \gamma K\bar{K}$	$< 2.6 \times10^{-4}$	CL=90%	4576
$\gamma f_0(2200) \to \gamma K^+K^-$	$< 2 \times10^{-4}$	CL=90%	4475
$\gamma f_J(2220) \to \gamma K^+K^-$	$< 1.5 \times10^{-5}$	CL=90%	4469
$\gamma\eta(2225) \to \gamma\phi\phi$	$< 3 \times10^{-3}$	CL=90%	4469
γX	$< 3 \times10^{-5}$	CL=90%	–
X = pseudoscalar with $m<7.2$ GeV)			
$\gamma X\overline{X}$	$< 1 \times10^{-3}$	CL=90%	–
$X\overline{X}$ = vectors with $m<3.1$ GeV)			

$\chi_{b0}(1P)$ [iii] $I^G(J^{PC}) = 0^+(0^{++})$
J needs confirmation.

Mass $m = 9859.8 \pm 1.3$ MeV

$\chi_{b0}(1P)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\gamma\Upsilon(1S)$	<6 %	90%	391

$\chi_{b1}(1P)$ [iii] $I^G(J^{PC}) = 0^+(1^{++})$
J needs confirmation.

Mass $m = 9891.9 \pm 0.7$ MeV

$\chi_{b1}(1P)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\gamma\Upsilon(1S)$	(35±8) %	422

$\chi_{b2}(1P)$ [iii] $I^G(J^{PC}) = 0^+(2^{++})$
J needs confirmation.

Mass $m = 9913.2 \pm 0.6$ MeV

$\chi_{b2}(1P)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\gamma\Upsilon(1S)$	(22±4) %	443

$\Upsilon(2S)$ $I^G(J^{PC}) = 0^-(1^{--})$

Mass $m = 10.02330 \pm 0.00031$ GeV
Full width $\Gamma = 44 \pm 7$ keV
$\Gamma_{ee} = 0.520 \pm 0.032$ keV

$\Upsilon(2S)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\Upsilon(1S)\pi^+\pi^-$	(18.5 ±0.8) %		475
$\Upsilon(1S)\pi^0\pi^0$	(8.8 ±1.1) %		480
$\tau^+\tau^-$	(1.7 ±1.6) %		4686
$\mu^+\mu^-$	(1.31±0.21) %		5011
e^+e^-	(1.18±0.20) %		5012
$\Upsilon(1S)\pi^0$	$< 8 \times10^{-3}$	90%	531
$\Upsilon(1S)\eta$	$< 2 \times10^{-3}$	90%	127
$J/\psi(1S)$anything	$< 6 \times10^{-3}$	90%	4533
Radiative decays			
$\gamma\chi_{b1}(1P)$	(6.7 ±0.9) %		131
$\gamma\chi_{b2}(1P)$	(6.6 ±0.9) %		110
$\gamma\chi_{b0}(1P)$	(4.3 ±1.0) %		162
$\gamma f_J(1710)$	$< 5.9 \times10^{-4}$	90%	4866
$\gamma f_2'(1525)$	$< 5.3 \times10^{-4}$	90%	4896
$\gamma f_2(1270)$	$< 2.41 \times10^{-4}$	90%	4931

$\chi_{b0}(2P)$ [iii] $I^G(J^{PC}) = 0^+(0^{++})$
J needs confirmation.

Mass $m = 10.2321 \pm 0.0006$ GeV

$\chi_{b0}(2P)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\gamma\Upsilon(2S)$	(4.6±2.1) %	210
$\gamma\Upsilon(1S)$	$(9\ \ \pm6\ \ )\times10^{-3}$	746

$\chi_{b1}(2P)$ [iii] $I^G(J^{PC}) = 0^+(1^{++})$
J needs confirmation.

Mass $m = 10.2552 \pm 0.0005$ GeV
$m_{\chi_{b1}(2P)} - m_{\chi_{b0}(2P)} = 23.5 \pm 1.0$ MeV

$\chi_{b1}(2P)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor	p (MeV/c)
$\gamma\Upsilon(2S)$	(21 ±4) %	1.5	229
$\gamma\Upsilon(1S)$	(8.5±1.3) %	1.3	764

$\chi_{b2}(2P)$ [iii] $I^G(J^{PC}) = 0^+(2^{++})$
J needs confirmation.

Mass $m = 10.2685 \pm 0.0004$ GeV
$m_{\chi_{b2}(2P)} - m_{\chi_{b1}(2P)} = 13.5 \pm 0.6$ MeV

$\chi_{b2}(2P)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\gamma\Upsilon(2S)$	(16.2±2.4) %	242
$\gamma\Upsilon(1S)$	(7.1±1.0) %	776

$\Upsilon(3S)$ $I^G(J^{PC}) = 0^-(1^{--})$

Mass $m = 10.3553 \pm 0.0005$ GeV
Full width $\Gamma = 26.3 \pm 3.5$ keV

$\Upsilon(3S)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\Upsilon(2S)$ anything	(10.6 ±0.8) %		296
$\Upsilon(2S)\pi^+\pi^-$	(2.8 ±0.6) %	S=2.2	177
$\Upsilon(2S)\pi^0\pi^0$	(2.00±0.32) %		190
$\Upsilon(2S)\gamma\gamma$	(5.0 ±0.7) %		327
$\Upsilon(1S)\pi^+\pi^-$	(4.48±0.21) %		814
$\Upsilon(1S)\pi^0\pi^0$	(2.06±0.28) %		816
$\Upsilon(1S)\eta$	$< 2.2 \times 10^{-3}$	CL=90%	–
$\mu^+\mu^-$	(1.81±0.17) %		5177
e^+e^-	seen		5177
Radiative decays			
$\gamma\chi_{b2}(2P)$	(11.4 ±0.8) %	S=1.3	87
$\gamma\chi_{b1}(2P)$	(11.3 ±0.6) %		100
$\gamma\chi_{b0}(2P)$	(5.4 ±0.6) %	S=1.1	123

$\Upsilon(4S)$ or $\Upsilon(10580)$ $I^G(J^{PC}) = ?^?(1^{--})$

Mass $m = 10.5800 \pm 0.0035$ GeV
Full width $\Gamma = 10 \pm 4$ MeV
$\Gamma_{ee} = 0.248 \pm 0.031$ keV (S = 1.3)

$\Upsilon(4S)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$B\overline{B}$	> 96 %	95%	–
non-$B\overline{B}$	< 4 %	95%	–
e^+e^-	$(2.8\pm0.7)\times10^{-5}$		5290
$J/\psi(3097)$ anything	$(2.2\pm0.7)\times10^{-3}$		–
D^{*+} anything + c.c.	< 7.4 %	90%	5099
ϕ anything	$< 2.3 \times 10^{-3}$	90%	5240
$\Upsilon(1S)$ anything	$< 4 \times 10^{-3}$	90%	1053

$\Upsilon(10860)$ $I^G(J^{PC}) = ?^?(1^{--})$

Mass $m = 10.865 \pm 0.008$ GeV (S = 1.1)
Full width $\Gamma = 110 \pm 13$ MeV
$\Gamma_{ee} = 0.31 \pm 0.07$ keV (S = 1.3)

$\Upsilon(10860)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
e^+e^-	$(2.8\pm0.7)\times10^{-6}$	5432

$\Upsilon(11020)$ $I^G(J^{PC}) = ?^?(1^{--})$

Mass $m = 11.019 \pm 0.008$ GeV
Full width $\Gamma - 79 \pm 16$ MeV
$\Gamma_{ee} = 0.130 \pm 0.030$ keV

$\Upsilon(11020)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
e^+e^-	$(1.6\pm0.5)\times10^{-6}$	5509

NOTES

In this Summary Table:

When a quantity has "(S = ...)" to its right the error on the quantity has been enlarged by the "scale factor" S defined as $S = \sqrt{\chi^2/(N-1)}$ where N is the number of measurements used in calculating the quantity. We do this when $S > 1$ which often indicates that the measurements are inconsistent. When $S > 1.25$ we also show in the Particle Listings an ideogram of the measurements. For more about S see the Introduction.

A decay momentum p is given for each decay mode. For a 2-body decay p is the momentum of each decay product in the rest frame of the decaying particle. For a 3-or-more-body decay p is the largest momentum any of the products can have in this frame.

[a] See the "Note on $\pi^\pm \to \ell^\pm\nu\gamma$ and $K^\pm \to \ell^\pm\nu\gamma$ Form Factors" in the $\pi^\pm$ Particle Listings for definitions and details.

[b] Measurements of $\Gamma(e^+\nu_e)/\Gamma(\mu^+\nu_\mu)$ always include decays with γ's and measurements of $\Gamma(e^+\nu_e\gamma)$ and $\Gamma(\mu^+\nu_\mu\gamma)$ never include low-energy γ's. Therefore, since no clean separation is possible, we consider the modes with γ's to be subreactions of the modes without them and let $[\Gamma(e^+\nu_e) + \Gamma(\mu^+\nu_\mu)]/\Gamma_{\text{total}} = 100\%$.

[c] See the $\pi^\pm$ Particle Listings for the energy limits used in this measurement; low-energy γ's are not included.

[d] Derived from an analysis of neutrino-oscillation experiments.

[e] Astrophysical and cosmological arguments give limits of order 10^{-13}; see the π^0 Particle Listings.

[f] See the "Note on the Decay Width $\Gamma(\eta \to \gamma\gamma)$" in our 1994 edition, Phys. Rev. **D50**, 1 August 1994, Part I, p. 1451.

[g] C parity forbids this to occur as a single-photon process.

[h] See the "Note on scalar mesons" in the $f_0(1370)$ Particle Listings . The interpretation of this entry as a particle is controversial.

[i] See the "Note on $\rho(770)$" in the $\rho(770)$ Particle Listings .

[j] The $e^+e^- \to \pi^+\pi^-$ branching fraction is from $e^+e^- \to \pi^+\pi^-$ experiments only. The $\omega\rho$ interference is then due to $\omega\rho$ mixing only, and is expected to be small. If $e\mu$ universality holds, $\Gamma(\rho^0 \to \mu^+\mu^-) = \Gamma(\rho^0 \to e^+e^-) \times 0.99785$.

[k] See the "Note on scalar mesons" in the $f_0(1370)$ Particle Listings .

[l] See the "Note on $a_1(1260)$" in the $a_1(1260)$ Particle Listings .

[m] This is only an educated guess; the error given is larger than the error on the average of the published values. See the Particle Listings for details.

[n] See the "Note on the $f_1(1420)$" in the $\eta(1440)$ Particle Listings.

[o] See also the $\omega(1600)$ Particle Listings.

[p] See the "Note on the $\eta(1440)$" in the $\eta(1440)$ Particle Listings.

[q] See the "Note on the $\rho(1450)$ and the $\rho(1700)$" in the $\rho(1700)$ Particle Listings.

[r] See the "Note on non-$q\overline{q}$ mesons" in the Particle Listings (see the index for the page number).

[s] See also the $\omega(1420)$ Particle Listings.

[t] See the "Note on $f_J(1710)$" in the $f_J(1710)$ Particle Listings .

[u] See the note in the $K^\pm$ Particle Listings.

[v] The definition of the slope parameter g of the $K \to 3\pi$ Dalitz plot is as follows (see also "Note on Dalitz Plot Parameters for $K \to 3\pi$ Decays" in the $K^\pm$ Particle Listings):

$$|M|^2 = 1 + g(s_3 - s_0)/m^2_{\pi^-} + \cdots .$$

[*w*] For more details and definitions of parameters see the Particle Listings.

[*x*] See the $K^{\pm}$ Particle Listings for the energy limits used in this measurement.

[*y*] Most of this radiative mode's the low-momentum γ part's is also included in the parent mode listed without γ's.

[*z*] Direct-emission branching fraction.

[*aa*] Structure-dependent part.

[*bb*] Derived from measured values of ϕ_{+-}, ϕ_{00}, $|\eta|$, $|m_{K^0_L} - m_{K^0_S}|$, and $\tau_{K^0_S}$, as described in the introduction to "Tests of Conservation Laws."

[*cc*] The *CP*-violation parameters are defined as follows (see also "Note on *CP* Violation in $K_S \to 3\pi$" and "Note on *CP* Violation in K^0_L Decay" in the Particle Listings):

$$\eta_{+-} = |\eta_{+-}|e^{i\phi_{+-}} = \frac{A(K^0_L \to \pi^+\pi^-)}{A(K^0_S \to \pi^+\pi^-)} = \epsilon + \epsilon'$$

$$\eta_{00} = |\eta_{00}|e^{i\phi_{00}} = \frac{A(K^0_L \to \pi^0\pi^0)}{A(K^0_S \to \pi^0\pi^0)} = \epsilon - 2\epsilon'$$

$$\delta = \frac{\Gamma(K^0_L \to \pi^-\ell^+\nu) - \Gamma(K^0_L \to \pi^+\ell^-\nu)}{\Gamma(K^0_L \to \pi^-\ell^+\nu) + \Gamma(K^0_L \to \pi^+\ell^-\nu)}$$

$$\mathrm{Im}(\eta_{+-0})^2 = \frac{\Gamma(K^0_S \to \pi^+\pi^-\pi^0)_{CP\ \mathrm{viol.}}}{\Gamma(K^0_L \to \pi^+\pi^-\pi^0)}$$

$$\mathrm{Im}(\eta_{000})^2 = \frac{\Gamma(K^0_S \to \pi^0\pi^0\pi^0)}{\Gamma(K^0_L \to \pi^0\pi^0\pi^0)}.$$

where for the last two relations *CPT* is assumed valid, *i.e.*, $\mathrm{Re}(\eta_{+-0}) \simeq 0$ and $\mathrm{Re}(\eta_{000}) \simeq 0$.

[*dd*] See the K^0_S Particle Listings for the energy limits used in this measurement.

[*ee*] Calculated from K^0_L semileptonic rates and the K^0_S lifetime assuming $\Delta S = \Delta Q$.

[*ff*] ϵ'/ϵ is derived from $|\eta_{00}/\eta_{+-}|$ measurements using theoretical input on phases.

[*gg*] The value is for the sum of the charge states of particle/antiparticle states indicated.

[*hh*] See the K^0_L Particle Listings for the energy limits used in this measurement.

[*ii*] Allowed by higher-order electroweak interactions.

[*jj*] Violates *CP* in leading order. Test of direct *CP* violation since the indirect *CP*-violating and *CP*-conserving contributions are expected to be suppressed.

[*kk*] See the "Note on $f_0(1370)$" in the $f_0(1370)$ Particle Listings and in the 1994 edition.

[*ll*] See the note in the $L(1770)$ Particle Listings in Reviews of Modern Physics **56** No. 2 Pt. II (1984), p. S200. See also the "Note on $K_2(1770)$ and the $K_2(1820)$" in the $K_2(1770)$ Particle Listings .

[*mm*] See the "Note on $K_2(1770)$ and the $K_2(1820)$" in the $K_2(1770)$ Particle Listings .

[*nn*] This is a weighted average of $D^{\pm}$ (44%) and D^0 (56%) branching fractions. See "D^+ and $D^0 \to$ (η anything) / (total D^+ and D^0)" under "D^+ Branching Ratios" in the Particle Listings.

[*oo*] This value averages the e^+ and μ^+ branching fractions, after making a small phase-space adjustment to the μ^+ fraction to be able to use it as an e^+ fraction; hence our ℓ^+ here is really an e^+.

[*pp*] An ℓ indicates an e or a μ mode, not a sum over these modes.

[*qq*] The branching fraction for this mode may differ from the sum of the submodes that contribute to it, due to interference effects. See the relevant papers in the Particle Listings.

[*rr*] The two experiments measuring this fraction are in serious disagreement. See the Particle Listings.

[*ss*] This mode is not a useful test for a ΔC=1 weak neutral current because both quarks must change flavor in this decay.

[*tt*] The D^0_1-D^0_2 limits are inferred from the D^0-$\overline{D}^0$ mixing ratio $\Gamma(K^+\ell^-\overline{\nu}_\ell(\mathrm{via}\ \overline{D}^0))\ /\ \Gamma(K^-\ell^+\nu_\ell)$.

[*uu*] The larger limit (from E791) allows interference between the doubly Cabibbo-suppressed and mixing amplitudes; the smaller limit (from E691) doesn't. See the papers for details.

[*vv*] The experiments on the division of this charge mode amongst its submodes disagree, and the submode branching fractions here add up to considerably more than the charged-mode fraction.

[*ww*] However, these upper limits are in serious disagreement with values obtained in another experiment.

[*xx*] For now, we average together measurements of the $X e^+\nu_e$ and $X \mu^+\nu_\mu$ branching fractions. This is the *average*, not the *sum*.

[*yy*] This branching fraction includes all the decay modes of the final-state resonance.

[*zz*] This value includes only K^+K^- decays of the $f_J(1710)$, because branching fractions of this resonance are not known.

[*aaa*] This value includes only $\pi^+\pi^-$ decays of the $f_0(1500)$, because branching fractions of this resonance are not known.

[*bbb*] B^0 and B^0_s contributions not separated. Limit is on weighted average of the two decay rates.

[*ccc*] These values are model dependent. See 'Note on Semileptonic Decays' in the B^+ Particle Listings.

[*ddd*] D^{**} stands for the sum of the $D(1\,^1P_1)$, $D(1\,^3P_0)$, $D(1\,^3P_1)$, $D(1\,^3P_2)$, $D(2\,^1S_0)$, and $D(2\,^1S_1)$ resonances.

[*eee*] Inclusive branching fractions have a multiplicity definition and can be greater than 100%.

[*fff*] D_j represents an unresolved mixture of pseudoscalar and tensor D^{**} (P-wave) states.

[*ggg*] Not a pure measurement. See note at head of B^0_S Decay Modes.

[*hhh*] Includes $p\bar{p}\pi^+\pi^-\gamma$ and excludes $p\bar{p}\eta$, $p\bar{p}\omega$, $p\bar{p}\eta'$.

[*iii*] J^{PC} known by production in e^+e^- via single photon annihilation. I^G is not known; interpretation of this state as a single resonance is unclear because of the expectation of substantial threshold effects in this energy region.

[*jjj*] Spectroscopic labeling for these states is theoretical, pending experimental information.

See also the table of suggested $q\bar{q}$ quark-model assignments in the Quark Model section.

- • Indicates particles that appear in the preceding Meson Summary Table. We do not regard the other entries as being established.
- † Indicates that the value of J given is preferred, but needs confirmation.

LIGHT UNFLAVORED ($S = C = B = 0$)

	$I^G(J^{PC})$
• $\pi^{\pm}$	$1^-(0^{-+})$
• π^0	$1^-(0^{-+})$
• η	$0^+(0^{-+})$
• $f_0(400\text{–}1200)$	$0^+(0^{++})$
• $\rho(770)$	$1^+(1^{--})$
• $\omega(782)$	$0^-(1^{--})$
• $\eta'(958)$	$0^+(0^{-+})$
• $f_0(980)$	$0^+(0^{++})$
• $a_0(980)$	$1^-(0^{++})$
• $\phi(1020)$	$0^-(1^{--})$
• $h_1(1170)$	$0^-(1^{+-})$
• $b_1(1235)$	$1^+(1^{+-})$
• $a_1(1260)$	$1^-(1^{++})$
• $f_2(1270)$	$0^+(2^{++})$
• $f_1(1285)$	$0^+(1^{++})$
• $\eta(1295)$	$0^+(0^{-+})$
• $\pi(1300)$	$1^-(0^{-+})$
• $a_2(1320)$	$1^-(2^{++})$
• $f_0(1370)$	$0^+(0^{++})$
$h_1(1380)$	$?^-(1^{+-})$
$\hat{\rho}(1405)$	$1^-(1^{-+})$
• $f_1(1420)$	$0^+(1^{++})$
• $\omega(1420)$	$0^-(1^{--})$
$f_2(1430)$	$0^+(2^{++})$
• $\eta(1440)$	$0^+(0^{-+})$
• $a_0(1450)$	$1^-(0^{++})$
• $\rho(1450)$	$1^+(1^{--})$
• $f_0(1500)$	$0^+(0^{++})$
$f_1(1510)$	$0^+(1^{++})$
• $f_2'(1525)$	$0^+(2^{++})$
$f_2(1565)$	$0^+(2^{++})$
• $\omega(1600)$	$0^-(1^{--})$
$X(1600)$	$2^+(2^{++})$
$f_2(1640)$	$0^+(2^{++})$
$\eta_2(1645)$	$0^+(2^{-+})$
$X(1650)$	$0^+(?^{?-})$
• $\omega_3(1670)$	$0^-(3^{--})$
• $\pi_2(1670)$	$1^-(2^{-+})$
• $\phi(1680)$	$0^-(1^{--})$
• $\rho_3(1690)$	$1^+(3^{--})$
• $\rho(1700)$	$1^+(1^{--})$
• $f_J(1710)$	$0^+(\text{even}^{++})$
$\eta(1760)$	$0^+(0^{-+})$
$X(1775)$	$1^-(?^{-+})$
• $\pi(1800)$	$1^-(0^{-+})$
$f_2(1810)$	$0^+(2^{++})$
• $\phi_3(1850)$	$0^-(3^{--})$
$\eta_2(1870)$	$0^+(2^{-+})$
$X(1910)$	$0^+(?^{?+})$
$f_2(1950)$	$0^+(2^{++})$
$X(2000)$	$1^-(?^{?+})$
• $f_2(2010)$	$0^+(2^{++})$
$f_0(2020)$	$0^+(0^{++})$
• $a_4(2040)$	$1^-(4^{++})$
• $f_4(2050)$	$0^+(4^{++})$
$f_0(2060)$	$0^+(0^{++})$
$\pi_2(2100)$	$1^-(2^{-+})$
$f_2(2150)$	$0^+(2^{++})$
$\rho(2150)$	$1^+(1^{--})$
$f_0(2200)$	$0^+(0^{++})$
$f_J(2220)$	$0^+(2^{++}$ or $4^{++})$
$\eta(2225)$	$0^+(0^{-+})$
$\rho_3(2250)$	$1^+(3^{--})$
• $f_2(2300)$	$0^+(2^{++})$
$f_4(2300)$	$0^+(4^{++})$
• $f_2(2340)$	$0^+(2^{++})$
$\rho_5(2350)$	$1^+(5^{--})$
$a_6(2450)$	$1^-(6^{++})$
$f_6(2510)$	$0^+(6^{++})$
$X(3250)$	$?^?(?^{??})$

OTHER LIGHT UNFLAVORED ($S = C = B = 0$)

$e^+e^-(1100\text{–}2200)$	$?^?(1^{--})$
$\overline{N}N(1100\text{–}3600)$	
$X(1900\text{–}3600)$	

STRANGE ($S = \pm 1$, $C = B = 0$)

	$I(J^P)$
• $K^{\pm}$	$1/2(0^-)$
• K^0	$1/2(0^-)$
• K_S^0	$1/2(0^-)$
• K_L^0	$1/2(0^-)$
• $K^*(892)$	$1/2(1^-)$
• $K_1(1270)$	$1/2(1^+)$
• $K_1(1400)$	$1/2(1^+)$
• $K^*(1410)$	$1/2(1^-)$
• $K_0^*(1430)$	$1/2(0^+)$
• $K_2^*(1430)$	$1/2(2^+)$
$K(1460)$	$1/2(0^-)$
$K_2(1580)$	$1/2(2^-)$
$K_1(1650)$	$1/2(1^+)$
• $K^*(1680)$	$1/2(1^-)$
• $K_2(1770)$	$1/2(2^-)$
• $K_3^*(1780)$	$1/2(3^-)$
• $K_2(1820)$	$1/2(2^-)$
$K(1830)$	$1/2(0^-)$
$K_0^*(1950)$	$1/2(0^+)$
$K_2^*(1980)$	$1/2(2^+)$
• $K_4^*(2045)$	$1/2(4^+)$
$K_2(2250)$	$1/2(2^-)$
$K_3(2320)$	$1/2(3^+)$
$K_5^*(2380)$	$1/2(5^-)$
$K_4(2500)$	$1/2(4^-)$
$K(3100)$	$?^?(?^{??})$

CHARMED ($C = \pm 1$)

• $D^{\pm}$	$1/2(0^-)$
• D^0	$1/2(0^-)$
• $D^*(2007)^0$	$1/2(1^-)$
• $D^*(2010)^{\pm}$	$1/2(1^-)$
• $D_1(2420)^0$	$1/2(1^+)$
$D_1(2420)^{\pm}$	$1/2(?^?)$
• $D_2^*(2460)^0$	$1/2(2^+)$
• $D_2^*(2460)^+$	$1/2(2^+)$

CHARMED, STRANGE ($C = S = \pm 1$)

• $D_s^{\pm}$	$0(0^-)$
• $D_s^{*\pm}$	$0(?^?)$
• $D_{s1}(2536)^{\pm}$	$0(1^+)$
• $D_{sJ}(2573)^{\pm}$	$0(?^?)$

BOTTOM ($B = \pm 1$)

• $B^{\pm}$	$1/2(0^-)$
• B^0	$1/2(0^-)$
• B^*	$1/2(1^-)$
$B_J^*(5732)$	$?(?^?)$

BOTTOM, STRANGE ($B = \pm 1$, $S = \mp 1$)

	$I^G(J^{PC})$
• B_s^0	$0(0^-)$
B_s^*	$0(1^-)$
$B_{sJ}^*(5850)$	$?(?^?)$

BOTTOM, CHARMED ($B = C = \pm 1$)

$B_c^{\pm}$	$0(0^-)$

$c\bar{c}$

	$I^G(J^{PC})$
• $\eta_c(1S)$	$0^+(0^{-+})$
• $J/\psi(1S)$	$0^-(1^{--})$
• $\chi_{c0}(1P)$	$0^+(0^{++})$
• $\chi_{c1}(1P)$	$0^+(1^{++})$
$h_c(1P)$	$?^?(?^{??})$
• $\chi_{c2}(1P)$	$0^+(2^{++})$
$\eta_c(2S)$	$?^?(?^{?+})$
• $\psi(2S)$	$0^-(1^{--})$
• $\psi(3770)$	$?^?(1^{--})$
• $\psi(4040)$	$?^?(1^{--})$
• $\psi(4160)$	$?^?(1^{--})$
• $\psi(4415)$	$?^?(1^{--})$

$b\bar{b}$

	$I^G(J^{PC})$
• $\Upsilon(1S)$	$0^-(1^{--})$
• $\chi_{b0}(1P)$	$0^+(0^{++})$
• $\chi_{b1}(1P)$	$0^+(1^{++})$
• $\chi_{b2}(1P)$	$0^+(2^{++})$
• $\Upsilon(2S)$	$0^-(1^{--})$
• $\chi_{b0}(2P)$	$0^+(0^{++})$
• $\chi_{b1}(2P)$	$0^+(1^{++})$
• $\chi_{b2}(2P)$	$0^+(2^{++})$
• $\Upsilon(3S)$	$0^-(1^{--})$
• $\Upsilon(4S)$	$?^?(1^{--})$
• $\Upsilon(10860)$	$?^?(1^{--})$
• $\Upsilon(11020)$	$?^?(1^{--})$

NON-$q\bar{q}$ CANDIDATES

Non-$q\bar{q}$ Candidates

BARYON SUMMARY TABLE

This short table gives the name, the quantum numbers (where known), and the status of baryons in the Review. Only the baryons with 3- or 4-star status are included in the main Baryon Summary Table. Due to insufficient data or uncertain interpretation, the other entries in the short table are not established as baryons. The names with masses are of baryons that decay strongly. See our 1986 edition (Physics Letters **170B**) for listings of evidence for Z baryons (KN resonances).

p	P_{11}	****	$\Delta(1232)$	P_{33}	****	Λ	P_{01}	****	Σ^+	P_{11}	****	Ξ^0	P_{11}	****
n	P_{11}	****	$\Delta(1600)$	P_{33}	***	$\Lambda(1405)$	S_{01}	****	Σ^0	P_{11}	****	Ξ^-	P_{11}	****
$N(1440)$	P_{11}	****	$\Delta(1620)$	S_{31}	****	$\Lambda(1520)$	D_{03}	****	Σ^-	P_{11}	****	$\Xi(1530)$	P_{13}	****
$N(1520)$	D_{13}	****	$\Delta(1700)$	D_{33}	****	$\Lambda(1600)$	P_{01}	***	$\Sigma(1385)$	P_{13}	****	$\Xi(1620)$		*
$N(1535)$	S_{11}	****	$\Delta(1750)$	P_{31}	*	$\Lambda(1670)$	S_{01}	****	$\Sigma(1480)$		*	$\Xi(1690)$		***
$N(1650)$	S_{11}	****	$\Delta(1900)$	S_{31}	**	$\Lambda(1690)$	D_{03}	****	$\Sigma(1560)$		**	$\Xi(1820)$	D_{13}	***
$N(1675)$	D_{15}	****	$\Delta(1905)$	F_{35}	****	$\Lambda(1800)$	S_{01}	***	$\Sigma(1580)$	D_{13}	**	$\Xi(1950)$		***
$N(1680)$	F_{15}	****	$\Delta(1910)$	P_{31}	****	$\Lambda(1810)$	P_{01}	***	$\Sigma(1620)$	S_{11}	**	$\Xi(2030)$		***
$N(1700)$	D_{13}	***	$\Delta(1920)$	P_{33}	***	$\Lambda(1820)$	F_{05}	****	$\Sigma(1660)$	P_{11}	***	$\Xi(2120)$		*
$N(1710)$	P_{11}	***	$\Delta(1930)$	D_{35}	***	$\Lambda(1830)$	D_{05}	****	$\Sigma(1670)$	D_{13}	****	$\Xi(2250)$		**
$N(1720)$	P_{13}	****	$\Delta(1940)$	D_{33}	*	$\Lambda(1890)$	P_{03}	****	$\Sigma(1690)$		**	$\Xi(2370)$		**
$N(1900)$	P_{13}	**	$\Delta(1950)$	F_{37}	****	$\Lambda(2000)$		*	$\Sigma(1750)$	S_{11}	***	$\Xi(2500)$		*
$N(1990)$	F_{17}	**	$\Delta(2000)$	F_{35}	**	$\Lambda(2020)$	F_{07}	*	$\Sigma(1770)$	P_{11}	*			
$N(2000)$	F_{15}	**	$\Delta(2150)$	S_{31}	*	$\Lambda(2100)$	G_{07}	****	$\Sigma(1775)$	D_{15}	****	Ω^-		****
$N(2080)$	D_{13}	**	$\Delta(2200)$	G_{37}	*	$\Lambda(2110)$	F_{05}	***	$\Sigma(1840)$	P_{13}	*	$\Omega(2250)^-$		***
$N(2090)$	S_{11}	*	$\Delta(2300)$	H_{39}	**	$\Lambda(2325)$	D_{03}	*	$\Sigma(1880)$	P_{11}	**	$\Omega(2380)^-$		**
$N(2100)$	P_{11}	*	$\Delta(2350)$	D_{35}	*	$\Lambda(2350)$	H_{09}	***	$\Sigma(1915)$	F_{15}	****	$\Omega(2470)^-$		**
$N(2190)$	G_{17}	****	$\Delta(2390)$	F_{37}	*	$\Lambda(2585)$		**	$\Sigma(1940)$	D_{13}	***			
$N(2200)$	D_{15}	**	$\Delta(2400)$	G_{39}	**				$\Sigma(2000)$	S_{11}	*	Λ_c^+		****
$N(2220)$	H_{19}	****	$\Delta(2420)$	$H_{3,11}$	****				$\Sigma(2030)$	F_{17}	****	$\Lambda_c(2593)^+$		***
$N(2250)$	G_{19}	****	$\Delta(2750)$	$I_{3,13}$	**				$\Sigma(2070)$	F_{15}	*	$\Lambda_c(2625)^+$		***
$N(2600)$	$I_{1,11}$	***	$\Delta(2950)$	$K_{3,15}$	**				$\Sigma(2080)$	P_{13}	**	$\Sigma_c(2455)$		****
$N(2700)$	$K_{1,13}$	**							$\Sigma(2100)$	G_{17}	*	$\Sigma_c(2520)$		***
									$\Sigma(2250)$		***	Ξ_c^+		***
									$\Sigma(2455)$		**	Ξ_c^0		***
									$\Sigma(2620)$		**	$\Xi_c(2645)$		***
									$\Sigma(3000)$		*	Ω_c^0		***
									$\Sigma(3170)$		*			
												Λ_b^0		***
												Ξ_b^0, Ξ_b^-		*

**** Existence is certain, and properties are at least fairly well explored.

*** Existence ranges from very likely to certain, but further confirmation is desirable and/or quantum numbers, branching fractions, etc. are not well determined.

** Evidence of existence is only fair.

* Evidence of existence is poor.

N BARYONS
($S = 0$, $I = 1/2$)

p or $N^+ = uud$; n or $N^0 = udd$

p

$I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$

Mass $m = 938.27231 \pm 0.00028$ MeV [a]
$= 1.007276470 \pm 0.000000012$ u
$|\frac{q_p}{m_p}|/(\frac{q_p}{m_p}) = 1.0000000015 \pm 0.0000000011$
$|q_p + q_p|/e < 2 \times 10^{-5}$
$|q_p + q_e|/e < 1.0 \times 10^{-21}$ [b]
Magnetic moment $\mu = 2.79284739 \pm 0.00000006\ \mu_N$
Electric dipole moment $d = (-4 \pm 6) \times 10^{-23}$ $e$cm
Electric polarizability $\overline{\alpha} = (12.1 \pm 0.9) \times 10^{-4}$ fm^3
Magnetic polarizability $\overline{\beta} = (2.1 \pm 0.9) \times 10^{-4}$ fm^3
Mean life $\tau > 1.6 \times 10^{25}$ years (independent of mode)
$> 10^{31}$ to 5×10^{32} years [c] (mode dependent)

Below Γ for N decays Γ_p and n distinguish proton and neutron partial lifetimes. See also the "Note on Nucleon Decay" in our 1994 edition (Phys. Rev. **D50** Γ 1673) for a short review.

The "partial mean life" limits tabulated here are the limits on $\tau/B_i \Gamma$ where τ is the total mean life and B_i is the branching fraction for the mode in question.

p DECAY MODES	Partial mean life (10^{30} years)	Confidence level	p (MeV/c)
Antilepton + meson			
$N \to e^+\pi$	> 130 (n) $\Gamma > 550$ (p)	90%	459
$N \to \mu^+\pi$	> 100 (n) $\Gamma > 270$ (p)	90%	453
$N \to \nu\pi$	> 100 (n) $\Gamma > 25$ (p)	90%	459
$p \to e^+\eta$	> 140	90%	309
$p \to \mu^+\eta$	> 69	90%	296
$n \to \nu\eta$	> 54	90%	310
$N \to e^+\rho$	> 58 (n) $\Gamma > 75$ (p)	90%	153
$N \to \mu^+\rho$	> 23 (n) $\Gamma > 110$ (p)	90%	119
$N \to \nu\rho$	> 19 (n) $\Gamma > 27$ (p)	90%	153
$p \to e^+\omega$	> 45	90%	142
$p \to \mu^+\omega$	> 57	90%	104
$n \to \nu\omega$	> 43	90%	144
$N \to e^+K$	> 1.3 (n) $\Gamma > 150$ (p)	90%	337
$p \to e^+K^0_S$	> 76	90%	337
$p \to e^+K^0_L$	> 44	90%	337
$N \to \mu^+K$	> 1.1 (n) $\Gamma > 120$ (p)	90%	326
$p \to \mu^+K^0_S$	> 64	90%	326
$p \to \mu^+K^0_L$	> 44	90%	326
$N \to \nu K$	> 86 (n) $\Gamma > 100$ (p)	90%	339
$p \to e^+K^*(892)^0$	> 52	90%	45
$N \to \nu K^*(892)$	> 22 (n) $\Gamma > 20$ (p)	90%	45
Antilepton + mesons			
$p \to e^+\pi^+\pi^-$	> 21	90%	448
$p \to e^+\pi^0\pi^0$	> 38	90%	449
$n \to e^+\pi^-\pi^0$	> 32	90%	449
$p \to \mu^+\pi^+\pi^-$	> 17	90%	425
$p \to \mu^+\pi^0\pi^0$	> 33	90%	427
$n \to \mu^+\pi^-\pi^0$	> 33	90%	427
$n \to e^+K^0\pi^-$	> 18	90%	319
Lepton + meson			
$n \to e^-\pi^+$	> 65	90%	459
$n \to \mu^-\pi^+$	> 49	90%	453
$n \to e^-\rho^+$	> 62	90%	154
$n \to \mu^-\rho^+$	> 7	90%	120
$n \to e^-K^+$	> 32	90%	340
$n \to \mu^-K^+$	> 57	90%	330
Lepton + mesons			
$p \to e^-\pi^+\pi^+$	> 30	90%	448
$n \to e^-\pi^+\pi^0$	> 29	90%	449
$p \to \mu^-\pi^+\pi^+$	> 17	90%	425
$n \to \mu^-\pi^+\pi^0$	> 34	90%	427
$p \to e^-\pi^+K^+$	> 20	90%	320
$p \to \mu^-\pi^+K^+$	> 5	90%	279
Antilepton + photon(s)			
$p \to e^+\gamma$	> 460	90%	469
$p \to \mu^+\gamma$	> 380	90%	463
$n \to \nu\gamma$	> 24	90%	470
$p \to e^+\gamma\gamma$	> 100	90%	469
Three (or more) leptons			
$p \to e^+e^+e^-$	> 510	90%	469
$p \to e^+\mu^+\mu^-$	> 81	90%	457
$p \to e^+\nu\nu$	> 11	90%	469
$n \to e^+e^-\nu$	> 74	90%	470
$n \to \mu^+e^-\nu$	> 47	90%	464
$n \to \mu^+\mu^-\nu$	> 42	90%	458
$p \to \mu^+e^+e^-$	> 91	90%	464
$p \to \mu^+\mu^+\mu^-$	> 190	90%	439
$p \to \mu^+\nu\nu$	> 21	90%	463
$p \to e^-\mu^+\mu^+$	> 6	90%	457
$n \to 3\nu$	> 0.0005	90%	470
Inclusive modes			
$N \to e^+$ anything	> 0.6 ($n\Gamma_p$)	90%	–
$N \to \mu^+$ anything	> 12 ($n\Gamma_p$)	90%	–
$N \to e^+\pi^0$ anything	> 0.6 ($n\Gamma_p$)	90%	–
$\Delta B = 2$ dinucleon modes			
The following are lifetime limits per iron nucleus.			
$pp \to \pi^+\pi^+$	> 0.7	90%	–
$pn \to \pi^+\pi^0$	> 2	90%	–
$nn \to \pi^+\pi^-$	> 0.7	90%	–
$nn \to \pi^0\pi^0$	> 3.4	90%	–
$pp \to e^+e^+$	> 5.8	90%	–
$pp \to e^+\mu^+$	> 3.6	90%	–
$pp \to \mu^+\mu^+$	> 1.7	90%	–
$pn \to e^+\overline{\nu}$	> 2.8	90%	–
$pn \to \mu^+\overline{\nu}$	> 1.6	90%	–
$nn \to \nu_e\overline{\nu}_e$	> 0.000012	90%	–
$nn \to \nu_\mu\overline{\nu}_\mu$	> 0.000006	90%	–

$\overline{p}$ DECAY MODES

$\overline{p}$ DECAY MODES	Partial mean life (years)	Confidence level	p (MeV/c)
$\overline{p} \to e^-\gamma$	> 1848	95%	469
$\overline{p} \to e^-\pi^0$	> 554	95%	459
$\overline{p} \to e^-\eta$	> 171	95%	309
$\overline{p} \to e^-K^0_S$	> 29	95%	337
$\overline{p} \to e^-K^0_L$	> 9	95%	337

n

$I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$

Mass $m = 939.56563 \pm 0.00028$ MeV [a]
$= 1.008664904 \pm 0.000000014$ u
$m_n - m_p = 1.293318 \pm 0.000009$ MeV
$= 0.001388434 \pm 0.000000009$ u
Mean life $\tau = 886.7 \pm 1.9$ s (S = 1.2)
$c\tau = 2.658 \times 10^8$ km
Magnetic moment $\mu = -1.9130428 \pm 0.0000005\ \mu_N$
Electric dipole moment $d < 0.97 \times 10^{-25}$ $e$cm Γ CL = 90%
Electric polarizability $\alpha = (0.98^{+0.19}_{-0.23}) \times 10^{-3}$ fm^3 (S = 1.1)
Charge $q = (-0.4 \pm 1.1) \times 10^{-21}$ e
Mean $n\overline{n}$-oscillation time $> 1.2 \times 10^8$ s Γ CL = 90% [d] (bound n)
$> 0.86 \times 10^8$ s Γ CL = 90% (free n)

Decay parameters [e]

$pe^-\overline{\nu}_e$	$g_A/g_V = -1.2670 \pm 0.0035$	(S = 1.9)
"	$A = -0.1162 \pm 0.0013$	(S = 1.8)
"	$B = 0.990 \pm 0.008$	
"	$a = -0.102 \pm 0.005$	
"	$\phi_{AV} = (180.07 \pm 0.18)^\circ$ [f]	
"	$D = (-0.5 \pm 1.4) \times 10^{-3}$	

n DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$pe^-\overline{\nu}_e$	100 %		1.19
Charge conservation (Q) violating mode			
$p\nu_e\overline{\nu}_e$	$Q < 8 \times 10^{-27}$	68%	1.29

$N(1440)\,P_{11}$ $I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$

Breit-Wigner mass = 1430 to 1470 (≈ 1440) MeV
Breit-Wigner full width = 250 to 450 (≈ 350) MeV
p_{beam} = 0.61 GeV/c $4\pi\lambda^2$ = 31.0 mb
Re(pole position) = 1345 to 1385 (≈ 1365) MeV
−2Im(pole position) = 160 to 260 (≈ 210) MeV

N(1440) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	60–70 %	397
$N\pi\pi$	30–40 %	342
$\Delta\pi$	20–30 %	143
$N\rho$	<8 %	†
$N(\pi\pi)^{I=0}_{S\text{-wave}}$	5–10 %	–
$p\gamma$	0.035–0.048 %	414
$p\gamma$ Γhelicity=1/2	0.035–0.048 %	414
$n\gamma$	0.009–0.032 %	413
$n\gamma$ Γhelicity=1/2	0.009–0.032 %	413

$N(1520)\,D_{13}$ $I(J^P) = \frac{1}{2}(\frac{3}{2}^-)$

Breit-Wigner mass = 1515 to 1530 (≈ 1520) MeV
Breit-Wigner full width = 110 to 135 (≈ 120) MeV
p_{beam} = 0.74 GeV/c $4\pi\lambda^2$ = 23.5 mb
Re(pole position) = 1505 to 1515 (≈ 1510) MeV
−2Im(pole position) = 110 to 120 (≈ 115) MeV

N(1520) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	50–60 %	456
$N\pi\pi$	40–50 %	410
$\Delta\pi$	15–25 %	228
$N\rho$	15–25 %	†
$N(\pi\pi)^{I=0}_{S\text{-wave}}$	<8 %	–
$p\gamma$	0.46–0.56 %	470
$p\gamma$ Γhelicity=1/2	0.001–0.034 %	470
$p\gamma$ Γhelicity=3/2	0.44–0.53 %	470
$n\gamma$	0.30–0.53 %	470
$n\gamma$ Γhelicity=1/2	0.04–0.10 %	470
$n\gamma$ Γhelicity=3/2	0.25–0.45 %	470

$N(1535)\,S_{11}$ $I(J^P) = \frac{1}{2}(\frac{1}{2}^-)$

Breit-Wigner mass = 1520 to 1555 (≈ 1535) MeV
Breit-Wigner full width = 100 to 250 (≈ 150) MeV
p_{beam} = 0.76 GeV/c $4\pi\lambda^2$ = 22.5 mb
Re(pole position) = 1495 to 1515 (≈ 1505) MeV
−2Im(pole position) = 90 to 250 (≈ 170) MeV

N(1535) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	35–55 %	467
$N\eta$	30–55 %	182
$N\pi\pi$	1–10 %	422
$\Delta\pi$	<1 %	242
$N\rho$	<4 %	†
$N(\pi\pi)^{I=0}_{S\text{-wave}}$	<3 %	–
$N(1440)\pi$	<7 %	†
$p\gamma$	0.15–0.35 %	481
$p\gamma$ Γhelicity=1/2	0.15–0.35 %	481
$n\gamma$	0.004–0.29 %	480
$n\gamma$ Γhelicity=1/2	0.004–0.29 %	480

$N(1650)\,S_{11}$ $I(J^P) = \frac{1}{2}(\frac{1}{2}^-)$

Breit-Wigner mass = 1640 to 1680 (≈ 1650) MeV
Breit-Wigner full width = 145 to 190 (≈ 150) MeV
p_{beam} = 0.96 GeV/c $4\pi\lambda^2$ = 16.4 mb
Re(pole position) = 1640 to 1680 (≈ 1660) MeV
−2Im(pole position) = 150 to 170 (≈ 160) MeV

N(1650) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	55–90 %	547
$N\eta$	3–10 %	346
ΛK	3–11 %	161
$N\pi\pi$	10–20 %	511
$\Delta\pi$	1–7 %	344
$N\rho$	4–12 %	†
$N(\pi\pi)^{I=0}_{S\text{-wave}}$	<4 %	–
$N(1440)\pi$	<5 %	147
$p\gamma$	0.04–0.18 %	558
$p\gamma$ Γhelicity=1/2	0.04–0.18 %	558
$n\gamma$	0.003–0.17 %	557
$n\gamma$ Γhelicity=1/2	0.003–0.17 %	557

$N(1675)\,D_{15}$ $I(J^P) = \frac{1}{2}(\frac{5}{2}^-)$

Breit-Wigner mass = 1670 to 1685 (≈ 1675) MeV
Breit-Wigner full width = 140 to 180 (≈ 150) MeV
p_{beam} = 1.01 GeV/c $4\pi\lambda^2$ = 15.4 mb
Re(pole position) = 1655 to 1665 (≈ 1660) MeV
−2Im(pole position) = 125 to 155 (≈ 140) MeV

N(1675) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	40–50 %	563
ΛK	<1 %	209
$N\pi\pi$	50–60 %	529
$\Delta\pi$	50–60 %	364
$N\rho$	< 1–3 %	†
$p\gamma$	0.004–0.023 %	575
$p\gamma$ Γhelicity=1/2	0.0–0.015 %	575
$p\gamma$ Γhelicity=3/2	0.0–0.011 %	575
$n\gamma$	0.02–0.12 %	574
$n\gamma$ Γhelicity=1/2	0.006–0.046 %	574
$n\gamma$ Γhelicity=3/2	0.01–0.08 %	574

$N(1680)\,F_{15}$ $I(J^P) = \frac{1}{2}(\frac{5}{2}^+)$

Breit-Wigner mass = 1675 to 1690 (≈ 1680) MeV
Breit-Wigner full width = 120 to 140 (≈ 130) MeV
p_{beam} = 1.01 GeV/c $4\pi\lambda^2$ = 15.2 mb
Re(pole position) = 1665 to 1675 (≈ 1670) MeV
−2Im(pole position) = 105 to 135 (≈ 120) MeV

N(1680) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	60–70 %	567
$N\pi\pi$	30–40 %	532
$\Delta\pi$	5–15 %	369
$N\rho$	3–15 %	†
$N(\pi\pi)^{I=0}_{S\text{-wave}}$	5–20 %	–
$p\gamma$	0.21–0.32 %	578
$p\gamma$ Γhelicity=1/2	0.001–0.011 %	578
$p\gamma$ Γhelicity=3/2	0.20–0.32 %	578
$n\gamma$	0.021–0.046 %	577
$n\gamma$ Γhelicity=1/2	0.004–0.029 %	577
$n\gamma$ Γhelicity=3/2	0.01–0.024 %	577

$N(1700)$ D_{13} $I(J^P) = \frac{1}{2}(\frac{3}{2}^-)$

Breit-Wigner mass = 1650 to 1750 (≈ 1700) MeV
Breit-Wigner full width = 50 to 150 (≈ 100) MeV
p_{beam} = 1.05 GeV/c $4\pi\lambda^2$ = 14.5 mb
Re(pole position) = 1630 to 1730 (≈ 1680) MeV
−2Im(pole position) = 50 to 150 (≈ 100) MeV

$N(1700)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	5–15 %	580
ΛK	<3 %	250
$N\pi\pi$	85–95 %	547
$N\rho$	<35 %	†
$p\gamma$	0.01–0.05 %	591
$p\gamma$ Γhelicity=1/2	0.0–0.024 %	591
$p\gamma$ Γhelicity=3/2	0.002–0.026 %	591
$n\gamma$	0.01–0.13 %	590
$n\gamma$ Γhelicity=1/2	0.0–0.09 %	590
$n\gamma$ Γhelicity=3/2	0.01–0.05 %	590

$N(1710)$ P_{11} $I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$

Breit-Wigner mass = 1680 to 1740 (≈ 1710) MeV
Breit-Wigner full width = 50 to 250 (≈ 100) MeV
p_{beam} = 1.07 GeV/c $4\pi\lambda^2$ = 14.2 mb
Re(pole position) = 1670 to 1770 (≈ 1720) MeV
−2Im(pole position) = 80 to 380 (≈ 230) MeV

$N(1710)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	10–20 %	587
ΛK	5–25 %	264
$N\pi\pi$	40–90 %	554
$\Delta\pi$	15–40 %	393
$N\rho$	5–25 %	48
$N(\pi\pi)^{I=0}_{S\text{-wave}}$	10–40 %	–
$p\gamma$	0.002–0.05%	598
$p\gamma$ Γhelicity=1/2	0.002–0.05%	598
$n\gamma$	0.0–0.02%	597
$n\gamma$ Γhelicity=1/2	0.0–0.02%	597

$N(1720)$ P_{13} $I(J^P) = \frac{1}{2}(\frac{3}{2}^+)$

Breit-Wigner mass = 1650 to 1750 (≈ 1720) MeV
Breit-Wigner full width = 100 to 200 (≈ 150) MeV
p_{beam} = 1.09 GeV/c $4\pi\lambda^2$ = 13.9 mb
Re(pole position) = 1650 to 1750 (≈ 1700) MeV
−2Im(pole position) = 110 to 390 (≈ 250) MeV

$N(1720)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	10–20 %	594
ΛK	1–15 %	278
$N\pi\pi$	>70 %	561
$N\rho$	70–85 %	104
$p\gamma$	0.003–0.10 %	604
$p\gamma$ Γhelicity=1/2	0.003–0.08 %	604
$p\gamma$ Γhelicity=3/2	0.001–0.03 %	604
$n\gamma$	0.002–0.39 %	603
$n\gamma$ Γhelicity=1/2	0.0–0.002 %	603
$n\gamma$ Γhelicity=3/2	0.001–0.39 %	603

$N(2190)$ G_{17} $I(J^P) = \frac{1}{2}(\frac{7}{2}^-)$

Breit-Wigner mass = 2100 to 2200 (≈ 2190) MeV
Breit-Wigner full width = 350 to 550 (≈ 450) MeV
p_{beam} = 2.07 GeV/c $4\pi\lambda^2$ = 6.21 mb
Re(pole position) = 1950 to 2150 (≈ 2050) MeV
−2Im(pole position) = 350 to 550 (≈ 450) MeV

$N(2190)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	10–20 %	888

$N(2220)$ H_{19} $I(J^P) = \frac{1}{2}(\frac{9}{2}^+)$

Breit-Wigner mass = 2180 to 2310 (≈ 2220) MeV
Breit-Wigner full width = 320 to 550 (≈ 400) MeV
p_{beam} = 2.14 GeV/c $4\pi\lambda^2$ = 5.97 mb
Re(pole position) = 2100 to 2240 (≈ 2170) MeV
−2Im(pole position) = 370 to 570 (≈ 470) MeV

$N(2220)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	10–20 %	905

$N(2250)$ G_{19} $I(J^P) = \frac{1}{2}(\frac{9}{2}^-)$

Breit-Wigner mass = 2170 to 2310 (≈ 2250) MeV
Breit-Wigner full width = 290 to 470 (≈ 400) MeV
p_{beam} = 2.21 GeV/c $4\pi\lambda^2$ = 5.74 mb
Re(pole position) = 2080 to 2200 (≈ 2140) MeV
−2Im(pole position) = 280 to 680 (≈ 480) MeV

$N(2250)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	5–15 %	923

$N(2600)$ $I_{1,11}$ $I(J^P) = \frac{1}{2}(\frac{11}{2}^-)$

Breit-Wigner mass = 2550 to 2750 (≈ 2600) MeV
Breit-Wigner full width = 500 to 800 (≈ 650) MeV
p_{beam} = 3.12 GeV/c $4\pi\lambda^2$ = 3.86 mb

$N(2600)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	5–10 %	1126

Δ BARYONS ($S = 0$, $I = 3/2$)

$\Delta^{++} = uuu\Gamma$ $\Delta^{+} = uud\Gamma$ $\Delta^{0} = udd\Gamma$ $\Delta^{-} = ddd$

$\Delta(1232)$ P_{33} $I(J^P) = \frac{3}{2}(\frac{3}{2}^+)$

Breit-Wigner mass (mixed charges) = 1230 to 1234 (≈ 1232) MeV
Breit-Wigner full width (mixed charges) = 115 to 125 (≈ 120) MeV
p_{beam} = 0.30 GeV/c $4\pi\lambda^2$ = 94.8 mb
Re(pole position) = 1209 to 1211 (≈ 1210) MeV
−2Im(pole position) = 98 to 102 (≈ 100) MeV

$\Delta(1232)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	>99 %	227
$N\gamma$	0.52–0.60 %	259
$N\gamma$ Γhelicity=1/2	0.11–0.13 %	259
$N\gamma$ Γhelicity=3/2	0.41–0.47 %	259

$\Delta(1600)$ P_{33} $I(J^P) = \frac{3}{2}(\frac{3}{2}^+)$

Breit-Wigner mass = 1550 to 1700 (≈ 1600) MeV
Breit-Wigner full width = 250 to 450 (≈ 350) MeV
p_{beam} = 0.87 GeV/c $4\pi\lambda^2$ = 18.6 mb
Re(pole position) = 1500 to 1700 (≈ 1600) MeV
−2Im(pole position) = 200 to 400 (≈ 300) MeV

$\Delta(1600)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	10–25 %	512
$N\pi\pi$	75–90 %	473
$\Delta\pi$	40–70 %	301
$N\rho$	<25 %	†
$N(1440)\pi$	10–35 %	74
$N\gamma$	0.001–0.02 %	525
$N\gamma$ Γhelicity=1/2	0.0–0.02 %	525
$N\gamma$ Γhelicity=3/2	0.001–0.005 %	525

Δ(1620) S_{31} $I(J^P) = \frac{3}{2}(\frac{1}{2}^-)$

Breit-Wigner mass = 1615 to 1675 (≈ 1620) MeV
Breit-Wigner full width = 120 to 180 (≈ 150) MeV
p_{beam} = 0.91 GeV/c $4\pi\lambda\!\!\!^{-2}$ = 17.7 mb
Re(pole position) = 1580 to 1620 (≈ 1600) MeV
−2Im(pole position) = 100 to 130 (≈ 115) MeV

Δ(1620) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	20–30 %	526
$N\pi\pi$	70–80 %	488
$\Delta\pi$	30–60 %	318
$N\rho$	7–25 %	†
$N\gamma$	0.004–0.044 %	538
$N\gamma$ Γhelicity=1/2	0.004–0.044 %	538

Δ(1700) D_{33} $I(J^P) = \frac{3}{2}(\frac{3}{2}^-)$

Breit-Wigner mass = 1670 to 1770 (≈ 1700) MeV
Breit-Wigner full width = 200 to 400 (≈ 300) MeV
p_{beam} = 1.05 GeV/c $4\pi\lambda\!\!\!^{-2}$ = 14.5 mb
Re(pole position) = 1620 to 1700 (≈ 1660) MeV
−2Im(pole position) − 150 to 250 (≈ 200) MeV

Δ(1700) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	10–20 %	580
$N\pi\pi$	80–90 %	547
$\Delta\pi$	30–60 %	385
$N\rho$	30–55 %	†
$N\gamma$	0.12–0.26 %	591
$N\gamma$ Γhelicity=1/2	0.08–0.16 %	591
$N\gamma$ Γhelicity=3/2	0.025–0.12 %	591

Δ(1905) F_{35} $I(J^P) = \frac{3}{2}(\frac{5}{2}^+)$

Breit-Wigner mass = 1870 to 1920 (≈ 1905) MeV
Breit-Wigner full width = 280 to 440 (≈ 350) MeV
p_{beam} = 1.45 GeV/c $4\pi\lambda\!\!\!^{-2}$ = 9.62 mb
Re(pole position) = 1800 to 1860 (≈ 1830) MeV
−2Im(pole position) = 230 to 330 (≈ 280) MeV

Δ(1905) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	5–15 %	713
$N\pi\pi$	85–95 %	687
$\Delta\pi$	<25 %	542
$N\rho$	>60 %	421
$N\gamma$	0.01–0.03 %	721
$N\gamma$ Γhelicity=1/2	0.0–0.1 %	721
$N\gamma$ Γhelicity=3/2	0.004–0.03 %	721

Δ(1910) P_{31} $I(J^P) = \frac{3}{2}(\frac{1}{2}^+)$

Breit-Wigner mass = 1870 to 1920 (≈ 1910) MeV
Breit-Wigner full width = 190 to 270 (≈ 250) MeV
p_{beam} = 1.46 GeV/c $4\pi\lambda\!\!\!^{-2}$ = 9.54 mb
Re(pole position) = 1830 to 1880 (≈ 1855) MeV
−2Im(pole position) = 200 to 500 (≈ 350) MeV

Δ(1910) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	15–30 %	716
$N\gamma$	0.0–0.2 %	725
$N\gamma$ Γhelicity=1/2	0.0–0.2 %	725

Δ(1920) P_{33} $I(J^P) = \frac{3}{2}(\frac{3}{2}^+)$

Breit-Wigner mass = 1900 to 1970 (≈ 1920) MeV
Breit-Wigner full width = 150 to 300 (≈ 200) MeV
p_{beam} = 1.48 GeV/c $4\pi\lambda\!\!\!^{-2}$ = 9.37 mb
Re(pole position) = 1850 to 1950 (≈ 1900) MeV
−2Im(pole position) = 200 to 400 (≈ 300) MeV

Δ(1920) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	5–20 %	722

Δ(1930) D_{35} $I(J^P) = \frac{3}{2}(\frac{5}{2}^-)$

Breit-Wigner mass = 1920 to 1970 (≈ 1930) MeV
Breit-Wigner full width = 250 to 450 (≈ 350) MeV
p_{beam} = 1.50 GeV/c $4\pi\lambda\!\!\!^{-2}$ = 9.21 mb
Re(pole position) = 1840 to 1940 (≈ 1890) MeV
−2Im(pole position) = 200 to 300 (≈ 250) MeV

Δ(1930) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	10–20 %	729
$N\gamma$	0.0–0.02 %	737
$N\gamma$ Γhelicity=1/2	0.0–0.01 %	737
$N\gamma$ Γhelicity=3/2	0.0–0.01 %	737

Δ(1950) F_{37} $I(J^P) = \frac{3}{2}(\frac{7}{2}^+)$

Breit-Wigner mass = 1940 to 1960 (≈ 1950) MeV
Breit-Wigner full width = 290 to 350 (≈ 300) MeV
p_{beam} = 1.54 GeV/c $4\pi\lambda\!\!\!^{-2}$ = 8.91 mb
Re(pole position) = 1880 to 1890 (≈ 1885) MeV
−2Im(pole position) = 210 to 270 (≈ 240) MeV

Δ(1950) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	35–40 %	741
$N\pi\pi$		716
$\Delta\pi$	20–30 %	574
$N\rho$	<10 %	469
$N\gamma$	0.08–0.13 %	749
$N\gamma$ Γhelicity=1/2	0.03–0.055 %	749
$N\gamma$ Γhelicity=3/2	0.05–0.075 %	749

Δ(2420) $H_{3,11}$ $I(J^P) = \frac{3}{2}(\frac{11}{2}^+)$

Breit-Wigner mass = 2300 to 2500 (≈ 2420) MeV
Breit-Wigner full width = 300 to 500 (≈ 400) MeV
p_{beam} = 2.64 GeV/c $4\pi\lambda\!\!\!^{-2}$ = 4.68 mb
Re(pole position) = 2260 to 2400 (≈ 2330) MeV
−2Im(pole position) = 350 to 750 (≈ 550) MeV

Δ(2420) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	5–15 %	1023

Λ BARYONS ($S = -1, I = 0$)

$\Lambda^0 = uds$

Λ $I(J^P) = 0(\frac{1}{2}^+)$

Mass $m = 1115.683 \pm 0.006$ MeV
Mean life $\tau = (2.632 \pm 0.020) \times 10^{-10}$ s (S = 1.6)
$c\tau = 7.89$ cm
Magnetic moment $\mu = -0.613 \pm 0.004\ \mu_N$
Electric dipole moment $d < 1.5 \times 10^{-16}\ e$cm, CL = 95%

Decay parameters

$p\pi^-$	$\alpha_- = 0.642 \pm 0.013$
"	$\phi_- = (-6.5 \pm 3.5)^\circ$
"	$\gamma_- = 0.76$ [g]
"	$\Delta_- = (8 \pm 4)^\circ$ [g]
$n\pi^0$	$\alpha_0 = +0.65 \pm 0.05$
$pe^-\overline{\nu}_e$	$g_A/g_V = -0.718 \pm 0.015$ [e]

Λ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$p\pi^-$	(63.9 ±0.5) %	101
$n\pi^0$	(35.8 ±0.5) %	104
$n\gamma$	(1.75±0.15) × 10^{-3}	162
$p\pi^-\gamma$	[h] (8.4 ±1.4) × 10^{-4}	101
$pe^-\overline{\nu}_e$	(8.32±0.14) × 10^{-4}	163
$p\mu^-\overline{\nu}_\mu$	(1.57±0.35) × 10^{-4}	131

Λ(1405) S_{01} $I(J^P) = 0(\frac{1}{2}^-)$

Mass $m = 1407 \pm 4$ MeV
Full width $\Gamma = 50.0 \pm 2.0$ MeV
Below $\overline{K}N$ threshold

Λ(1405) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Sigma\pi$	100 %	152

Λ(1520) D_{03} $I(J^P) = 0(\frac{3}{2}^-)$

Mass $m = 1519.5 \pm 1.0$ MeV [i]
Full width $\Gamma = 15.6 \pm 1.0$ MeV [i]
$p_{beam} = 0.39$ GeV/c $4\pi\lambda\!\!\!^{-2} = 82.8$ mb

Λ(1520) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	45 ± 1%	244
$\Sigma\pi$	42 ± 1%	267
$\Lambda\pi\pi$	10 ± 1%	252
$\Sigma\pi\pi$	0.9 ± 0.1%	152
$\Lambda\gamma$	0.8 ± 0.2%	351

Λ(1600) P_{01} $I(J^P) = 0(\frac{1}{2}^+)$

Mass $m = 1560$ to 1700 (≈ 1600) MeV
Full width $\Gamma = 50$ to 250 (≈ 150) MeV
$p_{beam} = 0.58$ GeV/c $4\pi\lambda\!\!\!^{-2} = 41.6$ mb

Λ(1600) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	15–30 %	343
$\Sigma\pi$	10–60 %	336

Λ(1670) S_{01} $I(J^P) = 0(\frac{1}{2}^-)$

Mass $m = 1660$ to 1680 (≈ 1670) MeV
Full width $\Gamma = 25$ to 50 (≈ 35) MeV
$p_{beam} = 0.74$ GeV/c $4\pi\lambda\!\!\!^{-2} = 28.5$ mb

Λ(1670) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	15–25 %	414
$\Sigma\pi$	20–60 %	393
$\Lambda\eta$	15–35 %	64

Λ(1690) D_{03} $I(J^P) = 0(\frac{3}{2}^-)$

Mass $m = 1685$ to 1695 (≈ 1690) MeV
Full width $\Gamma = 50$ to 70 (≈ 60) MeV
$p_{beam} = 0.78$ GeV/c $4\pi\lambda\!\!\!^{-2} = 26.1$ mb

Λ(1690) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	20–30 %	433
$\Sigma\pi$	20–40 %	409
$\Lambda\pi\pi$	~ 25 %	415
$\Sigma\pi\pi$	~ 20 %	350

Λ(1800) S_{01} $I(J^P) = 0(\frac{1}{2}^-)$

Mass $m = 1720$ to 1850 (≈ 1800) MeV
Full width $\Gamma = 200$ to 400 (≈ 300) MeV
$p_{beam} = 1.01$ GeV/c $4\pi\lambda\!\!\!^{-2} = 17.5$ mb

Λ(1800) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	25–40 %	528
$\Sigma\pi$	seen	493
$\Sigma(1385)\pi$	seen	345
$N\overline{K}^*(892)$	seen	†

Λ(1810) P_{01} $I(J^P) = 0(\frac{1}{2}^+)$

Mass $m = 1750$ to 1850 (≈ 1810) MeV
Full width $\Gamma = 50$ to 250 (≈ 150) MeV
$p_{beam} = 1.04$ GeV/c $4\pi\lambda\!\!\!^{-2} = 17.0$ mb

Λ(1810) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	20–50 %	537
$\Sigma\pi$	10–40 %	501
$\Sigma(1385)\pi$	seen	356
$N\overline{K}^*(892)$	30–60 %	†

Λ(1820) F_{05} $I(J^P) = 0(\frac{5}{2}^+)$

Mass $m = 1815$ to 1825 (≈ 1820) MeV
Full width $\Gamma = 70$ to 90 (≈ 80) MeV
$p_{beam} = 1.06$ GeV/c $4\pi\lambda\!\!\!^{-2} = 16.5$ mb

Λ(1820) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	55–65 %	545
$\Sigma\pi$	8–14 %	508
$\Sigma(1385)\pi$	5–10 %	362

Λ(1830) D_{05} $I(J^P) = 0(\frac{5}{2}^-)$

Mass $m = 1810$ to 1830 (≈ 1830) MeV
Full width $\Gamma = 60$ to 110 (≈ 95) MeV
$p_{beam} = 1.08$ GeV/c $4\pi\lambda\!\!\!^{-2} = 16.0$ mb

Λ(1830) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	3–10 %	553
$\Sigma\pi$	35–75 %	515
$\Sigma(1385)\pi$	>15 %	371

$\Lambda(1890)$ P_{03} $I(J^P) = 0(\frac{3}{2}^+)$

Mass $m = 1850$ to 1910 (≈ 1890) MeV
Full width $\Gamma = 60$ to 200 (≈ 100) MeV
$p_{\text{beam}} = 1.21$ GeV/c $4\pi\lambda^2 = 13.6$ mb

$\Lambda(1890)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\bar{K}$	20–35 %	599
$\Sigma\pi$	3–10 %	559
$\Sigma(1385)\pi$	seen	420
$N\bar{K}^*(892)$	seen	233

$\Lambda(2100)$ G_{07} $I(J^P) = 0(\frac{7}{2}^-)$

Mass $m = 2090$ to 2110 (≈ 2100) MeV
Full width $\Gamma = 100$ to 250 (≈ 200) MeV
$p_{\text{beam}} = 1.68$ GeV/c $4\pi\lambda^2 = 8.68$ mb

$\Lambda(2100)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\bar{K}$	25–35 %	751
$\Sigma\pi$	~ 5 %	704
$\Lambda\eta$	< 3 %	617
ΞK	< 3 %	483
$\Lambda\omega$	< 8 %	443
$N\bar{K}^*(892)$	10–20 %	514

$\Lambda(2110)$ F_{05} $I(J^P) = 0(\frac{5}{2}^+)$

Mass $m = 2090$ to 2140 (≈ 2110) MeV
Full width $\Gamma = 150$ to 250 (≈ 200) MeV
$p_{\text{beam}} = 1.70$ GeV/c $4\pi\lambda^2 = 8.53$ mb

$\Lambda(2110)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\bar{K}$	5–25 %	757
$\Sigma\pi$	10–40 %	711
$\Lambda\omega$	seen	455
$\Sigma(1385)\pi$	seen	589
$N\bar{K}^*(892)$	10–60 %	524

$\Lambda(2350)$ H_{09} $I(J^P) = 0(\frac{9}{2}^+)$

Mass $m = 2340$ to 2370 (≈ 2350) MeV
Full width $\Gamma = 100$ to 250 (≈ 150) MeV
$p_{\text{beam}} = 2.29$ GeV/c $4\pi\lambda^2 = 5.85$ mb

$\Lambda(2350)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\bar{K}$	~ 12 %	915
$\Sigma\pi$	~ 10 %	867

Σ BARYONS
($S = -1$, $I = 1$)

$\Sigma^+ = uus$, $\Sigma^0 = uds$, $\Sigma^- = dds$

Σ^+ $I(J^P) = 1(\frac{1}{2}^+)$

Mass $m = 1189.37 \pm 0.07$ MeV (S = 2.2)
Mean life $\tau = (0.799 \pm 0.004) \times 10^{-10}$ s
$c\tau = 2.396$ cm
Magnetic moment $\mu = 2.458 \pm 0.010\ \mu_N$ (S = 2.1)
$\Gamma(\Sigma^+ \to n\ell^+\nu)/\Gamma(\Sigma^- \to n\ell^-\bar{\nu}) < 0.043$

Decay parameters

$p\pi^0$	$\alpha_0 = -0.980^{+0.017}_{-0.015}$
"	$\phi_0 = (36 \pm 34)^\circ$
"	$\gamma_0 = 0.16$ [g]
"	$\Delta_0 = (187 \pm 6)^\circ$ [g]
$n\pi^+$	$\alpha_+ = 0.068 \pm 0.013$
"	$\phi_+ = (167 \pm 20)^\circ$ (S = 1.1)
"	$\gamma_+ = -0.97$ [g]
"	$\Delta_+ = (-73^{+133}_{-10})^\circ$ [g]
$p\gamma$	$\alpha_\gamma = -0.76 \pm 0.08$

Σ^+ DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$p\pi^0$		(51.57±0.30) %		189
$n\pi^+$		(48.31±0.30) %		185
$p\gamma$		(1.23±0.05) $\times 10^{-3}$		225
$n\pi^+\gamma$	[h]	(4.5 ±0.5) $\times 10^{-4}$		185
$\Lambda e^+\nu_e$		(2.0 ±0.5) $\times 10^{-5}$		71
$\Delta S = \Delta Q$ (SQ) violating modes or $\Delta S = 1$ weak neutral current ($S1$) modes				
$ne^+\nu_e$	SQ	< 5 $\times 10^{-6}$	90%	224
$n\mu^+\nu_\mu$	SQ	< 3.0 $\times 10^{-5}$	90%	202
pe^+e^-	$S1$	< 7 $\times 10^{-6}$		225

Σ^0 $I(J^P) = 1(\frac{1}{2}^+)$

Mass $m = 1192.642 \pm 0.024$ MeV
$m_{\Sigma^-} - m_{\Sigma^0} = 4.807 \pm 0.035$ MeV (S = 1.1)
$m_{\Sigma^0} - m_\Lambda = 76.959 \pm 0.023$ MeV
Mean life $\tau = (7.4 \pm 0.7) \times 10^{-20}$ s
$c\tau = 2.22 \times 10^{-11}$ m
Transition magnetic moment $|\mu_{\Sigma\Lambda}| = 1.61 \pm 0.08\ \mu_N$

Σ^0 DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\Lambda\gamma$		100 %		74
$\Lambda\gamma\gamma$		< 3 %	90%	74
Λe^+e^-	[j]	5×10^{-3}		74

Σ^- $I(J^P) = 1(\frac{1}{2}^+)$

Mass $m = 1197.449 \pm 0.030$ MeV (S = 1.2)
$m_{\Sigma^-} - m_{\Sigma^+} = 8.08 \pm 0.08$ MeV (S = 1.9)
$m_{\Sigma^-} - m_{\Lambda} = 81.766 \pm 0.030$ MeV (S = 1.2)
Mean life $\tau = (1.479 \pm 0.011) \times 10^{-10}$ s (S = 1.3)
$c\tau = 4.434$ cm
Magnetic moment $\mu = -1.160 \pm 0.025\ \mu_N$ (S = 1.7)

Decay parameters

$n\pi^-$	$\alpha_- = -0.068 \pm 0.008$
"	$\phi_- = (10 \pm 15)^\circ$
"	$\gamma_- = 0.98$ [g]
"	$\Delta_- = (249^{+12}_{-120})^\circ$ [g]
$ne^-\overline{\nu}_e$	$g_A/g_V = 0.340 \pm 0.017$ [e]
"	$f_2(0)/f_1(0) = 0.97 \pm 0.14$
"	$D = 0.11 \pm 0.10$
$\Lambda e^-\overline{\nu}_e$	$g_V/g_A = 0.01 \pm 0.10$ [e] (S = 1.5)
"	$g_{WM}/g_A = 2.4 \pm 1.7$ [e]

Σ^- DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$n\pi^-$	(99.848±0.005) %	193
$n\pi^-\gamma$	[h] (4.6 ±0.6) × 10^{-4}	193
$ne^-\overline{\nu}_e$	(1.017±0.034) × 10^{-3}	230
$n\mu^-\overline{\nu}_\mu$	(4.5 ±0.4) × 10^{-4}	210
$\Lambda e^-\overline{\nu}_e$	(5.73 ±0.27) × 10^{-5}	79

$\Sigma(1385)\ P_{13}$ $I(J^P) = 1(\frac{3}{2}^+)$

$\Sigma(1385)^+$ mass $m = 1382.8 \pm 0.4$ MeV (S = 2.0)
$\Sigma(1385)^0$ mass $m = 1383.7 \pm 1.0$ MeV (S = 1.4)
$\Sigma(1385)^-$ mass $m = 1387.2 \pm 0.5$ MeV (S = 2.2)
$\Sigma(1385)^+$ full width $\Gamma = 35.8 \pm 0.8$ MeV
$\Sigma(1385)^0$ full width $\Gamma = 36 \pm 5$ MeV
$\Sigma(1385)^-$ full width $\Gamma = 39.4 \pm 2.1$ MeV (S = 1.7)
Below $\overline{K}N$ threshold

$\Sigma(1385)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Lambda\pi$	88±2 %	208
$\Sigma\pi$	12±2 %	127

$\Sigma(1660)\ P_{11}$ $I(J^P) = 1(\frac{1}{2}^+)$

Mass $m = 1630$ to 1690 (≈ 1660) MeV
Full width $\Gamma = 40$ to 200 (≈ 100) MeV
$p_{\text{beam}} = 0.72$ GeV/c $4\pi\lambda^2 = 29.9$ mb

$\Sigma(1660)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	10–30 %	405
$\Lambda\pi$	seen	439
$\Sigma\pi$	seen	385

$\Sigma(1670)\ D_{13}$ $I(J^P) = 1(\frac{3}{2}^-)$

Mass $m = 1665$ to 1685 (≈ 1670) MeV
Full width $\Gamma = 40$ to 80 (≈ 60) MeV
$p_{\text{beam}} = 0.74$ GeV/c $4\pi\lambda^2 = 28.5$ mb

$\Sigma(1670)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	7–13 %	414
$\Lambda\pi$	5–15 %	447
$\Sigma\pi$	30–60 %	393

$\Sigma(1750)\ S_{11}$ $I(J^P) = 1(\frac{1}{2}^-)$

Mass $m = 1730$ to 1800 (≈ 1750) MeV
Full width $\Gamma = 60$ to 160 (≈ 90) MeV
$p_{\text{beam}} = 0.91$ GeV/c $4\pi\lambda^2 = 20.7$ mb

$\Sigma(1750)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	10–40 %	486
$\Lambda\pi$	seen	507
$\Sigma\pi$	<8 %	455
$\Sigma\eta$	15–55 %	81

$\Sigma(1775)\ D_{15}$ $I(J^P) = 1(\frac{5}{2}^-)$

Mass $m = 1770$ to 1780 (≈ 1775) MeV
Full width $\Gamma = 105$ to 135 (≈ 120) MeV
$p_{\text{beam}} = 0.96$ GeV/c $4\pi\lambda^2 = 19.0$ mb

$\Sigma(1775)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	37–43%	508
$\Lambda\pi$	14–20%	525
$\Sigma\pi$	2–5%	474
$\Sigma(1385)\pi$	8–12%	324
$\Lambda(1520)\pi$	17–23%	198

$\Sigma(1915)\ F_{15}$ $I(J^P) = 1(\frac{5}{2}^+)$

Mass $m = 1900$ to 1935 (≈ 1915) MeV
Full width $\Gamma = 80$ to 160 (≈ 120) MeV
$p_{\text{beam}} = 1.26$ GeV/c $4\pi\lambda^2 = 12.8$ mb

$\Sigma(1915)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	5–15 %	618
$\Lambda\pi$	seen	622
$\Sigma\pi$	seen	577
$\Sigma(1385)\pi$	<5 %	440

$\Sigma(1940)\ D_{13}$ $I(J^P) = 1(\frac{3}{2}^-)$

Mass $m = 1900$ to 1950 (≈ 1940) MeV
Full width $\Gamma = 150$ to 300 (≈ 220) MeV
$p_{\text{beam}} = 1.32$ GeV/c $4\pi\lambda^2 = 12.1$ mb

$\Sigma(1940)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	<20 %	637
$\Lambda\pi$	seen	639
$\Sigma\pi$	seen	594
$\Sigma(1385)\pi$	seen	460
$\Lambda(1520)\pi$	seen	354
$\Delta(1232)\overline{K}$	seen	410
$N\overline{K}^*(892)$	seen	320

$\Sigma(2030)\ F_{17}$ $I(J^P) = 1(\frac{7}{2}^+)$

Mass $m = 2025$ to 2040 (≈ 2030) MeV
Full width $\Gamma = 150$ to 200 (≈ 180) MeV
$p_{\text{beam}} = 1.52$ GeV/c $4\pi\lambda^2 = 9.93$ mb

$\Sigma(2030)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	17–23 %	702
$\Lambda\pi$	17–23 %	700
$\Sigma\pi$	5–10 %	657
ΞK	<2 %	412
$\Sigma(1385)\pi$	5–15 %	529
$\Lambda(1520)\pi$	10–20 %	430
$\Delta(1232)\overline{K}$	10–20 %	498
$N\overline{K}^*(892)$	<5 %	438

$\Sigma(2250)$ $I(J^P) = 1(?^?)$

Mass $m = 2210$ to 2280 (≈ 2250) MeV
Full width $\Gamma = 60$ to 150 (≈ 100) MeV
$p_{beam} = 2.04$ GeV/c $4\pi\lambda^2 = 6.76$ mb

$\Sigma(2250)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\overline{K}$	<10 %	851
$\Lambda\pi$	seen	842
$\Sigma\pi$	seen	803

Ξ BARYONS ($S = -2, I = 1/2$)

$\Xi^0 = uss$, $\Xi^- = dss$

Ξ^0 $I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$

P is not yet measured; + is the quark model prediction.

Mass $m = 1314.9 \pm 0.6$ MeV
$m_{\Xi^-} - m_{\Xi^0} = 6.4 \pm 0.6$ MeV
Mean life $\tau = (2.90 \pm 0.09) \times 10^{-10}$ s
$c\tau = 8.71$ cm
Magnetic moment $\mu = -1.250 \pm 0.014\ \mu_N$

Decay parameters

$\Lambda\pi^0$	$\alpha = -0.411 \pm 0.022$	(S = 2.1)
"	$\phi = (21 \pm 12)^\circ$	
"	$\gamma = 0.85$ [g]	
"	$\Delta = (218^{+12}_{-19})^\circ$ [g]	
$\Lambda\gamma$	$\alpha = 0.4 \pm 0.4$	
$\Sigma^0\gamma$	$\alpha = 0.20 \pm 0.32$	

Ξ^0 DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\Lambda\pi^0$	(99.54±0.05) %		135
$\Lambda\gamma$	(1.06±0.16) $\times 10^{-3}$		184
$\Sigma^0\gamma$	(3.5 ±0.4) $\times 10^{-3}$		117
$\Sigma^+ e^-\overline{\nu}_e$	< 1.1 $\times 10^{-3}$	90%	120
$\Sigma^+ \mu^-\overline{\nu}_\mu$	< 1.1 $\times 10^{-3}$	90%	64
$\Delta S = \Delta Q$ (SQ) violating modes or $\Delta S = 2$ forbidden ($S2$) modes			
$\Sigma^- e^+\nu_e$	SQ < 9 $\times 10^{-4}$	90%	112
$\Sigma^- \mu^+\nu_\mu$	SQ < 9 $\times 10^{-4}$	90%	49
$p\pi^-$	$S2$ < 4 $\times 10^{-5}$	90%	299
$pe^-\overline{\nu}_e$	$S2$ < 1.3 $\times 10^{-3}$		323
$p\mu^-\overline{\nu}_\mu$	$S2$ < 1.3 $\times 10^{-3}$		309

Ξ^- $I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$

P is not yet measured; + is the quark model prediction.

Mass $m = 1321.32 \pm 0.13$ MeV
Mean life $\tau = (1.639 \pm 0.015) \times 10^{-10}$ s
$c\tau = 4.91$ cm
Magnetic moment $\mu = -0.6507 \pm 0.0025\ \mu_N$

Decay parameters

$\Lambda\pi^-$	$\alpha = -0.456 \pm 0.014$	(S = 1.8)
"	$\phi = (4 \pm 4)^\circ$	
"	$\gamma = 0.89$ [g]	
"	$\Delta = (188 \pm 8)^\circ$ [g]	
$\Lambda e^-\overline{\nu}_e$	$g_A/g_V = -0.25 \pm 0.05$ [e]	

Ξ^- DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\Lambda\pi^-$	(99.887±0.035) %		139
$\Sigma^-\gamma$	(1.27 ±0.23) $\times 10^{-4}$		118
$\Lambda e^-\overline{\nu}_e$	(5.63 ±0.31) $\times 10^{-4}$		190
$\Lambda\mu^-\overline{\nu}_\mu$	(3.5 $^{+3.5}_{-2.2}$) $\times 10^{-4}$		163
$\Sigma^0 e^-\overline{\nu}_e$	(8.7 ±1.7) $\times 10^{-5}$		122
$\Sigma^0 \mu^-\overline{\nu}_\mu$	< 8 $\times 10^{-4}$	90%	70
$\Xi^0 e^-\overline{\nu}_e$	< 2.3 $\times 10^{-3}$	90%	6
$\Delta S = 2$ forbidden ($S2$) modes			
$n\pi^-$	$S2$ < 1.9 $\times 10^{-5}$	90%	303
$ne^-\overline{\nu}_e$	$S2$ < 3.2 $\times 10^{-3}$	90%	327
$n\mu^-\overline{\nu}_\mu$	$S2$ < 1.5 %	90%	314
$p\pi^-\pi^-$	$S2$ < 4 $\times 10^{-4}$	90%	223
$p\pi^- e^-\overline{\nu}_e$	$S2$ < 4 $\times 10^{-4}$	90%	304
$p\pi^-\mu^-\overline{\nu}_\mu$	$S2$ < 4 $\times 10^{-4}$	90%	250
$p\mu^-\mu^-$	L < 4 $\times 10^{-4}$	90%	272

$\Xi(1530)\ P_{13}$ $I(J^P) = \frac{1}{2}(\frac{3}{2}^+)$

$\Xi(1530)^0$ mass $m = 1531.80 \pm 0.32$ MeV (S = 1.3)
$\Xi(1530)^-$ mass $m = 1535.0 \pm 0.6$ MeV
$\Xi(1530)^0$ full width $\Gamma = 9.1 \pm 0.5$ MeV
$\Xi(1530)^-$ full width $\Gamma = 9.9^{+1.7}_{-1.9}$ MeV

$\Xi(1530)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\Xi\pi$	100 %		152
$\Xi\gamma$	<4 %	90%	200

$\Xi(1690)$ $I(J^P) = \frac{1}{2}(?^?)$

Mass $m = 1690 \pm 10$ MeV [l]
Full width Γ < 50 MeV

$\Xi(1690)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Lambda\overline{K}$	seen	240
$\Sigma\overline{K}$	seen	51
$\Xi^-\pi^+\pi^-$	possibly seen	214

$\Xi(1820)\ D_{13}$ $I(J^P) = \frac{1}{2}(\frac{3}{2}^-)$

Mass $m = 1823 \pm 5$ MeV [l]
Full width $\Gamma = 24^{+15}_{-10}$ MeV [l]

$\Xi(1820)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Lambda\overline{K}$	large	400
$\Sigma\overline{K}$	small	320
$\Xi\pi$	small	413
$\Xi(1530)\pi$	small	234

$\Xi(1950)$ $I(J^P) = \frac{1}{2}(?^?)$

Mass $m = 1950 \pm 15$ MeV [l]
Full width $\Gamma = 60 \pm 20$ MeV [l]

$\Xi(1950)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Lambda\overline{K}$	seen	522
$\Sigma\overline{K}$	possibly seen	460
$\Xi\pi$	seen	518

$\Xi(2030)$ $I(J^P) = \frac{1}{2}(\geq \frac{5}{2}^?)$

Mass $m = 2025 \pm 5$ MeV [l]
Full width $\Gamma = 20^{+15}_{-5}$ MeV [l]

$\Xi(2030)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Lambda\overline{K}$	~20 %	589
$\Sigma\overline{K}$	~80 %	533
$\Xi\pi$	small	573
$\Xi(1530)\pi$	small	421
$\Lambda\overline{K}\pi$	small	501
$\Sigma\overline{K}\pi$	small	430

Ω BARYONS ($S=-3, I=0$)

$\Omega^- = sss$

Ω^-

$I(J^P) = 0(\frac{3}{2}^+)$

J^P is not yet measured; $\frac{3}{2}^+$ is the quark model prediction.

Mass $m = 1672.45 \pm 0.29$ MeV
Mean life $\tau = (0.822 \pm 0.012) \times 10^{-10}$ s
$c\tau = 2.46$ cm
Magnetic moment $\mu = -2.02 \pm 0.05\ \mu_N$

Decay parameters

ΛK^-	$\alpha = -0.026 \pm 0.026$
$\Xi^0\pi^-$	$\alpha = 0.09 \pm 0.14$
$\Xi^-\pi^0$	$\alpha = 0.05 \pm 0.21$

Ω^- DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
ΛK^-	(67.8±0.7) %		211
$\Xi^0\pi^-$	(23.6±0.7) %		294
$\Xi^-\pi^0$	(8.6±0.4) %		290
$\Xi^-\pi^+\pi^-$	$(4.3^{+3.4}_{-1.3}) \times 10^{-4}$		190
$\Xi(1530)^0\pi^-$	$(6.4^{+5.1}_{-2.0}) \times 10^{-4}$		17
$\Xi^0 e^-\bar{\nu}_e$	$(5.6\pm2.8) \times 10^{-3}$		319
$\Xi^-\gamma$	$< 4.6 \times 10^{-4}$	90%	314
$\Delta S = 2$ forbidden ($S2$) modes			
$\Lambda\pi^-$	$S2$ $< 1.9 \times 10^{-4}$	90%	449

$\Omega(2250)^-$

$I(J^P) = 0(?^?)$

Mass $m = 2252 \pm 9$ MeV
Full width $\Gamma = 55 \pm 18$ MeV

$\Omega(2250)^-$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Xi^-\pi^+K^-$	seen	531
$\Xi(1530)^0K^-$	seen	437

CHARMED BARYONS ($C=+1$)

$\Lambda_c^+ = udc\Gamma\ \ \Sigma_c^{++} = uuc\Gamma\ \ \Sigma_c^+ = udc\Gamma\ \ \Sigma_c^0 = ddc\Gamma$
$\Xi_c^+ = usc\Gamma\ \ \Xi_c^0 = dsc\Gamma\ \ \Omega_c^0 = ssc$

Λ_c^+

$I(J^P) = 0(\frac{1}{2}^+)$

J not confirmed; $\frac{1}{2}$ is the quark model prediction.

Mass $m = 2284.9 \pm 0.6$ MeV
Mean life $\tau = (0.206 \pm 0.012) \times 10^{-12}$ s
$c\tau = 61.8\ \mu$m

Decay asymmetry parameters

$\Lambda\pi^+$	$\alpha = -0.98 \pm 0.19$
$\Sigma^+\pi^0$	$\alpha = -0.45 \pm 0.32$
$\Lambda\ell^+\nu_\ell$	$\alpha = -0.82^{+0.11}_{-0.07}$

Nearly all branching fractions of the Λ_c^+ are measured relative to the $pK^-\pi^+$ mode. But there are no model-independent measurements of this branching fraction. We explain how we arrive at our value of $B(\Lambda_c^+ \to pK^-\pi^+)$ in a Note at the beginning of the branching-ratio measurements in the Listings. When this branching fraction is eventually well determined, all the other branching fractions will slide up or down proportionally as the true value differs from the value we use here.

Λ_c^+ DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Hadronic modes with a p and one $\bar{K}$				
$p\bar{K}^0$		(2.5 ± 0.7) %		872
$pK^-\pi^+$	[k]	(5.0 ± 1.3) %		822
$p\bar{K}^*(892)^0$	[l]	(1.8 ± 0.6) %		681
$\Delta(1232)^{++}K^-$		(8 ± 5) $\times 10^{-3}$		709
$\Lambda(1520)\pi^+$	[l]	$(4.5 \pm {}^{2.5}_{2.1}) \times 10^{-3}$		626
$pK^-\pi^+$ nonresonant		(2.8 ± 0.9) %		822
$p\bar{K}^0\eta$		(1.3 ± 0.4) %		567
$p\bar{K}^0\pi^+\pi^-$		(2.4 ± 1.1) %		753
$pK^-\pi^+\pi^0$		seen		758
$pK^*(892)^-\pi^+$	[l]	(1.1 ± 0.6) %		579
$p(K^-\pi^+)_{\text{nonresonant}}\pi^0$		(3.6 ± 1.2) %		758
$\Delta(1232)\bar{K}^*(892)$		seen		416
$pK^-\pi^+\pi^+\pi^-$		(1.1 ± 0.8) $\times 10^{-3}$		670
$pK^-\pi^+\pi^0\pi^0$		(8 ± 4) $\times 10^{-3}$		676
$pK^-\pi^+\pi^0\pi^0\pi^0$		(5.0 ± 3.4) $\times 10^{-3}$		573
Hadronic modes with a p and zero or two K's				
$p\pi^+\pi^-$		(3.5 ± 2.0) $\times 10^{-3}$		926
$pf_0(980)$	[l]	(2.8 ± 1.9) $\times 10^{-3}$		621
$p\pi^+\pi^+\pi^-\pi^-$		(1.8 ± 1.2) $\times 10^{-3}$		851
pK^+K^-		(2.3 ± 0.9) $\times 10^{-3}$		615
$p\phi$	[l]	(1.2 ± 0.5) $\times 10^{-3}$		589
Hadronic modes with a hyperon				
$\Lambda\pi^+$		(9.0 ± 2.8) $\times 10^{-3}$		863
$\Lambda\pi^+\pi^0$		(3.6 ± 1.3) %		843
$\Lambda\rho^+$		< 5 %	CL=95%	638
$\Lambda\pi^+\pi^+\pi^-$		(3.3 ± 1.0) %		806
$\Lambda\pi^+\eta$		(1.7 ± 0.6) %		690
$\Sigma(1385)^+\eta$	[l]	(8.5 ± 3.3) $\times 10^{-3}$		569
$\Lambda K^+\bar{K}^0$		(6.0 ± 2.1) $\times 10^{-3}$		441
$\Sigma^0\pi^+$		(9.9 ± 3.2) $\times 10^{-3}$		824
$\Sigma^+\pi^0$		(1.00± 0.34) %		826
$\Sigma^+\eta$		(5.5 ± 2.3) $\times 10^{-3}$		712
$\Sigma^+\pi^+\pi^-$		(3.4 ± 1.0) %		803
$\Sigma^+\rho^0$		< 1.4 %	CL=95%	578
$\Sigma^-\pi^+\pi^+$		(1.8 ± 0.8) %		798
$\Sigma^0\pi^+\pi^0$		(1.8 ± 0.8) %		802
$\Sigma^0\pi^+\pi^+\pi^-$		(1.1 ± 0.4) %		762
$\Sigma^+\pi^+\pi^-\pi^0$		—		766
$\Sigma^+\omega$	[l]	(2.7 ± 1.0) %		568
$\Sigma^+\pi^+\pi^+\pi^-\pi^-$		$(3.0 \pm {}^{4.1}_{2.1}) \times 10^{-3}$		707
$\Sigma^+K^+K^-$		(3.5 ± 1.2) $\times 10^{-3}$		346
$\Sigma^+\phi$	[l]	(3.5 ± 1.7) $\times 10^{-3}$		292
$\Sigma^+K^+\pi^-$		$(7 \pm {}^{6}_{4}) \times 10^{-3}$		668
Ξ^0K^+		(3.9 ± 1.4) $\times 10^{-3}$		652
$\Xi^-K^+\pi^+$		(4.9 ± 1.7) $\times 10^{-3}$		564
$\Xi(1530)^0K^+$	[l]	(2.6 ± 1.0) $\times 10^{-3}$		471
Semileptonic modes				
$\Lambda\ell^+\nu_\ell$	[m]	(2.0 ± 0.6) %		–
$\Lambda e^+\nu_e$		(2.1 ± 0.6) %		–
$\Lambda\mu^+\nu_\mu$		(2.0 ± 0.7) %		–
e^+ anything		(4.5 ± 1.7) %		–
pe^+ anything		(1.8 ± 0.9) %		–
Λe^+ anything		—		–
$\Lambda\mu^+$ anything		—		–
$\Lambda\ell^+\nu_\ell$ anything		—		–
Inclusive modes				
p anything		(50 ±16) %		–
p anything (no Λ)		(12 ±19) %		–
p hadrons		—		–
n anything		(50 ±16) %		–
n anything (no Λ)		(29 ±17) %		–
Λ anything		(35 ±11) %	S=1.4	–
$\Sigma^\pm$ anything	[n]	(10 ± 5) %		–

$\Delta C = 1$ weak neutral current ($C1$) modes, or Lepton number (L) violating modes

$p\mu^+\mu^-$	$C1$	$<$ 3.4	$\times 10^{-4}$	CL=90%	936
$\Sigma^-\mu^+\mu^+$	L	$<$ 7.0	$\times 10^{-4}$	CL=90%	811

$\Lambda_c(2593)^+$

$I(J^P) = 0(\frac{1}{2}^-)$

The spin-parity follows from the fact that $\Sigma_c(2455)\pi$ decays, with little available phase space, are dominant.

Mass $m = 2593.9 \pm 0.8$ MeV
$m - m_{\Lambda_c^+} = 308.9 \pm 0.6$ MeV (S = 1.1)
Full width $\Gamma = 3.6^{+2.0}_{-1.3}$ MeV

$\Lambda_c^+\pi\pi$ and its submode $\Sigma_c(2455)\pi$ — the latter just barely — are the only strong decays allowed to an excited Λ_c^+ having this mass; and the $\Lambda_c^+\pi^+\pi^-$ mode seems to be largely via $\Sigma_c^{++}\pi^-$ or $\Sigma_c^0\pi^+$.

$\Lambda_c(2593)^+$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Lambda_c^+\pi^+\pi^-$	[o] $\approx 67\%$	124
$\Sigma_c(2455)^{++}\pi^-$	$24 \pm 7\%$	17
$\Sigma_c(2455)^0\pi^+$	$24 \pm 7\%$	23
$\Lambda_c^+\pi^+\pi^-$ 3-body	$18 \pm 10\%$	124
$\Lambda_c^+\pi^0$	not seen	261
$\Lambda_c^+\gamma$	not seen	290

$\Lambda_c(2625)^+$

$I(J^P) = 0(?^?)$

J^P is expected to be $3/2^-$.

Mass $m = 2626.6 \pm 0.8$ MeV (S = 1.2)
$m - m_{\Lambda_c^+} = 341.7 \pm 0.6$ MeV (S = 1.6)
Full width $\Gamma < 1.9$ MeV, CL = 90%

$\Lambda_c^+\pi\pi$ and its submode $\Sigma(2455)\pi$ are the only strong decays allowed to an excited Λ_c^+ having this mass.

$\Lambda_c(2625)^+$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Lambda_c^+\pi^+\pi^-$	seen	184
$\Sigma_c(2455)^{++}\pi^-$	small	100
$\Sigma_c(2455)^0\pi^+$	small	101
$\Lambda_c^+\pi^+\pi^-$ 3-body	large	184
$\Lambda_c^+\pi^0$	not seen	293
$\Lambda_c^+\gamma$	not seen	319

$\Sigma_c(2455)$

$I(J^P) = 1(\frac{1}{2}^+)$

J^P not confirmed; $\frac{1}{2}^+$ is the quark model prediction.

$\Sigma_c(2455)^{++}$ mass $m = 2452.8 \pm 0.6$ MeV
$\Sigma_c(2455)^+$ mass $m = 2453.6 \pm 0.9$ MeV
$\Sigma_c(2455)^0$ mass $m = 2452.2 \pm 0.6$ MeV
$m_{\Sigma_c^{++}} - m_{\Lambda_c^+} = 167.87 \pm 0.19$ MeV
$m_{\Sigma_c^+} - m_{\Lambda_c^+} = 168.7 \pm 0.6$ MeV
$m_{\Sigma_c^0} - m_{\Lambda_c^+} = 167.30 \pm 0.20$ MeV
$m_{\Sigma_c^{++}} - m_{\Sigma_c^0} = 0.57 \pm 0.23$ MeV
$m_{\Sigma_c^+} - m_{\Sigma_c^0} = 1.4 \pm 0.6$ MeV

$\Lambda_c^+\pi$ is the only strong decay allowed to a Σ_c having this mass.

$\Sigma_c(2455)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Lambda_c^+\pi$	$\approx 100\%$	90

$\Sigma_c(2520)$

$I(J^P) = 1(?^?)$

$\Sigma_c(2520)^{++}$ mass $m = 2519.4 \pm 1.5$ MeV
$\Sigma_c(2520)^0$ mass $m = 2517.5 \pm 1.4$ MeV
$m_{\Sigma_c(2520)^{++}} - m_{\Lambda_c^+} = 234.5 \pm 1.4$ MeV
$m_{\Sigma_c(2520)^0} - m_{\Lambda_c^+} = 232.6 \pm 1.3$ MeV
$m_{\Sigma_c(2520)^{++}} - m_{\Sigma_c(2520)^0} = 1.9 \pm 1.9$ MeV
$\Sigma_c(2520)^{++}$ full width $\Gamma = 18 \pm 5$ MeV
$\Sigma_c(2520)^0$ full width $\Gamma = 13 \pm 5$ MeV

Ξ_c^+

$I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$

$I(J^P)$ not confirmed; $\frac{1}{2}(\frac{1}{2}^+)$ is the quark model prediction.

Mass $m = 2465.6 \pm 1.4$ MeV
Mean life $\tau = (0.35^{+0.07}_{-0.04}) \times 10^{-12}$ s
$c\tau = 106\ \mu$m

Ξ_c^+ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Lambda K^-\pi^+\pi^+$	seen	784
$\Lambda\overline{K}^*(892)^0\pi^+$	not seen	601
$\Sigma(1385)^+K^-\pi^+$	not seen	676
$\Sigma^+K^-\pi^+$	seen	808
$\Sigma^+\overline{K}^*(892)^0$	seen	653
$\Sigma^0K^-\pi^+\pi^+$	seen	733
$\Xi^0\pi^+$	seen	875
$\Xi^-\pi^+\pi^+$	seen	850
$\Xi(1530)^0\pi^+$	not seen	748
$\Xi^0\pi^+\pi^0$	seen	854
$\Xi^0\pi^+\pi^+\pi^-$	seen	817
$\Xi^0e^+\nu_e$	seen	882

Ξ_c^0

$I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$

$I(J^P)$ not confirmed; $\frac{1}{2}(\frac{1}{2}^+)$ is the quark model prediction.

Mass $m = 2470.3 \pm 1.8$ MeV (S = 1.3)
$m_{\Xi_c^0} - m_{\Xi_c^+} = 4.7 \pm 2.1$ MeV (S = 1.2)
Mean life $\tau = (0.098^{+0.023}_{-0.015}) \times 10^{-12}$ s
$c\tau = 29\ \mu$m

Ξ_c^0 DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Lambda\overline{K}^0$	seen	864
$\Xi^-\pi^+$	seen	875
$\Xi^-\pi^+\pi^+\pi^-$	seen	816
$pK^-\overline{K}^*(892)^0$	seen	406
Ω^-K^+	seen	522
$\Xi^-e^+\nu_e$	seen	882
$\Xi^-\ell^+$ anything	seen	–

$\Xi_c(2645)$

$I(J^P) = ?(?^?)$

$\Xi_c(2645)^+$ mass $m = 2644.6 \pm 2.1$ MeV (S = 1.2)
$\Xi_c(2645)^0$ mass $m = 2643.8 \pm 1.8$ MeV
$m_{\Xi_c(2645)^+} - m_{\Xi_c^0} = 174.3 \pm 1.1$ MeV
$m_{\Xi_c(2645)^0} - m_{\Xi_c^+} = 178.2 \pm 1.1$ MeV
$\Xi_c(2645)^+$ full width $\Gamma < 3.1$ MeV, CL = 90%
$\Xi_c(2645)^0$ full width $\Gamma < 5.5$ MeV, CL = 90%

$\Xi_c\pi$ is the only strong decay allowed to a Ξ_c resonance having this mass.

$\Xi_c(2645)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Xi_c^0\pi^+$	seen	101
$\Xi_c^+\pi^-$	seen	107

Ω_c^0

$I(J^P) = 0(\frac{1}{2}^+)$

$I(J^P)$ not confirmed; $0(\frac{1}{2}^+)$ is the quark model prediction.

Mass $m = 2704 \pm 4$ MeV (S = 1.8)
Mean life $\tau = (0.064 \pm 0.020) \times 10^{-12}$ s
$c\tau = 19\ \mu$m

Ω_c^0 DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Sigma^+ K^- K^- \pi^+$	seen	697
$\Xi^- K^- \pi^+ \pi^+$	seen	838
$\Omega^- \pi^+$	seen	827
$\Omega^- \pi^- \pi^+ \pi^+$	seen	759

BOTTOM BARYONS ($B = -1$)

$\Lambda_b^0 = udb$, $\Xi_b^0 = usb$, $\Xi_b^- = dsb$

Λ_b^0

$I(J^P) = 0(\frac{1}{2}^+)$

$I(J^P)$ not yet measured; $0(\frac{1}{2}^+)$ is the quark model prediction.

Mass $m = 5624 \pm 9$ MeV (S = 1.8)
Mean life $\tau = (1.24 \pm 0.08) \times 10^{-12}$ s
$c\tau = 372\ \mu$m

These branching fractions are actually an average over weakly decaying b-baryons weighted by their production rates in Z decay (or high-energy $p\bar{p}$) branching ratios and detection efficiencies. They scale with the LEP Λ_b production fraction $B(b \to \Lambda_b)$ and are evaluated for our value $B(b \to \Lambda_b) = (10.1^{+3.9}_{-3.1})\%$.

The branching fractions B(b-baryon $\to \Lambda \ell^- \bar{\nu}_\ell$ anything) and $B(\Lambda_b^0 \to \Lambda_c^+ \ell^- \bar{\nu}_\ell$ anything) are not pure measurements because the underlying measured products of these with $B(b \to \Lambda_b)$ were used to determine $B(b \to \Lambda_b)$ as described in the note "Production and Decay of b-Flavored Hadrons."

Λ_b^0 DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$J/\psi(1S)\Lambda$	$(4.7 \pm 2.8) \times 10^{-4}$		1744
$\Lambda_c^+ \pi^-$	seen		2345
$\Lambda_c^+ a_1(1260)^-$	seen		2156
$\Lambda_c^+ \ell^- \bar{\nu}_\ell$ anything	[p] $(9.0^{+3.1}_{-3.8})\%$		–
$p\pi^-$	$< 5.0 \times 10^{-5}$	90%	2732
pK^-	$< 5.0 \times 10^{-5}$	90%	2711

b-baryon ADMIXTURE (Λ_b, Ξ_b, Σ_b, Ω_b)

Mean life $\tau = (1.20 \pm 0.07) \times 10^{-12}$ s

These branching fractions are actually an average over weakly decaying b-baryons weighted by their production rates in Z decay (or high-energy $p\bar{p}$) branching ratios and detection efficiencies. They scale with the LEP Λ_b production fraction $B(b \to \Lambda_b)$ and are evaluated for our value $B(b \to \Lambda_b) = (10.1^{+3.9}_{-3.1})\%$.

The branching fractions B(b-baryon $\to \Lambda \ell^- \bar{\nu}_\ell$ anything) and $B(\Lambda_b^0 \to \Lambda_c^+ \ell^- \bar{\nu}_\ell$ anything) are not pure measurements because the underlying measured products of these with $B(b \to \Lambda_b)$ were used to determine $B(b \to \Lambda_b)$ as described in the note "Production and Decay of b-Flavored Hadrons."

b-baryon ADMIXTURE (Λ_b/Ξ_b/Σ_b/Ω_b)	Fraction (Γ_i/Γ)	p (MeV/c)
$p\mu^-\bar{\nu}$ anything	$(4.9 \pm 2.4)\%$	–
$\Lambda\ell^-\bar{\nu}_\ell$ anything	$(3.1^{+1.0}_{-1.2})\%$	–
$\Lambda/\bar{\Lambda}$ anything	$(35^{+12}_{-14})\%$	–
$\Xi^-\ell^-\bar{\nu}_\ell$ anything	$(5.5^{+2.0}_{-2.4}) \times 10^{-3}$	–

NOTES

This Summary Table only includes established baryons. The Particle Listings include evidence for other baryons. The masses, widths, and branching fractions for the resonances in this Table are Breit-Wigner parameters, but pole positions are also given for most of the N and Δ resonances.

For most of the resonances, the parameters come from various partial-wave analyses of more or less the same sets of data, and it is not appropriate to treat the results of the analyses as independent or to average them together. Furthermore, the systematic errors on the results are not well understood. Thus, we usually only give ranges for the parameters. We then also give a best guess for the mass (as part of the name of the resonance) and for the width. The *Note on N and Δ Resonances* and the *Note on Λ and Σ Resonances* in the Particle Listings review the partial-wave analyses.

When a quantity has "(S = ...)" to its right, the error on the quantity has been enlarged by the "scale factor" S, defined as $S = \sqrt{\chi^2/(N-1)}$, where N is the number of measurements used in calculating the quantity. We do this when S > 1, which often indicates that the measurements are inconsistent. When S > 1.25, we also show in the Particle Listings an ideogram of the measurements. For more about S, see the Introduction.

A decay momentum p is given for each decay mode. For a 2-body decay, p is the momentum of each decay product in the rest frame of the decaying particle. For a 3-or-more-body decay, p is the largest momentum any of the products can have in this frame. For any resonance, the *nominal* mass is used in calculating p. A dagger ("†") in this column indicates that the mode is forbidden when the nominal masses of resonances are used, but is in fact allowed due to the nonzero widths of the resonances.

[a] The masses of the p and n are most precisely known in u (unified atomic mass units). The conversion factor to MeV, 1 u = 931.49432 ± 0.00028 MeV, is less well known than are the masses in u.

[b] The limit is from neutrality-of-matter experiments; it assumes $q_n = q_p + q_e$. See also the charge of the neutron.

[c] The first limit is geochemical and independent of decay mode. The second entry, a range of limits, assumes the dominant decay modes are among those investigated. For antiprotons the best limit, inferred from the observation of cosmic ray $\bar{p}$'s is $\tau_{\bar{p}} > 10^7$ yr, the cosmic-ray storage time, but this limit depends on a number of assumptions. The best direct observation of stored antiprotons gives $\tau_{\bar{p}}/B(\bar{p} \to e^-\gamma) > 1848$ yr.

[d] There is some controversy about whether nuclear physics and model dependence complicate the analysis for bound neutrons (from which the best limit comes). The second limit here is from reactor experiments with free neutrons.

[e] The parameters g_A, g_V, and g_{WM} for semileptonic modes are defined by $\overline{B}_f[\gamma_\lambda(g_V + g_A\gamma_5) + i(g_{WM}/m_{B_i})\,\sigma_{\lambda\nu}\,q^\nu]B_i$, and ϕ_{AV} is defined by $g_A/g_V = |g_A/g_V|e^{i\phi_{AV}}$. See the "Note on Baryon Decay Parameters" in the neutron Particle Listings.

[f] Time-reversal invariance requires this to be 0° or 180°.

[g] The decay parameters γ and Δ are calculated from α and ϕ using

$$\gamma = \sqrt{1-\alpha^2}\cos\phi, \qquad \tan\Delta = -\frac{1}{\alpha}\sqrt{1-\alpha^2}\sin\phi.$$

See the "Note on Baryon Decay Parameters" in the neutron Particle Listings.

[h] See the Particle Listings for the pion momentum range used in this measurement.

[i] The error given here is only an educated guess. It is larger than the error on the weighted average of the published values.

[j] A theoretical value using QED.

[k] See the "Note on Λ_c^+ Branching Fractions" in the Branching Fractions of the Λ_c^+ Particle Listings.

[l] This branching fraction includes all the decay modes of the final-state resonance.

[m] An ℓ indicates an e or a μ mode, not a sum over these modes.

[n] The value is for the sum of the charge states of particle/antiparticle states indicated.

[o] Assuming isospin conservation, so that the other third is $\Lambda_c^+\pi^0\pi^0$.

[p] Not a pure measurement. See note at head of Λ_b^0 Decay Modes.

MONOPOLES, SUPERSYMMETRY, COMPOSITENESS, etc., SEARCHES FOR

Magnetic Monopole Searches

Isolated supermassive monopole candidate events have not been confirmed. The most sensitive experiments obtain negative results.

Best cosmic-ray supermassive monopole flux limit:

$< 1.0 \times 10^{-15}$ cm^{-2}sr^{-1}s^{-1} for $1.1 \times 10^{-4} < \beta < 0.1$

Supersymmetric Particle Searches

Limits are based on the Minimal Supersymmetric Standard Model. Assumptions include: 1) $\widetilde{\chi}_1^0$ (or $\widetilde{\gamma}$) is lightest supersymmetric particle; 2) R-parity is conserved; 3) All scalar quarks (except $\widetilde{t}_L$ and $\widetilde{t}_R$) are degenerate in mass, and $m_{\widetilde{q}_R} = m_{\widetilde{q}_L}$. 4) Limits for selectrons and smuons refer to the $\widetilde{\ell}_R$ states.

See the Particle Listings for a Note giving details of supersymmetry.

$\widetilde{\chi}_i^0$ — neutralinos (mixtures of $\widetilde{\gamma}$, $\widetilde{Z}^0$, and $\widetilde{H}_i^0$)

Mass $m_{\widetilde{\chi}_1^0} > 10.9$ GeV, CL = 95%

Mass $m_{\widetilde{\chi}_2^0} > 45.3$ GeV, CL = 95% [$\tan\beta > 1$]

Mass $m_{\widetilde{\chi}_3^0} > 75.8$ GeV, CL = 95% [$\tan\beta > 1$]

Mass $m_{\widetilde{\chi}_4^0} > 127$ GeV, CL = 95% [$\tan\beta > 3$]

$\widetilde{\chi}_i^\pm$ — charginos (mixtures of $\widetilde{W}^\pm$ and $\widetilde{H}_i^\pm$)

Mass $m_{\widetilde{\chi}_1^\pm} > 65.7$ GeV, CL = 95% [$m_{\widetilde{\chi}_1^\pm} - m_{\widetilde{\chi}_1^0} \geq 2$ GeV]

Mass $m_{\widetilde{\chi}_2^\pm} > 99$ GeV, CL = 95% [GUT relations assumed]

$\widetilde{\nu}$ — scalar neutrino (sneutrino)

Mass $m > 37.1$ GeV, CL = 95% [one flavor]

Mass $m > 43.1$ GeV, CL = 95% [three degenerate flavors]

$\widetilde{e}$ — scalar electron (selectron)

Mass $m > 58$ GeV, CL = 95% [$m_{\widetilde{e}_R} - m_{\widetilde{\chi}_1^0} \geq 4$ GeV]

$\widetilde{\mu}$ — scalar muon (smuon)

Mass $m > 55.6$ GeV, CL = 95% [$m_{\widetilde{\mu}_R} - m_{\widetilde{\chi}_1^0} \geq 4$ GeV]

$\widetilde{\tau}$ — scalar tau (stau)

Mass $m > 45$ GeV, CL = 95% [if $m_{\widetilde{\chi}_1^0} < 38$ GeV]

$\widetilde{q}$ — scalar quark (squark)

These limits include the effects of cascade decays, evaluated assuming a fixed value of the parameters μ and $\tan\beta$. The limits are weakly sensitive to these parameters over much of parameter space. Limits assume GUT relations between gaugino masses and the gauge coupling; in particular that for $|\mu|$ not small, $m_{\widetilde{\chi}_1^0} \approx m_{\widetilde{g}}/6$.

Mass $m > 176$ GeV, CL = 95% [any $m_{\widetilde{g}} < 300$ GeV, $\mu = -250$ GeV, $\tan\beta = 2$]

Mass $m > 224$ GeV, CL = 95% [$m_{\widetilde{g}} \leq m_{\widetilde{q}}$, $\mu = -400$ GeV, $\tan\beta = 4$]

$\widetilde{g}$ — gluino

There is some controversy on whether gluinos in a low-mass window ($1 \lesssim m_{\widetilde{g}} \lesssim 5$ GeV) are excluded or not. See the Supersymmetry Listings for details.

The limits summarised here refere to the high-mass region ($m_{\widetilde{g}} \gtrsim 5$ GeV), and include the effects of cascade decays, evaluated assuming a fixed value of the parameters μ and $\tan\beta$. The limits are weakly sensitive to these parameters over much of parameter space. Limits assume GUT relations between gaugino masses and the gauge coupling; in particular that for $|\mu|$ not small, $m_{\widetilde{\chi}_1^0} \approx m_{\widetilde{g}}/6$.

Mass $m > 173$ GeV, CL = 95% [any $m_{\widetilde{q}}$, $\mu = -200$ GeV, $\tan\beta = 2$]

Mass $m > 212$ GeV, CL = 95% [$m_{\widetilde{g}} \geq m_{\widetilde{q}}$, $\mu = -250$ GeV, $\tan\beta = 2$]

Quark and Lepton Compositeness, Searches for

Scale Limits Λ for Contact Interactions (the lowest dimensional interactions with four fermions)

If the Lagrangian has the form

$$\pm \frac{g^2}{2\Lambda^2}\, \overline{\psi}_L \gamma_\mu \psi_L \overline{\psi}_L \gamma^\mu \psi_L$$

(with $g^2/4\pi$ set equal to 1), then we define $\Lambda \equiv \Lambda_{LL}^\pm$. For the full definitions and for other forms, see the Note in the Listings on Searches for Quark and Lepton Compositeness in the full *Review* and the original literature.

$\Lambda_{LL}^+(eeee) > 2.4$ TeV, CL = 95%

$\Lambda_{LL}^-(eeee) > 3.6$ TeV, CL = 95%

$\Lambda_{LL}^+(ee\mu\mu) > 2.6$ TeV, CL = 95%

$\Lambda_{LL}^-(ee\mu\mu) > 2.9$ TeV, CL = 95%

$\Lambda_{LL}^+(ee\tau\tau) > 1.9$ TeV, CL = 95%

$\Lambda_{LL}^-(ee\tau\tau) > 3.0$ TeV, CL = 95%

$\Lambda_{LL}^+(\ell\ell\ell\ell) > 3.5$ TeV, CL = 95%

$\Lambda_{LL}^-(\ell\ell\ell\ell) > 3.8$ TeV, CL = 95%

$\Lambda_{LL}^+(eeqq) > 2.5$ TeV, CL = 95%

$\Lambda_{LL}^-(eeqq) > 3.7$ TeV, CL = 95%

$\Lambda_{LL}^+(eebb) > 3.1$ TeV, CL = 95%

$\Lambda_{LL}^-(eebb) > 2.9$ TeV, CL = 95%

$\Lambda_{LL}^+(\mu\mu qq) > 2.9$ TeV, CL = 95%

$\Lambda_{LL}^-(\mu\mu qq) > 4.2$ TeV, CL = 95%

$\Lambda_{LR}^\pm(\nu_\mu \nu_e \mu e) > 3.1$ TeV, CL = 90%

$\Lambda_{LL}^\pm(qqqq) > 1.6$ TeV, CL = 95%

Excited Leptons

The limits from $\ell^{*+}\ell^{*-}$ do not depend on λ (where λ is the $\ell\ell^*$ transition coupling). The λ-dependent limits assume chiral coupling, except for the third limit for e^* which is for nonchiral coupling. For chiral coupling, this limit corresponds to $\lambda_\gamma = \sqrt{2}$.

$e^{*\pm}$ — excited electron

Mass $m > 85.0$ GeV, CL = 95% (from $e^{*+}e^{*-}$)

Mass $m > 91$ GeV, CL = 95% (if $\lambda_Z > 1$)

Mass $m > 194$ GeV, CL = 95% (if $\lambda_\gamma = 1$)

$\mu^{*\pm}$ — excited muon

Mass $m > 85.3$ GeV, CL = 95% (from $\mu^{*+}\mu^{*-}$)

Mass $m > 91$ GeV, CL = 95% (if $\lambda_Z > 1$)

$\tau^{*\pm}$ — excited tau

Mass $m > 84.6$ GeV, CL = 95% (from $\tau^{*+}\tau^{*-}$)

Mass $m > 90$ GeV, CL = 95% (if $\lambda_Z > 0.18$)

ν^* — excited neutrino

Mass $m > 84.9$ GeV, CL = 95% (from $\nu^*\overline{\nu}^*$)

Mass $m > 91$ GeV, CL = 95% (if $\lambda_Z > 1$)

Mass $m =$ none 40–96 GeV, CL = 95% (from $ep \to \nu^* X$)

q^* — excited quark

Mass $m > 45.6$ GeV, CL = 95% (from $q^*\overline{q}^*$)

Mass $m > 88$ GeV, CL = 95% (if $\lambda_Z > 1$)

Mass $m > 570$ GeV, CL = 95% ($p\overline{p} \to q^* X$)

Color Sextet and Octet Particles

Color Sextet Quarks (q_6)

Mass $m > 84$ GeV, CL = 95% (Stable q_6)

Color Octet Charged Leptons (ℓ_8)

Mass $m > 86$ GeV, CL = 95% (Stable ℓ_8)

Color Octet Neutrinos (ν_8)

Mass $m > 110$ GeV, CL = 90% ($\nu_8 \to \nu g$)

TESTS OF CONSERVATION LAWS

TESTS OF CONSERVATION LAWS

Revised by L. Wolfenstein and T.G. Trippe May 1998.

In keeping with the current interest in tests of conservation laws we collect together a Table of experimental limits on all weak and electromagnetic decays mass differences and moments and on a few reactions whose observation would violate conservation laws. The Table is given only in the full *Review of Particle Physics* not in the Particle Physics Booklet. For the benefit of Booklet readers we include the best limits from the Table in the following text. Limits in this text are for CL=90% unless otherwise specified. The Table is in two parts: "Discrete Space-Time Symmetries" *i.e.* PC P T PT CP and CPT; and "Number Conservation Laws" *i.e.* lepton baryon hadronic flavor and charge conservation. The references for these data can be found in the the Particle Listings in the *Review*. A discussion of these tests follows.

CPT INVARIANCE

General principles of relativistic field theory require invariance under the combined transformation CPT. The simplest tests of CPT invariance are the equality of the masses and lifetimes of a particle and its antiparticle. The best test comes from the limit on the mass difference between K^0 and $\overline{K}^0$. Any such difference contributes to the CP-violating parameter ϵ. Assuming CPT invariance ϕ_ϵ the phase of ϵ should be very close to 44°. (See the "Note on CP Violation in K_L^0 Decay" in the Particle Listings.) In contrast if the entire source of CP violation in K^0 decays were a $K^0 - \overline{K}^0$ mass difference ϕ_ϵ would be $44° + 90°$. Assuming that there is no other source of CPT violation than this mass difference it is possible to deduce that [1]

$$m_{\overline{K}^0} - m_{K^0} \approx \frac{2(m_{K_L^0} - m_{K_S^0})\,|\eta|\,(\frac{2}{3}\phi_{+-} + \frac{1}{3}\phi_{00} - \phi_0)}{\sin\phi_0}\,,$$

where $\phi_0 = 43.5°$ with an uncertainty of less than 0.1°. Using our best values of the CP-violation parameters we get $|(m_{\overline{K}^0} - m_{K^0})/m_{K^0}| \leq 10^{-18}$. Limits can also be placed on specific CPT-violating decay amplitudes. Given the small value of $(1 - |\eta_{00}/\eta_{+-}|)$ the value of $\phi_{00} - \phi_{+-}$ provides a measure of CPT violation in $K_L^0 \to 2\pi$ decay. Results from CERN [1] and Fermilab [2] indicate no CPT-violating effect.

CP AND *T* INVARIANCE

Given CPT invariance CP violation and T violation are equivalent. So far the only evidence for CP or T violation comes from the measurements of η_{+-} η_{00} and the semileptonic decay charge asymmetry for K_L *e.g.* $|\eta_{+-}| = |A(K_L^0 \to \pi^+\pi^-)/A(K_S^0 \to \pi^+\pi^-)| = (2.285 \pm 0.019) \times 10^{-3}$ and $[\Gamma(K_L^0 \to \pi^- e^+ \nu) - \Gamma(K_L^0 \to \pi^+ e^- \overline{\nu})]/[\text{sum}] = (0.333 \pm 0.014)\%$. Other searches for CP or T violation divide into (a) those that involve weak interactions or parity violation and (b) those that involve processes otherwise allowed by the strong or electromagnetic interactions. In class (a) the most sensitive are probably the searches for an electric dipole moment of the neutron measured to be $< 1.0 \times 10^{-25}$ e cm and the electron $(-0.18 \pm 0.16) \times 10^{-26}$ e cm. A nonzero value requires both P and T violation. Class (b) includes the search for C violation in η decay believed to be an electromagnetic process *e.g.* as measured by $\Gamma(\eta \to \mu^+\mu^-\pi^0)/\Gamma(\eta \to \text{all}) < 5 \times 10^{-6}$ and searches for T violation in a number of nuclear and electromagnetic reactions.

CONSERVATION OF LEPTON NUMBERS

Present experimental evidence and the standard electroweak theory are consistent with the absolute conservation of three separate lepton numbers: electron number L_e muon number L_μ and tau number L_τ. Searches for violations are of the following types:

a) $\Delta L = 2$ for one type of lepton. The best limit comes from the search for neutrinoless double beta decay $(Z, A) \to (Z + 2, A) + e^- + e^-$. The best laboratory limit is $t_{1/2} > 1.1 \times 10^{25}$ yr (CL=90%) for ^{76}Ge.

b) Conversion of one lepton type to another. For purely leptonic processes the best limits are on $\mu \to e\gamma$ and $\mu \to 3e$ measured as $\Gamma(\mu \to e\gamma)/\Gamma(\mu \to \text{all}) < 5 \times 10^{-11}$ and $\Gamma(\mu \to 3e)/\Gamma(\mu \to \text{all}) < 1.0 \times 10^{-12}$. For semileptonic processes the best limit comes from the coherent conversion process in a muonic atom $\mu^- + (Z, A) \to e^- + (Z, A)$ measured as $\Gamma(\mu^-\text{Ti} \to e^-\text{Ti})/\Gamma(\mu^-\text{Ti} \to \text{all}) < 4 \times 10^{-12}$. Of special interest is the case in which the hadronic flavor also changes as in $K_L \to e\mu$ and $K^+ \to \pi^+ e^- \mu^+$ measured as $\Gamma(K_L \to e\mu)/\Gamma(K_L \to \text{all}) < 3.3 \times 10^{-11}$ and $\Gamma(K^+ \to \pi^+ e^- \mu^+)/\Gamma(K^+ \to \text{all}) < 2.1 \times 10^{-10}$. Limits on the conversion of τ into e or μ are found in τ decay and are much less stringent than those for $\mu \to e$ conversion *e.g.* $\Gamma(\tau \to \mu\gamma)/\Gamma(\tau \to \text{all}) < 3.0 \times 10^{-6}$ and $\Gamma(\tau \to e\gamma)/\Gamma(\tau \to \text{all}) < 2.7 \times 10^{-6}$.

c) Conversion of one type of lepton into another type of antilepton. The case most studied is $\mu^- + (Z, A) \to e^+ + (Z - 2, A)$ the strongest limit being $\Gamma(\mu^-\text{Ti} \to e^+\text{Ca})/\Gamma(\mu^-\text{Ti} \to \text{all}) < 9 \times 10^{-11}$.

d) Relation to neutrino mass. If neutrinos have mass then it is expected even in the standard electroweak theory that the lepton numbers are not separately conserved as a consequence of lepton mixing analogous to Cabibbo quark mixing. However in this case lepton-number-violating processes such as $\mu \to e\gamma$ are expected to have extremely small probability. For small neutrino masses the lepton-number violation would be observed first in neutrino oscillations which have been the subject of extensive experimental searches. For example searches for $\overline{\nu}_e$ disappearance which we label as $\overline{\nu}_e \not\to \overline{\nu}_e$ give measured limits $\Delta(m^2) < 9 \times 10^{-4}$ eV^2 for $\sin^2(2\theta) = 1$ and $\sin^2(2\theta) < 0.02$ for large $\Delta(m^2)$ where θ is the neutrino mixing angle. Possible evidence for mixing has come from two sources. The deficit in the solar neutrino flux compared with solar model calculations could be explained by oscillations with $\Delta(m^2) \leq 10^{-5}$ eV^2 causing the disappearance of ν_e. In addition underground detectors observing neutrinos produced by cosmic rays in the atmosphere have measured a ν_μ/ν_e ratio much less than expected and also a deficiency of upward going ν_μ compared to downward. This could be explained by oscillations leading to the disappearance of ν_μ with $\Delta(m^2)$ of the order 10^{-2}–10^{-3} eV^2.

CONSERVATION OF HADRONIC FLAVORS

In strong and electromagnetic interactions hadronic flavor is conserved *i.e.* the conversion of a quark of one flavor (d, u, s, c, b, t) into a quark of another flavor is forbidden. In the Standard Model the weak interactions violate these conservation laws in a manner described by the Cabibbo-Kobayashi-Maskawa mixing (see the section "Cabibbo-Kobayashi-Maskawa Mixing Matrix"). The way in which these conservation laws are violated is tested as follows:

a) $\Delta S = \Delta Q$ rule. In the semileptonic decay of strange particles the strangeness change equals the change in charge of the hadrons. Tests come from limits on decay rates such as

$\Gamma(\Sigma^+ \to n e^+ \nu)/\Gamma(\Sigma^+ \to \text{all}) < 5 \times 10^{-6}$Γand from a detailed analysis of $K_L \to \pi e \nu$Γwhich yields the parameter xΓmeasured to be $(\mathrm{Re}\, x, \mathrm{Im}\, x) = (0.006 \pm 0.018, -0.003 \pm 0.026)$. Corresponding rules are $\Delta C = \Delta Q$ and $\Delta B = \Delta Q$.

b) Change of flavor by two units. In the Standard Model this occurs only in second-order weak interactions. The classic example is $\Delta S = 2$ via $K^0 - \overline{K}^0$ mixingΓwhich is directly measured by $m(K_S) - m(K_L) = (3.489 \pm 0.009) \times 10^{-12}$ MeV. There is now evidence for $B^0 - \overline{B}^0$ mixing $(\Delta B = 2)$Γwith the corresponding mass difference between the eigenstates $(m_{B^0_H} - m_{B^0_L}) = (0.723 \pm 0.032)\Gamma_{B^0} = (3.05 \pm 0.12) \times 10^{-10}$ MeVΓand for B^0_s–$\overline{B}^0_s$ mixingΓwith $(m_{B^0_{sH}} - m_{B^0_{sL}}) > 14\Gamma_{B^0_s}$ or $> 6 \times 10^{-9}$ MeV (CL=95%). No evidence exists for $D^0 - \overline{D}^0$ mixingΓwhich is expected to be much smaller in the Standard Model.

c) Flavor-changing neutral currents. In the Standard Model the neutral-current interactions do not change flavor. The low rate $\Gamma(K_L \to \mu^+\mu^-)/\Gamma(K_L \to \text{all}) = (7.2 \pm 0.5) \times 10^{-9}$ puts limits on such interactions; the nonzero value for this rate is attributed to a combination of the weak and electromagnetic interactions. The best test should come from $K^+ \to \pi^+ \nu \overline{\nu}$Γ which occurs in the Standard Model only as a second-order weak process with a branching fraction of $(1 \text{ to } 8) \times 10^{-10}$. Observation of one event has been reported [4]Γyielding $\Gamma(K^+ \to \pi^+ \nu \overline{\nu})/\Gamma(K^+ \to \text{all}) = (4.2^{+9.7}_{-3.5}) \times 10^{-10}$. Limits for charm-changing or bottom-changing neutral currents are much less stringent: $\Gamma(D^0 \to \mu^+\mu^-)/\Gamma(D^0 \to \text{all}) < 4 \times 10^{-6}$ and $\Gamma(B^0 \to \mu^+\mu^-)/\Gamma(B^0 \to \text{all}) < 7 \times 10^{-7}$. One cannot isolate flavor-changing neutral current (FCNC) effects in non leptonic decays. For exampleΓthe FCNC transition $s \to d + (\overline{u} + u)$ is equivalent to the charged-current transition $s \to u + (\overline{u} + d)$. Tests for FCNC are therefore limited to hadron decays into lepton pairs. Such decays are expected only in second-order in the electroweak coupling in the Standard Model.

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TESTS OF DISCRETE SPACE-TIME SYMMETRIES

CHARGE CONJUGATION (*C*) INVARIANCE

$\Gamma(\pi^0 \to 3\gamma)/\Gamma_{\text{total}}$		$<3.1 \times 10^{-8}$ΓCL = 90%
η *C*-nonconserving decay parameters		
$\pi^+\pi^-\pi^0$ left-right asymmetry parameter		$(0.09 \pm 0.17) \times 10^{-2}$
$\pi^+\pi^-\pi^0$ sextant asymmetry parameter		$(0.18 \pm 0.16) \times 10^{-2}$
$\pi^+\pi^-\pi^0$ quadrant asymmetry parameter		$(-0.17 \pm 0.17) \times 10^{-2}$
$\pi^+\pi^-\gamma$ left-right asymmetry parameter		$(0.9 \pm 0.4) \times 10^{-2}$
$\pi^+\pi^-\gamma$ parameter β (*D*-wave)		0.05 ± 0.06 (S = 1.5)
$\Gamma(\eta \to 3\gamma)/\Gamma_{\text{total}}$		$<5 \times 10^{-4}$ΓCL = 95%
$\Gamma(\eta \to \pi^0 e^+ e^-)/\Gamma_{\text{total}}$	[a]	$<4 \times 10^{-5}$ΓCL = 90%
$\Gamma(\eta \to \pi^0 \mu^+ \mu^-)/\Gamma_{\text{total}}$	[a]	$<5 \times 10^{-6}$ΓCL = 90%
$\Gamma(\omega(782) \to \eta\pi^0)/\Gamma_{\text{total}}$		$<1 \times 10^{-3}$ΓCL = 90%
$\Gamma(\omega(782) \to 3\pi^0)/\Gamma_{\text{total}}$		$<3 \times 10^{-4}$ΓCL = 90%
$\Gamma(\eta'(958) \to \pi^0 e^+ e^-)/\Gamma_{\text{total}}$	[a]	$<1.3 \times 10^{-2}$ΓCL = 90%
$\Gamma(\eta'(958) \to \eta e^+ e^-)/\Gamma_{\text{total}}$	[a]	$<1.1 \times 10^{-2}$ΓCL = 90%
$\Gamma(\eta'(958) \to 3\gamma)/\Gamma_{\text{total}}$		$<1.0 \times 10^{-4}$ΓCL = 90%
$\Gamma(\eta'(958) \to \mu^+\mu^-\pi^0)/\Gamma_{\text{total}}$	[a]	$<6.0 \times 10^{-5}$ΓCL = 90%
$\Gamma(\eta'(958) \to \mu^+\mu^-\eta)/\Gamma_{\text{total}}$	[a]	$<1.5 \times 10^{-5}$ΓCL = 90%

Limits are given at the 90% confidence levelΓwhile errors are given as ±1 standard deviation.

PARITY (*P*) INVARIANCE

e electric dipole moment		$(0.18 \pm 0.16) \times 10^{-26}$ *e* cm
μ electric dipole moment		$(3.7 \pm 3.4) \times 10^{-19}$ *e* cm
τ electric dipole moment (d_τ)		> -3.1 and $< 3.1 \times 10^{-16}$ *e* cmΓ CL = 95%
$\Gamma(\eta \to \pi^+\pi^-)/\Gamma_{\text{total}}$		$<9 \times 10^{-4}$ΓCL = 90%
$\Gamma(\eta'(958) \to \pi^+\pi^-)/\Gamma_{\text{total}}$		$<2 \times 10^{-2}$ΓCL = 90%
$\Gamma(\eta'(958) \to \pi^0\pi^0)/\Gamma_{\text{total}}$		$<9 \times 10^{-4}$ΓCL = 90%
p electric dipole moment		$(-4 \pm 6) \times 10^{-23}$ *e* cm
n electric dipole moment		$<0.97 \times 10^{-25}$ *e* cmΓCL = 90%
Λ electric dipole moment		$<1.5 \times 10^{-16}$ *e* cmΓCL = 95%

TIME REVERSAL (*T*) INVARIANCE

Limits on *e*, μ, τ, *p*, *n*, and Λ electric dipole moments under Parity Invariance above are also tests of Time Reversal Invariance.

μ decay parameters		
transverse e^+ polarization normal to plane of μ spinΓe^+ momentum		0.007 ± 0.023
α'/A		$(0 \pm 4) \times 10^{-3}$
β'/A		$(2 \pm 6) \times 10^{-3}$
τ electric dipole moment (d_τ)		> -3.1 and $< 3.1 \times 10^{-16}$ *e* cmΓ CL = 95%
$\mathrm{Im}(\xi)$ in $K^\pm_{\mu 3}$ decay (from transverse μ pol.)		-0.017 ± 0.025
$\mathrm{Im}(\xi)$ in $K^0_{\mu 3}$ decay (from transverse μ pol.)		-0.007 ± 0.026
$n \to p e^- \nu$ decay parameters		
ϕ_{AV}Γphase of g_A relative to g_V	[b]	$(180.07 \pm 0.18)^\circ$
triple correlation coefficient *D*		$(-0.5 \pm 1.4) \times 10^{-3}$
triple correlation coefficient *D* for $\Sigma^- \to n e^- \overline{\nu}_e$		0.11 ± 0.10

CP INVARIANCE

$\mathrm{Re}(d^W_\tau)$		$<0.56 \times 10^{-17}$ *e* cmΓCL = 95%
$\mathrm{Im}(d^W_\tau)$		$<1.5 \times 10^{-17}$ *e* cmΓCL = 95%
$\Gamma(\eta \to \pi^+\pi^-)/\Gamma_{\text{total}}$		$<9 \times 10^{-4}$ΓCL = 90%
$\Gamma(\eta'(958) \to \pi^+\pi^-)/\Gamma_{\text{total}}$		$<2 \times 10^{-2}$ΓCL = 90%
$\Gamma(\eta'(958) \to \pi^0\pi^0)/\Gamma_{\text{total}}$		$<9 \times 10^{-4}$ΓCL = 90%
$K^\pm \to \pi^\pm\pi^+\pi^-$ rate difference/average		$(0.07 \pm 0.12)\%$
$K^\pm \to \pi^\pm\pi^0\pi^0$ rate difference/average		$(0.0 \pm 0.6)\%$
$K^\pm \to \pi^\pm\pi^0\gamma$ rate difference/average		$(0.9 \pm 3.3)\%$
$(g_{\tau^+} - g_{\tau^-}) / (g_{\tau^+} + g_{\tau^-})$ for $K^\pm \to \pi^\pm\pi^+\pi^-$		$(-0.7 \pm 0.5)\%$
CP-violation parameters in K^0_S decay		
$\mathrm{Im}(\eta_{+-0}) = \mathrm{Im}(A(K^0_S \to \pi^+\pi^-\pi^0)$Γ *CP*-violating) / $A(K^0_L \to \pi^+\pi^-\pi^0))$		-0.002 ± 0.008
$\mathrm{Im}(\eta_{000})^2 = \Gamma(K^0_S \to 3\pi^0)$ / $\Gamma(K^0_L \to 3\pi^0)$		<0.1ΓCL = 90%
charge asymmetry *j* for $K^0_L \to \pi^+\pi^-\pi^0$		0.0011 ± 0.0008
$\lvert\epsilon'_{+-\gamma}\rvert/\epsilon$ for $K^0_L \to \pi^+\pi^-\gamma$		<0.3ΓCL = 90%
$\Gamma(K^0_L \to \pi^0\mu^+\mu^-)/\Gamma_{\text{total}}$	[c]	$<5.1 \times 10^{-9}$ΓCL = 90%
$\Gamma(K^0_L \to \pi^0 e^+ e^-)/\Gamma_{\text{total}}$	[c]	$<4.3 \times 10^{-9}$ΓCL = 90%
$\Gamma(K^0_L \to \pi^0\nu\overline{\nu})/\Gamma_{\text{total}}$	[d]	$<5.8 \times 10^{-5}$ΓCL = 90%
$A_{CP}(K^+K^-\pi^\pm)$ in $D^\pm \to K^+K^-\pi^\pm$		-0.017 ± 0.027
$A_{CP}(K^\pm K^{*0})$ in $D^+ \to K^+\overline{K}^{*0}$ and $D^- \to K^-K^{*0}$		-0.02 ± 0.05
$A_{CP}(\phi\pi^\pm)$ in $D^\pm \to \phi\pi^\pm$		-0.014 ± 0.033
$A_{CP}(\pi^+\pi^-\pi^\pm)$ in $D^\pm \to \pi^+\pi^-\pi^\pm$		-0.02 ± 0.04
$A_{CP}(K^+K^-)$ in $D^0\Gamma\overline{D}^0 \to K^+K^-$		0.026 ± 0.035
$A_{CP}(\pi^+\pi^-)$ in $D^0\Gamma\overline{D}^0 \to \pi^+\pi^-$		-0.05 ± 0.08
$A_{CP}(K^0_S\phi)$ in $D^0\Gamma\overline{D}^0 \to K^0_S\phi$		-0.03 ± 0.09
$A_{CP}(K^0_S\pi^0)$ in $D^0\Gamma\overline{D}^0 \to K^0_S\pi^0$		-0.018 ± 0.030
$\lvert\mathrm{Re}(\epsilon_{B^0})\rvert$		0.002 ± 0.008
$[\alpha_-(\Lambda) + \alpha_+(\overline{\Lambda})] / [\alpha_-(\Lambda) - \alpha_+(\overline{\Lambda})]$		-0.03 ± 0.06

CP VIOLATION OBSERVED

K_L^0 branching ratios		
charge asymmetry in $K_{\ell 3}^0$ decays		
$\delta(\mu) = [\Gamma(\pi^- \mu^+ \nu_\mu) - \Gamma(\pi^+ \mu^- \overline{\nu}_\mu)]$/sum		$(0.304 \pm 0.025)\%$
$\delta(e) = [\Gamma(\pi^- e^+ \nu_e) - \Gamma(\pi^+ e^- \overline{\nu}_e)]$/sum		$(0.333 \pm 0.014)\%$
parameters for $K_L^0 \to 2\pi$ decay		
$\lvert\eta_{00}\rvert = \lvert A(K_L^0 \to 2\pi^0) / A(K_S^0 \to 2\pi^0)\rvert$		$(2.275 \pm 0.019) \times 10^{-3}$ (S = 1.1)
$\lvert\eta_{+-}\rvert = \lvert A(K_L^0 \to \pi^+\pi^-) / A(K_S^0 \to \pi^+\pi^-)\rvert$		$(2.285 \pm 0.019) \times 10^{-3}$
$\epsilon'/\epsilon \approx \mathrm{Re}(\epsilon'/\epsilon) = (1 - \lvert\eta_{00}/\eta_{+-}\rvert)/3$	[e]	$(1.5 \pm 0.8) \times 10^{-3}$ (S = 1.8)
ϕ_{+-} Γphase of η_{+-}		$(43.5 \pm 0.6)^\circ$
ϕ_{00} Γphase of η_{00}		$(43.4 \pm 1.0)^\circ$
parameters for $K_L^0 \to \pi^+\pi^-\gamma$ decay		
$\lvert\eta_{+-\gamma}\rvert = \lvert A(K_L^0 \to \pi^+\pi^-\gamma$ Γ*CP* violating)/$A(K_S^0 \to \pi^+\pi^-\gamma)\rvert$		$(2.35 \pm 0.07) \times 10^{-3}$
$\phi_{+-\gamma}$ = phase of $\eta_{+-\gamma}$		$(44 \pm 4)^\circ$
$\Gamma(K_L^0 \to \pi^+\pi^-)/\Gamma_{\text{total}}$		$(2.067 \pm 0.035) \times 10^{-3}$ (S = 1.1)
$\Gamma(K_L^0 \to \pi^0\pi^0)/\Gamma_{\text{total}}$		$(9.36 \pm 0.20) \times 10^{-4}$

CPT INVARIANCE

$(m_{W^-} - m_{W^-}) / m_{\text{average}}$		-0.002 ± 0.007
$(m_{e^-} - m_{e^-}) / m_{\text{average}}$		$<4 \times 10^{-8}$ Γ CL = 90%
$\lvert q_{e^-} + q_{e^-}\rvert/e$		$<2 \times 10^{-18}$
$(g_{e^-} - g_{e^-}) / g_{\text{average}}$		$(-0.5 \pm 2.1) \times 10^{-12}$
$(\tau_{\mu^-} - \tau_{\mu^-}) / \tau_{\text{average}}$		$(2 \pm 8) \times 10^{-5}$
$(g_{\mu^-} - g_{\mu^-}) / g_{\text{average}}$		$(-2.6 \pm 1.6) \times 10^{-8}$
$(m_{\pi^-} - m_{\pi^-}) / m_{\text{average}}$		$(2 \pm 5) \times 10^{-4}$
$(\tau_{\pi^-} - \tau_{\pi^-}) / \tau_{\text{average}}$		$(6 \pm 7) \times 10^{-4}$
$(m_{K^-} - m_{K^-}) / m_{\text{average}}$		$(-0.6 \pm 1.8) \times 10^{-4}$
$(\tau_{K^-} - \tau_{K^-}) / \tau_{\text{average}}$		$(0.11 \pm 0.09)\%$ (S = 1.2)
$K^\pm \to \mu^\pm \nu_\mu$ rate difference/average	[f]	$(-0.5 \pm 0.4)\%$
$K^\pm \to \pi^\pm \pi^0$ rate difference/average	[f]	$(0.8 \pm 1.2)\%$
$\lvert m_{K^0} - m_{\overline{K}^0}\rvert / m_{\text{average}}$	[g]	$<10^{-18}$
phase difference $\phi_{00} - \phi_{+-}$		$(-0.1 \pm 0.8)^\circ$
CPT-violation parameters in K^0 decay		
real part of Δ		0.018 ± 0.020
imaginary part of Δ		0.02 ± 0.04
$(\lvert\frac{q_p}{m_p}\rvert - \lvert\frac{q_p}{m_p}\rvert)/\lvert\frac{q}{m}\rvert_{\text{average}}$		$(1.5 \pm 1.1) \times 10^{-9}$
$\lvert q_p + q_{\overline{p}}\rvert/e$		$<2 \times 10^{-5}$
$(\mu_p + \mu_{\overline{p}}) / \lvert\mu\rvert_{\text{average}}$		$(-2.6 \pm 2.9) \times 10^{-3}$
$(m_n - m_{\overline{n}}) / m_{\text{average}}$		$(9 \pm 5) \times 10^{-5}$
$(m_\Lambda - m_{\overline{\Lambda}}) / m_\Lambda$		$(-1.0 \pm 0.9) \times 10^{-5}$
$(\tau_\Lambda - \tau_{\overline{\Lambda}}) / \tau_{\text{average}}$		0.04 ± 0.09
$(\mu_{\Sigma^-} + \mu_{\overline{\Sigma}^-}) / \lvert\mu\rvert_{\text{average}}$		0.014 ± 0.015
$(m_{\Xi^-} - m_{\overline{\Xi}^-}) / m_{\text{average}}$		$(1.1 \pm 2.7) \times 10^{-4}$
$(\tau_{\Xi^-} - \tau_{\overline{\Xi}^-}) / \tau_{\text{average}}$		0.02 ± 0.18
$(m_{\Omega^-} - m_{\overline{\Omega}^-}) / m_{\text{average}}$		$(0 \pm 5) \times 10^{-4}$

Limits are given at the 90% confidence level Γwhile errors are given as ±1 standard deviation.

TESTS OF NUMBER CONSERVATION LAWS

LEPTON FAMILY NUMBER

Lepton family number conservation means separate conservation of each of L_e, L_μ, L_τ.

$\Gamma(Z \to e^\pm \mu^\mp)/\Gamma_{\text{total}}$	[h]	$<1.7 \times 10^{-6}$ Γ CL = 95%
$\Gamma(Z \to e^\pm \tau^\mp)/\Gamma_{\text{total}}$	[h]	$<9.8 \times 10^{-6}$ Γ CL = 95%
$\Gamma(Z \to \mu^\pm \tau^\mp)/\Gamma_{\text{total}}$	[h]	$<1.2 \times 10^{-5}$ Γ CL = 95%
limit on $\mu^- \to e^-$ conversion		
$\sigma(\mu^- {}^{32}\mathrm{S} \to e^- {}^{32}\mathrm{S}) / \sigma(\mu^- {}^{32}\mathrm{S} \to \nu_\mu {}^{32}\mathrm{P}^*)$		$<7 \times 10^{-11}$ Γ CL = 90%
$\sigma(\mu^- \mathrm{Ti} \to e^- \mathrm{Ti}) / \sigma(\mu^- \mathrm{Ti} \to \text{capture})$		$<4.3 \times 10^{-12}$ Γ CL = 90%
$\sigma(\mu^- \mathrm{Pb} \to e^- \mathrm{Pb}) / \sigma(\mu^- \mathrm{Pb} \to \text{capture})$		$<4.6 \times 10^{-11}$ Γ CL = 90%
limit on muonium → antimuonium conversion $R_g = G_C / G_F$		<0.018 Γ CL = 90%
$\Gamma(\mu^- \to e^- \nu_e \overline{\nu}_\mu)/\Gamma_{\text{total}}$	[i]	$<1.2 \times 10^{-2}$ Γ CL = 90%
$\Gamma(\mu^- \to e^- \gamma)/\Gamma_{\text{total}}$		$<4.9 \times 10^{-11}$ Γ CL = 90%
$\Gamma(\mu^- \to e^- e^+ e^-)/\Gamma_{\text{total}}$		$<1.0 \times 10^{-12}$ Γ CL = 90%
$\Gamma(\mu^- \to e^- 2\gamma)/\Gamma_{\text{total}}$		$<7.2 \times 10^{-11}$ Γ CL = 90%
$\Gamma(\tau^- \to e^- \gamma)/\Gamma_{\text{total}}$		$<2.7 \times 10^{-6}$ Γ CL = 90%
$\Gamma(\tau^- \to \mu^- \gamma)/\Gamma_{\text{total}}$		$<3.0 \times 10^{-6}$ Γ CL = 90%
$\Gamma(\tau^- \to e^- \pi^0)/\Gamma_{\text{total}}$		$<3.7 \times 10^{-6}$ Γ CL = 90%
$\Gamma(\tau^- \to \mu^- \pi^0)/\Gamma_{\text{total}}$		$<4.0 \times 10^{-6}$ Γ CL = 90%
$\Gamma(\tau^- \to e^- K^0)/\Gamma_{\text{total}}$		$<1.3 \times 10^{-3}$ Γ CL = 90%
$\Gamma(\tau^- \to \mu^- K^0)/\Gamma_{\text{total}}$		$<1.0 \times 10^{-3}$ Γ CL = 90%
$\Gamma(\tau^- \to e^- \eta)/\Gamma_{\text{total}}$		$<8.2 \times 10^{-6}$ Γ CL = 90%
$\Gamma(\tau^- \to \mu^- \eta)/\Gamma_{\text{total}}$		$<9.6 \times 10^{-6}$ Γ CL = 90%
$\Gamma(\tau^- \to e^- \rho^0)/\Gamma_{\text{total}}$		$<2.0 \times 10^{-6}$ Γ CL = 90%
$\Gamma(\tau^- \to \mu^- \rho^0)/\Gamma_{\text{total}}$		$<6.3 \times 10^{-6}$ Γ CL = 90%
$\Gamma(\tau^- \to e^- K^*(892)^0)/\Gamma_{\text{total}}$		$<5.1 \times 10^{-6}$ Γ CL = 90%
$\Gamma(\tau^- \to \mu^- K^*(892)^0)/\Gamma_{\text{total}}$		$<7.5 \times 10^{-6}$ Γ CL = 90%
$\Gamma(\tau^- \to e^- \overline{K}^*(892)^0)/\Gamma_{\text{total}}$		$<7.4 \times 10^{-6}$ Γ CL = 90%
$\Gamma(\tau^- \to \mu^- \overline{K}^*(892)^0)/\Gamma_{\text{total}}$		$<7.5 \times 10^{-6}$ Γ CL = 90%
$\Gamma(\tau^- \to e^- \phi)/\Gamma_{\text{total}}$		$<6.9 \times 10^{-6}$ Γ CL = 90%
$\Gamma(\tau^- \to \mu^- \phi)/\Gamma_{\text{total}}$		$<7.0 \times 10^{-6}$ Γ CL = 90%
$\Gamma(\tau^- \to e^- e^+ e^-)/\Gamma_{\text{total}}$		$<2.9 \times 10^{-6}$ Γ CL = 90%
$\Gamma(\tau^- \to e^- \mu^+ \mu^-)/\Gamma_{\text{total}}$		$<1.8 \times 10^{-6}$ Γ CL = 90%
$\Gamma(\tau^- \to e^+ \mu^- \mu^-)/\Gamma_{\text{total}}$		$<1.5 \times 10^{-6}$ Γ CL = 90%
$\Gamma(\tau^- \to \mu^- e^+ e^-)/\Gamma_{\text{total}}$		$<1.7 \times 10^{-6}$ Γ CL = 90%
$\Gamma(\tau^- \to \mu^+ e^- e^-)/\Gamma_{\text{total}}$		$<1.5 \times 10^{-6}$ Γ CL = 90%
$\Gamma(\tau^- \to \mu^- \mu^+ \mu^-)/\Gamma_{\text{total}}$		$<1.9 \times 10^{-6}$ Γ CL = 90%
$\Gamma(\tau^- \to e^- \pi^+ \pi^-)/\Gamma_{\text{total}}$		$<2.2 \times 10^{-6}$ Γ CL = 90%
$\Gamma(\tau^- \to \mu^- \pi^+ \pi^-)/\Gamma_{\text{total}}$		$<8.2 \times 10^{-6}$ Γ CL = 90%
$\Gamma(\tau^- \to e^- \pi^+ K^-)/\Gamma_{\text{total}}$		$<6.4 \times 10^{-6}$ Γ CL = 90%
$\Gamma(\tau^- \to e^- \pi^- K^+)/\Gamma_{\text{total}}$		$<3.8 \times 10^{-6}$ Γ CL = 90%
$\Gamma(\tau^- \to e^- K^+ K^-)/\Gamma_{\text{total}}$		$<6.0 \times 10^{-6}$ Γ CL = 90%
$\Gamma(\tau^- \to \mu^- \pi^+ K^-)/\Gamma_{\text{total}}$		$<7.5 \times 10^{-6}$ Γ CL = 90%
$\Gamma(\tau^- \to \mu^- \pi^- K^+)/\Gamma_{\text{total}}$		$<7.4 \times 10^{-6}$ Γ CL = 90%
$\Gamma(\tau^- \to \mu^- K^+ K^-)/\Gamma_{\text{total}}$		$<1.5 \times 10^{-5}$ Γ CL = 90%
$\Gamma(\tau^- \to e^- \pi^0 \pi^0)/\Gamma_{\text{total}}$		$<6.5 \times 10^{-6}$ Γ CL = 90%
$\Gamma(\tau^- \to \mu^- \pi^0 \pi^0)/\Gamma_{\text{total}}$		$<1.4 \times 10^{-5}$ Γ CL = 90%
$\Gamma(\tau^- \to e^- \eta\eta)/\Gamma_{\text{total}}$		$<3.5 \times 10^{-5}$ Γ CL = 90%
$\Gamma(\tau^- \to \mu^- \eta\eta)/\Gamma_{\text{total}}$		$<6.0 \times 10^{-5}$ Γ CL = 90%
$\Gamma(\tau^- \to e^- \pi^0 \eta)/\Gamma_{\text{total}}$		$<2.4 \times 10^{-5}$ Γ CL = 90%
$\Gamma(\tau^- \to \mu^- \pi^0 \eta)/\Gamma_{\text{total}}$		$<2.2 \times 10^{-5}$ Γ CL = 90%
$\Gamma(\tau^- \to e^-$ light boson$)/\Gamma_{\text{total}}$		$<2.7 \times 10^{-3}$ Γ CL = 95%
$\Gamma(\tau^- \to \mu^-$ light boson$)/\Gamma_{\text{total}}$		$<5 \times 10^{-3}$ Γ CL = 95%
ν oscillations. (For other lepton mixing effects in particle decays Γsee the Particle Listings.)		
$\overline{\nu}_e \not\to \overline{\nu}_e$		
$\Delta(m^2)$ for $\sin^2(2\theta) = 1$		$<9 \times 10^{-4}$ eV^2 Γ CL = 90%
$\sin^2(2\theta)$ for "Large" $\Delta(m^2)$		<0.02 Γ CL = 90%
$\nu_e \to \nu_\tau$		
$\Delta(m^2)$ for $\sin^2(2\theta) = 1$		<9 eV^2 Γ CL = 90%
$\sin^2(2\theta)$ for "Large" $\Delta(m^2)$		<0.25 Γ CL = 90%
$\overline{\nu}_e \to \overline{\nu}_\tau$		
$\sin^2(2\theta)$ for "Large" $\Delta(m^2)$		<0.7 Γ CL = 90%
$\nu_\mu \to \nu_e$		

$\Delta(m^2)$ for $\sin^2(2\theta) = 1$		<0.09 eV^2 CL = 90%
$\sin^2(2\theta)$ for "Large" $\Delta(m^2)$		$<3.0 \times 10^{-3}$ CL = 90%
$\bar{\nu}_\mu \to \bar{\nu}_e$		
$\Delta(m^2)$ for $\sin^2(2\theta) = 1$		<0.14 eV^2 CL = 90%
$\sin^2(2\theta)$ for "Large" $\Delta(m^2)$		<0.004 CL = 95%
$\nu_\mu(\bar{\nu}_\mu) \to \nu_e(\bar{\nu}_e)$		
$\Delta(m^2)$ for $\sin^2(2\theta) = 1$		<0.075 eV^2 CL = 90%
$\sin^2(2\theta)$ for "Large" $\Delta(m^2)$		$<1.8 \times 10^{-3}$ CL = 90%
$\nu_\mu \to \nu_\tau$		
$\Delta(m^2)$ for $\sin^2(2\theta) = 1$		<0.9 eV^2 CL = 90%
$\sin^2(2\theta)$ for "Large" $\Delta(m^2)$		<0.004 CL = 90%
$\bar{\nu}_\mu \to \bar{\nu}_\tau$		
$\Delta(m^2)$ for $\sin^2(2\theta) = 1$		<2.2 eV^2 CL = 90%
$\sin^2(2\theta)$ for "Large" $\Delta(m^2)$		$<4.4 \times 10^{-2}$ CL = 90%
$\nu_\mu(\bar{\nu}_\mu) \to \nu_\tau(\bar{\nu}_\tau)$		
$\Delta(m^2)$ for $\sin^2(2\theta) = 1$		<1.5 eV^2 CL = 90%
$\sin^2(2\theta)$ for "Large" $\Delta(m^2)$		$<8 \times 10^{-3}$ CL = 90%
$\nu_e \not\to \nu_e$		
$\Delta(m^2)$ for $\sin^2(2\theta) = 1$		<0.17 eV^2 CL = 90%
$\sin^2(2\theta)$ for "Large" $\Delta(m^2)$		$<7 \times 10^{-2}$ CL = 90%
$\nu_\mu \not\to \nu_\mu$		
$\Delta(m^2)$ for $\sin^2(2\theta) = 1$		<0.23 or >1500 eV^2
$\sin^2(2\theta)$ for $\Delta(m^2) = 100$eV^2	[j]	<0.02 CL = 90%
$\bar{\nu}_\mu \not\to \bar{\nu}_\mu$		
$\Delta(m^2)$ for $\sin^2(2\theta) = 1$		<7 or >1200 eV^2
$\sin^2(2\theta)$ for 190 eV^2 $<$ $\Delta(m^2)$ $<$ 320 eV^2	[k]	<0.02 CL = 90%
$\Gamma(\pi^+ \to \mu^+\nu_e)/\Gamma_{\text{total}}$	[l]	$<8.0 \times 10^{-3}$ CL = 90%
$\Gamma(\pi^+ \to \mu^- e^+ e^+ \nu)/\Gamma_{\text{total}}$		$<1.6 \times 10^{-6}$ CL = 90%
$\Gamma(\pi^0 \to \mu^+ e^- + e^- \mu^+)/\Gamma_{\text{total}}$		$<1.72 \times 10^{-8}$ CL = 90%
$\Gamma(\eta \to \mu^+ e^- + \mu^- e^+)/\Gamma_{\text{total}}$		$<6 \times 10^{-6}$ CL = 90%
$\Gamma(K^+ \to \mu^- \nu e^+ e^+)/\Gamma_{\text{total}}$		$<2.0 \times 10^{-8}$ CL = 90%
$\Gamma(K^+ \to \mu^+\nu_e)/\Gamma_{\text{total}}$	[l]	$<4 \times 10^{-3}$ CL = 90%
$\Gamma(K^+ \to \pi^+\mu^+ e^-)/\Gamma_{\text{total}}$		$<2.1 \times 10^{-10}$ CL = 90%
$\Gamma(K^+ \to \pi^+\mu^- e^+)/\Gamma_{\text{total}}$		$<7 \times 10^{-9}$ CL = 90%
$\Gamma(K_L^0 \to e^\pm\mu^\mp)/\Gamma_{\text{total}}$	[h]	$<3.3 \times 10^{-11}$ CL = 90%
$\Gamma(K_L^0 \to e^\pm e^\pm \mu^\mp \mu^\mp)/\Gamma_{\text{total}}$	[h]	$<6.1 \times 10^{-9}$ CL = 90%
$\Gamma(D^+ \to \pi^+ e^+ \mu^-)/\Gamma_{\text{total}}$		$<1.1 \times 10^{-4}$ CL = 90%
$\Gamma(D^+ \to \pi^+ e^- \mu^+)/\Gamma_{\text{total}}$		$<1.3 \times 10^{-4}$ CL = 90%
$\Gamma(D^+ \to K^+ e^+ \mu^-)/\Gamma_{\text{total}}$		$<1.3 \times 10^{-4}$ CL = 90%
$\Gamma(D^+ \to K^+ e^- \mu^+)/\Gamma_{\text{total}}$		$<1.2 \times 10^{-4}$ CL = 90%
$\Gamma(D^0 \to \mu^\pm e^\mp)/\Gamma_{\text{total}}$	[h]	$<1.9 \times 10^{-5}$ CL = 90%
$\Gamma(D^0 \to \pi^0 e^\pm \mu^\mp)/\Gamma_{\text{total}}$	[h]	$<8.6 \times 10^{-5}$ CL = 90%
$\Gamma(D^0 \to \eta e^\pm \mu^\mp)/\Gamma_{\text{total}}$	[h]	$<1.0 \times 10^{-4}$ CL = 90%
$\Gamma(D^0 \to \rho^0 e^\pm \mu^\mp)/\Gamma_{\text{total}}$	[h]	$<4.9 \times 10^{-5}$ CL = 90%
$\Gamma(D^0 \to \omega e^\pm \mu^\mp)/\Gamma_{\text{total}}$	[h]	$<1.2 \times 10^{-4}$ CL = 90%
$\Gamma(D^0 \to \phi e^\pm \mu^\mp)/\Gamma_{\text{total}}$	[h]	$<3.4 \times 10^{-5}$ CL = 90%
$\Gamma(D^0 \to \bar{K}^0 e^\pm \mu^\mp)/\Gamma_{\text{total}}$	[h]	$<1.0 \times 10^{-4}$ CL = 90%
$\Gamma(D^0 \to \bar{K}^*(892)^0 e^\pm \mu^\mp)/\Gamma_{\text{total}}$	[h]	$<1.0 \times 10^{-4}$ CL = 90%
$\Gamma(B^+ \to \pi^+ e^+ \mu^-)/\Gamma_{\text{total}}$		$<6.4 \times 10^{-3}$ CL = 90%
$\Gamma(B^+ \to \pi^+ e^- \mu^+)/\Gamma_{\text{total}}$		$<6.4 \times 10^{-3}$ CL = 90%
$\Gamma(B^+ \to K^+ e^+ \mu^-)/\Gamma_{\text{total}}$		$<6.4 \times 10^{-3}$ CL = 90%
$\Gamma(B^+ \to K^+ e^- \mu^+)/\Gamma_{\text{total}}$		$<6.4 \times 10^{-3}$ CL = 90%
$\Gamma(B^+ \to \pi^- e^+ \mu^+)/\Gamma_{\text{total}}$		$<6.4 \times 10^{-3}$ CL = 90%
$\Gamma(B^+ \to K^- e^+ \mu^+)/\Gamma_{\text{total}}$		$<6.4 \times 10^{-3}$ CL = 90%
$\Gamma(B^0 \to e^\pm \mu^\mp)/\Gamma_{\text{total}}$	[h]	$<5.9 \times 10^{-6}$ CL = 90%
$\Gamma(B^0 \to e^\pm \tau^\mp)/\Gamma_{\text{total}}$	[h]	$<5.3 \times 10^{-4}$ CL = 90%
$\Gamma(B^0 \to \mu^\pm \tau^\mp)/\Gamma_{\text{total}}$	[h]	$<8.3 \times 10^{-4}$ CL = 90%
$\Gamma(B \to e^\pm \mu^\mp s)/\Gamma_{\text{total}}$		$<2.2 \times 10^{-5}$ CL = 90%
$\Gamma(B_s^0 \to e^\pm \mu^\mp)/\Gamma_{\text{total}}$	[h]	$<4.1 \times 10^{-5}$ CL = 90%

TOTAL LEPTON NUMBER

Violation of total lepton number conservation also implies violation of lepton family number conservation.

limit on $\mu^- \to e^+$ conversion		
$\sigma(\mu^- {}^{32}\text{S} \to e^+ {}^{32}\text{Si}^*) / \sigma(\mu^- {}^{32}\text{S} \to \nu_\mu {}^{32}\text{P}^*)$		$<9 \times 10^{-10}$ CL = 90%
$\sigma(\mu^- {}^{127}\text{I} \to e^+ {}^{127}\text{Sb}^*) / \sigma(\mu^- {}^{127}\text{I} \to \text{anything})$		$<3 \times 10^{-10}$ CL = 90%
$\sigma(\mu^- \text{Ti} \to e^+ \text{Ca}) / \sigma(\mu^- \text{Ti} \to \text{capture})$		$<8.9 \times 10^{-11}$ CL = 90%
$\Gamma(\tau^- \to \pi^-\gamma)/\Gamma_{\text{total}}$		$<2.8 \times 10^{-4}$ CL = 90%
$\Gamma(\tau^- \to \pi^-\pi^0)/\Gamma_{\text{total}}$		$<3.7 \times 10^{-4}$ CL = 90%
$\Gamma(\tau^- \to e^+\pi^-\pi^-)/\Gamma_{\text{total}}$		$<1.9 \times 10^{-6}$ CL = 90%
$\Gamma(\tau^- \to \mu^+\pi^-\pi^-)/\Gamma_{\text{total}}$		$<3.4 \times 10^{-6}$ CL = 90%
$\Gamma(\tau^- \to e^+\pi^- K^-)/\Gamma_{\text{total}}$		$<2.1 \times 10^{-6}$ CL = 90%
$\Gamma(\tau^- \to e^+ K^- K^-)/\Gamma_{\text{total}}$		$<3.8 \times 10^{-6}$ CL = 90%
$\Gamma(\tau^- \to \mu^+\pi^- K^-)/\Gamma_{\text{total}}$		$<7.0 \times 10^{-6}$ CL = 90%
$\Gamma(\tau^- \to \mu^+ K^- K^-)/\Gamma_{\text{total}}$		$<6.0 \times 10^{-6}$ CL = 90%
$\Gamma(\tau^- \to \bar{p}\gamma)/\Gamma_{\text{total}}$		$<2.9 \times 10^{-4}$ CL = 90%
$\Gamma(\tau^- \to \bar{p}\pi^0)/\Gamma_{\text{total}}$		$<6.6 \times 10^{-4}$ CL = 90%
$\Gamma(\tau^- \to \bar{p}\eta)/\Gamma_{\text{total}}$		$<1.30 \times 10^{-3}$ CL = 90%
$\nu_e \to (\bar{\nu}_e)_L$		
$\alpha\Delta(m^2)$ for $\sin^2(2\theta) = 1$		<0.14 eV^2 CL = 90%
$\alpha^2 \sin^2(2\theta)$ for "Large" $\Delta(m^2)$		<0.032 CL = 90%
$\nu_\mu \to (\bar{\nu}_e)_L$		
$\alpha\Delta(m^2)$ for $\sin^2(2\theta) = 1$		<0.16 eV^2 CL = 90%
$\alpha^2 \sin^2(2\theta)$ for "Large" $\Delta(m^2)$		<0.001 CL = 90%
$\Gamma(\pi^+ \to \mu^+\bar{\nu}_e)/\Gamma_{\text{total}}$	[l]	$<1.5 \times 10^{-3}$ CL = 90%
$\Gamma(K^+ \to \pi^-\mu^+ e^+)/\Gamma_{\text{total}}$		$<7 \times 10^{-9}$ CL = 90%
$\Gamma(K^+ \to \pi^- e^+ e^+)/\Gamma_{\text{total}}$		$<1.0 \times 10^{-8}$ CL = 90%
$\Gamma(K^+ \to \pi^-\mu^+\mu^+)/\Gamma_{\text{total}}$	[l]	$<1.5 \times 10^{-4}$ CL = 90%
$\Gamma(K^+ \to \mu^+\bar{\nu}_e)/\Gamma_{\text{total}}$	[l]	$<3.3 \times 10^{-3}$ CL = 90%
$\Gamma(K^+ \to \pi^0 e^+ \bar{\nu}_e)/\Gamma_{\text{total}}$		$<3 \times 10^{-3}$ CL = 90%
$\Gamma(D^+ \to \pi^- e^+ e^+)/\Gamma_{\text{total}}$		$<1.1 \times 10^{-4}$ CL = 90%
$\Gamma(D^+ \to \pi^-\mu^+\mu^+)/\Gamma_{\text{total}}$		$<8.7 \times 10^{-5}$ CL = 90%
$\Gamma(D^+ \to \pi^- e^+\mu^+)/\Gamma_{\text{total}}$		$<1.1 \times 10^{-4}$ CL = 90%
$\Gamma(D^+ \to \rho^-\mu^+\mu^+)/\Gamma_{\text{total}}$		$<5.6 \times 10^{-4}$ CL = 90%
$\Gamma(D^+ \to K^- e^+ e^+)/\Gamma_{\text{total}}$		$<1.2 \times 10^{-4}$ CL = 90%
$\Gamma(D^+ \to K^-\mu^+\mu^+)/\Gamma_{\text{total}}$		$<1.2 \times 10^{-4}$ CL = 90%
$\Gamma(D^+ \to K^- e^+\mu^+)/\Gamma_{\text{total}}$		$<1.3 \times 10^{-4}$ CL = 90%
$\Gamma(D^+ \to K^*(892)^-\mu^+\mu^+)/\Gamma_{\text{total}}$		$<8.5 \times 10^{-4}$ CL = 90%
$\Gamma(D_s^+ \to \pi^-\mu^+\mu^+)/\Gamma_{\text{total}}$		$<4.3 \times 10^{-4}$ CL = 90%
$\Gamma(D_s^+ \to K^-\mu^+\mu^+)/\Gamma_{\text{total}}$		$<5.9 \times 10^{-4}$ CL = 90%
$\Gamma(D_s^+ \to K^*(892)^-\mu^+\mu^+)/\Gamma_{\text{total}}$		$<1.4 \times 10^{-3}$ CL − 90%
$\Gamma(B^+ \to \pi^- e^+ e^+)/\Gamma_{\text{total}}$		$<3.9 \times 10^{-3}$ CL = 90%
$\Gamma(B^+ \to \pi^-\mu^+\mu^+)/\Gamma_{\text{total}}$		$<9.1 \times 10^{-3}$ CL = 90%
$\Gamma(B^+ \to K^- e^+ e^+)/\Gamma_{\text{total}}$		$<3.9 \times 10^{-3}$ CL = 90%
$\Gamma(B^+ \to K^-\mu^+\mu^+)/\Gamma_{\text{total}}$		$<9.1 \times 10^{-3}$ CL = 90%
$\Gamma(\Xi^- \to p\mu^-\mu^-)/\Gamma_{\text{total}}$		$<4 \times 10^{-4}$ CL = 90%
$\Gamma(\Lambda_c^+ \to \Sigma^-\mu^+\mu^+)/\Gamma_{\text{total}}$		$<7.0 \times 10^{-4}$ CL = 90%

BARYON NUMBER

$\Gamma(\tau^- \to \bar{p}\gamma)/\Gamma_{\text{total}}$		$<2.9 \times 10^{-4}$ CL = 90%
$\Gamma(\tau^- \to \bar{p}\pi^0)/\Gamma_{\text{total}}$		$<6.6 \times 10^{-4}$ CL = 90%
$\Gamma(\tau^- \to \bar{p}\eta)/\Gamma_{\text{total}}$		$<1.30 \times 10^{-3}$ CL = 90%
p mean life		$>1.6 \times 10^{25}$ years

A few examples of proton or bound neutron decay follow. For limits on many other nucleon decay channels see the Baryon Summary Table.

$\tau(N \to e^+\pi)$		>130 (n) >550 (p) $\times 10^{30}$ years CL = 90%
$\tau(N \to \mu^+\pi)$		>100 (n) >270 (p) $\times 10^{30}$ years CL = 90%
$\tau(N \to e^+ K)$		>1.3 (n) >150 (p) $\times 10^{30}$ years CL = 90%
$\tau(N \to \mu^+ K)$		>1.1 (n) >120 (p) $\times 10^{30}$ years CL = 90%
limit on $n\bar{n}$ oscillations (bound n)	[m]	$>1.2 \times 10^8$ s CL = 90%
limit on $n\bar{n}$ oscillations (free n)		$>0.86 \times 10^8$ s CL = 90%

Limits are given at the 90% confidence level while errors are given as ±1 standard deviation.

ELECTRIC CHARGE (Q)

e mean life / branching fraction	[n]	$>4.3\times10^{23}$ yr CL = 68%
$\Gamma(n\to p\nu_e\bar{\nu}_e)/\Gamma_{\text{total}}$		$<8\times10^{-27}$ CL = 68%

$\Delta S=\Delta Q$ RULE

Allowed in second-order weak interactions.

$\Gamma(K^+\to\pi^+\pi^+e^-\bar{\nu}_e)/\Gamma_{\text{total}}$	$<1.2\times10^{-8}$ CL = 90%
$\Gamma(K^+\to\pi^+\pi^+\mu^-\bar{\nu}_\mu)/\Gamma_{\text{total}}$	$<3.0\times10^{-6}$ CL = 95%
$x=A(\bar{K}^0\to\pi^-\ell^+\nu)/A(K^0\to\pi^-\ell^+\nu)=A(\Delta S=-\Delta Q)/A(\Delta S=\Delta Q)$	
real part of x	0.006 ± 0.018 (S = 1.3)
imaginary part of x	-0.003 ± 0.026 (S = 1.2)
$\Gamma(\Sigma^+\to n\ell^+\nu)/\Gamma(\Sigma^-\to n\ell^-\bar{\nu})$	<0.043
$\Gamma(\Sigma^+\to ne^+\nu_e)/\Gamma_{\text{total}}$	$<5\times10^{-6}$ CL = 90%
$\Gamma(\Sigma^+\to n\mu^+\nu_\mu)/\Gamma_{\text{total}}$	$<3.0\times10^{-5}$ CL = 90%
$\Gamma(\Xi^0\to\Sigma^-e^+\nu_e)/\Gamma_{\text{total}}$	$<9\times10^{-4}$ CL = 90%
$\Gamma(\Xi^0\to\Sigma^-\mu^+\nu_\mu)/\Gamma_{\text{total}}$	$<9\times10^{-4}$ CL = 90%

$\Delta S=2$ FORBIDDEN

Allowed in second-order weak interactions.

$\Gamma(\Xi^0\to p\pi^-)/\Gamma_{\text{total}}$	$<4\times10^{-5}$ CL = 90%
$\Gamma(\Xi^0\to pe^-\bar{\nu}_e)/\Gamma_{\text{total}}$	$<1.3\times10^{-3}$
$\Gamma(\Xi^0\to p\mu^-\bar{\nu}_\mu)/\Gamma_{\text{total}}$	$<1.3\times10^{-3}$
$\Gamma(\Xi^-\to n\pi^-)/\Gamma_{\text{total}}$	$<1.9\times10^{-5}$ CL = 90%
$\Gamma(\Xi^-\to ne^-\bar{\nu}_e)/\Gamma_{\text{total}}$	$<3.2\times10^{-3}$ CL = 90%
$\Gamma(\Xi^-\to n\mu^-\bar{\nu}_\mu)/\Gamma_{\text{total}}$	$<1.5\times10^{-2}$ CL = 90%
$\Gamma(\Xi^-\to p\pi^-\pi^-)/\Gamma_{\text{total}}$	$<4\times10^{-4}$ CL = 90%
$\Gamma(\Xi^-\to p\pi^-e^-\bar{\nu}_e)/\Gamma_{\text{total}}$	$<4\times10^{-4}$ CL = 90%
$\Gamma(\Xi^-\to p\pi^-\mu^-\bar{\nu}_\mu)/\Gamma_{\text{total}}$	$<4\times10^{-4}$ CL = 90%
$\Gamma(\Omega^-\to\Lambda\pi^-)/\Gamma_{\text{total}}$	$<1.9\times10^{-4}$ CL = 90%

$\Delta S=2$ VIA MIXING

Allowed in second-order weak interactions, e.g. mixing.

$m_{K_L^0}-m_{K_S^0}$	$(0.5301\pm0.0014)\times10^{10}$ ħ s^{-1}
$m_{K_L^0}-m_{K_S^0}$	$(3.489\pm0.009)\times10^{-12}$ MeV

$\Delta C=2$ VIA MIXING

Allowed in second-order weak interactions, e.g. mixing.

$\lvert m_{D_1^0}-m_{D_2^0}\rvert$	[o]	$<24\times10^{10}$ ħ s^{-1} CL = 90%
$\lvert\Gamma_{D_1^0}-\Gamma_{D_2^0}\rvert/\Gamma_{D^0}$ mean life difference/average	[o]	<0.20 CL = 90%
$\Gamma(K^+\ell^-\bar{\nu}_\ell(\text{via }\bar{D}^0))/\Gamma(K^-\ell^+\nu_\ell)$		<0.005 CL = 90%
$\Gamma(K^+\pi^-\text{ or }K^+\pi^-\pi^+\pi^-(\text{via }\bar{D}^0))/\Gamma(K^-\pi^+\text{ or }K^-\pi^+\pi^+\pi^-)$	[p]	< 0.0085 (or < 0.0037) CL = 90%
$\Gamma(D^0\to K^+\ell^-\bar{\nu}_\ell(\text{via }\bar{D}^0))/\Gamma_{\text{total}}$		$<1.7\times10^{-4}$ CL = 90%
$\Gamma(D^0\to K^+\pi^-\text{ or }K^+\pi^-\pi^+\pi^-(\text{via }\bar{D}^0))/\Gamma_{\text{total}}$		$<1.0\times10^{-3}$ CL = 90%

$\Delta B=2$ VIA MIXING

Allowed in second-order weak interactions, e.g. mixing.

χ_d	0.172 ± 0.010
$\Delta m_{B^0}=m_{B_H^0}-m_{B_L^0}$	$(0.464\pm0.018)\times10^{12}$ ħ s^{-1}
$x_d=\Delta m_{B^0}/\Gamma_{B^0}$	0.723 ± 0.032
χ_B at high energy	0.118 ± 0.006
$\Delta m_{B_s^0}=m_{B_{sH}^0}-m_{B_{sL}^0}$	$>9.1\times10^{12}$ ħ s^{-1} CL = 95%
$x_s=\Delta m_{B_s^0}/\Gamma_{B_s^0}$	>14.0 CL = 95%
χ_s	>0.4975 CL = 95%

$\Delta S=1$ WEAK NEUTRAL CURRENT FORBIDDEN

Allowed by higher-order electroweak interactions.

$\Gamma(K^+\to\pi^+e^+e^-)/\Gamma_{\text{total}}$		$(2.74\pm0.23)\times10^{-7}$
$\Gamma(K^+\to\pi^+\mu^+\mu^-)/\Gamma_{\text{total}}$		$(5.0\pm1.0)\times10^{-8}$
$\Gamma(K^+\to\pi^+\nu\bar{\nu})/\Gamma_{\text{total}}$		$(4.2^{+9.7}_{-3.5})\times10^{-10}$
$\Gamma(K_S^0\to\mu^+\mu^-)/\Gamma_{\text{total}}$		$<3.2\times10^{-7}$ CL = 90%
$\Gamma(K_S^0\to e^+e^-)/\Gamma_{\text{total}}$		$<1.4\times10^{-7}$ CL = 90%
$\Gamma(K_S^0\to\pi^0e^+e^-)/\Gamma_{\text{total}}$		$<1.1\times10^{-6}$ CL = 90%
$\Gamma(K_L^0\to\mu^+\mu^-)/\Gamma_{\text{total}}$		$(7.2\pm0.5)\times10^{-9}$ (S = 1.4)
$\Gamma(K_L^0\to\mu^+\mu^-\gamma)/\Gamma_{\text{total}}$		$(3.25\pm0.28)\times10^{-7}$
$\Gamma(K_L^0\to e^+e^-)/\Gamma_{\text{total}}$		$<4.1\times10^{-11}$ CL = 90%
$\Gamma(K_L^0\to e^+e^-\gamma)/\Gamma_{\text{total}}$		$(9.1\pm0.5)\times10^{-6}$
$\Gamma(K_L^0\to e^+e^-\gamma\gamma)/\Gamma_{\text{total}}$	[q]	$(6.5\pm1.2)\times10^{-7}$
$\Gamma(K_L^0\to\pi^+\pi^-e^+e^-)/\Gamma_{\text{total}}$	[q]	$<4.6\times10^{-7}$ CL = 90%
$\Gamma(K_L^0\to\mu^+\mu^-e^+e^-)/\Gamma_{\text{total}}$		$(2.9^{+6.7}_{-2.4})\times10^{-9}$
$\Gamma(K_L^0\to e^+e^-e^+e^-)/\Gamma_{\text{total}}$		$(4.1\pm0.8)\times10^{-8}$ (S = 1.2)
$\Gamma(K_L^0\to\pi^0\mu^+\mu^-)/\Gamma_{\text{total}}$		$<5.1\times10^{-9}$ CL = 90%
$\Gamma(K_L^0\to\pi^0e^+e^-)/\Gamma_{\text{total}}$		$<4.3\times10^{-9}$ CL = 90%
$\Gamma(K_L^0\to\pi^0\nu\bar{\nu})/\Gamma_{\text{total}}$		$<5.8\times10^{-5}$ CL = 90%
$\Gamma(\Sigma^+\to pe^+e^-)/\Gamma_{\text{total}}$		$<7\times10^{-6}$

$\Delta C=1$ WEAK NEUTRAL CURRENT FORBIDDEN

Allowed by higher-order electroweak interactions.

$\Gamma(D^+\to\pi^+e^+e^-)/\Gamma_{\text{total}}$	$<6.6\times10^{-5}$ CL = 90%
$\Gamma(D^+\to\pi^+\mu^+\mu^-)/\Gamma_{\text{total}}$	$<1.8\times10^{-5}$ CL = 90%
$\Gamma(D^+\to\rho^+\mu^+\mu^-)/\Gamma_{\text{total}}$	$<5.6\times10^{-4}$ CL = 90%
$\Gamma(D^0\to e^+e^-)/\Gamma_{\text{total}}$	$<1.3\times10^{-5}$ CL = 90%
$\Gamma(D^0\to\mu^+\mu^-)/\Gamma_{\text{total}}$	$<4.1\times10^{-6}$ CL = 90%
$\Gamma(D^0\to\pi^0e^+e^-)/\Gamma_{\text{total}}$	$<4.5\times10^{-5}$ CL = 90%
$\Gamma(D^0\to\pi^0\mu^+\mu^-)/\Gamma_{\text{total}}$	$<1.8\times10^{-4}$ CL = 90%
$\Gamma(D^0\to\eta e^+e^-)/\Gamma_{\text{total}}$	$<1.1\times10^{-4}$ CL = 90%
$\Gamma(D^0\to\eta\mu^+\mu^-)/\Gamma_{\text{total}}$	$<5.3\times10^{-4}$ CL = 90%
$\Gamma(D^0\to\rho^0e^+e^-)/\Gamma_{\text{total}}$	$<1.0\times10^{-4}$ CL = 90%
$\Gamma(D^0\to\rho^0\mu^+\mu^-)/\Gamma_{\text{total}}$	$<2.3\times10^{-4}$ CL = 90%
$\Gamma(D^0\to\omega e^+e^-)/\Gamma_{\text{total}}$	$<1.8\times10^{-4}$ CL = 90%
$\Gamma(D^0\to\omega\mu^+\mu^-)/\Gamma_{\text{total}}$	$<8.3\times10^{-4}$ CL = 90%
$\Gamma(D^0\to\phi e^+e^-)/\Gamma_{\text{total}}$	$<5.2\times10^{-5}$ CL = 90%
$\Gamma(D^0\to\phi\mu^+\mu^-)/\Gamma_{\text{total}}$	$<4.1\times10^{-4}$ CL = 90%
$\Gamma(D^0\to\pi^+\pi^-\pi^0\mu^+\mu^-)/\Gamma_{\text{total}}$	$<8.1\times10^{-4}$ CL = 90%
$\Gamma(D_s^+\to K^+\mu^+\mu^-)/\Gamma_{\text{total}}$	$<5.9\times10^{-4}$ CL = 90%
$\Gamma(D_s^+\to K^*(892)^+\mu^+\mu^-)/\Gamma_{\text{total}}$	$<1.4\times10^{-3}$ CL = 90%
$\Gamma(\Lambda_c^+\to p\mu^+\mu^-)/\Gamma_{\text{total}}$	$<3.4\times10^{-4}$ CL = 90%

Limits are given at the 90% confidence level. Γ while errors are given as ±1 standard deviation.

$\Delta B = 1$ WEAK NEUTRAL CURRENT FORBIDDEN

Allowed by higher-order electroweak interactions.

$\Gamma(B^+ \to \pi^+ e^+ e^-)/\Gamma_{\text{total}}$	$<3.9 \times 10^{-3}$ CL = 90%
$\Gamma(B^+ \to \pi^+ \mu^+ \mu^-)/\Gamma_{\text{total}}$	$<9.1 \times 10^{-3}$ CL = 90%
$\Gamma(B^+ \to K^+ e^+ e^-)/\Gamma_{\text{total}}$	$<6 \times 10^{-5}$ CL = 90%
$\Gamma(B^+ \to K^+ \mu^+ \mu^-)/\Gamma_{\text{total}}$	$<1.0 \times 10^{-5}$ CL = 90%
$\Gamma(B^+ \to K^*(892)^+ e^+ e^-)/\Gamma_{\text{total}}$	$<6.9 \times 10^{-4}$ CL = 90%
$\Gamma(B^+ \to K^*(892)^+ \mu^+ \mu^-)/\Gamma_{\text{total}}$	$<1.2 \times 10^{-3}$ CL = 90%
$\Gamma(B^0 \to \gamma\gamma)/\Gamma_{\text{total}}$	$<3.9 \times 10^{-5}$ CL = 90%
$\Gamma(B^0 \to e^+ e^-)/\Gamma_{\text{total}}$	$<5.9 \times 10^{-6}$ CL = 90%
$\Gamma(B^0 \to \mu^+ \mu^-)/\Gamma_{\text{total}}$	$<6.8 \times 10^{-7}$ CL = 90%
$\Gamma(B^0 \to K^0 e^+ e^-)/\Gamma_{\text{total}}$	$<3.0 \times 10^{-4}$ CL = 90%
$\Gamma(B^0 \to K^0 \mu^+ \mu^-)/\Gamma_{\text{total}}$	$<3.6 \times 10^{-4}$ CL = 90%
$\Gamma(B^0 \to K^*(892)^0 e^+ e^-)/\Gamma_{\text{total}}$	$<2.9 \times 10^{-4}$ CL = 90%
$\Gamma(B^0 \to K^*(892)^0 \mu^+ \mu^-)/\Gamma_{\text{total}}$	$<2.3 \times 10^{-5}$ CL = 90%
$\Gamma(B^0 \to K^*(892)^0 \nu\bar{\nu})/\Gamma_{\text{total}}$	$<1.0 \times 10^{-3}$ CL = 90%
$\Gamma(B \to e^+ e^- s)/\Gamma_{\text{total}}$	$<5.7 \times 10^{-5}$ CL = 90%
$\Gamma(B \to \mu^+ \mu^- s)/\Gamma_{\text{total}}$	$<5.8 \times 10^{-5}$ CL = 90%
$\Gamma(\bar{b} \to \mu^+ \mu^-$ anything$)/\Gamma_{\text{total}}$	$<3.2 \times 10^{-4}$ CL = 90%
$\Gamma(B_s^0 \to \mu^+ \mu^-)/\Gamma_{\text{total}}$	$<2.0 \times 10^{-6}$ CL = 90%
$\Gamma(B_s^0 \to e^+ e^-)/\Gamma_{\text{total}}$	$<5.4 \times 10^{-5}$ CL = 90%
$\Gamma(B_s^0 \to \phi\nu\bar{\nu})/\Gamma_{\text{total}}$	$<5.4 \times 10^{-3}$ CL = 90%

Limits are given at the 90% confidence level, while errors are given as ± 1 standard deviation.

NOTES

In this Summary Table:

When a quantity has "(S = ...)" to its right, the error on the quantity has been enlarged by the "scale factor" S, defined as $S = \sqrt{\chi^2/(N-1)}$, where N is the number of measurements used in calculating the quantity. We do this when S > 1, which often indicates that the measurements are inconsistent. When S > 1.25, we also show in the Particle Listings an ideogram of the measurements. For more about S, see the Introduction.

[a] C parity forbids this to occur as a single-photon process.

[b] Time-reversal invariance requires this to be 0° or 180°.

[c] Allowed by higher-order electroweak interactions.

[d] Violates CP in leading order. Test of direct CP violation since the indirect CP-violating and CP-conserving contributions are expected to be suppressed.

[e] ϵ'/ϵ is derived from $|\eta_{00}/\eta_{+-}|$ measurements using theoretical input on phases.

[f] Neglecting photon channels. See, e.g., A. Pais and S.B. Treiman, Phys. Rev. **D12**, 2744 (1975).

[g] Derived from measured values of ϕ_{+-}, ϕ_{00}, $|\eta|$, $|m_{K_L^0} - m_{K_S^0}|$, and $\tau_{K_S^0}$, as described in the introduction to "Tests of Conservation Laws."

[h] The value is for the sum of the charge states of particle/antiparticle states indicated.

[i] A test of additive vs. multiplicative lepton family number conservation.

[j] $\Delta(m^2) = 100$ eV^2.

[k] 190 eV^2 $< \Delta(m^2) <$ 320 eV^2.

[l] Derived from an analysis of neutrino-oscillation experiments.

[m] There is some controversy about whether nuclear physics and model dependence complicate the analysis for bound neutrons (from which the best limit comes). The second limit here is from reactor experiments with free neutrons.

[n] This is the best "electron disappearance" limit. The best limit for the mode $e^- \to \nu\gamma$ is $> 2.35 \times 10^{25}$ yr (CL=68%).

[o] The D_1^0-D_2^0 limits are inferred from the D^0-$\bar{D}^0$ mixing ratio $\Gamma(K^+\ell^-\bar{\nu}_\ell$(via $\bar{D}^0$)) / $\Gamma(K^-\ell^+\nu_\ell)$.

[p] The larger limit (from E791) allows interference between the doubly Cabibbo-suppressed and mixing amplitudes; the smaller limit (from E691) doesn't. See the papers for details.

[q] See the K_L^0 Particle Listings for the energy limits used in this measurement.

TABLE OF THE ISOTOPES

Norman E. Holden

This table presents an evaluated set of values for the experimental quantities that characterize the decay of radioactive nuclides. A list of the major references used in this evaluation is given below. When uncertainties are not listed, they are assumed to be five or less in the last digit quoted. If they exceed five in the last digit, the value is prefaced by an approximate sign. For quasi-stable nuclides, the measured width, Γ, of the resonance is given. To estimate the approximate half-life, the Heisenberg relationship may be used, the half-life = 4.56×10^{-22} seconds / Γ(MeV). The effective literature cutoff date for data in this edition of the Table is December, 2005.

Table Layout

Column No.	Column title	Description
1	Isotope or Element	For elements, the atomic number and chemical symbol are listed. For nuclides, the mass number and chemical symbol are listed. Isomers are indicated by the addition of m, m1, or m2.
2	Isotopic Abundance	In atom percent.
3	Atomic Mass or Atomic Weight	Atomic mass relative to $^{12}C = 12$. Atomic weight of elements is given on the same scale.
4	Half-life/Resonance Width	Half-life in decimal notation. μs = microseconds; ms = milliseconds; s = seconds; m = minutes; h = hours; d = days; and y = years. For quasi-stable nuclides, the measured width at half maximum of the energy resonance is given
5	Decay Mode/Energy	Decay modes are α = alpha particle emission; β = negative beta emission; β+ = positron emission; EC = orbital electron capture; IT = isomeric transition from upper to lower isomeric state; n = neutron emission; sf = spontaneous fission; ββ = double beta decay. Total disintegration energy in MeV units.
6	Particle Energy/Intensity	End point energies of beta transitions and discrete energies of alpha particles in MeV and their intensities in percent.
7	Spin and Parity	Nuclear spin or angular momentum of the nuclides in units of $h/2\pi$; parity is positive or negative.
8	Magnetic Dipole Moment	Magnetic dipole moments in nuclear magneton units.
9	Electric Quadrupole Moment	Electric quadrupole moments in barn units (10^{-24} cm^2).
10	Gamma Ray Energy/ Intensity	Gamma ray energies in MeV and intensities in percent. Ann. rad. refers to the 511.006 keV photons emitted in the annihilation of positrons in matter.

General Nuclear Data References

The following references represent the major sources of the nuclear data presented, along with subsequent published journal articles and reports:

1. G. Audi, O. Bersillon, J. Blachot, A.H. Wapstra, *The Nubase Evaluation of Nuclear and Decay Properties,* Nuclear Physics A729, 3 (2003).
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3. International Commission on Atomic Weights, *Atomic Weights of the Elements - 1999*, Pure & Applied Chemistry 75, 667 (2001).
4. E.M. Baum, H.D. Knox, T.R. Miller, *Chart of the Nuclides, 16th Edition*, Knolls Atomic Power Lab. (2002)
5. N.E. Holden, *Total and Spontaneous Fission Half-lives for Uranium, Plutonium, Americium and Curium Nuclides*, Pure & Applied Chemistry 61, 1483 (1989).
6. N.E. Holden, *Half-lives of Selected Nuclides*, Pure & Applied Chemistry 62, 941 (1990).
7. N.E. Holden, *Review of Thermal Neutron Cross Sections and Isotopic Composition of the Elements*, BNL-NCS-42224 (March 1989).
8. P. Raghavan, *Table of Nuclear Moments*, Atomic Data Nuclear Data Tables 42, 189 (1989).
9. E. Brown, R. Firestone, *Radioactivity Handbook*, Wiley Interscience Press (1986).
10. J.K. Tuli, *Nuclear Wallet Cards*, Brookhaven National Laboratory (April 2005).
11. N.E. Holden, D.C. Hoffman, *Spontaneous Fission Half-lives for Ground State Nuclides*, Pure & Applied Chemistry 72 1525 (2000).
12. N. Stone, *Table of New Nuclear Moments*, private communication, www.nndc.bnl.gov/nndc/stone_moments/moments.html (Dec 2000)

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Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($\hbar/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
$_0$n		1.008664916	614. s	β- /0.78235	0.782/100.	1/2+	-1.913043		
				β-, γ	/ < 0.069				
$_1$H		**1.00794(7)**							
^{1}H	99.9885(70)	1.007825032	> 2.8 × 10^{23} y			1/2+	+2.79285		
^{2}H	0.0115(70)	2.014101778				1+	+0.85744	+2.86 mb	
^{3}H		3.016049278	12.33 y	β-/0.01859	0.01860/100.	1/2+	+2.97896		
^{4}H		4.0278	Γ ~ 3	n/	/100	2-			
^{5}H		5.0353	Γ < 0.5	n/	/100	(1/2+)			
^{6}H		6.0449	Γ = 1.6(4)	n/		(2-)			
^{7}H		7.053	Γ ~ 20.						
$_2$He		**4.002602(2)**							
^{3}He	0.000134(3)	3.016029319				1/2+	-2.12762		
^{4}He	99.999866(3)	4.002603254				0+			
^{5}He		5.01222	Γ = 0.60(2)	n, α		3/2-			
^{6}He		6.018889	0.807 s	β-/3.508	3.510/100.	0+			
				β, d	/0.00076				
^{7}He		7.02802	Γ = 0.15(2)	n		(3/2)-			
^{8}He		8.03392	0.119 s	β-/10.65	/84.	0+			0.9807/84.
				n/	/16.				0.4776/5.
				β, t	/0.82				
^{9}He		9.04395	Γ = 0.10(6)	n	/100	(1/2-)			
^{10}He		10.0524	Γ = 0.3(2)	2n	/100	0+			
$_3$Li		**6.941(2)**							
^{4}Li		4.0272	Γ = 6.0	p/	/100	2-			
^{5}Li		5.01254	Γ = 1.2	p/α		3/2-			
^{6}Li	7.59(4)	6.01512280				1+	+0.82205	-0.8 mb	
^{7}Li	92.41(4)	7.0160046				3/2-	+3.25644	-0.0400	
^{8}Li		8.0224874	0.840 s	β-/16.004	12.5/100.	2+	+1.6536	+0.0314	
				α/	α(1.6)				
^{9}Li		9.026790	0.178 s	β-/13.606	13.5/75.	3/2-	3.4368	-0.0306	
				β-/	11/25.				
^{10}Li		10.03548	Γ = 0.11(5)	n	/7.	1+			
^{11}Li		11.04380	8.8 ms	β-/20.6	/8.3	3/2(-)	3.668	-0.031	3.368/33.
				β-, n	/85.7				0.320/7.
				β-, 2n	/4.1				2.590/8.
				β-, 3n	/1.9				5.958/3.
				β-, d	/>0.01				2.895/1.5
				β-, t	/0.02				2.811/1.1
^{12}Li		12.054	< 0.01 μs						
$_4$Be		**9.012182(3)**							
^{5}Be		5.041		p, ^{3}He		(1/2+)			
^{6}Be		6.01973	Γ = 0.092(6)	2p,α		0+			
^{7}Be		7.0169298	53.28 d	EC/0.8618		3/2-	-1.4		0.4776/10.4
^{8}Be		8.00530510	Γ = 6.8(17)eV	2α/0.046		0+			
^{9}Be	100.	9.0121822				3/2-	-1.1776	+0.0529	
^{10}Be		10.0135338	1.52 × 10^6 y	β-/0.5559	0.555/100.	0+			
^{11}Be		11.02166	13.8 s	β-, β-α/11.51	11.48/61.	1/2+			2.125/35.5
^{12}Be		12.02692	22.0 ms	β-, (n)/11.71	n//0.5	0+			(0.95 - 4.4)
^{13}Be		13.0357	Γ ~ 1.						
^{14}Be		14.0429	4.6 ms	β-/16.2		0+			3.5346/0.9
				β-, n	0.288/94.				3.6845/7.
				β-, 2n	/6.				
				β-, α	/<0.012				
				β-, t	/<0.04				
^{15}Be		15.053	< 0.2 μs	β^-					

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^{16}Be		16.062	< 0.2 μs	β⁻		0+			
$_5$B		**10.811(7)**							
^{7}B		7.0299	Γ = 1.4(2)	p, α		(3/2-)			
^{8}B		8.024607	0.770 s	β+, 2α/17.979	13.7(β+)/93.	2+	1.0355	0.068	ann.rad.
^{9}B		9.013329	Γ = 0.5(2) keV	p, 2α/		3/2-			
^{10}B	19.9(7)	10.0129370				3+	+1.8006	+0.085	
^{11}B	80.1(7)	11.0093054				3/2-	+2.6886	+0.0406	
^{12}B		12.014352	0.0202 s	β-/13.369		1+	+1.0027	0.0132	4.438/1.3
				β- α/1.6/					3.215/0.00065
^{13}B		13.017780	0.0174 s	β- /13.437	13.4	3/2-	+3.1778	0.037	3.68/7.6
				β- n/0.25/	2.43(n)/0.09				
					3.55(n)/0.16				
^{14}B		14.02540	14. ms	β-/20.64		2-	1.185	0.0298	6.094/90.
^{15}B		15.03110	9.9 ms	β-, (n)/19.09	n//99.7	(3/2-)	2.66	0.038	
^{16}B		16.0398	Γ < 0.1	n					
^{17}B		17.0470	5.1 ms	β-, (n)/22.7			2.54	0.039	
^{18}B		18.056	< 0.026 μs			0-			
^{19}B		19.0637	2.9 ms	β-, (n)/26.5	1n//72.	(3/2-)			
					2n//16.				
					3n// < 9.				
$_6$C		**12.0107(8)**							
^{8}C		8.03768	Γ = 0.25(4)	p		0+			
^{9}C		9.031037	127. ms	β+, p, 2α/16.498		(3/2-)	-1.391		ann.rad.
^{10}C		10.0168532	19.3 s	β+/3.648	1.865	0+			ann.rad.
									0.71829/100.
^{11}C		11.011434	20.3 m	β+, EC/1.982	0.9608/99.	3/2-	-0.964	0.0333	ann.rad.
^{12}C	98.93(8)	12.000000000				0+			
^{13}C	1.07(8)	13.003354838				½-	+0.70241		
^{14}C		14.003241989	5715. y	β-/0.15648	0.1565/100.	0+			
^{15}C		15.010599	2.45 s	β-/9.772	4.51/68.	½+	1.32		5.298/68.
					9.82/32.				(7.30–9.05)
^{16}C		16.014701	~ 0.750 s	β-/8.012	β/3.3, 4.3/84, 16	0+			
				β, n	n/0.8, 1.7/84, 16				
^{17}C		17.02259	0.19 s	β-/13.17		3/2+			1.375
				β-, n	n/1.6–3.7/11.				1.849
									1.906
^{18}C		18.02676	0.092 s	β-/11.81		0+			
				β-, n	n/0.88–4.59/21.				
^{19}C		19.0348	0.05 s	n		½+			
^{20}C		20.0403	0.02 s	β,n	1n// ~ 65.	0+			
					2n// < 19.				
^{21}C		21.049	< 0.03 μs						
^{22}C		22.057	6 ms	β-, n	1n// ~ 61.	0+			
					2n// < 37.				
$_7$N		**14.0067(2)**							
^{10}N		10.0417	Γ = 2.3(16)						
^{11}N		11.02609	Γ ~ 1.			½+			
^{12}N		12.018613	11.00 ms	β+, β+α/17.338	16.38/95.	1+	+0.457	+10. mb	ann.rad.
									4.438/2.
^{13}N		13.0057386	9.97 m	β+ /2.2204	1.190/100.	½-	0.3222		
^{14}N	99.636(20)	14.003074005				1+	+0.40376	+0.0200	
^{15}N	0.364(20)	15.00010898				½-	-0.28319		
^{16}N		16.006102	7.13 s	β- /10.419	4.27/68.	2-			6.129/68.8
					10.44/26.		1.986	18 mb	7.115/4.7
				β-, α	1.85/.0012				(0.99–8.87)
^{17}N		17.00845	4.17 s	β-, β- n/8.68	3.7/100.	½-	0.352		0.871/3.

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				0.4−1.7n/95.					2.1842/0.3
				β- α/	8.0, 8.2				
^{18}N		18.01408	0.62 s	β- /13.90	9.4/100.	1-	0.328	0.012	0.822/48.
				β-, α	/12.				1.65/47.
				β-,n	/14				1.982/77.
									(0.535−7.13)
^{19}N		19.01703	0.32 s	β-/12.53			< 0.32		(0.096−3.14)
^{20}N		20.0234	0.14 s	β- /17.97					
^{21}N		21.0271	0.08 s						
^{22}N		22.0344	0.02 s	β-,n	1n// ~ 41.				
					2n// < 13.				
^{23}N		23.0412	15. ms	β-, n	n// ~ 42.				
					2n// ~ 8.				
					3n// < 3.4				
^{24}N		24.0510	< 0.052 μs						
^{25}N		25.061	< 0.26 μs						
$_{8}$O		**15.9994(3)**							
^{12}O		12.03441	Γ = 0.51(16)	2p		0+			
^{13}O		13.02481	8.9 ms	β+, p/17.77	1.560 (p)	(3/2-)	1.389	0.011	ann.rad.
					p/(1.00 - 13.5)				4.438/0.56
^{14}O		14.0085963	70.63 s	β+ /5.1430	1.81/99.	0+			ann.rad.
									2.312/99.4
^{15}O		15.0030656	122.2 s	β+ /2.754	1.723/100.	1/2-	0.7195		ann.rad.
^{16}O	99.757(16)	15.9949146196				0+			
^{17}O	0.038(1)	16.9991317				5/2+	-1.8938	-0.026	
^{18}O	0.205(14)	17.999161				0+			
^{19}O		19.003580	26.9 s	β- /4.820	3.25/60.	5/2+	1.5320	3.7 mb	0.197/95.9
					4.60/40.				1.3569/50.4
									(0.11−4.18)
^{20}O		20.004077	13.5 s	β- /3.814		0+			1.057/100.
^{21}O		21.00866	3.4 s	β- /8.11					(0.28−4.6)
^{22}O		22.0100	2.2 s	β- /6.5		0+			0.072/100
									0.638/98
									1.862/63
									(0.918-2.499)
^{23}O		23.0157	0.08 s						
^{24}O		24.0205	~ 65. ms	β-, n	n//18.	0+			1.83/28.
									0.52/14.
									1.31/12.
^{25}O		25.0295	< 0.05 μs						
^{26}O		26.0383	< 0.04 μs			0+			
^{27}O		27.048	< 0.026 μs						
^{28}O		28.058	< 0.10 μs			0+			
$_{9}$F		**18.9984032(5)**							
^{14}F		14.0351							
^{15}F		15.0180	Γ = 0.8(3)	p		(1/2+)			
^{16}F		16.01147	Γ = 0.037(14)	p		0-			
^{17}F		17.0020952	64.5 s	β+ /2.761	1.75/	5/2+	+4.721	0.058	ann.rad.
^{18}F		18.000938	1.829 h	β+, EC/1.656	0.635/97.	1+			ann.rad.
^{19}F	100.	18.9984032				½+	+2.62887	0.072	
^{20}F		19.9999813	11.00 s	β- /7.0245	5.398/100.	2+	+2.0934	0.042	1.634/100.
									3.33/0.009
^{21}F		20.999949	4.16 s	β- /5.684	3.7/8.	5/2+	3.9		0.3507/90.
					5.0/63.				1.395/15.
					5.4/29.				(1.746−4.684)
^{22}F		22.00300	4.23 s	β- /10.82	3.48/15.	4+			1.2746/100.
					4.67/7.				2.0826/82.

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					5.50/62.				(0.82−4.37)
^{23}F		23.0036	2.2 s	β- /8.5		5/2+			1.701/48.
									2.129/34.
									(0.493−3.83)
^{24}F		24.0081	0.3 s	β- /13.5					1.9816/
^{25}F		25.0121	~ 50. ms	β-, (n)	n//14.				1.70/39.
									(0.57−2.19)
^{26}F		26.0196	10. ms	β-, (n)	n//11.				2.02/67.
									1.67/19.
^{27}F		27.0268	5.0 ms	β-, (n)	n//90.				2.02/18.
^{28}F		28.036	< 0.04 μs						
^{29}F		29.043	2.5 ms	β-, (n)	n//100.				
^{30}F		30.053	< 0.26 μs						
^{31}F		31.060	> 0.26 μs						
$_{10}$Ne		**20.1797(6)**							
^{16}Ne		16.02576	Γ = 0.12(4)	2p		0+			
^{17}Ne		17.01767	109. ms	β+, p/14.53	1.4−10.6/6.9	1/2-	0.787		ann.rad./
				β+, α	/0.014				0.495
^{18}Ne		18.0057082	1.668 s	β+ /4.446	3.416/92.	0+			ann.rad./
									1.0413/7.8
									(0.658−1.70)
^{19}Ne		19.0018802	17.22 s	β+ /3.238	2.24/99.	1/2+	-1.885		ann.rad./
									(0.11−1.55)
^{20}Ne	90.48(3)	19.992440175				0+			
^{21}Ne	0.27(1)	20.99384668				3/2+	-0.66180	+0.103	
^{22}Ne	9.25(3)	21.99138511				0+		-0.19	
^{23}Ne		22.9944669	37.2 s	β- /4.376	3.95/32.	5/2+	-1.08	+0.15	0.440/33.
					4.39/67.				(1.64−2.98)
^{24}Ne		23.9936108	3.38 m	β- /2.47	1.10/8.	0+			0.4723/100.
					1.98/92.				0.874/7.9
^{25}Ne		24.99774	0.61 s	β- /7.30	6.3/	1/2+	-1.006		0.0895/96.
					7.3/				(0.98−3.69)
^{26}Ne		26.00046	197 ms	β-, n/7.3	n//0.13	0+			0.082/100
									1.278/6
									0.233/5
									0.151/3
									1.211/1
									2.489/1
^{27}Ne		27.0076	31. ms	β-, n/12.7	n//2.	(3/2+)			
^{28}Ne		28.0121	19. ms	β-, n/12.3	n//12.	0+			2.06/19.
					2n//3.				0.86/3.
^{29}Ne		29.0194	15. ms	β-, (n)/15.4	n//29.	(3/2+)			2.92/55.
				β-, 2n	2n//4.				(0.22−1.18)
^{30}Ne		30.025	7. ms	β-, (n)	n//9.	0+			0.151/9.
^{31}Ne		31.033	3. ms						
^{32}Ne		32.040	~ 3.5 ms			0+			
^{33}Ne		33.049	< 0.26 μs						
^{34}Ne		34.057	> 1.5 μs			0+			
$_{11}$Na		**22.98976928(2)**							
^{18}Na		18.02597	Γ = 0.34(9)						
^{19}Na		19.01388	0.03 s	β+, p/11.18					
^{20}Na		20.00735	0.446 s	β+ /13.89		2+	+0.3694	~ + 0.04	ann.rad./
				α	2.15/				1.634/79.
^{21}Na		20.997655	22.48 s	β+ /3.547	2.50/95.	3/2+	+2.3863	~ +0.05	ann.rad./
									0.351/5.
^{22}Na		21.9944364	2.605 y	β+ /90/2.842	0.545/90.	3+	+1.746	+0.19	ann.rad./
				EC/10/					1.2745/99.9

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^{23}Na	100.	22.989769281				3/2+	+2.21752	+0.106	
^{24m}Na			20.2 ms	I.T., β-		1+			0.4723/100.
^{24}Na		23.9909628	14.96 h	β- /5.5158	1.389/>99.	4+	+1.690		1.3686/100.
									2.754/100.
									(0.997−4.238)
^{25}Na		24.989954	59.3 s	β- /3.835	2.6/7.	5/2+	+3.683	~ -0.06	0.3897/12.7
					3.15/25.				0.5850/13.
					4.0/65.				0.9747/14.9
									(0.836−2.80)
^{26}Na		25.99263	1.071 s	β- /9.31		3+	+2.851	-5.3 mb	1.809/98.9
									(0.24-7.37)
^{27}Na		26.994077	0.290 s	β- /9.01	7.95/	5/2+	+3.90	-7.2 mb	0.9847/87.4
				β-, n/					1.698/11.9
^{28}Na		27.99894	31. ms	β- /14.0	12.3/	1+	+2.42	+0.04	1.473/37.
				β-, n/					2.389/18.6
^{29}Na		29.00286	44. ms	β-, n/13.3	11.5/	3/2+	+2.46	+86. mb	2.560/36.
									(1.04−3.99)
^{30}Na		30.00898	50. ms	β-, n/17.5	n//30.	2+	+2.07		1.483/46.
^{31}Na		31.0136	17.2 ms	β-, n/15.9	n//37.	3/2-	+2.30		1.483/14.
									(0.05−3.54)
^{32}Na		32.0205	13.5 ms	β- /19.1					0.240−3.935
^{33}Na		33.027	8.0 ms	β- /20.	/ ~ 38				0.886/16
				β-, n	0.8,1.02/47(6)				0.546/6.4
				β-, 2n	/13(3)				0.050−2.55
^{34}Na		34.035	5. ms	β- /24.					
^{35}Na		35.042	1.5 ms	β- /24					
^{36}Na		36.051	< 0.26 μs						
^{37}Na		37.059	> 1.5 μs						
$_{12}$Mg		**24.3050(6)**							
^{19}Mg		19.0355	< 0.02 μs						
^{20}Mg		20.01886	96. ms	β+ /10.73	/70	0+			
				β+, p	/30				
^{21}Mg		21.01171	122. ms	β+, p/13.10		5/2+			0.332/51.
^{22}Mg		21.999574	3.876 s	β+ /4.786	3.05/	0+			0.0729/60.
									0.5820/100.
									(1.28−1.93)
^{23}Mg		22.994124	11.32 s	β+ /4.057	3.09/92.	3/2+	0.536	1.25	0.440/8.2
^{24}Mg	78.99(4)	23.98504170				0+			
^{25}Mg	10.00(1)	24.98583692				5/2+	-0.85545	+0.200	
^{26}Mg	11.01(3)	25.98259293				0+			
^{27}Mg		26.98434059	9.45 m	β- /2.6103	1.59/41.	1/2+			0.17068/0.9
					1.75/58.				0.84376/72.
					2.65/0.3				1.01443/28.
^{28}Mg		27.983877	20.9 h	β- /1.832	0.459/95.	0+			0.0306/95.
									0.4006/36.
									0.9418/36.
									1.342/54.
^{29}Mg		28.98860	1.3 s	β-/7.55	5.4/	3/2+			0.960/15.
									1.398/16.
									2.224/36.
^{30}Mg		29.99043	0.32 s	β- /7.0		0+			0.224/85.
^{31}Mg		30.99655	0.24 s	β- /11.7	8.4/29.9	(3/2+)	-0.8836		1.613/47.
									0.947/37.
									(0.666-4.640)
				β-, n	/1.7				
^{32}Mg		31.99898	0.12 s	β- /10.3		0+			2.765/25.
^{33}Mg		33.00525	91. ms	β- /13.7	/83.				1.848/
				β-, n	/17.				

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^{34}Mg		34.0095	0.02 s	β- /11.3		0+			
^{35}Mg		35.0173	0.07 s			(7/2-)			
^{36}Mg		36.023	4. ms			0+			
^{37}Mg		37.031	> 0.26 μs			(7/2-)			
^{38}Mg		38.038	> 0.26 μs			0+			
^{39}Mg		39.047	< 0.26 μs						
^{40}Mg		40.054				0+			
$_{13}$Al		**26.9815386(8)**							
^{21}Al		21.0280	< 0.035 μs						
^{22}Al		22.0195	59. ms	β+ /18.6	p/1.3/18.	4+			ann.rad./
				β+, p, 2p, α/	α/3.3/0.3				
^{23m}Al			~ 0.35 s	β+, p/0.17					0.554
									0.839
^{23}Al		23.00727	0.47 s	β+ /12.24					ann.rad./
				β+, p/					
^{24m}Al			0.129 s	I.T./0.4259					
				β+	13.3	1+			1.3686/5.3
^{24}Al		23.999939	2.07 s	β+ /13.878,p	3.40/48.	4+			1.078(2)/16.
					4.42/41.				1.368(2)/96.
					6.80/3.				2.753(2)/43.
					8.74/8.				4.315(3)/15.
									5.392(3)/20.
									7.0662(2)/41.
^{25}Al		24.9904281	7.17 s	β+ /4.277	3.27/	5/2+	3.646		ann.rad./
									1.6115(2)/100.
									0.975(2)/5.
^{26m}Al			6.345 s	β+ /	3.2/	0+			ann.rad./
^{26}Al		25.9868917	7.1×10^5 y	β+ /82/4.0042	1.16/	5+	+2.804	+0.17	ann.rad./
				EC/18					1.8087/99.8
^{27}Al	100.	26.9815386				5/2+	+3.64151	+0.140	
^{28}Al		27.9819103	2.25 m	β- /4.6422	2.865/100.	3+	3.24	0.18	1.7778(6)/100.
^{29}Al		28.980445	6.5 m	β- /3.680	1.4/30.	5/2+			1.2732(8)/89.
					2.5/70.				2.0282(8)/4.
									2.4262(8)/7.
^{30}Al		29.98296	3.68 s	β- /8.56	5.05/	3+	3.01		1.26313(3)/35.
									2.23525(5)/65.
^{31}Al		30.98395	0.64 s	β- /8.00	6.25/	5/2+			0.75223(3)/18.
									1.69473(3)/59.
									2.31664(4)/73.
^{32}Al		31.9881	33. ms	β- /13.0		1+	1.96		
^{33}Al		32.9908	41.7 ms	β- /12.0	/91.5				1.940/2.5
				β-, n	/8.5				(1.01−4.34)
^{34}Al		33.9969	56. ms	β- /17.1	4.255/44	4			0.929/57
				β-, n	/26.				(0.12−4.26)
^{35}Al		34.9999	38. ms	β-/14.3	0.974/48	5/2+			0.064/45.
				β-, n	/ 38.				(0.12−5.63)
^{36}Al		36.0062	0.09 s	β-/18.3					
				β-, n	/<31.				
^{37}Al		37.0107	11. ms	β-/16.					
^{38}Al		38.017	> 7.6 ms						
^{39}Al		39.023	> 8. ms						
^{40}Al		40.031	> 0.26 μs						
^{41}Al		41.038	> 0.26 μs						
$_{14}$Si		**28.0855(3)**							
^{22}Si		22.0345	29. ms	β+, p	1.99/20	0+			
^{23}Si		23.0255	40.7 ms	β+, p/5.9	1.32,(0.6−11.6)				
^{24}Si		24.01155	0.14 s	β+, p/10.81	1.44,3.92,1.09	0+			ann.rad./

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					(1.66−4.47)				
^{25}Si		25.00411	221 ms	β+, p/12.74	p/4.25/9.5	5/2+			ann.rad./
					p/0.40/4.75				
					p/0.56-6.80				
^{26}Si		25.992330	2.23 s	β+ /5.066	3.282/	0+			ann.rad./
									0.8294(8)/22.
^{27}Si		26.9867049	4.14 s	β+ /4.8118	3.85/100.	5/2+	-0.8554		ann.rad./
									2.211(5)/0.2
^{28}Si	92.223(19)	27.976926533				0+			
^{29}Si	4.685(8)	28.97649470				1/2+	-0.5553		
^{30}Si	3.092(11)	29.97377017				0+			
^{31}Si		30.97536323	2.62 h	β- /1.4920	1.471/99.9	3/2+			1.2662(5)/0.05
^{32}Si		31.97414808	1.6×10^2 y	β- /0.224	0.213/100.	0+			
^{33}Si		32.97800	6.1 s	β- /5.85	3.92	(3/2+)	1.21		1.4313(5)/13.
									1.8477/100.
									2.538(2)/10.
^{34}Si		33.97858	2.8 s	β- /4.60	3.09/	0+			0.42907(5)/60.
									1.17852(2)/64.
									1.60756(5)/36.
^{35}Si		34.98458	0.9 s	β- /10.50					
^{36}Si		35.9866	0.5 s	β- /7.9		0^+			
				β-, n	/~ 12.				
^{37}Si		36.9929	~ 0.09 s	β- /12.5					
				β-, n	/~ 17.				
^{38}Si		37.9956	> 1 μs	β- /10.7		0^+			
				β-, n					
^{39}Si		39.0021	48. ms	β- /14.8					
^{40}Si		40.006	33. ms			0^+			
^{41}Si		41.015	20. ms						
^{42}Si		42.020	13. ms			0^+			
^{43}Si		43.029	> 0.26 μs						
$_{15}$P		**30.973762(2)**							
^{24}P		24.034							
^{25}P		25.0203	< 0.03 μs						
^{26}P		26.0118	44. ms	β+, p/18.1	p/0.41/18.0	3+			
					p/1.98/2.4				
					p/0.78-7.49				
^{27}P		26.99923	0.3 s	β+, p/11.63	p/0.73, 0.61/0.07	1/2+			
^{28}P		27.992315	270. ms	β+ /14.332	3.94/13.	3+			ann.rad./
					5.25/13.				1.779(2)/98.
					6.96/16.				2.839(2)/2.8
					8.8/7.				3.040(2)/3.2
					11.49/52.				4.498(2)/12.
									7.537(2)/9.
^{29}P		28.981801	4.14 s	β+ /4.9431	3.945/98.	1/2+	1.2349		ann.rad./
									1.273/1.32
									2.426/0.39
^{30}P		29.9783138	2.50 m	β+ /4.2323	3.245/99.9	1+			ann.rad./
									2.230(3)/0.07
^{31}P	100.	30.9737616				1/2+	+1.13160		
^{32}P		31.9739073	14.28 d	β- /1.7106	1.710/100.	1+	-0.2524		
^{33}P		32.971726	25.3 d	β- /0.249	0.249/100.	1/2+			
^{34}P		33.973636	12.4 s	β- /5.374	3.2/15.	1+			1.78−4.1/
					5.1/85.				2.127(5)/15.
^{35}P		34.973314	47. s	β- /3.989	2.34/100.	1/2+			1.572(1)/100.
^{36}P		35.97826	5.7 s	β- /10.41					0.902/77.
									3.291/100.
^{37}P		36.97961	2.3 s	β- /7.90					0.6462/

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									1.5829/
^{38}P		37.9842	0.6 s	β- /12.4					1.2923/
				β-, n	/~ 12.				2.224/
^{39}P		38.9862	0.3 s	β- /10.5					
				β-, n	/26				
^{40}P		39.9913	0.15 s	β- /14.5					
				β-,n	/~ 30.				
^{41}P		40.9943	0.10 s	β-/~ 13.8					
				β-, n	/~ 30.				
^{42}P		42.0010	49. ms	β-/17.					
				β-, n	/ ~ 50.				
^{43}P		43.006	36. ms	β-/16.					
				β-, n	/100.				
^{44}P		44.013	19. ms						
^{45}P		45.019	> 0.2 μs						
^{46}P		46.027	> 0.2 μs						
$_{16}$S		**32.065(5)**							
^{26}S		26.0279	~ 10 ms			0^+			
^{27}S		27.0188	16. ms	β+, 2p/18.3	p/2.26, 7.80				
^{28}S		28.0044	0.13 s			0^+			
^{29}S		28.99661	0.188 s	β+ /13.79		5/2+			ann.rad./
				β+, p/					
^{30}S		29.984903	1.18 s	β+ /6.138	4.42/78.	0+			ann.rad./
					5.08/20.				0.678/79.
^{31}S		30.979555	2.56 s	β+ /5.396	4.39/99.	1/2+	0.48793		ann.rad./
									1.2662(5)/1.2
^{32}S	94.99(26)	31.9720710				0+			
^{33}S	0.75(2)	32.9714588				3/2+	+0.64382	-0.068	
^{34}S	4.25(24)	33.9678669				0+			
^{35}S		34.9690322	87.2 d	β- /0.1672	0.1674/100.	3/2+	+1.00	+0.047	
^{36}S	0.01(1)	35.9670808				0+			
^{37}S		36.9711256	5.05 m	β- /4.8653	1.64/94.	7/2-			0.9083(4)/0.06
					4.75/5.6				3.1033(2)/94.2
^{38}S		37.97116	2.84 h	β- /2.94	1.00/	0+			0.1962(4)/0.2
									1.9421(3)/84.
^{39}S		38.97513	11.5 s	β- /6.64					1.301/52.
									1.697/44.
^{40}S		39.9755	9. s	β- /4.7		0+			
^{41}S		40.9796	~ 2.6 s	β- /8.7					
				β-, n					
^{42}S		41.9810	~ 0.56 s	β- /7.8		0+			
				β-, n	/ < 4.				
^{43}S		42.9872	0.26 s	β-/12.					
				β-, n	/ ~ 40				
^{44}S		43.9902	0.10 s	β-/9.		0+			
				β-, n	/18.				
^{45}S		44.997	68. ms	β-/14.					
				β-, n	/54.				
^{46}S		46.001	0.05 s			0+			
^{47}S		47.009	> 0.2 μs						
^{48}S		48.014	> 0.2 μs			0+			
^{49}S		49.024	< 0.2 μs						
$_{17}$Cl		**35.453(2)**							
^{28}Cl		28.029							
^{29}Cl		29.0141	< 0.02 μs						
^{30}Cl		30.0048	< 0.03 μs						
^{31}Cl		30.99241	0.15 s	β+, p/11.98	0.986, 1.52/0.7	3/2+			ann.rad./

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^{32}Cl		31.98569	297. ms	β+ /12.69	9.47/50.	1+	1.11		ann.rad./
				β+, α	/0.05				2.2305/92
				β+, p	/0.026				(1.55−4.77)
^{33}Cl		32.9774519	2.511 s	β+ /5.583	4.51/98.	3/2+	+0.755		ann.rad./
									0.8409/0.52
									1.966/0.45
									2.866/0.44
^{34m}Cl			32.2 m	β+/	1.35/24.	3+			ann.rad./
					2.47/28.				
				I.T./					0.1457(8)/42.
									2.1276(5)/42.
^{34}Cl		33.9737628	1.528 s	β+ /5.4922	4.50/100.	0+			ann.rad./
^{35}Cl	75.76(10)	34.96885268				3/2+	+0.82187	-0.0825	
^{36}Cl		35.9683070	3.01×10^5 y	β- /0.7086	0.7093/98.	0+	+1.28547	-0.018	
				β+, EC/1.1421	0.115/0.002				ann.rad./
^{37}Cl	24.24(10)	36.96590259				3/2+	+0.68412	-0.0649	
^{38m}Cl			0.715 s	I.T./		5-			0.6714/100
^{38}Cl		37.9680104	37.2 m	β- /4.9168	1.11/31.	2-	2.05		1.64216(1)/33.3
					2.77/11.				2.16760(2)/44.8
					4.91/58.				
^{39}Cl		38.968008	55.6 m	β- /3.442	1.91/85.	3/2+			0.25026(1)/47.
					2.18/8.				1.26720(5)/54.
					3.45/7.				0.986−1.517
^{40}Cl		39.97042	1.38 m	β- /7.48		2-			0.6431(3)/6.
									1.4608(1)/77.
									2.8402(2)/17.
^{41}Cl		40.9707	34. s	β- /5.7	3.8/				(0.167−1.359)
^{42}Cl		41.9733	6.8 s	β- /9.4					
^{43}Cl		42.9741	3.3 s	β- /8.0					
^{44}Cl		43.9783	~ 0.43 s	β-/12.3					
				β-, n	/ < 8.				
^{45}Cl		44.9803	0.40 s	β-/11.					
				β-, n	/24.				
^{46}Cl		45.984	0.23 s	β-/14.9					
				β-, n	/ ~ 60				
^{47}Cl		46.989	0.10 s	β-/15.					
				β-, n	/ < 3.				
^{48}Cl		47.995	> 0.2 μs						
^{49}Cl		48.000	> 0.17 s						
^{50}Cl		50.008							
^{51}Cl		51.014	> 0.2 μs						
$_{18}$Ar		**39.948(1)**							
^{30}Ar		30.0216	< 0.02 μs			0+			
^{31}Ar		31.0121	~ 14.1 ms	β+ /18.4	p/2.08/100.	5/2+			
				β+, p	/55.				
				β+, 2p	/2.5				
				β+, 3p	/0.11				
^{32}Ar		31.997638	98. ms	β+ /11.2	p/3.35, 0.6−5.55	0+			ann.rad./
				β+, p	/43.				
^{33}Ar		32.9899257	174. ms	β+ /11.62	3.17,2.10	1/2+	-0.72		ann.rad./
				β+, p/	(1.32−5.72)				0.810(2)/48.
^{34}Ar		33.9802712	0.844 s	β+/6.061	5.0/95.	0+			ann.rad./
									0.6658(1)/2.5
									3.1290(1)/1.3
^{35}Ar		34.975258	1.77 s	β+/5.965	4.94/93.	3/2+	+0.633	-0.08	ann.rad./
									1.2185(5)/1.22
									1.763(1)/0.25

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									2.964(1)/0.2
^{36}Ar	0.3365(30)	35.96754511				0+			
^{37}Ar		36.9667763	35.0 d	EC/.813		3/2+	+1.15	+0.076	
^{38}Ar	0.0632(5)	37.9627324				0+			
^{39}Ar		38.964313	268. y	β-/0.565	0.565/100.	7/2-	-1.59	-0.12	
^{40}Ar	99.6003(30)	39.962383123				0+			
^{41}Ar		40.9645006	1.82 h	β-/2.492	1.198/	7/2-			1.29364(5)/99.
									1.6770(3)/0.05
^{42}Ar		41.96305	33. y	β-/0.60	0.60/100.	0+			
^{43}Ar		42.96564	5.4 m	β-/4.6					0.4791(2)/10.
									0.7380(1)/43.
									0.9752(1)/100.
									1.4400(3)/39.
^{44}Ar		43.964924	11.87 m	β-/3.55		0+			0.182−1.866
^{45}Ar		44.968040	21.5 s	β-/6.9		7/2-			0.0610/25.
									1.020/35.
									3.707/34.
^{46}Ar		45.96809	8.4 s	β-/5.70		0+			1.944/
^{47}Ar		46.9722	1.23 s	β-					0.36/100
									1.66/53
									1.74/41
									(2.02 - 4.01)
^{48}Ar		47.9745	0.48 s			0+			
^{49}Ar		48.981	0.17 s	β- ,n	n// ~ 65.				
^{50}Ar		49.984	~ 0.085 s	β- ,n	n// ~ 35.	0+			
^{51}Ar		50.992	> 0.2 μs	β-					
^{52}Ar		51.997	10 ms	β-		0+			
^{53}Ar		53.005		β-					
$_{19}$K		**39.0983(1)**							
^{32}K		32.022							
^{33}K		33.0073	< 0.025 μs						
^{34}K		33.9984	< 0.04 μs						
^{35}K		34.98801	0.19 s	β+ /11.88		3/2+			ann.rad./
				β+, p/	/0.37				1.751/14.
									2.5698/26.
									2.9827/51.
^{36}K		35.98129	0.342 s	β+ /12.81	5.3/42.	2+	+0.548		ann.rad./
					9.9/44.				1.97044(5)/82.
				β+, p	/0.048				2.20783(5)/30.
									2.43343(2)/32.
^{37}K		36.9733759	1.23 s	β+ /6.149	5.13/	3/2+	+0.2032		ann.rad./
									2.7944(8)/2.
									3.602(2)/0.05
^{38m}K			0.924 s	β+ /6.742	5.02/100.	0+			ann.rad./
^{38}K		37.9690812	7.63 m	β+ /5.913	2.60/99.8	3+	+1.37		ann.rad./
									2.1675(3)/99.8
									3.9356(5)/0.2
^{39}K	93.2581(44)	38.9637067				3/2+	+0.39146	+0.049	
^{40}K	0.0117(1)	39.9639985	1.248 × 10^9 y	β- /1.3111	1.312/89.	4-	-1.29810	-0.061	ann.rad./
				β+, EC/1.505	1.50/10.7				1.4608/10.5
^{41}K	6.7302(44)	40.9618258				3/2+	+0.21487	+0.060	
^{42}K		41.9624028	12.36 h	β- /3.525	1.97/19.	2-	-1.1425		0.31260(2)/0.3
					3.523/81.				1.5246(3)/18.1
^{43}K		42.96072	22.3 h	β- /1.82	0.465/8.	3/2+	+0.163		0.2211(2)/4.
					0.825/87.				0.3729(2)/88.
					1.24/3.5				0.3971(2)/11.
					1.814/1.3				0.6178(2)/81.
^{44}K		43.96156	22.1 m	β- /5.66	5.66/34.	2-	-0.856		0.36821/2.2

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									1.15700(1)/58.
									2.15079(2)/22.
^{45}K		44.96070	17.8 m	β- /4.20	1.1/23.	3/2+	+0.173		0.1743(5)/80.
					2.1/69.				1.2607(8)/7.
					4.0/8.				1.7056(6)/69.
									2.3542(5)/14.
^{46}K		45.96198	1.8 m	β- /7.72	6.3/	2-	-1.05		1.347(1)/91.
									3.700(5)/28.
^{47}K		46.96168	17.5 s	β- /6.64	4.1/99.	½+	+1.93		0.56474(3)/15.
					6.0/1.				0.58575(3)/85.
									2.0131/100
^{48}K		47.96551	6.8 s	β- /12.09	5.0/	(2-)			0.67122(1)/4.
									0.6723(5)/20.
									0.78016(1)/32.
									3.83153(7)/80.
^{49}K		48.9675	1.26 s	β- /11.0					2.025/
									2.252/
^{50}K		49.9728	0.472 s	β- /14.2					
^{51}K		50.976	0.365 s	β- /					
^{52}K		51.983	0.105 s	β-					
^{53}K		52.987	30. ms	β-		3/2+			
^{54}K		53.994	10. ms	β-					
$_{20}$Ca		**40.078(4)**							
^{34}Ca		34.0141	< 0.035 μs			0+			
^{35}Ca		35.0049	25.7 ms	β+, p/15.6	p/1.43/49				
					1.9–8.8				
^{36}Ca		35.99309	0.10 s	β+, (p)/10.99	2.52	0+			ann.rad./
				β+, n/					
^{37}Ca		36.98587	0.18 s	β+ /11.64	3.103	3/2+			ann.rad./
				β+, n/					1.369
^{38}Ca		37.976318	0.44 s	β+ /6.74		0+			ann.rad./
									1.5677(5)/25.
									3.210(2)/1.
^{39}Ca		38.970720	0.861 s	β+ /6.531	5.49/100.	3/2+	1.02168		ann.rad./
^{40}Ca	96.941(156)	39.9625910				0+			
^{41}Ca		40.9622781	1.02×10^5 y	EC/0.4214		7/2-	-1.5948	-0.090	
^{42}Ca	0.647(23)	41.9586180				0+			
^{43}Ca	0.135(10)	42.9587666				7/2-	-1.3173	-0.055	
^{44}Ca	2.086(110)	43.9554818				0+			
^{45}Ca		44.9561866	162.7 d	β- /0.257	0.257/100.	7/2-	-1.327	+0.05	
^{46}Ca	0.004(3)	45.953693	$> 0.4 \times 10^{16}$ y	β-β-		0+			
^{47}Ca		46.954546	4.536 d	β-/1.992	0.684/84.	7/2-	-1.38	+0.02	1.297/75
					1.98/16.				(0.041–1.88)
^{48}Ca	0.187(21)	47.952534	4.3×10^{19} y	β-β-		0+			
			$> 7.1 \times 10^{19}$ y	β-					
^{49}Ca		48.955674	8.72 m	β- /5.262	0.89/7.	3/2-			3.0844(1)/90.7
					1.95/92.				4.0719(1)/8.12
									(0.143 - 4.738)
^{50}Ca		49.95752	14. s	β- /4.97	3.12/	0+			0.2569/98.
									(0.0715–1.59)
^{51}Ca		50.9615	10. s	β- /7.3		(3/2-)			
^{52}Ca		51.965	4.6 s	β- /8.0		0+			
^{53}Ca		52.9701	0.09 s	β- /10.9					
^{54}Ca		53.974	> 0.3 μs			0+			
^{55}Ca		54.981	> 0.3 μs						
^{56}Ca		55.986	> 0.3 μs			0+			
$_{21}$Sc		**44.955912(6)**							

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^{36}Sc		36.0149	0.102 s						
^{37}Sc		37.0031	0.181 s						
^{38}Sc		37.9947	< 0.3 μs						
^{39}Sc		38.98479	< 0.3 μs	p					
^{40}Sc		39.977967	0.182 s	β+ /14.320	5.73/50.	4-			ann.rad./
					7.53/15.				0.752/41.
					8.76/15.				3.732/99.5
					9.58/20.				(1.12−3.92)
^{41}Sc		40.9692511	0.596 s	β+ /6.4953	5.61/100.	7/2-	+5.431	-0.156	ann.rad./
^{42m}Sc			61.6 s	β+ /	2.82/	7+			ann.rad./
									0.4375(5)/100.
									1.2270(5)/100.
									1.5245(5)/100.
^{42}Sc		41.9655164	0.682 s	β+ /6.4259	5.32/100.	0+			ann.rad./
^{43}Sc		42.961151	3.89 h	β+, EC/2.221	0.82/22.	7/2-	+4.62	-0.26	ann.rad./
					1.22/78.				0.3729(1)/22.
^{44m}Sc			58.2 h	I.T./0.27		6+	+3.88		0.27124(1)/87.
				EC/3.926					(1.00−1.16)
^{44}Sc		43.959403	3.93 h	β+, EC/3.653	1.47/	2+	+2.56	+0.10	ann.rad./
									1.157/100
^{45}Sc	100.	44.955912				7/2-	+4.75649	-0.220	
^{46m}Sc			18.7 s	I.T./0.14253		1-			0.14253(2)/62.
^{46}Sc		45.955172	83.81 d	β- /2.367	0.357/100.	4+	+3.03	+0.12	0.8893/100
									1.121/100
^{47}Sc		46.952408	3.349 d	β- /0.600	0.439/69.	7/2-	+5.34	-0.22	0.15938(1)/68.
					0.601/31.				
^{48}Sc		47.95223	43.7 h	β- /3.99	0.655/	6+			0.9835/100
									1.03750(1)/97.
									1.3121/100
^{49}Sc		48.950024	57.3 m	β- /2.006	2.00/99.9.	7/2-			1.7619(3)/0.05
^{50}Sc		49.95219	1.71 m	β- /6.89	3.05/76.	(5+)			0.5235(1)/88.
					3.60/24.				1.1210(1)/100.
									1.5537(2)/100.
^{51}Sc		50.95360	12.4 s	β- /6.51	4.4/	7/2-			1.4373(4)/52.
					5.0/				0.718−2.144
^{52}Sc		51.9567	8.2 s	β- /9.0		(3+)			
^{53}Sc		52.9596	> 3. ms	β- /8.1					
^{54m}Sc			~ 7 μs	I.T.		(5+)			0.110/IT
^{54}Sc		53.9633	0.27 s	β- /11.6					0.100/50
									1.70/40
									0.50/40
^{55}Sc		54.968	0.103 s	β- /13					0.593(1)/40
^{56m}Sc			0.06 s						1.161/21
									0.690/19
^{56}Sc		55.973	35. ms	β-		(1+)			1.129/48
^{57}Sc		56.978	13. ms	β-					
^{58}Sc		57.984	12. ms	β-					
$_{22}$Ti		**47.867(1)**							
^{38}Ti		38.0098	< 0.12 μs			0+			
^{39}Ti		39.0016	30. ms	β+ /15.4					
^{40}Ti		39.9905	54. ms	β+ /11.7	p/2.16/29	0+			
				β+, p	3.73/23				
					1.70/22				
					0.242−5.74				
^{41}Ti		40.9832	80. ms	β+, p/12.93	p/4.73/107	3/2+			ann.rad./
					3.10/67				
					3.75/39				
					0.744−6.73				

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^{42}Ti		41.97303	0.20 s	β+ /7.000	6.0/	0+			ann.rad./
									0.6107(5)/56.
^{43}Ti		42.96852	0.50 s	β+ /6.87	5.80/	7/2-	0.85		ann.rad./
^{44}Ti		43.959690	60. y	EC/0.268		0+			0.06787/91
									0.07832/97
^{45}Ti		44.958126	3.078 h	β+/86/2.062	1.04	7/2-	0.095	0.015	ann.rad./
				EC/14/					(0.36−1.66)
^{46}Ti	8.25(3)	45.952632				0+			
^{47}Ti	7.44(2)	46.951763				5/2-	-0.78848	+0.30	
^{48}Ti	73.72(3)	47.947946				0+			
^{49}Ti	5.41(2)	48.947870				7/2-	-1.10417	+0.24	
^{50}Ti	5.18(2)	49.944791				0+			
^{51}Ti		50.946615	5.76 m	β- /2.471	1.50/92.	3/2-			0.3197(2)/93.
					2.13/				0.6094−0.9291
^{52}Ti		51.94690	1.7 m	β- /1.97	1.8/100.	0+			0.0170(5)/100.
									0.1245/100
^{53}Ti		52.9497	33. s	β- /5.0	(2.2−3)/	3/2-			0.1008(1)/20.
									0.1276(1)/45.
									0.2284(1)/39.
									1.6755(5)/45.
									(1.72−2.8)/
^{54}Ti		53.9511	1.5 s	β- /4.3		0+			
^{55}Ti		54.9553	1.3 s	β- /7.4					0.672/44
									(0.32 - 1.83)
^{56}Ti		55.9582	0.20 s	β- /7.0		0+			
^{57}Ti		56.9640	98. ms	β- /11.					
^{58}Ti		57.967	53. ms	β-		0+			0.114
^{59}Ti		58.973	30. ms	β-					
^{60}Ti		59.978	22. ms	β-		0+			
^{61}Ti		60.983	> 0.3 μs						
$_{23}$V		**50.9415(1)**							
^{40}V		40.0111							
^{41}V		40.9998							
^{42}V		41.9912	< 0.055 μs						
^{43}V		42.9807	> 0.8 s	β+ /11.3					
^{44}V		43.9741	0.09 s	β+, α/13.7					ann.rad./
^{45}V		44.96578	0.54 s	β+ /7.13		7/2-			
^{46}V		45.960201	0.4223 s	β+ /7.051	6.03/100.	0+			ann.rad./
^{47}V		46.954909	32.6 m	β+, EC/2.928	1.90/99.+	3/2-			ann.rad./
									1.7949(8)/0.19
									(0.2−2.16)
^{48}V		47.952254	15.98 d	β+ /4.012	0.698/50.	4+	2.01		ann.rad./
									0.9835/100
									(1.3−2.4)
^{49}V		48.948516	337. d	EC/0.602		7/2-	4.47		
^{50}V	0.250(4)	49.947159	1.4×10^{17} y	EC	/82.7	6+	+3.34569	+0.21	
				β-	/17.3				
^{51}V	99.750(4)	50.943960				7/2-	+5.148706	-0.04	
^{52}V		51.944776	3.76 m	β- /3.976	2.47/	3+			1.4341(1)/100.
^{53}V		52.944338	1.56 m	β- /3.436	2.52/	7/2-			1.0060(5)/90.
									1.2891(3)/10.
^{54m}V			0.9 μs	I.T.		(5+)			0.108/IT
^{54}V		53.94644	49.8 s	β- /7.04	1.00/5.	3+			0.8348/97.
					2.00/12.				0.9887/80.
					2.95/45.				2.259/46.
					5.20/11.				(0.56−3.38)
^{55}V		54.9472	6.5 s	β- /6.0	6.0/	(7/2-)			0.5177/73.
									(0.224−1.21)

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^{56}V		55.9505	0.22 s	β- /9.1					1.01/30.
									0.688/26.
									(0.82 − 1.32)
^{57}V		56.9526	0.35 s	β- /8.1					0.268/52.
									0.692/20.
									(0.25 − 1.31)
^{58}V		57.9567	0.19 s	β- /11.6					0.880/62
									1.056/28
									2.217/13
									(1.04 − 1.57)
^{59}V		58.9602	97. ms	β- /9.9					0.90/80.
^{60m}V			0.12 s						
^{60}V		59.9650	0.07 s	β- /14.					0.102−0.208
^{61}V		60.9685	47. ms						(0.071-1.144)
^{62}V		61.9738	34. ms						
^{63}V		62.978	17. ms						
^{64}V		63.983	> 0.3 μs						
$_{24}$Cr		**51.9961(6)**							
^{42}Cr		42.0064	13. ms	β+, p	p/1.90/29	0+			
					p/1.50−3.7				
^{43}Cr		42.9977	21. ms	β+, p	p/3.83/18				
					p/4.29/15				
					p/1.01−4.59				
^{44}Cr		43.98555	53. ms	β+, (p)/10.3	p/0.95−3.1	0+			
^{45}Cr		44.9796	0.05 s	β+, p/12.5		7/2-			ann.rad./
^{46}Cr		45.96836	0.3 s	β+ /7.60		0+			ann.rad./
^{47}Cr		46.96290	0.51 s	β^+/7.45		3/2-			ann.rad./
^{48}Cr		47.95403	21.6 h	EC/1.66		0+			ann.rad./
									0.116(2)/95.
									0.305(10)/100.
^{49}Cr		48.951336	42.3 m	β+, EC/2.631	1.39/	5/2-	0.476		ann.rad./
					1.45/				0.09064(1)/51.
					1.54/				0.15293(1)/27.
									(0.062-1.6)
^{50}Cr	4.345(13)	49.946044	> 1.3×10^{18} y	β+EC		0+			
^{51}Cr		50.944767	27.70 d	EC/0.7527		7/2-	-0.934		0.3201/10.2
^{52}Cr	83.789(18)	51.940508				0+			
^{53}Cr	9.501(17)	52.940649				3/2-	-0.47454	-0.15	
^{54}Cr	2.365(7)	53.938880				0+			
^{55}Cr		54.940840	3.497 m	β- /2.603	2.5/	3/2-			1.5282(2)/0.04
									(0.13−2.37)
^{56}Cr		55.940653	5.9 m	β- /1.62	1.50/100.	0+			0.026(2)/100.
									0.083(3)/100.
^{57}Cr		56.943613	21. s	β- /5.1	3.3/	3/2-	0.0834		0.850/8.
					3.5/				(0.083-2.62)
^{58}Cr		57.9444	7.0 s	β- /4.0		0+			(0.131−0.683)
^{59m}Cr			0.10 ms	I.T.		(9/2+)			0.208/IT
									0.193
									0.102
^{59}Cr		58.9486	1.0 s	β- /7.7					1.236
^{60}Cr		59.9500	0.6 s	β- /6.0		0+			
^{61}Cr		60.9547	0.26 s	β- /8.8					0.354−1.860
^{62}Cr		61.9566	0.19 s	β- /7.3		0+			(0.156-1.215)
^{63}Cr		62.9619	0.129 s	β-					(0.250-3.454)
^{64}Cr		63.9644	0.043 s	β-		0+			0.188
^{65}Cr		64.9702	0.027 s	β-					0.272, 1.368
^{66}Cr		65.973	0.01 s	β-		0+			
^{67}Cr		66.980	> 0.3 μs						

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$_{25}$Mn		**54.938045(5)**							
^{44}Mn		44.0069	< 0.105 μs						
^{45}Mn		44.9945	< 0.07 μs						
^{46}Mn		45.9867	34. ms	β+ /17.1					
				β+, p	// ~ 58				
^{47}Mn		46.9761	~ 0.1 s	β+ /12.3					
^{48}Mn		47.9685	0.15 s	β+ /13.5	5.79/58.	4+			
					4.43/10.				
^{49}Mn		48.95962	0.38 s	β+ /7.72	6.69/	5/2-			ann.rad./
^{50m}Mn			1.74 m	β+ /7.887	3.54/	5+			ann.rad./
									1.0980/94.
									0.783/91.
									(0.66−3.11)
^{50}Mn		49.954238	0.283 s	β+ /7.6330	6.61/	0+			ann.rad./
^{51}Mn		50.948211	46.2 m	β+, EC/3.208	2.2/	5/2-	3.568	0.4	ann.rad./
									0.7491(1)/0.26
									(1.148−1.164)
^{52m}Mn			21.1 m	β+ /98/5.09	2.631/	2+	0.0076		ann.rad./
				I.T./2/0.378					0.3778 (I.T.)
									1.43406(1)/98.
									(0.7−4.8)
^{52}Mn		51.945566	5.591 d	β+ /4.712	0.575/	6+	+3.063	+0.5	ann.rad./
				EC/					0.74421(1)/90.
									1.4341/100
^{53}Mn		52.941290	3.7×10^6 y	EC/0.5970		7/2-	5.024		
^{54}Mn		53.940359	312.1 d	EC/1.377		3+	+3.282	+0.33	0.8340/100
			6.7×10^8 y	β+	$//1.3 \times 10^{-7}$				
^{55}Mn	100.	54.938045				5/2-	+3.4687	+0.32	
^{56}Mn		55.938905	2.579 h	β- /3.6954	0.718/18.	3+	+3.2266		0.84675/98.9
					1.028/34.				1.81072(4)/26.3
									2.113/13.8
									(1.04 − 3.37)
^{57}Mn		56.938285	1.45 m	β- /2.691		5/2-			
^{58}Mn		57.93998	65 s	β- /6.25	3.8/	3+			0.45916(2)/20.
					5.1/				0.81076(1)/82.
									1.32309(5)/53.
^{59}Mn		58.94044	4.6 s	β- /5.19	4.5/	5/2-			0.726/
									0.473/
									0.287−2.35
^{60m}Mn			1.77 s	β- /IT	5.7/	3+			0.824/
^{60}Mn		59.9429	50. s	β- /8.6		0+			1.969/
^{61}Mn		60.9447	0.67 s	β- /7.4		(5/2)-			
^{62}Mn		61.9484	0.67 s	β- /10.4		(3+)			0.877/
									0.942−1.299
^{63}Mn		62.9502	0.28 s	β- /8.8					0.356,0.450
^{64m}Mn			> 0.1 ms						0.135/IT
^{64}Mn		63.9543	87 ms	β- /11.8					0.746
^{65}Mn		64.9563	0.092 s	β- /10.					0.366
^{66}Mn		65.9611	64 ms						0.471
^{67}Mn		66.9641	45 ms						
^{68}Mn		67.969	~ 28 ms						
^{69}Mn		68.973	14 ms						
$_{26}$Fe		**55.845(2)**							
^{45}Fe		45.0146	1.8 ms	2p /1.14	p// ~ 59.				
^{46}Fe		46.0008	11. ms	β+ /13.1	p// ~ 36.	0+			
^{47}Fe		46.9929	21.7 ms	β+ /15.6	p//87.				

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^{48}Fe		47.9805	~ 44. ms	β+ /11.2		0+			
^{49}Fe		48.9736	70. ms	β+ /13.0		(7/2-)			ann.rad./
^{50}Fe		49.9630	0.15 s	β+ /8.2		0+			0.651
^{51}Fe		50.95682	0.31 s	β+ /8.02		(5/2-)			ann.rad./
^{52m}Fe			46. s	β+ /4.4		(12+)			ann.rad./
									(0.622−2.286)/
^{52}Fe		51.94811	8.28 h	β+ /57/2.37	0.804/	0+			ann.rad./
				EC/43/					0.16868(1)/99.
				I.T./					0.377 (I.T.)/
^{53m}Fe			2.6 m	I.T./3.0407		19/2-			0.7011(1)/99.
									1.0115(1)/87.
									1.3281(1)/87.
									2.3396(1)/13.
^{53}Fe		52.945308	8.51 m	β+ /3.743	2.40/42.	7/2-			ann.rad./
					2.80/57.				0.3779(1)/42.
									(1.2−3.2)
^{54}Fe	5.845(35)	53.939611	> 3.1 × 10^{22} y	EC-EC		0+			
^{55}Fe		54.938293	2.73 y	EC/0.2314		3/2-			Mn x-ray
^{56}Fe	91.754(36)	55.934938				0+			
^{57}Fe	2.119(10)	56.935394				½-	+0.0906	0.16	
^{58}Fe	0.282(4)	57.933276				0+			
^{59}Fe		58.934876	44.51 d	β-/1.565	0.273/48.	3/2-	-0.336		1.099/57
					0.475/51.				1.292/43.
									(0.14−1.48)
^{60}Fe		59.934072	1.5 × 10^{6} y	β- /0.237	0.184/100.	0+			0.0586/100
^{61m}Fe			0.25 μs	I.T.		(9/2+)			0.654/IT
									0.207
^{61}Fe		60.93675	6.0 m	β- /3.98	2.5/13.				1.205/44.
					2.63/54.				1.028/43.
					2.80/31.				(0.12−3.37)
^{62}Fe		61.93677	68. s	β- /2.53	2.5/100.	0+			0.5061(1)/100.
^{63}Fe		62.9404	6. s	β- /6.3		5/2-			0.995/
									(1.365−1.427)
^{64}Fe		63.9412	2.0 s	β- /4.9		0+			
^{65m}Fe			0.4 μs	I.T.		(5/2-)			0.364/IT
^{65}Fe		64.9454	1.3 s	β- /7.9					
^{66}Fe		65.9468	0.44 s	β- /5.7		0+			0.471−1.425
^{67m}Fe			~ 0.04 ms	I.T.		(5/2-)			0.367/IT
^{67}Fe		66.9510	0.48 s	β- /8.8					0.189
^{68}Fe		67.954	0.19 s	β- / ~ 7.6		0+			
^{69}Fe		68.959	0.11 s						
^{70}Fe		69.961	0.10 s			0+			
^{71}Fe		70.967	> 0.3 μs						
^{72}Fe		71.970	> 0.3 μs			0+			
$_{27}$Co		**58.933195(5)**							
^{47}Co		47.0115							
^{48}Co		48.0018							
^{49}Co		48.9897	< 0.035 μs						
^{50}Co		49.9815	44. ms	β+ /17.0	2.03−2.79				
^{51}Co		50.9707	> 0.2 μs	β+ /12.8					
^{52}Co		51.9636	0.12 s	β+ /14.0					0.849−1.942
^{53m}Co			0.25 s	β+, p/		19/2-			ann.rad./
^{53}Co		52.95422	0.24 s	β+ /8.30		7/2-			ann.rad./
^{54m}Co			1.46 m	β+ /8.44	4.25/100.	7+			ann.rad./
									0.411(1)/99.
									1.130(1)/100.
									1.408(1)/100.
^{54}Co		53.948460	0.1932 s	β+ /8.2430	7.34/100.	0+			ann.rad./

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^{55}Co		54.941999	17.53 h	β+ /3.4513	0.53/	7/2-	+4.822		ann.rad./
				EC/	1.03/				0.9312/75.
					1.50/				0.4772/20.
									(0.092−3.11)
^{56}Co		55.939839	77.3 d	β+/4.566	1.459/18.	4+	3.85	+0.25	ann.rad./
				EC/					0.8468/99.9
									1.2383/68.
									(0.26−3.61)
^{57}Co		56.936291	271.8 d	EC/0.8361		7/2-	+4.72	+0.5	0.12206/86
									(0.014−0.706)
^{58m}Co			9.1 h	I.T./		5+			0.02489/0.035
^{58}Co		57.935753	70.88 d	β+ /2.307		2+	+4.04	+0.22	ann.rad./
				EC/					0.81076/99
^{59}Co	100.	58.933195				7/2-	+4.63	+0.41	
^{60m}Co			10.47 m	I.T./99.8/0.059		2+	+4.40	+0.3	0.0586/2.0
				β- /0.2/1.56					
^{60}Co		59.933817	5.271 y	β- /2.824	0.315/99.7	5+	+3.799	+0.44	1.1732/100
									1.3325/100
^{61}Co		60.932476	1.650 h	β- /1.322	1.22/95.	7/2-			0.0674/86.
									0.842−0.909
^{62m}Co			13.9 m	β- /	0.88/25.	5+			1.1635(3)/70.
					2.88/75.				1.1730(3)/98.
									2.0039(3)/19.
^{62}Co		61.93405	1.50 m	β- /5.32	1.03/10.	2+			1.1292(3)/13.
					1.76/5.				1.1730(3)/83.
					2.9/20.				1.9851(1)/3.
					4.05/60.				2.3020(1)/19.
^{63}Co		62.93361	27.5 s	β- /3.67	3.6/	7/2-			0.08713(1)/49.
									0.9817(3)/2.6
									0.156−2.17
^{64}Co		63.93581	0.30 s	β- /7.31	7.0/	1+			
^{65}Co		64.93648	1.14 s	β- /5.96		(7/2)-			
^{66m2}Co			> 0.1 ms	I.T.		(8-)			0.252/IT
									0.214
									0.175
^{66m1}Co			1.2 μs	I.T.		(5+)			0.175/IT
^{66}Co		65.9398	0.25 s	β- /10.0					(1.245−1.425)
^{67}Co		66.9409	0.43 s	β- /8.4					0.694
^{68}Co		67.9449	0.19 s	β- /11.7					
^{69}Co		68.9463	0.20 s	β- /9.3					
^{70}Co		69.951	0.12 s	β- 13.					1.26/102
									0.97/100
									(0.45 − 0.92)
^{71}Co		70.953	97. ms	β-					0.566/100
				β-,n	// > 3				(0.25 − 0.77)
^{72}Co		71.958	60. ms	β-					1.096/100
				β-,n	// > 6				0.845
									(0.455 − 1.197)
^{73}Co		72.960	41. ms	β-					0.524/100
				β-,n	// > 9				(0.24 − 0.76)
^{74}Co		73.965	30. ms	β-					0.739
				β-,n	// > 26				1.024
^{75}Co		74.968	> 0.3 μs						
$_{28}$Ni		**58.6934(2)**							
^{48}Ni		48.020	~ 2.1 ms	2p	p// ~ 25	0+			
^{49}Ni		49.0097	12. ms						
^{50}Ni		49.9959	12. ms	β+, p	p//70.	0+			
^{51}Ni		50.9877	> 0.2 μs	β+ /16.0					

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^{52}Ni		51.9757	38. ms	β+ /11.7		0+			
^{53}Ni		52.9685	0.05 s	β+, p/13.3		7/2-			ann.rad./
^{54}Ni		53.95791	0.10 s	β+ /8.80		0+			0.937
^{55}Ni		54.95133	0.20 s	β+ /8.70	7.66/	7/2-			ann.rad./
^{56}Ni		55.94213	6.08 d	EC/2.14		0+			0.15838/99
				β+ /<10^{-6}					0.81185(3)/87.
									0.2695−0.7500
^{57}Ni		56.939794	35.6 h	β+ /3.264	0.712/10.	3/2-	-0.798		ann.rad./
				EC/	0.849/76.				1.3776/78.
									(0.127−3.177)
^{58}Ni	68.0769(89)	57.935343	>4 × 10^{19} y	EC-EC		0+			
^{59}Ni		58.934347	~ 7.6 × 10^{4} y	EC/		3/2-			
^{60}Ni	26.2231(77)	59.930786				0+			
^{61}Ni	1.1399(6)	60.931056				3/2-	-0.75002	+0.16	
^{62}Ni	3.6345(17)	61.928345				0+			
^{63}Ni		62.929669	100. y	β- /0.066945	0.065/	½-			
^{64}Ni	0.9256(9)	63.927966				0+			
^{65}Ni		64.930084	2.517 h	β- /2.137	0.65/30.	5/2-	0.69		0.36627(3)/5.
					1.020/11.				1.11553(4)/16.
					2.140/58.				1.48184(5)/23.
^{66}Ni		65.929139	54.6 h	β- /0.23		0+			
^{67m}Ni			13.3 μs	I.T.		9/2+			0.313/IT
									0.694
^{67}Ni		66.931569	21. s	β- /3.56	3.8/	½-	+0.601		1.0722/100.
									1.6539/100.
									(0.10−1.98)
^{68m2}Ni			0.34 μs						0.511
^{68m1}Ni			0.86 ms	I.T.		(5-)			0.814/IT
									2.033
^{68}Ni		67.931869	29. s	β- /2.06		0+			
^{69m2}Ni			0.44 μs	I.T.		(17/2)			0.148/IT
									0.593
									1.959
^{69m1}Ni			3.5 s						
^{69}Ni		68.935610	11. s	β- /5.4					0.6807(3)/100.
									(0.207−1.213)
^{70m}Ni			0.21 μs	I.T.		(8+)			0.183/IT
									0.448
									0.970
									1.259
^{70}Ni		69.9365	6.0 s	β- /3.5		0+			
^{71}Ni		70.9407	2.56 s	β- /6.9					
^{72}Ni		71.9421	1.6 s	β- /5.2		0+			
^{73}Ni		72.9465	0.84 s	β- /9.					
^{74}Ni		73.9481	0.9 s	β- /7.		0+			
^{75}Ni		74.9529	0.34 s						
^{76}Ni		75.955	0.24 s			0+			
^{77}Ni		76.961	0.13 s						
^{78}Ni		77.963	~ 0.11 s			0+			
$_{29}$Cu		**63.546(3)**							
^{52}Cu		51.9972							
^{53}Cu		52.9856	< 0.3 μs						
^{54}Cu		53.9767	< 0.075 μs						
^{55}Cu		54.9661	> 0.2 μs	β+ /13.2					
^{56}Cu		55.9586	93. ms	β+ /15.3					0.511/233
									2.700/100
									0.9507−3.287
^{57}Cu		56.94921	196. ms	β+ /8.77		3/2-			0.77−3.01

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^{58}Cu		57.944539	3.21 s	β+ /8.563	4.5/15.	1+			ann.rad./
				EC/	7.439/83.				0.0403(4)/5.
									1.4483(2)/11.
									1.4546(2)/16.
^{59}Cu		58.939498	1.36 m	β+ /4.800	1.9/	3/2-	+ 1.89		ann.rad./
					3.75/				0.3393(1)/8.
									0.8780(1)/12.
									1.3015(1)/15.
									(0.4−2.6)
^{60}Cu		59.937365	23.7 m	β+ /6.127	2.00/69.	2+	+1.219		ann.rad./
				EC/	3.00/18.				1.3325/88.
					3.92/6.				1.7915/45.
									(0.12−5.048)
^{61}Cu		60.933458	3.35 h	β+ /2.237	0.56/3.	3/2-	+2.14		ann.rad./
					0.94/5.				0.2830/13.
					1.15/2.				0.6560/11.
					1.220/51.				(0.067−2.123)
^{62}Cu		61.932584	9.67 m	β+ /98/3.948	2.93/98.	1+	-0.380		ann.rad./
				EC/					1.17302(1)/0.6
									(0.87−3.37)
^{63}Cu	69.15(15)	62.929598				3/2-	+2.2233	-0.211	
^{64}Cu		63.929764	12.701 h	β- /38/0.579	0.578/	1+	-0.217		ann.rad./
				β+ /19/1.6751	0.65/				1.3459(3)/0.6
				EC/41/					
^{65}Cu	30.85(15)	64.927790				3/2-	+2.3817	-0.195	
^{66}Cu		65.928869	5.09 m	β- /2.642	1.65/6.	1+	-0.282		0.8330(1)/0.22
					2.7/94.				1.0392(2)/9.2
^{67}Cu		66.927730	2.580 d	β- /0.58	0.395/56.	3/2-	+ 2.54		0.09125(1)/7.
					0.484/23.				0.09325(1)/17.
					0.577/20.				0.18453(1)/47.
^{68m}Cu			3.79 m	I.T./86/		6-	+1.24		0.0843(5)/70.
				β- /14/1.8					0.1112(5)/18.
									0.5259(5)/74.
									(0.64−1.34)
^{68}Cu		67.929611	31. s	β- /4.46	3.5/40.	1+	+2.48		1.0774(5)/58.
					4.6/31.				1.2613(5)/17.
									(0.15−2.34)
^{69m}Cu			0.36 μs	I.T.		(13/2+)			0.075/IT
									0.190/IT
									0.680
									1.871
^{69}Cu		68.929429	2.8 m	β- /2.68	2.48/80.	3/2-	+2.84		0.5307(3)/3.
									0.8340(5)/6.
									1.0065(8)/10.
^{70m2}Cu			6.6 s	β/93					0.8849/100
									1.072/19
				IT/7					0.141/ IT
^{70m1}Cu			33. s	β- /52	2.52/10.	5-	+1.9		0.8848(2)/100.
				IT/48					0.9017(2)/90.
									1.2517(5)/60.
									(0.39−3.06)
^{70}Cu		69.932392	44.5 s	β- /6.60	5.42/54.	1+	+1.5		0.8848(2)/100.
					6.09/46.				0.9017/99.7
									(0.438 - 3.062)
^{71m}Cu			0.28 μs	I.T.		(19/2)			0.133/IT
									0.494
									0.939
									1.189
^{71}Cu		70.932677	20. s	β- /4.56		3/2-			0.490/
^{72m}Cu			1.76 μs	I.T.		(4-)			0.051/IT

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									0.082
									0.138
^{72}Cu		71.935820	6.6 s	β- /8.2		(1+)			0.652/
^{73}Cu		72.936675	4.2 s	β- /6.3	5.8/43				0.450/100
					6.25/42				0.307−1.559
^{74}Cu		73.93988	1.59 s	β- /9.9					
^{75}Cu		74.942	1.2 s	β- /7.9					
^{76m}Cu			1.2 s						
^{76}Cu		75.94528	0.64 s	β- /11.					
^{77}Cu		76.9479	0.46 s	β- / ~ 10.					
^{78}Cu		77.9520	0.33 s	β- /12.					
^{79}Cu		78.9546	0.19 s	β- /11.					
^{80}Cu		79.961	> 0.3 μs						
$_{30}$Zn		**69.409(4)**							
^{54}Zn		53.9930	~ 3.2 ms	2p	p//87	0+			
^{55}Zn		54.9840	> 1.6 μs						
^{56}Zn		55.9724	0.04 s			0+			
^{57}Zn		56.9648	0.04 s	β+, p/14.6		(7/2-)			ann.rad./
^{58}Zn		57.95459	0.09 s	β+		0+			
^{59}Zn		58.94926	183. ms	β+, p/9.09	8.1/	3/2-			ann.rad./
									(0.491−0.914)
^{60}Zn		59.94183	2.40 m	β+ /97/4.16		0+			ann.rad./
				EC/3/					0.669/47.
									(0.062−0.947)
^{61}Zn		60.93951	1.485 m	β+ /5.64	4.38/68.	3/2-			ann.rad./
									0.4748/17.
									(0.15−3.52)
^{62}Zn		61.93433	9.22 h	β+ /3/1.63	0.66/7.	0+			ann.rad./
				EC/93/					0.0408/25
									0.5967/26.
									(0.20−1.526)/
^{63}Zn		62.933212	38.5 m	β+ /93/3.367	1.02/	3/2-	-0.28164	+0.29	ann.rad./
				EC/7/	1.40/				0.66962(5)/8.4
					1.71/				0.96206(5)/6.6
					2.36/84.				(0.24−3.1)
^{64}Zn	48.268(321)	63.929142	> 4.3×10^{18} y	EC-β+		0+			
^{65}Zn		64.929241	244.0 d	β+ /98/1.3514	0.325/	5/2-	+0.7690	-0.023	ann.rad./
				EC/1.5/					1.1155/49.8
^{66}Zn	27.975(77)	65.926033				0+			
^{67}Zn	4.102(21)	66.927127				5/2-	+0.8755	+0.15	
^{68}Zn	19.024(123)	67.924844				0+			
^{69m}Zn			13.76 h	I.T./99+/0.439		9/2+			0.4390(2)/95.
^{69}Zn		68.926550	56. m	β- /0.906	0.905/99.9	½-			0.318/
^{70}Zn	0.631(9)	69.925319	> 1.3×10^{16} y	β-β-		0+			
^{71m}Zn			3.97 h	β- /	1.45/	9/2+			0.3864/93.
									0.4874/62.
									0.6203/57.
									(0.099−2.489)
^{71}Zn		70.92772	2.4 m	β- /2.81		½-			0.5116(1)/30.
									0.9103(1)/7.5
									(0.12−2.29)
^{72}Zn		71.92686	46.5 h	β- /0.46	0.25/14.	0+			0.0164(3)/8.
					0.30/86.				0.1447(1)/83.
									0.1915(2)/9.4
^{73m}Zn			6. s		I.T./0.196	(7/2+)			0.042
^{73}Zn		72.92978	24. s	β- /4.29	4.7/	(1/2-)			0.216(1)/100.
									0.496−0.911
^{74}Zn		73.92946	1.60 m	β- /2.3	2.1/	0+			0.0565/

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									0.1401/
									(0.05−0.35)
^{75}Zn		74.9329	10.2 s	β- /6.0					0.229/
^{76}Zn		75.9333	5.7 s	β- /4.2	3.6/	0+			0.119/
^{77m}Zn			1.0 s	β- /		(1/2-)			0.772
^{77}Zn		76.9370	2.1 s	β- /7.3	4.8/				0.189/
^{78m}Zn			> 0.03 ms						1.070
^{78}Zn		77.9384	1.5 s	β- /6.4		0+			0.225/
^{79}Zn		78.9427	1.0 s	β- /8.6					0.702/
^{80}Zn		79.9443	0.54 s	β- /7.3		0+			0.713/
									0.2248/
^{81}Zn		80.9505	0.29 s	β- /11.9					
^{82}Zn		81.9544	> 0.15 μs			0+			
^{83}Zn		82.9610	> 0.15 μs						
$_{31}$Ga		**69.723(1)**							
^{56}Ga		55.9949							
^{57}Ga		56.9829							
^{58}Ga		57.9743							
^{59}Ga		58.9634	< 0.043 μs						
^{60}Ga		59.9571	0.07 s	β+					1.004
				β+, p	// ~ 1.6				3.848
				β+, α	// ~ 0.02				1.555−2.559
^{61}Ga		60.9495	0.17 s	β+ /9.0		3/2-			0.088−1.362
^{62}Ga		61.94418	116.0 ms	β+ /9.17	8.3/	0+			ann.rad./
				EC/					0.954/0.0012
^{63}Ga		62.939294	32. s	β+ /5.5	4.5/				ann.rad./
				EC/					0.6271(2)/10.
									0.6370(2)/11.
									1.0652(4)/45.
^{64m}Ga			0.022 ms						0.0429
^{64}Ga		63.936839	2.63 m	β+ /7.165	2.79/	0+			ann.rad./
					6.05/				0.80785(1)/14.
									0.99152(1)/43.
									1.38727(1)/12.
									3.3659(1)/13.
^{65}Ga		64.932735	15.2 m	β+ /86/3.255	0.82/10.	3/2-			ann.rad./
				EC/	1.39/19.				0.1151(2)/55.
					2.113/56.				0.1530(2)/96.
					2.237/15.				0.2069(2)/39.
									(0.06−2.4)
^{66}Ga		65.931589	9.5 h	β+ /56/5.175	0.74/1.	0+			ann.rad./
				EC/43/	1.84/54.				1.03935(8)/38.
					4.153/51.				2.7523(1)/23.
									(0.28−5.01)
^{67}Ga		66.928202	3.261 d	EC/1.001		3/2-	+1.8507	0.20	0.09332/37.
									0.18459/20.
									0.30024/17.
									(0.091−0.89)
^{68}Ga		67.927980	1.130 h	β+ /90/2.921	1.83/	1+	0.01175	0.028	ann.rad./
				EC/10/					1.0774(1)/3.
									(0.57−2.33)/
^{69}Ga	60.108(9)	68.925574				3/2-	+2.01659	+0.17	
^{70}Ga		69.926022	21.1 m	EC/0.2/0.655		1+			0.1755(5)/0.15
				β- /99.8/1.656	1.65/99.				1.042(5)/0.48
^{71}Ga	39.892(9)	70.924701	> 2.4×10^{26} y	β-		3/2-	+2.56227	+0.11	
^{72}Ga		71.926366	14.10 h	β- /4.001	0.64/40.	3-	-0.13224	+0.5	0.8340/95.53
					1.51/9.				2.202/26.9
					2.52/8.				0.630/26.2

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					3.15/11.				(0.113−3.678)
^{73}Ga		72.925175	74.87 h	β- /1.59		3/2-			0.05344(5)/10.
									0.29732(5)/47.
									(0.01−1.00)/
^{74m}Ga			10. s	I.T./		1+			0.0565(1)/75.
^{74}Ga		73.926946	8.1 m	β- /5.4	2.6/	3-			0.5959/92.
									2.354/45.
									(0.23−3.99)
^{75}Ga		74.926500	2.10 m	β- /3.39	3.3/	3/2-			0.2529/
									0.5746/
									(0.12−2.10)
^{76}Ga		75.928828	29. s	β- /7.0		3-			0.5629/66.
									0.5455/26.
									(0.34−4.25)
^{77}Ga		76.929154	13.0 s	β- /5.3	5.2/				0.469/
									0.459/
^{78}Ga		77.931608	5.09 s	β- /8.2		3+			0.619/77.
									1.187/20.
^{79}Ga		78.9329	2.85 s	β- /7.0	4.6/				0.465/
^{80}Ga		79.9365	1.68 s	β- /10.4	10./				0.659/
^{81}Ga		80.9378	1.22 s	β- /8.3	5.1/				0.217/
^{82}Ga		81.9430	0.599 s	β- /12.6					1.348/
^{83}Ga		82.9470	0.308 s	β- /~ 11.5					
^{84}Ga		83.9527	~ 0.085 s	β- /14					
^{85}Ga		84.9570	> 0.3 μs						
^{86}Ga		85.963	> 0.3 μs						
$_{32}$Ge		**72.64(1)**							
^{58}Ge		57.9910				0+			
^{59}Ge		58.9818							
^{60}Ge		59.9702	> 0.11 μs			0+			
^{61}Ge		60.9638	0.04 s	β+ /13.6					
^{62}Ge		61.9547	0.13 s			0+			
^{63}Ge		62.9496	0.15 s	β- /9.8					
^{64}Ge		63.94165	1.06 m	β+ /4.4	3.0/	0+			ann.rad./
				EC/					0.1282(2)/11.
				β+, p					0.4270(3)/37.
									0.6671(3)/17.
^{65}Ge		64.9394	31. s	β+ /6.2	0.82/10.				ann.rad./
				EC/	1.39/19.				0.0620/27.
				EC, p	2.113/56.				0.6497/33.
					2.237/15.				0.8091/21.
				β+, p	//0.011				(0.19−3.28)
^{66}Ge		65.93384	2.26 h	β+ /27/2.10		0+			ann.rad./
				EC/73/					0.0438/29.
									0.3819/28.
									(0.022−1.77)
^{67}Ge		66.932734	19.0 m	β+ /96/4.225	1.6/	½-			ann.rad./
				EC/4/	2.3/				0.1670/84.
					3.15/				(0.25−3.73)
^{68}Ge		67.92809	270.8 d	EC/0.11		0+			Ga k x-ray/39.
^{69}Ge		68.927965	1.63 d	β+ /36/2.2273	0.70/	5/2-	0.735	0.02	ann.rad./
				EC/64/	1.2/				0.574/13.
									1.1068/36.
									(0.2−2.04)
^{70}Ge	20.38(18)	69.924247				0+			
^{71m}Ge			20.4 ms		I.T./0.0234	9/2+			0.1749
^{71}Ge		70.924951	11.2 d	EC/0.229		½-	+0.547		
^{72}Ge	27.31(26)	71.922076				0+			

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^{73}Ge	7.76(8)	72.923459	> 1.8 × 10^{23} y	β-		9/2+	-0.879467	-0.17	
^{74}Ge	36.72(15)	73.921178				0+			
^{75m}Ge			48. s	I.T./		7/2+			0.13968(3)/39.
^{75}Ge		74.922859	1.380 h	β- /1.177	1.19/	½-	+0.510		0.26461(5)/11.
									0.41931(5)/0.2
^{76}Ge	7.83(7)	75.921403	1.6 × 10^{21} y	β-β-		0+			
^{77m}Ge			53. s	I.T./20/		½-			1.605/0.22
				β- /80/2.861	2.9/				1.676/0.16
									0.195−1.482
^{77}Ge		76.923549	11.25 h	β- /2.702	0.71/23.	7/2+			0.2110/29.
					1.38/35.				0.2155/27.
					2.19/42.				0.2644/51.
									(0.15−2.35)
^{78}Ge		77.922853	1.45 h	β- /0.95	0.70/	0+			0.2773(5)/96.
									0.2939(5)/4.
^{79m}Ge			39. s	β- /IT		7/2+			
^{79}Ge		78.9254	19.1 s	β- /4.2	4.0/20.	½-			0.1096/21.
					4.3/80.				(0.10−2.59)
									0.5427(4)/15.
^{80}Ge		79.92537	29.5 s	β- /2.67	2.4/	0+			0.1104(4)/6.
									0.2656(4)/25.
^{81m}Ge			~ 7.6 s	β- /	3.75/	½+			0.3362(4)/
									0.7935(4)/
^{81}Ge		80.9288	~ 7.6 s	β- /6.2	3.44/	9/2+			0.1976(4)/21.
									0.3362(4)/100.
^{82}Ge		81.9296	4.6 s	β- /4.7	1.093/80	0+			1.093/
^{83}Ge		82.9346	1.9 s	β- /8.9					
^{84}Ge		83.9375	0.98 s	β- /7.7		0+			
^{85}Ge		84.9430	0.54 s	β- /10.					
^{86}Ge		85.9465	> 0.3 μs			0+			
^{87}Ge		86.9525	> 0.3 μs						
^{88}Ge		87.957	> 0.3 μs			0+			
^{89}Ge		88.964	> 0.3 μs						
$_{33}$As		**74.92160(2)**							
^{60}As		59.993							
^{61}As		60.981							
^{62}As		61.9732							
^{63}As		62.9637	< 0.043 μs						
^{64}As		63.9576	0.02 s						
^{65}As		64.9496	0.13 s	β+ /9.4					
^{66m2}As			8. μs						
^{66m1}As			1.1 μs						
^{66}As		65.945	95.8 ms	β+ /9.55					
^{67}As		66.9392	42. s	β+ /6.0	5.0/	5/2-			0.121/
				EC/					0.123/
									0.244/
^{68}As		67.93677	2.53 m	β+ /8.1		3+			ann.rad./
									0.652/32.
									0.762/33.
									1.016/77.
									(0.61−3.55)
^{69}As		68.93227	15.2 m	β+ /98/4.01	2.95/	5/2-	+ 1.623		ann.rad./
				EC/2/					0.0868(5)/1.5
									0.1458(3)/2.4
^{70}As		69.93092	52.6 m	β+ /84/6.22	1.44/	4+	+2.1061	+0.09	ann.rad./
				EC/16/2.14					1.0395(7)/82.
				/2.89					(0.17−4.4)/
^{71}As		70.927112	2.72 d	β+ /32/2.013		5/2-	+1.6735	-0.02	ann.rad./

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				EC/68/					0.1749(2)/84.
									1.0957(2)/4.2
^{72}As		71.926752	26.0 h	β+ /77/4.356	0.669/5.	2-	-2.1566	-0.08	ann.rad./
					1.884/12.				0.83395(5)/80.
					2.498/62.				1.0507(1)/9.6
					3.339/19.				(0.1−4.0)
^{73}As		72.923825	80.3 d	EC/0.341		3/2-			0.0133/0.1
									0.0534/10.5
									Se k x-ray/90.
^{74}As		73.923829	17.78 d	β+ /31/2.562	0.94/26.	2-	-1.597		ann.rad./
				EC/37/	1.53/3.				0.59588(1)/60.
				β- /1.353	0.71/16.				0.6084(1)/0.6
					1.35/16.				0.6348(1)/15.
^{75m}As			0.017 s						
^{75}As	100.	74.921597				3/2-	+1.43947	+0.31	
^{76}As		75.922394	26.3 h	β- /2.962	0.54/3.	2-	-0.903		0.5591(1)/45.
					1.785/8.				0.65703(5)/6.2
					2.410/36.				1.21602(1)/3.4
					2.97/51.				(0.3−2.67)
^{77}As		76.920647	38.8 h	β- /0.683	0.70/98.	3/2-	+1.295		0.2391(2)/1.6
									0.2500(3)/0.4
									0.5208/0.43
^{78}As		77.92183	1.512 h	β- /4.21	3.00/12.	2-			0.6136(3)/54.
					3.70/17.				0.6954(3)/18.
					4.42/37.				1.3088(3)/10.
^{79m}As			1.21 μs	I.T.		9/2+			0.542/IT
									0.231
^{79}As		78.92095	9.0 m	β- /2.28	1.80/95.	3/2-			0.0955(5)/16.
									0.3645(5)/1.9
^{80}As		79.92253	16. s	β- /5.64	3.38/	1+			0.6662(2)/42.
									(2.5−3.0)
^{81}As		80.92213	33. s	β- /3.856		3/2-			0.4676(2)/20.
									0.4911(2)/8.
^{82m}As			13.7 s	β- /	3.6/	5-			0.6544(1)/77.
									0.344/65.
									(0.561 − 1.894)
^{82}As		81.9245	19. s	β- /7.4	7.2/80.	(2-)			0.6544(1)/54.
									(0.755 − 3.667)
^{83}As		82.9250	13.4 s	β- /5.5					0.7345/100.
									1.1131/34.
									2.0767/28.
^{84m}As			0.6 s	β-					
^{84}As		83.9291	4. s	β-, n/7.2		1-			0.6671(2)/21.
									1.4439(5)/49.
									(0.325−5.150)
^{85}As		84.9320	2.03 s	β-, n/8.9		3/2-			0.667(1)/42.
									1.4551(2)/100.
^{86}As		85.9365	0.95 s	β-, n/11.4					0.704/
^{87}As		86.9399	0.49 s	β-, n/10.					0.704/
^{88}As		87.9449	> 0.3 μs						
^{89}As		88.9494	> 0.3 μs						
^{90}As		89.956	> 0.3 μs						
^{91}As		90.960	> 0.3 μs						
^{92}As		91.967	> 0.3 μs						
$_{34}$Se		**78.96(3)**							
^{64}Se			> 0.18 μs			0+			
^{65}Se		64.965	0.011 s	β+ /60/14.					

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				β+, p	3.55/				
^{66}Se		65.9552	0.03 s			0+			
^{67}Se		66.9501	0.13 s	β+ /10.2					ann.rad./
				β+, (p)/					0.352
^{68}Se		67.94180	36. s	β+ /4.7		0+			ann.rad./
									(0.050–0.426)
^{69}Se		68.93956	27.4 s	β+ /6.78	5.006/				ann.rad./
				EC/					0.0664(4)/27.
				β+, p	// ~ 0.045				0.0982(4)/63.
^{70}Se		69.9334	41.1 m	β+ /2.4		0+			ann.rad
									0.04951(5)/35.
									0.4262(2)/29.
^{71}Se		70.93224	4.7 m	β+ /4.4	3.4/36.	5/2-			ann.rad
				EC/					0.1472(3)/47.
									0.8309(3)/13.
									1.0960(3)/10.
^{72}Se		71.92711	8.5 d	EC/0.34		0+			0.0460(2)/57.
^{73m}Se			40. m	I.T./73/0.0257	0.85	3/2-			ann.rad.
				β+ /27/2.77	1.45/				0.0257(2)/27.
					1.70/				0.2538(1)/2.5
^{73}Se		72.92677	7.1 h	β+ /65/2.74	0.80/	9/2+	0.86		ann.rad
				EC/35/	1.32/95.				0.0670(1)/72.
					1.68/1.				0.3609(1)/97.
									(0.6–1.5)
^{74}Se	0.89(4)	73.922476				0+			
^{75}Se		74.922523	119.78 d	EC/0.864		5/2+	0.67	1.0	0.13600/55
									0.26465/58
									(0.024–0.821)
^{76}Se	9.37(29)	75.919214				0+			
^{77m}Se			17.4 s	I.T./		7/2+			0.1619(2)/52.
^{77}Se	7.63(16)	76.919914				½-	+0.53506		
^{78}Se	23.77(28)	77.917309				0+			
^{79m}Se			3.92 m	I.T./					0.09573(3)/9.5
^{79}Se		78.918499	2.9×10^5 y	β- /0.151		7/2+	-1.018	+0.8	
^{80}Se	49.61(41)	79.916521				0+			
^{81m}Se			57.3 m	I.T./99/0.1031		7/2+			0.1031(3)/9.7
									0.2602(2)/0.06
									0.2760/0.06
^{81}Se		80.917993	18.5 m	β- /1.585	1.6/98.	½-			0.2759/0.85
									0.2901/0.75
									0.8283/0.32
^{82}Se	8.73(22)	81.916699	~ 1×10^{20} y	β-β-		0+			
^{83m}Se			1.17 m	β- /3.96	2.88/	½-			0.35666(6)/17.
					3.92/				0.9879(1)/15.
									1.0305(1)/21.
									2.0514(2)/11.
									(0.19–3.1)
^{83}Se		82.919118	22.3 m	β- /3.668	0.93/	9/2+			0.22516(6)/33.
					1.51/				0.35666(6)/69.
									0.51004(8)/45.
									(0.21–2.42)
^{84}Se		83.91846	3.3 m	β- /1.83	1.41/100.	0+			0.4088(5)/100.
^{85}Se		84.92225	32. s	β- /6.18	5.9/	5/2+			0.3450(1)/22.
									0.6094(1)/41.
^{86}Se		85.92427	15. s	β- /5.10		0+			2.0124(1)/24.
									2.4433(8)/100.
									2.6619(1)/49.
^{87}Se		86.92852	5.4 s	β- /7.28		5/2+			0.468(1)/100.
				n/					1.4979(1)/23.
^{88}Se		87.93142	1.5 s	β-, n/6.85		0+			0.5346/

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^{89}Se		88.9365	0.41 s	β-, n/9.0					
^{90}Se		89.9400	> 0.3 μs			0+			
^{91}Se		90.9460	0.27 s	β-, n/8.					
^{92}Se		91.950	> 0.3 μs			0+			
^{93}Se		92.956	> 0.3 μs						
^{94}Se		93.960	> 0.3 μs			0+			
$_{35}$Br		**79.904(1)**							
^{67}Br		66.9648							
^{68}Br		67.9585	< 1.5 μs						
^{69}Br		68.9501	< 0.024 μs	β+ /9.6					
^{70m}Br			2.2 s			9+			
^{70}Br		69.9446	~ 0.08 s	β+ /10.0	/0.75				
^{71}Br		70.939	21. s	β+ /6.9					
^{72}Br		71.9366	1.31 m	β+ /8.7		3	~ 0.55		0.4547−1.3167
^{73}Br		72.93169	3.4 m	β+ /4.7	3.7/	3/2-			ann.rad
									0.065−0.700
^{74m}Br			46. m	β+ /	4.5/	4-	1.82		ann.rad
									0.6348
									0.7285
									(0.2−4.38)
^{74}Br		73.92989	25.4 m	β+ /6.91					ann.rad
									0.6341
									0.6348
									(0.2−4.7)
^{75}Br		74.92578	1.62 h	β+ /76/3.03		3/2-	+0.75		ann.rad
									0.28650
									(0.1−1.56)
^{76m}Br			1.4 s	I.T./5.05		4+			0.104548
									0.05711
^{76}Br		75.92454	16.0 h	β+ /57/4.96	1.9/	1-	0.54821	0.270	ann.rad
					3.68/				0.55911
									1.85368
									(0.4−4.6)
^{77m}Br			4.3 m	I.T./0.1059		9/2+			0.1059
^{77}Br		76.921379	2.376 d	EC/99/1.365		3/2-	0.973	+0.53	ann.rad.
									0.23898
									0.52069
									(0.08−1.2)
^{78}Br		77.921146	6.45 m	β+ /92/3.574	1.2/	1+	0.13		ann.rad.
				EC/8/	2.5/				0.61363
									(0.7−3.0)
^{79m}Br			4.86 s	I.T./0.207		9/2+			0.2072
^{79}Br	50.69(7)	78.918337				3/2-	+2.106400	+0.331	
^{80m}Br			4.42 h	I.T./0.04885		5-	+1.3177	+0.75	Br k x-ray
									0.03705/39.1
									0.04885/0.3
^{80}Br		79.918529	17.66 m	β- /92/2.004	1.38 β-/7.6	1+	0.5140	0.196	ann.rad.
				EC/5.7/1.8706	1.99 β-/82				0.6169/6.7
				β+ /2.6/	0.85 β+ /2.8				(0.64−1.45)
^{81}Br	49.31(7)	80.916291				3/2-	+2.270562	+0.276	
^{82m}Br			6.1 m	I.T./98/0.046		2-			0.046/0.24
				β- /2 /3.139					(0.62−2.66)
^{82}Br		81.916804	1.471 d	β- /3.093	0.444/	5-	+1.6270	0.751	0.5544/71
									0.61905/43
									0.77649/84
									(0.013−1.96)
^{83}Br		82.915180	2.40 h	β- /0.972	0.395/1	3/2-			0.52964
					0.925/99				(0.12−0.68)

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^{84m}Br			6.0 m	β- /4.97	2.2/100	(6-)			0.4240/100
									0.8817/98
									1.4637/101
^{84}Br		83.91648	31.8 m	β- /4.65	2.70/11	2-	2.		0.8816/41
					3.81/20				1.8976/13
					4.63/34				(0.23−4.12)
^{85}Br		84.91561	2.87 m	β- /2.87	2.57	3/2-			0.80241/2.56
									0.92463/1.6
									(0.09−2.4)
^{86}Br		85.91880	55.5 s	β- /7.63	3.3	(2-)			1.56460/64
					7.4				2.75106/21
									(0.5−6.8)
^{87}Br		86.92071	55.6 s	β- /6.85	6.1/	3/2-			1.41983
				n/					1.4762
									(0.2−6.1)
^{88m}Br			5.1 μs						
^{88}Br		87.92407	16.3 s	β- /8.96		1-			0.7649
				n/					0.7753
									0.8021
									(0.1−6.99)
^{89}Br		88.92640	4.35 s	β- /8.16		3/2-			0.7753
				n/					1.0978
^{90}Br		89.9306	1.91 s	β- /10.4	8.3/	2-			0.6555
				n/	9.8/				0.7071
									1.3626
^{91}Br		90.9340	0.54 s	β- /90 /9.80					0.263
				β- n/10 /					0.803
^{92}Br		91.93926	0.31 s	β- /12.20					0.740
				β- n/					
^{93}Br		92.9431	0.10 s	β- /11					0.117
				β- n	//11				(0.237−3.606)
^{94}Br		93.9487	0.07 s	β- n/					
^{95}Br		94.9529	> 0.3 μs						
^{96}Br		95.959	> 0.3 μs						
^{97}Br		96.963	> 0.3 μs						
$_{36}$Kr		**83.798(2)**							
^{69}Kr		68.9652	0.03 s	β+, (p)	4.07/				
^{70}Kr		69.9553	0.06 s			0+			
^{71}Kr		70.950	100. ms	β+, EC/10.1					(0.198−0.207)
^{72}Kr		71.94209	17.1 s	β+ /5.0		0+			ann.rad
				EC/					0.3099/15.3
									0.4150/12.8
									(0.305 − 3.305)
^{73}Kr		72.93929	28. s	β+ /6.7		5/2-			ann.rad.
				EC/					0.1781/66
				β+, p/	/0.25				(0.06−0.86)
^{74}Kr		73.933084	11.5 m	β+ /3.1		0+			ann.rad.
				EC/					0.08970/31
									0.2030/20
									(0.010−1.06)
^{75}Kr		74.93095	4.3 m	β+ /4.90	3.2/	5/2+	-0.531	+1.1	ann.rad.
				EC/					0.1325/68
									0.1547/21
									(0.02−1.7)
^{76}Kr		75.925910	14.8 h	EC/1.31		0+			Br k x-ray
									0.270/21
									0.3158/39
									(0.03−1.07)

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($\hbar/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
^{77}Kr		76.924670	1.24 h	β+ /80/3.06		5/2+	-0.583	+0.9	ann.rad.
				EC/20/	1.55/				0.1297/80
					1.70/				0.1465/38
					1.87/				(0.02−2.3)
^{78}Kr	0.355(3)	77.920365	> 2.3 × 10^{20} y	EC-EC		0+			
^{79m}Kr			53. s	I.T./0.1299		7/2+	-0.786	+0.40	Kr x-ray
^{79}Kr		78.920082	1.455 d	β+ /7 /1.626		½-	+0.536		ann.rad.
				EC/93 /					0.2613/13
									0.39756/19
									0.6061/8
									(0.04−1.3)
^{80}Kr	2.286(10)	79.916379				0+			
^{81m}Kr			13.1 s	I.T./0.1904		½-	+0.586		0.1904
^{81}Kr		80.916592	2.1 × 10^{5} y	EC/0.2807		7/2+	-0.908	+0.63	Br k x-ray
									0.2760
^{82}Kr	11.593(31)	81.913484				0+			
^{83m}Kr			1.86 h	I.T./0.0416		½-	+0.591		Kr k x-ray
									0.00940
									0.03216
^{83}Kr	11.500(19)	82.914136				9/2+	-0.970699	+0.259	
^{84}Kr	56.987(15)	83.911507				0+			
^{85m}Kr			4.48 h	β- /79 /	0.83/79	½-	+ 0.633		0.30487
				I.T./21 /0.305					0.15118
^{85}Kr		84.912527	10.73 y	β- /0.687	0.15/0.4	9/2+	1.005	+0.43	0.51399
^{86}Kr	17.279(41)	85.9106107				0+			
^{87}Kr		86.9133549	1.27 h	β- /3.887	1.33/8	5/2+	-1.023	-0.30	0.40258/49.6
					3.49/43				2.5548/9.2
					3.89/30				(0.13−3.31)
^{88}Kr		87.91445	2.84 h	β- /2.91		0+			0.19632/26.
									2.392/34.6
									(0.03−2.8)
^{89}Kr		88.9176	3.15 m	β- /4.99	3.8/	5/2+	-0.330	+0.16	0.19746
					4.6/				0.2209/19.9
					4.9/				0.5858/16.4
									1.4728/6.8
									(0.2−4.7)
^{90}Kr		89.91952	32.3 s	β- /4.39	2.6/77	0+			0.12182/32.9
					2.8/6				0.5395/28.6
									1.1187/36.2
									(0.1−4.2)
^{91}Kr		90.9235	8.6 s	β- /6.4	4.33/	5/2+	-0.583	+0.30	0.10878/43.5
					4.59/				0.50658/19.
									(0.2−4.4)
^{92}Kr		91.92616	1.84 s	β- /5.99		0+			0.1424/66.
				n/					(0.14−3.7)
^{93}Kr		92.9313	1.29 s	β- /8.6	7.1/	½+	-0.413		0.1820
				n/					0.2534/42.
									0.32309/24.6
									(0.057−4.03)
^{94}Kr		93.9344	0.21 s	β- /7.3		0+			0.2196/67
				n	n//1.0				0.6293/100.
									(0.098−0.985)
^{95}Kr		94.9398	0.10 s	β- /9.7	n//2.9		- 0.410		
^{96}Kr		95.9431	~ 80 ms	β- ,n	n//3.7	0+			
^{97}Kr		96.9486	0.06 s	β- ,n	n//7.				
^{98}Kr		97.952	0.05 s	β- ,n	n//7.	0+			
^{99}Kr		98.958	0.04 s	β- ,n	n// ~ 11.				
^{100}Kr		99.9611	> 0.34 μs			0+			

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$_{37}$Rb		**85.4678(3)**							
^{71}Rb		70.9653							
^{72}Rb		71.9591	< 1.5 μs						
^{73}Rb		72.9506	< 0.03 μs						
^{74}Rb		73.944265	64.8 ms	β+ /10.4					0.456/0.0025
									(0.053 − 4.244)
^{75}Rb		74.93857	19. s	β+ /7.02	2.31/				ann.rad
									0.179
^{76}Rb		75.935072	39. s	β+ /8.50	4.7/	1-	-0.372623	+0.4	ann.rad
									0.4240/92.
									(0.064−1.68)
^{77}Rb		76.93041	3.8 m	β+ /5.34	3.86/	3/2-	+0.654468	+0.70	ann.rad
									0.0665/59
									(0.04−2.82)
^{78m}Rb			5.7 m	I.T./0.1034		4-	+2.549	+0.81	ann.rad
				β+ /	3.4				0.4553/81.
				EC/					(0.103−4.01)
^{78}Rb		77.92814	17.7 m	β+ /7.22		0+			ann.rad
				EC/					0.4553/63.
									(0.42−5.57)
^{79}Rb		78.92399	23. m	β+ /84/3.65		5/2+	+0.3358	-0.10	ann.rad.
				EC/16 /					0.68812/23.
									(0.017−3.02)
^{80}Rb		79.92252	34. s	β+ /5.72	4.1/22	1+	-0.0836	+0.35	ann.rad.
					4.7/74				0.6167/25.
^{81m}Rb			30.5 m	I.T./0.85	1.4	9/2+	+5.598	-0.74	ann.rad.
				β+, EC/					(0.085−1.9)
^{81}Rb		80.91900	4.57 h	β+ /27/2.24	1.05/	3/2-	+2.060	+0.40	ann.rad./
				EC/73					0.19030/64.
									(0.05−1.9)
^{82m}Rb			6.47 h	β+/26/	0.80/	5-	+1.5100	+1.0	ann.rad./
				EC/74/					0.5544/63.
									0.7765/85.
									(0.092−2.3)
^{82}Rb		81.918209	1.258 m	β+/96/4.40	3.3/	1+	+0.554508	+0.19	ann.rad./
				EC/4/					0.7665/13.
									(0.47−3.96)
^{83}Rb		82.91511	86.2 d	EC/0.91		5/2-	+1.425	+0.20	Kr x-ray
									0.5205/46.
									(0.03−0.80)
^{84m}Rb			20.3 m	I.T./0.216		6-	+0.2129	+0.6	0.2163/34.
									0.2482/63.
									0.4645/32.
^{84}Rb		83.914385	32.9 d	β+/22/2.681	0.780/11	2-	-1.32412	-0.015	ann.rad./
				EC/75 /	1.658/11				0.8817/68.
				β-/3/0.894	0.893/				(1.02−1.9)
^{85}Rb	72.17(2)	84.91178974				5/2-	+1.353	+0.23	
^{86m}Rb			1.018 m	I.T./0.5560		6-	+1.815	+0.37	0.556/98.
^{86}Rb		85.9111674	18.65 d	β-/1.775	1.774/8.8	2-	-1.6920	+0.19	1.0768/8.8
^{87}Rb	27.83(2)	86.90918053	4.88×10^{10} y	β-/0.283	0.273/100	3/2-	+2.7512	+0.13	
^{88}Rb		87.9113156	17.7 m	β-/5.316	5.31	2-	0.508		0.8980/14.4
									1.8360/22.8
									(0.34−4.85)
^{89}Rb		88.91228	15.4 m	β-/4.50	1.26/38	3/2-	+2.304	+0.14	1.032/58.
					1.9/5				1.248/42.
					2.2/34				2.1960/13
					4.49/18				(0.12−4.09)

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^{90m}Rb			4.3 m	β-/4.50	1.7/	4-	+1.616	+0.20	0.1069(IT)
					6.5/				0.8317/94
									(0.20−5.00)
^{90}Rb		89.91480	2.6 m	β-/6.59	6.6	1-			0.8317/28.
									(0.31−5.60)
^{91}Rb		90.91654	58.0 s	β-/5.861	5.9	3/2-	+2.182	+0.15	0.0936/34.
									(0.35−4.70)
^{92}Rb		91.91073	4.48 s	β-/8.11	8.1/94	1-			0.8148/8.
									(0.1−6.1)
^{93}Rb		92.92204	5.85 s	β-/7.46	7.4/	5/2-	+1.410	+0.18	0.2134/4.8
				n/1					0.4326/12.5
									0.9861/4.9
									(0.16−5.41)
^{94}Rb		93.92641	2.71 s	β-/10.31	9.5/	3	+1.498	+0.16	0.8369/87.
				n/10					1.5775/32.
									(0.12−6.35)
^{95}Rb		94.92930	0.377 s	β-/9.30	8.6/	5/2-	+1.334	+0.21	0.352/65.
				n/8					0.680/22.
									(0.20−2.27)
^{96m}Rb			1.7 μs						0.2999
									0.4612
									0.2400
									0.093−0.369
^{96}Rb		95.93427	0.199 s	β-/11.76	10.8/	2+	+1.466	+0.25	0.815/76.
				n/13/					(0.20−5.42)
^{97}Rb		96.93735	0.169 s	β-/10.42	10.0	3/2+	+1.841	+0.58	0.167/100.
				n/27/					0.585/79.
									0.599/56.
									1.258/52.
									(0.14−2.08)
^{98}Rb		97.94179	0.107 s	β-/12.34	0.144/				
				n/13					(0.07−3.68)
^{99}Rb		98.9454	59. ms	β-/11.3					
^{100}Rb		99.9499	53. ms	β- /13.5					0.129
									(0.058−4.483)
^{101}Rb		100.9532	0.03 s	β- /11.8					
^{102}Rb		101.9589	0.09 s	β-					
$_{38}$Sr		**87.62(1)**							
^{73}Sr		72.966	> 25 ms						
^{74}Sr		73.9563	> 1.5 μs			0+			
^{75}Sr		74.9499	88. ms	β+ ,p	p//5.				0.144/4.5
^{76}Sr		75.94177	7.9 s	β+ /6.1		0+			
^{77}Sr		76.93795	9.0 s	β+ /6.9	5.6		-0.35	+1.4	0.147
				β+, p	//0.08				
^{78}Sr		77.93218	2.7 m	β+ /3.76		0+			(0.047−0.793)
^{79}Sr		78.92971	2.1 m	β+ /5.32	4.1	3/2-	-0.474	+0.74	ann.rad./
									0.039/28.
									0.105/22.
									(0.135−0.612)
^{80}Sr		79.92452	1.77 h	β+ /1.87		0+			ann.rad./
									0.174/10.
									0.589/39.
									(0.24−0.55)
^{81}Sr		80.92321	22.3 m	β+ /87/3.93	2.43/	1/2-	+0.544		ann.rad./
				EC/13/	2.68/				0.148/31.
									0.1534/35
									(0.06−1.7)
^{82}Sr		81.91840	25.36 d	EC/0.18		0+			Rb x-ray

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^{83m}Sr			5.0 s	I.T./0.2591		½-	+0.582		0.2591/87.5
^{83}Sr		82.91756	1.350 d	β+/24/2.28	0.465/	7/2+	-0.898	+0.79	ann.rad./
				EC/76/	0.803/				0.3816/12.
					1.227/				0.3816
									0.7627/30.
									(0.094–2.15)
^{84}Sr	0.56(1)	83.913425				0+			
^{85m}Sr			1.127 h	I.T./87/0.2387		½-	+0.601		0.2318/84.
				EC/13					(0.15–0.24)
^{85}Sr		84.912933	64.85 d	EC/1.065		9/2+	-1.001	+0.30	0.51399/99.3
^{86}Sr	9.86(1)	85.909260				0+			
^{87m}Sr			2.81 h	I.T./0.3884		½-	+0.63		0.3884(IT)
^{87}Sr	7.00(1)	86.908877				9/2+	-1.093	+0.34	
^{88}Sr	82.58(1)	87.905612				0+			
^{89}Sr		88.907451	50.52 d	β-/1.497	1.492/100	5/2+	-1.149	-0.3	0.9092
^{90}Sr		89.907738	29.1 y	β-/0.546	0.546/100	0+			
^{91}Sr		90.910203	9.5 h	β-/2.70	0.61/7	5/2+	-0.887	+0.044	0.5556/61.
					1.09/33				0.7498/24.
					1.36/29				1.0243/33.
					2.66/26				(0.12–2.4)
^{92}Sr		91.911038	2.71 h	β-/1.91	0.55/96	0+			1.3831/90.
					1.5/3				(0.24–1.1)
^{93}Sr		92.91403	7.4 m	β-/4.08	2.2/10	5/2+	-0.794	+0.26	0.5903/
					2.6/25				0.7104
					3.2/65				0.87573
									0.8883/
									(0.17–3.97)
^{94}Sr		93.91536	1.25 m	β-/3.511	2.1/	0+			0.6219
					3.3/				0.7043
									0.7241
									0.8064
									1.4283
^{95}Sr		94.91936	25.1 s	β-/6.08		½+	-0.5379		0.6859
					6.1/50				0.8269
									2.7173
									2.9332
^{96}Sr		95.92170	1.06 s	β-/5.37	4.2/	0+			0.1222
									0.5305
									0.8094
									0.9318
^{97}Sr		96.92615	0.42 s	β-/7.47	5.3	(1/2+)	-0.500		0.2164
									0.3071
									0.6522
									0.9538
									1.2580
									1.9050
^{98}Sr		97.92845	0.65 s	β-/5.83	5.1	0+			0.0365
									0.1190
									0.4286
									0.4447
									0.5636
^{99}Sr		98.9332	0.27 s	β-/8.0			-0.26	0.8	
^{100}Sr		99.9354	0.201 s	β-/7.1		0+			
^{101}Sr		100.9405	0.115 s	β-/9.5					
^{102}Sr		101.9430	68. ms	β-/8.8		0+			
^{103}Sr		102.9490	> 0.3 μs						
^{104}Sr		103.952	> 0.3 μs			0+			
^{105}Sr		104.959	> 0.3 μs						

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$_{39}$**Y**		**88.90585(2)**							
^{76}Y		75.9585	> 0.2 μs						
^{77}Y		76.9497	~ 57. ms						
^{78m}Y			5.8 s			(5+)			
^{78}Y		77.9436	53 ms	β+/10.5					0.279/100
									0.504/90
									0.713/40
^{79}Y		78.9374	15. s	β+/7.1					(0.152−1.106)
^{80m}Y			4.8 s						0.2285
^{80}Y		79.9343	30. s	β+/7.0	5.5	(4-)			ann.rad./
					5.0/				0.3858/100
									0.5951/42
									0.756−1.396
^{81}Y		80.9291	1.21 m	β+/5.5	3.7/				ann.rad./
					4.2/				0.428
									0.469
^{82}Y		81.9268	9.5 s	β+/7.8	6.3/	1+			ann.rad./
									0.5736
									0.6017
									0.7375
^{83m}Y			2.85 m	β+/95/4.6	2.9	1/2-			ann.rad./
				EC/5 /					0.2591
									0.4218
									0.4945
^{83}Y		82.92235	7.1 m	β+/4.47	3.3	9/2+			ann.rad./
				EC/					0.0355
									0.4899
									0.8821
									(0.03−3.4)
^{84m}Y			4.6 s	β+/		1+			ann.rad./
				EC/					0.7930
^{84}Y		83.9204	40. m	β+/6.4	1.64/47	5-			ann.rad./
				EC/	2.24/25				0.4628
					2.64/21				0.6606
					3.15/7				0.7931
									0.9744
									1.0398
									(0.2−3.3)
^{85m}Y			4.9 h	β+/70/		9/2+	6.2		ann.rad./
				EC/30/					0.2317
									0.5356
									2.1238
									(0.1−3.1)
									0.7673
^{85}Y		84.91643	2.6 h	β+/55/3.26	1.54/	1/2-			ann.rad./
				EC/45/					0.2317
									0.5045
									0.9140
									(0.07−1.4)
^{86m}Y			48. m	I.T./99/		8+	4.8		ann.rad./
				β+/					0.0102(IT)
				EC/					0.2080
									(0.09−1.1)
^{86}Y		85.91489	14.74 h	β+/5.24		4-	<0.6		ann.rad./
				EC/					0.3070
									0.6277
									1.0766
									1.1531

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									1.9207
									(0.1−3.8)
^{87m}Y			13. h	I.T./98/		9/2+	6.1		0.3807
				β+/0.7/	1.15/0.7				
				EC/					
^{87}Y		86.910876	3.35 d	EC/99+/1.862	0.78/	1/2-			0.3880
									0.4870
^{88}Y		87.909501	106.6 d	EC/99+/3.623	0.76/	4-			ann.rad./
				β+/0.2/					0.89802
									1.83601
									2.73404
									3.2190
^{89m}Y			15.7 s	I.T./0.909		9/2+			0.9092(IT)
^{89}Y	100.	88.905848				1/2-	-0.13742		
^{90m}Y			3.24 h	I.T./99+/	0.68204	7+	5.1		0.2025
				β-/0.002/					0.4794
									0.6820
^{90}Y		89.907152	2.67 d	β-/2.282	2.28/	2-	-1.630	-0.155	
^{91m}Y			49.7 m	I.T./0.555		9/2+	5.96		0.5556(IT)
^{91}Y		90.907305	58.5 d	β-/1.544	1.545/	1/2-	0.1641		1.208
^{92}Y		91.90895	3.54 h	β-/3.63	3.64/	2-			0.4485
									0.5611
									0.9345
									1.4054
									(0.4−3.3)
^{93m}Y			0.82 s	I.T./0.759		9/2+			0.1686(IT)
									0.5902
^{93}Y		92.90958	10.2 h	β-/2.87	2.88/90	1/2-			0.2669
									0.9471
									1.9178
^{94m}Y			1.4 μs						0.4322
									0.7699
									1.2024
^{94}Y		93.91160	18.7 m	β-/4.919	4.92/	2-			0.3816
									0.9188
									1.1389
									(0.3−4.1)
^{95}Y		94.91282	10.3 m	β-/4.42		1/2-			0.4324
									0.9542
									2.1760
									3.5770
^{96m}Y			9.6 s	β-/		(3+)			0.1467
									0.6174
									0.9150
									1.1071
									1.7507
^{96}Y		95.91589	6.2 s	β- /7.09	7.12/	0-			1.594
^{97m}Y			1.21 s	β- /7.4	4.8/	9/2+			0.1614
					6.0/				0.9700
									1.1030
^{97}Y		96.91813	3.76 s	β- /6.69	6.7	1/2-			0.2969
									1.9960
									3.2876
									3.4013
^{98m}Y			2.1 s	β- /9.8	5.5/	(4-)			0.2415
									0.6205
									0.6473
									1.2228
									1.8016
^{98}Y		97.92220	0.59 s	β- /8.83	8.7/	1+			0.2131

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									1.2228
									1.5907
									2.9413
									4.4501
^{99m}Y			0.011 ms						
^{99}Y		98.92464	1.47 s	β- /7.57		1/2-			0.1218/43.8
				n	/2.5/				0.5362
									0.7242
									1.0130
^{100m}Y			0.94 s	β-, n /		3+			
^{100}Y		99.9278	0.73 s	β-, n/9.3	n/1.8/	1+			
^{101}Y		100.9303	0.43 s	β-, n/8.6	n/1.5/	(5/2+)			
^{102}Y		101.9336	0.36 s	β-, n/9.9	n/4.0/				
^{103}Y		102.9367	0.23 s	β-, n	n/8.3/				
^{104}Y		103.9411	0.18 s						
^{105}Y		104.9449	> 0.15 μs						
^{106}Y		105.950	> 0.15 μs						
^{107}Y		106.9414	> 0.15 μs						
^{108}Y		107.959	> 0.15 μs						
$_{40}$Zr		91.224(2)							
^{78}Zr		77.9552	> 0.2 μs			0+			
^{79}Zr		78.9492	0.06 s						
^{80}Zr		79.940	~ 4.5 s	β+ /8.0		0+			0.290
									0.538
^{81}Zr		80.9372	5.3 s	β+ /7.2	6.1	(3/2-)			
^{82}Zr		81.9311	32. s	β+ /4.0	3.	0+			ann.rad./
^{83m}Zr			7. s	β+ /7.0		(7/2+)			ann.rad./
^{83}Zr		82.9287	44. s	β+ /5.9	4.8	(1/2-)			ann.rad./
				EC					0.0556
									0.1050
									0.2560
									0.474
									1.525
^{84}Zr		83.9233	26. m	β+ /2.7		0+			ann.rad./
				EC/					0.0449
									0.1125
									0.3729
									0.667
^{85m}Zr			10.9 s	I.T./0.2922		½-			ann.rad./
				β+, EC/					0.2922(IT)
									0.4165
^{85}Zr		84.9215	7.9 m	β+ /4.7	3.1	7/2+			ann.rad./
				EC/					0.2663
									0.4163
									0.4543
^{86}Zr		85.91647	16.5 h	EC/1.47		0+			0.0280
									0.243
									0.612
^{87m}Zr			14.0 s	I.T./0.3362		½-	+ 0.64		0.1352(IT)
									0.2010
^{87}Zr		86.91482	1.73 h	β+ /3.67	2.26	9/2+	- 0.895	+ 0.42	ann.rad./
				EC/					0.3811
									1.228
^{88m}Zr			1.4 μs			(8+)			0.077
^{88}Zr		87.91023	83.4 d	EC/0.67		0+			0.3929
^{89m}Zr			4.18 m	I.T./94/0.5877		½-	+ 0.80		ann.rad./
				β+ /1.5/					0.5877(IT)
				EC/4.7/					1.507

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
^{89}Zr		88.908889	3.27 d	β+ /23/2.832	0.9/	9/2+	-1.05	+ 0.28	ann.rad./
				EC/77/					0.9092
^{90m}Zr			0.809 s	I.T./		5-	6.3		0.1326
									2.1862
									2.3189(IT)
^{90}Zr	51.45(40)	89.904704				0+			
^{91}Zr	11.22(5)	90.905646				5/2+	-1.30362	-0.18	
^{92}Zr	17.15(8)	91.905041				0+			
^{93}Zr		92.906476	1.5×10^6 y	β- /0.091		5/2+			0.0304
^{94}Zr	17.38(28)	93.906315	$>10^{17}$ y	β-β-		0+			
^{95}Zr		94.908043	64.02 d	β- /1.125	0.366/55	5/2+	1.13	+0.29	0.7242
					0.400/44				0.7567
^{96}Zr	2.80(9)	95.908273	3×10^{19} y	β-β-		0+			
			$>1.7 \times 10^{18}$ y	β-					
^{97}Zr		96.910953	16.75 h	β- /2.658	1.91/	½-	- 0.937		0.7434
^{98}Zr		97.91274	30.7 s	β- /2.26	2.2/100	0+			
^{99}Zr		98.91651	2.2 s	β- /4.56	3.9/	½+	- 0.930		0.4692/55.2
					3.5/				0.5459/48
									0.028−1.321
^{100}Zr		99.91776	7.1 s	β- /3.34		0+			0.4006
									0.5043
^{101}Zr		100.92114	2.1 s	β- /5.49	6.2/	3/2-	- 0.27	+ 0.81	0.1194
									0.2057
									0.2089
^{102}Zr		101.92298	2.9 s	β- /4.61		0+			
^{103}Zr		102.9266	1.3 s	β- /7.0					
^{104}Zr		103.9288	1.2 s	β- /5.9		0+			
^{105}Zr		104.9331	~ 1. s	β- /8.5					
^{106}Zr		105.9359	> 0.24 μs			0+			
^{107}Zr		106.9408	> 0.24 μs						
^{108}Zr		107.944	> 0.15 μs			0+			
^{109}Zr		108.9492	> 0.15 μs						
^{110}Zr		109.953	> 0.15 μs			0+			
$_{41}$Nb		**92.90638(2)**							
^{81}Nb		80.949	<0.08 μs						
^{82}Nb		81.9431	50 ms	β+ /11.					
^{83}Nb		82.9367	4.1 s	β+ /7.5					
^{84}Nb		83.9336	10. s	β+, EC/9.6		(3+)			0.540
									(0.456-1.427)
^{85m}Nb			3. s						0.069
^{85}Nb		84.9279	21. s	β+ /6.0					
^{86m}Nb			56. s	β+					
^{86}Nb		85.9250	1.46 m	β+ /8.0					ann.rad./
									0.751
									1.003
^{87m}Nb			3.7 m	β+ /		1/2-			ann.rad./
				EC/					0.1352
									0.2010
^{87}Nb		86.92036	2.6 m	β+ /5.2/		(9/2+)			ann.rad./
				EC/					0.2010
									0.4706
									0.6165
									1.0665
									1.8842
^{88m}Nb			7.7 m	β+ /		4-			ann.rad./
				EC/					0.2625
									0.3996
									1.0569

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									1.0825
^{88}Nb		87.9183	14.3 m	β+ /7.6	3.2/	8+			ann.rad./
				EC/					1.0570
									1.0828
									(0.07−2.5)
^{89m}Nb			2.0 h	β+ /	3.3/	9/2+			0.5880/10(D)
				EC/					(0.17−4.0)
^{89}Nb		88.91342	1.10 h	β+ /74/4.29	2.8/	1/2-	+6.216		ann.rad./
				EC/26 /					0.5074
									0.5880
									0.7696
									1.2775
^{90m}Nb			18.8 s	I.T./0.1246		4-			0.002
									0.1225
^{90}Nb		89.911265	14.6 h	β/53 /6.111	0.86/5	8+	4.961		ann.rad./
				EC/47 /	1.5/92				0.1412
									1.1292
									2.1862
									2.3189
									(0.1−3.3)
^{91m}Nb			62. d	I.T./97 /		1/2-			0.1045(IT)
				EC/3 /					1.2050
^{91}Nb		90.906996	7×10^2 y	EC/1.253		9/2+			Mo k x-ray
^{92m}Nb			10.13 d	EC/99+/		2+	6.114		0.9126
									0.9345
									1.8475
^{92}Nb		91.907194	3.7×10^7 y	EC/2.006		7+			0.5611
									0.9345
^{93m}Nb			16.1 y	I.T./0.0304		1/2-			Nb x-ray
									0.0304
^{93}Nb	100.	92.906378				9/2+	+6.1705	-0.32	
^{94m}Nb			6.26 m	I.T./99+	/2.086	3+			Nb k x-ray
				β- /0.5/					0.0409
									0.87109
^{94}Nb		93.907284	2.4×10^4 y	β- /2.045	0.47/	6+			0.70263
									0.87109
^{95m}Nb			3.61 d	I.T./97.5/	0.2357	1/2-			0.2040
				β- /2.5 /					0.2356
^{95}Nb		94.906836	34.97 d	β- /0.926	0.160/	9/2+	6.141		0.76578
^{96}Nb		95.908101	23.4 h	β- /3.187	0.5/10	6+	4.976		0.7782
					0.75/90				0.2191−1.498
^{97m}Nb			58.1 s	I.T./0.7434	0.734/98	1/2-			0.7434
^{97}Nb		96.908099	1.23 h	β- /1.934	1.27/98	9/2+	6.15		0.4809
									0.6579
^{98m}Nb			51. m	β- /4.67		5+			0.7874
									0.1726−1.89
^{98}Nb		97.91033	2.9 s	β- /4.59	4.6/	1+			0.6451
									0.7874
									1.0243
^{99m}Nb			2.6 m	β- /	3.2/	1/2-			0.0978/100
									(0.138−3.010)
^{99}Nb		98.91162	15.0 s	β- /3.64	3.5/100	9/2+			0.0977
									0.1378/3.1
^{100m2}Nb			0.013 ms						
^{100m1}Nb			3.0 s	β- /6.74	5.8				Nb k x-ray
									0.159
									0.6364
									1.0637
^{100}Nb		99.91418	1.5 s	β- /6.25	6.2/				0.5354
					5.3/				0.6001−1.566

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^{101}Nb		100.91525	7.1 s	β- /4.57	4.3/				0.1105–0.810
^{102m}Nb			4.3 s	β- /					
^{102}Nb		101.91804	1.3 s	β- /7.21	7.2/				0.2960–2.184
^{103}Nb		102.9191	1.5 s	β- /5.53	5.3/	5/2+			
^{104m}Nb			0.9 s	β-, n/	n/0.06				
^{104}Nb		103.9225	4.8 s	β-, n/8.1	n/0.05				
^{105}Nb		104.9239	3.0 s	β-, n/6.5	n/1.7				
^{106}Nb		105.9280	1.0 s	β-, n/9.3	n/4.5				
^{107}Nb		106.9303	0.30 s	β-, n/7.9	n/6.0				
^{108}Nb		107.9348	0.19 s	β, n/	n/6.2				(0.193–0.590)
^{109}Nb		108.9376	0.19 s	β, n/	n/31				
^{110}Nb		109.9424	0.17 s	β, n/	n/40				
^{111}Nb		110.9457	> 0.15 μs						
^{112}Nb		111.951	> 0.15 μs						
^{113}Nb		112.955	> 0.15 μs						
$_{42}$Mo		**95.94(2)**							
^{83}Mo		82.9487	~ 6. ms						
^{84}Mo		83.9401	~ 3.7 s	β+ /6.		0+			
^{85}Mo		84.9366	3.2 s	β+/8.1		½+			
^{86}Mo		85.9307	19. s	β+ /4.8		0+			
^{87}Mo		86.9273	14. s	EC, β+/6.5					(0.752–1.004)
^{88}Mo		87.92195	8.0 m	β+ /3.4		0+	+0.5		ann.rad./
				EC					0.0800
									0.1399
									0.1707
^{89m}Mo			0.19 s	I.T./0.118		½-			0.118(IT)
									0.268
^{89}Mo		88.91948	2.2 m	β+ /5.58		9/2+			ann.rad./
				EC/					0.659
									0.803
									1.155
									1.272
^{90m}Mo			1.2 μs						0.063
^{90}Mo		89.91394	5.7 h	β+ /25/2.489	1.085/	0+			ann.rad./
				EC/75 /					0.04274
									0.12237
									0.25734
^{91m}Mo			1.08 m	I.T./50/0.653		½-			ann.rad./
				β+, EC/50 /	2.5/				0.6529
					2.8/				1.2081
					4.0/				1.5080
									2.2407
^{91}Mo		90.91175	15.5 m	β+ /94/4.43	3.44/94	9/2-			ann.rad./
				EC/6/					1.6373
									2.6321
									3.0286
									(0.1–4.2)
^{92}Mo	14.77(31)	91.906811	> 3 × 10^{17} y	β+-EC		0+			
^{93m}Mo			6.9 h	I.T./99+ /2.425		21/2+	+9.21		0.26306(IT)
									0.68461
									1.47711
^{93}Mo		92.906813	3.5 × 10^{3} y	EC/0.405		5/2+			0.0304
^{94}Mo	9.23(10)	93.905088				0+			
^{95}Mo	15.90(9)	94.905842				5/2+	-0.9142	-0.02	
^{96}Mo	16.68(1)	95.904680				0+			
^{97}Mo	9.56(5)	96.906022				5/2+	-0.9335	+0.26	
^{98}Mo	24.19(26)	97.905408				0+			
^{99}Mo		98.907712	2.7476 d	β- /1.357	0.45/14	½+	0.375		0.144048

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					0.84/2				0.18109
					1.21/84				0.36644
									0.73947
^{100}Mo	9.67(20)	99.90748	~1 × 10^{19} y	β-β-		0+			
^{101}Mo		100.91035	14.6 m	β- /2.82	2.23/	1/2+			0.0063
					0.7/				0.19193
									0.5909
									(0.0809−2.405)
^{102}Mo		101.91030	11.3 m	β- /1.01	1.2/	0+			0.1493/89.
									0.2116/100.
									0.2243/32.
^{103}Mo		102.9132	1.13 m	β- /3.8		3/2+			0.1028(2)/
									0.1440(2)
									0.2511(2)
^{104}Mo		103.9138	1.00 m	β- /2.16		0+			0.0686(1)/100.
									0.4239(4)/21.
^{105}Mo		104.9170	36. s	β- /4.95		3/2+			0.0642/
									0.0856/
									0.2495/
^{106}Mo		105.91814	8.4 s	β- /3.52		0+			0.1894(2)/22.
									0.3644(2)/6.
									0.3723(2)/12.
^{107}Mo		106.9217	3.5 s	β- /6.2					
^{108}Mo		107.9235	1.1 s	β- /5.1		0+			(0.028−0.636)
^{109}Mo		108.9278	0.5 s	β- /7.2					
^{110}Mo		109.9297	0.27 s	β- /5.7		0+			Tc k x-ray
									0.142
									(0.039−0.599)
^{111}Mo		110.9344	> 0.15 μs						
^{112}Mo		111.937	> 0.15 μs			0+			
^{113}Mo		112.942	> 0.15 μs						
^{114}Mo		113.945	> 0.15 μs			0+			
^{115}Mo		114.950	> 0.15 μs						
^{116}Mo			> 0.15 μs			0+			
^{117}Mo			> 0.15 μs						
$_{43}$Tc									
^{85}Tc		84.9488	< 0.1 ms						
^{86}Tc		85.9429	0.05 s	β+ /11.9					
^{87}Tc		86.9365	2.4 s	β+ /8.6					
^{88}Tc		87.9327	5.8 s	β+ /10.1					
^{89m}Tc			13. s						
^{89}Tc		88.9272	13. s	β+ /7.5					
^{90m}Tc			49.2 s	β^+	5.3/	6+			ann.rad./
									0.9479/
									1.0542/
^{90}Tc		89.9236	8.3 s	β+ /8.9	7.0/15	1+			ann.rad./
					7.9/95.				0.9479/
^{91m}Tc			3.3 m	β+		½+			ann.rad./170.
				EC					0.8110(5)/5.
									1.6052(1)/7.8
									1.6339(1)/9.1
									1.9023(1)/6.
									2.4509(1)/13.5
^{91}Tc		90.9184	3.14 m	β+ /6.2	5.2	9/2+			ann.rad./200.
^{92}Tc		91.91526	4.4 m	β+ /7.87	4.1	8+			ann.rad./200.
				EC					0.0850/
									0.1475
									0.3293

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									0.7731
									1.5096
^{93m}Tc			43. m	I.T./13		½-			0.3924(IT)
				EC/20					0.9437
									2.6445
^{93}Tc		92.910249	2.73 h	β+ /13/3.201	0.81	9/2+	6.26		ann.rad./
				EC/87/					1.3629
									1.4771
									1.5203
									(0.1−3.0)
^{94m}Tc			52. m	β+ /72/4.33		2+			ann.rad./
				EC/28/					0.8710
									1.8686
^{94}Tc		93.909657	4.88 h	β+ /11/4.256		7+	5.08		ann.rad./
				EC/89/					0.4491
									0.7026
									0.8496
									0.8710
^{95m}Tc			61. d	I.T./4/		1/2-			ann.rad./
				β+ /0.3	0.5/				0.0389(IT)
				EC/96	0.7/				0.2041
									0.5821
									0.5821
									0.8351
^{95}Tc		94.90766	20.0 h	EC/100/1.691		9/2+	5.89		0.7657
									1.0738
^{96m}Tc			52. m	I.T./90/		4+			0.0342(IT)
				β+, EC/2/					0.7782
									1.2002
^{96}Tc		95.90787	4.3 d	EC/2.973		7+	+5.04		Mo k x-ray
									0.7782
									0.8125
									0.8498
									1.12168
^{97m}Tc			91. d	I.T./0.0965		1/2-			Tc k x-ray
				EC	/3.9				0.0965
^{97}Tc		96.906365	4.2×10^6 y	EC/100/0.320		9/2+			Mo k x-ray
^{98}Tc		97.907216	~ 6.6×10^6 y	β- /1.80	0.40/100	6+			0.65241
									0.74535
^{99m}Tc			6.01 h	I.T./100/0.142		1/2-			Tc k x-ray
									0.14049
									0.14261
^{99}Tc		98.906255	2.13×10^5 y	β- /0.294	0.293/100	9/2+	+5.6847	-0.129	
^{100}Tc		99.907658	15.8 s	β- /3.202	2.2/	1+			0.5396
				EC /1.8(10)$^{-3}$/	2.9/				0.5908
					3.3				(0.3 79−2.30)
^{101}Tc		100.90732	14.2 m	β- /1.61	1.32/	9/2+			0.1272
									0.1841
									0.3068
									0.5451
									(0.073−0.969)
^{102m}Tc			4.4 m	I.T./2/4.8	1.8/				0.4184
				β- /98/					0.4752
									0.6281
									0.6302
									1.0464
									1.1033
									1.6163
									2.2447
^{102}Tc		101.90922	5.3 s	β- /4.53	3.4/	1+			0.4686

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
					4.2				0.4751
					2.2/				1.1055
^{103}Tc		102.90918	54. s	β- /2.66	2.0/	5/2+			0.1361
					2.2/				0.1743
									0.2104
									0.3464
									0.5629
									(0.13−1.0)
^{104m}Tc			0.005 ms						
^{104}Tc		103.91145	18.2 m	β- /5.60	5.3/	(3+)			0.3483
									0.3580
									0.5305
									0.5351
									0.8844
									0.8931
									1.6768
									(0.3−3.7)
^{105}Tc		104.9117	7.6 m	β- /3.6	3.4/	5/2+			0.1079
									0.1432
									0.3215
^{106}Tc		105.91436	36. s	β- /6.55		2+			0.2703
									0.5222
									1.9694
									2.2393
									2.7893
^{107}Tc		106.9151	21.2 s	β- /4.8					0.1027
									0.1063
									0.1770
									0.4587
^{108}Tc		107.9185	5.1 s	β- /7.72		(3)			0.2422
									0.4656
									0.7078
									0.7326
									1.5835
^{109}Tc		108.9200	1.4 s	β- /6.3	p/0.08				
^{110}Tc		109.9238	0.83 s	β- /8.8	p/0.04				0.2407
^{111}Tc		110.9257	0.30 s	β- .n/7.0	n/0.85				0.150/92.7
									0.063−1.435
^{112}Tc		111.9292	0.26 s	β, n	n/2.6				
^{113}Tc		112.9316	0.15 s	β-, n/8.	/2.1				0.0985/100
									0.0658−1.520
^{114}Tc		113.936	0.15 s	β-, n	/1.3				
^{115}Tc		114.939	> 0.15 μs						
^{116}Tc		115.943	> 0.15 μs						
^{117}Tc		116.946	> 0.15 μs						
^{118}Tc		117.951	> 0.15 μs						
$_{44}$Ru		**101.07(2)**							
^{87}Ru		86.949	> 1.5 μs						
^{88}Ru		87.9403	1.2 s			0^+			
^{89}Ru		88.9361	1.4 s	β+ .p/8.					
^{90}Ru		89.9299	12. s	β+ /5.9		0^+			ann.rad./
									0.155−1.551
^{91}Ru		90.9263	7.9 s	β+, EC/7.4		9/2+			ann.rad./
									(0.205-1.998)
^{92}Ru		91.9201	3.7 m	β+ /53/4.5		0+			ann.rad./
				EC/47/					0.1346
									0.2138
									0.2593

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
^{93m}Ru			10.8 s	I.T./21/		1/2-			ann.rad./
				β+, EC/79/	5.3/				0.7344
									1.1112
									1.3962
									2.0931
^{93}Ru		92.9171	1.0 m	β+ /6.3		9/2+			ann.rad./
				EC/					0.6807
									1.4349
									(0.5−4.2)weak
^{94}Ru		93.91136	52. m	EC/100/1.59		0+			0.3672
									0.5247
									0.8922
^{95}Ru		94.91041	1.64 h	EC/85/2.57	1.20/	5/2+	0.86		ann.rad./
				β+ /15/	0.91/				0.3364
									0.6268
									0.036−2.424
^{96}Ru	5.54(14)	95.90760	> 3.1×10^{16} y	β+β+		0+			
^{97}Ru		96.90756	2.89 d	EC/1.12		5/2+	-0.78		Tc k x-ray
									0.2157
									0.3245
									0.4606
^{98}Ru	1.87(3)	97.90529				0+			
^{99}Ru	12.76(14)	98.905939				5/2+	-0.6413	+0.079	
^{100}Ru	12.60(7)	99.904220				0+			
^{101}Ru	17.06(2)	100.905582				5/2+	-0.7188	+0.46	
^{102}Ru	31.55(14)	101.904349				0+			
^{103}Ru		102.906324	39.27 d	β- /0.763	0.223	3/2+	0.206	+0.62	0.05329
									0.29498
									0.4438
									0.49708
									0.55704
									0.61033
									(0.04−1.6)
^{104}Ru	18.62(27)	103.905433				0+			
^{105}Ru		104.907753	4.44 h	β- /1.917	1.11/22	3/2+	-0.3		0.12968
					1.134/13				0.1491
					1.187/49				0.2629
									0.31664
									0.46943
									0.67634
									0.72420
									(0.1−1.8)
^{106}Ru		105.90733	1.020 y	β- /0.0394	0.0394/100	0+			
^{107}Ru		106.9099	3.8 m	β- /2.9	2.1/				0.1939
					3.2/				0.3741
									0.4625
									0.8488
^{108}Ru		107.9102	4.5 m	β- /1.4	1.2/	0^+			0.0923
									0.1651
									0.4339
									0.4975
									0.6189
^{109}Ru		108.9132	34.5 s	β- /4.2					0.1164
									0.3584
^{110}Ru		109.9141	15. s	β- /2.81		0+			0.1121
									0.3737
									0.4397
									0.7967
^{111}Ru		110.9177	1.5 s	β- /5.5					
^{112}Ru		111.9190	4.5 s	β- /4.5		0+			

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
^{113m}Ru			0.6 s						
^{113}Ru		112.9225	0.80 s	β- /7.					0.2632
									0.048−2.418
^{114}Ru		113.9243	0.57 s	β- /6.1		0+			0.127/24
									(0.053−0.180)
^{115}Ru		114.9287	~ 0.74 s	β- /8.					
^{116}Ru		115.931	> 0.15 μs			0+			
^{117}Ru		116.936	> 0.15 μs						
^{118}Ru		117.938	> 0.15 μs			0+			
^{119}Ru		118.943	> 0.15 μs						
^{120}Ru		119.945	> 0.15 μs			0+			
$_{45}$Rh		**102.90550(2)**							
^{89}Rh		88.9488	> 0.15 μs						
^{90m}Rh			~ 12. ms						
^{90}Rh		89.9429	1.0 s						
^{91m}Rh			1.5 s	IT					0.387
^{91}Rh		90.9366	1.5 s						(0.438-0.973)
^{92m}Rh			0.5 s						0.866
^{92}Rh		91.9320	4.7 s	β+ /11.1					(0.163-0.991)
^{93}Rh		92.9257	12. s	β+ /8.1					(0.138−1.493)
^{94m}Rh			25.8 s	β+ /		8+			ann.rad./
									0.1264
									0.3117
									0.7562
									1.0752
									1.4307
^{94}Rh		93.9217	1.18 m	β+ /9.6	6.4/	3+			ann.rad./
									0.1461
									0.3117
									0.7562
									1.4307
^{95m}Rh			1.96 m	I.T./88/		½+			ann.rad./
				β+, EC/12/					0.5433(IT)
									0.7837
^{95}Rh		94.9159	5.0 m	β+ /5.1	3.2	9/2+			ann.rad./
									0.2293
									0.4103
									0.6610
									0.9416
									1.3520
									(0.2−3.8)
^{96m}Rh			1.51 m	I.T./60/0.052		2+			ann.rad./
				β+, EC/40/	4.70/				Tc,Ru x-rays
									0.8326
									1.0985
									1.6921
									(0.4−3.3)
^{96}Rh		95.91446	9.6 m	β+/6.45	3.3/	5+			ann.rad./
				EC/					0.4299
									0.6315
									0.6853
									0.7418
									0.8326
									(0.2−3.4)
^{97m}Rh			46. m	I.T./5 /	2.6/	1/2-			ann.rad./
				β+, EC/95/					0.1886
									0.4215
									2.2452

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^{97}Rh		96.91134	31.0 m	β+ /3.52	2.1/	9/2+			ann.rad./
									0.1886
									0.3892
									0.4515
									0.8398
									0.8788
									(0.2−3.5)
^{98m}Rh			3.5 m	β+ /		5+			ann.rad./
									0.6154
									0.6524
									0.7452
^{98}Rh		97.91071	8.7 m	β+ /90/5.06	3.4/	2+			ann.rad./
									0.6524
									0.7623
^{99m}Rh			4.7 h	β+ /8/	.74/	9/2+	5.67		ann.rad./
				EC/92/					0.2766/
									0.3408
									0.6178
									1.2612
^{99}Rh		98.90813	16. d	β+/4/2.10	0.54/	1/2-			ann.rad./
				EC/97/	0.68/				0.0894/
									0.3530
									0.5277
									(0.1−2.0)
^{100m}Rh			4.7 m	I.T./99/		5+			ann.rad./
				β+ /0.4/					0.0748/
									0.2647(IT)
^{100}Rh		99.90812	20.8 h	β+ /3.63	2.62/	1-			0.4462
				EC/	2.07/				0.5396
									0.5882
									0.8225
									1.5534
									2.3761
^{101m}Rh			4.35 d	EC/92/		9/2+	+5.51		Rh k x-ray
				I.T./8/0.1573					0.1272/
									0.3069
									0.5451
^{101}Rh		100.90616	3.3 y	EC/0.54		1/2-			Ru k x-ray
									0.1272
									0.1980
									0.3252
^{102m}Rh			3.74 y	EC/2.323		6^+	4.04		0.4751
				IT/0.0419					0.6313
			> 1.2 × 10^6 y	β^+	/<0.00025				0.6975
									0.7668
									1.0466
									1.1032
^{102}Rh		101.906843	207. d	EC/62			0.5		ann.rad./
				β- /19/					0.4686
				β+ /14/					0.4751
									0.5566
									0.6280
									1.1032
									(0.4−1.6)
^{103m}Rh			56.12 m	IT		7/2+	4.54		
^{103}Rh	100.	102.905504				1/2-	-0.0884		
^{104m}Rh			4.36 m	I.T./99+ /		5+			Rh k x-ray
				β^-	1.3/				0.0514
									0.0971
									0.5558

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^{104}Rh		103.906656	42.3 s	β-/99+/2.441	1.88/2	1+			0.3581
				EC/0.4/1.141	2.44/98				0.5558
									1.2370
									(0.35−1.8)
^{105m}Rh			43. s	I.T./1.296		1/2-			Rh k x-ray
									0.1296
^{105}Rh		104.905694	35.4 h	β- /0.567	0.247/30	7/2+	+4.45		0.2801
					0.567/70				0.3061
									0.3189
^{106m}Rh			2.18 h	β- /	0.92/	6+			0.2217
									0.4510
									0.5119
									0.6162
									0.7173
									0.7484
									1.0458
									1.5277
^{106}Rh		105.90729	29.9 s	β- /3.54	2.4/2	1+	+2.58		0.51186/
					3.0/12				0.61612
					3.54/79				0.62187
									(0.05−3.04)
^{107}Rh		106.90675	21.7 m	β- /1.51	1.20/65	7/2+			0.2776
					1.5/17				0.3028
									0.3925
^{108m}Rh			6.0 m	β- /	1.57/				0.4339
									0.4973
									0.6189
^{108}Rh		107.9087	17. s	β- /4.5		1+			0.4046
									0.4339
									0.4973
									0.5811
									0.6146
									0.9014
									0.9471
^{109}Rh		108.90874	1.34 m	β- /2.59	2.25/	7/2+			0.1134
									0.1780
									0.2914
									0.3254
									0.3268
									0.4261
									(0.1−1.6)
^{110m}Rh			29. s	β- /	6/				0.3737
									0.4397
									0.7967
^{110}Rh		109.91114	3.1 s	β- /5.4	5.5/	1+			0.3737
									0.4400
									0.5463
									0.6877
									0.8381
									0.9045
^{111}Rh		110.91159	11. s	β- /3.7					0.275
^{112m}Rh			6.8 s	β- /					
^{112}Rh		111.9144	3.5 s	β- /6.2		1+			0.3489
^{113}Rh		112.91553	0.9 s	β- /4.9					0.1285
^{114m}Rh			1.9 s	β- /					(0.103-1.923)
^{114}Rh		113.9188	1.8 s	β- /6.5		1+			(0.276-0.783)
^{115}Rh		114.9203	0.99 s	β- /6.0					
^{116m}Rh			0.9 s	β- /					0.3405
^{116}Rh		115.9241	0.7 s	β- /8.0		1+			0.340
									0.398−1.665

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^{117}Rh		116.9260	0.44 s	β- /7.					0.0346
									0.1317
^{118}Rh		117.9301	~ 0.30 ms						0.379
									0.575
									0.370−1.037
^{119}Rh		118.932	0.17 s						
^{120}Rh		119.936	0.12 s						
^{121}Rh		120.939	> 0.15 μs						
^{122}Rh		121.943							
$_{46}$Pd		**106.42(1)**							
^{91}Pd		90.949	> 1.5 μs						
^{92}Pd		91.9404	1.0 s			0+			
^{93}Pd		92.9359	1.2 s	β+, p		9/2+			0.240/81
									0.382−0.864
^{94}Pd		93.9288	9. s	EC, β+ /~ 6.6		0+			0.5582
									(0.0546−0.798)
^{95m}Pd		94.92684	13.4 s	EC, β+ /10.2		21/2+			
^{95}Pd		94.9247							
^{96}Pd		95.9182	2.03 m	EC, β+ /3.5	1.15/	0+			0.1248
									0.4995
^{97}Pd		96.9165	3.1 m	β+, EC/4.8	3.5/	5/2+			ann.rad./
									0.2653
									0.4752
									0.7927
									(0.2−3.4)
^{98}Pd		97.91272	17.7 m	β+ /1.87		0+			ann.rad./
				EC/					0.0677
									0.1125
									0.6630
									0.8379
^{99}Pd		98.91177	21.4 m	β+ /49/3.37	2.18/	5/2+			ann.rad./
				EC/51/					0.1360
									0.2636
									0.6734
									(0.2−2.85)
^{100}Pd		99.90851	3.7 d	EC/0.36		0+			0.03271
									0.0748
									0.0840
^{101}Pd		100.90829	8.4 h	β+ /5/1.980	0.776/	5/2+	-0.66		ann.rad./
				EC/95/					0.0244
									0.2963
									0.5904
^{102}Pd	1.02(1)	101.905609				0+			
^{103}Pd		102.906087	16.99 d	EC/0.543		5/2+			Rh k x-ray
									0.03975
									0.3575
									0.4971
^{104}Pd	11.14(8)	103.904036				0+			
^{105}Pd	22.33(8)	104.905085				5/2+	-0.642	+0.66	
^{106}Pd	27.33(3)	105.903486				0+			
^{107m}Pd			20.9 s	I.T./0.2149		11/2-			Pd k x-ray
									0.2149(IT)
^{107}Pd		106.905133	6.5×10^6 y	β- /0.033	0.03/	5/2+			
^{108}Pd	26.46(9)	107.903893				0+			
^{109m}Pd			4.75 m	I.T./0.1889		11/2-			Pd x-ray
									0.1889(IT)
^{109}Pd		108.905950	13.5 h	β- /1.116	1.028	5/2+			0.0880
									(0.08−1.0)

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^{110}Pd	11.72(9)	109.905153				0+			
^{111m}Pd			5.5 h	I.T./73/0.172		11/2-			0.0704
				β- /27/	0.35				0.1722
					0.77				0.3912
									(0.1−1.97)
^{111}Pd		110.90767	23.4 m	β- /2.19	2.2/95	5/2+			0.0598
									0.2454
									0.5800
									0.6504
									1.3885
									1.4590
^{112}Pd		111.90731	21.04 h	β- /0.29	0.28/	0+			0.018
^{113m}Pd			1.48 m	β- /		5/2+			0.0959
^{113}Pd		112.91015	1.64 m	β- /3.34					0.0958
									0.4824
									0.6436
									0.7394
^{114}Pd		113.91036	2.48 m	β- /1.45		0+			0.1266
									0.2320
									0.5582
									0.5760
^{115m}Pd			50. s			(9/2-)			0.089
^{115}Pd		114.9137	25. s	β- /4.58		(3/2+)			0.1255
									0.2554
									0.3428
^{116}Pd		115.9142	12.7 s	β- /2.61		0+			0.1015
									0.1147
									0.1778
^{117m}Pd			19. ms			(9/2-)			0.203
^{117}Pd		116.9178	4.4 s	β- /5.7		(3/2+)			0.2473
									0.077−0.403
^{118}Pd		117.9190	2.4 s	β- /4.1		0+			0.1254
									0.028−0.596
^{119}Pd		118.9231	0.9 s	β- /6.5					0.2566
									0.070−0.326
^{120}Pd		119.9247	0.5 s	β- /5.0		0+			0.1581
									0.053−0.595
^{121}Pd		120.9289	> 0.24 μs						
^{122}Pd		121.9306	> 0.24 μs			0+			
^{123}Pd		122.935	> 0.15 μs						
^{124}Pd		123.9369				0+			
$_{47}$Ag		**107.8682(2)**							
^{93}Ag		92.950							
^{94m}Ag			0.41 s	β+	p/0.79/1.9				(0.096-1.092)
				β+,p/27.	p/1.01/2.2				
^{94}Ag		93.9428	0.60 s	β+					(0.659-0.905)
				β+,p/20.					
^{95}Ag		94.9355	2.0 s	β+, p/					(0.089−2.940)
^{96m}Ag			4.4 s	β^+		8+			
				β+, p	/8.				
^{96}Ag		95.9307	7. s	β+ /11.6		2+			ann.rad./
				EC/					0.1248
				β+, p	/18.				0.4995
									(0.1066−1.416)
^{97}Ag		96.9240	19. s	β+ /7.0					ann.rad./
				EC/					0.6862
									1.2941
									(0.352−3.294)

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
^{98}Ag		97.9216	47.6 s	β+ /8.4		5+			ann.rad./
				EC/	/36.				0.5711
				β+, p	/0.11				0.6786
									0.8631
									(0.153−1.185)
^{99m}Ag			11. s	I.T./100/		½-			Ag k x-ray
									0.1636(IT)
									0.3426
^{99}Ag		98.9176	2.07 m	β+ /87 5.4		9/2+			ann.rad./
				EC/13/					0.2199
									0.2645
									0.8056
									0.8323
									(0.2−3.5)
^{100m}Ag			2.3 m	β+ /		2+			ann.rad./
				EC/					0.6657
									1.6941
^{100}Ag		99.9161	2.0 m	β+/7.1	4.7/	5+			ann.rad./
				EC/					0.2807
									0.4503
									0.6657
									0.7508
									0.7732
^{101m}Ag			3.1 s	I.T./0.23		½-			Ag k x-ray
									0.0981
									0.176(IT)
^{101}Ag		100.9128	11.1 m	β+ /69/4.2	2.7/	9/2+	5.7		ann.rad./
				EC/31/					0.2610
					2.18/				0.2747
					2.73/				0.3269
					3.38/				0.4392
									0.6673
									1.1739
									(0.2−3.1)
^{102m}Ag			7.8 m	β+ /38/	3.4	2+	+4.14		ann.rad./
				EC/13/					0.5567
				I.T./49/					0.9777
									1.8347
									2.0545
									2.1594
									3.2386
^{102}Ag		101.91169	13.0 m	β+ /78/5.92	2.26/	5+	4.6		ann.rad./
				EC/22/					0.5564
									0.7193
									0.163−2.242
^{103m}Ag			5.7 s	I.T./0.134		1/2-			Ag k x-ray
									0.1344
^{103}Ag		102.90897	1.10 h	β+ /28/2.69	1.7	7/2+	+4.47		ann.rad./
				EC/72/	1.3				0.1187
									0.1482
^{104m}Ag			33. m	β+ /64/	2.71/	2+	+3.7		ann.rad./
				EC/36/					0.5558
				I.T./0.07/					0.7657
									(0.5−3.4)
^{104}Ag		103.90863	69. m	β+ /16/4.28	0.99/	5+	3.92		ann.rad./
				EC/84/					0.5558
									0.9259
									0.9416
									(0.18−2.27)
^{105m}Ag			7.2 m	I.T./98/0.0255		7/2+	+4.41		Ag x-ray

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
				EC/2 /					0.3063
									0.3192
									(0.1−1.0)
^{105}Ag		104.90653	41.3 d	EC/1.35		1/2-	0.1014		0.0640
									0.2804
									0.3445
									0.4434
^{106m}Ag			8.4 d	EC/		6+	3.71	+1.1	Pd k x-ray
									0.4510
									0.5118
									0.7173
									1.0458
^{106}Ag		105.90667	24.0 m	β+ /59/2.965	/1.96	1+	+2.85		ann.rad./
				EC/41 /					0.5119
^{107m}Ag			44.2 s	I.T./0.093		7/2+	+4.40	1.0	Ag x-ray
									0.0931
^{107}Ag	51.839(8)	106.905097				1/2-	-0.11357		
^{108m}Ag			418. y	EC/92/		6+	3.580	+1.3	Ag k x-ray
				I.T./8 /0.079					Pd k x-ray
									0.43392
									0.61427
									0.72290
^{108}Ag		107.905956	2.39 m	β- /97/1.65	1.02/1.7	1+	+2.6884		ann.rad./
				EC/2/	1.65/96				0.43392
				β- /1/1.92	0.88/0.3				0.61885
									0.63298
^{109m}Ag			39.8 s	I.T./0.088		7/2+	+4.40	+1.0	Ag k x-ray
									0.0880
^{109}Ag	48.161(8)	108.904752				1/2-	-0.13069		
^{110m}Ag			249.8 d	β- /99/	0.087	6+	+3.60	+1.4	0.65774
				I.T./1 /0.1164	0.530				0.76393
									0.88467
									0.93748
									1.38427
									(0.447−1.56)
^{110}Ag		109.906107	24.6 s	β- /2.892	2.22/5	1+	+2.7271	0.2	0.65774
					2.89/95				0.8154
									1.1257
^{111m}Ag			1.08 m	IT/99/0.0598		7/2+			Ag k x-ray
				β- /1/					0.0598
									0.2454
^{111}Ag		110.905294	7.47 d	β- /1.037	1.035/	1/2-	-0.146		0.2454
									0.3421
^{112}Ag		111.90701	3.13 h	β- /3.96	3.94/	2-	0.0547		0.6067
					3.4				0.6174
									1.3877
									(0.4−2.9)
^{113m}Ag			1.14 m	I.T./80 /0.043		7/2+			0.1422
				β- /20 /	1.5				0.2983
									0.3161
									0.3923
^{113}Ag		112.90657	5.3 h	β- /2.02	2.01/	1/2-	0.159		0.2588
									0.2986
^{114}Ag		113.90880	4.6 s	β- /5.08	4.9/	1+			0.5582
									0.5760
									1.9946
^{115m}Ag			18.7 s	β- /		7/2+			0.1134
									0.1315
									0.2288
									0.3887

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
^{115}Ag		114.90876	20. m	β- /3.10		1/2-			0.1316
									0.2128
									0.2291
									0.4727
									(0.13−2.49)
^{116m2}Ag			20. s	β-,IT/7	IT/0.0479				
^{116m}Ag			9.8 s	β-/92 /	3.2/	5+			0.5134
					2.9				0.7055
				I.T./8	IT/.0809				0.255−2.838
^{116}Ag		115.91136	2.68 m	β- /6.16	5.3	2-			0.5134
									0.6993
									2.4779
^{117m}Ag			5.3 s	β- /	3.2/	7/2+			0.1354
									0.2981
									0.3868
									0.1571
^{117}Ag		116.91168	1.22 m	β- /4.18	2.3	1/2-			0.1354
									0.3377
^{118m}Ag			2.8 s	β- /59/					0.1277
				I.T./41 /0.1277					0.4878
									0.6771
									0.7709
									(0.190-2.778)
^{118}Ag		117.9146	4.0 s	β- /7.1					0.4878
									0.6771
									3.2259
^{119}Ag		118.9157	2.1 s	β- /5.35		7/2+			0.0674
									0.3662
									0.3991
									0.6264
^{120m}Ag			0.40 s	β- /63.					0.2030
				I.T./37.					0.5059
									0.6978
									0.8300
									(0.115-1.644)
^{120}Ag		119.9188	1.23 s	β- /8.2					0.5059
				β-,n	n//<0.0030%				0.6978
									0.8171
									(0.442-3.044)
^{121}Ag		120.9199	0.78 s	β- /6.4					0.1150
									0.3148
									0.3537
									0.3696
									0.5007
									1.5105
									(0.11−2.5)
^{122m}Ag			1. s	β- /					
^{122}Ag		121.9235	0.44 s	β- /9.2					
^{123}Ag		122.9249	0.31 s	β- /7.4					
^{124}Ag		123.9286	0.22 s	β- /10.1					
^{125}Ag		124.9304	0.17 s	β-					
^{126}Ag		125.9345	0.11 s	β-					
^{127}Ag		126.9368	0.11 s	β-					
^{128}Ag		127.9412	58 ms	β-					
^{129m}Ag			0.16 s						
^{129}Ag		128.9437	~ 46. ms	β-, n					
^{130}Ag		129.9505	~ 35 ms						
$_{48}$Cd		**112.411(8)**							

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
^{95}Cd		94.950							
^{96}Cd		95.9398				0+			
^{97}Cd		96.9349	3. s	β+, (p)					
^{98}Cd		97.9274	9.2 s	β+ /5.4		0+			
				(p)	/0.025				
^{99}Cd		98.9250	16. s	β+, EC/6.9					ann.rad./
^{100}Cd		99.9203	1.1 m	β+, EC/3.9		0+			ann.rad./
									(0.090−1.043)
^{101}Cd		100.9187	1.2 m	β+ /83/5.5	4.5	5/2+			In k x-ray
				EC/17/					0.0985
									1.7225
									0.31−2.84)
^{102}Cd		101.91446	5.8 m	β+ /27/2.59		0+			ann.rad./
				EC/73					0.0974
									0.4810
									1.0366
									1.3598
^{103}Cd		102.91342	7.5 m	β+ /33/4.14		5/2+	-0.81	-0.8	ann.rad./
				EC/67/					Ag k x-ray
									1.0799
									1.4487
									1.4618
									(0.1−2.8)
^{104}Cd		103.90985	58. m	EC/1.14		0+			Ag k x-ray
									0.0835
									0.7093
^{105}Cd		104.90947	55.5 m	β+ /26/2.739	1.69/	5/2+	-0.7393	+0.43	Ag k x-ray
				EC/74/					0.3469
									0.6072
									0.9618
									1.3025
									(0.25−2.4)
^{106}Cd	1.25(6)	105.90646	> 5.8×10^{17} y	EC, EC		0+			
^{107}Cd		106.90662	6.52 h	EC/99+/1.417		5/2+	-0.615055	+0.68	Ag k x-ray
				β+ /					0.0931
									0.8289
^{108}Cd	0.89(3)	107.90418	>4.1×10^{17} y	EC EC		0+			
^{109}Cd		108.904982	462.0 d	EC/0.214		5/2+	-0.827846	+0.69	Ag k x-ray
									0.08804
^{110}Cd	12.49(18)	109.903002				0+			
^{111m}Cd			48.5 m	I.T./		11/2-			Cd k x-ray
									0.1508(IT)
									0.2454
^{111}Cd	12.80(12)	110.904178				1/2+	-0.594886		
^{112}Cd	24.13(21)	111.902758				0+			
^{113m}Cd			14.1 y	β- /99.9/0.59	0.59/99.9	11/2-	-1.087	-0.71	0.2637
^{113}Cd	12.22(12)	112.904402	8.2×10^{15} y	β-		1/2+	-0.622301		
^{114}Cd	28.73(42)	113.903359	>6.0×10^{17} y	β-β-		0+			
^{115m}Cd			44.6 d	β- /1.629	0.68/1.6	11/2-	-1.042	-0.54	0.48450
					1.62/97				0.93381
									1.29064
^{115}Cd		114.905431	2.228 d	β- /1.446	0.593/42	1/2+	-0.648426		0.23141
					1.11/58				0.26085
									0.33624
									0.49227
									0.52780
^{116}Cd	7.49(18)	115.904756	3.8×10^{19} y	β·β·		0+			
^{117m}Cd			3.4 h	β- /2.66	0.72/	11/2-			0.1586
									0.5529
									0.37−2.42

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
^{117}Cd		116.907219	2.49 h	β- /2.52	0.67/51	1/2+			0.2209
					2.2/10				0.2733
									0.3445
									1.3033
^{118}Cd		117.90692	50.3 m	β- /0.52		0+			
^{119m}Cd			2.20 m	β- /		11/2-			0.1056
									0.7208
									1.0250
									2.0213
^{119}Cd		118.9099	2.69 m	β- /3.8	~ 3.5/	1/2+			0.1340
									0.2929
									0.3429
^{120}Cd		119.90985	50.8 s	β- /1.76	1.5/	0+			
^{121m}Cd			8. s	β- /		11/2-			0.1008
									0.9878
									1.0209
									1.1815
									2.0594
^{121}Cd		120.9130	13.5 s	β- /4.9		(3/2+)			0.2102
									0.3242
									0.3492
									1.0403
^{122}Cd		121.91333	5.3 s	β- /3.0		0+			
^{123m}Cd			1.9 s	β- /					
^{123}Cd		122.91700	2.09 s	β- /6.12		3+			
^{124}Cd		123.9177	1.24 s	β- /4.17		0+			0.0365
									0.0628
									0.1799
^{125m}Cd			0.66 s	β- /					
^{125}Cd		124.9213	0.68 s	β- /7.16		3/2+			
^{126}Cd		125.9224	0.52 s	β- /5.49		0+			0.2601
^{127}Cd		126.9264	0.4 s	β- /8.5		3/2+			
^{128}Cd		127.9278	0.28 s	β- /7.1		0+			0.247
^{129}Cd		128.9322	0.24 s	β- /5.9					0.281
^{130}Cd		129.9339	0.162 s	β- /		0+			
				β-, n	/~ 3.5				
^{131}Cd		130.9407	68 ms						
^{132}Cd		131.9456	0.10 s	β-, n/	/60	0+			
^{133}Cd			0.06 s						
$_{49}$In		**114.818(3)**							
^{97}In		96.950							
^{98m}In			~ 0.03 s						
^{98}In		97.9421	1. s						
^{99}In		98.9342	~ 3.8 s	β+ /8.9					
^{100}In		99.9311	5.9 s	β+, (p)/10.5					(0.297-1.365)
^{101}In		100.9263	15. s	β+ /7.3					
^{102}In		101.9241	23. s	EC/8.9		(5)			0.1566
									0.7767
									(0.397−0.923)
^{103m}In			34. s						
^{103}In		102.91991	1.1 m	β+, EC/6.05	4.2	9/2+			ann.rad./
				EC	/45				0.1879
									(0.157−3.98)
^{104m}In			16. s	IT/0.0935					
^{104}In		103.9183	1.84 m	β+, EC/7.9	4.8	5+	+4.44	+0.7	ann.rad./
									0.6580
									0.8341
									0.8781

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
^{105m}In			43. s	I.T.		½-			In k x-ray
									0.6740
^{105}In		104.91467	5.1 m	β+, EC/4.85	3.7	9/2+	+5.675	+0.83	0.1310
									0.2600
									0.6038
^{106m}In			5.3 m	β+ /85/	4.90	3+			ann.rad./
				EC/15/					0.6326
									0.8611
									1.7164
^{106}In		105.91347	6.2 m	β+ /65/6.52	2.6	7+	+4.92	+0.97	ann.rad./
				EC/35/					0.2259
									0.6327
									0.8611
									0.9978
									1.0091
^{107m}In			51. s	I.T./0.6786		½-			In k x-ray
									0.6785
^{107}In		106.91030	32.4 m	β+ /35/3.43	2.20/	9/2+	+5.59	+0.81	ann.rad./
				E.C/65/					Cd k x-ray
									0.2050
									0.3209
									0.5055
									(0.2−2.99)
^{108m}In			57. m	β+ /53/	1.3	6+	+4.94	+0.47	ann.rad./
				EC/47/					Cd k x-ray
									0.6329
									1.9863
									3.4522
^{108}In		107.90970	40. m	β+ /33/5.15	3.49/	3+	+4.56	+1.01	ann.rad./
				EC/67/					Cd k x-ray
									0.2429
									0.6331
									0.8756
^{109m}In			1.3 m	I.T./0.650		½-			In k x-ray
									0.6498
^{109}In		108.90715	4.17 h	β+ /8/2.02	0.79/	9/2+	+5.54	+0.84	ann.rad./
				EC/92/					Cd k x-ray
									0.2035
									0.6235
^{110m}In			4.9 h	EC/		7+	+4.72	+1.00	Cd k x-ray
									0.6577
									0.8847
									0.9375
									(0.1−1.98)
^{110}In		109.90717	1.15 h	β+ /62/3.88	2.22/	2+	+4.37	+0.35	ann.rad./
				EC/38/					Cd k x-ray
									0.6577
									(0.6−3.6)
^{111m}In			7.7 m	I.T./0.537		½-	+5.53		In k x-ray
									0.537
^{111}In		110.905103	2.8049 d	EC/0.866		9/2+	+5.50	+0.80	Cd k x-ray
									0.1712
									0.2453
^{112m}In			20.8 m	I.T./0.155		4+			In k x-ray
									0.1555
^{112}In		111.90553	14.4 m	β+ /22/2.586		1+	+2.82	+0.09	ann.rad./
				EC/34/					Cd k x-ray
				β- /0.663					0.6171
^{113m}In			1.658 h	I.T./0.3917		½-	-0.210		In k x-ray
									0.3917

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
^{113}In	4.29(5)	112.904058				9/2+	+5.529	+0.80	
^{114m}In			49.51 d	I.T./97/0.190		5+	+4.65	+0.74	In k x-ray
				EC/3 /					0.19027
^{114}In		113.904914	1.198 m	β- /97/1.989	1.984/	1+	+2.82		Cd k x-ray
				EC/3/1.453					0.5584
									0.5727
									1.2998
^{115m}In			4.486 h	I.T./95/0.336		½-	-0.255		In k x-ray
				β- /5 /0.83					0.3362
									0.4974
^{115}In	95.71(5)	114.903878	4.4×10^{14} y	β- /0.495		9/2+	+5.541	+0.81	
^{116m2}In			2.16 s	I.T./0.162		8-	+3.22	+0.31	In k x-ray
				EC	/0.023				0.1624
^{116m1}In			54.1 m	β- /	1.0	5+	+4.43	+0.80	0.13792
									0.41688/27
									1.09723/58.5
									1.29349/85
^{116}In		115.905260	14.1 s	β- /3.274	3.3/99	1+	2.788	0.11	0.46313
									1.2526
									1.29349
^{117m}In			1.94 h	β- /53/1.769	1.77/	½-	-0.2517		In k x-ray
				I.T./47 /					0.15855
									0.31531
									0.55294
^{117}In		116.90451	44. m	β- /1.455	0.74/	9/2+	+5.52	+0.83	0.15855
									0.3966
									0.55294
^{118m2}In			8.5 s	I.T./98/		(8-)	+3.32	+0.44	In k x-ray
				β- /2/					0.1382
^{118m1}In			4.40 m	β- /	1.3	5+	+4.23	+0.80	0.2086
					2.0				0.6833
									1.2295
^{118}In		117.90635	5.0 s	β- /4.42	4.2/	1+			0.5282
									1.1734
									1.2295
									2.0432
^{119m}In			17.9 m	β- /97/	2.7/	½-	-0.32		0.3114
				I.T./3/0.311					0.7631
^{119}In		118.90585	2.3 m	β- /2.36	1.6/	9/2+	+5.52	+0.85	0.0239
									0.6495
									0.7631
									1.2149
^{120m2}In			47 s	β- /6.1		8-	+3.692	+0.53	1.171
									1.023
^{120m1}In			46. s	β- /5.8	2.2/	5+	+4.30	+0.81	1.171
									1.023
^{120}In		119.90796	3.1 s	β- /5.37	5.6/	(1+)			0.4146
					3.1/				0.5924
									0.8637
									1.0232
									1.1714
									(0.4–2.7)
^{121m}In			3.8 m	β- /99/	3.7/	1/2-	-0.36		0.0601
				I.T./1/0.313					0.3136
									0.9256
									1.0412
									1.1022
									1.1204
^{121}In		120.90785	23. s	β- /3.36	2.5	9/2+	+5.50	+0.81	0.2620
									0.6573

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									0.9256
^{122m}In			10. s	β- /	4.4/	8-	+3.78	+0.59	1.0014
									1.1403
^{122}In		121.91028	1.5 s	β- /6.37	5.3/	(1+)			0.2391
									1.0014
									1.1403
									1.164
									1.1903
^{123m}In			47. s	β- /	4.6/	(1/2-)	-0.40		0.1258
									1.170
									3.234
^{123}In		122.91044	6.0 s	β- /4.39	3.3/	(9/2+)	+5.49	+0.76	0.6188
									1.0197
									1.1305
^{124m}In			3.4 s	β-		8-	+3.89	+0.66	0.1029
									0.9699
									1.0729
									1.1316
^{124}In		123.91318	3.18 s	β- /7.36	5/	3+	+4.04	+0.61	0.7070
									0.9978
									1.1316
									3.2142
									(0.3−4.6)
^{125m}In			12.2 s	β- /	5.5/	1/2-	-0.43		0.1876
^{125}In		124.91360	2.33 s	β- /5.42	4.1/	9/2+	+5.50	+0.71	0.4260
									1.0318
									1.3350
^{126m}In			1.53 s		4.9/	3+	+4.03	+0.49	0.9086
									0.9696
									1.1411
^{126}In		125.91646	1.63 s	β- /8.21	4.2/	8-	+4.06		0.1118
									0.9086
									1.1411
^{127m}In			3.73 s	β- /	6.4/	(1/2-)			0.2523
									3.074
^{127}In		126.91735	1.14 s	β- /6.51	4.9/	(9/2+)	+5.52	+0.59	0.4680
									0.6461
									0.8051
									1.5977
^{128m}In			0.7 s	β- /	5.4/	(8-)			1.8670
									1.9739
									(0.1205−2.12)
^{128}In		127.92017	0.80 s	β- /8.98	5.0/	3+			0.9352
									1.1688
									3.5198
									4.2970
^{129m}In			1.23 s	β- /98/	~ 7.5/	1/2-			0.3153
				n/2/					0.9067
									1.2220
^{129}In		128.9217	0.63 s	β- /7.66	5.5/	9/2+			0.2853
									0.7693
									1.8650
									2.1180
^{130m2}In			0.53 s	β- /	8.8/	5+			0.0892
									0.7744
									1.2212
^{130m1}In			0.51 s	β- /	6.1/	10-			0.0892
									0.1298
									0.7744
									1.2212

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									1.9052
^{130}In		129.92497	0.29 s	β- /10.25	10.0/	1-			
^{131m2}In			0.3 s	β- /		(21/2+)			
^{131m1}In			0.35 s	β- /		(1/2-)			
^{131}In		130.92685	0.28 s	β- /9.18	6.4/	(9/2+)			0.3328
									2.433
^{132}In		131.9330	~ 0.206 s	β- /13.6	6.0/	(7-)			0.1320
					8.8/				0.2992
									0.3747
									4.0406
^{133}In		132.9378	0.165 s	β-, (n)					
^{134}In		133.9442	0.14 s						(0.354−2.005)
^{135}In		134.9493	0.09 s						
$_{50}$Sn		**118.710(7)**							
^{99}Sn		98.949							
^{100}Sn		99.939	1.0 s	β+ /7.3	3.4/	0+			
^{101}Sn		100.9361	3. s	β+ /9.					
^{102}Sn		101.9303	3.8 s	β+ /5.8		0+			
^{103}Sn		102.9281	7. s	β+ /7.7					1.3558
				β+,p	p//1.2				(0.351-2.813)
				EC	/ 20.				
^{104}Sn		103.9231	21. s	β+, EC/4.5		0+			
^{105}Sn		104.9214	28. s	β+ /6.3					In-x-ray
									(0.2879−3.819)
^{106}Sn		105.91688	2.0 m	β+ /20/3.18		0+			ann.rad./
				EC/80/					In k x-ray
									0.3865
									0.4772
^{107}Sn		106.9156	2.92 m	EC/5.0	1.2/				0.4218
				β+ /					0.6105
									0.6785
									1.0013
									1.1290
									1.542
^{108}Sn		107.91193	10.3 m	β+ /1/2.09	0.36/	0+			In k x-ray
				EC/99/					0.2724
									0.3965
									(0.105−1.68)
^{109}Sn		108.91128	18.0 m	β+ /9/3.85	1.52/	7/2+	-1.08	+0.3	ann.rad./
				EC/91/					In k x-ray
									0.6498
									1.0992
^{110}Sn		109.90784	4.17 h	EC/0.64		0+			In k x-ray
									0.283
^{111}Sn		110.90773	35. m	β+ /31/2.45	1.5/	7/2+	+0.61	+0.2	In k x-ray
				EC/69/					0.7620
									1.1530
									1.9147
^{112}Sn	0.97(1)	111.904818				0+			
^{113m}Sn			21.4 m	I.T./92/0.077		7/2+			Sn k x-ray
				EC/8/					In x-ray
									0.0774
^{113}Sn		112.905171	115.1 d	EC/1.036		½+	-0.879		In k x-ray
									0.25511
									0.39169
^{114}Sn	0.66(1)	113.902779				0+			
^{115}Sn	0.34(1)	114.903342				½+	-0.9188		
^{116}Sn	14.54(9)	115.901741				0+			

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^{117m}Sn			14.0 d	I.T./0.3146		11/2-	-1.396	-0.4	Sn k x-ray
									0.15856
^{117}Sn	7.68(7)	116.902952				½+	-1.0010		
^{118}Sn	24.22(9)	117.901603				0+			
^{119m}Sn			293. d	I.T./0.0896		11/2-	-1.4	0.21	Sn k x-ray
									0.02387
^{119}Sn	8.59(4)	118.903308				½+	-1.0473		
^{120}Sn	32.58(9)	119.902195				0+			
^{121m}Sn			44. y	I.T./78/0.006		11/2-	-1.388	-0.14	Sn k x-ray
				β- /22/	0.354/				0.03715
^{121}Sn		120.904236	1.128 d	β- /0.388	0.383/100	3/2+	0.698	-0.02	
^{122}Sn	4.63(3)	121.903439				0+			
^{123m}Sn			40.1 m	β- /1.428	1.26/99	3/2+			0.1603
									0.3814
^{123}Sn		122.905721	129.2 d	β- /1.404	1.42/99.4	11/2-	-1.370	+0.03	0.1603
									1.0302
									1.0886
^{124}Sn	5.79(5)	123.905274	> 2.2 × 10^{18} y	β-β-		0+			
^{125m}Sn			9.51 m	β- /2.387	2.03/98	3/2+	+0.764	+0.8	0.3321
									1.4040
^{125}Sn		124.907784	9.63 d	β- /2.364	2.35/82	11/2-	-1.35	+0.1	1.0671
									(0.2−2.3)
^{126}Sn		125.90765	2.34 × 10^{5} y	β- /0.38	0.25/100	0+			0.0643
									0.0876
									0.4148
									0.6663
									0.6950
^{127m}Sn			4.15 m	β- /3.21	2.72/	3/2+	+0.757	+0.60	0.4909
									1.3480
									1.5640
^{127}Sn		126.91036	2.12 h	β- /3.20	2.42/	11/2-	-1.33	+0.3	0.8231
					3.2/				1.0956
									(0.120−2.84)
^{128m}Sn			6.5 s	IT/0.091		(7-)			
^{128}Sn		127.91054	59.1 m	β- /1.27	0.48/	0+			0.4823
					0.63/				0.5573
									0.6805
^{129m}Sn			6.9 m	β- /		11/2-	-1.30	-0.2	1.1611
^{129}Sn		128.91348	2.4 m	β- /4.0		3/2+	+0.754	+0.05	0.6456
^{130m}Sn			1.7 m	β- /		(7-)	-0.381	-0.4	0.1449
									0.8992
^{130}Sn		129.91397	3.7 m	β- /2.15	1.10/	0+			0.0700
									0.1925
									0.7798
^{131m}Sn			1.02 m	β- /	3.4/	11/2-	-1.28	+0.02	0.3043
									0.4500
									0.7985
									1.2260
									(0.08−3.21)
^{131}Sn		130.91700	39. s	β- /4.69	3.8/	3/2+	+0.747	-0.04	see ^{131m}Sn
^{132}Sn		131.91782	40. s	β- /3.12	1.8/	0+			0.0855
									0.2467
									0.3402
									0.8985
^{133}Sn		132.92383	1.44 s	β- /7.8	7.5/	7/2-			
^{134}Sn		133.9283	1.04 s	β- /6.8		0+			(0.053-2.417)
^{135}Sn		134.9347	0.53 s	β-					(0.053-0.830)
				β-,n	/21.				0.733−1.855
^{136}Sn		135.9393	0.25 s	β-, n	/30.	0+			
^{137}Sn		136.946	0.19 s	β-, n	/~ 58				

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^{138}Sn			0.15 s			0+			
$_{51}$Sb		**121.760(1)**							
^{103}Sb		102.9397	> 1.5 μs						
^{104}Sb		103.9365	0.5 s						
^{105}Sb		104.9315	1.1 s	β+,p	p//<0.1				
^{106}Sb		105.9288	0.6 s	β+ /10.5					
^{107}Sb		106.9242	4.0 s	β+ /7.9					1.280
									0.1515
									0.6666
									0.553−2.046
^{108}Sb		107.9222	7.0 s	β+ /9.5					(0.151−1.280)
^{109}Sb		108.91813	17.3 s	β+ /6.38	4.42/	5/2+			0.925
				EC/	4.67/				1.062
					4.33/				0.261−2.127
^{110}Sb		109.9168	24. s	β+ /9.0	6.8/	3+			ann.rad./
				EC/					0.6365
									0.9847
									1.2117
									1.2433
^{111}Sb		110.91316	1.25 m	β+ /87/4.47	3.3/	5/2+			ann.rad./
				EC/13 /					0.1002
									0.1545
									0.4891
									1.0326
^{112}Sb		111.91240	51.4 s	β+ /90/7.06	4.75/	3+			ann.rad./
				EC/10/					0.6700
									0.9909
									1.2571
^{113}Sb		112.90937	6.7 m	β+ /65/3.91	2.42/	5/2+			ann.rad./
									(0.3−3.6)
				EC/35/					Sn k x-ray
									0.3324
									0.4980
^{114}Sb		113.90927	3.49 m	β+ /78/5.9	3.4/	3+	1.7		ann.rad./
				EC/22/					Sn k x-ray
									0.8876
									1.2999
^{115}Sb		114.90660	32.1 m	β+ /67/3.03	1.51/	5/2+	+3.46	-0.4	ann.rad./
				EC/33/					Sn k x-ray
									0.4973
^{116m}Sb			1.00 h	β+ /78/	1.16/	8-	2.6		ann.rad./
				EC/22/					Sn k x-ray
									0.4073
									0.5429
									0.9725
									1.2935
									(0.0998−1.501)
^{116}Sb		115.90679	16. m	β+ /50/4.707	1.3/	3+	2.72		ann.rad./
				EC/50/	2.3/				Sn k x-ray
									0.93180
									1.29354
									(0.138−3.903)
^{117}Sb		116.90484	2.80 h	β+ /2/1.76	0.57/	5/2+	+3.4		Sn k x-ray
				EC/98/					0.1586
^{118m}Sb			5.00 h	EC/99/		8-	2.3		Sn k x-ray
									0.25368
									1.05069
									1.22964

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^{118}Sb		117.905529	3.6 m	β+ /74/3.657	2.65/	1+	2.5		ann.rad./
				EC/26/					Sn k x-ray
									1.22964
^{119}Sb		118.90394	38.1 h	EC/0.59		5/2+	+3.45	-0.4	Sn k x-ray
									0.0239
^{120m}Sb			5.76 d	EC/		8-	2.34		Sn k x-ray
									0.0898
									0.19730
									1.02301
									1.17121
^{120}Sb		119.90507	15.89 m	β+ /41/2.68	1.72/	1+	+2.3		ann.rad./
				EC/59/					Sn k x-ray
									0.7038
									1.17121
^{121}Sb	57.21(5)	120.903816				5/2+	+3.363	-0.4	
^{122m}Sb			4.19 m	I.T./0.162		8-			Sb x-ray
									0.0614
									0.0761
^{122}Sb		121.905174	2.72 d	β- /98/1.979	1.414/65	2-	-1.90	+0.9	0.56409
				β+ /2/1.620	1.980/26				0.69277
									1.14050
									1.2569
^{123}Sb	42.79(5)	122.904214				7/2+	+2.550	-0.5	
^{124m2}Sb			20.3 m	I.T./0.035		8-			
^{124m1}Sb			1.6 m	I.T./80/	1.2/	5+			0.4984
				β- /20/	1.7/				0.6027
									0.6458
									1.1010
^{124}Sb		123.905936	60.20 d	β- /2.905	0.61/52	3-	1.2	+1.9	0.60271/97.8
					2.301/23				0.64583/7.4
									0.72277/10.5
									1.69094/48.2
									(0.0274–2.808)
^{125}Sb		124.905254	2.758 y	β- /0.767	0.13/30	7/2+	+2.63		0.0355
					0.302/45				0.17632
					0.62/13				0.38044
									0.42786
									0.46336
									0.60060
									0.63595
^{126m2}Sb			11. s	I.T./		3-			L x-ray
									0.0227
^{126m1}Sb			19.0 m	β- /86 /	1.9	5+			0.4148
				I.T./14 /					0.6663
									0.6950
^{126}Sb		125.90725	12.4 d	β- /3.67	1.9	8-	1.3		0.2786
									0.4148/83.3
									0.6663/99.7
									0.6950/99
									0.7205
^{127}Sb		126.90692	3.84 d	β- /1.581	0.89/	7/2+	2.70		0.2524
					1.10/				0.2908
					1.50/				0.4121
									0.4370
									0.6857
									0.7837
^{128m}Sb			10.1 m	β- /96/	2.6/	5+			0.3140
				I.T./4/					0.5941
									0.7432
									0.7539

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^{128}Sb		127.90917	9.1 h	β- /4.38	2.3/	8-	1.3		0.2148
									0.3141
									0.5265
									0.7433
									0.7540
^{129m}Sb			17.7 m	β- /					0.4338
									0.6578
									0.7598
^{129}Sb		128.90915	4.40 h	β- /2.38	0.65/	7/2-	2.82		0.0278
									0.1808
									0.3594
									0.4596
									0.5447
									0.8128
									0.9146
									1.0301
^{130m}Sb			6.5 m	β- /2.6	2.12/				0.1023
									0.7934
									0.8394
^{130}Sb		129.91166	38.4 m	β- /4.96	2.9/	8-			0.1823
									0.3309
									0.4680
									0.7394
									0.8394
^{131}Sb		130.91198	23.0 m	β- /3.20	1.31/	7/2+			0.6423
					3.0/				0.6579
									0.9331
									0.9434
^{132m}Sb			2.8 m	β- /	3.9/	4+			0.1034
									0.3538
									0.6968
									0.9739
									0.9896
^{132}Sb		131.91447	4.2 m	β- /5.49		8-			0.1034
									0.1506
									0.6968
									0.9739
^{133}Sb		132.91525	2.5 m	β- /4.00	1.20/	7/2+	3.00		0.4235
									0.6318
									0.8165
									1.0764
^{134m}Sb			10.4 s	β- /	6.1	7-			
^{134}Sb		133.92038	0.8 s	β- /8.4	8.4	0-			0.1152
									0.2970
									0.7063
									1.2791
^{135}Sb		134.9252	1.71 s	β- /8.12		7/2+			1.127
									1.279
^{136}Sb		135.9304	0.82 s	β- /9.3					
^{137}Sb		136.9353	> 0.15 μs						
^{138}Sb		137.9408	> 0.15 μs						
^{139}Sb		138.9460	> 0.15 μs						
$_{52}$Te		**127.60(3)**							
^{105}Te		104.9436							
^{106}Te		105.9375	0.07 ms	α/4.3	/100	0+			
^{107}Te		106.9350	3.1 ms	α/ 70/	3.86(1)/				(0.090-0.721)
				β+, EC/10.1					
^{108}Te		107.9294	2.1 s	α /68 /	3.314(4)/	0+			

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
				β+, EC/32 /6.8					
^{109}Te		108.9274	4.6 s	β+ EC/96 /8.7					0.7523
				α/4 /	3.107(4)/				0.287−2.045
^{110}Te		109.9224	19. s	β+, EC/4.5		0+			ann.rad./
									0.2191
									0.6059
^{111}Te		110.9211	19.3 s	β+, EC/8.0		(7/2+)			ann.rad./
									0.267
									0.322
									0.341
^{112}Te		111.9170	2.0 m	β+, EC/4.3		0+			ann.rad./
									0.2962
									0.3727
									0.4187
^{113}Te		112.9159	1.7 s	β+ /85/5.7	4.5/	(7/2+)			ann.rad./
				EC/15/					Sb k x-ray
									0.8144
									1.0181
									1.1812
^{114}Te		113.91209	15. m	β+ /40/3.2		0+			ann.rad./
				EC/60/					Sb k x-ray
									0.0838
									0.0903
^{115m}Te			6.7 m	β+ /45/		(1/2+)			ann.rad./
				EC/55/					Sb k x-ray
									0.7236
									0.7704
^{115}Te		114.91190	5.8 m	β+ /45/4.6	2.7/	7/2+			ann.rad./
				EC/55/					Sb k x-ray
									0.7236
									1.3268
									1.3806
									(0.22−2.7)
^{116}Te		115.90846	2.49 h	EC/1.5		0+			Sb k x-ray
									0.0937
^{117}Te		116.90865	1.03 h	EC/75/3.54	1.78/	½+			ann.rad./
				β+ /25/					Sb k x-ray
									0.9197
									1.7164
									2.3000
^{118}Te		117.90583	6.00 d	EC/0.28		0+			Sb k x-ray
^{119m}Te			4.69 d	EC/		11/2-	0.89		Sb k x-ray
									0.15360
									0.2705
									1.21271
^{119}Te		118.90640	16.0 h	β+ /2/2.293	0.627/	½+	0.25		ann.rad.
				EC/98/					Sb k x-ray
									0.6440
									0.6998
^{120}Te	0.09(1)	119.90402				0+			
^{121m}Te			~ 154. d	I.T. (89%)		11/2-	0.90		Te k x-ray
				EC (11%)					0.2122
^{121}Te		120.90494	16.8 d	EC/1.04		½+			Sb k x-ray
									0.5076
									0.5731
^{122}Te	2.55(12)	121.903044				0+			
^{123m}Te			119.7 d	I.T./0.247		11/2-	-0.93		Te k x-ray
									0.1590/84.1
^{123}Te	0.89(3)	122.904270	> 9.2×10^{16} y	EC/0.051		½+	-0.73695		
^{124}Te	4.74(14)	123.902818				0+			

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^{125m}Te			58. d	I.T./0.145		11/2-	-0.99	-0.06	Te k x-ray
									0.0355
^{125}Te	7.07(15)	124.904431				½+	-0.8885		
^{126}Te	18.84(25)	125.903312				0+			
^{127m}Te			109. d	I.T./98/0.088		11/2-	-1.04		Te k x-ray
				β- /2/0.77					0.0883
^{127}Te		126.905226	9.4 h	β- /0.698	0.696/	3/2+	0.64		0.3603
^{128}Te	31.74(8)	127.904463	2.2×10^{24} y	β-β-		0+			
^{129m}Te			33.6 d	I.T./63/0.105		11/2-	-1.09		Te k x-ray
				β- /37/	1.60/				0.45984
									0.6959
^{129}Te		128.906598	1.16 h	β- /1.498	0.99/9	3/2+	0.70	0.06	0.0278
					1.45/89				0.45984
									0.48728
^{130}Te	34.08(62)	129.906224	8×10^{20} y	β-β-		0+			
^{131m}Te			1.35 d	β- /78/2.4	0.42/	11/2-	-1.04		0.0811
				I.T./22/0.18					0.1021
									0.14973
									0.77369
									0.79375
									0.85225
^{131}Te		130.908524	25.0 m	β- /2.233	1.35/12	3/2+	0.70		0.14973
					1.69/22				0.45327
					2.14/60				0.49269
^{132}Te		131.90855	3.26 d	β- /0.51	0.215	0+			0.049725
									0.11198
									0.22830
^{133m}Te			55.4 m	β- /82/	2.4/30	11/2-			Te k x-ray
				I.T./18/0.334					0.0949
									0.1689
									0.3121
									0.3341
^{133}Te		132.91096	12.4 m	β- /2.94	2.25/25	3/2+			0.3121
					2.65				0.4079
									1.3334
^{134}Te		133.91137	42. m	β- /1.51	0.6/	0+			0.7672/29
					0.7/				0.0794–0.9255
^{135}Te		134.9165	19.0 s	β- /6.0	5.4/				0.267
					6.0				0.603
									0.870
^{136}Te		135.92010	17.5 s	β- /5.1	2.5/	0+			2.0779/25
									0.0873–3.235
^{137}Te		136.9253	2.5 s	β- /98 /6.9	6.8	7/2-			0.2436
				n/2 /					
^{138}Te		137.9292	1.4 s	β- /6.4		0+			
^{139}Te		138.9347	> 0.15 μs						
^{140}Te		139.9389	> 0.15 μs			0+			
^{141}Te		140.9447	> 0.15 μs						
^{142}Te		141.949	> 0.15 μs			0+			
$_{53}$I		**126.90447(3)**							
^{108}I		107.9435	0.04 s	α/91/4.	3.95				
^{109}I		108.9382	0.11 ms	p					0.593/100
									0.717/63
									0.496–1.057
^{110}I		109.9352	0.65 s	β+, EC/83/11.4					ann.rad./
				α/17/~ 3.6	3.457(10)/				
				p/11/					
^{111}I		110.9303	2.5 s	β+, E.C./8.5					ann.rad./

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									0.2665
									0.3215
									0.3412
^{112}I		111.9280	3.4 s	β+, EC/10.2					ann.rad./
									0.6889
									0.7869
^{113}I		112.9236	5.9 s	β+, EC/7.6					ann.rad./
									0.4625/100
									0.6224/74
									0.0550−1.422
^{114}I		113.9219	2.1 s	β+, EC/8.7					ann.rad./
									0.6826
									0.7088
^{115}I		114.9181	1.3 m	β+, EC/6.7		5/2+			ann.rad./
									0.275
									0.284
									0.460
									0.709
^{116}I		115.9168	2.9 s	β+ /97/7.8	6.7/	1+			ann.rad./
				EC/3/					0.5402
									0.6789
^{117}I		116.91365	2.22 m	β+, EC/4.7	3.2/	(5/2+)	3.1		ann.rad./
									0.2744
									0.3259
^{118m}I			8.5 m	β+, EC/	4.9/	7-	4.2		ann.rad./
				I.T.					0.104
									0.5998
									0.6052
									0.6138
^{118}I		117.91307	14. m	β+, EC/7.0		2-	2.0		ann.rad./
									0.5448
									0.6052
									1.3384
^{119}I		118.91007	19. m	β+ /54/3.5	2.4/	(5/2+)	+2.9		ann.rad./
				EC/46/					Te k x-ray
									0.2575
^{120m}I			53. m	β+ /80/	3.8		4.2		ann.rad.
				EC/20/					Te k x-ray
									0.4257
									0.5604
									0.6147
									1.3459
^{120}I		119.91005	1.35 h	β+ /56/5.62	4.03	2-	1.23		ann.rad./
				EC/	4.60				Te k x-ray
									0.5604
									0.6411
									1.5230
									(0.111−3.1)
^{121}I		120.90737	2.12 h	β+ /13/2.27	1.2/	5/2+	2.3		ann.rad./
				EC/87/					Te k x-ray
									0.2122
									(0.14−1.1)
^{122}I		121.90759	3.6 m	β+ /4.234	3.1/	1+	+0.94		ann.rad./
				EC/					Te k x-ray
									0.5641
^{123}I		122.905589	13.2 h	EC/1.242		5/2+	2.82		Te k x-ray
									0.1590
^{124}I		123.906210	4.18 d	β+ /23/3.160	1.54/	2-	1.44		ann.rad./
				EC/77/	2.14/				Te k x-ray
					0.75/				0.6027/62.9

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									0.7228/10.3
									1.6910/11.2
									(0.31−1.73)
^{125}I		124.904630	59.4 d	EC/0.1861		5/2+	2.82	-0.89	Te k x-ray
									0.0355
^{126}I		125.905624	13.0 d	EC/		2-	1.44		ann.rad./
				β+ /2.155	1.13/				Te k x-ray
				β- /1.258/47	0.87/				0.3887
					1.25/				0.6622
^{127}I	100.	126.904473				5/2+	+2.8133	-0.79	
^{128}I		127.905809	25.00 m	β- /2.118	2.13/	1+			Te k x-ray
				EC/1.251					0.44287
									0.52658
^{129}I		128.904988	1.7×10^7 y	β- /0.194	0.15/	7/2+	+2.621	-0.55	Xe k x-ray
									0.0396
^{130m}I			9.0 m	I.T./83/0.048		2+			I k x-ray
				β- /17/					0.5361
^{130}I		129.906674	12.36 h	β- /2.949	1.04/	5+	3.35		0.4180
					0.62				0.5361
									0.6685
									0.7395
^{131}I		130.906125	8.021 d	β- /0.971	0.606/	7/2+	+2.742	-0.40	0.08017
									0.28431
									0.36446
									0.63699
^{132m}I			1.39 h	IT		8-			
^{132}I		131.90800	2.28 h	β- /14/3.58	0.80/	4+	3.09	0.09	I k x-ray
				I.T./86/	1.03/				0.0980
					1.2/				0.5059
					1.6/				0.52264
					2.16/				0.63019
									0.6506
									0.66768
									0.77260
									0.95457
^{133m}I			9. s	I.T./1.63		19/2-			I Kx-ray
									0.0730
									0.6474
									0.9126
^{133}I		132.907797	20.8 h	β- /1.77	1.24/85	7/2+	+2.86	-0.27	0.51056
									0.52989
									0.87537
^{134m}I			3.7 m	I.T./98/0.316		8-			I k x-ray
				β- /2/					0.0444
									0.2719
^{134}I		133.90974	52.6 m	β- /4.05	1.2/	4+			0.1354
									0.84702
									0.88409
^{135}I		134.91005	6.57 h	β- /2.63	0.9/	7/2+	2.94		0.2884
					1.3/				0.41768
									0.52658
									1.13156
									1.26046
^{136m}I			47. s	β- /	4.7/	6-			0.1973
					5.2/				0.3468
									0.3701
									0.3814
									1.3130
									(0.16−2.36)
^{136}I		135.91465	1.39 m	β- /6.93	4.3/	2-			0.3447

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					5.6/				1.3130
									1.3211
									2.2896
									(0.3−6.1)
^{137}I		136.91787	24.5 s	β- /5.88	5.0/	(7/2+)			0.6010
									1.2180
									1.2201
									1.3026
									1.5343
									(0.25−4.4)
^{138}I		137.9224	6.5 s	β- /7.8	6.9/	2-			0.4836
					7.4/				0.5888
									0.8752
									(0.4−5.3)
^{139}I		138.92610	2.30 s	β- /6.81					0.192
				n/					0.198
									0.273
									0.382
									0.386
									0.468
									0.683
									1.313
^{140}I		139.9310	0.86 s	β- /8.8		(3)			0.372
				n/					0.377
									0.457
^{141}I		140.9350	0.45 s	β- /7.8					
^{142}I		141.9402	~ 0.2 s	β-					
^{143}I		142.9446	> 0.15 μs						
^{144}I		143.9500	> 0.15 μs						
$_{54}$Xe		**131.293(6)**							
^{110}Xe		109.9443	0.11 s	β+ /9.2		0+			
				α	/~ 64				
^{111m}Xe			0.9 s	EC, β+					
^{111}Xe		110.9416	0.7 s	EC, β+ /10.6					
				α/	3.58(1)/				
^{112}Xe		111.9356	3. s	EC, β+ /7.2	α/0.8/	0+			
^{113}Xe		112.9333	2.8 s	EC, β+ /9.1					
^{114}Xe		113.92798	10.0 s	β+, EC/5.9		0+			ann.rad./
									0.1031
									0.1616
									0.3085
									0.6826
									0.7088
^{115}Xe		114.92629	18. s	β+, EC/7.6		(5/2+)			ann.rad./
^{116}Xe		115.92158	56. s	β+, EC/4.3	3.3/	0+			ann.rad./
									0.1042
									0.1916
									0.2477
									0.3107
									0.4127
^{117}Xe		116.92036	1.02 m	β+, EC/6.5		(5/2+)	-0.594	+1.16	ann.rad./
									0.2214
									0.5190
									0.6389
									0.6613
^{118}Xe		117.91618	~ 4. m	β+, EC/3.	2.7/	0+			ann.rad./
									0.0535
									0.0600

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									0.1199
^{119}Xe		118.91541	5.8 m	β+, EC/5.0	3.5/	7/2+	-0.654	+1.31	0.0873
									0.1000
									0.2318
									0.4615
^{120}Xe		119.91178	40. m	β+, EC/97/1.96		0+			I k x-ray
				β+ /3/					0.0251
									0.0726
									0.1781
									(0.1−1.03)
^{121}Xe		120.91146	39. m	β+ /44/3.73	2.8/	5/2+	-0.701	+1.33	ann.rad./
				EC/56/					I k x-ray
									0.1328
									0.2527
									0.4452
									(0.1−3.1)
^{122}Xe		121.90837	20.1 h	EC/0.9		0+			I k x-ray
									0.3501
^{123}Xe		122.90848	2.00 h	β+ /23/2.68	1.51/	½+	-0.150		ann.rad./
				EC/77/					I k x-ray
									0.1489
									0.1781
									(0.1−2.1)
^{124}Xe	0.0952(3)	123.905893	> 10^{17} y	β-β-		0+			
^{125m}Xe			57. s	I.T./0.252		(9/2-)	-0.745	+0.42	Xe k x-ray
									0.1111
									0.141
^{125}Xe		124.906395	17.1 h	EC/1.653	0.47/	½+	-0.269		I k x-ray
									0.1884
									0.2434
^{126}Xe	0.0890(2)	125.90427				0+			
^{127m}Xe			1.15 m	I.T./0.297		(9/2-)	-0.884	+0.69	Xe k x-ray
									0.1246
									0.1725
^{127}Xe		126.905184	36.34 d	EC/0.662		½+	-0.504		I k x-ray
									0.1721
									0.2029
									0.3750
^{128}Xe	1.9102(8)	127.903531				0+			
^{129m}Xe			8.89 d	I.T./0.236		11/2-	-0.891	+0.64	Xe k x-ray
									0.0396
									0.1966
^{129}Xe	26.4006(82)	128.904779				½+	-0.7780		
^{130}Xe	4.0710(13)	129.903508				0+			
^{131m}Xe			11.9 d	I.T./0.164		11/2-	-0.9940	+0.73	Xe k x-ray
									0.16398
^{131}Xe	21.2324(30)	130.905082				3/2+	+0.69186	-0.12	
^{132}Xe	26.9086(33)	131.904153				0+			
^{133m}Xe			2.19 d	I.T./0.233		11/2-	-1.082	+0.77	Xe k x-ray
									0.23325
^{133}Xe		132.905911	5.243 d	β- /0.427	0.346/99	3/2+	+0.813	+0.14	Cs k x-ray
									0.080998
									0.1606
^{134}Xe	10.4357(21)	133.905394	> 1.1 × 10^{16} y	β- β-		0+			
^{135m}Xe			15.3 m	I.T./		11/2-	1.103	+0.62	Xe k x-ray
									0.52658
^{135}Xe		134.907227	9.10 h	β-/1.15	0.91/	3/2+	0.903	+0.21	0.24975
									0.60807
^{136}Xe	8.8573(44)	135.90722	> 2.4 × 10^{21} y	β-β-		0+			
^{137}Xe		136.91156	3.82 m	β- /4.17	4.1/	7/2-	-0.970	-0.49	0.45549

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					3.6/				0.8489
									0.9822
									1.2732
									1.7834
									2.8498
^{138}Xe		137.91395	14.1 m	β- /2.77	0.8/	0+			0.1538
					2.4/				0.2426
									0.2583
									0.4345
									1.76826
									2.0158
^{139}Xe		138.91879	39.7 s	β- /5.06	4.5/		-0.304	+0.40	0.1750
					5.0/				0.2186
									0.2965
									(0.1−3.37)
^{140}Xe		139.9216	13.6 s	β- /4.1	2.6	0+			0.0801
									0.6220
									0.8055
									1.4137
									(0.04−2.3)
^{141}Xe		140.9266	1.72 s	β- /6.2	6.2/	5/2+	+0.010	-0.58	0.1187
									0.9095
									(0.05−2.55)
^{142}Xe		141.9297	1.22 s	β- /5.0	3.7/	0+			0.0338
					4.2/				0.0729
									0.2038
									0.3091
									0.4145
									0.5382
									0.5718
									0.6181
									0.6448
^{143m}Xe			0.96 s	β-					
^{143}Xe		142.9351	0.30 s	β- /7.3			-0.460	+0.93	
^{144}Xe		143.9385	1.2 s	β- /6.1		0+			
^{145}Xe		144.9441	0.9 s	β-, (n)					
^{146}Xe		145.9478	> 0.15 μs			0+			
^{147}Xe		146.9536	> 0.15 μs						
$_{55}$Cs		**132.9054519(2)**							
^{112}Cs		111.9503	0.5 ms	p	0.81				
^{113}Cs		112.9445	17. μs	p	0.96				
^{114}Cs		113.9414	0.58 s	β+, EC/11.8		1+			ann.rad./
									0.6826
									0.7088
^{115}Cs		114.9359	~ 1.4 s	β+, EC/8.4					ann.rad./
^{116m}Cs			0.7 s	β, EC/					ann.rad./
									0.3935
^{116}Cs		115.9334	3.8 s	β+, EC/10.8					ann.rad./
									0.3935
									0.5243
									0.6151
									0.6223
^{117m}Cs			6.5 s	β+, EC/					
^{117}Cs		116.9287	~ 8.4 s	β+, EC/7.5					ann.rad./
^{118m}Cs			17. s	β+, EC/			5.		
^{118}Cs		117.92656	14. s	β+, EC/9.		2	+3.88	+1.4	ann.rad./
									0.3372
									0.4727

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									0.5865
									0.5906
^{119m}Cs			29. s			3/2	+0.84	+0.9	
^{119}Cs		118.92238	43. s	β+, EC/6.3		9/2+	+5.5	+2.8	ann.rad./
									0.169
									0.176
									0.224
									0.257
^{120m}Cs			60. s	β+, EC/					
^{120}Cs		119.92068	64. s	β+, EC/7.92		2+	+3.87	+1.45	ann.rad./
									0.3224
									0.4735
									0.5534
									(0.3−3.28)
^{121m}Cs			2.0 m	I.T./60/		(9/2+)	+5.41	+2.7	ann.rad./
				β+ /40/	4.4				0.1794
									0.1961
^{121}Cs		120.91723	2.3 m	β+, EC/5.40	4.38/	3/2+	+0.77	+0.84	ann.rad./
									0.1537
									(0.08−0.56)
^{122m2}Cs			4.4 m	β+, EC		8-	+4.77	+3.3	ann.rad./
^{122m1}Cs			0.36 s	IT					0.3311
									0.4971
									0.6385
									(0.27−2.22)
^{122}Cs		121.91611	21. s	β+, EC/7.1	5.8/	(1+)	-0.133	-0.19	ann.rad./
									0.3311
									0.5120
									0.8179
^{123m}Cs			1.6 s	I.T./		11/2-			Cs k x-ray
									0.0946
^{123}Cs		122.91300	5.87 m	β+ /75/4.20	3.0/	1/2+	+1.38		ann.rad./
				EC/25/					Xe k x-ray
									0.0974
									0.5964
^{124m}Cs			6.3 s	IT		7+			
^{124}Cs		123.91226	30. s	β+ /9 /5.92	~ 5.	1+	+0.673	-0.74	ann.rad./
				EC/8 /					Xe k x-ray
									0.3539
									0.4925
									0.9418
^{125}Cs		124.90973	45. m	β+ /40/3.09	2.06/	1/2+	+1.41		ann.rad./
				EC/60/					Xe k x-ray
									0.112
									0.526
^{126}Cs		125.90945	1.64 m.	β+ /81/4.83	3.4	1+	+0.78	-0.68	ann.rad./
				EC/19/	3.7/				Xe k x-ray
									0.3886
									0.4912
									0.9252
^{127}Cs		126.90742	6.2 h	β+ /96/2.08	0.65/	1/2+	+1.46		Xe k x-ray
				EC/4/	1.06				0.1247
									0.4119
^{128}Cs		127.90775	3.62 m	β+ /68/3.930	2.44/	1+	+0.97	-0.57	ann.rad./
				EC/32 /	2.88/				Xe k x-ray
									0.4429
^{129}Cs		128.90606	1.336 d	EC/1.195		1/2+	+1.49		Xe k x-ray
									0.3719
									0.4115
^{130m}Cs			3.5 m	IT, β+, EC		5-	+0.629	+1.45	

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
^{130}Cs		129.90671	29.21 m	β+ /55/2.98	1.98/	1+	+1.46	-0.06	ann.rad./
				EC/43/					Xe k x-ray
				β- /1.6/0.37	0.44/1.6				0.5361
^{131}Cs		130.90546	9.69 d	EC/0.352		5/2+	+3.54	-0.58	Xe k x-ray
^{132}Cs		131.906434	6.48 d	EC/98/		2-	+2.22	+0.51	Xe k x-ray
				β+ /0.3/2.120					0.4646
				β- / /1.280					0.6302
									0.66769
^{133}Cs	100.	132.90545193				7/2+	+2.582	-0.00355	
^{134m}Cs			2.91 h	I.T./0.139		8-	+1.098	+1.0	Cs k x-ray
									0.12749
^{134}Cs		133.90671848	2.065 y	β- /2.059	0.089/27	4+	+2.994	+0.39	0.56327
					0.658/70				0.56935
				EC/1.22					0.60473
									0.79584
^{135m}Cs			53. m	I.T./1.627		19/2-	+2.18	+0.9	0.7869
									0.8402
^{135}Cs		134.905977	2.3×10^6 y	β- /0.269	0.205/100	7/2+	+2.732	+0.05	
^{136m}Cs			19. s	I.T./		8-	+1.32	+0.7	
^{136}Cs		135.907312	13.16 d	β- /2.548	0.341/	5+	+3.71	+0.2	0.06691
									0.34057
									0.81850
									1.04807
^{137}Cs		136.907089	30.2 y	β- /1.176	0.514/95	7/2+	+2.84	+0.05	Ba k x-ray
									0.66164
^{138m}Cs			2.9 m	I.T./75	/0.080	6-	+1.71	-0.40	Cs k x-ray
				β- /25 /	3.3				0.0799
									0.1917
									0.4628
									1.43579
^{138}Cs		137.91102	32.2 m	β- /5.37	2.9/	3-	+0.700	+0.12	0.1381
									0.46269
									1.00969
									1.43579
									2.21788
^{139}Cs		138.913364	9.3 m	β- /4.213	4.21	7/2+	+2.70	-0.07	0.6272
									1.2832
									(0.4−3.66)
^{140}Cs		139.91728	1.06 m	β- /6.22	5.7/	1-	+0.13390	-0.11	0.5283
					6.21/				0.6023
									0.9084
									(0.41−3.94)
^{141}Cs		140.92005	24.9 s	β- /5.26	5.20/	7/2+	+2.44	-0.4	Ba k x-ray
									0.0485
									0.5616
									0.5887
									1.1940
									(0.05−3.33)
^{142}Cs		141.92430	1.8 s	β- /7.31	6.9/				0.3596
					7.28				0.9668
									1.1759
									1.3265
^{143}Cs		142.92735	1.78 s	β- /6.24	6.1	(3/2+)	+0.87	+0.47	0.1955
									0.2324
									0.3064
									(0.17−1.98)
^{144}Cs		143.93208	1.01 s	β- /8.47	8.46/	1	-0.546	+0.30	0.1993
					7.9/				0.5598
									0.6392
									0.7587

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^{145}Cs		144.93553	0.59 s	β- /7.89	7.4/	3/2+	+0.784	+0.6	0.1126
					7.9/				0.1755
									0.1990
^{146}Cs		145.9403	0.322 s	β-, (n)/9.38	~ 9.0	2-	-0.515	+0.22	
^{147}Cs		146.9442	0.227 s	β-, (n)/9.3					(0.024-2.2798)
^{148}Cs		147.9492	0.15 s	β-, (n)/10.5					
^{149}Cs		148.9529	> 50 ms						
^{150}Cs		149.9582	> 50 ms						
^{151}Cs		150.9622	> 50 ms						
$_{56}$Ba		**137.327(7)**							
^{114}Ba		113.9507	0.43 s	β+, (p)	p/20	0+			
				α	/0.9				
^{115}Ba		114.947	0.45 s	β+, (p)	p/<15				
^{116}Ba		115.9414	1.3 s	β+, (p)	p/3	0+			
^{117}Ba		116.9385	1.8 s	β+, (p), EC/8.4	p/16	(3/2-)			(0.0457−0.364)
^{118}Ba		117.9330	5.2 s	β+,		0+			(0.040−0.156)
^{119}Ba		118.9307	5.4 s	β+, EC/8.					
^{120}Ba		119.9260	24. s	β+, EC/5.0		0+			ann.rad./
									0.140
									(0.075−0.146)
^{121}Ba		120.9241	30. s	β+, EC/6.8		5/2+	+0.660	+1.8	ann.rad./
^{122}Ba		121.91990	2.0 m	β+, EC/3.8		0+			ann.rad./
^{123}Ba		122.91878	2.7 m	β+, EC/5.5			-0.68	+1.5	ann.rad./
									0.0306
									0.0927
									0.1161
									0.1235
^{124}Ba		123.91509	12. m	β+, EC/2.65		0+			ann.rad./
									0.1695
									0.1888
									1.2160
^{125m}Ba			8. m	β+, EC/	4.5		0.174		
^{125}Ba		124.9145	3.5 m	β+, EC/4.6	3.4	½+	+0.18		ann.rad./
									0.0550
									0.0776
									0.0854
									0.1409
^{126}Ba		125.91125	1.65 h	β+ /2/1.67		0+			Cs k x-ray
				EC/98 /					0.2179
									0.2336
									0.2576
^{127m}Ba			1.9 s	IT		7/2-	-0.723	1.6	
^{127}Ba		126.91109	12.9 m	β+ /54/3.5		1/2+	+0.083		ann.rad./
				EC/46/					Cs k x-ray
									0.1148
									0.1808
									(0.07−2.5)
^{128}Ba		127.90832	2.43 d	EC/0.52		0+			Cs k x-ray
									0.27344
^{129m}Ba			2.17 h	EC/98/		7/2+	+0.93	+1.6	Cs k x-ray
				β+ /2/					0.1769
									0.1823
									0.2023
									1.4593
^{129}Ba		128.90868	2.2 h	β+ /20/2.43	1.42/	1/2+	-0.40		ann.rad./
				EC/80/					Cs k x-ray
									0.1291
									0.2143

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									0.2208
^{130m}Ba			9.5 ms	I.T./2.475	/100.	8-	-0.04	+2.8	0.080−0.802
^{130}Ba	0.106(1)	129.906321	2.2×10^{21} y	β+β+		0+			
^{131m}Ba			14.6 m	I.T./0.187		9/2-	-0.87	+1.5	Ba k x-ray
									0.1085
^{131}Ba		130.906941	11.7 d	EC/1.37		1/2+	0.7081		Cs k x-ray
									0.12381/28.4
									0.21608/21.3
									0.49636/42.9
									(0.0549−1.171)
^{132}Ba	0.101(1)	131.905061	1.3×10^{21} y	EC EC		0+			
^{133m}Ba			1.621 d	I.T./0.288		11/2-	-0.91	+0.9	Ba k x-ray
									0.2761
^{133}Ba		132.906008	10.53 y	EC/0.517		1/2+	0.7717		Cs k x-ray
									0.08099
									0.35600
^{134}Ba	2.417(18)	133.904508				0+			
^{135m}Ba			1.20 d	I.T./0.2682		11/2-	-1.00	+1.0	Ba k x-ray
									0.2682
^{135}Ba	6.592(12)	134.9056886				3/2+	+0.838	+0.16	
^{136m}Ba			0.308 s	I.T./2.0305		7-			Ba k x-ray
									0.8185
									1.0481
^{136}Ba	7.854(24)	135.9045759				0+			
^{137m}Ba			2.552 m	I.T./0.6617		11/2-	-0.99	+0.8	Ba k x-ray
									0.66164
^{137}Ba	11.232(24)	136.9058274				3/2+	+0.9374	+0.245	
^{138}Ba	71.698(42)	137.9052472				0+			
^{139}Ba		138.9088412	1.396 h	β- /2.317	2.14/27	7/2-	-0.97	-0.57	0.16585
					2.27/72				1.2544
									1.42033
^{140}Ba		139.91060	12.75 d	β- /1.05	0.48	0+			0.16268
					1.0/				0.30485
					1.02/				0.53727
^{141}Ba		140.91441	18.3 m	β- /3.22	2.59/	3/2-	-0.34	+0.45	0.1903
					2.73/				0.2770
									0.3042
									(0.1−2.5)
^{142}Ba		141.91645	10.7 m	β- /2.212	1.0/	0+			0.23152
					1.10/				0.25512
									0.3090
									1.2040
^{143}Ba		142.92063	14.3 s	β- /4.24	4.2/	5/2+	+0.44	-0.88	0.1786
									0.21148
									0.7988
									(0.17−2.4)
^{144}Ba		143.92295	11.4 s	β- /3.1	2.4/	0+			La k x-ray
					2.9/				0.10386
									0.1566
									0.1728
									0.3882
									0.43048
^{145}Ba		144.9276	4.0 s	β- /4.9	4.9/	(5/2-)	-0.28	+1.22	La k x-ray
									0.0918
									0.09709
^{146}Ba		145.9302	2.20 s	β- /4.12	3.9/	0+			0.0644
									0.2513
									0.3270
									0.3329
									0.3622

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^{147}Ba		146.9349	0.892 s	β- /5.75	5.5/				
^{148}Ba		147.9377	0.64 s	β-, n/5.11		0+			
^{149}Ba		148.9426	0.36 s	β-, (n)/7.3					
^{150}Ba		149.9457	0.3 s			0+			
^{151}Ba		150.9508	> 0.15 μs						
^{152}Ba		151.9543				0+			
^{153}Ba		151.960							
$_{57}$La		**138.90547(7)**							
^{117}La		116.9501	23 ms	p	0.806/	3/2+			
^{118}La		117.9467							
^{119}La		118.9410							
^{120}La		119.9381	2.8 s	EC, β+ /11.					
^{121}La		120.9330	5.3 s						
^{122}La		121.9307	9. s	EC, β+/~ 9.7					
^{123}La		122.9262	17. s	EC/7.					
^{124}La		123.9246	30. s	EC/ ~ 8.8		(7+)			
^{125m}La			0.39 s						
^{125}La		124.92082	1.2 m	β+, EC/5.6		11/2-			ann.rad./
									0.0436
									0.0676
^{126m}La			< 50. s						
^{126}La		125.9195	54. s	β+, EC/7.6					ann.rad./
									0.256
									0.455
									0.117−3.853
^{127}La		126.91638	3.8 m	β+, EC/4.7		3/2+			ann.rad./
									0.025
									0.0562
^{128}La		127.9156	5.0 m	β+ /80/6.7		(5-)			ann.rad./
				EC/20/					Ba k x-ray
									0.2841/87
									0.4793/54
									(0.315−2.212)
^{129m}La			0.56 s	IT		(11/2-)			
^{129}La		128.91269	11.6 m	β+ /58/3.72	2.42/	3/2+			ann.rad./
				EC/42/					Ba k x-ray
									0.1105
									0.2786
									(0.1−1.8)
^{130}La		129.91237	8.7 m	β+ /78/5.6		3+			ann.rad./
				EC/22/					Ba k x-ray
									0.3573/81
									0.5506/27
									(0.1965−1.989)
^{131}La		130.91007	59. m	β+ /76/3.0	1.42/	3/2+			ann.rad./
				EC/24/	1.94/				Ba k x-ray
									0.1085
									0.3658
									0.5263
^{132m}La			24. m	I.T./76/		6-			La k x-ray
				β+, EC/24/					0.1352
									0.4645
^{132}La		131.91010	4.8 h	β+ /40/4.71	2.6/	2-			ann.rad./
				EC/60/	3.2				Ba k x-ray
					3.7/				0.4645
									0.5671
^{133}La		132.90822	3.91 h	β+ /4/2.2	1.2/	5/2+			Ba k x-ray
				EC/96/					0.2788

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									0.2901
									0.3024
^{134}La		133.90851	6.5 m	β+ /63/3.71	2.67/	1+			ann.rad./
				EC/37/					Ba k x-ray
									0.6047
									(0.5−1.9)
^{135}La		134.90698	19.5 h	EC/1.20		5/2+			Ba k x-ray
									0.4805
^{136}La		135.9076	9.87 m	β+ /36/2.9	1.8/	1+			ann.rad./
				EC/64/					Ba k x-ray
									0.8185
^{137}La		136.90649	6×10^4 y	EC/0.60		7/2+	+2.70	+0.2	0.2836
^{138}La	0.0888(6)	137.907112	1.06×10^{11} y			5+	+3.7136	+0.4	1.4358/65
									0.7887/35
^{139}La	99.9112(6)	138.906353				7/2+	+2.7830	+0.20	
^{140}La		139.909478	1.678 d	β- /3.762	1.35	3-	+0.73	+0.09	
					1.24/				
					1.67/				
^{141}La		140.910962	3.90 h	β- /2.502	2.43/	7/2+			
^{142}La		141.91408	1.54 h	β- /4.505	2.11/	2-			
					2.98/				
					4.52/				
^{143}La		142.91606	14.1 m	β- /3.43	3.3/	7/2-			
^{144}La		143.91960	40.7 s	β- /5.5	4.1/				
^{145}La		144.9216	24. s	β- /4.1	4.1/	3/2+			
^{146m}La			10.0 s	β- /6.7	5.5/	(6)			
^{146}La		145.9258	6.3 s	β- /6.6	6.2/	(2-)			
^{147}La		146.9282	4.02 s	β- /5.0	4.6/				
^{148}La		147.9322	1.1 s	β- /7.26		2-			
^{149}La		148.9347	1.10 s	β- /5.5					0.1335
									0.009−1.709
^{150}La		149.9388	0.51 s						x-ray
									(0.097−0.209)
^{151}La		150.9417	> 0.15 μs						
^{152}La		151.9462	> 0.15 μs						
^{153}La		152.950	> 0.15 μs						
^{154}La		153.955							
^{155}La		154.958							
$_{58}$Ce		**140.116(1)**							
^{119}Ce		118.953							
^{120}Ce		119.947				0+			
^{121}Ce		120.943	1.1 s	β+, p					
^{122}Ce		121.9379				0+			
^{123}Ce		122.9354	3.8 s	β+, EC/~ 8.6					ann.rad./
^{124}Ce		123.9304	6. s	EC/~ 5.6		0+			
^{125}Ce		124.9284	9.6 s	β+, EC/7.		7/2-			ann.rad./
									0.1346
									0.1666
									0.056−1.329
^{126}Ce		125.92397	50. s	EC/4.		0+			
^{127}Ce		126.9227	29. s	β+, EC/6.1					ann.rad./
									(0.058−1.961)
^{128}Ce		127.91891	4.1 m	β+, EC/3.2		0+			ann.rad./
									(0.023−0.880)
^{129}Ce		128.91810	3.5 m	β+, EC/5.6					ann.rad./
									(0.0675−1.015)
^{130}Ce		129.91474	26. m	β+, EC/2.2		0+			ann.rad./
									La k x-ray

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									0.047−1.431
^{131m}Ce			5. m	β+ EC					ann.rad./
									0.2304
									0.3955
									0.4213
^{131}Ce		130.91442	10. m	β+, EC/4.0	2.8/				ann.rad.
									0.119
									0.169
									0.414
^{132m}Ce			9.4 ms	IT/2.340					0.3255
									0.10−0.955
^{132}Ce		131.91146	3.5 h	EC/1.3		0+			La k x-ray
									0.1554
									0.1821
^{133m}Ce			1.6 h	β+, EC/		½+			ann.rad.
									0.0769
									0.0973
									0.5577
^{133}Ce		132.91152	5.4 h	β+/8/2.9	1.3/	9/2-			ann.rad.
				EC/92/					0.0584
									0.1308
									0.4722
									0.5104
^{134}Ce		133.90892	3.16 d	EC/0.5		0+			La k x-ray
									0.1304
									0.1623
									0.6047
^{135m}Ce			20. s	I.T./0.446		11/2-			Ce k x-ray
									0.0826
									0.1497
									0.2134
^{135}Ce		134.90915	17.7 h	β+/1 /2.026	0.8/	1/2+			La k x-ray
				EC/99 /					0.0345
									0.2656
									0.3001
									0.6068
^{136}Ce	0.185(2)	135.90717	> 0.7 × 10^{14} y	EC EC		0+			
^{137m}Ce			1.43 d	I.T./99 /0.254		11/2-	1.0		Ce k x-ray
				EC/0.8 /					0.1693
									0.2543
^{137}Ce		136.90781	9.0 h	β+/1.222		3/2+	0.96		La k x-ray
									0.4472
^{138}Ce	0.251(2)	137.90599	> 0.9 × 10^{14} y	EC EC		0+			
^{139m}Ce			56.4 s	I.T./0.7542		11/2-			Ce k x-ray
									0.7542
^{139}Ce		138.90665	137.6 d	EC/0.28		3/2+	1.06		La k x-ray
^{140}Ce	88.450(51)	139.905439				0+			0.16585
^{141}Ce		140.908276	32.50 d	β-/0.581	0.436/69	7/2-	1.1		Pr k x-ray
					0.581/31				0.14544/48.0
^{142}Ce	11.114(51)	141.909244	> 1.6 × 10^{17} y	β- β-		0+			
^{143}Ce		142.912386	1.38 d	β-/1.462	1.404/	3/2-	0.43		Pr k x-ray
					1.110/47				0.0574
									0.2933
^{144}Ce		143.913647	284.6 d	β-/0.319	0.185/20	0+			Pr k x-ray
					0.318/				0.0801
									0.1335
^{145}Ce		144.91723	3.00 m	β-/2.54	1.7/24	3/2-			Pr k x-ray
					1.3				0.0627
									0.7245
^{146}Ce		145.9188	13.5 m	β-/1.04	0.7/90	0+			Pr k x-ray

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									0.0986
									0.2182
									0.3167
									0.0930
^{147}Ce		146.92267	56. s	β-/3.29	3.3/				0.2687
^{148}Ce		147.92443	56. s	β-/2.1	1.66/	0+			0.0904
									0.0985
									0.1212
									0.2918
^{149}Ce		148.9284	5.2 s	β-/4.2					0.0577
									0.0864
									0.3800
									0.1099
^{150}Ce		149.93041	4.4 s	β-/3.0		0+			0.0526
^{151}Ce		150.9340	1.0 s	β-/5.3					Pr k x-ray
^{152}Ce		151.9365	1.4 s	β-/4.4		0+			0.098
									0.115
^{153}Ce		152.9406	> 0.15 μs						
^{154}Ce		153.9434	> 0.15 μs			0+			
^{155}Ce		154.948	> 0.15 μs						
^{156}Ce		155.951				0+			
^{157}Ce		156.956							
$_{59}$Pr		**140.90765(2)**							
^{121}Pr		120.955	0.01 s	p	p/0.882				
^{122}Pr		121.9518							
^{123}Pr		122.946							
^{124}Pr		123.943	1.2 s	β+, EC/12.					ann.rad./
^{125}Pr		124.9378	~ 3.3 s	β+					ann.rad./
									0.1358
^{126}Pr		125.9353	3.1 s	β+, EC/~ 10.4					ann.rad./
									(0.170−0.985)
^{127}Pr		126.9308	4.2 s	β+ /~ 7.5					ann.rad./
									(0.028−0.8949)
^{128}Pr		127.92879	3.0 s	β+, EC/~ 9.3					ann.rad./
									0.207/100
									0.400−1.373
^{129}Pr		128.92510	32 s	β+, EC/5.8					ann.rad./
									(0.0395−1.865)
^{130}Pr		129.9236	40. s	β+, EC/8.1					ann.rad./
^{131m}Pr			5.7 s						(0.06−0.16)
^{131}Pr		130.9203	1.7 m	β+, EC/5.3				~ 5.5	ann.rad./
									(0.059−0.980)
^{132}Pr		131.9193	1.6 m	β+, EC/7.1					ann.rad./
									0.325
									0.496
									0.533
^{133m}Pr			1.1 s	IT/0.192					0.1305
									0.0617
^{133}Pr		132.91633	6.5 m	β+, EC/4.3		5/2+			ann.rad./
									0.074
									0.1343
									0.2419
									0.3156
									0.3308
									0.4650
^{134m}Pr			~ 11. m	β+, EC/					ann.rad./
									0.294
									0.460

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									0.495
									0.632
^{134}Pr		133.91571	17. m	β+, EC/6.2		2+			ann.rad./
									0.294
									0.495
^{135}Pr		134.91311	24. m	β+, EC/3.7	2.5/	3/2+			ann.rad./
									0.0826
									0.2135
									0.2961
									0.5832
^{136}Pr		135.91269	13.1 m	β+ /57 /5.13	2.98/	2+			ann.rad./
				EC/43					Ce k x-ray
									0.5398
									0.5522
^{137}Pr		136.91071	1.28 h	β+ /26 /2.70	1.68/	5/2+			ann.rad./
				EC/74 /					Ce k x-ray
									0.4339
									0.5140
									0.8367
									(0.16−1.8)
^{138m}Pr			2.1 h	β+ /24 /	1.65/	7-			ann.rad./
				EC/76 /					Ce k x-ray
									0.3027
									0.7887
									1.0378
									(0.07−2.0)
^{138}Pr		137.91075	1.45 m	β+ /75 /4.44	3.42/	1+			ann.rad./
				EC/25 /					Ce k x-ray
									0.7887
^{139}Pr		138.90894	4.41 h	β+ /8 /2.129	1.09/	5/2+			ann.rad./
				EC/92 /					Ce k x-ray
									0.2551
									1.3473
									1.6307
^{140}Pr		139.90908	3.39 m	β+ /51 /3.39	2.37/	1+			ann.rad./
				EC/49 /					Ce k x-ray
									0.3069
									1.5965
^{141}Pr	100.	140.907653				5/2+	+4.275	-0.08	
^{142m}Pr			14.6 m	I.T./0.004	c.e.	5-	2.2		
^{142}Pr		141.910045	19.12 h	β- /2.162	0.58/4	2-	+0.234	+0.030	0.5088
				EC/0.744	2.16/96				1.57580
^{143}Pr		142.910817	13.57 d	β- /0.934	0.933/	7/2+	+2.70	+0.8	0.7420
^{144m}Pr			7.2 m	IT/99+/0.059		3-			Pr k x-ray
				β- /					0.0590
									0.6965
									0.8142
^{144}Pr		143.913305	17.28 m	β- /2.998	0.807/1	0-			0.69649
					2.30/				1.48912
					2.996/98				2.18562
^{145}Pr		144.91451	5.98 h	β- /1.81	1.80/97	7/2+			0.0725
									0.6758
									0.7483
^{146}Pr		145.9176	24.2 m	β- /4.2	2.2/30	2-			0.4539/48
					3.7/10				1.5247
					4.2/40				
^{147}Pr		146.91900	13.4 m	β- /2.69	1.5/	3/2+			0.3146/24.
					2.1/				0.5779/16
									0.6413/19.
^{148m}Pr			2.0 m	β- /	4.0/	(4)			0.3016

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
					3.8/				0.4506
									0.6975
^{148}Pr		147.92213	2.27 m	β- /4.9	4.8/	1^-			0.3017
					4.5/				
^{149}Pr		148.9237	2.3 m	β- /3.40	3.0	(5/2+)			0.1085
									0.1385
									0.1651
^{150}Pr		149.92667	6.2 s	β- /5.7		1^-			0.1302
					~ 5.5				0.8044
									0.8527
^{151}Pr		150.92832	22.4 s	β- /4.2					
^{152}Pr		151.9315	3.2 s	β- /6.7		4^+			0.0726
									0.164
									0.285
^{153}Pr		152.9338	4.3 s	β- /5.5					
^{154}Pr		153.9375	2.3 s	β- /7.9					
^{155}Pr		154.9401	> 0.3 μs						
^{156}Pr		155.9443	> 0.3 μs						
^{157}Pr		156.9474							
^{158}Pr		157.952							
^{159}Pr		158.956							
$_{60}$Nd		**144.242(3)**							
^{124}Nd		123.952				0+			
^{125}Nd		124.9489	0.6 s	β+, p					
^{126}Nd		125.9432				0+			
^{127}Nd		126.9405	1.8 s	β+, EC/9.		(5/2)			ann.rad./
^{128}Nd		127.9354	4. s	β+, EC/6.					ann.rad./
^{129}Nd		128.9332	4.9 s	β+, EC/8.		5/2(-)			ann.rad./
									(0.091−0.875)
^{130}Nd		129.92851	28. s	β+, EC/5.		0+			ann.rad./
^{131}Nd		130.92725	0.5 m	β+, EC/6.6					ann.rad./
									(0.09−0.36)
^{132}Nd		131.92332	1.5 m	β+, EC/3.7		0+			ann.rad./
									(0.099−0.567)
^{133}Nd		132.92235	1.2 m	β+, EC/5.6					ann.rad./
									(0.06−0.37)
^{134}Nd		133.91879	~ 8.5 m	β+ /17 /2.8		0+			ann.rad./
				EC/83 /					Pr k x-ray
									0.1631/58
									(0.09−1.00)
^{135m}Nd			5.5 m	β+ /					
^{135}Nd		134.91818	12. m	β+ /65 /4.8		9/2-	-0.78	+2.0	ann.rad./
				EC/35 /					Pr k x-ray
									0.0415/23.
									0.204/51.
									(0.11−1.8)
^{136}Nd		135.91498	50.6 m	EC/94 /2.21	1.04/	0+			Pr Kx-ray
				β+ /6 /					0.0401/21.
									0.1091/35.
									(0.10−0.97)
^{137m}Nd			1.6 s	I.T./0.5196		11/2-			Nd k x-ray
									0.1084
									0.1775
									0.2337
^{137}Nd		136.91457	38. m	β+ /40 /3.69	1.7/20	1/2+	-0.63		ann.rad./
				EC/60 /	2.40/20				Pr k x-ray
									0.0755
									0.5806

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^{138}Nd		137.91195	5.1 h	EC/1.1		0+			Pr k x-ray
									0.1995
									0.3258
^{139m}Nd			5.5 h	I.T./12 /0.231	1.17/	11/2-			Nd k x-ray
				β+ /88 /					Pr k x-ray
									0.1139/34.
									0.7382/30.
^{139}Nd		138.91198	30. m	β+ /25 /2.79	1.77/	3/2+	0.91	+0.3	ann.rad./
				EC/75 /					Pr k x-ray
									0.4050
^{140}Nd		139.90955	3.37 d	EC /0.22		0+			Pr k x-ray
^{141m}Nd			1.04 m	IT/99+/0.756		11/2-			Nd k x-ray
									0.7565
^{141}Nd		140.909610	2.49 h	EC/98 /1.823	0.802/	3/2+	1.01	+0.3	Pr k x-ray
				β+ /2 /					(0.15−1.7)
^{142}Nd	27.153(39)	141.907723				0+			
^{143}Nd	12.173(27)	142.909814				7/2-	-1.07	-0.60	
^{144}Nd	23.798(18)	143.910087	2.1×10^{15} y	α	1.83	0+			
^{145}Nd	8.293(12)	144.912574				7/2-	-0.66	-0.31	
^{146}Nd	17.189(33)	145.913117				0+			
^{147}Nd		146.916100	10.98 d	β- /0.896	0.805/	5/2-	0.58	0.9	Pr k x-ray
									0.53102
									0.09111−0.686
^{148}Nd	5.756(21)	147.916893				0+			
^{149}Nd		148.920149	1.73 h	β- /1.691	1.03/25	5/2-	0.35	1.3	Pr k x-ray
					1.13/26				0.1143/19.
					1.42/				0.2113/27.
									(0.026−1.6)
^{150}Nd	5.638(29)	149.920891	1.4×10^{20} y	β-β-		0+			
^{151}Nd		150.923829	12.4 m	β- /2.442	1.2/	(3/2+)			Pm k x-ray
									0.1168
									0.2557
									1.1806
									(0.10−1.9)m
^{152}Nd		151.92468	11.4 m	β- /1.1		0+			0.2785/29.
									0.2501/18.
									(0.016−0.66)
^{153}Nd		152.92770	28.9 s	β- /3.6					0.418
^{154}Nd		153.9295	25.9 s	β- /2.8		0+			0.1519
									0.7998
^{155}Nd		154.9329	8.9 s	β- /5.0					0.1807
^{156}Nd		155.9350	5.5 s	β- /4.1		0+			0.0848
^{157}Nd		156.9390	> 0.3 μs						
^{158}Nd		157.9416	> 0.3 μs			0+			
^{159}Nd		158.946							
^{160}Nd		159.949				0+			
^{161}Nd		160.954							
$_{61}$Pm									
^{128}Pm		127.9484	1.0 s	β+, p					ann.rad.
^{129}Pm		128.9432	~ 2.4 s						
^{130}Pm		129.9405	2.5 s	β+, EC/11.					0.1589
									0.326−1.062
^{131}Pm		130.9359	~ 6.3 s	β+					0.185
									0.220
									0.146
^{132}Pm		131.9338	6. s	β+, EC/10.					ann.rad./
^{133}Pm		132.92978	12. s	β+, EC/~ 7.0					ann.rad./
^{134}Pm		133.9284	24. s	β+, EC/~ 8.9		(5+)			ann.rad./

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									0.294
									0.495
^{135}Pm		134.9249	0.8 m	β+, EC/6.0		11/2-			(0.13−0.47)
^{136}Pm		135.9236	1.8 m	β+ /89 /7.9		(3+)			ann.rad./
				EC/11 /					Nd k x-ray
									0.3735
									0.6027
^{137}Pm		136.92048	2.4 m	β+, EC/5.6		(11/2-)			ann.rad./
									0.1086
									0.1775
^{138m}Pm			3.2 m	β+ /50 /~ 7.0	3.9/	3+	3.		ann.rad./
				EC/50 /					Nd k x-ray
									0.5209
									0.7290
^{138}Pm		137.91955	10. s	β+ /6.9	6.1/	1+			ann.rad./
^{139m}Pm			0.18 s	IT/		(11/2-)			0.1887
^{139}Pm		138.91680	4.14 m	β+ /68 /4.52	3.52/	(5/2+)			ann.rad./
				EC/32 /					Nd k x-ray
									0.4028
									(0.27−2.4)
^{140m}Pm			5.87 m	β+ /70 /	3.2	7/2-			ann.rad./
				EC/30 /					Nd k x-ray
									0.4199
									0.7738
									1.0283
^{140}Pm		139.91604	9.2 s	β+ /89 /6.09	5.07/74	1+			ann.rad./
				EC/11 /					Nd k x-ray
									0.7738
									1.4898
^{141}Pm		140.91356	20.9 m	β+ /52 /3.72	2.71	5/2+			ann.rad./
				EC/48 /					Nd k x-ray
									0.8862
									1.2233
^{142m}Pm			67 μs						(0.208-0.882)
^{142}Pm		141.91287	40.5 s	β+ /86 /4.87	3.8/	1+			ann.rad./
				EC/20 /					Nd k x-ray
									0.6414
									1.5758
^{143}Pm		142.910933	265. d	EC/1.041		5/2+	3.8		Nd k x-ray
				β+ /< 6×10^{-6}/					0.7420
^{144}Pm		143.912591	360. d	EC/2.332		5-	1.7		Nd k x-ray
				β+ /7×10^{-6}/					0.6180
									0.6965
^{145}Pm		144.912749	17.7 y	EC/0.163		5/2+	+3.8	+0.2	Nd k x-ray
									0.0723
^{146}Pm		145.914696	5.53 y	EC/63 /1.472		3-			Nd k x-ray
				β- /37 /1.542	0.795/				0.4538
									0.7362
									0.7474
^{147}Pm		146.915139	2.623 y	β- /0.224	0.224/	7/2+	+2.6	+0.7	0.1213
									0.1974
^{148m}Pm			41.3 d	β- /95 /2.6	0.4/60	6-	1.8		0.5503/94.
				I.T./5 /0.137	0.5/17				0.6300/89.
					0.7/21				0.7257/33
^{148}Pm		147.91748	5.37 d	β- /2.47	1.02/	1-	+2.0	+0.2	0.5503
					2.47/				0.9149
									1.4651
^{149}Pm		148.918334	2.212 d	β- /1.071	0.78/9	7/2+	3.3		0.2859
					1.072/90				0.5909
									0.8594

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
^{150}Pm		149.92098	2.68 h	β- /3.45	1.6/	(1-)			0.3339/69.
					2.3/				1.1658/16.
					1.8/				1.3245/17.
									(0.25−2.9)
^{151}Pm		150.92121	1.183 d	β- /1.187	0.84/	5/2+	+1.8	1.9	0.1677/8
									0.2751/7
									0.3401/22
^{152m2}Pm			15. m	β-, I.T./		(>6)			(0.14−1.4)
^{152m1}Pm			7.5 m	β- /		(4-)			0.1218
									0.2447
									0.3404
									1.0971
									1.4375
^{152}Pm		151.92350	4.1 m	β- /3.5	3.5/20	1+			0.1218
					3.50/60				(0.12−2.1)
^{153}Pm		152.92412	5.4 m	β- /1.90	1.7/	(5/2-)			0.0910
									0.1198
									0.1273
^{154m}Pm			2.7 m	β- /	2.0/				0.0820
									0.1848
									1.4403
^{154}Pm		153.92646	1.7 m	β- /4.1	1.9/				0.0820
									0.8396
									1.3940
									2.0589
									(0.08−2.8)
^{155}Pm		154.92810	48. s	β- /3.2		(5/2-)			(0.05−0.78)
^{156}Pm		155.93106	26.7 s	β- /5.16					
^{157}Pm		156.9330	10.9 s	β- /4.6					
^{158}Pm		157.9366	5. s	β- /6.3					
^{159}Pm		158.9390	1.5 s						(0.072-0.261)
^{160}Pm		159.9430							
^{161}Pm		160.9459							
^{162}Pm		161.950							
^{163}Pm		162.954							
$_{62}$Sm		**150.36(2)**							
^{129}Sm		128.954	~ 0.55 s	β+, p					
^{130}Sm		129.9489				0+			
^{131}Sm		130.9461	1.2 s	β+, EC/					ann.rad./
^{132}Sm		131.9407	4.0 s	β+		0+			
^{133}Sm		132.9387	2.9 s	β+, EC/~ 8.4		5/2+			ann.rad./
									0.3696
									0.0845
^{134}Sm		133.9340	11. s	β+, EC/5.		0+			ann.rad./
^{135}Sm		134.9325	10. s	β+, EC/7.		7/2+			ann.rad./
^{136}Sm		135.92828	42. s	β+, EC/4.5		0+			ann.rad./
^{137}Sm		136.92697	45. s	β+, EC/6.1					ann.rad./
^{138}Sm		137.92324	3.0 m	β+, EC/3.9		0+			ann.rad./
									0.0536
									0.0747
^{139m}Sm			10. s	I.T./94 /0.457		(11/2-)	1.1		Sm k x-ray
				β+ /6 /	4.7				0.1118
									0.1553
									0.1901
									0.2673
^{139}Sm		138.92230	2.6 m	β+ /75 /5.5	4.1/	½+	-0.53		Pm k x-ray
				EC/25 /					0.3678
									0.4028

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									(0.27−2.4)
^{140}Sm		139.91900	14.8 m	β+, EC/3.4	1.9/	0+			ann.rad./
									Pm k x-ray
									0.1396
									0.2255
									(0.07−1.7)
^{141m}Sm			22.6 m	β+ /32 /	1.6/	11/2-	-0.83	+1.6	ann.rad./
				EC/68 /	2.19/				Pm k x-ray
				I.T./0.3 /0.1758					0.1966
									0.4318
									0.7774
^{141}Sm		140.91848	10.2 m	β+ /52 /4.54	3.2/	½+	-0.74		ann.rad./
				EC/48 /					Pm k x-ray
									0.4382
^{142}Sm		141.91520	1.208 h	β+ /6 /2.10	1.0/	0+			ann.rad./
				EC/94 /					Pm k x-ray
^{143m}Sm			1.10 m	IT/99/0.7540		11/2-			Sm k x-ray
									0.7540
^{143}Sm		142.914628	8.83 m	β+ /46 /3.443	2.47/	3/2+	+1.01	+0.4	ann.rad./
				EC/54 /					Pm k x-ray
									1.0565
^{144}Sm	3.083(20)	143.911999				0+			
^{145}Sm		144.913410	340. d	EC/0.617		7/2-	-1.12	-0.60	Pm k x-ray
									0.0613
									0.4924
^{146}Sm		145.913041	1.03×10^8 y	α/	2.50/	0+			
^{147}Sm	15.017(75)	146.914898	1.06×10^{11} y	α/	2.23/	7/2-	-0.815	-0.26	
^{148}Sm	11.254(51)	147.914823	7×10^{15} y	α/	1.96/	0+			
^{149}Sm	13.830(56)	148.917185	10^{16} y	α/		7/2-	-0.672	+0.075	
^{150}Sm	7.351(36)	149.917276				0+			
^{151}Sm		150.919932	90. y	β- /0.0768	0.076/	5/2-	-0.363	+0.7	0.02154
^{152}Sm	26.735(48)	151.919732				0+			
^{153}Sm		152.922097	1.929 d	β- /0.808	0.64/	3/2+	-0.0216	+1.3	Eu k x-ray
					0.69/				0.0697/4.7
									0.10318/29
									0.075−0.714
^{154}Sm	22.730(78)	153.922209				0+			
^{155}Sm		154.924640	22.2 m	β- /1.627	1.52	3/2-		1.1	Eu k x-ray
									0.1043/75.
^{156}Sm		155.92553	9.4 h	β- /0.72	0.43/	0+			0.0872
					0.71/				0.1657
									0.2038
^{157}Sm		156.92836	8.0 m	β- /2.7	2.4/	3/2-			Eu k x-ray
									0.1964
									0.1978
									0.3942
^{158}Sm		157.9300	5.5 m	β- /2.0		0+			0.1894/100.
									0.3636/82.
^{159}Sm		158.9332	11.3 s	β- /3.8					0.1898
^{160}Sm		159.9351	9.6 s	β- /3.6		0+			0.110
^{161}Sm		160.9388	~ 4.8 s						0.264
^{162}Sm		161.941	2.4 s			0+			(0.036-0.741)
^{163}Sm		162.945							
^{164}Sm		163.948				0+			
^{165}Sm		164.953							
$_{63}$Eu		**151.964(1)**							
^{130}Eu		129.964	0.9 ms	p	1.027/				
^{131}Eu		130.9578	~ 26. ms	β+, p	p/0.95				

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^{132}Eu		131.9544							
^{133}Eu		132.9492							
^{134}Eu		133.9465	0.5 s	EC, β+					ann.rad./
^{135}Eu		134.9418	1.5 s	EC, β+ /~ 8.7					ann.rad./
^{136m}Eu			~ 3.2 s			7+			0.255
^{136}Eu		135.9396	~ 3.9 s	EC, β+ /10.		1+			ann.rad./
^{137}Eu		136.9356	11. s	EC/~ 7.5		11/2-			ann.rad./
^{138}Eu		137.93371	12. s	EC, β+ /~ 9.2		7+	5		ann.rad./
^{139}Eu		138.92979	18. s	EC, β+ /6.7			6		ann.rad./
^{140m}Eu			0.125 s	EC, β+					ann.rad./
^{140}Eu		139.9281	1.51 s	EC, β+ /8.4		1-			ann.rad./
^{141m}Eu			3.0 s	β+ /58 /		11/2-			ann.rad./
				EC/9 /					Eu k x-ray
				I.T./33 /0.0964					(0.09−1.6)
^{141}Eu		140.92493	40. s	β+ /81 /5.6		5/2+	+3.49	+0.85	ann.rad./
				EC/15 /					Sm k x-ray
									0.3845
									0.3940
^{142m}Eu			1.22 m	β+ /83 /	4.8/	8-	+2.98	+1.4	ann.rad./
				EC/17 /					Sm k x-ray
									0.5566
									0.7680
									1.0233
^{142}Eu		141.92343	2.4 s	β- /94/7.4	7.0/	1+	+1.54	+0.12	ann.rad./
				EC/6 /					0.7680
^{143}Eu		142.92030	2.62 m	β+ /72/5.17	4.1/	5/2+	+3.67	+0.51	ann.rad./
				EC/28/	5.1/				Sm k x-ray
									0.1107/7
									1.5368/3.
									1.9127/2.
^{144}Eu		143.91882	10.2 s	β+ /86 /6.33	5.31/	1+	+1.89	+0.10	ann.rad./
				EC/13 /					Sm k x-ray
									1.6601
^{145}Eu		144.916265	5.93 d	β+ /2 /2.660	0.79/	5/2+	+4.00	+0.29	ann.rad./
				EC/98 /1.71					Sm k x-ray
									0.6535
									0.8937
									1.6587
^{146}Eu		145.91721	4.57 d	β+ /5 /3.88	1.47/	4-	+1.42	-0.18	ann.rad./
				EC/95 /					Sm k x-ray
									0.6336
									0.6341
									0.7470
									(0.27−2.64)
^{147}Eu		146.916746	24.4 d	EC/99. /1.722		5/2+	+3.72	+0.53	Sm k x-ray
				β+ /0.4 /					0.12113/20.6
									0.19725/24.0
									(0.601-1.077)
^{148}Eu		147.91809	54.5 d	EC/3.11	0.92	5-	+2.34	+0.35	Sm k x-ray
									0.5503/99.
									0.6299/71.
									(0.067−2.17)
^{149}Eu		148.917931	93.1 d	EC/0.692		5/2+	+3.57	+0.75	Sm k x-ray
									0.2770/4.1
									0.3275/4.8
^{150}Eu		149.91970	36. y	EC/2.26		5-	+2.71	+1.13	Sm k x-ray
									0.3340
									0.4394
									0.5843
									(0.25−1.8)

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^{150m}Eu			12.8 h	β- /92 /	1.013/	0-			Sm k x-ray
				β+ /0.4 /	1.24/				0.3339
				EC/8 /					0.4065
^{151}Eu	47.81(6)	150.919850				5/2+	+3.472	+0.90	
^{152m2}Eu			1.60 h	I.T./0.1478		8-			Eu k x-ray
									0.0898
^{152m1}Eu			9.30 h	β- /72 /	1.85/	0-			Sm k x-ray
				EC/28 /	0.89/				0.12178
									0.84153
									0.96334
^{152}Eu		151.921745	13.5 y	EC/72 /1.874	0.69/	3-	-1.941	+2.71	Sm k x-ray
				β- /28 /1.818	1.47/				Gd k x-ray
									0.12178
									0.34427
									1.40802
									(0.252−1.528)
^{153}Eu	52.19(6)	152.921230				5/2+	+1.533	+2.41	
^{154m}Eu			46.1 m	I.T./~ 0.16		8-			Eu k x-ray
									0.0682
									0.1009
^{154}Eu		153.922979	8.59 y	β- /99.9/1.969	0.27/29	3-	-2.01	+2.8	Gd k x-ray
				EC/0.02/0.717	0.58/38				0.12299/40.
					0.84/17				0.72331/20.
					0.98/4				1.2745/36
					1.87/11				(0.059-1.90)
^{155}Eu		154.922893	4.76 y	β- /0.252	0.15/	5/2+	+1.52	+2.4	Gd k x-ray
									0.0865/30
									0.1053/20
^{156}Eu		155.92475	15.2 d	β- /2.451	0.30/11	1+	≈1.1		0.08899/9.
					0.49/30				0.64623/7.
					1.2/12				0.723441/6.
					2.45/31				0.8118/10.
^{157}Eu		156.92542	15.13 h	β- /1.36	0.98/	(5/2+)	+1.50	+2.6	Gd k x-ray
					1.30/41				0.0639/100.
									0.3705/48.
									0.4107/76.
^{158}Eu		157.9279	45.9 m	β- /3.5	2.5/	(1-)	+1.44	+0.7	0.0795
									0.8976
									0.9442
									0.9771
^{159}Eu		158.92909	18.1 m	β- /2.51	2.4/	(5/2+)	+1.38	+2.7	0.0678
					2.57/				0.0786
									0.0957
^{160}Eu		159.9320	38. s	β- /4.1	2.7/	(0-)			0.0753
					4.1/				0.1735
									0.4131
									0.5155
									0.8217
									0.9110
									0.9246
^{161}Eu		160.9337	27. s	β- /3.7					0.0719
^{162}Eu		161.9370	11. s	β- /5.6					
^{163}Eu		162.9392							
^{164}Eu		163.943							
^{165}Eu		164.946							
^{166}Eu		165.950							
^{167}Eu		166.953							
$_{64}$Gd		**157.25(3)**							

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^{135}Gd		134.953	1.1 s	β+					(0.163−0.360)
^{136}Gd		135.9473				0+			
^{137}Gd		136.9450	7. s	EC, β+ /~ 8.8					ann.rad./
^{138}Gd		137.9401	~ 4.7 s	EC, β+		0+			0.0647
^{139m}Gd			~ 4.8 s						0.1216
^{139}Gd		138.9382	5. s	EC, β+ /~ 7.7					0.104−0.323
^{140}Gd		139.93367	16. s	EC/4.8		0+			0.1748
^{141m}Gd			25. s	EC, β+ /		11/2-			ann.rad./
^{141}Gd		140.93213	21. s	β+ /7.3		½+			ann.rad./
^{142}Gd		141.92812	1.17 m	EC, β+ /4.2		0+			ann.rad./
^{143m}Gd			1.84 m	β+ /67 /		11/2-			ann.rad./
				EC/33 /					Eu k x-ray
				I.T./					0.1176
									0.2719
									0.5880
									0.6681
									0.7999
^{143}Gd		142.9268	39. s	β+ /82 /6.0		1/2+			ann.rad./
				EC/18 /					Eu k x-ray
									0.2048
									0.2588
^{144}Gd		143.92296	4.5 m	β+ /45 /4.3	3.3/	0+			ann.rad./
				EC/55 /					Eu k x-ray
									0.3332
^{145m}Gd			1.44 m	I.T./95 /0.749		11/2-	-1.0		0.0273
				β+ /4 /5.7					0.3295
									0.3866
									0.7214
^{145}Gd		144.92171	23.4 m	β+ /33 /5.05	2.5/	1/2+	-0.74		ann.rad./
				EC/67 /					Eu k x-ray
									1.7579
									1.8806
									(0.32−3.69)
^{146}Gd		145.918311	48.3 d	EC/99.9 /1.03	0.35/	0+			Eu k x-ray
				β+ /0.2					0.1147
									0.1155
									0.1546
^{147}Gd		146.919094	1.588 d	EC/99.8 /2.188	0.93/	7/2-	1.0		Eu k x-ray
				EC/0.2 /					0.2293
									0.3699
									0.3960
									0.9289
									(0.1−1.8)
^{148}Gd		147.918115	71. y	α/3.27	3.1828/	0+			
^{149}Gd		148.919341	9.3 d	EC/1.32		7/2-	0.9		Eu k x-ray
									0.1496
									0.2985
									0.3465
^{150}Gd		149.91866	1.8×10^6 y	α/2.80	2.73/	0+			
^{151}Gd		150.920348	124. d	EC/0.464		7/2-	0.8		Eu k x-ray
									0.1536
									0.2432
^{152}Gd	0.20(1)	151.919791				0+			
^{153}Gd		152.921750	240. d	EC/0.485		3/2-	0.4		Eu k x-ray
									0.09743
									0.10318
^{154}Gd	2.18(3)	153.920867				0+			
^{155}Gd	14.80(12)	154.922622				3/2-	-0.259	+1.30	
^{156}Gd	20.47(9)	155.922123				0+			
^{157}Gd	15.65(2)	156.923960				3/2-	-0.340	+1.36	

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^{158}Gd	24.84(7)	157.924104				0+			
^{159}Gd		158.926389	18.6 h	β- 0.971	0.971/58	3/2-	-0.44		Tb k x-ray
					0.913/29				0.36351
					0.607/12				0.058-0.855
^{160}Gd	21.86(19)	159.927054	> 1.9 × 10^{19} y	β- β-		0+			
^{161}Gd		160.929669	3.66 m	β- /1.956	1.56/85	5/2-			Tb k x-ray
									0.1023
									0.3149
									0.3609
^{162}Gd		161.930985	8.4 m	β- /1.39	1.0/	0+			0.4030
									0.4421
^{163}Gd		162.9340	1.13 m	β- /3.1					0.2868
									0.214
									1.685
^{164}Gd		163.9359	45. s	β- /2.3		0+			
^{165}Gd		164.9394	10 s	β-					
^{166}Gd		165.942	~ 4.8 s			0+			(0.040-1.015)
^{167}Gd		166.946							
^{168}Gd		167.948				0+			
^{169}Gd		168.953							
$_{65}$Tb		**158.92535(2)**							
^{135}Tb			0.9 ms	p	p/1.179				
^{138}Tb		137.9532							
^{139}Tb		138.9483	1.6 s						0.109
									0.120
^{140}Tb		139.946	2.4 s	β+, EC/11					0.329
									0.355−0.740
^{141}Tb		140.9415	3.5 s	β+, EC/~ 8.3					
^{142m2}Tb			25 μs						
^{142m}Tb			0.30 s	β+, EC/		4-			
^{142}Tb		141.9387	0.60 s	β+, EC/10.		0+			
^{143}Tb		142.9351	12. s	β+, EC/7.4		11/2-			
^{144m}Tb			4.1 s	IT		5-			
^{144}Tb		143.93305	< 1.5 s	β+, EC/8.4		1+			
^{145m}Tb			30. s	β+, EC/~ 6.6		11/2-			ann.rad./
									0.2577
									0.5370
									0.9876
^{145}Tb		144.9293		β+, EC/6.5		½+			
^{146m}Tb			23. s	β+ /76 /		(5-)			ann.rad./
				EC/24 /					Gd k x-ray
									1.0789
									1.5795
^{146}Tb		145.92725	~ 8. s	β+ /8.1		1+			
^{147m}Tb			1.8 m	β+ /35 /		11/2-			ann.rad./
				EC/65 /					Gd k x-ray
									1.3977
									1.7978
^{147}Tb		146.92405	1.6 h	β+ /42 /4.61		5/2+	+1.70		ann.rad./
				EC/58 /					Gd k x-ray
									0.6944
									1.1522
									(0.120−3.318)
^{148m}Tb			2.3 m	β+ /25 /		9+			ann.rad./
				EC/75 /					Gd k x-ray
									0.3945
									0.6319
									0.7845

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									0.8824
^{148}Tb		147.92427	1.00 h	β+, EC/5.69		2-	-1.75	-0.3	ann.rad./
									Gd k x-ray
									0.4888
									0.7845
									(0.14−3.8)
^{149m}Tb			4.16 m	EC/88 /		11/2-			ann.rad./
				β+ /12 /					Gd k x-ray
									0.1650
									0.7960
^{149}Tb		148.923246	4.13 h	β+ /4 /3.636	1.8/	½+	+1.35		Gd k x-ray
				α/16/	3.97/				0.1650
									0.3522
									0.3886
									(0.1−3.2)
^{150m}Tb			6.0 m	β+ /17 /					ann.rad./
				EC/83 /					Gd k x-ray
									0.4384
									0.6380
									0.6504
									0.8275
^{150}Tb		149.92366	3.3 h	β+, EC/4.66		2-	-0.90		ann.rad./
									0.4963
									0.6380
									(0.3−4.29)
^{151m}Tb			25. s	I.T./95 /		11/2-			0.0229
				β+, EC/7 /					0.0495
									0.3797
									0.8305
^{151}Tb		150.923103	17.61 h	β+/1 /2.565	0.70/	1/2+	+0.92		Gd k x-ray
				EC/99 /					0.1083
									0.2517
									0.2870
									(0.1−1.8)
^{152m}Tb			4.3 m	I.T./79 /0.5018		(8+)			Tb k x-ray
				EC/21 /4.35					Gd k x-ray
									0.2833
									0.3443
									0.4111
^{152}Tb		151.92407	17.5 h	β+ /20 /3.99	2.5/	2-	-0.58	+0.3	ann.rad./
				EC/80 /	2.8/				Gd k x-ray
									0.3443
									(0.2−2.88)
^{153}Tb		152.923435	2.34 d	EC/1.570		5/2+	+3.44	+1.1	Gd k x-ray
									0.2119
									(0.05−1.1)
^{154m2}Tb			23.1 h	EC/98 /		(7-)	0.9		Gd k x-ray
				I.T./2 /					0.1231
									0.2479
									0.3467
									1.4199
^{154m1}Tb			9. h	β+ /78 /		(3-)	1.7	+3.	Gd k x-ray
				I.T./22 /					0.1231
									0.2479
									0.5401
									(0.12−2.57)
^{154}Tb		153.92468	21.5 h	EC/99 /3.56	1.86/	0-			Gd k x-ray
				β+ /1 /	2.45				0.1231
									1.2744
									2.1872

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									(0.12−3.14)
^{155}Tb		154.92351	5.3 d	EC/0.82		3/2+	+2.01	+1.41	Gd k x-ray
									0.08654
									0.10530
^{156m2}Tb			1.02 d	I.T./		(7-)			Tb k x-ray
									0.0496
^{156m1}Tb			5.3 h	I.T./0.0884		(0+)			Tb k x-ray
									0.0884
^{156}Tb		155.924747	5.3 d	EC/2.444		3-	~ 1.7	+2.	Gd k x-ray
									0.08896
									0.19921
									0.53435
									1.22245
^{157}Tb		156.924025	1.1×10^2 y	EC/0.0601		3/2+	+2.01	+1.4	Gd k x-ray
									0.0545
^{158m}Tb			10.5 s	I.T./0.11		0-			Gd k x-ray
									0.0110
^{158}Tb		157.925413	1.8×10^2 y	EC/80 /1.220		3-	+1.76	+2.7	Gd k x-ray
				β- /20 /0.937					0.0795
									0.9442
									0.9621
^{159}Tb	100.	158.925347				3/2+	+2.014	+1.43	
^{160}Tb		159.927168	72.3 d	β- /1.835	0.57/47	3-	+1.79	3.8	Dy k x-ray
					0.86/27				0.08678
									0.29857
									0.87936
									0.96615
^{161}Tb		160.927570	6.91 d	β- /0.593	0.46/23	3/2+	2.2	+1.2	Dy k x-ray
					0.52/66				0.02565
					0.6/10				0.04892
									0.07458
^{162}Tb		161.92949	7.6 m	β- /2.51	1.4	(1/2-)			Dy k x-ray
									0.2600
									0.8075
									0.8882
^{163}Tb		162.930648	19.5 m	β- /1.785	0.80/	3/2+			Dy k x-ray
									0.3511
									0.3897
									0.4945
^{164}Tb		163.9334	3.0 m	β- /3.9	1.7/	(5+)			Dy k x-ray
									0.1689
									0.2157
									0.6110
									0.6885
									0.7548
^{165}Tb		164.9349	2.1 m	β- /3.0		3/2+			0.5389
									1.1785
									1.2920
									1.6648
^{166}Tb		165.9380	26 s	β-/					
^{167}Tb		166.9401	19 s						0.057
									0.070
^{168}Tb		167.944	8 s						0.075−0.227
^{169}Tb		168.946							
^{170}Tb		169.950							
^{171}Tb		170.953							
$_{66}$Dy		**162.500(1)**							
^{139}Dy		138.960	0.6 s	β+, p					

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
^{140}Dy		139.954				0+			
^{141}Dy		140.9514	0.9 s	EC, β+ /9.					
^{142}Dy		141.9464	2.3 s	EC, β+ /7.1		0+			
^{143}Dy		142.9438	3.9 s	EC, β+ /~ 8.8					
^{144}Dy		143.93925	9.1 s	EC, β+ /~ 6.2		0+			
^{145m}Dy		144.9365	14. s	EC, β+		11/2-			
^{146m}Dy			0.15 s	I.T.		10+			
^{146}Dy		145.93285	30. s	EC, β+ /5.2		0+			
^{147m}Dy			56. s	I.T./40 /		(11/2-)	-0.66	+0.7	Dy k x-ray
				β+, EC/60 /					0.072
									0.6787
^{147}Dy		146.93109	75. s	EC, β+ /6.37		½+	-0.92		ann.rad./
									0.1007
									0.2534
									0.3653
^{148}Dy		147.92715	3.1 m	β+ /4 /2.68	1.2/	0+			ann.rad./
				EC/96 /					Tb k x-ray
									0.6202
^{149}Dy		148.92731	4.2 m	β+, EC/3.81		(7/2-)	-0.12	-0.62	ann.rad./
									0.1008
									0.1063
									0.2534
									0.6536
									0.7894
									1.7765
									1.8062
^{150}Dy		149.925585	7.18 m	β+, EC/67 /1.79		0+			Tb k x-ray
				α/33 /	4.233/				0.3967
^{151}Dy		150.926185	17. m	β+ /5 /2.871		7/2-	-0.95	-0.30	Tb k x-ray
				EC/89 /					0.1764
				α /6 /	4.067/				0.3030
									0.3861
									0.5463
									(0.16−2.09)
^{152}Dy		151.92472	2.37 h	EC/0.60		0+			Tb k x-ray
				α /	3.63/				0.2569
^{153}Dy		152.925765	6.3 h	β+ /1 /2.171	0.89/	(7/2-)	-0.78	~-0.15	Tb k x-ray
				EC/99 /					0.0807
				α /0.01 /	3.46/				0.0997
									0.2137
									(0.08−1.66)
^{154}Dy		153.92442	3. × 10^6 y	α/2.95	2.87/	0+			
^{155}Dy		154.92575	9.9 h	β+ /2 /2.095	0.845/	3/2-	-0.385	+1.04	Tb k x-ray
				EC/98 /					0.0655
									0.2269
^{156}Dy	0.056(3)	155.92428				0+			
^{157}Dy		156.92547	8.1 h	EC/1.34		3/2-	-0.301	+1.30	Tb k x-ray
									(0.0609−1.319)
^{158}Dy	0.095(3)	157.924409				0+			
^{159}Dy		158.925739	144. d	EC/0.366		3/2-	-0.354	+1.37	Tb k x-ray
									0.3262
^{160}Dy	2.329(18)	159.925198				0+			
^{161}Dy	18.889(42)	160.926933				5/2+	-0.480	+2.51	
^{162}Dy	25.475(36)	161.926798				0+			
^{163}Dy	24.896(42)	162.928731				5/2-	+0.673	+2.65	
^{164}Dy	28.260(54)	163.929175				0+			
^{165m}Dy			1.26 m	I.T./98 /0.108		1/2-			Dy k x-ray
				β- /2 /					0.1082
									0.5155
^{165}Dy		164.931703	2.33 h	β- /1.286	1.29/	7/2+	-0.52	+3.5	Ho k x-ray

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									0.09468/3.8
^{166}Dy		165.932807	3.400 d	β- /0.486	0.40/	0+			Ho k x-ray
									0.0282
									0.0825
^{167}Dy		166.9357	6.2 m	β- /~ 2.35	1.78	(1/2-)			Ho k x-ray
									0.2593
									0.3103
									0.5697
									(0.06−1.4)
^{168}Dy		167.9371	8.5 m	β- /1.6		0+			Ho k x-ray
									0.1925
									0.4867
^{169}Dy		168.9403	~ 39. s	β- /3.2					
^{170}Dy		169.9424				0+			
^{171}Dy		170.9462							
^{172}Dy		171.9488				0+			
^{173}Dy		172.953							
$_{67}$Ho		**164.93032(2)**							
^{140}Ho		139.969	6 ms	p/	p/1.09				
^{141m}Ho			8 μs	p/	p/1.23				
^{141}Ho		140.963	4.2 ms	β+, p	p/1.71				
^{142}Ho		141.960	0.4 s	EC/β+, p					0.307
^{143}Ho		142.9546	> 0.2 μs						
^{144}Ho		143.9515	0.7 s	β+, EC/12					
^{145}Ho		144.9472	2.4 s	β+					
^{146}Ho		145.9446	3.3 s	β+, EC/10.7		(10+)			ann.rad./
^{147}Ho		146.94006	5.8 s	β+, EC/8.2		11/2-			ann.rad./
^{148m}Ho			9. s	β+, EC/		4-			ann.rad./
^{148}Ho		147.9377	2. s	β+, EC/9.4		1+			ann.rad./
									0.6615
									1.6883
^{149m}Ho			21. s	β+, EC/		11/2-			ann.rad./
									1.0733
									1.0911
^{149}Ho		148.93378	> 30. s	β+, EC/6.01		1/2+			
^{150m}Ho			25. s	β+, EC/		(9+)			ann.rad./
									0.3939
									0.5511
									0.6534
									0.8034
^{150}Ho		149.93350	1.3 m	β+, EC/6.6					ann.rad./
									0.5913
									0.6534
									0.8034
^{151m}Ho			47. s	β+, EC/87 /					ann.rad./
				α/13	4.605/				0.2102
									0.4889
									0.6948
									0.7762
^{151}Ho		150.93169	35.2 s	β+, EC/80/5.13					ann.rad./
				α/20 /	4.519/				0.3522
									0.5274
									0.9676
									1.0471
^{152m}Ho			50. s	β+, EC/90/		(9+)	+5.9	-1.	ann.rad./
				α/10/	4.453/				0.4929
									0.6138
									0.6474

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									0.6835
^{152}Ho		151.93171	2.4 m	β+, EC/88/6.47		(3+)	-1.02	+0.1	ann.rad./
				α/12/	4.387/				0.6140
									0.6476
^{153m}Ho			9.3 m	β+, EC/99+/4.12		5/2	+1.19		ann.rad./
				α/	4.01/				0.0905
									0.1089
									0.1618
									0.2302
									0.2707
									0.3659
									0.4565
^{153}Ho		152.93020	2.0 m	β+, EC/99+/4.13		11/2-	+6.8	-1.1	ann.rad./
				α/	3.91/				0.2958
									0.3346
									0.4381
									0.6383
^{154m}Ho			3.3 m	β+, EC/		(8+)	5.7	-1.0	ann.rad./
									0.3346
									0.4124
									0.4771
^{154}Ho		153.93060	12. m	β+, EC/5.75		1-	-0.64	+0.2	ann.rad./
									Dy k x-ray
									0.3346
									0.5700
									0.8734
^{155}Ho		154.92910	48. m	β+/6/3.10		(5/2+)	+3.51	+1.5	ann.rad./
				EC/94 /					Dy k x-ray
									0.0474
									0.1363
									0.3254
									(0.06−2.24)
^{156m}Ho			5.8 m	I.T./0.0352			+2.99	+2.3	ann.rad./
				β+ /25 /	1.8/				Dy k x-ray
				EC/75 /	2.9/				0.1378
									0.2666
									(0.28−2.9)
^{156}Ho		155.92984	56. m	β+, EC/4.4		(5+)			ann.rad./
									0.1378
									0.2665
^{157}Ho		156.92826	12.6 m	β+/5/2.54	1.18/	7/2-	+4.35	+3.0	ann.rad./
				EC/95/					Dy k x-ray
									0.2800
									0.3411
^{158m2}Ho			28. m	I.T./44/		2-	+2.44	+1.6	ann.rad./
				EC/56/					Dy k x-ray
									0.0989
									0.2182
^{158m1}Ho			21. m	β+, EC/		(9+)			ann.rad./
									0.0981
									0.1664
									0.2182
									0.3205
									0.4062
									0.9774
									1.0532
									0.4846
^{158}Ho		157.92894	11.3 m	β+/8/4.24	1.30/	5+	+3.77	+4.1	ann.rad./
				EC/92/					Dy k x-ray
									0.0989

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									0.2182
									0.9488
^{159m}Ho			8.3 s	IT/0.206		1/2+			Ho k x-ray
									0.1660
									0.2059
^{159}Ho		158.927712	33.0 m	EC/1.838		7/2-	+4.28	+3.2	Dy k x-ray
									0.1210
									0.1320
									0.2529
									0.3096
									(0.06−1.2)
^{160m2}Ho			3. s			1+			
^{160m}Ho			5.0 h	IT/67/0.060		2-	+2.52	+1.8	0.0868
				EC/33/3.35					0.1970
									0.6464
									0.7281
									0.8791
									0.9619
									0.9658
^{160}Ho		159.92873	25.6 m	β+, EC/3.29	0.57/	5+	+3.71	+4.0	See Ho[166m]
									0.7282
									0.8794
^{161m}Ho			6.8 s	IT/0.211					Ho k x-ray
									0.2112
^{161}Ho		160.927855	2.48 h	EC/0.859		7/2-	+4.25	+3.2	Dy k x-ray
									0.0256
									0.0592
									0.0774
									0.1031
^{162m}Ho			1.12 h	IT/61/		6-	+3.60	+4.	Dy k x-ray
				EC/39/					Ho k x-ray
									0.0807
									0.1850
									0.2828
									0.9372
									1.2200
^{162}Ho		161.929096	15. m	EC/96 /0.295		1+			Dy k x-ray
				β+ /4 /					0.0807
									1.3196
									1.3728
^{163m}Ho			1.09 s	I.T./0.298		(1/2+)			Ho k x-ray
									0.2798
^{163}Ho		162.928734	4.57×10^3 y	EC/0.00258		7/2-	+4.23	+3.6	Dy M x-rays
^{164m}Ho			38. m	I.T./0.140		(6-)			Ho k x-ray
									0.0373
									0.0566
									0.0940
^{164}Ho		163.930234	29. m	EC/58 /0.987		1+			Dy k x-ray
				β- /42 /0.963					0.0734
									0.0914
^{165}Ho	100.	164.930322				7/2-	+4.17	+3.49	
^{166m}Ho			1.2×10^3 y	β- /		7-	3.6	-3.	Er k x-ray
									0.18407
									0.71169
									0.81031
^{166}Ho		165.932284	1.117 d	β- /1.855	1.776/48	0-			Er k x-ray
					1.855/51				0.08057
									1.37943
^{167}Ho		166.93313	3.1 h	β- /1.007	0.31/43	(7/2-)			Er k x-ray
					0.61/21				0.0793

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
					0.96/15				0.0835
					0.97/15				0.2379
									0.3213
									0.3465
^{168m}Ho			2.2 m	I.T./					
^{168}Ho		167.93552	3.0 m	β- /2.91	2.0/	3+			Er k x-ray
									0.7413
									0.8159
									0.8211
									(0.08−2.34)
^{169}Ho		168.93687	4.7 m	β- /2.12	1.2/	(7/2-)			
					2.0/				0.1496
									0.7610
									0.7784
									0.7884
									0.8529
^{170m}Ho			43. s	β- /		1+			0.0787
									0.8123
									1.8940
									1.9726
^{170}Ho		169.93962	2.8 m	β- /3.87		6+			Er k x-ray
									0.1816
									0.2582
									0.8902
									0.9321
									0.9414
									1.1387
^{171}Ho		170.941	53 s	β- /					
^{172}Ho		171.9448	25. s	β- /					Er k x-ray
									(0.077−1.186)
^{173}Ho		172.9473							
^{174}Ho		173.951							
^{175}Ho		174.954							
$_{68}$Er		**167.259(3)**							
^{144}Er		143.9604	> 0.2 μs			0+			
^{145}Er		144.9574	0.9 s	β+					
^{146}Er		145.9520	~ 1.7 s	β+		0+			
^{147}Er		146.9495	2.5 s	E.C, β+ /~ 9.1					
^{148}Er		147.9446	4.5 s	β+, EC/6.8		0+			
^{149m}Er			10. s	IT		11/2-			
^{149}Er		148.94231	10.7 s	ECβ+ /8.1		½+			
^{150}Er		149.93791	18. s	β+ /36 /4.11		0+			ann.rad./
				EC/64 /					Ho k x-ray
									0.4758
^{151}Er		150.93745	23. s	β+, EC/5.2		7/2-			ann.rad./
^{152}Er		151.93505	10.2 s	β+, EC/10/3.11		0+			ann.rad./
				α/90/	4.804/				
^{153}Er		152.935063	37.1 s	α/	4.674		-0.934	-0.42	0.351
				β+, EC/47/4.56	4.35/				(0.0945−1.700)
^{154}Er		153.93278	3.7 m	β+, EC/99+/2.03		0+			ann.rad./
				α/0.5/	4.166/				
^{155}Er		154.93321	5.3 m	β+, EC/47/3.84		(7/2-)	-0.669	-0.27	ann.rad./
				EC/53 /					Ho k x-ray
									0.1101
									0.2415
^{156}Er		155.93107	20. m	β+, EC/1.7		0+			ann.rad./
									0.0298
									0.0352
									0.0522
									0.1336

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
^{157}Er		156.93192	25. m	β+, EC/3.5		3/2-	-0.412	+0.92	ann.rad./
									0.117
									0.385
									1.320
									1.660
									1.820
									2.000
^{158}Er		157.92989	2.2 h	EC/99.5 /1.78	0.74/	0+			Ho k x-ray
				β+ /0.5 /					0.0719
									0.2486
									0.3868
^{159}Er		158.930684	36. m	β+ /7 /2.769		3/2-	-0.304	+1.17	ann.rad./
				EC/93 /					Ho k x-ray
									0.6245
									0.6493
									(0.07−2.5)
^{160}Er		159.92908	1.191 d	EC/0.33		0+			Ho k x-ray
									(0.05−0.96)
^{161}Er		160.93000	3.21 h	EC/2.00		3/2-	-0.37	+1.36	Ho k x-ray
									0.8265
									(0.07−1.74)
^{162}Er	0.139(5)	161.928778				0+			
^{163}Er		162.93003	1.25 h	EC/1.210		5/2-	+0.557	+2.55	Ho k x-ray
									0.4361
									0.4399
									1.1135
^{164}Er	1.601(3)	163.929200				0+			
^{165}Er		164.930726	10.36 h	EC/0.376		5/2-	+0.643	+2.71	Ho k x-ray
^{166}Er	33.503(36)	165.930293				0+			
^{167m}Er			2.27 s	I.T./0.208		½-			Er k x-ray
									0.2078
^{167}Er	22.869(9)	166.932048				7/2+	-0.5639	+3.57	
^{168}Er	26.978(18)	167.932370				0+			
^{169}Er		168.934590	9.40 d	β- /0.351	0.35/~ 100	½-	+0.485		Tm k x-ray
									0.1098
									0.1182
^{170}Er	14.910(36)	169.935464				0+			
^{171}Er		170.938030	7.52 h	β- /1.491		5/2-	0.66	2.9	Tm k x-ray
									0.11160
									0.29591
									0.30832
									(0.08−1.4)
^{172}Er		171.939356	2.05 d	β-/0.891	0.28/48	0+			Tm k x-ray
					0.36/46				0.0597
									0.4073
									0.6101
^{173}Er		172.9424	1.4 m	β- /2.6		(7/2-)			Tm k x-ray
									0.1928
									0.1992
									0.8952
^{174}Er		173.9442	3.1 m	β- /1.8		0+			Tm k x-ray
									(0.100−0.152)
^{175}Er		174.9478	1.2 m	β-					(0.0765−1.168)
^{176}Er		175.9501				0+			
^{177}Er		176.954							
$_{69}$Tm		**168.93421(2)**							
^{144}Tm			~ 1.9 μs	p	1.70, 1.43				
^{145}Tm		144.9701	3.1 μs	p// ~ 10	1.73/91				

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
					1.4/9				
^{146m}Tm			0.198 s	β+, p	p/1.118/100				
					1.01/				
					0.89/8				
^{146}Tm		145.9664	0.08 s	β+/14.	p/1.19/100				
				p	1.01/28				
					0.94/22				
^{147m}Tm			0.4 ms	β+, p	p/1.115				
^{147}Tm		146.9610	0.56 s	EC, β+/85	~ 10.7				
				p/15/	1.052/				
^{148m}Tm		147.9578	0.7 s	β+, EC/12.					ann.rad./
^{148}Tm									
^{149}Tm		148.9527	0.9 s	β+, EC/~ 9.2		11/2-			
^{150}Tm		149.9500	2.3 s	β+, EC/~ 11.5		6-			(0.1007−2.177)
^{151}Tm		150.94548	4. s	β+, EC/7.5					ann.rad./
^{152m}Tm			8. s	β+, EC/		9+			
^{152}Tm		151.9444	5. s	β+, EC/8.8					ann.rad./
^{153}Tm		152.94201	1.6 s	β+, EC/10 /6.46					ann.rad./
				α/90 /	5.109/				
^{154m}Tm			3.3 s	β+, EC/15 /	α/5.031/100				ann.rad./
				α/	4.84/0.24				0.4605−0.7960
^{154}Tm		153.94157	8.1 s	β+, EC/56 /7.4	α/4.956/100				ann.rad./
				α/44 /	4.83/0.45				
^{155}Tm		154.93920	30. s	β+, EC/5.58					0.0315
				α/	4.46/				0.0638
									0.0881
									0.2268
									0.5320
									0.6067
^{156m}Tm			19. s	α/	4.46/				
^{156}Tm		155.93898	1.40 m	β+, EC/7.6		2-	+0.40	-0.5	ann.rad./
				α/	4.23/				0.3446
									0.4529
									0.5860
^{157}Tm		156.93697	3.6 m	β+, EC/4.5	2.6	½	+0.48		ann.rad./
				α/	3.97/				0.1104
									0.3484
									0.3855
									0.4550
									(0.1−1.58)
^{158}Tm		157.93698	4.0 m	β+, EC/74 /6.5		(2-)	+0.04	+0.7	ann.rad./
				EC/26 /					Er k x-ray
									0.1921
									0.3351
									0.6280
									1.1498
									(0.18−2.81)
^{159}Tm		158.93498	9.1 m	β+/23 /3.9		5/2+	+3.42	+1.9	ann.rad./
				EC/77 /					Er k x-ray
									0.0591
									0.0848
									0.2713
									(0.05−1.27)
^{160m}Tm			1.24 m	IT		(5)			
^{160}Tm		159.93526	9.4 m	β+/15 /5.9		1-	+0.16	+0.58	ann.rad./
				EC/85 /					Er k x-ray
									0.1264
									0.2642
									0.7285
									0.8544

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									0.8614
									1.3685
^{161}Tm		160.93355	31. m	β+, EC/3.2		7/2+	+2.40	+2.9	ann.rad./
									Er k x-ray
									0.0595
									0.0844
									1.6481
									(0.04−2.15)
^{162m}Tm			24. s	I.T./90 /		5+			Tm k x-ray
				β+, EC/10 /					Er k x-ray
									0.0669
									0.8115
									0.9003
^{162}Tm		161.93400	21.7 m	β+ /8 /4.81		1-	+0.07	+0.69	ann.rad./
				EC/92 /					Er k x-ray
									0.1020
									0.7987
									(0.1−3.75)
^{163}Tm		162.93265	1.81 h	EC/98 /2.439		½+	-0.082		Er k x-ray
				β+ /1 /					0.0692
									0.1043
									0.2414
^{164m}Tm			5.1 m	I.T./80 /		6-			0.0914
				β+, EC/20 /					0.1394
									0.2081
									0.2405
									0.3149
^{164}Tm		163.93356	2.0 m	β+ /36 /3.96	2.94/	1+	+2.38	+0.71	ann.rad./
				EC/64 /					Er k x-ray
									0.0914
^{165}Tm		164.932435	1.253 d	EC/1.593		½+	-0.139		Er k x-ray
									0.0472
									0.0544
									0.29728
									0.80636
^{166}Tm		165.93355	7.70 h	EC/98 /3.04		2+	+0.092	+2.14	Er k x-ray
				β+ /2 /					0.0806
									0.1844
									0.7789
									1.2734
									2.0524
^{167}Tm		166.932852	9.24 d	EC/0.748		½+	-0.197		Er k x-ray
									0.0571
									0.20778
^{168}Tm		167.934173	93.1 d	EC/1.679		3+	+0.23	+3.2	Er k x-ray
									0.19825
									0.4475
									0.81595
^{169}Tm	100	168.934213				½+	-0.232	-1.2	
^{170}Tm		169.935801	128.6 d	β- /99.8/0.968	0.883/24	1-	+0.247	+0.74	Yb k x-ray
				EC/0.2 /0.314	0.968/76				0.08425
^{171}Tm		170.936429	1.92 y	β- /0.096	0.03/2	½+	-0.230		0.06674
					0.096/98				
^{172}Tm		171.93840	2.65 d	β- /1.88	1.79/36	2-			Yb k x-ray
					1.88/29				0.07879
									1.38722
									1.46601
									1.52982
									1.60861
^{173}Tm		172.939604	8.2 h	β- /1.298	0.80/21	½+			Yb k x-ray

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
					0.86/71				0.3988
									0.4613
^{174m}Tm			2.29 s						
^{174}Tm		173.94217	5.4 m	β- /3.08	0.70/14	(4-)			Yb k x-ray
					1.20/83				0.07664
									0.17669
									0.27332
									0.3666
									0.99205
									(0.08−1.6)
^{175}Tm		174.94384	15.2 m	β- /2.39	0.9/36	(1/2+)			Yb k x-ray
					1.9/23				0.36396
									0.51487
									0.94125
									0.98247
^{176}Tm		175.9470	1.9 m	β-/4.2	2.0/	(4+)			Yb k x-ray
					1.2/				0.1898
									0.3819
									1.0691
^{177}Tm		176.9490	1.4 m	β-					
^{178}Tm		177.9526							
^{179}Tm		178.955							
$_{70}$Yb		**173.04(3)**							
^{148}Yb		147.967				0+			
^{149}Yb		148.964	0.7 s	β+, p	p/2.5−6.4/				0.647
^{150}Yb		149.9584	> 0.2 μs			0+			
^{151}Yb		150.9554	1.6 s	β+ /8.5					
^{152}Yb		151.9503	3.2 s	β+ EC/5.5		0+			
^{153}Yb		152.9495	4. s	β+ EC/6.7					
^{154}Yb		153.94639	0.40 s	β+ EC/7 /4.49		0+			ann.rad./
				α/93 /	5.32/				
^{155}Yb		154.9458	1.7 s	β+, EC/16 /6.0			-0.8	-1.	ann.rad./
				α/84 /	5.19/				
^{156}Yb		155.94282	26. s	β+, EC/21/3.57		0+			ann.rad./
				α/79 /	4.69/				
^{157}Yb		156.94263	39. s	β+, EC/99+/5.5			-0.64		ann.rad./
				α/0.5/	4.69/				0.231
									(0.035−0.670)
^{158}Yb		157.93987	1.5 m	β+, EC/1.9		0+			ann.rad./
									0.0741
									0.2526
^{159}Yb		158.94005	1.4 m	EC, β+/5.1			-0.37	-.022	Tm k x-ray
									0.1661
									0.1772
									0.3297
									0.3903
^{160}Yb		159.93755	4.8 m	β+, EC/2.0		0+			ann.rad./
									0.1404
									0.1737
									0.2158
^{161}Yb		160.93790	4.2 m	β+, EC/3.9		3/2-	-0.33	+1.03	ann.rad./
									Tm k x-ray
									0.0782
									0.5999
									0.6315
^{162}Yb		161.93577	18.9 m	β+, EC/1.7		0+			ann.rad./
									Tm k x-ray
									0.1188

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									0.1635
^{163}Yb		162.93633	11.1 m	β+ /26 /3.4	1.4/	3/2-	-0.37	+1.24	ann.rad./
									Tm k x-ray
									0.0636
									0.8603
									(0.06 −1.9)
^{164}Yb		163.93449	1.26 h	EC/1.0		0+			Tm k x-ray
									0.0914
									0.6752
^{165}Yb		164.93528	9.9 m	β+ /10 /2.76	1.58/	(5/2-)	+0.48	+2.48	ann.rad./
				EC/90 /					Tm k x-ray
									0.0801
									1.0903
^{166}Yb		165.93388	2.363 d	EC/0.30		0+			Tm k x-ray
									0.0828
									0.1844
									0.7789
									1.2734
									2.0524
^{167}Yb		166.934950	17.5 m	β+ /0.5 /1.954	0.639/	5/2-	+0.62	+2.70	Tm k x-ray
				EC/99.5 /					0.06296
									0.10616
									0.11337
									0.17633
^{168}Yb	0.13(1)	167.933897				0+			
^{169m}Yb			46. s	I.T./0.0242		1/2-			Yb L x-ray
									0.0242
^{169}Yb		168.935190	32.02 d	EC/0.909		7/2+	-0.63	+3.5	0.1979/35.9
									0.3078/10.05
									0.0207−0.2611
^{170}Yb	3.04(15)	169.934762				0+			
^{171}Yb	14.28(57)	170.936326				1/2-	+0.49367		
^{172}Yb	21.83(67)	171.936382				0+			
^{173}Yb	16.13(27)	172.938211				5/2-	-0.67989	+2.80	
^{174}Yb	31.83(92)	173.938862				0+			
^{175}Yb		174.941277	4.19 d	β- /0.470	0.466/73	7/2-	0.77		Lu k x-ray
					0.071/21				0.3963/13
					0.353/6.2				(0.114−0.28)
^{176m}Yb			11.4 s	I.T./1.051		(8-)			Yb k x-ray
									0.0961
									0.1901
									0.2929
									0.3897
^{176}Yb	12.76(41)	175.942572	10^{26} y	β-β-		0+			
^{177m}Yb			6.41 s	I.T./0.3315		1/2-			Yb k x-ray
									0.1131
									0.2084
^{177}Yb		176.945261	1.9 h	β- /1.399	1.40	9/2+			Lu k x-ray
									0.1504
^{178}Yb		177.94665	1.23 h	β- /0.65	0.25/	0+			0.1415
									0.3246
									0.3516
									0.3815
									0.6125
^{179}Yb		178.9502	8. m	β- /2.4					
^{180}Yb		179.9523	2. m	β-		0+			0.1028−0.4423
^{181}Yb		180.9562							
$_{71}$Lu		**174.967(1)**							

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
^{150m}Lu			0.045 ms	p/1.29					
^{150}Lu		149.973	43. ms	p					
^{151m}Lu			16 μs	p/1.31					
^{151}Lu		150.9676	0.08 s	p/1.231					
^{152}Lu		151.9641	0.7 s						
^{153}Lu		152.9588	0.9 s						
^{154}Lu		153.9575	1.0 s	β+, EC/10.8					
^{155m}Lu			2.6 ms	α/7.41					
^{155}Lu		154.95432	0.07 s	EC/8.0					
				α/	5.66/90				
^{156m}Lu			0.20 s	α/	5.57/				
^{156}Lu		155.9530	~ 0.5 s	β+, EC/9.5					ann.rad./
				α/	5.45/				
^{157m}Lu			~ 9.6 s	α	4.925/				
^{157}Lu		156.95010	4.8 s	β+, EC/94 /6.93					ann.rad./
				α/	5.00/				
^{158}Lu		157.94931	10.4 s	β+, EC/99 /8.0					ann.rad./
				α/	4.67/				0.3682
									0.4770
^{159}Lu		158.94663	12.3 s	β+, EC/6.0					ann.rad./
									0.1505
									0.1875
									0.3693
^{160}Lu		159.9460	36.1 s	β+, EC/7.3					ann.rad./
									0.2434
									0.3957
									0.5773
^{161}Lu		160.94357	1.2 m	β+, EC/5.3					ann.rad./
									0.0437
									0.0671
									0.1003
									0.1108
									0.1562
									0.2562
^{162m}Lu			~ 1.5 m	EC/		4-			
^{162}Lu		161.9433	1.37 m	β+, EC/6.9		1-			ann.rad./
									0.1666
									0.6314
^{163}Lu		162.94118	4.1 m	β+, EC/4.6					ann.rad./
									0.0539
									0.0581
									0.1504
									0.1631
									0.3717
^{164}Lu		163.94134	3.14 m	β+, EC/6.3	1.6/				0.1238
					3.8/				0.2621
									0.7404
									0.8639
									0.8804
^{165}Lu		164.93941	10.7 m	β+, EC/3.9	2.06/	1/2+			ann.rad./
									0.1206
									0.1324
									0.1742
									0.2036
									(0.04−2.0)
^{166m2}Lu			2.1 m	β+ /35 /		(0-)			ann.rad./
				EC/65 /					Yb k x-ray
									1.0673
									1.2566
									2.0986

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
^{166m1}Lu			1.4 m	β+, EC/58 /		(3-)			ann.rad./
				I.T./42 /0.0344					0.1024
									0.2281
									0.2861
									0.8119
									0.8301
^{166}Lu		165.93986	2.8 m	β+ /25 /5.5		(6-)			ann.rad./
				EC/75 /					Yb k x-ray
									0.1024
									0.2281
									0.3375
									0.3679
^{167}Lu		166.93827	52. m	β+ /2 /3.1	2.1/	7/2+			Yb k x-ray
				EC/98 /					0.0297
									0.2392
									(0.03−2.0)
^{168m}Lu			6.7 m	β+ /12 /		3+			ann.rad./
				EC/88 /					Yb k x-ray
				IT/<0.8					0.1988/190
									0.8960/100
									0.9792/128
									0.018−2.65
^{168}Lu		167.93874	5.5 m	β+ /6 /4.5	1.2/	(6-)			ann.rad./
				EC/94 /					Yb k x-ray
									0.1114
									0.1124
									0.2286
									0.3483
									1.4836
^{169m}Lu			2.7 m	I.T./0.0290		1/2-			Lu L x-ray
									0.0290
^{169}Lu		168.93765	1.419 d	EC/2.293	1.271/	7/2+	2.30	3.5	Yb k x-ray
									0.19121
									0.9606
									(0.08−2.1)
^{170m}Lu			0.7 s	I.T./0.0929		4-			Lu L x-ray
									0.04449
									0.0484
^{170}Lu		169.93848	2.01 d	EC/3.46	2.44/	0+			Yb k x-ray
									0.58711
									0.5908
									1.28029
									(0.1−3.38)
^{171m}Lu			1.31 m	I.T./0.0711		1/2-			Lu k x-ray
									0.07119
^{171}Lu		170.937913	8.24 d	EC/1.479	0.362/	7/2+	2.30	3.42	Yb k x-ray
									0.01939
									0.66744
									(0.02−1.3)
^{172m}Lu			3.7 m	I.T./0.0419		1-			Lu L x-rays
									0.04186
^{172}Lu		171.939086	6.64 d	EC/2.519		4-	2.90	3.80	Yb k x-ray
									0.18156
									1.09367
									(0.07−2.2)
^{173}Lu		172.938931	1.37 y	EC/0.671		7/2+	2.28	3.63	Yb k x-ray
									0.07860
									0.27198
^{174m}Lu			142. d	IT/99.3/	0.17086	6-	1.50		Lu k x-ray
				EC/0.7 /					0.067055

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
^{174}Lu		173.940338	3.3 y	EC/1.374		1-	1.9		Yb k x-ray
									0.07664
									1.2419
^{175}Lu	97.41(2)	174.940772				7/2+	+2.2327	+3.49	
^{176m}Lu			3.66 h	β- /1.315	1.229/	1-	+0.318	-1.47	Hf k x-ray
					1.317/				0.088372
^{176}Lu	2.59(2)	175.942686	3.73×10^{10} y	β- /1.192		7-	+3.169	+4.92	Hf k x-ray
				β+/ < 0.9					0.20187
									0.30691
^{177m2}Lu			6. m	β-		39/2-			0.089
^{177m}Lu			160.7 d	IT/22/0.9702		23/2-	2.33	5.4	Lu k x-ray
				β- /78					Hf k x-ray
									0.11295
									0.20836
									0.37850
									0.41853
^{177}Lu		176.943758	6.65 d	β- /0.498	0.497/	7/2+	+2.239	+3.39	0.11295
									0.20836
^{178m}Lu			23.1 m	β- /		(9-)			0.2166
									0.3317
^{178}Lu		177.945955	28.5 m	β-/2.099	2.03/	1+			Hf k x-ray
									0.0932
									1.3099
									1.3408
									(0.09−1.7)
^{179}Lu		178.94733	4.6 h	β- /1.405	1.35/	7/2+			0.2143
									0.3377
^{180}Lu		179.9499	5.7 m	β- /3.1	1.49/				0.40795/50.
									(0.07−1.9)
^{181}Lu		180.9520	3.5 m	β- /2.5		(7/2+)			0.0458
									0.2059
									0.5749
^{182}Lu		181.9550	2.0 m	β- /~ 4.1					0.0978
									0.7208
									0.8182
^{183}Lu		182.9576	58. s	β- /		7/2+			
^{184}Lu		183.9609	20 s	β-					
$_{72}$Hf		**178.49(2)**							
^{153}Hf		152.971	> 0.2 μs						
^{154}Hf		153.965	2. s	EC, β+/~ 6.7		0+			
^{155}Hf		154.9634	0.9 s	EC, β+/8.					
^{156}Hf		155.9594	25. ms	α/		0+			
^{157}Hf		156.9584	0.11 s	α/					
^{158}Hf		157.95480	2.9 s	EC/54 /5.1		0+			
				α/46 /	5.27/				
^{159}Hf		158.95400	5.6 s	β+, EC/88 /6.9					ann.rad./
				α/12 /	5.09/				
^{160}Hf		159.95068	~ 12. s	β+, EC/97 /4.9		0+			ann.rad./
				α/4.78					
^{161}Hf		160.95028	17. s	α/	4.60/				
^{162}Hf		161.94721	38. s	β+, EC/3.7		0+			ann.rad./
									0.1739
									0.1963
									0.4101
^{163}Hf		162.94709	40. s	β+, EC/5.5					ann.rad./
									0.0454
									0.0621
									0.0710

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									0.6882
^{164}Hf		163.94438	2.8 m	EC, β+/3.0		0+			
^{165}Hf		164.94457	1.32 m	EC/4.6		11/2-			
^{166}Hf		165.94218	6.8 m	EC/93 /2.3		0+			ann.rad./
				β+ /7 /					Lu k x-ray
									0.0788
^{167}Hf		166.94260	2.0 m	β+ /40 /4.0		(5/2-)			ann.rad./
				EC/60 /					Lu k x-ray
									0.1754
									0.3152
^{168}Hf		167.94057	25.9 m	β+, EC/1.8		0+			ann.rad./
									(0.0144–1.311)
^{169}Hf		168.94126	3.25 m	EC/85 /3.3		(5/2-)			ann.rad./
				β+ /15 /					Lu k x-ray
									0.3695
									0.4929
^{170}Hf		169.93961	16.0 h	EC/1.1		0+			Lu k x-ray
									0.0985
									0.1202
									0.1647
									0.5729
									0.6207
^{171m}Hf			30. s			(1/2-)	+0.53		
^{171}Hf		170.94049	12.2 h	EC, β+ /2.4		7/2+	-0.67	+3.46	ann.rad./
									Lu k x-ray
									0.1221
									0.6620
									1.0714
^{172}Hf		171.93945	1.87 y	EC/0.35		0+			Lu k x-ray
									0.02399
									0.12582
									(0.0818–0.123)
^{173}Hf		172.94051	23.6 h	EC/1.6		½-			Lu k x-ray
									0.12367
									0.13963
									0.29697
									0.31124
									(0.1–2.1)
^{174}Hf	0.16(1)	173.940046	2.0×10^{15} y			0+			
^{175}Hf		174.941509	71. d	EC/0.686		5/2-	-0.60	+2.7	Lu k x-ray
									0.08936
									0.34340
^{176}Hf	5.26(7)	175.941409				0+			
^{177m2}Hf			51.4 m	I.T./2.740		37/2-			Hf k x-ray
									0.2140
									0.2951
									0.3115
									0.3267
^{177m1}Hf			1.1 s	I.T./		23/2+			Hf k x-ray
									0.20836
									0.22847
									0.37851
^{177}Hf	18.60(9)	176.943221				7/2-	+0.7935	+0.337	
^{178m2}Hf			31. y	I.T./		16+	+8.16	+6.00	Hf k x-ray
									0.32555
									0.42635
									0.089–0.574
^{178m1}Hf			4.0 s	I.T./		8-			Hf k x-ray
									0.21342
									0.32555

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									0.42635
^{178}Hf	27.28(7)	177.943699				0+			
^{179m2}Hf			25.1 d	I.T./1.1057		25/2-	7.4		Hf k x-ray
									0.1227
									0.1461
									0.3626
									0.4537
^{179m1}Hf			18.7 s	I.T./0.375		½-			Hf k x-ray
									0.1607
									0.2141
^{179}Hf	13.62(2)	178.945816				9/2+	-0.641	+3.79	
^{180m}Hf			5.52 h	I.T./1.1416		8-	+9.	+4.6	Hf k x-ray
									0.2152
									0.3323
									0.4432
^{180}Hf	35.08(16)	179.946550				0+			
^{181m}Hf			1.5 ms	/1.738		25/2-			
^{181}Hf		180.949101	42.4 d	β- /1.027	0.408/	1/2-			Ta k x-ray
									0.13294/54
									0.48200/100
									0.3459/20
^{182m}Hf			62. m	β- /54 /1.60	0.49/43	8-			Hf k x-ray
				IT/46 /1.173	0.95/10				0.0509
									0.2244
									0.3441
									0.4558
									0.5066
									0.9428
^{182}Hf		181.95055	8.9×10^6 y	β- /0.37		0+			Ta k x-ray
									0.2704/79
									(0.098-0.270)
^{183}Hf		182.95353	1.07 h	β- /2.01	1.18/68	3/2-			Ta k x-ray
					1.54/25				0.0732
									0.4591
									0.7837
^{184}Hf		183.95545	4.1 h	β- /1.34	0.74/38	0+			Ta k x-ray
					0.85/16				0.0414
					1.10/46				0.1391
									0.3449
^{185}Hf		184.9588	~ 3.5 m	β- /					0.165
^{186}Hf		185.9609	~ 2.6 m			0+			0.738
^{187}Hf		186.9646	> 0.3 μs						
^{188}Hf		187.967	> 0.3 μs			0+			
$_{73}$Ta		**180.94788(2)**							
^{155}Ta		154.975	12 μs	p/1.77					
^{156}Ta		155.9723	0.11 s	β+ /~ 11.6					
				p/	1.02/~ 100				
^{157}Ta		156.9682	10 ms	α/	6.117				
				p/	0.927/3.4				
^{158}Ta		157.9667	37. ms	α/	6.05/100				
					5.97/100				
^{159}Ta		158.96302	0.6 s	β+, EC/20 /8.5	α/5.52/34				ann.rad./
				α/80 /	5.60/55				
^{160}Ta		159.9615	1.4 s	β+, EC/10.1					ann.rad./
				α	5.41/				
^{161}Ta		160.9584	3.16 s	β+, EC/7.5					ann.rad./
				α/	5.15				
^{162}Ta		161.9573	4. s	EC/8.6					

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
^{163}Ta		162.95433	10.6 s	EC/6.8					
^{164}Ta		163.95353	14.2 s	β+ /8.5		3+			ann.rad./
				α/	4.62/				0.2110
									0.3768
^{165}Ta		164.95077	31. s	ECβ+/5.9					
^{166}Ta		165.95051	34. s	β+ /82 /7.7					ann.rad./
				EC/18 /					Hf k x-ray
									0.1587
									0.3117
									0.8101
^{167}Ta		166.94809	1.4 m	β+, EC/5.6					ann.rad./
^{168}Ta		167.94805	2.4 m	β+ /77 /6.7		3+			ann.rad./
				EC/23 /					Hf k x-ray
									0.1239
									0.2615
									0.7502
^{169}Ta		168.94601	4.9 m	β+, EC/4.4					ann.rad./
									0.0288
									0.1535
									0.1924
^{170}Ta		169.94618	6.8 m	β +/70 /6.0		(3+)			ann.rad./
				EC/35 /					Hf k x-ray
									0.1008
									0.2212
^{171}Ta		170.94448	23.3 m	β+, EC/3.7		(5/2-)			0.0496
									0.5018
									0.5064
									(0.05−1.02)
^{172}Ta		171.94490	36.8 m	β+ /25 /4.9		(3-)			ann.rad./
				EC/75 /					Hf k x-ray
									0.21396
									1.10923
									(0.09 −3.8)
^{173}Ta		172.94375	3.6 h	β+ /24 /3.7		(5/2-)	1.70	-1.9	ann.rad./
				EC/76 /					Hf k x-ray
									0.06972
									0.17219
									(0.06 −2.7)
^{174}Ta		173.94445	1.12 h	β+ /27 /3.8		(3+)			ann.rad./
				EC/73 /					Hf k x-ray
									0.09089
									0.20638
									(0.09−3.64)
^{175}Ta		174.94374	10.5 h	EC/2.0		7/2+	2.27	+3.7	Hf k x-ray
									0.2077
									0.2671
									0.3487
^{176}Ta		175.94486	8.1 h	EC/3.1		1-			Hf k x-ray
									0.08837
									1.15735
^{177}Ta		176.944472	2.356 d	EC/1.166		7/2+	2.25		Hf k x-ray
									0.11295
									(0.07−1.06)
^{178m}Ta			2.4 h	EC/		(7-)			Hf k x-ray
									0.08886
									0.21342
									0.32555
									0.42635
^{178}Ta		177.94578	9.29 m	EC/99 /1.9		1+	+2.74	+0.65	ann.rad./
				β+ /1 /					Hf k x-ray

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									0.09316
^{179}Ta		178.945930	1.8 y	EC/0.110		7/2+	2.29	3.37	Hf k x-ray
^{180m}Ta	0.0120(2)		>1.2 × 10^{15} y			(9-)	4.82		
^{180}Ta		179.947465	8.15 h	EC/87 /0.854		1+			Hf k x-ray
				β- /13 /0.708	0.61/3				W k x-ray
					0.71/10				0.09333
									0.10340
^{181}Ta	99.9880(2)	180.947996				7/2+	+2.370	+3.3	
^{182m}Ta			15.8 m	I.T./0.5198		10-			Ta k x-ray
									0.14678
									0.17157
^{182}Ta		181.950152	114.43 d	β- /1.814	0.25/30	3-	+3.02	+2.6	W k x-ray
					0.44/20				1.12127/100
					0.52/40				1.22138/79
									0.085−1.289
^{183}Ta		182.951373	5.1 d	β- /1.070	0.45/5	7/2+	+2.36		W k x-ray
					0.62/91				0.0847
									0.0991
									0.1079
									0.2461
									0.3540
^{184}Ta		183.95401	8.7 h	β- /2.87	1.11/15	(5-)			W k x-ray
					1.17/81				0.2528/44.
									0.4140/74.
									(0.09−1.4)
^{185}Ta		184.95556	49. m	β- /1.99	1.21/5	(7/2+)			W k x-ray
					1.77/81				0.0697
									0.1739
									0.1776
^{186}Ta		185.9586	10.5 m	β- /3.9	2.2/	(3-)			W k x-ray
									0.1979
									0.2149
									0.5106
									(0.09−1.5)
^{187}Ta		186.9605	> 0.3 μs						
^{188}Ta		187.9637	5 μs						0.292
^{189}Ta		188.9658	> 0.3 μs						
$_{74}$W		**183.84(1)**							
^{158m}W			0.14 ms	α	8.28(3)/				
^{158}W		157.975	1.3 ms	α/	6.433/96	0+			
^{159}W		158.9729	7. ms	α/					
^{160}W		159.9685	0.08 s	α/	5.92/	0+			
^{161}W		160.9674	0.41 s	β+, EC/18 /8.1					
				α/82 /	5.78/				
^{162}W		161.9635	1.39 s	β+, EC/54 /5.8		0+			
				α/46 /	5.54/				
^{163}W		162.9625	2.8 s	β+, EC/59 /7.5					
				α/41 /	5.38/				
^{164}W		163.95895	6. s	β+, EC/97 /5.0		0+			ann.rad./
				α/3 /	5.15/				
^{165}W		164.95828	5.1 s	β+, EC/99 /7.0					ann.rad./
				α/1 /	4.91/				
^{166}W		165.95503	16. s	β+, EC/99 /4.2		0+			ann.rad./
				α/1 /	4.74/				
^{167}W		166.95482	20. s	EC/5.6					
^{168}W		167.95181	53. s	EC/3.8		0+			ann.rad./
				α/10^{-5}/	4.40(1)				Ta k x-ray
									0.1755

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									(0.037–0.573)
^{169}W		168.95178	1.3 m	EC/5.4					ann.rad./
									Ta k x-ray
									0.123
									(0.097–0.699)
^{170}W		169.94923	2.4 m	EC/2.2		0+			ann.rad./
									Ta k x-ray
									0.3162
									(0.060–0.144)
^{171}W		170.94945	2.4 m	EC/4.6					ann.rad./
									Ta k x-ray
									0.1842
									(0.052–0.479)
^{172}W		171.94729	6.6 m	β+, EC/2.5		0+			ann.rad./
									Ta k x-ray
									0.0389
									(0.034–0.674)
^{173}W		172.94769	6.3 m	EC/4.0					ann.rad./
									Ta k x-ray
									0.4576
									(0.035–0.623)
^{174}W		173.94608	35. m	EC/1.9		0+			ann.rad./
									Ta k x-ray
									0.3287
									0.4288
									(0.056–0.429)
^{175}W		174.94672	35. m	EC/2.9		½-			(0.015–0.27)
^{176}W		175.94563	2.5 h	β+, EC/0.8		0+			0.03358
									0.06129
									0.09487
									0.10020
^{177}W		176.94664	2.21 h	EC/2.0		(1/2-)			Ta k x-ray
									0.15505
									0.18569
									0.42694
^{178}W		177.94588	21.6 d	EC/0.091		0+			Ta k x-ray
^{179m}W			6.4 m	IT/99.7/0.222		(1/2-)			W k x-ray
				EC/0.3/					0.2220
^{179}W		178.94707	38. m	EC/1.06		(7/2-)			Ta k x-ray
									0.0307
^{180}W	0.12(1)	179.946704	1.8×10^{18} y	α/		0+			
^{181}W		180.948197	121.1 d	EC/0.188		9/2+			Ta k x-ray
									0.13617
									0.15221
^{182}W	26.50(16)	181.948204	$> 7.7 \times 10^{21}$ y	α/		0+			
^{183m}W			5.15 s	I.T./		(11/2+)			W k x-ray
									0.0465
									0.0526
									0.0991
									0.1605
^{183}W	14.31(4)	182.950223	$> 4.1 \times 10^{21}$ y	α/		½-	+0.1177848		
^{184}W	30.64(2)	183.950931	$> 8.9 \times 10^{21}$ y	α/		0+			
^{185m}W			1.6 m	I.T./0.1974		11/2+			W k x-ray
									0.0659
									0.1315
									0.1737
^{185}W		184.953419	74.8 d	β- /0.433	0.433/99.9	3/2-			0.12536
^{186}W	28.43(19)	185.954364	$> 8.2 \times 10^{21}$ y	α/		0+			
^{187m}W			1.6 μs	IT	0.411	11/2+			(0.014-0.287)
^{187}W		186.957161	23.9 h	β- /1.311	0.624/66	3/2-	0.62		Re k x-ray

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					1.315/16				0.68572/33
					0.081−1.18				0.134−0.773
^{188}W		187.958489	69.78 d	β- /0.349	0.349/99	0+			0.0636
									0.2271
									0.2907
^{189}W		188.9619	9.7 m	β- /2.5	1.4/	(3/2-)			0.2604
					2.5/				(0.1262-1.466)
^{190m}W			~ 0.06 ms						(0.0585-0.694)
^{190}W		189.9632	30. m	β- /1.3	0.95/	0+			Re k x-ray
									0.1576
									0.1621
^{191}W		190.9666	> 0.3 μs						
^{192}W		191.968	> 0.3 μs			0+			
$_{75}$Re		**186.207(1)**							
^{160}Re		159.9821	0.7 ms	p/	1.261(6)/91				
				α/	6.54/				
^{161}Re		160.9776	14 ms	α/	6.24				
				p	1.35				
^{162}Re		161.9760	0.10 s	α/	6.12/94				
					6.09/94				
^{163}Re		162.97208	0.26 s	β+, EC/9.0	α/5.87/32				
				α/	5.92/66				
^{164}Re		163.9703	0.9 s	β+, EC/10.7					
				α/	5.78/				
^{165m}Re			~ 2.37 s	α/	5.502/				
^{165}Re		164.96709	2.6 s	β+, EC/87 /8.1					
				α/	5.49/ < 5.				
^{166}Re		165.9658	2.5 s	β+, EC/9.4					
				α/	5.50/				
^{167m}Re			6.2 s	α, EC/					
^{167}Re		166.9626	3.4 s	β+, EC/7.4					
				α/	5.015/				
^{168}Re		167.96157	4.4 s	β+, EC/9.1					
				α/	4.833/				0.1117
^{169m}Re			8.1 s	α	4.70/				
					4.87/				
^{169}Re		168.95879	16. s						
^{170}Re		169.95822	9.2 s	β+, EC/9.0					0.1560
									0.3055
									0.4125
^{171}Re		170.95572	15.2 s	EC/~ 5.7					
^{172m}Re			55. s	β+, EC/		(2)			ann.rad./
									0.1234
									0.2537
									0.3504
^{172}Re		171.9554	15. s	β+, EC/7.3					ann.rad./
									0.1234
									0.2537
^{173}Re		172.95324	2.0 m	EC/~ 3.9					ann.rad./
^{174}Re		173.95312	2.4 m	β+, EC/5.6					ann.rad./
									0.1119
									0.2430
^{175}Re		174.95138	5.8 m	β+, EC/4.3					ann.rad./
^{176}Re		175.95162	5.3 m	β+, EC/5.6		(3+)			ann.rad./
									0.1089
									0.2406
^{177}Re		176.95033	14. m	EC/78 /3.4		(5/2-)			ann.rad./
				β+ /22 /					W k x-ray

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									0.0797
									0.0843
									0.1968
^{178}Re		177.95099	13.2 m	β+ /11 /4.7	3.3/	(3+)			ann.rad./
				EC/89 /					W k x-ray
									0.1059
									0.2373
									0.9391
^{179m}Re			0.47 ms						
^{179}Re		178.94999	19.7 m	EC/99 /2.71	0.95/	(5/2+)	2.8		W k x-ray
				β+ /1 /					0.1199
									0.2900
									0.4154
									0.4302
									1.6803
^{180}Re		179.95079	2.45 m	EC/92 /3.80	1.76/	1-	1.6		ann.rad./
				β+ /8 /					W k x-ray
									0.1036
									0.9028
									(0.07−2.2)
^{181}Re		180.95007	20. h	EC /1.74		5/2+	3.19		W k x-ray
									0.3607
									0.3655
									0.6390
^{182m}Re			12.7 h	EC/	0.55/	2+	3.3	+1.8	W k x-ray
					1.74/				0.0677
									1.1214
									1.2215
									(0.06−2.2)
^{182}Re		181.9512	2.67 d	EC/2.8		(7+)	2.8	+4.1	W k x-ray
									0.0678
									0.2293
									1.1213
									1.2214
^{183}Re		182.95082	70. d	EC/0.56		(5/2+)	+3.17	+2.3	W k x-ray
									0.16232
^{184m}Re			165. d	I.T./75 /0.188		8+	+2.9		Re k x-ray
				EC/25 /					0.1047
									0.2165
									0.92093
									(0.10−1.1)
^{184}Re		183.952521	38. d	EC/1.48		3-	+2.53	+2.8	W k x-ray
									0.79207
									0.90328
									(0.1−1.4)
^{185}Re	37.40(2)	184.952955				5/2+	+3.1871	+2.18	
^{186m}Re			2.0×10^5 y	I.T./0.150		8+			Re k x-ray
									0.0590
^{186}Re		185.954986	3.718 d	β- /92 /1.070	0.973/21	1-	+1.739	+0.62	W k x-ray
				EC/8 /0.582	1.07/71				0.1227/0.6
									0.1372/9.5
									(0.63−0.77)
^{187}Re	62.60(2)	186.955753	4.2×10^{10} y	β- /0.00266	0.0025/	5/2+	+3.2197	+2.07	
^{188m}Re			18.6 m	I.T./0.172		(6-)			Re k x-ray
									0.0925
									0.1059
^{188}Re		187.958114	17.00 h	β- /2.120	1.962/20	1-	+1.788	+0.57	Os k x-ray
					2.118/79				0.15502
									0.309−2.022
^{189}Re		188.95923	24. h	β- /1.01	1.01/	(5/2+)			0.1471

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									0.2167
									0.2194
									0.2451
^{190m}Re			3.0 h	β- /51 /		(6-)			Re k x-ray
				I.T./49 /					0.1191
									0.2238
									0.6731
									(0.1−1.79)
^{190}Re		189.9618	3.0 m	β- /3.2	1.8/	(2-)			Os k x-ray
									0.1867
									0.5580
									0.6051
^{191}Re		190.96313	9.7 m	β- /2.05	1.8/				
^{192m}Re			~ 0.12 ms						(0.0606-0.146)
^{192}Re		191.9660	16. s	β- /4.2	~ 2.5/				(0.2−0.75)
^{193m}Re			~ 0.08 ms						(0.061-0.146)
^{193}Re		192.9675	> 0.3 μs						
^{194}Re		193.9704	> 0.3 μs						
$_{76}$Os		**190.23(3)**							
^{162}Os		161.984	1.8 ms	α/	6.60	0+			
^{163}Os		162.9827	5.5 ms	α/	6.51				
^{164}Os		163.9780	0.04 s	α		0+			
^{165}Os		164.9768	0.07 s	α					
^{166}Os		165.97269	0.18 s	β+, EC/28 /6.3	6.27/	0+			ann. rad./
				α/72 /	5.98/				
^{167}Os		166.9716	0.7 s	β+, EC/76 /8.2					ann.rad./
				α/24 /	5.84/				
^{168}Os		167.96780	2.2 s	β+, EC/51 /5.7		0+			ann. rad./
				α/49 /					
^{169}Os		168.96702	3.3 s	β+, EC/89 /7.7	5.57/80				ann.rad./
				α/13 /	5.51/12				
					5.54/8				
^{170}Os		169.96358	7.1 s	β+, EC/5.0		0+			ann.rad./
				α/	5.40/				(0.162−0.216)
^{171}Os		170.96319	8.4 s	β+, EC/98 /7.1	α/5.24/93.5				ann.rad./
				α/19 /	5.17/6.5				0.190−0.705
^{172}Os		171.96002	19. s	β+, EC/99 /4.5		0+			ann.rad./
				α/1.1/	5.10/				(0.063−1.120)
^{173}Os		172.95981	16. s	β+, EC/6.3					ann.rad./
				α/0.4 /	4.94/				0.142−0.299
^{174}Os		173.95706	44. s	β+, EC/3.9		0+			0.118
				α/0.02 /	4.76/				0.138 / 0.001
									0.158
									0.325
^{175}Os		174.95695	1.4 m	β+, EC/5.3					0.125
									0.181
									0.248
^{176}Os		175.95481	3.6 m	β+, EC/3.2		0+			0.8155
									0.7758
									0.8573
									1.2093
									1.2909
^{177}Os		176.95497	2.8 m	β+, EC/4.5		(1/2-)			0.0848
									0.1958
									0.3002
									1.2686
^{178}Os		177.95325	5.0 m	β+, EC/2.3		0+			ann.rad./
									0.5946

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									0.6850
									0.9687
									1.3311
^{179}Os		178.95382	7. m	β+, EC/3.7					ann.rad./
									0.0654
									0.2186
									0.5938
^{180}Os		179.95238	21.5 m	β+, EC/1.5		0+			Re k x-ray
									0.0202−0.7174
^{181m}Os			1.75 h	EC/		(1/2-)			ann.rad./
									0.0489
^{181}Os		180.95324	2.7 m	EC/2.9		(7/2-)			ann.rad./
									0.11794
									0.23868
									0.8267
									(0.07−2.64)
^{182}Os		181.95211	21.5 h	EC/0.9		0+			Re k x-ray
									0.1802
									0.5100
^{183m}Os			9.9 h	EC/84 /		½-			Os k x-ray
				I.T./16 /					Re k x-ray
									1.1020
									1.1080
^{183}Os		182.95313	13. h	EC/2.1		9/2+	-0.79	+3.1	Re k x-ray
									0.1144
									0.3818
^{184}Os	0.02(1)	183.952489				0+			
^{185}Os		184.954042	93.6 d	EC/1.013		½-			Re k x-ray
									0.6461
									0.8748
									0.8805
^{186}Os	1.59(3)	185.953838	2. × 10^{15} y	α/	~ 2.75/	0+			
^{187}Os	1.96(2)	186.955750				½-	+0.0646519		
^{188}Os	13.24(8)	187.955838				0+			
^{189m}Os			5.8 h	I.T./0.0308		9/2-			Os L x-ray
									0.0308
^{189}Os	16.15(5)	188.958148				3/2+	+0.65993	+0.86	
^{190m}Os			9.9 m	I.T./1.705		10-	-0.6		Os k x-ray
									0.1867
									0.3611
									0.5026
									0.6161
^{190}Os	26.26(2)	189.958447				0+			
^{191m}Os			13.1 h	I.T./0.0744		3/2-			Os k x-ray
									0.0744
^{191}Os		190.960930	15.4 d	β- /0.314	0.140/100	9/2-		+2.5	Ir k x-ray
									0.1294
^{192m}Os			6.0 s	I.T./2.0154		(10-)			Os k x-ray
									0.2058/65.9
									0.5692/70
									(0.201−1.000)
^{192}Os	40.78(19)	191.961481				0+			
^{193}Os		192.964152	30.5 h	β- /1.141	1.04/20	3/2-	+0.730	+0.47	Ir k x-ray
									0.1389
									0.4605
^{194}Os		193.965182	6.0 y	β- /0.097	0.054/33	0+			Ir L x-ray
					0.096/67				0.0429
^{195}Os		194.968	6.5 m	β- /2.0	2.0/				
^{196}Os		195.96964	34.9 m	β- /1.16	0.84/	0+			0.1262/5
									0.4079/5.9

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
^{197}Os			2.8 m	β-					0.2239
									(0.0412-0.406)
$_{77}$Ir		**192.217(3)**							
^{164}Ir		163.9922	0.06 ms	p	1.78				
^{165}Ir		164.9875	0.3 ms	p/87	1.71				
				α/13	6.72				
^{166m}Ir			14.3 ms	α/98.2	6.545				
				p/1.8	1.32				
^{166}Ir		165.9858	0.010 s	α/93	6.56				
				p/6.9	1.15				
^{167m}Ir			26. ms	α/48, β+	6.39/90				
				p/32	1.25/0.42				
^{167}Ir		166.98167	32. ms	α/80, β+	6.35/48				
				p/0.4	1.06/39.3				
^{168}Ir		167.9799	0.16 s	α/82					
^{169m}Ir			280. ms	α/	6.12/59				
^{169}Ir		168.97630	353. ms	α/	5.99/42				
^{170}Ir		169.9750	0.43 s	α/	6.03/				
^{171}Ir		170.97163	1.3 s	α/	5.91/				
^{172}Ir		171.9705	2.1 s	α/	5.811/				0.228
									(0.379−0.475)
^{173}Ir		172.96750	3.0 s	α/	5.665/				0.0493
									(0.092−0.296)
^{174}Ir		173.96686	4. s	α/	5.478/				0.1587
									(0.276−1.33)
^{175}Ir		174.96411	~ 4.5 s	α/	5.393/				0.1056
^{176}Ir		175.96365	8. s	EC, β+/80					0.260
				α/3.2/	5.118/				(0.135−0.415)
^{177}Ir		176.96130	30. s	EC, β+/5.7					0.184
				α/0.06/	5.011/				(0.062−0.194)
^{178}Ir		177.96108	12. s	β+, EC/6.3					
									0.1320
									0.2667
									0.3633
^{179}Ir		178.95912	4. m	EC/4.9					0.0975
									(0.045−0.220)
^{180}Ir		179.95923	1.5 m	EC/6.4					0.2765
									((0.132−1.106)
^{181}Ir		180.95763	4.9 m	β+, EC/4.1		(7/2+)			ann.rad./
									0.1076
									(0.0196−1.715)
^{182}Ir		181.95808	15. m	β+ /44 /5.6					ann.rad./
				EC/56 /					Os k x-ray
									0.1273
									0.2370
^{183}Ir		182.95685	57. m	β+, EC/3.5					ann.rad./
									0.0877
									0.2285
									0.2824
^{184}Ir		183.95748	3.0 h	β+ /12 /4.6	2.3/	5-	0.70	+2.41	ann.rad./
				EC/88 /	2.9/				Os k x-ray
									0.11968
									0.2640
									0.3904
^{185}Ir		184.95670	14. h	β+ /3 /2.4		(5/2-)	2.60	-2.1	ann.rad./
				EC/97 /					Os k x-ray
									0.2543
									1.8288

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^{186m}Ir			1.7 h	EC /		(2-)	0.64	+1.46	Os k x-ray
									0.1371
									0.7675
^{186}Ir		185.95795	15.7 h	EC/98 /3.83		(5+)	3.9	-2.55	Os k x-ray
				β+ /2 /					0.1372
									0.2968
									0.4348
									(0.13−3.0)
^{187}Ir		186.95736	10.5 h	EC/1.50		3/2+		+0.94	Os k x-ray
									0.0743
									0.4009
									0.4271
									0.6109
									0.9128
^{188}Ir		187.95885	1.72 d	β+ /2.81	1.13/	(2-)	0.30	+0.48	Os k x-ray
				EC/99+ /	1.64/				0.1550
									0.4780
									0.6330
									2.2146
^{189}Ir		188.95872	13.2 d	EC/0.53		3/2+	0.13	+0.88	Os k x-ray
									0.2449
^{190m2}Ir			3.09 h	β+, EC/95 /		(11-)			0.376
				I.T./5 /					
^{190m1}Ir			1.12 h	I.T. /0.0263		7+			Ir L x-ray
^{190}Ir		189.960546	11.8 d	EC/2.0		(4+)	0.04	+2.8	Os k x-ray
									0.1867
									0.4072
									0.5186
									0.5580
									0.6051
									(0.2−1.4)
^{191m}Ir			4.93 s	I.T./0.1714		11/2-	+0.603		Ir k x-ray
									0.1294
^{191}Ir	37.3(2)	190.960594				3/2+	+0.151	+0.82	
^{192m2}Ir			241. y	I.T./0.161		(9+)			Ir k x-ray
^{192m1}Ir			1.44 m	I.T./0.0580		(1+)			Ir L x-ray
									0.0580
									0.3165
^{192}Ir		191.962605	73.83 d	β- /1.460		(4-)	+1.92	+2.15	Pt k x-ray
									0.31649/83.
									0.46806/48.
^{193m}Ir			10.53 d	I.T./0.0802		11/2-			Ir L x-ray
									0.0803
^{193}Ir	62.7(2)	192.962926				3/2+	+0.164	+0.75	
^{194m}Ir			170. d	β- /		11			Pt k x-ray
									0.3284
									0.4829
									0.5624
^{194}Ir		193.965078	19.3 h	β-/2.247	1.92/9	1-	+0.39	+0.34	0.2935
					2.25/86				0.3284
									0.6451
									(0.1−2.2)
^{195m}Ir			3.9 h	β- /	0.41/	(11/2-)			Pt k x-ray
					0.97/				0.3199/9.6
									0.3649/9.5
									0.4329/9.6
									0.6849/9.6
^{195}Ir		194.965980	2.8 h	β- /1.120	1.0/80	(3/2+)			Pt k x-ray
					1.11/13				0.0989/9.7
^{196m}Ir			1.40 h	β-/	1.16/				Pt k x-ray

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									0.3557
									0.3935
									0.4471
									0.5214
									0.6473
^{196}Ir		195.96840	52. s	β- /3.21	2.1/15	0-			0.3329
					3.2/80				0.3557
									0.7796
^{197m}Ir			8.9 m	β- /		(11/2-)			0.3465
				I.T./					see Ir[197]
^{197}Ir		196.96965	5.8 m	β- /2.16	1.5/	(3/2+)			0.0531
					2.0/				0.1351
									0.4306
									0.4697
^{198}Ir		197.9723	8. s	β- /4.1					0.4074
									0.5070
^{199}Ir		198.97380							
$_{78}$Pt		**195.084(9)**							
^{166}Pt		165.995	0.3 ms	α/	7.11/	0+			
^{167}Pt		166.930	0.9 ms	α/	6.98/				
^{168}Pt		167.9882	2.1 ms	α	6.82	0+			0.582/69
									0.594/69
									0.725/62
^{169}Pt		168.9867	7.0 ms	α	6.69				
^{170}Pt		169.98250	14.0 ms	α	6.55	0+			0.509/100
									0.662/86
									0.214–0.726
^{171}Pt		170.9812	0.05 s	α	6.45				0.4450
									(0.1564-1.208)
^{172}Pt		171.97735	0.10 s	α/	6.31/94	0+			
^{173}Pt		172.9764	0.36 s	β+, EC/8.2	6.23				
				α/	6.20/				
^{174}Pt		173.97282	0.89 s	β+, EC/17 /5.6		0+			
				α/83 /	6.040/				
^{175}Pt		174.97242	2.5 s	β+, EC/65 /7.6					0.0774
				α/35 /	5.831/5				0.1354
					5.96/54				0.2128
					6.038/				
^{176}Pt		175.96895	6.3 s	β+, EC/60 /5.1		0+			ann.rad./
				α/40 /	5.528/0.6				0.2277
					5.750/41				
^{177}Pt		176.96847	11. s	EC/91 /6.8	5.53/				0.0908
				α/9 /	5.485/3				
					5.525/6				
^{178}Pt		177.96565	21. s	EC/93 /4.5		0+			
				α/7 /	5.286/0.2				
					5.442/7				
^{179}Pt		178.96536	33. s	β+, EC/5.7			+0.43		
				α/	5.16/				
^{180}Pt		179.96303	52. s	β+, EC/99.7 /3.7	0+				
				α/0.3 /	5.140/				
^{181}Pt		180.96310	51. s	β+, EC/5.2			+0.48		
^{182}Pt		181.96117	2.7 m	β+, EC/2.9		0+			ann.rad./
									0.1360
									0.1460
									0.2100
^{183m}Pt			43. s	β+, EC/		(7/2-)	+0.78	+3.4	ann.rad./
				I.T./					0.3132/26

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									0.3164/59
									0.6296/100
									0.058−1.75
^{183}Pt		182.96160	7. m	β+, EC/4.6			+0.50		ann.rad./
									0.119/100
									0.307/93
									0.260/90
									0.058−1.377
^{184}Pt		183.95992	17.3 m	β+, EC/2.3		0+			ann.rad./
									0.1549
									0.1919
									0.5484
^{185m}Pt			33. m	β+, EC/		½-	+0.5		
^{185}Pt		184.96062	1.18 h	β+, EC/3.8		(9/2+)	-0.75	+3.7	ann.rad./
									0.1353
									0.1974
									0.2296
									0.2551
^{186}Pt		185.95935	2.0 h	β+, EC/1.38		0+			ann.rad./
									0.6115
									0.6892
^{187}Pt		186.96059	2.35 h	β+, EC/3.1		3/2-	-0.41	-1.1	ann.rad./
									Ir k x-ray
									0.1064
									0.1100
									0.2015
									0.2849
									0.7092
^{188}Pt		187.95940	10.2 d	EC/0.51		0+			Ir k x-ray
									0.1876
									0.1951
^{189}Pt		188.96083	10.9 h	β+, EC/1.97		3/2-	-0.43	-1.2	Ir k x-ray
									0.0943
									0.6076
									0.7214
									(0.09−1.47)
^{190}Pt	0.014(1)	189.95993	4.5×10^{11} y			0+			
^{191}Pt		190.961677	2.86 d	EC/1.02		(3/2-)	-0.50	-0.9	Ir k x-ray
									0.3599
									0.4094
									0.5389
^{192}Pt	0.782(7)	191.961038				0+			
^{193m}Pt			4.33 d	I.T./0.1498		13/2+	-0.75		Pt k x-ray
									0.1355
^{193}Pt		192.962988	60. y	EC/0.0566		(1/2-)	+0.60		Ir k x-rays
^{194}Pt	32.967(99)	193.962680				0+			
^{195m}Pt			4.01 d	I.T./0.2952		13/2+	-0.61	+1.4	Pt k x-ray
									0.0989
^{195}Pt	33.832(10)	194.964791				1/2-	+0.6095		
^{196}Pt	25.242(41)	195.964952				0+			
^{197m}Pt			1.590 h	I.T./97 /		13/2+			Pt k x-ray
				β- /3 /					0.0530
									0.3465
^{197}Pt		196.967340	19.9 h	β- /0.719		1/2-	0.51		Au k x-ray
									0.1914
									0.2688
^{198}Pt	7.163(55)	197.967893				0+			
^{199m}Pt			13.6 s	I.T./0.424		13/2+			Pt k x-ray
									0.3919
^{199}Pt		198.970593	30.8 m	β- /1.70	0.90/18	(5/2-)			0.3170/3.88

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
					1.14/14				0.49375/4.47
									0.5430/11.7
									(0.055−1.293)
^{200}Pt		199.971441	12.5 h	β- /~ 0.66		0+			Au k x-ray
									0.13590
									0.22747
									0.24371
^{201}Pt		200.97451	2.5 m	β- /2.66		(5/2-)			0.070
									0.152
									0.222
									1.760
^{202m}Pt			0.3 ms						(0.535-0.719)
^{202}Pt		201.9757	1.8 d			0+			0.440
$_{79}$Au		**196.966569(4)**							
^{170m}Au			0.62 ms	p/58	1.74/				
				α/42	7.11/				
^{170}Au		169.9961	0.30 ms	p/89	1.46/				
				α/11	7.00/				
^{171m}Au			1.09 ms	α/66	6.995				
				p/34	1.694				
^{171}Au		170.99188	0.022 ms	p/100	1.437				
^{172}Au		171.9900	4 ms	α/7.02	6.86				
^{173m}Au			15 ms	α/92	6.732				
^{173}Au		172.98624	0.02 s	α/94	6.672				
^{174}Au		173.9848	0.14 s	α	6.54				
^{175}Au		174.98127	0.15 s	α					
^{176}Au		175.9801	0.9 s	β+, EC/10.5					
				α/	6.260/80				
					6.290/20				
^{177}Au		176.97687	1.2 s	α/	6.115/				
					6.150/				
^{178}Au		177.9760	2.6 s	α/	5.920/				
^{179}Au		178.97321	7.5 s	α/	5.85/				
^{180}Au		179.97252	8.1 s	EC/8.6	5.65				0.1522
				α/	5.61				0.2564
					5.50				0.5242
									0.6765
									0.8084
									0.8597
^{181}Au		180.97008	11.4 s	EC/97.5/6.3	5.482/				
				α/2.7/					
^{182}Au		181.96962	21. s	β+, EC/6.9					ann.rad./
				α/0.13/					0.1549
									0.2649
									(0.13−1.4)
^{183}Au		182.96759	42. s	EC/5.5			+1.97		0.1630
				α/0.8/					0.2730
									0.3625
^{184m}Au			48 s	I.T.		(2+)	+1.44	+1.9	0.069(IT)
^{184}Au		183.96745	21. s	EC, β+/7.1		(5+)	+2.07	+4.7	
				α/0.013/					
^{185m}Au			6.8 m	β+, EC/					
				I.T./0.145					
^{185}Au		184.96579	4.3 m	β+, EC/4.71		(5/2-)	+2.17	-1.1	ann.rad./
				α/0.26/					
^{186m}Au			< 2. m	β+, EC/					0.1915
^{186}Au		185.96595	10.7 m	β+, EC/6.0		3-	-1.26	+3.1	ann.rad./

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
				α/8(10)$^{-4}$/					0.1915
									0.2988
^{187m}Au			2.3 s	IT		9/2-			
^{187}Au		186.96457	8.3 m	β+, EC/3.60		1/2+	+0.54		ann.rad./
									0.9152
									1.2668
									1.3321
									1.4081
^{188}Au		187.96532	8.8 m	β+, EC/5.3		(1-)	-0.07		ann.rad./
									0.2660
									0.3404
									0.6061
^{189m}Au			4.6 m	β+, EC/		11/2-	+6.19		0.1667
^{189}Au		188.96395	28.7 m	EC/96 /3.2		1/2+	+0.49		ann.rad./
				β+ /4 /					Pt k x-ray
									0.4478
									0.7133
									0.8128
^{190}Au		189.96470	43. m	β+ /2 /4.44		1-	-0.07		ann.rad./
				EC/98 /					Pt k x-ray
									0.2958
									0.3018
									0.5977
^{191m}Au			0.9 s	I.T./0.2663		(11/2-)	6.6		Au k x-ray
									0.2414
									0.2526
^{191}Au		190.96370	3.2 h	EC/1.83		3/2+	+0.137	+0.72	Pt k x-ray
									0.5864/16
									(0.088−1.30)
^{192}Au		191.96481	4.9 h	β+ /5 /3.52	2.19/	1-	-0.011	-0.23	ann.rad./
				EC/95 /	2.49/				Pt k x-ray
									0.2959
									0.3165
^{193m}Au			3.9 s	I.T./0.2901		11/2-	6.2	+1.98	Au k x-ray
									0.2580
^{193}Au		192.96415	17.6 h	EC/1.07		3/2+	+0.140	+0.66	Pt k x-ray
									0.1862
									0.2556
^{194}Au		193.96537	1.64 d	β+ /3 /2.49	1.49/	1-	+0.076	-0.24	ann.rad./
				EC/97 /					Pt k x-ray
									0.2935
									0.3284/61
^{195m}Au			30.5 s	I.T./0.3186		11/2-	6.2	+1.9	Au k x-ray
									0.2617
^{195}Au		194.965035	186.10 d	EC/0.227		3/2+	+0.149	+0.61	Pt k x-ray
^{196m2}Au			9.7 h	I.T./0.5954		12-	5.7		Au k x-ray
									0.1478
									0.1883
^{196m1}Au			8.1 s	I.T./0.0846		8+			0.0847
^{196}Au		195.966570	6.17 d	EC/92 /1.506		2-	+0.591	0.81	Pt k x-ray
^{197m}Au			7.8 s	I.T./0.4094		11/2-	+6.0	+1.7	Au k x-ray
				β- /8 /0.686					0.1302
									0.2790
^{197}Au	100.	196.966569				3/2+	+0.14575	+0.55	
^{198m}Au			2.30 d	I.T./0.812		(12-)			Au k x-ray
									0.0972
									0.1803
									0.2419
^{198}Au		197.968242	2.695 d	β- /1.372	0.290/1	2-	+0.5934	+0.64	Hg k x-ray
					0.961/99				0.411794

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^{199}Au		198.968765	3.14 d	β- /0.453	0.25/22	3/2+	+0.2715	+0.51	Hg k x-ray
					0.292/72				0.15837
					0.462/6				0.20820
^{200m}Au			18.7 h	β- /84 /1.0	0.56/	12-	5.9		Au k x-ray
				I.T./16 /					0.2559/71
									0.3680/77
									0.4978/73
									0.5793/72
									0.084–0.904)
^{200}Au		199.97073	48.4 m	β- /2.24	0.7/15	1-			0.3679/19
					2.2/77				1.2254/10.6
									(0.077–1.570)
^{201}Au		200.971657	26. m	β- /1.28	1.27/82	3/2+			(0.027–0.732)
^{202}Au		201.9738	29. s	β- /3.0		(1-)			0.4396
^{203}Au		202.975155	1.0 m	β- /2.14	~ 1.9/	3/2+			(0.04–0.37)
^{204}Au		203.9777	40. s	β- /4.5		(2-)			0.4366
									1.5113
^{205}Au		204.9799	31. s	β- /					(0.38–1.33)
$_{80}$Hg		**200.59(2)**							
^{171}Hg		171.0038	0.06 ms	α	7.49				
^{172}Hg		171.9988	0.3 ms	α	7.36	0+			
^{173}Hg		172.9972	0.8 ms	α	7.20				
^{174}Hg		173.99286	1.9 ms	α	7.07	0+			
^{175}Hg		174.9914	0.02 s	α					
^{176}Hg		175.98736	21 ms	α	6.74/94	0+			
^{177m}Hg			1.5 μs	IT					0.246
^{177}Hg		176.9863	0.13 s	α	6.58				
^{178}Hg		177.98248	0.26 s	EC/50 /6.1		0+			
				α/50 /	6.43/				
^{179}Hg		178.98183	1.05 s	EC/8.0					
				α/	6.29/				
^{180}Hg		179.97827	2.6 s	EC/5.5		0+			0.1250
				α/	6.12/33				0.3005
					5.69/.03				0.3812
^{181}Hg		180.97782	3.6 s	β+ EC/76 /~ 7.3		(1/2-)	+0.507		0.0663
				α/24 /					0.0811
									0.0924
									0.1474
									0.1587
									0.2142
									0.2398
^{182}Hg		181.97469	10.8 s	β+, EC/85/5.0		0+			0.129/122
				α/15/	5.87/8.6				0.2176/66
					5.45/0.03				0.0256–0.543
^{183}Hg		182.97445	9. s	β+, EC/77/6.3		½-	+0.524		0.0714
				α/	5.83/				0.0874
					5.91/				0.1538
^{184}Hg		183.97171	30.9 s	β+, EC/99/4.1		0+			0.1565/102
				α/1/	5.54/1.3				0.2367/100
					5.07/0.002				0.2384/18
									(0.018-0.4227)
^{185m}Hg			21. s	β+, EC, IT, α/	5.37/	13/2+	-1.02	+0.2	0.211
									0.292
^{185}Hg		184.97190	51. s	β+, EC/95/5.8		½-	+0.509		0.02–0.55
^{186}Hg		185.96936	1.4 m	β+, EC/3.3		0+			0.1119
				α	5.09/0.02				0.2518
^{187m}Hg			1.7 m	β+, EC/		13/2+	-1.04	+0.5	see Hg187
^{187}Hg		186.96981	2.4 m	β+, EC/4.9		3/2-	-0.594	-0.8	0.1034/32

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									0.2334/100
									0.2403/33
									0.27151/31
									0.3763/38
									0.5254/30
									0.10−2.18
^{188}Hg		187.96758	3.2 m	β+, EC/2.3		0+			0.0988
				α	4.61				0.1148
									0.1424
									0.1900
^{189m}Hg			8.6 m	EC/		13/2+	-1.06	+0.7	0.0780
									0.3210
									0.4345
									0.5655
									(0.08−2.170)
^{189}Hg		188.96819	7.6 m	EC/4.2		3/2-	-0.6086	-0.8	0.2005
									0.2038
									0.2386
									0.2485
^{190}Hg		189.96632	20.0 m	EC/1.5		0+			0.1296
									0.1426
^{191m}Hg			51. m	β+ /6 /		13/2+	-1.07	+0.6	ann.rad./
				EC/94 /					Au k x-ray
									0.2741
									0.4203
									0.5787
									(0.07−1.9)
^{191}Hg		190.96716	50. m	β+, EC/3.2		(3/2-)	-0.62	-0.8	0.1963
									0.2247
									0.2524
^{192}Hg		191.96563	5.0 h	EC/~ 0.5		0+			Au k x-ray
									0.1572
									0.2748
									0.3065
^{193m}Hg			11.8 h	β+, EC/91 /		13/2+	-1.05843	+0.92	Hg k x-ray
				I.T./9 /0.2901					0.1866
									0.2580
									0.4076
									0.5733
									0.9324
									(0.1−1.96)
^{193}Hg		192.96667	3.8 h	EC, B+/2.34		3/2-	-0.6276	-0.7	0.1866
									0.2580
									0.8611
^{194}Hg		193.96544	520. y	EC/0.04		0+			Au L x-rays
^{195m}Hg			1.67 d	I.T./(54)/0.3186		13/2+	-1.04465	+1.1	Hg k x-ray
				EC/(46)/					Au k x-ray
									0.2617
									0.5603
									0.7798
^{195}Hg		194.96672	10.5 h	EC/1.51		1/2-	+0.541475		Au k x-ray
									0.0614
									0.7798
^{196}Hg	0.15(1)	195.965833	>2.5 × 10^{18} y			0+			
^{197m}Hg			23.8 h	I.T./(93)/0.2989		13/2+	-1.02768	+1.2	Hg k x-ray
									Au k x-ray
									0.13398
^{197}Hg		196.967213	2.69 d	EC/0.600		1/2-	+0.527374		Au k x-ray
									0.07735
^{198}Hg	9.97(20)	197.9667690				0+			

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
^{199m}Hg			42.7 m	I.T./0.532		13/2+	-1.014703	+1.2	Hg k x-ray
									0.15841
^{199}Hg	16.87(22)	198.9682799				1/2-	+0.505885		
^{200}Hg	23.10(19)	199.9683260				0+			
^{201}Hg	13.18(9)	200.970302				3/2-	-0.560226	+0.39	
^{202}Hg	29.86(26)	201.970643				0+			
^{203}Hg		202.972873	46.61 d	β- /0.492	0.213/100	5/2-	+0.8489	+0.34	Tl k x-ray
									0.279188
^{204}Hg	6.87(15)	203.9734939				0+			
^{205}Hg		204.976073	5.2 m	β- /1.531	1.33/4	1/2-	+0.6010		0.20378
									(0.2−1.4)
^{206}Hg		205.97751	8.2 m	β- /1.31	0.935/34	0+			Tl k x-ray
					1.3/63				0.3052
									0.6502
^{207}Hg		206.9826	2.9 m	β- /4.8		(9/2+)			
^{208}Hg		207.9859	41. m	β-		0+			0.474
^{209}Hg		208.9910	36 s	β-					0.324
^{210}Hg		209.9945	> 0.3 μs	β-		0+			
$_{81}$Tl		**204.3833(2)**							
^{176}Tl		176.0006	5 ms	p	1.26/~ 100				
^{177m}Tl			0.23 ms	p/51	1.95				
				α/49	7.48				
^{177}Tl		176.99643	0.017 s	α/73					
				p/27					
^{178}Tl		177.9949	0.25 s	α/	6.704				
					6.785				
					6.62				
					6.859				
^{179m}Tl			1.7 ms	α	/7.21/80				
				α	/7.10/20				
^{179}Tl		178.99109	0.3 s	α	6.57/				
^{180}Tl		179.9899	1.5 s	α//8	6.28/30				
					6.36/30				
					6.21/18				
					6.56/15				
					6.47/7				
^{181m}Tl			1.4 ms	α	6.58/100				
^{181}Tl		180.98626	3.2 ms	α/ < 10	6.19/100				
^{182}Tl		181.9857	3. s	β+, EC/10.9					0.351
									(0.26−0.41)
^{183m}Tl			53. ms	α	6.33/80	9/2-			0.0618
					6.38/16				(0.046-0.0894)
					6.46/4				
^{183}Tl		182.98219	5. s	β+, EC/7.7		½+			0.208
^{184}Tl		183.98187	11. s	β+, EC/(98)/9.2					0.2868
				α/(2)/	6.16/				0.3399
									0.3667
^{185m}Tl			1.8 s	I.T./0.453		(9/2-)			0.1688
				α/5.97	6.01				0.2840
^{185}Tl		184.9788	20. s	EC/β+/6.6					
^{186m}Tl			4. s	I.T./0.374					0.3738
^{186}Tl		185.9783	28. s	β+, EC/7.5					0.3567
									0.4026
									0.4053
^{187m}Tl			15.6 s	I.T./~ 0.33		(9/2+)	+3.8	-2.4	0.2995
^{187}Tl		186.97591	50. s	β+, EC/6.0		½+	1.6		
^{188m}Tl			1.18 m	β+, EC/		(7+)			Hg k x-ray
									0.4129

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									0.5043
									0.5921
^{188}Tl		187.97601	1.2 m	β+, EC/7.8		(2-)	+0.48	+0.13	see Tl[188m]
									0.4129
^{189m}Tl			1.4 m	β+, EC/		(9/2-)	+3.878	-2.29	0.2156
									0.2284
									0.3175
									0.4452
^{189}Tl		188.97359	2.3 m	β+, EC/5.2		(1/2+)			0.3337
									0.4510
									0.5223
									0.9422
^{190m}Tl			3.7 m	β+, EC/	4.2/	(7+)	+0.495	+0.29	0.1968
									0.4164
									0.7311
^{190}Tl		189.97388	2.6 m	β+, EC/7.0	5.7/	(2-)	+0.25	-0.33	0.4164
									0.6254
									0.6838
									1.0999
^{191m}Tl			5.2 m	β+, EC/(98)/		(9/2+)	+3.903	-2.3	0.2157
									0.2647
									0.3256
									0.3359
^{191}Tl		190.97179				(1/2)	1.59		
^{192m}Tl			10.8 m	β+, EC/		(7+)	+0.518	0.46	0.1740
									0.4228
									0.6348
									0.7863
									0.7455
^{192}Tl		191.97223	9.6 m	β+, EC/6.4		(2-)	+0.20	-0.33	0.3975
									0.4228
									0.6908
^{193m}Tl			2.1 m	I.T./(75)/		(9/2-)	+3.948	-2.2	0.3650
^{193}Tl		192.9707	22. m	β+, EC/3.6		(1/2+)	+1.591		0.2077
									0.3244
									0.3440
									0.6761
									1.0447
									1.5793
^{194m}Tl			32.8 m	β+ /(20)/~ 0.30		(7+)	+0.540	+0.61	ann.rad./
				EC/(80)/					Hg k x-ray
									0.4282
									0.6363
									0.7490
^{194}Tl		193.9712	33.0 m	β+, EC/5.3		2-	0.140	-0.28	0.4279/75.2
									0.6452/10.8
									(0.395-1.623)
^{195m}Tl			3.6 s	I.T./0.483		9/2-			Tl k x-ray
									0.0990
									0.3836
^{195}Tl		194.96977	1.16 h	EC/97/2.8		1/2+	+1.58		ann.rad./
				β+ /(3)/					Hg k x-ray
									0.2422
									0.5635
									0.8845
									1.3639
									(0.13−2.5)
^{196m}Tl			1.41 h	β+, EC/95/4.9		(7+)	0.55	+0.76	0.0840
									0.4261
									0.6353

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									0.6954
									(0.08−1.0)
^{196}Tl		195.97048	1.84 h	β+ /(15)/4.4		2-	+0.072	-0.18	ann.rad./
				EC/(85)/					Hg k x-ray
									0.4257
									0.6105
									(0.03−2.4)
^{197m}Tl			0.54 s	IT/53/0.608		9/2-			Tl k x-ray
				β+, EC/47/					0.2262
									0.4118
									0.5872
									0.6367
^{197}Tl		196.96958	2.83 h	β+ /(1)/2.18		1/2+	+1.58		Hg k x-ray
				EC/(99)/					0.1522/8.2
									0.4258
^{198m}Tl			1.87 h	β+, EC/(53)/		7+	+0.64		Hg k x-ray
				IT/47/0.5347					Tl k x-ray
									0.4118
									0.5872
									0.6367
^{198}Tl		197.9405	5.3 h	EC, β+ /(1)/3.5	1.4/	2-			Hg k x-ray
					2.1/				0.4118
					2.4/				0.6367
									0.6759
									(0.23−2.8)
^{199}Tl		198.96988	7.4 h	EC/1.4		1/2-	+1.60		Hg k x-ray
									0.2082
									0.2473
									0.4555
^{200}Tl		199.97096	1.087 d	EC/2.46	1.07/	2-	0.04		Hg k x-ray
					1.44/				0.36799
									1.2057
									(0.11−2.3)
^{201}Tl		200.97082	3.038 d	EC/0.48		1/2+	+1.605		Hg k x-ray
									0.13528
									0.16740/10.0
^{202}Tl		201.97211	12.47 d	EC/1.36		2-	0.06		Hg k x-ray
									0.43957
^{203}Tl	29.524(14)	202.972344				1/2+	+1.622258		
^{204}Tl		203.973864	3.78 y	β- /97/0.7637	0.763/97	2-	0.09		Hg k x-ray
				EC/(3)/0.347					
^{205}Tl	70.476(14)	204.974428				1/2+	+1.638215		
^{206m}Tl			3.76 m	I.T./2.644		12-			Tl k x-ray
									0.2166
									0.2661
									0.4534
									0.6866
									1.0219
^{206}Tl		205.976110	4.20 m	β- /1.533	1.53/99.9	0-			Pb k x-ray
									0.80313
^{207m}Tl			1.3 s	I.T./1.350		11/2-			Tl k x-ray
									0.3501
									1.0000
^{207}Tl		206.97742	4.77 m	β- /1.423	1.43/99.8	1/2+	+1.88		0.89723
^{208}Tl		207.982019	3.053 m	β- /5.001	1.28/23	(5+)	+0.29		Pb k x-ray
					1.52/22				0.27728
					1.796/51				0.51061
									0.58302
									2.61448
^{209}Tl		208.98536	2.16 m	β-/3.98	1.8 /100	(1/2+)			Pb k x-ray

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									1.5670/100
									0.4651/95
									(0.12−1.33)
^{210}Tl		209.99007	1.30 m	β- /5.48	1.3/25	(5+)			Pb k x-ray
					1.9/56				0.081
									0.2981
									0.79788
^{211}Tl		210.9935	> 0.3 μs	β-					
^{212}Tl		211.9982	> 0.3 μs	β-					
$_{82}$Pb		**207.2(1)**							
^{178}Pb		178.00383	~ 0.2 ms			0+			
^{179}Pb		179.0022							
^{180}Pb		179.99792	5 ms	α/	7.25	0+			
^{181}Pb		180.9966	0.05 s	α/	7.07				
^{182}Pb		181.99267	55 ms	α	6.90	0+			
^{183m}Pb			0.42 s	α	6.70/82.7	13/2+			
					6.86/1.9				
^{183}Pb		182.99187	0.54 s	α/	6.57/4.3	(3/2-)			
					6.78/11.0				
^{184}Pb		183.98814	0.48 s	α/~ 80	6.63/	0+			
^{185m}Pb			4.3 s	α	6.41/100	13/2+	-1.2		
^{185}Pb		184.98761	6.3 s	α/	6.29/56	3/2-	-1.1		0.205
					6.49/44				0.269
					6.55/<1.4				
^{186}Pb		185.98424	5. s	β+, EC/95/5.5		0+			
				α/(5)/	6.32/				
					6.34/<100				
					6.01/<0.2				
^{187m}Pb			15.2 s	β+, EC/	5.99/	(1/2-)			0.0674
				α/12	6.19/				0.2080
									0.2755
									0.2995
									0.4487
									0.7477
^{187}Pb		186.98392	18.3 s	EC/7.2		13/2+			0.1930
				α/7	6.08/				0.3314
									0.3435
									0.3934
^{188}Pb		187.98087	23. s	EC/(78)/4.8		0+			0.1850
				α/(22)/	5.98/<10				0.7582
					5.61/<0.1				
^{189}Pb		188.98081	51. s	EC/6.1					
				α/	5.58/				
^{190}Pb		189.97808	1.2 m	β+ (13)/4.1		0+			ann.rad./
				EC/(86)/					Tl k x-ray
				α/(0.9)/	5.58/				0.1415
									0.1512
									0.9422
^{191m}Pb			2.2 m	β+, EC/		13/2+	-1.17	+0.085	ann.rad./
									0.3871
									0.6135
									0.7122
^{191}Pb		190.97827	1.3 m	β+, EC/5.5					ann.rad./
									0.9368
^{192}Pb		191.97579	3.5 m	β+, EC/~ 3.4		0+			ann.rad./
				α/.006/	5.11				0.1675
									0.6082
									1.1954

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
^{193m}Pb			5.8 m	β+, EC/		13/2+	-1.15	+0.19	ann.rad./
									0.3650
									0.3922
^{193}Pb		192.97617	~ 2. m	EC/5.2		3/2 (-)			
^{194}Pb		193.97401	10. m	β+, EC/2.7		0+			ann.rad./
				α	4.64				0.2036
^{195m}Pb			15. m	β+ /(8)/		13/2+	-1.132	+0.30	ann.rad./
				EC/(92)/					Tl k x-ray
									0.3836
									0.3942
									0.8784
^{195}Pb		194.97454	~ 15. m	β+, EC/5.8					ann.rad./
									0.3836
									0.3937
									0.7776
^{196}Pb		195.97277	37. m	β+, EC/2.1		0+			Tl k x-ray
									0.2531
									0.5021
^{197m}Pb			43. m	EC/79/		13/2+	-1.104	+0.38	Tl k x-ray
				β+ /2/					0.3079
				IT/19/0.3193					0.3877
									0.7743
									(0.2−2.2)
^{197}Pb		196.97343	~ 8. m	EC/97/3.6		(3/2-)	-1.075	-0.08	Tl k x-ray
				β+ /3/					0.3755
									0.3858
									0.7611
^{198}Pb		197.97203	2.4 h	EC/1.4		0+			Tl k x-ray
									0.1734
									0.2903
									0.3654
^{199m}Pb			12.2 m	IT/93/0.4248		13/2+			Pb k x-ray
				β+, EC/(7)/					0.4255
^{199}Pb		198.97292	1.5 h	EC/(99)/2.9		5/2-	-1.074	+0.08	Tl k x-ray
				β+ /(1)/					0.3534
									0.7202
									1.1350
									(0.22−2.4)
^{200}Pb		199.97183	21.5 h	EC/0.81		0+			Tl k x-ray
									0.14763
^{201m}Pb			1.02 m	I.T./0.6291		13/2+			Pb k x-ray
									0.6288
^{201}Pb		200.97289	9.33 h	EC/1.90		5/2-	+0.675	-0.009	Tl k x-ray
									0.33120
									0.36131
									(0.11−1.8)
^{202m}Pb			3.53 h	IT/90/2.170		9-	-0.228	+0.58	Pb k x-ray
				β+ /10/					Tl k x-ray
									0.42219
									0.78700
									0.96271
^{202}Pb		201.97216	5.3×10^4 y	EC/0.05		0+			Tl L x-ray
^{203m}Pb			6.2 s	I.T./0.8252		13/2+			Pb k x-ray
									0.8203
									0.8252
^{203}Pb		202.97339	2.163 d	EC/0.98		5/2-	+0.686	+0.10	Tl k x-ray
									0.279188
^{204m}Pb			1.13 h	I.T./2.185		9-			Pb k x-ray
									0.37481
									0.89922

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									0.91175
^{204}Pb	1.4(1)	203.973044				0+			
^{205}Pb		204.974482	1.51×10^{7} y	EC/0.0512		5/2-	+0.712	+0.23	Tl L x-ray
^{206}Pb	24.1(1)	205.974465				0+			
^{207m}Pb			0.80 s	I.T./1.632		13/2+			Pb k x-ray
									0.56915
									1.06310
^{207}Pb	22.1(1)	206.975897				1/2-	+0.59258		
^{208}Pb	52.4(1)	207.976652	$> 2 \times 10^{19}$ y	sf		0+			
^{209}Pb		208.981090	3.25 h	β- /0.644	0.645/100	9/2+	-1.474	-0.3	
^{210}Pb		209.984189	22.6 y	β- /0.0635	0.017/81	0+			
					0.061/19				
				α	3.72				
^{211}Pb		210.988737	36.1 m	β- /1.37	0.57/5	(9/2+)	-1.404	+0.09	0.40486
					1.36/92				0.42700
									0.83186
									(0.09−1.27)
^{212}Pb		211.991898	10.64 h	β- /0.574	0.28/83	0+			Bi k x-ray
					0.57/12				0.23858
^{213}Pb		212.99658	10.2 m	β- /2.1					
^{214}Pb		213.999805	26.9 m	β- /1.0	0.67/48	0+			Bi k x-ray
					0.73/42				0.24192
									0.29509
									0.35187
^{215}Pb		215.0048	36 s						
$_{83}$Bi		**208.98040(1)**							
^{184m}Bi			0.007 s	α	(7.22-7.85)				0.449
^{184}Bi		184.0011	13. ms	α					0.124
^{185}Bi		184.9976	60. μs	p/90	1.55				
				α/10	8.03				
^{186m}Bi			15. ms	α	7.07-7.23				(0.087-0.520)
				p/<0.5					
^{186}Bi		185.9966	9.8 ms	α	7.26				0.1085
					7.37				
^{187m}Bi			~ 8. ms	α/12					
^{187}Bi		186.99316	32. ms	α/7	7.00/88.3				
					7.61/8.0				
					7.37/3.7				
^{188}Bi		187.99227	0.271 s	α	6.81				(0.071-0.320)
^{189m}Bi			7.0 ms	α	7.30				
^{189}Bi		188.9892	0.68 s	α					
^{190m}Bi			5.7 s	α/90	6.43				(0.105-0.314)
					(6.23-6.72)				
^{190}Bi		189.9883	~ 5.9 s	β+, EC/(30)/8.7	α/6.45				(0.089-0.374)
				α/70	(6.39-6.82)				
^{191m}Bi			0.12 ms	α/	6.87/100				
^{191}Bi		190.98579	12.4 s	β+, EC/(60)/7.3					
				α/(40)/	6.31				
^{192}Bi		191.98546	40. s	β+, EC/(80)/9.0					
				α/(20)/	6.06/				
^{193m}Bi			3.2 s	β+, EC/		1/2+			
				α/	6.48/				
^{193}Bi		192.98296	1.11 m	β+, EC/40/7.1		9/2+			
				α/(60)/	5.91/				
^{194}Bi		193.98283	1.8 m	β+, EC/99.9/8.2		(10-)			0.1661
				α/0.1/					0.1740
									0.2802
									0.421

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									0.5754
									0.9650
^{195m}Bi			1.45 m	β+, EC/(94)/					
				α/(6)/	6.11/				
^{195}Bi		194.98065	2.9 m	β+, EC/99.8/5.8		3/2-			
				α/(0.2)	5.45/				
^{196}Bi		195.98067	5. m	EC/~ 7.4					0.1376
									0.3720
									0.6880
									1.0486
^{197}Bi		196.97886	5. m	β+, EC/5.2		1/2+			
^{198m}Bi			7.7 s	I.T./0.2485		(10-)			0.2485
^{198}Bi		197.97921	11.8 m	β+, EC/6.6		(7+)			0.0900
									0.1976
									0.5624
									1.0635
^{199m}Bi			24.7 m	β+, EC/					ann.rad./
^{199}Bi		198.97767	27. m	β+, EC/4.3		9/2-	4.6		0.7203
									0.8374
									0.8417
									0.9460
									1.0528
									1.3056
									(0.12−3.2)
^{200m}Bi			31. m	β+, EC/		(2+)			0.2453
									0.4198
									0.4624
									1.0265
^{200}Bi		199.97813	36. m	EC/(90)/5.9		7+			ann.rad./
				β+ /(10)/					Pb k x-ray
									0.4198
									0.4623
									1.0265
^{201m}Bi			59.1 m	I.T./0.846		(1/2+)			Bi k x-ray
				β+, EC/					0.8464
^{201}Bi		200.97701	1.8 h	EC/3.84		9/2-	4.8		Pb k x-ray
									0.6288
									0.9357
									1.0138
									(0.13−2.4)
^{202}Bi		201.97774	1.72 h	β+ /(3)/5.16		5+	+4.26	-0.72	ann.rad./
				EC/(97)/					Pb k x-ray
									0.57860
									0.92734
									(0.08−3.5)
^{203}Bi		202.97688	11.8 h	EC/99.8/3.25		9/2-	+4.02	-0.69	Pb k x-ray
				β+ /(0.2)/	1.35/				0.1865
									0.8203
									0.8969
									1.8475
									(0.1−2.9)
^{204}Bi		203.97781	11.2 h	EC/4.44		6+	+4.32	-0.43	Pb k x-ray
									0.37481
									0.89922
									0.98409
^{205}Bi		204.97739	15.31 d	EC/2.71		9/2-	+4.07	-0.59	Pb k x-ray
									0.70347
									1.76435
^{206}Bi		205.97850	6.243 d	EC/3.76		6+	+4.36	-0.39	Pb k x-ray
									0.51619

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									0.80313
									0.88100
^{207}Bi		206.978471	31.55 y	EC/2.399		9/2-	4.08	-0.6	Pb k x-ray
									0.56915
									1.06310
^{208}Bi		207.979742	3.68×10^5 y	EC/2.880		5+	4.63	-0.64	Pb k x-ray
									2.61435
^{209}Bi	100.	208.980399	1.9×10^{19} y	α	3.13	9/2-	+4.111	-0.37	
^{210m}Bi			3.0×10^6 y	α/	4.420(3)/0.29	9-	+2.73	-0.47	Tl k x-ray
					4.569(3)/3.9				0.2661
					4.584(3)/1.4				0.3052
					4.908(4)/39				0.6502
					4.946(3)/55				
^{210}Bi		209.984120	5.01 d	β- /1.163	1.16/99	1-	-0.0445	+0.136	0.2661
									0.3.52
^{211}Bi		210.98727	2.14 m	α/(99.7)/	6.279/16	9/2-			Tl k x-ray
				β- /(0.3)/0.58	6.623/84				0.3501
^{212m2}Bi			7. m	β- /		(15-)			
^{212m1}Bi			25.0 m	α/(93)/	6.300/40	(9-)			0.120
				β- /(7)/	6.340/53				0.233
									0.275
									0.404
									0.727
^{212}Bi		211.991286	1.009 h	β- /(64)/2.254		(1-)	+0.32	+0.1	Tl k x-ray
				α/(36)/	6.051/25				Po k x-ray
					6.090/9.6				0.2881
									0.72725
									0.78551
									1.62066
^{213}Bi		212.994385	45.6 m	β- /(98)/1.43	1.02/31	9/2-	+3.72	-0.60	Po k x-ray
				α/(2)/	1.42/66				0.4404
					5.549/0.16				(0.15−1.328)
					5.869/2.0				
									1.10006
^{214}Bi		213.99871	19.7 m	β- /3.27					0.60931
									1.12027
									1.76449
									(0.19−3.2)
^{215m}Bi			37. s	β					(0.158-0.498)
^{215}Bi		215.00177	7.7 m	β- /2.3					0.2937/35.2
									(0.271−1.399)
^{216}Bi		216.00631	2.3 m	β-/4.0					0.5498
									0.4192
^{217}Bi		217.0095	98 s	β/					0.2646/100
									(0.254-1.017)
^{218}Bi		218.0143	33. s	β-					0.5097/134
									0.3857/100
									(0.174-0.703)
$_{84}$Po									
^{188}Po		187.99942	0.27 ms	α	7.91/80	0+			
					7.320				
^{189}Po		188.99848	5 ms	α	7.532/8				
					7.259/80				
					7.309/12				
^{190}Po		189.99510	2.4 ms	α/	7.53/96.4	0+			
					7.01/3.3				
^{191m}Po			93. ms	α	7.376/50				
					6.888/46				

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
^{191}Po		190.99457	22 ms	α/	7.334/77				
					6.97/8				
^{192}Po		191.99134	32. ms	α/8.5	7.17/98.6	0+			
					6.59/1.4				
^{193m}Po			~ 0.07 s	α/	7.00				
^{193}Po		192.99103	0.45 s	α/	6.95				
^{194}Po		193.98819	0.2 s	α/	6.84/93	0+			
					6.19/0.22				
^{195m}Po			~ 2.8 s	α/	6.70/				
^{195}Po		194.98811	~ 3.9 s	α/	6.62/				
^{196}Po		195.98554	5. s	α/(95)/	6.53/94	0+			
				β+, EC/(5)/~4.6	5.77/0.02				
^{197m}Po			25.8 s	α/(84)/	6.385(3)/55	13/2+			
				β+, EC/(16)/					
^{197}Po		196.98566	53. s	α/(44)/	6.282(4)/76	(3/2-)			
				β+, EC/(56)/6.2					
^{198}Po		197.98339	1.76 m	α/(70)/	6.18/57	0+			
				β+, EC/(30)/4.0	$5.27/7.6 \times 10^{-4}$				
^{199m}Po			4.2 m	β+, EC/(51)/		13/2+	0.99		ann.rad./
				α/(39)/	6.059/24				0.2745
									0.4998
									1.0020
^{199}Po		198.98367	5.2 m	β+, EC/(88)/7.		(3/2-)			Bi k x-ray
				α/(12)/	5.952/7.5				0.1877
									0.3616
									1.0214
									1.0344
^{200}Po		199.981780	11.5 m	β+, EC/85/3.4		0+			0.14748
				α/(15)/	5.863/11.1				0.32792
									0.6176
									0.6709
^{201m}Po			8.9 m	β+, EC/(57)/		13/2+	1.00		Bi k x-ray
				IT/40/0.418					Po k x-ray
				α/(3)/	5.786/~ 3.				0.2726
									0.4123
									0.4179
									0.9670
^{201}Po		200.98226	15.3 m	β+, EC/98/4.9		3/2-	0.94		Bi k x-ray
				α/(2)/	5.683(3)/1.1				0.2056
									0.2250
									0.8483
									0.9048
^{202}Po		201.98076	45. m	β+, EC/98/2.8		0+			0.0410
				α/(2)/	5.588/1.9				0.1656
									0.3158
									0.6884
^{203m}Po			1.2 m	IT/96/0.6414		13/2+			Bi k x-ray
				β-EC/(4)/					Po k x-ray
									0.6414
^{203}Po		202.98142	35. m	β+, EC/4.2		5/2-	+0.74		0.17516
									0.21477
									0.89350
									0.90863
									1.09095
^{204}Po		203.98032	3.53 h	EC/2.34		0+			Bi k x-ray
				α	5.377/0.66				0.2702
									0.8844
									1.0162
									(0.11−1.9)
^{205}Po		204.98120	1.7 h	β+, EC/3.53		5/2-	+0.76	+0.17	Bi k x-ray

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									0.83681
									0.84983
									0.87241
									1.00124
									(0.12−2.7)
^{206}Po		205.98048	8.8 d	EC/(95)/1.85		0+			Bi k x-ray
				α/(5)/	5.223/5.5				0.28644
									0.31156
									0.51134
									0.80737
									1.03228
									(0.11−1.5)
^{207m}Po			2.8 s	I.T./1.383		19/2-			Po k x-ray
									0.2682
									0.30074
									0.81448
^{207}Po		206.98159	5.80 h	EC, β+/2.91		5/2-	+0.79	+0.28	Bi k x-ray
									0.74263
									0.91176
									0.99225
^{208}Po		207.981246	2.898 y	α/5.213	4.233/0.0002	0+			
					5.1158/100				
^{209}Po		208.982430	102. y	α/4.976	4.624/0.56	1/2-	~ +0.77		0.26049
					4.879/99.2				0.8964
^{210}Po		209.982874	138.4 d	α/5.407	4.516/0.001	0+			0.80313
					5.304/100				
^{211m}Po			25.2 s	α/	7.273/91	25/2+			Pb k x-ray
					7.994/1.7				0.32808
					8.316/0.25				0.56915
					8.875/7.0				0.89723
									1.06310
^{211}Po		210.986653	0.516 s	α/7.594	6.570/0.54	9/2+			0.56915
					6.892/0.55				0.89723
					7.450/98.9				
^{212m}Po			45. s	α/	8.514/2.0	16+			
					9.086/1.0				
					11.650/97				
^{212}Po		211.988868	0.298 μs	α/8.953	8.784/100	0+			
^{213}Po		212.992857	3.7 μs	α/8.537	7.614/0.003	9/2+			
					8.375/100				
^{214}Po		213.995201	163.7 μs	α/7.833	6.904/0.01	0+			0.7995
					7.686/99.99				0.298
^{215}Po		214.999420	1.780 ms	α/7.526	6.950/0.02	(9/2+)			
					6.957/0.03				
					7.386/100				
^{216}Po		216.001915	0.145 s	α/6.906	5.895/0.002	0+			
					6.778/99.99				
^{217}Po		217.00634	1.53 s	α/6.662	6.539/				
^{218}Po		218.008973	3.04 m	α/6.114	6.003/99.999	0+			
					5.181/0.11				
^{219}Po		219.0137	~ 2 m						
^{220}Po		220.0166	> 0.3 μs			0+			
$_{85}$At									
^{191m}At			2.1 ms	α	7.65/98				
					7.72/2				
^{191}At			~ 1.7 ms	α	7.55/100				
^{193m}At			21 ms	α	7.33/98				
					7.42/2				

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^{193}At		192.9998	28 ms	α/	7.24/100				
^{194}At		193.9987	40 ms	α/					
^{195m}At			147 ms	α	7.07-7.22				
^{195}At		194.99627	0.33 s	α/	6.95				
^{196m}At			8 μs						0.158
^{196}At		195.9958	0.39 s	α/	7.05/				
^{197m}At			2.0 s	α	6.707	(1/2+)			
^{197}At		196.99319	0.39 s	β+, EC/7.8		(9/2-)			
				α/	6.960/				
^{198m}At			1.0 s	β+, EC/(75)/					
				α/(25)/	6.856/86				
^{198}At		197.99284	4.1 s	α/	6.755/94				
^{199}At		198.99053	6.9 s	β+, EC/8/5.6		9/2-			
				α/(92)/	6.643/				
^{200m2}At			47. s	α	6.411/				
^{200m}At			3.5 s	β+, EC/(80)		10-			
				α/(20)/	6.538/12				
^{200}At		199.99035	43. s	β+, EC/65/~ 8.0		5+			
				α/(35)/	6.412/44				
					6.465/57				
^{201}At		200.98842	1.48 m	β+, EC/29/5.9		9/2-			
				α/(71)/6.474	6.344/				
^{202m}At			0.46 s	I.T./0.391					
^{202}At		201.98863	3.02 m	β+, EC/88/7.2		5+			ann.rad./
				α/(12)/	6.135/7.7				0.4413
					6.225/4.3				0.5697
									0.6753
^{203}At		202.98694	7.4 m	β+, EC/69/5.1		9/2-			0.1458
				α/(31)/6.210	6.088/				0.2459
									0.6414
									1.0020
									1.0340
^{204}At		203.98725	9.1 m	β+, EC/95/6.5		(5+)			Po k x-ray
				α/(5)/	5.951/				0.3271
									0.4254
									0.5156
									0.6837
^{205}At		204.98607	26. m	β+, EC/90/4.54		(9/2-)			Po k x-ray
				α/(10)/6.020	5.902/				0.1543
									0.6696
									0.7194
^{206}At		205.98667	29.4 m	β+, EC/99/5.72		5+			Po k x-ray
				α/(1)/5.881	5.703/				0.20186
									0.39561
									0.47716
									0.70071
^{207}At		206.98578	1.81 h	β+, EC/90/3.91		9/2-			Po k x-ray
				α/(10)/5.873	5.758/				0.16801
									0.58842
									0.81448
^{208}At		207.98650	1.63 h	β+, EC/99/4.97		(6+)			Po k x-ray
				α/(1)/5.752	5.626/0.01				0.1770
					5.641/0.53				0.2060
									0.6601
									0.6852
									0.8450
									1.0281
^{209}At		208.98617	5.4 h	β+, EC/96/3.49		(6+)			Po k x-ray
				α/(4)/5.757	5.647/4.1				0.10422
									0.54503

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
									0.78189
									0.79020
									(0.1–2.6)
^{210}At		209.98715	8.1 h	EC/99.8/3.98		5+			Po k x-ray
				α/(0.2)/5.632	5.361/0.05				0.24535
					5.442/0.05				0.52758
									1.18143
									1.43678
									1.48335
									(0.04–2.4)
^{211}At		210.987496	7.21 h	EC/(58)/0.787		9/2-			Po k x-ray
				α/(42)/5.980	5.211/0.004				0.66956
					5.868/42				0.6870
									0.74263
^{212m}At			0.119 s	α/	7.837/65	(9-)			
					7.897/33				
^{212}At		211.99075	0.314 s	α/7.828	7.058/0.4	(1-)			
					7.088/0.6				
					7.618/15				
					7.681/84				
^{213}At		212.992937	0.11 μs	α/9.254	9.080/	9/2-			
^{214m}At			0.76 μs	α/8.762		(9-)			
^{214}At		213.996372	0.56 μs	α/8.987	8.819/100	(1-)			
^{215}At		214.99865	0.10 ms	α/8.178	7.626/0.045	(9/2-)			0.40486
					8.023/99.9				
^{216}At		216.002423	0.30 ms	α/7.947	7.595/0.2	(1-)			
					7.697/2.1				
					7.800/97				
^{217}At		217.004719	32. ms	α/7.202	6.812/0.06	(9/2-)			0.2595
					7.067/99.9				0.3345
									0.5940
^{218}At		218.00869	1.6 s	α/6.883	6.654/6				
					6.695/90				
					6.748/4				
^{219}At		219.011162	50. s	α/6.390	6.275/				
^{220}At		220.0154	3.71 m	β- /3.7					(0.24–0.70)
^{221}At		221.0181	2.3 m	β					
^{222}At		222.0223	0.9 m	β					
^{223}At		223.0252	50. s	β					
$_{86}$Rn									
^{195m}Rn			5 ms	α	7.56				
^{195}Rn		195.00544	6 ms	α	7.54				
^{196}Rn		196.00212	4. ms	α/	7.46	0+			
^{197m}Rn			0.02 s	α	7.36				
^{197}Rn		197.0016	0.07 s	α/	7.26				
^{198}Rn		197.99868	64. ms	α	7.205	0+			
^{199m}Rn			0.32 s	α	7.060	(13/2+)			
^{199}Rn		198.9984	0.62 s	α/	6.989	3/2-			
^{200}Rn		199.99570	1.06 s	α/(98)/	6.901/	0+			0.4329
				EC/(2)/5.					0.5043
^{201m}Rn			3.8 s	EC/(10)/		13/2+			
				α/(90)/	6.773/				
^{201}Rn		200.9956	7.0 s	α/(80)/	6.725/	(3/2-)			
				EC/(20)/	α/6.778				
^{202}Rn		201.99326	9.9 s	α/(12)/	6.641/	0+			0.5695
				EC/(88)/					0.2876–0.6255
^{203m}Rn			28. s	α/	6.551	13/2+	-0.96	+1.3	

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^{203}Rn		202.99339	45. s	α/(66)/6.629	6.499/	3/2-			
				EC/(34)/~ 7.4					
^{204}Rn		203.99143	1.24 m	α/(68)/	6.420/	0+			
				EC/(32)/3.8					
^{205}Rn		204.99172	2.8 m	α/(23)/6.390	6.123(3)/0.02	(5/2-)	+0.80	+0.06	0.2652
				EC/(77)/5.2	6.262(3)/23				0.3553
									0.4648
									0.6205
									0.6753
									0.7300
^{206}Rn		205.99021	5.7 m	α/(68)/6.384	6.258(3)/	0+			0.06170
				EC/(32)/3.3					0.0968
									0.3245
									0.3862
									0.4822
									0.4973
									0.7728
^{207}Rn		206.99073	9.3 m	β+, EC/77/4.6		5/2-	+0.82	+0.22	At k x-ray
				α/(23)/6.252	5.995(4)/0.02				0.32947
					6.068(3)/0.15				0.34455
					6.126(3)/22.8				0.36767
									0.40267
									0.74723
									(0.18−1.4)
^{208}Rn		207.98964	24.3 m	α/(60)/6.260	5.469(2)/0.003	0+			
				EC/(40)/2.85	6.140(2)/60				
^{209}Rn		208.99042	29. m	β+ /(83)/3.93	2.16/2.3	5/2-	+0.8388	+0.31	At k x-ray
				α/(17)/	5.887(3)/0.04				0.27933
					5.898(3)/0.02				0.33753
					6.039(2)/16.9				0.40841
									0.68942
									0.74594
									(0.18−3.2)
^{210}Rn		209.98970	2.4 h	α/(96)/6.157	5.351(2)/0.005	0+			At k x-ray
				EC/(4)/2.37	6.039(2)/96				0.19625
									0.45824
									0.57104
									0.64868
									(0.14−1.7)
^{211}Rn		210.99060	14.6 h	β+, EC/74/2.89		1/2-	+0.60		At k x-ray
				α/(26)/5.964	5.619(1)/0.7				0.16877
					5.784(1)/16.4				0.25022
					5.851(1)/8.8				0.37049
									0.67412
									0.67839
									1.36298
									(0.11−2.7)
^{212}Rn		211.990704	24. m	α/6.385	5.587(4)/0.05	0+			
					6.260(4)/99.95				
^{213}Rn		212.99388	19. ms	α/8.243	7.552(8)/1.0	9/2+			0.540
					8.087(8)/98.2				
					7.254/0.8				
^{214}Rn		213.99536	0.27 μs	α/9.209	9.037(9)/	0+			
^{215}Rn		214.99875	2.3 μs	α/8.840	8.674(8)/	(9/2+)			
^{216}Rn		216.00027	45. μs	α		0+			
^{217}Rn		217.003928	0.6 ms	α/7.885	7.500/0.1	9/2+			
					7.742(4)/100				
^{218}Rn		218.005601	35. ms	α/7.267	6.534(1)/0.16	0+			0.6093
					7.133(1)/99.8				0.6653
^{219}Rn		219.009480	3.96 s	α/6.946(1)	6.3130(5)/0.05	(5/2+)	-0.44	+0.93	Po k x-ray

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
					6.425(3)/7.5				0.13057
					6.5309(4)/0.12				0.27113
					6.5531(3)/12.2				0.40170
					6.8193(3)/81				(0.1−1.05)
^{220}Rn		220.011394	55.6 s	α/6.404	5.7486(5)/0.07	0+			
					6.2883(1)/99.9				
^{221}Rn		221.01554	25. m	α/(22)/6.148	5.778(3)/1.8	7/2+	-0.020	-0.38	Fr L x-ray
				β- /(78)/1.2	5.788(3)/2.2				0.07384
					6.037(3)/18				0.08323
									0.0610
									0.18639
^{222}Rn		222.017578	3.823 d	α/5.590	4.987(1)/0.08	0+			0.510
					5.4897(3)/99.9				
^{223}Rn		223.0218	23. m	β- /			-0.78	+0.80	
^{224}Rn		224.0241	1.8 h	β- /		0+			0.1085
									0.2601
									0.2655
^{225}Rn		225.0284	4.5 m	β- /		7/2-	-0.70	+0.84	
^{226}Rn		226.0309	7.4 m	β- /		0+			
^{227}Rn		227.0354	2. s	β- /					
^{228}Rn		228.0380	65. s	β- /		0+			
$_{87}$Fr									
^{199}Fr		199.00726	12 s	α	7.66				
^{200}Fr		200.0066	49 ms	α	7.47				
^{201m}Fr			~ 0.02 s	α/	7.454				
^{201}Fr		201.0039	~ 60 ms	α/	7.36/	(9/2-)			
^{202m}Fr			0.29 s	α	7.236/				
^{202}Fr		202.00337	0.30 s	α/7.590	7.24/100				
^{203}Fr		203.00093	0.54 s	α/7.280	7.132(5)/	(9/2-)			
^{204m2}Fr			0.8 s	α	7.01				
^{204m1}Fr			2. s	α	6.97				
^{204}Fr		204.00065	1.8 s	α/	7.03/96				
					6.97/90				
					7.01/74				
^{205}Fr		204.99859	3.9 s	α/7.050	6.914(5)/	(9/2-)			
^{206m}Fr			0.7 s	α/	6.93				0.531(IT)
^{206}Fr		205.99867	16.0 s	α/7.416	6.792(5)/84				
^{207}Fr		206.99695	14.8 s	α/6.900	6.766(5)/	9/2-	+3.9	-0.16	
^{208}Fr		207.99714	59.1 s	α/(77)/6.770	6.636(5)/	7+	-4.8	+0.004	
				EC/(23)/6.99					
^{209}Fr		208.99595	50.0 s	α/(89)/5.1	6.646(3)/	9/2-	+3.9	-0.24	0.7978
				EC/(11)/5.16					(0.1103−1.384)
^{210}Fr		209.99641	3.2 m	α/6.670/71	6.543(5)/99.87	6+	+4.4	+0.19	0.2030
				EC/6.26	(5.90-6.42)				0.6438
									0.8175
									0.9008
^{211}Fr		210.99554	3.10 m	α/6.660/87	6.534(5)/99.94	9/2-	+4.0	-0.19	0.220
				EC/4.61	(5.87-6.20)				0.2799
									0.5389
									0.9169
^{212}Fr		211.99620	20. m	EC/(57)/5.12	6.261(1)/16	(5+)	+4.6	-0.10	Rn x-ray
				α/(43)/6.529	6.335(1)/4				0.08107
					6.335(1)/4				0.08378
					6.343(1)/1.3				0.2277
					6.383(1)/10				1.1856
					6.406(1)/9.5				1.2748
					6.08−6.18				0.014−1.178
^{213}Fr		212.99619	34.6 s	α/6.905	8.476(4)/51	9/2-	+4.0	-0.14	(0.408-0.577)

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
^{214m}Fr			3.4 ms	α/	8.547(4)/46	9-			
					6.775−8.046				
^{214}Fr		213.99897	5.0 ms	α/8.587	7.409(3)/0.3	(1-)			(0.073-0.966)
					7.605(8)/1.0				
					7.940(3)/1.0				
					8.355(3)/4.7				
					8.427(3)/93				
^{215}Fr		215.00034	0.12 μs	α/9.537	9.360(8)/	(9/2-)			
^{216}Fr		216.00320	0.70 μs	α/9.175	9.005(10)/95				(0.045−0.160)
^{217}Fr		217.00463	0.016 ms	α/8.471	8.315(8)/	(9/2-)			
^{218m}Fr			22. ms	α					
^{218}Fr		218.007578	1. ms	α/8.014	7.384(10)/0.5	(1-)			
					7.542(15)/1.0				
					7.572(10)/5				
					7.732(10)/0.5				
					7.867(2)/93				
^{219}Fr		219.00925	21. ms	α/8.132	6.802(2)/0.25	(9/2-)			
					6.967(2)/0.6				
					7.146(2)/0.25				
					7.313(2)/99				
^{220}Fr		220.012327	27.4 s	α/6.800	6.582(1)/10	1+	-0.67	+0.47	0.0450
					6.630(2)/6				0.061
					6.641(1)/12				0.1060
					6.686(1)/61				0.1539
					6.39−6.58				0.1617
^{221}Fr		221.014255	4.8 m	α/6.457	5.9393(7)/0.17	(5/2-)	+1.58	-1.0	At k x-ray
					5.9797(7)/0.49				0.0995
					6.0751(7)/0.15				0.21798
					6.1270(7)/				0.4091
					6.2433(3)/1.3				
					6.3410(7)/83.4				
^{222}Fr		222.01755	14.3 m	β- /2.03	1.78/	2-	+0.63	+0.51	
				α/5.850					
^{223}Fr		223.019736	22.0 m	β- /1.149	α/5.291	(3/2+)	+1.17	+1.17	0.1509
				α//0.006	5.314				0.0589
					5.403				0.1453
^{224}Fr		224.02325	3.0 m	β- /2.82		1-	+0.40	+0.517	0.13150
									0.21575
									0.8367
									(0.1−2.21)
^{225}Fr		225.02557	3.9 m	β- /1.87		3/2	+1.07	+1.3	
^{226}Fr		226.0294	49. s	β- /3.6		1	+0.071	-1.35	0.18606
									0.25373
^{227}Fr		227.0318	2.48 m	β- /2.5		1/2	+1.50		
^{228}Fr		228.0357	39. s	β- /~ 3.5		2-	-0.76	+2.4	
^{229}Fr		229.03845	50. s	β- /					
^{230}Fr		230.0425	19. s	β- /		(3)			
^{231}Fr		231.0454	17. s	β- /					
^{232}Fr		232.050	5. s	β- /					(0.0545-0.721)
$_{88}$Ra									
^{201}Ra			~ 1.6 ms	α	7.91/				
^{202}Ra		202.0099	~ 0.02 ms	α	7.74	0+			
^{203m}Ra			24 ms	α	7.61				
^{203}Ra		203.0093	~ 31 ms	α	7.59				
^{204}Ra		204.0065	0.06 s	α	7.48	0+			
^{205m}Ra			~ 0.17 s						
^{205}Ra		205.0063	0.22 s	α	7.34				
^{206}Ra		206.00383	0.4 s	α/7.416	7.272(5)/	0+			

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^{207}Ra		207.0038	1.3 s	α/7.270	7.133(5)/				
^{208}Ra		208.00184	1.4 s	α/7.273	7.133(5)/	0+			
^{209}Ra		209.00199	4.6 s	α/7.150	(6.50-7.14)	5/2-	+0.87	+0.40	(0.387-0.634)
^{210m}Ra			2.4 μs						(0.0967-0.775)
^{210}Ra		210.00050	3.7 s	α/7.610	7.020(5)/	0+			574.9
^{211m}Ra			3.9 μs						(0.396-0.802)
^{211}Ra		211.00090	13. s	α/7.046	6.907/99.	(5/2-)	+0.878	+0.48	
				EC/5.0	(6.26-6.79)				(0.120-0.665)
^{212m}Ra			8.3 μs						(0.440-0.824)
^{212}Ra		211.99979	13.0 s	α/7.033	6.901(2)/	0+			
^{213m}Ra			2.1 ms	IT					
									(0.160-1.061)
^{213}Ra		213.00038	2.7 m	EC/(20)/3.88		(1/2-)	+0.613		0.1024
				α/(80)/6.860	6.521(3)/4.8				0.11010
					6.622(3)/39				0.2125
					6.730(3)/36				
^{214m}Ra			> 0.015 ms						(0.181-1.382)
^{214}Ra		214.00011	2.46 s	α/7.272	7.14/99.8/	0+			0.642
					6.51/0.2				
^{215m}Ra			7.6 μs						(0.196-1.048)
^{215}Ra		215.00272	1.64 ms	α/8.864	7.883(6)/2.8	(9/2+)			0.773/100
					8.171(3)/1.4				0.852/74
					8.700(3)/95.9				0.055−1.048
^{216}Ra		216.00353	0.18 μs	α/9.526	9.349(8)/	0+			
^{217}Ra		217.00632	1.6 μs	α/9.161	8.992(8)/	9/2-			
^{218}Ra		218.00714	26. μs	α/8.547	8.390(8)/	0+			
^{219}Ra		219.01009	0.010 s	α/8.132	7.680(10)/65				
					7.982(9)/35				
^{220}Ra		220.01103	18. ms	α/7.593	7.39/5	0+			0.465
					7.45/95				
^{221}Ra		221.013917	29. s	α/6.879	6.254(10)/0.7	5/2+	-0.180	+1.9	
					6.578(5)/3				
					6.585(3)/8				
					6.608(3)/35				
					6.669(3)/21				
					6.758(3)/31				
^{222}Ra		222.015375	36.2 s	α/5.590	6.237(2)/3.0	0+			0.324
					6.556(2)/97				0.1448−0.8402
^{223}Ra		223.018502	11.43 d	α/5.979	5.287(1)/0.15	(3/2+)	+0.271	+1.25	Rn k x-ray
					5.338(1)/0.13				0.12231
					5.365(1)/0.13				0.14418
					5.433(5)/2.3				0.15418
					5.502(1)/1.0				0.15859
					5.540(1)/9.2				0.26939
					5.607(3)/24				0.32388
					5.716(3)/52				0.33328
					5.747(1)/9				0.44494
					5.857(1)/0.32				(0.10−0.7)
					5.872(1)/0.85				
^{224}Ra		224.020212	3.66 d	α/5.789	5.034(10)/0.003	0+			Rn k x-ray
					5.047(1)/0.007				0.2407
					5.164(5)/0.007				0.4093
					5.449(2)/4.9				0.6501
					5.685(2)/95				
^{225}Ra		225.023612	14.9 d	β- /0.36	0.32/100	(3/2+)	-0.734		Ac k x-ray
				α	5.01×10^{-5}				0.0434
					4.98×10^{-6}				
^{226}Ra		226.025410	1599. y	α/4.870	4.194(1)/0.001	0+			Rn k x-ray
			$> 4 \times 10^{18}$ y	sf/4×10^{-14}	4.343(1)/0.006				0.1861/3.64
					4.601(1)/6.16				0.2624

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					4.784(1)/93.8				0.053−2.448
^{227}Ra		227.029178	42. m	β- /1.325	1.03/	(3/2+)	-0.404	+1.5	Ac L x-ray
					1.30/				Ac k x-ray
									0.02739
^{228}Ra		228.031070	5.76 y	β- /0.046	0.039/50	0+			0.0135
					0.014/30				(0.006−0.0306)
					0.026/20				
^{229}Ra		229.03496	4.0 m	β- /1.76	1.76/	(3/2+)	+0.503	+3.1	0.0145−0.1715
^{230}Ra		230.03706	1.5 h	β- /1.0	0.7/	0+			0.0631
									0.0720
									0.2028
									0.4698
									0.4787
^{231}Ra		231.0412	1.7 m	β-					
^{232}Ra		232.0436	4. m	β-		0+			
^{233}Ra		233.0481	30. s	β-					
^{234}Ra		234.051	~ 30. s	β-/		0+			
$_{89}$Ac									
^{206m}Ac			0.04 s	α	7.79				
^{206}Ac		206.0145	~ 26 ms	α	7.75				
^{207}Ac		207.0120	27 ms	α/	7.69				
^{208m}Ac			~ 25. ms	α/	7.72				
^{208}Ac		208.0116	~ 0.1 s	α/	7.62				
^{209}Ac		209.00949	~ 0.10 s	α/	7.58				
^{210}Ac		210.0094	0.34 s	α/7.610	7.462(8)/				
^{211}Ac		211.0077	0.20 s	α/7.620	7.480(8)/				
^{212}Ac		212.0078	0.9 s	α/7.520	7.379(8)/				
^{213}Ac		213.0066	0.73 s	α/7.500	7.364(8)/	(9/2-)			
^{214}Ac		214.00690	8.2 s	α/(86)/7.350	7.215/54	(5+)			(0.0626-0.754)
				EC/(14)/6.34	7.081/42				
					(6.48-7.15)				
^{215}Ac		215.00645	0.17 s	α/7.750	7.60/99.57	(9/2-)			0.399
					7.21/0.46				0.582
					7.03/0.20				0.654
					6.96/0.14				
^{216m}Ac			0.44 ms	α/	8.198(8)/1.7	(9-)			(0.0826-1.375)
					8.283(8)/2.5				
					9.028(5)/49				
					9.106(5)/46				
^{216}Ac		216.00872	44. ms	α/9.241	8.990(2)/10	(1-)			
					9.070(8)/90				
^{217m}Ac			0.7 μs	α/	10.540/100				
^{217}Ac		217.00935	0.07 μs	α/9.832	9.650(10)/100	9/2-			
^{218}Ac		218.01164	1.1 μs	α/9.380	9.205(15)/				
^{219}Ac		219.01242	0.012 ms	α/8.830	8.664(10)/	(9/2-)			
^{220}Ac		220.01476	26. ms	α/8.350	7.610(20)/23				
					4.680(20)/21				
					7.790(10)/13				
					7.850(10)/24				
					7.985(10)/4				
					8.005(10)/5				
					8.060(10)/6				
					8.195(10)/3				
^{221}Ac		221.01559	52. ms	α/7.790	7.170(10)/2				
					7.375(10)/10				
					7.440(15)/20				
					7.645(10)/70				
^{222m}Ac			63. s	α/(>89)/	6.710(20)/7				

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				EC/(1)/	6.750(20)/13				
				I.T./(<10)/	6.810(20)/24				
					6.840(20)/9				
					6.890(20)/13				
					6.970(20)/7				
					7.000(20)/13				
^{222}Ac		222.01784	5. s	α/7.141	6.967(10)/6	1-			
					7.013(2)/94				
^{223}Ac		223.01914	2.1 m	α/(99)/6.783	6.131(2)/0.12	(5/2-)			0.0725
				EC/(1)/0.59	6.177(2)/0.94				0.0839
					6.293(1)/0.47				0.0927
					6.326(1)/0.3				0.0990
					6.332(2)/0.14				0.1917
					6.360(1)/0.22				0.2158
					6.397(1)/0.13				0.3588
					6.448(1)/0.2				0.4768
					6.473(1)/3.1				
					6.523(2)/0.6				
					6.528(1)/3.1				
					6.563(1)/13.6				
					6.582(3)/0.3				
					6.646(1)/44				
					6.661(1)/31				
^{224}Ac		224.021723	2.7 h	EC/(90)/1.403	5.841(1)/0.5	0-			Ra L x-ray
				α/(10)/6.323	5.860(1)/0.75				Ra k x-ray
					5.875(1)/1.7				0.08426
					5.941(1)/4.4				0.13150
					6.000(1)/6.7				0.1571
					6.013(1)/1.4				0.21575
					6.056(1)/22				0.2619
					6.138(1)/26				(0.03−0.3)
					6.154(1)/1.0				
					6.204(1)/12				
					6.210(1)/20				
^{225}Ac		225.023230	10.0 d	α/5.935	5.286(1)/0.2	3/2			Fr k x-ray
					5.444(3)/0.1				0.06296/0.48
					5.554(1)/0.1				0.09982/1.36
					5.608(1)/1.1				0.1084
					5.636(1)/4.5				0.1116
					5.681(1)/1.4				0.1451
					5.722(1)/2.9				0.150.02/0.691
					5.731(1)/10				0.15724
					5.791(1)/9				0.18795/0.54
					5.793(1)/18				0.0075−0.8085
^{226}Ac		226.026098	1.224 d	EC/(17)/0.640		(1-)			Ra k x-ray
				β- /(83)/1.116					Th k x-ray
				α/(0.006)/5.51	5.399(5)/0.006				0.07218
									0.15816
									0.23034
^{227}Ac		227.027752	21.77 y	β- /98.6/0.045	0.045/54	(3/2-)	+1.1	+1.7	0.0838/23.
				α/(1.4)/5.043	4.869(1)/0.09				0.0811/14.
					4.938(1)/0.52				0.2696/13.
					4.951(1)/0.65				(0.044−1.27)
^{228}Ac		228.031021	6.15 h	β- /2.127	1.11/32	(3+)			Th L x-ray
					1.85/12				Th k x-ray
					2.18/11				0.12903
									0.33842
									0.91116
									0.96897
									(0.2−1.96)

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^{229}Ac		229.03302	1.04 h	β- /1.10	1.1/	(3/2+)			0.09335/2.43
									0.16451/2.61
									0.56916/2.24
									0.0111−0.898
^{230}Ac		230.0363	2.03 m	β- /2.7	1.4/	1+			Th k x-ray
				β-, sf	/0.000119				0.45497
									0.50820
									(0.12−2.5)
^{231}Ac		231.0386	7.5 m	β- /2.1	2.1/100	(1/2+)			0.14379
									0.18574
									0.22140
									0.28250
									0.3070
^{232}Ac		232.0420	2.0 m	β- /3.7		(2-)			
^{233}Ac		233.0446	2.4 m	β- /		(1/2+)			
^{234}Ac		234.0484	40. s	β- /		(1+)			
$_{90}$Th		**232.03806(2)**							
^{209}Th		209.0177	~ 0.01 s	α	8.08				
^{210}Th		210.0158	~ 9 ms	α	7.90	0+			
^{211}Th		211.0149	0.04 s	α	7.79				
^{212}Th		212.01298	~ 30. ms	α/	7.80/	0+			
^{213}Th		213.0130	0.14 s	α/7.840	7.692(10)/				
^{214}Th		214.01150	0.10 s	α/7.825	7.677(10)/	0+			
^{215}Th		215.01173	1.2 s	α/7.660	7.33(10)/8	(1/2-)			0.134
					7.395(8)/52				0.192
					7.524(8)/40				(0.069-0.295)
^{216m}Th			0.14 ms	α	9.93/74				(0.0905-1.478)
					8.00, 9.31				
^{216}Th		216.01106	27. ms	α/8.071	7.92/99.46	0+			0.628
					7.30/0.54				
^{217}Th		217.01311	0.25 ms	α/9.424	9.27/94.6				(0.546-0.822)
					8.46/3.8				
					8.73/1.6				
^{218}Th		218.01328	0.11 μs	α/9.847	9.665(10)/	0+			
^{219}Th		219.01554	1.05 μs	α/9.510	9.340(20)/				
^{220}Th		220.01575	10. μs	α/8.953	8.790(20)/	0+			
^{221}Th		221.01818	2. ms	α/8.628	7.732/7				
					8.142/72				
					8.469/21				
^{222}Th		222.01847	2.24 ms	α/8.129	7.980/97.7	0+			
					7.599/2.3				
^{223}Th		223.02081	0.60 s	α/7.454	7.29(1)/41(5)				
					7.32(1)/29(5)				
					7.350(15)/20(5)				
					7.390(15)/10(4)				
^{224}Th		224.02147	1.05 s	α/7.305	6.768(5)/1.2	0+			
					6.997(5)/19				
					7.170(5)/7				
^{225}Th		225.023951	8.72 m	EC/(10)/0.68		(3/2+)			
				α/(90)/6.920	6.441(2)/15				
					6.479(2)/43				
					6.501(3)/14				
					6.627(3)/3				
					6.650(5)/3				
					6.700(5)/2				
					6.743(3)/7				
					6.796(2)/9				
^{226}Th		226.024903	30.83 m	α/6.454	6.026(1)/0.2	0+			Ra k x-ray

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					6.041(1)/0.19				0.1112
					6.098(1)/1.3				0.2421
					6.2283(4)/23				0.1310
					6.3375(4)/75				0.1733−0.9295
^{227}Th		227.027704	18.72 d	α/6.146		(3/2+)			Ra L x-ray
									Ra k x-ray
									0.05014
									0.23597
									0.25624
									(0.02−1.0)
^{228}Th		228.028741	1.913 y	α/5.520	5.1770(2)/0.18	0+			
					5.2114(1)/0.4				
					5.3405(1)/26.7				
					5.4233(1)/73				
^{229m}Th			13.9 h	α	4.83-5.08				
^{229}Th		229.031762	7.9×10^3 y	α/5.168	4.814/9.3	5/2+	+0.46	+4.	0.1935/4.3
					4.845(5)/56				0.21089/277
					4.9008(5)/10.2				0.13697/1.21
					4.689−5.077				0.0111−0.6036
^{230}Th		230.033134	7.54×10^4 y	α/4.771	4.4383(6)/0.03	0+			0.0677/0.46
					4.4798(6)/0.12				0.1439/0.078
			$> 2 \times 10^{18}$ y	sf/$< 4 \times 10^{-12}$	4.6211(6)/23.4				
					4.6876(6)/76.3				
^{231}Th		231.036304	1.063 d	β- /0.390	0.138/22	5/2+			Pa L x-ray
					0.218/20				Pa k x-ray
					0.305/52				0.02564
									0.084203/
									(0.02−0.3)
^{232}Th	100.	232.038055	1.40×10^{10} y	α/4.081	3.830(10)/0.2	0+			0.0590
			1.2×10^{21} y	sf/1.1×10^{-9}	3.952(5)/23				0.124
					4.010(5)/77				
^{233}Th		233.041582	22.3 m	β-/1.245	1.245/	½+			Pa L x-ray
									Pa k x-ray
									0.02938
									0.08653
									0.45930
									(0.02−1.2)
^{234}Th		234.043601	24.10 d	β- /0.273	0.102/20	0+			Pa L x-ray
					0.198/72				0.06329/4.1
									0.09235/2.4
									0.09278/2.4
^{235}Th		235.04751	7.2 m	β- /1.9					0.4162
									0.6594
									0.7272
									0.747
									0.9318
^{236}Th		236.0499	37.5 m	β- /~ 1.0		0+			Pa k x-ray
									0.1107
^{237}Th		237.0539	5.0 m	β-					
^{238}Th		238.0565	9.4 m			0+			0.0890
$_{91}$Pa		**231.03588(2)**							
^{212}Pa		212.0232	~ 5 ms	α	8.27				
^{213}Pa		213.0211	7 ms	α	8.24				
^{214}Pa		214.0209	17 ms	α	8.12				
^{215}Pa		215.0192	15. ms	α	8.08/100				
^{216}Pa		216.0191	0.19 s	α/	7.95/51				0.134
					7.82/45				
					7.79/4				

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
^{217m}Pa			1.08 ms	α/	10.16/72				0.4504–0.8208
					8.306/11				
					9.55/6				
					9.69/2				
^{217}Pa		217.0183	3.8 ms	α/8.490	8.337/99				0.0466–0.634
					7.873/0.4				
					7.728/0.3				
					7.710/0.3				
^{218}Pa		218.02004	0.12 ms	α/	9.54/31				0.092
					9.61/69				
^{219}Pa		219.0199	0.05 μs	α					
^{220}Pa		220.0219	0.8 μs	α					
^{221}Pa		221.0219	6. μs	α	9.08(3)				
^{222}Pa		222.0237	~ 4.3 ms	α/8.700	8.180/50				
					8.330/20				
					8.540/30				
^{223}Pa		223.0240	~ 6.5 ms	α/8.340	8.006(10)/55				
					8.196(10)/45				
^{224}Pa		224.02563	0.84 s	α/7.630	7.555(10)/75(3)				0.1945
					7.46(1)/25(3)				(0.028–0.412)
^{225}Pa		225.0261	1.8 s	α/7.380	7.195(10)/30				
					7.245(10)/70				
^{226}Pa		226.02795	1.8 m	α/(74)/6.987	6.728(10)/0.7				
				EC/(26)/2.83	6.823(10)/35				
					6.863(10)/39				
^{227}Pa		227.02881	38.3 m	α/(85)/6.582	6.357(4)/7	(5/2-)			0.0649
				EC/(15)/1.02	6.376(10)/2.2				0.0669
					6.401(4)/8				0.1100
					6.416(4)/13				
					6.423(10)/10				
					6.465(4)/43				
^{228}Pa		228.031051	22. h	EC/(98)/2.111		(3+)	+3.5		Th k x-ray
				α/(2)	5.779/0.23				0.409/100
					5.805/0.15				0.4631/222
					6.078/0.4				0.91116/242
					6.105/0.25				0.96464/120
					6.118/0.22				0.96897/149
									0.058–1.96
^{229}Pa		229.032097	1.5 d	EC/(99.8)/0.32		(5/2+)			0.04244
				α/(0.2)/5.836	5.536(2)/0.02				(0.024–0.18)
					5.579(2)/0.09				
					5.668(2)/0.05				
^{230}Pa		230.034541	17.4 d	EC/(90)/1.310	0.51/	(2-)	2.0		Th L x-ray
				β-/(10)/0.563					Th k x-ray
									0.4437
									0.45477
									0.89876
									0.91856
									0.95199
									(0.053–1.07)
^{231}Pa		231.035884	3.25×10^4 y	α/5.148	4.6781(5)/1.5	3/2-	2.01	-1.7	Ac L x-ray
					4.7102(5)/1.0				Ac k x-ray
			$> 2 \times 10^{17}$ y	sf/$< 1.6 \times 10^{-15}$	4.7343(5)/8.4				0.01899
					4.8513(5)/1.4				0.027396
					4.9339(5)/3				0.03823
					4.9505(5)/22.8				0.04639
					4.9858(5)/1.4				0.25586
					5.0131(5)/25.4				0.26029
					5.0292(5)/20				0.28367
					5.0318(5)/2.5				0.30007

Elem. or Isot.	Natural Abundance (Atom %)	Atomic Mass or Weight	Half-life/ Resonance Width (MeV)	Decay Mode/ Energy (/MeV)	Particle Energy/ Intensity (MeV/%)	Spin ($h/2\pi$)	Nuclear Magnetic Mom. (nm)	Elect. Quadr. Mom. (b)	γ-Energy / Intensity (MeV/%)
					5.0587(5)/11				0.30264
									0.33007
									(0.02−0.61)
^{232}Pa		232.03859	1.31 d	β- /1.34		(2-)			U k x-ray
									0.10900
									0.15009
									0.89439
									0.96934
									(0.10−1.17)
^{233}Pa		233.040247	27.0 d	β-/0.571	0.15/40	3/2-	+4.0	-3.0	U L x-ray
					0.256/60				U k x-ray
									0.30017
									0.31201/38.4
									(0.0286-0.456)
^{234m}Pa			1.17 m	β- /99.9/2.29		(0-)			U k x-ray
				IT/0.13/					0.25818/0.07
									0.76641/0.32
									1.0009/0.86
									(0.06−1.96)
^{234}Pa		234.043308	6.69 h	β- /2.197	0.51/	(4+)			U L x-ray
									U k x-ray
									0.1312/0.03
									0.5695/0.02
									0.9256/0.02
									(0.02−1.99)
^{235}Pa		235.04544	24.4 m	β- /1.41	1.4/97	(3/2-)			0.0308−0.65893
^{236}Pa		236.0487	9.1 m	β- /2.9	1.1/40	(1-)			U k x-ray
					2.0/50				0.64235
					3.1/10				0.68759
									1.7630
									(0.04−2.18)
^{237}Pa		237.0512	8.7 m	β- /2.3	1.1/60	(1/2+)			0.4986
					1.6/30				0.5293
					2.3/10				0.5407
									0.8536
									0.8650
									(0.04−1.4)
^{238}Pa		238.0545	2.3 m	β- /3.5	1.2/	(3-)			0.10350
					1.7/				0.1785
									0.4484
									0.6350
									0.6800
									1.01446
									(0.04−2.5)
^{239}Pa		239.0573	1.8 h						
$_{92}$U		**238.02891(3)**							
^{217}U		217.0244	~ 0.2 ms	α	8.02				
^{218m}U			~ 0.56 ms	α	10.68				
^{218}U		218.02354	0.5 ms	α	8.61	0+			
^{219}U		219.0249	~ 0.08 ms	α	9.68(4)/				
^{222}U		222.0261	~ 1.μs	α		0+			
^{223}U		223.0277	0.02 s	α/	8.78(4)/				
^{224}U		224.02761	~ 1. ms	α/	8.46/100	0+			
^{225}U		225.02939	84. ms	α/	7.87/83				
					7.82/15				
					7.63/2				
^{226}U		226.02934	0.26 s	α/7.560	7.56/86	0+			
					7.38/14				

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^{227}U		227.03116	1.1 m	α/7.200	6.870/				
^{228}U		228.03137	9.1 m	α/6.803	6.404(6)/0.6	0+			0.095
					6.440(5)/0.7				0.152
					6.589(5)/29				0.187
					6.681(6)/70				0.246
^{229}U		229.03351	58. m	EC/(80)/1.31	6.223/3	(3/2+)			
				α/(20)/6.473	6.297(3)/11				
					6.332(3)/20				
					6.360(3)/64				
^{230}U		230.033940	20.8 d	α/5.992	5.5866(3)/0.01	0+			Th L x-ray
			> 4×10^{10} y	sf/< 10^{-10}	5.6624(3)/0.26				0.07218
					5.6663(3)/0.38				0.15421
					5.8178(3)/32				0.23034
					5.8887(3)/67				(0.081−0.8565)
^{231}U		231.036294	4.2 d	EC/0.36		(5/2-)			Pa L x-ray
				α/(10^{-3})	5.46/1.6 × 10^{-3}				Pa k x-ray
					5.47/1.4 × 10^{-3}				0.02564
					5.40/1. × 10^{-3}				0.08420
^{232}U		232.037156	70. y	α/5.414	4.9979(1)/0.003	0+			
			2.6 × 10^{15} y	sf/2.7 × 10^{-12}	5.1367(1)/0.3				
					5.2635(1)/31				
					5.3203(1)/69				
^{233}U		233.039635	1.592 × 10^{5} y	α/4.909	4.7830(8)/13.2	5/2+	+0.59	3.66	Th L x-ray
			> 2.7 × 10^{17} y	sf/6 × 10^{-11}	4.8247(8)/84.4				0.04244
					4.510−4.804				0.09714
									(0.0252−1.119)
^{234}U	0.0054(5)	234.040952	2.455 × 10^{5} y	α/4.856	4.604(1)/0.24	0+			0.05323/0.156
			1.5 × 10^{16} y	sf/1.6 × 10^{-9}	4.7231(1)/27.5				0.12091
					4.776(1)/72.5				
^{235m}U			26. m	IT/0.0007		1/2+			
^{235}U	0.7204(6)	235.043930	7.04 × 10^{8} y	α/4.6793	4.1525(9)/0.9	7/2-	-0.38	4.9	Th L x-ray
			1.0 × 10^{19} y	sf/7 × 10^{-9}	4.2157(9)/6.				Th k x-ray
					4.3237(9)/4.6				0.10917
					4.3641(9)/19.				0.14378
					4.370(4)/6				0.16338
					4.3952(9)/57.				0.18574
					4.4144(9)/2.1				0.20213
					4.5025(9)/1.7				0.20533
					4.5558(9)/4.2				0.22140
					4.5970(9)/4.8				(0.03−0.79)
^{236}U		236.045568	2.342 × 10^{7} y	α/4.569	4.332(8)/0.26	0+			Th L x-ray
			2.5 × 10^{16} y	sf/9 × 10^{-8}	4.445(5)/26				0.04946/100
					4.494(3)/74				0.11279/24.1
									0.17115/0.080
^{237}U		237.048730	6.75 d	β- /0.519	0.24/	1/2+			Np L x-ray
					0.25/				Np k x-ray
									0.05953
									0.20801
^{238}U	99.2742(10)	238.050788	4.47 × 10^{9} y	α	4.0395/0.23	0+			Th L x-ray
			8.2 × 10^{15}y	sf/5 × 10^{-5}	4.147(5)/23				0.04955/.06
					4.196(5)/77				0.1135/.01
^{239}U		239.054293	23.5 m	β- /1.265	1.2/	5/2+			(0.522−0.681)
					1.3/				
^{240}U		240.05659	14.1 h	β- /0.39	0.36/	0+			Np L x-ray
									0.04410
									0.05558
									0.06760
^{242}U		242.0629	16.8 m	β- /~ 1.2		0+			

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$_{93}$Np									
^{225}Np		225.0339	> 2 μs						
^{226}Np		226.0352	0.03 s	α/	8.04(2)/				
^{227}Np		227.0350	0.51 s	α/	7.65(2)/				
					7.68(1)/				
^{228}Np		228.0362	61. s	EC/60(7)/					
				α/40(7)/, sf					
^{229}Np		229.0363	4.0 m	α/7.010	6.890(20)				
^{230}Np		230.0378	4.6 m	EC/97 /3.6					
				α/3	6.660(20)				
^{231}Np		231.03825	48.8 m	EC/98 /1.8		5/2			0.2629
				α/2 /6.368	6.280/2				0.3475
									0.3703
^{232}Np		232.0401	14.7 m	EC/99 /2.7		(4-)			U L x-ray
									U k x-ray
									0.3268
									0.81925
									0.86683
^{233}Np		233.04074	36.2 m	EC/1.2		(5/2+)			U L x-ray
									U k x-ray
									0.29887
									0.31201
^{234}Np		234.04290	4.4 d	β+, EC/1.81	0.79/	(0+)			U L x-ray
									U k x-ray
									1.5272
									1.5587
									1.6022
^{235}Np		235.044063	1.085 y	EC/99.9 /0.124		5/2+			U k x-ray
				α/0.001/5.191					
^{236m}Np			22.5 h	EC/52 /		(1-)			U L x-ray
				β- /48 /					Pu L x-ray
									U k x-ray
									0.64235
									0.68759
^{236}Np		236.04657	1.55×10^5 y	EC/91 /0.94		(6-)			U L x-ray
				β- /9 /0.49					U k x-ray
									0.10423
									0.16031
^{237}Np		237.048173	2.14×10^6 y	α/4.957	4.6395(5)/6.5	5/2+	+3.14	+3.89	Pa L x-ray
			1×10^{18} y	sf/2.1×10^{-10}	4.766(5)/9.7				Pa k x-ray
					4.7715(5)/22.7				0.029378/15
					4.7884(5)/47.8				0.08653/12
					4.558−4.873				(0.03−0.28)
^{238}Np		238.050946	2.117 d	β- /1.292	1.2/	2+			Pu L x-ray
									Pu k x-ray
									0.98447/25.2
									1.02855/18.3
									(.044−1.026)
^{239}Np		239.052939	2.355 d	β- /0.722	0.341/30	5/2+			Pu L x-ray
					0.438/48				Pu k x-ray
									0.10613
									0.228186/11
									0.27760/15
									(0.04−0.50)
^{240m}Np			7.22 m	β- /99.9 /	2.18/	(1+)			0.25143
				IT/0.1 /					0.26333
									0.55454
									0.59735

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^{240}Np		240.05616	1.032 h	β- /2.20	0.89/	5+			0.1471/
									0.5664
									0.6008
^{241}Np		241.0583	13.9 m	β- /1.3	1.3/	5/2+			0.1330/
									0.1740
									0.280
^{242m}Np			2.2 m	β- /		(1+)			0.15910
									0.2651/
									0.78570
									0.9448/
^{242}Np		242.0616	5.5 m	β- /2.7	2.7/	6+			0.6209
									0.73620
									0.78074
									1.47340
									(0.04−2.37)
^{243}Np		243.06428	1.9 m						
^{244}Np		244.0679	2.3 m						
$_{94}$Pu									
^{228}Pu		228.03874	~ 1.1 s	α/	7.81(2)/	0+			
^{229}Pu		229.0402	~ 1.5 m	α/	7.46/				
^{230}Pu		230.03965	1.7 m	α/	7.06/81	0+			
					7.00/19				
^{231}Pu		231.04110	8.6 m	EC/90					
				α/10	6.72				
^{232}Pu		232.04119	34. m	EC/>80/1.1		0+			
				α/<20/6.716	6.542(10)/38				
					6.600(10)/62				
^{233}Pu		233.04300	20.9 m	EC(99.9)/1.9					0.1503
				α/0.1 /6.416	6.300(20)/0.1				0.1804
									0.2353
									0.5002
									0.5346/
									1.0352/
^{234}Pu		234.04332	8.8 h	EC/94 /0.39		0+			
				α/6 /6.310	6.035(3)/0.024				
					6.149(3)/1.9				
					6.200(3)/4.				
^{235}Pu		235.04529	25.3 m	EC/99+ /1.2		(5/2+)			
				α/0.003/5.957	5.850(20)/0.003				
^{236m}Pu			1.2 μs						
^{236}Pu		236.046058	2.87 y	α/5.867	5.611/0.21	0+			0.0476/0.07
			1.5×10^9 y	sf/1.9×10^{-7}	5.7210/30.5				0.109/0.02
					5.7677(1)/69.3				(0.17−0.97)
^{237}Pu		237.048410	45.7 d	EC/99.9 /0.220		7/2-			Np L x-ray
				α/0.003 /5.747	5.334(4)/0.0015				Np k x-ray
					5.356(4)/0.0006				0.026344
					5.650(4)/0.0007				0.03319
									0.05954
									(0.03−0.5)
^{238}Pu		238.049560	87.7 y	α/5.593	5.3583(1)/0.10	0+			U k x-ray
			4.75×10^{10} y	sf/1.8×10^{-7}	5.465(1)/28.3				0.04347
					5.4992(1)/71.6				(0.04−1.1)
^{239}Pu		239.052163	2.410×10^4 y	α/5.244	5.055/0.047	1/2+	+0.203		U k x-ray
			8. × 10^{15} y	sf/3×10^{-10}	5.076/0.078				0.05162
					5.106/11.9				0.05682
					5.144/17.1				0.12928
					5.157/70.8				0.37502
					(4.74 −5.03)				0.41369

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^{240}Pu		240.053814	6.56×10^{3} y	α/5.255	5.0212(1)/0.07	0+			U L x-ray
			1.14×10^{11} y	sf/5.7×10^{-6}	5.1237(1)/26.4				0.04524
					5.1681(1)/73.5				0.10423
									(0.04–0.97)
^{241}Pu		241.056852	14.3 y	β-/99+/0.0208	$4.853/3 \times 10^{-4}$	5/2+	-0.683	+6.	0.14854
				α/0.002 /5.139	4.897/0.002				0.1600
			< 6×10^{16} y	sf/> 2.4×10^{-14}					
^{242}Pu		242.058743	3.75×10^{5} y	α/4.983	4.7546(7)/0.098	0+			U L x-ray
			6.77×10^{10} y	sf/5.5×10^{-4}	4.8564(7)/22.4				0.04491
					4.9006(7)/78				0.10350
^{243}Pu		243.062003	4.956 h	β- /0.582	0.49/21	7/2+			Am L x-ray
					0.58/60				0.0417
									0.0839
^{244}Pu		244.064204	8.00×10^{7} y	α/99.9/4.665	4.546(1)/19.4	0+			U L x-ray
			6.6×10^{10} y	sf/0.12	4.589(1)/80.5				0.0439
^{245}Pu		245.06775	10.5 h	β- /1.21	0.93/57	(9/2-)			Am L x-ray
					1.21/11				Am k x-ray
									0.2804 /
									0.30832
									0.32752
									0.56014
									(0.03–1.2)
^{246}Pu		246.07021	10.85 d	β- /0.40	0.150/85	0+			Am L x-ray
					0.35/10				Am k x-ray
									0.04379
									0.22371
^{247}Pu		247.0741	2.3 d						
$_{95}$Am									
^{232}Am		232.0466	0.9 m	EC/~ 5.0					
^{233}Am		233.0464	~ 3.2 m	α	6.78				
^{234}Am		234.0478	2.3 m	EC/4.2					
^{235}Am		235.0480	10.3 m	EC					Pu K x-ray
				α	6.46/0.4				0.291/100
									(0.170-0.828)
^{236m}Am			2.9 m			(1-)			(0.583-0.713)
^{236}Am		236.0496	3.6 m	EC		(5-)			(0.158-1.038)
^{237}Am		237.0500	1.22 h	EC/99.98 /1.7		(5/2-)			Pu k x-ray
				α/0.02 /6.20	6.042(5)/0.02				0.14559
									0.28026
									0.43845
^{238}Am		238.05198	1.63 h	EC/2.26		1+			Pu L x-ray
				α/0.0001 /6.04	5.940/0.0001				Pu k x-ray
									0.91870
									0.96278
^{239}Am		239.053025	11.9 h	EC/99.99/0.803		5/2-			Pu L x-ray
				α/0.01/5.924	5.734(2)/0.001				Pu k x-ray
					5.776(2)/0.008				0.18172
									0.22818
									0.27760
^{240}Am		240.05530	2.12 d	EC/1.38		(3-)			Pu L x-ray
				α/5.592	$5.378(1)/16 \times 10^{-4}$				Pu k x-ray
									0.88878
									0.98764
									(0.1–1.3)
^{241}Am		241.056829	432.7 y	α/5.637	5.2443(1)/0.002	5/2-	+1.58	+3.1	Np L x-ray
			1.2×10^{14} y	sf/3.6×10^{-10}	5.3221(1)/0.015				0.02634 /.024
					5.3884(1)/1.4				0.03319/.00126
					5.4431(1)/12.8				0.05954/0.359

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					5.4857(1)/85.2				(0.03−1.128)
					5.5116(1)/0.20				
					5.5442(1)/0.34				
^{242m}Am			141. y	IT/99.5/0.048		5-	+1.0	+6.5	Am L x-ray
				α/0.5/5.62	5.141(4)/0.026				0.04863
			> 3 × 10^{12} y	sf/< 4.7 × 10^{-9}	5.2070(2)/0.4				0.08648
									0.10944
									0.16304
^{242}Am		242.059549	16.02 h	β- /83 /0.665	0.63/46	1-	+0.388	-2.4	Pu L x-ray
				EC/17 /0.750	0.67/37				Cm L x-ray
									Pu k x-ray
									0.0422
									0.04453
^{243}Am		243.061381	7.37 × 10^{3} y	α/5.438	5.1798(5)/1.1	5/2-	+1.5	+2.9	0.04354
			2. × 10^{14} y	sf/3.7 × 10^{-9}	5.2343(5)/11				0.07467
					5.2766(5)/88				0.08657
					5.394(5)/0.12				0.11770
					5.3500(5)/0.16				0.14197
^{244m}Am			~ 26. m	β- /1.498		(1-)			0.0429
^{244}Am		244.064285	10.1 h	β- /1.428					Am L x-ray
									Cm k x-ray
									0.7460
									0.9000
^{245}Am		245.066452	2.05 h	β- /0.894	0.65/19	(5/2+)			Cm L x-ray
					0.90/77				Cm k x-ray
									0.25299
^{246m}Am			25.0 m	β- /	1.3/79.	2-			Cm L x-ray
					1.60/14				Cm k x-ray
					2.1/7				0.27002
									0.79881
									1.06201
									1.07885
									(0.04−2.29)
^{246}Am		246.06978	39. m	β- /2.38	1.2/	(7-)			Cm L x-ray
									Cm k x-ray
									0.1529
									0.2046
									0.6786
^{247}Am		247.0721	22. m	β- /1.7					Cm L x-ray
									Cm k x-ray
									0.2267 /
									0.2853 /
$_{96}$Cm									
^{233}Cm		233.0508		α/	7.34/				
^{234}Cm		234.05016	~ 51. s	α	7.24/	0+			
^{235}Cm		235.0514							
^{236}Cm		236.0514		EC/1.7		0+			
^{237}Cm		237.0529		EC/2.5					
^{238}Cm		238.05303	2.4 h	EC/>90 /0.97		0+			
				α/<10 /6.632	6.520(50)/<10				
^{239}Cm		239.0550	~ 3. h	EC/1.7					
									0.0407
									0.1466
									0.1874
^{240}Cm		240.055530	27. d	α/6.397	5.989/0.014	0+			
					6.147/0.05				
			1.9 × 10^{6} y	sf/3.9 × 10^{-6}	6.2478(6) /28.8				
					6.2906(6) /70.6				

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^{241}Cm		241.057653	32.8 d	EC/99 /0.768		1/2+			Am k x-ray
				α/1 /6.184	5.8842(4)/0.12				0.13241
					5.9291(4)/0.18				0.16505
					5.9389(4)/0.69				0.18028
									0.43063
									0.47181
^{242}Cm		242.058836	162.8 d	α/6.216	5.9694(1)/0.035	0+			Pu L x-ray
					6.069(1)/25				0.04408
			7.0×10^{6} y	sf/6.4×10^{-6}	6.1129(1)/74				0.10189
									(0.04–1.2)
^{243}Cm		243.061389	29.1 y	α/6.167	5.6815(5) /0.2	5/2+	0.41		Pu L x-ray
					5.6856(5)/1.6				Pu k x-ray
			5.5×10^{11} y	sf/5.3×10^{-9}	5.7420(5)/10.6				0.10612
					5.7859(5)/73.3				0.20975
					5.9922(5)/6.5				0.22819
					6.0103(5)/1.0				0.27760
					6.0589(5)/5				0.28546
					6.0666(5)/1.5				0.33431
									(0.04–0.7)
^{244}Cm		244.062753	18.1 y	α/5.902	5.6656/0.02	0+			Pu L x-ray
					5.7528/23				0.04282
			1.32×10^{7} y	sf/1.4×10^{-4}	5.8050/77				0.09885
					5.515/0.004				0.15262
^{245}Cm		245.065491	8.48×10^{3} y	α/5.623	5.235(10)/0.3	7/2+	0.5		Pu L x-ray
					5.3038(10)/5.0				Pu k x-ray
			1.4×10^{12} y	sf/6.1×10^{-7}	5.3620(7)/93				0.04195
					5.4927(11)/0.8				0.13299
					5.5331(11)/0.6				0.13606
									0.17494
^{246}Cm		246.067224	4.76×10^{3} y	α/5.476	5.343(3)/21	0+			Pu L x-ray
			1.8×10^{7} y	sf/0.026	5.386(3)/79				0.04453
^{247}Cm		247.070354	1.56×10^{7} y	α/5.352	4.818(4)/4.7	9/2-	0.37		Pu k x-ray
					4.8690(20)/71				0.2792
					4.941(4)/1.6				0.2886
					4.9820(20)/2.0				0.3471
					5.1436(20)/1.2				0.4035
					5.2104(20)/5.7				
					5.2659(20)/13.8				
^{248}Cm		248.072349	3.48×10^{5} y	α/99.92 /5.162	4.931(5)/0.07	0+			
					5.0349(2)/16.5				
			4.15×10^{6} y	sf/8.38	5.0784(2)/(75)/1				
^{249}Cm		249.075953	64.15 m	β- /0.900	0.9/	1/2+			Bk k x-ray
									0.56039/0.84
									0.63431/1.5
									(0.085-0.653)
^{250}Cm		250.07836	~ 9.7×10^{3} y	sf/85.8		0+			
				α/5.27					
^{251}Cm		251.08229	16.8 m	β- /1.42	0.90/16	(1/2+)			0.3896 /
									0.5299
									0.5425
^{252}Cm		252.0849	< 2 d			0+			
$_{97}$Bk									
^{238}Bk		238.0583	2.4 m	EC/5.0					
^{239}Bk		239.0583							
^{240}Bk		240.0598	~ 4.8 m						
^{241}Bk		241.0602	4.6 m	EC					(0.152-0.262)
^{242}Bk		242.0620	7.0 m	EC/3.0					
^{243}Bk		243.063008	4.5 h	EC/99.8 /1.508	6.542(4)/0.03	(3/2-)			0.1466

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				α/0.15 /6.871	6.5738(2)/0.04				0.1874
					6.7180(22)/0.02				0.755
					6.7581(20)/0.02				0.840
									0.946
^{244}Bk		244.06518	4.4 h	EC/99.99 /2.26		(4-)			0.1445
				α/0.01 /6.778	6.625(4)/0.003				0.1876
					6.667(4)/0.003				0.2176
									0.9815
									0.9215/
^{245}Bk		245.066362	4.94 d	EC/99.9 /0.810		3/2-			Cm L x-ray
				α/0.1 /6.453	5.8851(5)/0.03				Cm k x-ray
					6.1176(9)/0.01				0.25299
					6.1467(5)/0.02				0.3809
					6.3087(5)/0.014				0.3851
					6.3492(5)/0.018				
^{246}Bk		246.0687	1.80 d	EC/1.35		(2-)			Cm L x-ray
									Cm k x-ray
									0.79881
									1.08142
^{247}Bk		247.07031	1.4×10^3 y	α/5.889	5.465(5)/1.5	(3/2-)			0.04175
					5.501(5)/7				0.0839
					5.532(5)/45				0.268
					5.6535(20)/5.5				
					5.678(2)/13				
					5.712(2)/17				
					5.753(2)/4.3				
					5.794(2)/5.5				
^{248}Bk		248.07310	23.7 h	β- /70 /0.87	0.86/	(1-)			Cm L x-ray
				EC/30 /0.72					Cf L x-ray
									Cm k x-ray
									Cf k x-ray
									0.5507
^{249}Bk		249.074987	320. d	β- /0.125	0.125/100	7/2+	2.0		$0.327/10^{-5}$
				α/0.001 /5.525	5.390(1)/0.0002				$0.308/10^{-6}$
			1.8×10^9 y	sf/4.9×10^{-8}	5.4174(6)/0.001				
^{250}Bk		250.078317	3.217 h	β- /1.780	0.74/	2-			Cf L x-ray
									Cf k x-ray
									0.98912
									1.03184
									(0.04–1.6)
^{251}Bk		251.08076	56. m	β- /1.09		(3/2-)			0.02481
									0.1528
									0.1776
^{252}Bk		252.0843	1.8 m						
$_{98}$Cf									
^{237}Cf		237.062	2.1 s	α, sf/10					
^{238}Cf		238.0614	21 ms	sf/~ 100		0+			
				α/~ 0.2					
^{239}Cf		239.0624	~ 0.7 m	α					
^{240}Cf		240.0623	1.1 m	α/7.719	7.590(10)/	0+			
				sf/ ~ 2.1					
^{241}Cf		241.0637	4. m	EC/3.3					
				α/7.60	7.335(5)/				
^{242}Cf		242.06370	3.5 m	α/7.509	7.351(6)/20	0+			
				sf/<0.014	7.385(4)/80				
^{243}Cf		243.0654	11. m	EC/86 /2.2	7.060(6)/20	(1/2+)			
				α/14 /7.40	7.170/4				
^{244}Cf		244.066001	20. m	α/7.328	7.168(5)/25	0+			

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					7.210(5)/75				
^{245}Cf		245.068049	44. m	α/36 /7.255	7.14/91.7				Cm K x-ray
				EC/64 /1.569	6.983/0.31				0.5709
					7.09/7				0.6014
					7.065/0.68				0.6163
^{246}Cf		246.068805	1.49 d	α/6.869	6.6156(10)/0.18	0+			Cm L x-ray
					6.7086(7)/21.8				0.04221
			1.8×10^3 y	sf/2.3×10^{-4}	6.7501(7)/78.0				0.0945
									0.147
^{247}Cf		247.07100	3.11 h	EC/99.96 /0.65		7/2+			Bk k x-ray
				α/0.04 /6.55	6.301(5)/				0.2941
									0.4778
^{248}Cf		248.07219	334. d	α/6.369	6.220(5)/17	0+			
			3.2×10^4 y	sf/0.0029	6.262(5)/83				
^{249}Cf		249.074854	351. y	α/6.295	5.758/3.7	9/2-			Cm L x-ray
					5.812/85.7				Cm k x-ray
			$8. \times 10^{10}$ y	sf/4.4×10^{-7}	5.8488(2)/1.0				0.25299/2.5
					5.9029(2)/2.8				0.33351/13.6
					5.9451(2)/4.0				0.38832/63.6
					6.1401(2)/1.1				(0.0376−1.103)
					6.1940(2)/2.2				
^{250}Cf		250.076406	13.1 y	α/6.129	5.8913(4)/0.3	0+			Cm L x-ray
			1.7×10^4 y	sf/0.077	5.9889(4)/15				0.04285
					6.0310(4)/84.5				
^{251m}Cf			26.3 μs						
^{251}Cf		251.079587	9.0×10^2 y	α/6.172	5.56448(7)/1.5	1/2+			0.109/19.8
					5.632(1)/4.5				0.1775/17.3
					5.648(1)/3.5				(0.0385-0.354)
					5.6773(6)/35				
					5.762(3)/3.8				
					5.7937(7)/2.0				
					5.8124(8)/4.2				
					5.8514(6)/27				
					6.0140(7)/11.6				
					6.0744(7)/2.7				
^{252}Cf		252.081626	2.65 y	α/96.9 /6.217	5.7977(1)/0.23	0+			Cm L x-ray
			86. y	sf/3.1/	6.0756(4)/15.2				0.04339
					6.1184(4)/81.6				0.1002
^{253}Cf		253.08513	17.8 d	β- /99.7 /0.29	0.27/100	(7/2+)			
				α/0.3 /6.126	5.921(5)/0.02				
^{254}Cf		254.08732	60.5 d	sf/99.7/		0+			
				α/0.3/5.930	5.792(5)/0.05				
					5.834(5)/0.26				
^{255}Cf		255.0911	1.4 h	β- /0.7					
^{256}Cf		256.0934	12. m	sf		0+			
$_{99}$Es									
^{241}Es		241.0685	~ 8 s	α	8.11				
^{242}Es		242.0698	16 s	α	7.92				
^{243}Es		243.0696	21. s	α/>30 /	7.89/>30				
				EC/<70 /4.0					
^{244}Es		244.0709	37. s	EC/76 /4.6					
				α/4 /	7.57/4				
^{245}Es		245.0713	1.3 m	α/40 /7.858	7.74				
				EC/60 /3.1					
^{246}Es		246.0729	7.7 m	EC/90 /3.9					
				α/10 /	7.35				
^{247}Es		247.07366	4.8 m	EC/93 /2.48					
				α/7 /	7.32				

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^{248}Es		248.0755	26. m	EC/99.7 /3.1					
				α/0.3 /	6.87				
^{249}Es		249.07641	1.70 h	EC/99.4 /1.45		(7/2+)			0.3795
				α/0.6 /	6.77				0.8132
^{250m}Es			2.2 h	EC/		(1-)			Cf L x-ray
				β+					Cf k x-ray
									0.9891
									1.0319
^{250}Es		250.0786	8.6 h	EC/2.1		(6+)			Cf L x-ray
									Cf k x-ray
									0.30339
									0.34948
									0.82883
^{251}Es		251.07999	1.38 d	EC/99.5 /0.38		(3/2-)			
				α/0.5 /	6.462/0.05				
					6.492/0.4				
^{252}Es		252.08298	1.29 y	α/76 /	6.632/61.0	(5-)			
				EC/24 /1.26	6.562/10.3				
^{253}Es		253.084825	20.47 d	α/	6.633/89.8	7/2+	+4.10	7.	0.04180/5.6
			6.3×10^5 y	sf/8.9×10^{-6}	6.5916/6.6				0.3892/2.7
									(0.0309-1.106)
^{254m}Es			1.64 d	β- /99.6 /	0.475	2+	2.9	3.7	Fm L x-ray
				α/0.3 /6.67	6.382	2+			Fm k x-ray
			> 10. y	sf/0.045					0.6488
									0.6938
^{254}Es		254.088022	276. d	α/	6.429	(7+)			0.064
			$> 2.5 \times 10^7$ y	sf/$< 3 \times 10^{-6}$					
^{255}Es		255.09027	40. d	β- /92 /0.29		(7/2+)			
				α/8 /	6.26				
			2.6×10^3 y	sf/0.0042	6.300				
^{256m}Es			7.6 h	β- /		(8+)			0.218
									0.232
									0.862
^{256}Es		256.0936	25. m	β-/1.7		(1+)			
^{257}Es		257.0960	7.7 d	β-					
$_{100}$Fm									
^{242}Fm		242.0734	0.8 ms	sf/> 96		0+			
^{243}Fm		243.0744	0.2 s	α/	8.55				
				sf/< 0.4					
^{244}Fm		244.0741	3.3 ms	sf/> 97		0+			
^{245}Fm		245.0754	4. s	α/	8.15/				
				sf/<0.1					
^{246}Fm		246.07530	1.2 s	α/85/	8.24/	0+			
				sf/15/					
^{247m}Fm			4.3 s	α/	8.17/				
^{247}Fm		247.0769	29. s	α/8.20	7.87/70				
				EC/2.9	7.93/30				
^{248}Fm		248.07720	33. s	α/99.9 /8.001	7.83/20	0+			
				sf/0.1/	7.87/80				
^{249}Fm		249.0790	1.6 m	EC/2.4		(7/2+)			
				α/	7.57				
^{250m}Fm			1.8 s	IT/					
				sf/$<8 \times 10^{-5}$					
^{250}Fm		250.07952	30. m	α/	7.43/	0+			
				EC/0.8					
				sf/0.007					
^{251}Fm		251.08158	5.3 h	EC/98 /1.47		(9/2-)			
				α/2 /	6.833				

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^{252}Fm		252.08247	1.058 d	α/7.154	6.998/15	0+			
				sf/0.0023	7.039/85				
^{253}Fm		253.085185	3.0 d	EC/88/0.333	6.676/	½+			Es k x-ray
				α/12 /	6.943/				0.2719
^{254}Fm		254.086854	3.240 h	α/	7.150	0+			
				sf/0.059	7.192				
^{255}Fm		255.089962	20.1 h	α/	6.9635(5)/5.0	7/2+			0.08148/1.
			1.0×10^4 y	sf/2.3×10^{-5}	7.0225(5)/93.4				(0.041-0.900)
^{256}Fm		256.09177	2.63 h	sf/91		0+			
				α/19	6.92/				
^{257}Fm		257.09511	100.5 d	α/99.79	6.519	(9/2+)			0.1794
				sf/0.21					0.2410
^{258}Fm		258.0971	0.37 ms	sf/		0+			
^{259}Fm		259.1006	1.5 s	sf/					
^{260}Fm		260.103	~ 4 ms	sf/		0+			
$_{101}$Md									
^{245m}Md			~ 0.4 s	α	8.64, 8.68				
^{245}Md		245.0808	0.9 ms	sf					
^{246}Md		246.0819	1.0 s	α	8.74				
					8.50−8.56				
^{247m}Md			~ 0.2 s	sf/					
^{247}Md		247.0816	3. s	α	8.43				
^{248}Md		248.0828	7. s	EC/80 /5.3	8.32/15				
				α/20 /	8.36/5				
				sf/<0.05					
^{249}Md		249.0830	24. s	EC>/<80 /3.7					
				α/>20 /8.46	8.030(20)/				
^{250}Md		250.0844	50. s	EC/94 /4.6	7.75/4				
				α/6 /8.25	7.83/2				
^{251}Md		251.0848	4.0 m	EC/>94 /3.1					
				α/<6 /	7.55/				
^{252}Md		252.0866	2. m	EC/>50 /3.9					
				α/<50 /	7.73/				
^{253}Md		253.0873	~ 6 m	EC/2.0					
^{254m}Md			30. m	EC/					
^{254}Md		254.0897	10. m	EC/2.7					
^{255}Md		255.09108	27. m	EC/92 /1.04	α/7.33/93	(7/2-)			0.121/100
				α/8 /	7.27/5				0.115/65
				sf/< 0.15	7.75/1				0.136/35
					7.71/1				0.141−0.453
^{256}Md		256.0941	1.30 h	EC/89 /2.13	7.21/71				Fm k x-ray
				α/11 /	7.14/22				0.121/409
				sf/< 2.6	7.68/2.5				0.115/266
					7.25/2.5				0.136/143
					7.64/2.1				0.634/119
									0.141−1.37
^{257}Md		257.095541	5.5 h	EC/85 /0.41	7.074	(7/2-)			Fm k x-ray
				α/15, sf/< 1	7.014				(0.181−0.389)
^{258m}Md			57. m	EC/		(1-)			Fm k x-ray
				sf/< 30					
^{258}Md		258.098431	51.5 d	α/7.40	6.718(2)/	(8-)			0.3678
				sf/< 0.003	6.763(4)/				0.057−0.448
^{259}Md		259.1005	1.64 h	sf/>98.7		7/2+			
				α/<1.3					
^{260}Md		260.1037	~ 27.8 d	sf/ 73−100					
$_{102}$No									
^{248}No		248.0866	< 1.0 μs	sf		0+			

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^{249}No		249.0878	0.05 ms	sf					
				α/ < 20					
^{250}No		250.0875	6. μs	sf/		0+			
				α/ < 10					
^{251m}No			0.9 s	α	8.67				
^{251}No		251.0890	0.78 s	α/91	8.62/96				
				sf/0.26	8.58/4				
^{252}No		252.08898	2.44 s	α/75/8.551	8.42	0+			
				sf/24/	8.37				
				EC, β+/<1.6					
^{253}No		253.0907	1.7 m	α/	8.00	(9/2-)			0.222/100
				EC/3.2					(0.151-0.280)
^{254m}No			0.28 s	I.T./					
				sf/< .2					
^{254}No		254.09096	49. s	α/	8.09	0+			0.102
				EC/1.1					0.152
				sf/0.17					
^{255}No		255.09324	3.1 m	α/62 /	8.12/	½+			0.187
				EC/38/2.01	7.93				
					8.08				
^{256}No		256.09428	2.9 s	α/	8.43	0+			
				sf/0.5					
^{257}No		257.09688	24.5 s	α/	8.222/83	(7/2+)			0.0770
				sf/<1.5	8.27				0.1018
					8.323/17				0.1241
^{258}No		258.0982	~ 1.2 ms	sf/		0+			
^{259}No		259.1010	58. m	α/78 /7.794	7.52	(9/2+)			
				EC/22/0.5	7.55				
				sf/<9.7					
^{260}No		260.1026	0.11 s	sf/		0+			
^{262}No		262.1073	~ 8. ms	sf/		0+			
$_{103}$Lr									
^{251}Lr		251.0944	39 m	sf					
^{252}Lr		252.0954	~ 0.36 s	α	9.02/73				
				sf/<1	8.97/27				
^{253m}Lr			~ 0.57 s	α	8.79				
				sf/1.3					
^{253}Lr		253.0952	1.5 s	α/	8.72				
				sf/8					
^{254}Lr		254.0965	13. s	α/	8.45				
				EC/5.2					
				sf/<0.1					
^{255}Lr		255.09669	22. s	α/	8.37/60				
				EC/3.2	8.43/40				
				sf/< 0.1					
^{256}Lr		256.0986	27. s	α/99.7 /8.554	8.43/				
				EC/4.2	8.39				
				sf/< 0.03					
^{257}Lr		257.0996	0.65 s	α/	8.80	7/2+			
				EC/2.5					
				sf/< 0.03					
^{258}Lr		258.1018	3.9 s	α/	8.60/46				
				EC/3.4	8.62/25				
				sf/< 5	8.56/20				
					8.65/9				
^{259}Lr		259.1029	6.1 s	α/80	8.44(1)				
				sf/20					
^{260}Lr		260.1055	3. m	α/	8.03				

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^{261}Lr		261.1069	40. m	sf					
^{262}Lr		262.1096	3.6 h	EC/2.					
				sf/<10					
$_{104}$Rf									
^{253}Rf		253.1007	~ 48. μs	sf					
				α/<10					
^{254}Rf		254.1002	23. μs	sf/>98.5		0+			
				α/<1.5					
^{255}Rf		255.1013	1.6 s	α	8.72/<0.05				0.203
				sf/52	8.77/94				0.142
					8.67/<0.05				
					8.58/<0.05				
					8.92/<0.05				
^{256}Rf		256.10117	6.2 ms	sf/99.68		0+			
				α/0.32	8.81				
^{257}Rf		257.1030	4.7 s	α/9.22	8.77				0.117
				EC/11	9.01				
				sf/<1.4	8.95				
					8.62				
^{258}Rf		258.1035	12. ms	sf/87		0+			
				α/13					
^{259}Rf		259.1056	3.4 s	α/9.09/93	8.77(2)/				
				sf/7	8.86/				
^{260}Rf		260.1064	20. ms	sf/		0+			
^{261m}Rf			1.3 m	α	8.28				
^{261}Rf		261.10877	5. s	α/60, sf/40	8.52/				
^{262}Rf		262.1099	2.1 s	sf/>99.2		0+			
^{263}Rf		263.1126	10. m	sf, α					
^{265}Rf		265.1167	~ 13 h	α					
^{267}Rf		267.122	~ 0.1 d	sf					
$_{105}$Db									
^{255}Db		255.1074	~ 1.5 s	α,					
				sf/~ 20					
^{256}Db		256.1081	1.6 s	α/64	9.02/67				
				EC/35	8.89/11				
				sf/0.05	9.08/11				
					9.12/11				
^{257m}Db			0.8 s	α	9.16				
				sf/<13					
^{257}Db		257.1077	1.5 s	α/	8.97/33				
				sf/<6	9.07/38				
					9.12/5.5				
					8.94/9				
					9.02/9				
					8.89/5.5				
^{258}Db		258.1092	4.2 s	α/	9.30/				
				EC/5.3	9.17/				
				sf/<33	9.08/				
^{259}Db		259.1096	~ 0.51 s	sf/					
				α/	9.47/				
^{260m}Db			0.3 m						
^{260}Db		260.1113	1.5 s	α/	9.05/				
				sf/<9.6	9.08/				
					9.13/				
^{261}Db		261.1121	1.8 s	α/	8.93/				
				sf/<18					
^{262}Db		262.1141	0.5 m	sf/<33					

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				α/	8.45/				
					8.53/				
					8.67/				
^{263}Db		263.1150	~ 0.45 m	sf/57	8.36/				
				α/41	8.41/				
				EC/3					
^{267}Db		267.1224	1.2 h	sf					
^{268}Db		268.125	1.2 d	sf, EC					
$_{106}$Sg									
^{258}Sg		258.1132	~ 2.9 ms	sf		0+			
				α/<20					
^{259}Sg		259.1145	0.5 s	α/	9.62				
				sf/<20	9.35				
					9.03				
^{260}Sg		260.11442	4. ms	α/50	9.76	0+			
				sf/50	9.72				
					9.81				
^{261}Sg		261.1161	0.3 s	α, sf/<10	9.56				
^{262}Sg		262.1164	0.007 s	sf		0+			
				α/<22					
^{263m}Sg			0.3 s	α	9.2				
^{263}Sg		263.1183	0.8 s	α	9.06				
				sf/<30	9.25				
^{265}Sg		265.1211	8. s	α/>65	8.84/46				
				sf/<35	8.76/23				
					8.94/23				
					8.69/8				
^{266}Sg		266.1221	~ 21. s	α/	8.77/66	0+			
				sf/<82	8.52/33				
^{271}Sg		271.133	~ 0.04 h	α/50	8.53				
				sf/50					
$_{107}$Bh									
^{260}Bh		260.122		α					
^{261}Bh		261.1217	12. ms	α/, sf <10	10.40				
					10.10				
					10.03				
^{262m}Bh			8. ms	α/	10.37				
				sf/<12	10.24				
^{262}Bh		262.1229	0.10 s	α/	10.06				
				sf/<12	9.91				
					9.74				
^{264}Bh		264.1246	1.0 s	α/	9.3 − 9.8				
				sf/					
^{265}Bh		265.1252	0.9 s	α	9.24				
^{266}Bh		266.1269	~ 2 s	α	9.08				
^{267}Bh		267.1277	~ 17 s	α	8.83				
$_{108}$Hs									
^{263}Hs		263.1286		α/					
^{264}Hs		264.12839	~ 0.08 ms	α/, sf/~ 50	11.0	0+			
^{265m}Hs			~ 0.75 ms	α	10.57/63				
					10.73				
					10.52				
					10.34				
^{265}Hs		265.1301	2.0 ms	α/	10.30/90				
				sf/<1	10.43				
					10.37				

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					10.25				
^{266}Hs		266.1301	~ 2.3 ms	α	10.2	0+			
^{267m}Hs			~ 0.8 s						
^{267}Hs		267.1318	0.05 s	α/>88	9.88				
					9.83				
					9.75				
^{269}Hs		269.1341	~ 14 s	α	9.23				
					9.18				
^{270}Hs		270.1347	~ 3.6 s	α	9.16	0+			
^{275}Hs		275.146	~ 0.15 s	α	9.3				
^{277}Hs		277.150	~ 11 m	sf					
$_{109}$Mt									
^{266m}Mt			~ 1.2 ms	α	10.46−10.81				
^{266}Mt		266.1373	~ 0.7 ms	α	10.48−11.31				
^{267}Mt		267.137	19 ms	α					
^{268}Mt		268.1387	~ 0.03 s	α/>68	10.3 - 10.8				
^{270}Mt		270.141	5 ms	α	10.0				
^{275}Mt		275.149	0.01 s	α	10.3				
^{276}Mt		276.151	~ 0.7 s	α	9.7				
$_{110}$Ds									
^{267}Ds		267.1443	~ 3 μs	α/>32	11.6				
^{269}Ds		269.1451	0.17 ms	α/>75	11.11				
^{270m}Ds			~ 6 ms	α	10.95				
					11.15				
					12.15				
^{270}Ds		270.1447	0.1 ms	α	11.03	0+			
^{271m}Ds			0.07 s	α	9.9				
^{271}Ds		271.1461	1.6 ms	α	10.8				
^{273m}Ds			0.076 ms	α	11.8				
^{273}Ds		273.1489	118 ms	α/	9.73				
^{279}Ds		279.159	0.18 s	sf/90					
				α/10	9.7				
^{280}Ds		280.160	~ 7.6 s	sf/		0+			
^{281}Ds		281.162	10. s	sf					
^{282}Ds			0.5 ms	sf					
$_{111}$Rg									
^{272}Rg		272.1536	~ 2 ms	α/>68	10.82				
^{274}Rg		274.156	~ 65 ms	α	11.2				
^{279}Rg		279.162	~ 0.17 s	α	10.4				
^{280}Rg		280.164	~ 3.6 s	α	~ 9.75				
$_{112}$112									
^{277}112		277.1639	~ 0.24 ms	α	11.45				
					11.65				
^{283}112		283.172	~ 4. s	sf/< 10					
				α/~ 100	9.5				
^{284}112		284.172	0.10 s	sf					
^{285}112		285.174	~ 34. s	α	9.16				
$_{113}$113									
^{278}113			0.24 ms	α	11.7				
^{283}113		283.176	~ 0.1 s	α	10.1				
^{284}113		284.178	~ 0.5 s	α	10.0				

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$_{114}$114									
^{286}114		286.184	0.16 s	α/40	10.2				
				sf/60					
^{287}114		287.186	0.5 s	α	10.0				
^{288}114		288.186	0.8 s	α	9.95				
^{289}114		289.187	~ 2.7 s	α	9.82				
$_{115}$115									
^{287}115		287.191	~ 0.03 s	α	10.6				
^{288}115		288.192	~ 0.09 s	α	10.5				
$_{116}$116									
^{290}116		290.199	~ 15 ms	α	10.9				
^{291}116		291.200	~ 6. ms	α	~ 10.74				
^{292}116		292.200	~ 18. ms	α	~ 10.66				
^{293}116			~ 0.05 s	α	10.5				
$_{118}$118									
^{294}118			~ 2.0 ms	α	11.7				