

**TABLE OF STABLE ISOTOPE ABUNDANCES AND
THERMAL NEUTRON CAPTURE GAMMA CROSS
SECTIONS, AND PRODUCT HALF LIVES**

TABLE I. THERMAL CROSS-SECTION VALUES

Element	Isotope	Abundance (Percent)	Product Half-Life	$\sigma_{n,\gamma}$ (barns)
Carbon	^{13}C	1.11	5730 years	$(0.9 \pm 0.2) \times 10^{-3}$
Nitrogen	^{14}N	99.63	5730 years (^{14}C)	$(\sigma_{n,p} = 1.82 \pm 0.03)$
	^{15}N	0.37	7.2 sec	$(24 \pm 8) \times 10^{-6}$
Oxygen	^{18}O	0.204	26.8 sec	$(0.16 \pm 0.01) \times 10^{-3}$
Fluorine	^{19}F	100	11.2 sec	$(9.8 \pm 0.7) \times 10^{-3}$
Sodium	^{23}Na	100	15 hours	0.528 ± 0.005
Magnesium	^{26}Mg	11.17	9.5 min	$(38 \pm 3) \times 10^{-3}$
Aluminum	^{27}Al	100	2.3 min	0.232 ± 0.003
Silicon	^{30}Si	3.09	2.62 hours	0.105 ± 0.005
Phosphorus	^{31}P	100	14.3 days	0.190 ± 0.010
Sulfur	^{34}S	4.22	88 days	0.034 ± 0.005
	^{36}S	0.014	5.06 min	0.15 ± 0.03
Chlorine	^{37}Cl	24.47	0.7 sec $^{38}\text{Cl}^m$	$(5 \pm 3) \times 10^{-3}$
			37 min $^{38}\text{Cl}^g$	0.43 ± 0.01
Argon	^{36}Ar	0.337	34 days	6 ± 2
	^{38}Ar	0.063	269 years	0.8 ± 0.2
	^{40}Ar	99.6	1.83 hours	0.65 ± 0.03
Potassium	^{41}K	6.88	12.4 hours	1.48 ± 0.03

TABLE I (cont.)

Element	Isotope	Abundance (Percent)	Product Half-Life	$\sigma_{n,\gamma}$ (barns)
Calcium	^{44}Ca	2.06	165 days	1.1 ± 0.3
	^{46}Ca	0.0033	4.53 days	0.7 ± 0.2
	^{48}Ca	0.18	8.8 minutes	1.1 ± 0.1
Scandium	^{45}Sc	100	20 sec $^{46}\text{Sc}^m$	10 ± 4
			83.8 days $^{46}\text{Sc}^g$	25 ± 2
Titanium	^{50}Ti	5.34	5.8 minutes	$0.179 \pm .003$
Vanadium	^{51}V	99.76	3.76 minutes	4.90 ± 0.05
Chromium	^{50}Cr	4.31	27.8 days	16.0 ± 0.5
	^{54}Cr	2.38	3.5 minutes	0.38 ± 0.04
Manganese	^{55}Mn	100	2.58 hours	13.3 ± 0.1
Iron	^{54}Fe	5.82	2.6 years	2.5 ± 0.4
	^{58}Fe	0.33	45 days	1.14 ± 0.05
Cobalt	^{59}Co	100	10.5 min $^{60}\text{Co}^m$	19.9 ± 0.91
			5.26 yrs $^{60}\text{Co}^g$	37.5 ± 0.2
	$(^{60}\text{Co}^m)$	10.5 min	99 minutes	58 ± 8
	$(^{60}\text{Co}^g)$	5.26 yrs	99 minutes	2.0 ± 0.2
Nickel	^{64}Ni	1.16	2.56 hours	1.50 ± 0.05
Copper	^{63}Cu	69.09	12.8 hours	4.4 ± 0.2
	^{65}Cu	30.91	5.1 minutes	2.20 ± 0.05

TABLE I (cont.)

Element	Isotope	Abundance (Percent)	Product Half-Life	$\sigma_{n,\gamma}$ (barns)
Zinc	^{64}Zn	48.89	245 days	0.82 ± 0.01
	^{68}Zn	18.57	13.8 hrs $^{69}\text{Zn}^m$	0.07 ± 0.01
			57 min $^{69}\text{Zn}^g$	1.0 ± 0.2 (dir. formation)
	^{70}Zn	0.62	3.97 hrs $^{71}\text{Zn}^m$	$(9 \pm 1) \times 10^{-3}$
2.4 min $^{71}\text{Zn}^g$			$(90 \pm 10) \times 10^{-3}$ (dir. form.)	
Gallium	^{69}Ga	60.4	21.1 minutes	1.7 ± 0.2
	^{71}Ga	39.6	36 μsec $^{72}\text{Ga}^m$	0.15 ± 0.05
			14 hrs $^{72}\text{Ga}^g$	4.7 ± 0.3
Germanium	^{70}Ge	20.52	20 msec $^{71}\text{Ge}^m$	0.28 ± 0.07
			11.4 days $^{71}\text{Ge}^g$	3.5 ± 0.13
	^{74}Ge	36.54	48 sec $^{75}\text{Ge}^m$	0.16 ± 0.03
			82 min $^{75}\text{Ge}^g$	0.52 ± 0.06
	^{76}Ge	7.76	54 sec $^{77}\text{Ge}^m$	0.09 ± 0.02
			11 hrs $^{77}\text{Ge}^g$	0.07 ± 0.02 (dir. formation)
Arsenic	^{75}As	100	26.5 hours	4.4 ± 0.2
Selenium	^{74}Se	0.87	120.4 days	55 ± 5
	^{76}Se	9.02	17.5 sec $^{77}\text{Se}^m$	21 ± 2
	^{78}Se	23.52	3.9 min $^{79}\text{Se}^m$	0.33 ± 0.04
	^{80}Se	49.82	57 min $^{81}\text{Se}^m$	0.08 ± 0.01
			18.6 min $^{81}\text{Se}^g$	0.54 ± 0.04 (dir. formation)
	^{82}Se	9.19	70 sec $^{83}\text{Se}^m$	$(6 \pm 1) \times 10^{-3}$
25 min $^{83}\text{Se}^g$			$(39 \pm 3) \times 10^{-3}$ (dir. form.)	

TABLE I (cont.)

Element	Isotope	Abundance (Percent)	Product Half-Life	$\sigma_{n,\gamma}$ (barns)
Bromine	^{79}Br	50.54	4.38 hrs $^{80}\text{Br}^m$	2.6 ± 0.2
			17.6 min $^{80}\text{Br}^g$	8.4 ± 0.3 (direct formation)
	^{81}Br	49.46	6.1 min $^{82}\text{Br}^m$	2.7 ± 0.3
			35.34 hrs $^{82}\text{Br}^g$	3.0 ± 0.3
Krypton	^{78}Kr	0.35	55 sec $^{78}\text{Kr}^m$	0.2 ± 0.05
			34.9 hrs $^{78}\text{Kr}^g$	4.7 ± 0.7
	^{80}Kr	2.27	13 sec $^{81}\text{Kr}^m$	4.6 ± 0.7
	^{82}Kr	11.56	1.86 hrs $^{83}\text{Kr}^m$	20 ± 4
	^{84}Kr	56.90	4.4 hrs $^{85}\text{Kr}^m$	0.10 ± 0.03
			10.76 yrs $^{85}\text{Kr}^g$	$(42 \pm 4) \times 10^{-3}$ (dir. form.)
^{86}Kr	17.37	76 minutes	$(60 \pm 20) \times 10^{-3}$	
Rubidium	^{85}Rb	72.15	1.05 min $^{86}\text{Rb}^m$	$(50 \pm 5) \times 10^{-3}$
			18.65 days $^{86}\text{Rb}^g$	0.45 ± 0.02
	^{87}Rb (5×10^{10} yrs)	27.85	17.8 minutes	0.12 ± 0.03
Strontium	^{84}Sr	0.56	70 min $^{85}\text{Sr}^m$	0.57 ± 0.05
			64 days $^{85}\text{Sr}^g$	0.3 ± 0.1 (direct formation)
	^{86}Sr	9.86	2.83 hrs $^{87}\text{Sr}^m$	0.8 ± 0.1
	^{88}Sr	82.56	52 days	$(5 \pm 1) \times 10^{-3}$
Yttrium	^{89}Y	100	3.1 hrs $^{90}\text{Y}^m$	$(1.0 \pm 0.2) \times 10^{-3}$
			64 hours $^{90}\text{Y}^g$	1.2 ± 0.1
Zirconium	^{94}Zr	17.40	65 days	$(75 \pm 8) \times 10^{-3}$
	^{96}Zr	2.80	17 hours	0.05 ± 0.01

TABLE I (cont.)

Element	Isotope	Abundance (Percent)	Product Half-Life	$\sigma_{n,\gamma}$ (barns)
Niobium	^{93}Nb	100	6.3 min $^{94}\text{Nb}^m$	0.15 ± 0.10
Molybdenum	^{98}Mo	23.78	67 hours	0.14 ± 0.02
	^{100}Mo	9.63	14.6 minutes	0.20 ± 0.05
Ruthenium	^{96}Ru	5.51	2.9 days	0.21 ± 0.02
	^{102}Ru	31.61	39.6 days	1.3 ± 0.1
	^{104}Ru	18.58	4.44 hours	0.47 ± 0.20
Rhodium	^{103}Rh	100	4.41 min $^{104}\text{Rh}^m$	11 ± 1
			43 sec $^{104}\text{Rh}^g$	139 ± 5 (direct formation)
Palladium	^{106}Pd	27.33	22 sec $^{107}\text{Pd}^m$	$(13 \pm 2) \times 10^{-3}$
	^{108}Pd	26.71	4.7 min $^{109}\text{Pd}^m$	0.17 ± 0.02
			13.47 hrs $^{109}\text{Pd}^g$	12 ± 2
	^{110}Pd	11.81	5.5 hrs $^{111}\text{Pd}^m$	$(20 \pm 15) \times 10^{-3}$
22 min $^{111}\text{Pd}^g$			0.36 ± 0.05 (dir. form.)	
Silver	^{107}Ag	51.82	2.42 min $^{108}\text{Ag}^g$	37 ± 2
	^{109}Ag	48.18	253 days $^{110}\text{Ag}^m$	4.7 ± 0.4
			24.2 sec $^{110}\text{Ag}^g$	89 ± 4
Cadmium	^{106}Cd	1.22	6.5 hours	1.0 ± 0.5
	^{114}Cd	28.86	43 days $^{115}\text{Cd}^m$	$(36 \pm 7) \times 10^{-3}$
			53.5 hrs $^{115}\text{Cd}^g$	0.300 ± 0.015
	^{116}Cd	7.58	3.4 hrs $^{117}\text{Cd}^m$	$(27 \pm 5) \times 10^{-3}$
2.4 hrs $^{117}\text{Cd}^g$			$(50 \pm 8) \times 10^{-3}$	

TABLE I (cont.)

Element	Isotope	Abundance (Percent)	Product Half-Life	$\sigma_{n,\gamma}$ (barns)
Indium	^{113}In	4.28	50 day $^{114}\text{In}^m$	7.8 ± 2.0
			72 sec $^{114}\text{In}^g$	3.0 ± 1.0
	^{115}In	95.72	2.2 sec $^{116}\text{In}^m$	91 ± 10
			54 min $^{116}\text{In}^m$	161 ± 5
			14 sec $^{116}\text{In}^g$	42 ± 4
Tin	^{112}Sn	0.96	20 min $^{113}\text{Sn}^m$	0.35 ± 0.08
			115 day $^{113}\text{Sn}^g$	0.71 ± 0.10
	^{116}Sn	14.30	14 day $^{117}\text{Sn}^m$	$(6 \pm 2) \times 10^{-3}$
	^{118}Sn	24.03	250 day $^{119}\text{Sn}^m$	$(8 \pm 2) \times 10^{-3}$
	^{120}Sn	32.85	27 hours	0.14 ± 0.03
	^{122}Sn	4.72	40 min $^{123}\text{Sn}^m$	0.15 ± 0.02
	^{124}Sn	5.94	9.7 min $^{125}\text{Sn}^m$	0.14 ± 0.02
9.4 day $^{125}\text{Sn}^g$			4 ± 2	
Antimony	^{121}Sb	57.25	4.2 min $^{122}\text{Sb}^m$	$(55 \pm 10) \times 10^{-3}$
			2.8 days $^{122}\text{Sb}^g$	6.2 ± 0.2
	^{123}Sb	42.75	21 min $^{124}\text{Sb}^{m_2}$	$(15 \pm 4) \times 10^{-3}$
			93 sec $^{124}\text{Sb}^{m_1}$	$(30 \pm 8) \times 10^{-3}$
		60 day $^{124}\text{Sb}^g$	4.0 ± 0.2	
Tellurium	^{120}Te	0.089	154 day $^{121}\text{Te}^m$	0.34 ± 0.06
			17 day $^{121}\text{Te}^g$	2.0 ± 0.3
	^{122}Te	2.46	117 day $^{123}\text{Te}^m$	1.1 ± 0.5
	^{124}Te	4.61	58 day $^{125}\text{Te}^m$	$(40 \pm 25) \times 10^{-3}$
	^{126}Te	18.71	109 day $^{127}\text{Te}^m$	0.125 ± 0.023
			9.4 hour $^{127}\text{Te}^g$	0.9 ± 0.15
^{128}Te	31.79	34 day $^{129}\text{Te}^m$	$(15 \pm 2) \times 10^{-3}$	
		69 min $^{129}\text{Te}^g$	0.155 ± 0.040	

TABLE I (cont.)

Element	Isotope	Abundance (Percent)	Product Half-Life	$\sigma_{n,\gamma}$ (barns)
Tellurium (cont.)	^{130}Te	34.48	30 hour $^{131}\text{Te}^m$	0.02 ± 0.01
			25 min $^{131}\text{Te}^g$	0.2 ± 0.1
Iodine	^{127}I	100	25 minutes	6.2 ± 0.2
Xenon	^{124}Xe	0.096	17 hours	100 ± 20
	^{128}Xe	1.92	8 day $^{129}\text{Xe}^m$	0.43 ± 0.10
	^{130}Xe	4.08	11.8 day $^{131}\text{Xe}^m$	0.34 ± 0.08
	^{132}Xe	26.89	2.26 day $^{133}\text{Xe}^m$	0.53 ± 0.10
			5.27 day $^{133}\text{Xe}^g$	0.05 ± 0.02 (dir. form.)
	^{134}Xe	10.44	9.2 hours	0.23 ± 0.02
^{136}Xe	8.87	3.9 minutes	0.16 ± 0.05	
Cesium	^{133}Cs	100	2.9 hour $^{134}\text{Cs}^m$	2.6 ± 0.2
			2.05 year $^{134}\text{Cs}^g$	30.0 ± 1.5
Barium	^{130}Ba	0.101	15 min $^{131}\text{Ba}^m$	2.5 ± 0.3
			12 day $^{131}\text{Ba}^g$	11 ± 3
	^{132}Ba	0.097	7.2 year $^{133}\text{Ba}^g$	8.5 ± 1.0
	^{134}Ba	2.42	29 hour $^{135}\text{Ba}^m$	0.16 ± 0.02
	^{136}Ba	7.81	2.55 min $^{137}\text{Ba}^m$	$(10 \pm 1) \times 10^{-3}$
^{138}Ba	71.66	82.9 minutes	0.35 ± 0.15	
Lanthanum	^{139}La	99.911	40.2 hours	9.0 ± 0.3
Cerium	^{136}Ce	0.193	34.4 hour $^{137}\text{Ce}^m$	0.95 ± 0.25
			9.0 hour $^{137}\text{Ce}^g$	6.3 ± 1.5 (dir. formation)
	^{138}Ce	0.250	55 sec $^{139}\text{Ce}^m$	$(15 \pm 5) \times 10^{-3}$
			140 day $^{139}\text{Ce}^g$	1.1 ± 0.3

TABLE I (cont.)

Element	Isotope	Abundance (Percent)	Product Half-Life	$\sigma_{n,\gamma}$ (barns)
Cerium (cont.)	^{140}Ce	88.48	33 days	0.58 ± 0.06
	^{142}Ce	11.07	33.7 hours	1.1 ± 0.3
Praseodymium	^{141}Pr	100	14.6 min $^{142}\text{Pr}^m$	3.9 ± 0.5
			19.2 hour $^{142}\text{Pr}^g$	11.1 ± 1.0
Neodymium	^{146}Nd	17.22	11.1 days	1.4 ± 0.2
	^{148}Nd	5.73	1.8 hours	2.5 ± 0.2
	^{150}Nd	5.62	12 minutes	1.3 ± 0.3
Samarium	^{144}Sm	3.09	340 days	0.7 ± 0.3
	^{150}Sm	7.44	87 years	102 ± 5
	^{152}Sm	26.72	47 hours	210 ± 10
	^{154}Sm	22.71	23 minutes	5.5 ± 1.1
Europium	^{151}Eu	47.82	96 min $^{152}\text{Eu}^m_2$	3.8 ± 1.9
			9 hour $^{152}\text{Eu}^m_1$	2800 ± 300
			12 year $^{152}\text{Eu}^g$	5300 ± 300
	^{153}Eu	52.18	16 years	400 ± 100
Gadolinium	^{152}Gd	0.20	242 days	1100 ± 100
	^{158}Gd	24.87	18 hours	3.5 ± 1.0
	^{160}Gd	21.90	3.7 minutes	0.77 ± 0.04
Terbium	^{159}Tb	100	72.1 days	25 ± 5
Dysprosium	^{158}Dy	0.090	144 days	96 ± 20
	^{164}Dy	28.18	1.26 min $^{165}\text{Dy}^m$	2100 ± 400
			139 min $^{165}\text{Dy}^g$	2600 ± 200
Holmium	^{165}Ho	100	26.9 hr $^{166}\text{Ho}^g$	61.5 ± 2.0

TABLE I (cont.)

Element	Isotope	Abundance (Percent)	Product Half-Life	$\sigma_{n,\gamma}$ (barns)
Erbium	^{162}Er	0.136	75 minutes	160 ± 30
	^{164}Er	1.56	10.3 hours	13 ± 5
	^{168}Er	27.07	9.4 days	1.9 ± 0.2
	^{170}Er	14.88	7.52 hours	6 ± 1
Thulium	^{169}Tm	100	130 days	106 ± 5
Ytterbium	^{168}Yb	0.135	32 days	3200 ± 400
	^{174}Yb	31.84	101 hr $^{175}\text{Yb}^g$	65 ± 5
	^{176}Yb	12.73	1.9 hr $^{177}\text{Yb}^g$	5.5 ± 1.0
Lutetium	^{175}Lu	97.41	3.69 hr $^{176}\text{Lu}^m$	18 ± 3
	^{176}Lu	2.59	155 day $^{177}\text{Lu}^m$	7 ± 2
			6.7 day $^{177}\text{Lu}^g$	2050 ± 50
Hafnium	^{174}Hf	0.18	70 days	390 ± 55
	^{177}Hf	18.50	4.3 sec $^{178}\text{Hf}^m$	1.1 ± 0.1
	^{178}Hf	27.14	18.6 sec $^{179}\text{Hf}^m$	52 ± 6
	^{179}Hf	13.75	5.5 hour $^{180}\text{Hf}^m$	0.34 ± 0.03
	^{180}Hf	35.24	42.3 days	12.6 ± 0.7
Tantalum	^{181}Ta	100	16.5 min $^{182}\text{Ta}^m$	$(10 \pm 2) \times 10^{-3}$
			115 day $^{182}\text{Ta}^g$	22 ± 1
Tungsten	^{184}W	30.64	1.6 min $^{185}\text{W}^m$	$(2.4 \pm 0.4) \times 10^{-3}$
			75 day $^{185}\text{W}^g$	1.8 ± 0.2
	^{186}W	38.41	23.9 hours	37 ± 2

TABLE I (cont.)

Element	Isotope	Abundance (Percent)	Product Half-Life	$\sigma_{n,\gamma}$ (barns)
Rhenium	^{185}Re	37.07	90 hours	110 ± 5
	^{187}Re	62.93	18.7 min $^{188}\text{Re}^m$	2.0 ± 1.0
			16.7 hour $^{188}\text{Re}^g$	75 ± 4
Osmium	^{184}Os	0.02	94 days	3000 ± 600
	^{189}Os	16.1	9.9 min $^{190}\text{Os}^m$	$(0.26 \pm 0.03) \times 10^{-3}$
	^{190}Os	26.4	13 hour $^{191}\text{Os}^m$	12 ± 6
			15 day $^{191}\text{Os}^g$	16 ± 6
	^{192}Os	41.0	31 hours	1.6 ± 0.4
Iridium	^{191}Ir	37.3	75 year $^{192}\text{Ir}^{m_2}$	0.4 ± 0.2
			1.4 min $^{192}\text{Ir}^{m_1}$	610 ± 60
			74 day $^{192}\text{Ir}^g$	925 ± 50
	^{193}Ir	62.7	17.4 hours	110 ± 15
Platinum	^{192}Pt	0.78	4.3 day $^{193}\text{Pt}^m$	2 ± 1
	^{194}Pt	32.9	4.1 day $^{195}\text{Pt}^m$	$(87 \pm 13) \times 10^{-3}$
	^{196}Pt	25.3	80 min $^{197}\text{Pt}^m$	$(60 \pm 20) \times 10^{-3}$
			18 hour $^{197}\text{Pt}^g$	0.8 ± 0.1
^{198}Pt	7.21	30 minutes	3.7 ± 0.2	
Gold	^{197}Au	100	2.7 days	98.8 ± 0.3
Mercury	^{196}Hg	0.146	24 hour $^{197}\text{Hg}^m$	120 ± 15
			65 hour $^{197}\text{Hg}^g$	3000 ± 100 (dir. form.)
	^{198}Hg	10.02	43 min $^{199}\text{Hg}^m$	0.02 ± 0.01
	^{202}Hg	29.80	46.9 days	4.9 ± 0.2
	^{204}Hg	6.85	5.5 minutes	0.43 ± 0.10

TABLE I (cont.)

Element	Isotope	Abundance (Percent)	Product Half-Life	$\sigma_{n,\gamma}$ (barns)
Thallium	^{203}Tl	29.50	3.8 years	1
	^{205}Tl	70.50	4.19 minutes	0.5 0.2
Lead	^{208}Pb	52.3	3.30 hours	$(20 \pm 10) \times 10^{-3}$
Bismuth	^{209}Bi	100	.0 days	$(19 \pm 2) \times 10^{-3}$
Thorium	^{232}Th	100	22.2 minutes	$7. \pm 0.1$
Uranium	^{235}U	0.72		$(\sigma_f = 580 \pm 2)$
	^{238}U	99.27	23.5 minutes	2.720 ± 0.025
Plutonium	^{239}Pu			$(\sigma_f = 742 \pm 3)$