

## 5. Electronic Structure of the Elements

**Table 5.1:** Reviewed 2011 by J.E. Sansonetti (NIST). The electronic configurations and the ionization energies are from the NIST database, “Ground Levels and Ionization Energies for the Neutral Atoms,” W.C. Martin, A. Musgrove, S. Kotochigova, and J.E. Sansonetti, [https://www.nist.gov/pml/data/ion\\_energy.cfm](https://www.nist.gov/pml/data/ion_energy.cfm). The electron configuration for, say, iron indicates an argon electronic core (see argon) plus six 3*d* electrons and two 4*s* electrons.

	Element	Electron configuration ( $3d^5$ = five 3 <i>d</i> electrons, <i>etc.</i> )		Ground state $2S+1L_J$	Ionization energy (eV)
1	H	Hydrogen	1 <i>s</i>	$^2S_{1/2}$	13.5984
2	He	Helium	1 <i>s</i> <sup>2</sup>	$^1S_0$	24.5874
3	Li	Lithium	(He) 2 <i>s</i>	$^2S_{1/2}$	5.3917
4	Be	Beryllium	(He) 2 <i>s</i> <sup>2</sup>	$^1S_0$	9.3227
5	B	Boron	(He) 2 <i>s</i> <sup>2</sup> 2 <i>p</i>	$^2P_{1/2}$	8.2980
6	C	Carbon	(He) 2 <i>s</i> <sup>2</sup> 2 <i>p</i> <sup>2</sup>	$^3P_0$	11.2603
7	N	Nitrogen	(He) 2 <i>s</i> <sup>2</sup> 2 <i>p</i> <sup>3</sup>	$^4S_{3/2}$	14.5341
8	O	Oxygen	(He) 2 <i>s</i> <sup>2</sup> 2 <i>p</i> <sup>4</sup>	$^3P_2$	13.6181
9	F	Fluorine	(He) 2 <i>s</i> <sup>2</sup> 2 <i>p</i> <sup>5</sup>	$^2P_{3/2}$	17.4228
10	Ne	Neon	(He) 2 <i>s</i> <sup>2</sup> 2 <i>p</i> <sup>6</sup>	$^1S_0$	21.5645
11	Na	Sodium	(Ne) 3 <i>s</i>	$^2S_{1/2}$	5.1391
12	Mg	Magnesium	(Ne) 3 <i>s</i> <sup>2</sup>	$^1S_0$	7.6462
13	Al	Aluminum	(Ne) 3 <i>s</i> <sup>2</sup> 3 <i>p</i>	$^2P_{1/2}$	5.9858
14	Si	Silicon	(Ne) 3 <i>s</i> <sup>2</sup> 3 <i>p</i> <sup>2</sup>	$^3P_0$	8.1517
15	P	Phosphorus	(Ne) 3 <i>s</i> <sup>2</sup> 3 <i>p</i> <sup>3</sup>	$^4S_{3/2}$	10.4867
16	S	Sulfur	(Ne) 3 <i>s</i> <sup>2</sup> 3 <i>p</i> <sup>4</sup>	$^3P_2$	10.3600
17	Cl	Chlorine	(Ne) 3 <i>s</i> <sup>2</sup> 3 <i>p</i> <sup>5</sup>	$^2P_{3/2}$	12.9676
18	Ar	Argon	(Ne) 3 <i>s</i> <sup>2</sup> 3 <i>p</i> <sup>6</sup>	$^1S_0$	15.7596
19	K	Potassium	(Ar) 4 <i>s</i>	$^2S_{1/2}$	4.3407
20	Ca	Calcium	(Ar) 4 <i>s</i> <sup>2</sup>	$^1S_0$	6.1132
21	Sc	Scandium	(Ar) 3 <i>d</i> 4 <i>s</i> <sup>2</sup>	T $^2D_{3/2}$	6.5615
22	Ti	Titanium	(Ar) 3 <i>d</i> <sup>2</sup> 4 <i>s</i> <sup>2</sup>	r e $^3F_2$	6.8281
23	V	Vanadium	(Ar) 3 <i>d</i> <sup>3</sup> 4 <i>s</i> <sup>2</sup>	a l $^4F_{3/2}$	6.7462
24	Cr	Chromium	(Ar) 3 <i>d</i> <sup>5</sup> 4 <i>s</i>	n e $^7S_3$	6.7665
25	Mn	Manganese	(Ar) 3 <i>d</i> <sup>5</sup> 4 <i>s</i> <sup>2</sup>	s m $^6S_{5/2}$	7.4340
26	Fe	Iron	(Ar) 3 <i>d</i> <sup>6</sup> 4 <i>s</i> <sup>2</sup>	i e $^5D_4$	7.9024
27	Co	Cobalt	(Ar) 3 <i>d</i> <sup>7</sup> 4 <i>s</i> <sup>2</sup>	t n $^4F_{9/2}$	7.8810
28	Ni	Nickel	(Ar) 3 <i>d</i> <sup>8</sup> 4 <i>s</i> <sup>2</sup>	i t $^3F_4$	7.6399
29	Cu	Copper	(Ar) 3 <i>d</i> <sup>10</sup> 4 <i>s</i>	o s $^2S_{1/2}$	7.7264
30	Zn	Zinc	(Ar) 3 <i>d</i> <sup>10</sup> 4 <i>s</i> <sup>2</sup>	n $^1S_0$	9.3942
31	Ga	Gallium	(Ar) 3 <i>d</i> <sup>10</sup> 4 <i>s</i> <sup>2</sup> 4 <i>p</i>	$^2P_{1/2}$	5.9993
32	Ge	Germanium	(Ar) 3 <i>d</i> <sup>10</sup> 4 <i>s</i> <sup>2</sup> 4 <i>p</i> <sup>2</sup>	$^3P_0$	7.8994
33	As	Arsenic	(Ar) 3 <i>d</i> <sup>10</sup> 4 <i>s</i> <sup>2</sup> 4 <i>p</i> <sup>3</sup>	$^4S_{3/2}$	9.7886
34	Se	Selenium	(Ar) 3 <i>d</i> <sup>10</sup> 4 <i>s</i> <sup>2</sup> 4 <i>p</i> <sup>4</sup>	$^3P_2$	9.7524
35	Br	Bromine	(Ar) 3 <i>d</i> <sup>10</sup> 4 <i>s</i> <sup>2</sup> 4 <i>p</i> <sup>5</sup>	$^2P_{3/2}$	11.8138
36	Kr	Krypton	(Ar) 3 <i>d</i> <sup>10</sup> 4 <i>s</i> <sup>2</sup> 4 <i>p</i> <sup>6</sup>	$^1S_0$	13.9996
37	Rb	Rubidium	(Kr) 5 <i>s</i>	$^2S_{1/2}$	4.1771
38	Sr	Strontium	(Kr) 5 <i>s</i> <sup>2</sup>	$^1S_0$	5.6949
39	Y	Yttrium	(Kr) 4 <i>d</i> 5 <i>s</i> <sup>2</sup>	T $^2D_{3/2}$	6.2173
40	Zr	Zirconium	(Kr) 4 <i>d</i> <sup>2</sup> 5 <i>s</i> <sup>2</sup>	r e $^3F_2$	6.6339
41	Nb	Niobium	(Kr) 4 <i>d</i> <sup>4</sup> 5 <i>s</i>	a l $^6D_{1/2}$	6.7589
42	Mo	Molybdenum	(Kr) 4 <i>d</i> <sup>5</sup> 5 <i>s</i>	n e $^7S_3$	7.0924
43	Tc	Technetium	(Kr) 4 <i>d</i> <sup>5</sup> 5 <i>s</i> <sup>2</sup>	s m $^6S_{5/2}$	7.28
44	Ru	Ruthenium	(Kr) 4 <i>d</i> <sup>7</sup> 5 <i>s</i>	i e $^5F_5$	7.3605
45	Rh	Rhodium	(Kr) 4 <i>d</i> <sup>8</sup> 5 <i>s</i>	t n $^4F_{9/2}$	7.4589
46	Pd	Palladium	(Kr) 4 <i>d</i> <sup>10</sup>	i t $^1S_0$	8.3369
47	Ag	Silver	(Kr) 4 <i>d</i> <sup>10</sup> 5 <i>s</i>	o s $^2S_{1/2}$	7.5762
48	Cd	Cadmium	(Kr) 4 <i>d</i> <sup>10</sup> 5 <i>s</i> <sup>2</sup>	n $^1S_0$	8.9938

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Element	Electron configuration ( $3d^5 =$ five $3d$ electrons, <i>etc.</i> )	Ground state $2S+1L_J$	Ionization energy (eV)
49 In	(Kr) $4d^{10} 5s^2 5p$	$^2P_{1/2}$	5.7864
50 Sn	(Kr) $4d^{10} 5s^2 5p^2$	$^3P_0$	7.3439
51 Sb	(Kr) $4d^{10} 5s^2 5p^3$	$^4S_{3/2}$	8.6084
52 Te	(Kr) $4d^{10} 5s^2 5p^4$	$^3P_2$	9.0096
53 I	(Kr) $4d^{10} 5s^2 5p^5$	$^2P_{3/2}$	10.4513
54 Xe	(Kr) $4d^{10} 5s^2 5p^6$	$^1S_0$	12.1298
55 Cs	(Xe) $6s$	$^2S_{1/2}$	3.8939
56 Ba	(Xe) $6s^2$	$^1S_0$	5.2117
57 La	(Xe) $5d 6s^2$	$^2D_{3/2}$	5.5769
58 Ce	(Xe) $4f 5d 6s^2$	$^1G_4$	5.5387
59 Pr	(Xe) $4f^3 6s^2$	L $^4I_{9/2}$	5.473
60 Nd	(Xe) $4f^4 6s^2$	a $^5I_4$	5.5250
61 Pm	(Xe) $4f^5 6s^2$	n $^6H_{5/2}$	5.582
62 Sm	(Xe) $4f^6 6s^2$	t $^7F_0$	5.6437
63 Eu	(Xe) $4f^7 6s^2$	a $^8S_{7/2}$	5.6704
64 Gd	(Xe) $4f^7 5d 6s^2$	n $^9D_2$	6.1498
65 Tb	(Xe) $4f^9 6s^2$	i $^6H_{15/2}$	5.8638
66 Dy	(Xe) $4f^{10} 6s^2$	d $^5I_8$	5.9389
67 Ho	(Xe) $4f^{11} 6s^2$	e $^4I_{15/2}$	6.0215
68 Er	(Xe) $4f^{12} 6s^2$	s $^3H_6$	6.1077
69 Tm	(Xe) $4f^{13} 6s^2$	$^2F_{7/2}$	6.1843
70 Yb	(Xe) $4f^{14} 6s^2$	$^1S_0$	6.2542
71 Lu	(Xe) $4f^{14} 5d 6s^2$	$^2D_{3/2}$	5.4259
72 Hf	(Xe) $4f^{14} 5d^2 6s^2$	T $^3F_2$	6.8251
73 Ta	(Xe) $4f^{14} 5d^3 6s^2$	r e $^4F_{3/2}$	7.5496
74 W	(Xe) $4f^{14} 5d^4 6s^2$	a l $^5D_0$	7.8640
75 Re	(Xe) $4f^{14} 5d^5 6s^2$	n e $^6S_{5/2}$	7.8335
76 Os	(Xe) $4f^{14} 5d^6 6s^2$	s m $^5D_4$	8.4382
77 Ir	(Xe) $4f^{14} 5d^7 6s^2$	i e $^4F_{9/2}$	8.9670
78 Pt	(Xe) $4f^{14} 5d^9 6s$	t n $^3D_3$	8.9588
79 Au	(Xe) $4f^{14} 5d^{10} 6s$	i t $^2S_{1/2}$	9.2255
80 Hg	(Xe) $4f^{14} 5d^{10} 6s^2$	o s $^1S_0$	10.4375
81 Tl	(Xe) $4f^{14} 5d^{10} 6s^2 6p$	$^2P_{1/2}$	6.1082
82 Pb	(Xe) $4f^{14} 5d^{10} 6s^2 6p^2$	$^3P_0$	7.4167
83 Bi	(Xe) $4f^{14} 5d^{10} 6s^2 6p^3$	$^4S_{3/2}$	7.2855
84 Po	(Xe) $4f^{14} 5d^{10} 6s^2 6p^4$	$^3P_2$	8.414
85 At	(Xe) $4f^{14} 5d^{10} 6s^2 6p^5$	$^2P_{3/2}$	
86 Rn	(Xe) $4f^{14} 5d^{10} 6s^2 6p^6$	$^1S_0$	10.7485
87 Fr	(Rn) $7s$	$^2S_{1/2}$	4.0727
88 Ra	(Rn) $7s^2$	$^1S_0$	5.2784
89 Ac	(Rn) $6d 7s^2$	$^2D_{3/2}$	5.3807
90 Th	(Rn) $6d^2 7s^2$	$^3F_2$	6.3067
91 Pa	(Rn) $5f^2 6d 7s^2$	A $^4K_{11/2}$	5.89
92 U	(Rn) $5f^3 6d 7s^2$	c $^5L_6^*$	6.1939
93 Np	(Rn) $5f^4 6d 7s^2$	t $^6L_{11/2}^*$	6.2657
94 Pu	(Rn) $5f^6 7s^2$	i $^7F_0$	6.0260
95 Am	(Rn) $5f^7 7s^2$	n $^8S_{7/2}$	5.9738
96 Cm	(Rn) $5f^7 6d 7s^2$	i $^9D_2$	5.9914
97 Bk	(Rn) $5f^9 7s^2$	d $^6H_{15/2}$	6.1979
98 Cf	(Rn) $5f^{10} 7s^2$	e $^5I_8$	6.2817
99 Es	(Rn) $5f^{11} 7s^2$	s $^4I_{15/2}$	6.3676
100 Fm	(Rn) $5f^{12} 7s^2$	$^3H_6$	6.50
101 Md	(Rn) $5f^{13} 7s^2$	$^2F_{7/2}$	6.58
102 No	(Rn) $5f^{14} 7s^2$	$^1S_0$	6.65
103 Lr	(Rn) $5f^{14} 7s^2 7p^?$	$^2P_{1/2}^?$	4.9?
104 Rf	(Rn) $5f^{14} 6d^2 7s^2?$	$^3F_2^?$	6.0?

\* The usual  $LS$  coupling scheme does not apply for these three elements.

See the introductory note to the NIST table from which this table is taken.