5. ELECTRONIC STRUCTURE OF THE ELEMENTS

Table 5.1. Reviewed 2005 by C.G. Wohl (LBNL). 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 (2003), `http://physics.nist.gov` (select "Physical Reference Data"). The electron configuration for, say, iron indicates an argon electronic core (see argon) plus six $3d$ electrons and two $4s$ electrons. The ionization energy is the least energy necessary to remove to infinity one electron from an atom of the element.

	Element		Electron configuration ($3d^5$ = five $3d$ electrons, *etc.*)		Ground state $^{2S+1}L_J$	Ionization energy (eV)
1	H	Hydrogen	$1s$		$^2S_{1/2}$	13.5984
2	He	Helium	$1s^2$		$^1S_0$	24.5874
3	Li	Lithium	(He) $2s$		$^2S_{1/2}$	5.3917
4	Be	Beryllium	(He) $2s^2$		$^1S_0$	9.3227
5	B	Boron	(He) $2s^2$ $2p$		$^2P_{1/2}$	8.2980
6	C	Carbon	(He) $2s^2$ $2p^2$		$^3P_0$	11.2603
7	N	Nitrogen	(He) $2s^2$ $2p^3$		$^4S_{3/2}$	14.5341
8	O	Oxygen	(He) $2s^2$ $2p^4$		$^3P_2$	13.6181
9	F	Fluorine	(He) $2s^2$ $2p^5$		$^2P_{3/2}$	17.4228
10	Ne	Neon	(He) $2s^2$ $2p^6$		$^1S_0$	21.5645
11	Na	Sodium	(Ne) $3s$		$^2S_{1/2}$	5.1391
12	Mg	Magnesium	(Ne) $3s^2$		$^1S_0$	7.6462
13	Al	Aluminum	(Ne) $3s^2$ $3p$		$^2P_{1/2}$	5.9858
14	Si	Silicon	(Ne) $3s^2$ $3p^2$		$^3P_0$	8.1517
15	P	Phosphorus	(Ne) $3s^2$ $3p^3$		$^4S_{3/2}$	10.4867
16	S	Sulfur	(Ne) $3s^2$ $3p^4$		$^3P_2$	10.3600
17	Cl	Chlorine	(Ne) $3s^2$ $3p^5$		$^2P_{3/2}$	12.9676
18	Ar	Argon	(Ne) $3s^2$ $3p^6$		$^1S_0$	15.7596
19	K	Potassium	(Ar) $4s$		$^2S_{1/2}$	4.3407
20	Ca	Calcium	(Ar) $4s^2$		$^1S_0$	6.1132
21	Sc	Scandium	(Ar) $3d$ $4s^2$	Transition elements	$^2D_{3/2}$	6.5615
22	Ti	Titanium	(Ar) $3d^2$ $4s^2$		$^3F_2$	6.8281
23	V	Vanadium	(Ar) $3d^3$ $4s^2$		$^4F_{3/2}$	6.7462
24	Cr	Chromium	(Ar) $3d^5$ $4s$		$^7S_3$	6.7665
25	Mn	Manganese	(Ar) $3d^5$ $4s^2$		$^6S_{5/2}$	7.4340
26	Fe	Iron	(Ar) $3d^6$ $4s^2$		$^5D_4$	7.9024
27	Co	Cobalt	(Ar) $3d^7$ $4s^2$		$^4F_{9/2}$	7.8810
28	Ni	Nickel	(Ar) $3d^8$ $4s^2$		$^3F_4$	7.6398
29	Cu	Copper	(Ar) $3d^{10}$ $4s$		$^2S_{1/2}$	7.7264
30	Zn	Zinc	(Ar) $3d^{10}$ $4s^2$		$^1S_0$	9.3942
31	Ga	Gallium	(Ar) $3d^{10}$ $4s^2$ $4p$		$^2P_{1/2}$	5.9993
32	Ge	Germanium	(Ar) $3d^{10}$ $4s^2$ $4p^2$		$^3P_0$	7.8994
33	As	Arsenic	(Ar) $3d^{10}$ $4s^2$ $4p^3$		$^4S_{3/2}$	9.7886
34	Se	Selenium	(Ar) $3d^{10}$ $4s^2$ $4p^4$		$^3P_2$	9.7524
35	Br	Bromine	(Ar) $3d^{10}$ $4s^2$ $4p^5$		$^2P_{3/2}$	11.8138
36	Kr	Krypton	(Ar) $3d^{10}$ $4s^2$ $4p^6$		$^1S_0$	13.9996
37	Rb	Rubidium	(Kr) $5s$		$^2S_{1/2}$	4.1771
38	Sr	Strontium	(Kr) $5s^2$		$^1S_0$	5.6949
39	Y	Yttrium	(Kr) $4d$ $5s^2$	Transition elements	$^2D_{3/2}$	6.2173
40	Zr	Zirconium	(Kr) $4d^2$ $5s^2$		$^3F_2$	6.6339
41	Nb	Niobium	(Kr) $4d^4$ $5s$		$^6D_{1/2}$	6.7589
42	Mo	Molybdenum	(Kr) $4d^5$ $5s$		$^7S_3$	7.0924
43	Tc	Technetium	(Kr) $4d^5$ $5s^2$		$^6S_{5/2}$	7.28
44	Ru	Ruthenium	(Kr) $4d^7$ $5s$		$^5F_5$	7.3605
45	Rh	Rhodium	(Kr) $4d^8$ $5s$		$^4F_{9/2}$	7.4589
46	Pd	Palladium	(Kr) $4d^{10}$		$^1S_0$	8.3369
47	Ag	Silver	(Kr) $4d^{10}$ $5s$		$^2S_{1/2}$	7.5762
48	Cd	Cadmium	(Kr) $4d^{10}$ $5s^2$		$^1S_0$	8.9938

49	In	Indium	(Kr) $4d^{10}5s^2\ 5p$		$^2P_{1/2}$	5.7864
50	Sn	Tin	(Kr) $4d^{10}5s^2\ 5p^2$		$^3P_0$	7.3439
51	Sb	Antimony	(Kr) $4d^{10}5s^2\ 5p^3$		$^4S_{3/2}$	8.6084
52	Te	Tellurium	(Kr) $4d^{10}5s^2\ 5p^4$		$^3P_2$	9.0096
53	I	Iodine	(Kr) $4d^{10}5s^2\ 5p^5$		$^2P_{3/2}$	10.4513
54	Xe	Xenon	(Kr) $4d^{10}5s^2\ 5p^6$		$^1S_0$	12.1298
55	Cs	Cesium	(Xe) $6s$		$^2S_{1/2}$	3.8939
56	Ba	Barium	(Xe) $6s^2$		$^1S_0$	5.2117
57	La	Lanthanum	(Xe) $5d\ 6s^2$		$^2D_{3/2}$	5.5769
58	Ce	Cerium	(Xe) $4f\ 5d\ 6s^2$		$^1G_4$	5.5387
59	Pr	Praseodymium	(Xe) $4f^3\ 6s^2$	Lanthanides	$^4I_{9/2}$	5.473
60	Nd	Neodymium	(Xe) $4f^4\ 6s^2$		$^5I_4$	5.5250
61	Pm	Promethium	(Xe) $4f^5\ 6s^2$		$^6H_{5/2}$	5.582
62	Sm	Samarium	(Xe) $4f^6\ 6s^2$		$^7F_0$	5.6437
63	Eu	Europium	(Xe) $4f^7\ 6s^2$		$^8S_{7/2}$	5.6704
64	Gd	Gadolinium	(Xe) $4f^7\ 5d\ 6s^2$		$^9D_2$	6.1498
65	Tb	Terbium	(Xe) $4f^9\ 6s^2$		$^6H_{15/2}$	5.8638
66	Dy	Dysprosium	(Xe) $4f^{10}\ 6s^2$		$^5I_8$	5.9389
67	Ho	Holmium	(Xe) $4f^{11}\ 6s^2$		$^4I_{15/2}$	6.0215
68	Er	Erbium	(Xe) $4f^{12}\ 6s^2$		$^3H_6$	6.1077
69	Tm	Thulium	(Xe) $4f^{13}\ 6s^2$		$^2F_{7/2}$	6.1843
70	Yb	Ytterbium	(Xe) $4f^{14}\ 6s^2$		$^1S_0$	6.2542
71	Lu	Lutetium	(Xe) $4f^{14}5d\ 6s^2$		$^2D_{3/2}$	5.4259
72	Hf	Hafnium	(Xe) $4f^{14}5d^2\ 6s^2$	Transition elements	$^3F_2$	6.8251
73	Ta	Tantalum	(Xe) $4f^{14}5d^3\ 6s^2$		$^4F_{3/2}$	7.5496
74	W	Tungsten	(Xe) $4f^{14}5d^4\ 6s^2$		$^5D_0$	7.8640
75	Re	Rhenium	(Xe) $4f^{14}5d^5\ 6s^2$		$^6S_{5/2}$	7.8335
76	Os	Osmium	(Xe) $4f^{14}5d^6\ 6s^2$		$^5D_4$	8.4382
77	Ir	Iridium	(Xe) $4f^{14}5d^7\ 6s^2$		$^4F_{9/2}$	8.9670
78	Pt	Platinum	(Xe) $4f^{14}5d^9\ 6s$		$^3D_3$	8.9588
79	Au	Gold	(Xe) $4f^{14}5d^{10}6s$		$2S_{1/2}$	9.2255
80	Hg	Mercury	(Xe) $4f^{14}5d^{10}6s^2$		$^1S_0$	10.4375
81	Tl	Thallium	(Xe) $4f^{14}5d^{10}6s^2\ 6p$		$^2P_{1/2}$	6.1082
82	Pb	Lead	(Xe) $4f^{14}5d^{10}6s^2\ 6p^2$		$^3P_0$	7.4167
83	Bi	Bismuth	(Xe) $4f^{14}5d^{10}6s^2\ 6p^3$		$^4S_{3/2}$	7.2855
84	Po	Polonium	(Xe) $4f^{14}5d^{10}6s^2\ 6p^4$		$^3P_2$	8.414
85	At	Astatine	(Xe) $4f^{14}5d^{10}6s^2\ 6p^5$		$^2P_{3/2}$	
86	Rn	Radon	(Xe) $4f^{14}5d^{10}6s^2\ 6p^6$		$^1S_0$	10.7485
87	Fr	Francium	(Rn) $7s$		$^2S_{1/2}$	4.0727
88	Ra	Radium	(Rn) $7s^2$		$^1S_0$	5.2784
89	Ac	Actinium	(Rn) $6d\ 7s^2$		$^2D_{3/2}$	5.17
90	Th	Thorium	(Rn) $6d^2\ 7s^2$		$^3F_2$	6.3067
91	Pa	Protactinium	(Rn) $5f^2\ 6d\ 7s^2$	Actinides	$^4K_{11/2}$*	5.89
92	U	Uranium	(Rn) $5f^3\ 6d\ 7s^2$		$^5L_6$*	6.1941
93	Np	Neptunium	(Rn) $5f^4\ 6d\ 7s^2$		$^6L_{11/2}$*	6.2657
94	Pu	Plutonium	(Rn) $5f^6\ 7s^2$		$^7F_0$	6.0260
95	Am	Americium	(Rn) $5f^7\ 7s^2$		$^8S_{7/2}$	5.9738
96	Cm	Curium	(Rn) $5f^7\ 6d\ 7s^2$		$^9D_2$	5.9914
97	Bk	Berkelium	(Rn) $5f^9\ 7s^2$		$^6H_{15/2}$	6.1979
98	Cf	Californium	(Rn) $5f^{10}\ 7s^2$		$^5I_8$	6.2817
99	Es	Einsteinium	(Rn) $5f^{11}\ 7s^2$		$^4I_{15/2}$	6.42
100	Fm	Fermium	(Rn) $5f^{12}\ 7s^2$		$^3H_6$	6.50
101	Md	Mendelevium	(Rn) $5f^{13}\ 7s^2$		$^2F_{7/2}$	6.58
102	No	Nobelium	(Rn) $5f^{14}\ 7s^2$		$^1S_0$	6.65
103	Lr	Lawrencium	(Rn) $5f^{14}\ 7s^2\ 7p$?		$^2P_{1/2}$?	4.9?
104	Rf	Rutherfordium	(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.