5. ELECTRONIC STRUCTURE OF THE ELEMENTS

Table 5.1. Reviewed 2002 by W.C. Martin (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 and A. Musgrove (2002), `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) $2s^2$ $2p^6$	$^1S_0$	21.5646
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) $3d$ $4s^2$	$^2D_{3/2}$	6.5615
22	Ti	Titanium	(Ar) $3d^2$ $4s^2$	$^3F_2$	6.8281
23	V	Vanadium	(Ar) $3d^3$ $4s^2$	$^4F_{3/2}$	6.7463
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) $4d$ $5s^2$	$^2D_{3/2}$	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

Transition elements

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)	$5d$	$6s^2$					$^2D_{3/2}$	5.5770
58	Ce	Cerium	(Xe) $4f$	$5d$	$6s^2$					$^1G_4$	5.5387
59	Pr	Praseodymium	(Xe) $4f^3$		$6s^2$					$^4I_{9/2}$	5.464
60	Nd	Neodymium	(Xe) $4f^4$		$6s^2$					$^5I_4$	5.5250
61	Pm	Promethium	(Xe) $4f^5$		$6s^2$					$^6H_{5/2}$	5.58
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) $4f^{14}$	$5d^2$	$6s^2$					$^3F_2$	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) $4f^{14}$	$5d^{10}$	$6s^2$	$6p^4$				$^3P_2$	8.4167
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) $5f^2$	$6d$	$7s^2$					$^4K_{11/2}$	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) $5f^6$		$7s^2$					$^7F_0$	6.0262
95	Am	Americium	(Rn) $5f^7$		$7s^2$					$^8S_{7/2}$	5.9738
96	Cm	Curium	(Rn) $5f^7$	$6d$	$7s^2$					$^9D_2$	5.9915
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) $5f^{14}$		$7s^2$	$7p$?				$^2P_{1/2}$?	
104	Rf	Rutherfordium	(Rn) $5f^{14}$	$6d^2$	$7s^2$?					$^3F_2$?	6.0?

Lanthanides

Transition elements

Actinides