

5. ELECTRONIC STRUCTURE OF THE ELEMENTS

Table 5.1. Reviewed 1998 by W.C. Martin (NIST). The electronic configurations and the ionization energies (except for a few newer values, marked with an *) are taken from “Atomic Spectroscopy,” W.C. Martin and W.L. Wiese, in *Atomic, Molecular, and Optical Physics Reference Book*, G.W.F. Drake, ed., Amer. Inst. Phys., 1995. The electron configuration for, say, iron indicates an argon electronic core (see argon) plus six 3*d* electrons and two 4*s* 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 3 <i>d</i> electrons, etc.)	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> ²	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> ²	1S_0	9.3227
5	B Boron	(He) 2 <i>s</i> ² 2 <i>p</i>	$^2P_{1/2}$	8.2980
6	C Carbon	(He) 2 <i>s</i> ² 2 <i>p</i> ²	3P_0	11.2603
7	N Nitrogen	(He) 2 <i>s</i> ² 2 <i>p</i> ³	$^4S_{3/2}$	14.5341
8	O Oxygen	(He) 2 <i>s</i> ² 2 <i>p</i> ⁴	3P_2	13.6181
9	F Fluorine	(He) 2 <i>s</i> ² 2 <i>p</i> ⁵	$^2P_{3/2}$	17.4228
10	Ne Neon	(He) 2 <i>s</i> ² 2 <i>p</i> ⁶	1S_0	21.5646
11	Na Sodium	(Ne) 3 <i>s</i>	$^2S_{1/2}$	5.1391
12	Mg Magnesium	(Ne) 3 <i>s</i> ²	1S_0	7.6462
13	Al Aluminum	(Ne) 3 <i>s</i> ² 3 <i>p</i>	$^2P_{1/2}$	5.9858
14	Si Silicon	(Ne) 3 <i>s</i> ² 3 <i>p</i> ²	3P_0	8.1517
15	P Phosphorus	(Ne) 3 <i>s</i> ² 3 <i>p</i> ³	$^4S_{3/2}$	10.4867
16	S Sulfur	(Ne) 3 <i>s</i> ² 3 <i>p</i> ⁴	3P_2	10.3600
17	Cl Chlorine	(Ne) 3 <i>s</i> ² 3 <i>p</i> ⁵	$^2P_{3/2}$	12.9676
18	Ar Argon	(Ne) 3 <i>s</i> ² 3 <i>p</i> ⁶	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> ²	1S_0	6.1132
21	Sc Scandium	(Ar) 3 <i>d</i> 4 <i>s</i> ²	$^2D_{3/2}$	6.5615
22	Ti Titanium	(Ar) 3 <i>d</i> ² 4 <i>s</i> ²	3F_2	6.8281
23	V Vanadium	(Ar) 3 <i>d</i> ³ 4 <i>s</i> ²	$^4F_{3/2}$	6.7463
24	Cr Chromium	(Ar) 3 <i>d</i> ⁵ 4 <i>s</i>	7S_3	6.7665
25	Mn Manganese	(Ar) 3 <i>d</i> ⁵ 4 <i>s</i> ²	$^6S_{5/2}$	7.4340
26	Fe Iron	(Ar) 3 <i>d</i> ⁶ 4 <i>s</i> ²	5D_4	7.9024
27	Co Cobalt	(Ar) 3 <i>d</i> ⁷ 4 <i>s</i> ²	$^4F_{9/2}$	7.8810
28	Ni Nickel	(Ar) 3 <i>d</i> ⁸ 4 <i>s</i> ²	3F_4	7.6398
29	Cu Copper	(Ar) 3 <i>d</i> ¹⁰ 4 <i>s</i>	$^2S_{1/2}$	7.7264
30	Zn Zinc	(Ar) 3 <i>d</i> ¹⁰ 4 <i>s</i> ²	1S_0	9.3942
31	Ga Gallium	(Ar) 3 <i>d</i> ¹⁰ 4 <i>s</i> ² 4 <i>p</i>	$^2P_{1/2}$	5.9993
32	Ge Germanium	(Ar) 3 <i>d</i> ¹⁰ 4 <i>s</i> ² 4 <i>p</i> ²	3P_0	7.8994
33	As Arsenic	(Ar) 3 <i>d</i> ¹⁰ 4 <i>s</i> ² 4 <i>p</i> ³	$^4S_{3/2}$	9.7886
34	Se Selenium	(Ar) 3 <i>d</i> ¹⁰ 4 <i>s</i> ² 4 <i>p</i> ⁴	3P_2	9.7524
35	Br Bromine	(Ar) 3 <i>d</i> ¹⁰ 4 <i>s</i> ² 4 <i>p</i> ⁵	$^2P_{3/2}$	11.8138
36	Kr Krypton	(Ar) 3 <i>d</i> ¹⁰ 4 <i>s</i> ² 4 <i>p</i> ⁶	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> ²	1S_0	5.6949
39	Y Yttrium	(Kr) 4 <i>d</i> 5 <i>s</i> ²	$^2D_{3/2}$	6.2171
40	Zr Zirconium	(Kr) 4 <i>d</i> ² 5 <i>s</i> ²	3F_2	6.6339
41	Nb Niobium	(Kr) 4 <i>d</i> ⁴ 5 <i>s</i>	$^6D_{1/2}$	6.7589
42	Mo Molybdenum	(Kr) 4 <i>d</i> ⁵ 5 <i>s</i>	7S_3	7.0924
43	Tc Technetium	(Kr) 4 <i>d</i> ⁵ 5 <i>s</i> ²	$^6S_{5/2}$	7.28
44	Ru Ruthenium	(Kr) 4 <i>d</i> ⁷ 5 <i>s</i>	5F_5	7.3605
45	Rh Rhodium	(Kr) 4 <i>d</i> ⁸ 5 <i>s</i>	$^4F_{9/2}$	7.4589
46	Pd Palladium	(Kr) 4 <i>d</i> ¹⁰	1S_0	8.3369
47	Ag Silver	(Kr) 4 <i>d</i> ¹⁰ 5 <i>s</i>	$^2S_{1/2}$	7.5763
48	Cd Cadmium	(Kr) 4 <i>d</i> ¹⁰ 5 <i>s</i> 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) $5d 6s^2$			$^2D_{3/2}$	5.5770
58	Ce	Cerium	(Xe) $4f 5d 6s^2$			1G_4	5.5387
59	Pr	Praseodymium	(Xe) $4f^3 6s^2$	L		$^4I_{9/2}$	5.464
60	Nd	Neodymium	(Xe) $4f^4 6s^2$	a		5I_4	5.5250
61	Pm	Promethium	(Xe) $4f^5 6s^2$	n		$^6H_{5/2}$	5.58
62	Sm	Samarium	(Xe) $4f^6 6s^2$	t		7F_0	5.6436
63	Eu	Europium	(Xe) $4f^7 6s^2$	h		$^8S_{7/2}$	5.6704
64	Gd	Gadolinium	(Xe) $4f^7 5d 6s^2$	a		9D_2	6.1501
65	Tb	Terbium	(Xe) $4f^9 6s^2$	n		$^6H_{15/2}$	5.8638
66	Dy	Dysprosium	(Xe) $4f^{10} 6s^2$	i		5I_8	5.9389
67	Ho	Holmium	(Xe) $4f^{11} 6s^2$	d		$^4I_{15/2}$	6.0215
68	Er	Erbium	(Xe) $4f^{12} 6s^2$	e		3H_6	6.1077
69	Tm	Thulium	(Xe) $4f^{13} 6s^2$	s		$^2F_{7/2}$	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) $4f^{14} 5d^2 6s^2$	T		3F_2	6.8251
73	Ta	Tantalum	(Xe) $4f^{14} 5d^3 6s^2$	r	e	$^4F_{3/2}$	7.5496
74	W	Tungsten	(Xe) $4f^{14} 5d^4 6s^2$	a	l	5D_0	7.8640
75	Re	Rhenium	(Xe) $4f^{14} 5d^5 6s^2$	n	e	$^6S_{5/2}$	7.8335
76	Os	Osmium	(Xe) $4f^{14} 5d^6 6s^2$	s	m	5D_4	8.4382*
77	Ir	Iridium	(Xe) $4f^{14} 5d^7 6s^2$	i	e	$^4F_{9/2}$	8.9670*
78	Pt	Platinum	(Xe) $4f^{14} 5d^9 6s$	t	n	3D_3	8.9587
79	Au	Gold	(Xe) $4f^{14} 5d^{10} 6s$	i	t	$^2S_{1/2}$	9.2255
80	Hg	Mercury	(Xe) $4f^{14} 5d^{10} 6s^2$	o	s	1S_0	10.4375
81	Tl	Thallium	(Xe) $4f^{14} 5d^{10} 6s^2 6p$	n		$^2P_{1/2}$	6.1082
82	Pb	Lead	(Xe) $4f^{14} 5d^{10} 6s^2 6p^2$			3P_0	7.4167
83	Bi	Bismuth	(Xe) $4f^{14} 5d^{10} 6s^2 6p^3$			$^4S_{3/2}$	7.2856
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) $5f^2 6d 7s^2$	A		$^4K_{11/2}$	5.89
92	U	Uranium	(Rn) $5f^3 6d 7s^2$	c		5L_6	6.1941
93	Np	Neptunium	(Rn) $5f^4 6d 7s^2$	t		$^6L_{11/2}$	6.2657
94	Pu	Plutonium	(Rn) $5f^6 7s^2$	i		7F_0	6.0262
95	Am	Americium	(Rn) $5f^7 7s^2$	n		$^8S_{7/2}$	5.9738
96	Cm	Curium	(Rn) $5f^7 6d 7s^2$	i		9D_2	5.9915*
97	Bk	Berkelium	(Rn) $5f^9 7s^2$	d		$^6H_{15/2}$	6.1979*
98	Cf	Californium	(Rn) $5f^{10} 7s^2$	e		5I_8	6.2817*
99	Es	Einsteinium	(Rn) $5f^{11} 7s^2$	s		$^4I_{15/2}$	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?