

5. ELECTRONIC STRUCTURE OF THE ELEMENTS

Table 5.1. Reviewed 1999 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>	$^2S_{1/2}$	7.5762*
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			² P _{1/2}	5.7864
50	Sn	Tin	(Kr) 4d ¹⁰ 5s ² 5p ²			³ P ₀	7.3439
51	Sb	Antimony	(Kr) 4d ¹⁰ 5s ² 5p ³			⁴ S _{3/2}	8.6084
52	Te	Tellurium	(Kr) 4d ¹⁰ 5s ² 5p ⁴			³ P ₂	9.0096
53	I	Iodine	(Kr) 4d ¹⁰ 5s ² 5p ⁵			² F _{3/2}	10.4513
54	Xe	Xenon	(Kr) 4d ¹⁰ 5s ² 5p ⁶			¹ S ₀	12.1298
55	Cs	Cesium	(Xe) 6s			² S _{1/2}	3.8939
56	Ba	Barium	(Xe) 6s ²			¹ S ₀	5.2117
57	La	Lanthanum	(Xe) 5d 6s ²			² D _{3/2}	5.5770
58	Ce	Cerium	(Xe) 4f 5d 6s ²			¹ G ₄	5.5387
59	Pr	Praseodymium	(Xe) 4f ³ 6s ²	L		⁴ I _{9/2}	5.464
60	Nd	Neodymium	(Xe) 4f ⁴ 6s ²	a		⁵ I ₄	5.5250
61	Pm	Promethium	(Xe) 4f ⁵ 6s ²	n		⁶ H _{5/2}	5.58
62	Sm	Samarium	(Xe) 4f ⁶ 6s ²	t		⁷ F ₀	5.6436
63	Eu	Europium	(Xe) 4f ⁷ 6s ²	h		⁸ S _{7/2}	5.6704
64	Gd	Gadolinium	(Xe) 4f ⁷ 5d 6s ²	a		⁹ D ₂	6.1498*
65	Tb	Terbium	(Xe) 4f ⁹ 6s ²	n		⁶ H _{15/2}	5.8638
66	Dy	Dysprosium	(Xe) 4f ¹⁰ 6s ²	i		⁵ I ₈	5.9389
67	Ho	Holmium	(Xe) 4f ¹¹ 6s ²	d		⁴ I _{15/2}	6.0215
68	Er	Erbium	(Xe) 4f ¹² 6s ²	e		³ H ₆	6.1077
69	Tm	Thulium	(Xe) 4f ¹³ 6s ²	s		² F _{7/2}	6.1843
70	Yb	Ytterbium	(Xe) 4f ¹⁴ 6s ²			¹ S ₀	6.2542
71	Lu	Lutetium	(Xe) 4f ¹⁴ 5d 6s ²			² D _{3/2}	5.4259
72	Hf	Hafnium	(Xe) 4f ¹⁴ 5d ² 6s ²	T		³ F ₂	6.8251
73	Ta	Tantalum	(Xe) 4f ¹⁴ 5d ³ 6s ²	r	e	⁴ F _{3/2}	7.5496
74	W	Tungsten	(Xe) 4f ¹⁴ 5d ⁴ 6s ²	a	l	⁵ D ₀	7.8640
75	Re	Rhenium	(Xe) 4f ¹⁴ 5d ⁵ 6s ²	n	e	⁶ S _{5/2}	7.8335
76	Os	Osmium	(Xe) 4f ¹⁴ 5d ⁶ 6s ²	s	m	⁵ D ₄	8.4382*
77	Ir	Iridium	(Xe) 4f ¹⁴ 5d ⁷ 6s ²	i	e	⁴ F _{9/2}	8.9670*
78	Pt	Platinum	(Xe) 4f ¹⁴ 5d ⁹ 6s	t	n	³ D ₃	8.9587
79	Au	Gold	(Xe) 4f ¹⁴ 5d ¹⁰ 6s	i	t	² S _{1/2}	9.2255
80	Hg	Mercury	(Xe) 4f ¹⁴ 5d ¹⁰ 6s ²	o	s	¹ S ₀	10.4375
81	Tl	Thallium	(Xe) 4f ¹⁴ 5d ¹⁰ 6s ² 6p	n		² P _{1/2}	6.1082
82	Pb	Lead	(Xe) 4f ¹⁴ 5d ¹⁰ 6s ² 6p ²			³ P ₀	7.4167
83	Bi	Bismuth	(Xe) 4f ¹⁴ 5d ¹⁰ 6s ² 6p ³			⁴ S _{3/2}	7.2855*
84	Po	Polonium	(Xe) 4f ¹⁴ 5d ¹⁰ 6s ² 6p ⁴			³ P ₂	8.4167
85	At	Astatine	(Xe) 4f ¹⁴ 5d ¹⁰ 6s ² 6p ⁵			² F _{3/2}	
86	Rn	Radon	(Xe) 4f ¹⁴ 5d ¹⁰ 6s ² 6p ⁶			¹ S ₀	10.7485
87	Fr	Francium	(Rn) 7s			² S _{1/2}	4.0727
88	Ra	Radium	(Rn) 7s ²			¹ S ₀	5.2784
89	Ac	Actinium	(Rn) 6d 7s ²			² D _{3/2}	5.17
90	Th	Thorium	(Rn) 6d ² 7s ²			³ F ₂	6.3067
91	Pa	Protactinium	(Rn) 5f ² 6d 7s ²	A		⁴ K _{11/2}	5.89
92	U	Uranium	(Rn) 5f ³ 6d 7s ²	c		⁵ L ₆	6.1941
93	Np	Neptunium	(Rn) 5f ⁴ 6d 7s ²	t		⁶ L _{11/2}	6.2657
94	Pu	Plutonium	(Rn) 5f ⁶ 7s ²	i		⁷ F ₀	6.0262
95	Am	Americium	(Rn) 5f ⁷ 7s ²	n		⁸ S _{7/2}	5.9738
96	Cm	Curium	(Rn) 5f ⁷ 6d 7s ²	i		⁹ D ₂	5.9915*
97	Bk	Berkelium	(Rn) 5f ⁹ 7s ²	d		⁶ H _{15/2}	6.1979*
98	Cf	Californium	(Rn) 5f ¹⁰ 7s ²	e		⁵ I ₈	6.2817*
99	Es	Einsteinium	(Rn) 5f ¹¹ 7s ²	s		⁴ I _{15/2}	6.42
100	Fm	Fermium	(Rn) 5f ¹² 7s ²			³ H ₆	6.50
101	Md	Mendelevium	(Rn) 5f ¹³ 7s ²			² F _{7/2}	6.58
102	No	Nobelium	(Rn) 5f ¹⁴ 7s ²			¹ S ₀	6.65
103	Lr	Lawrencium	(Rn) 5f ¹⁴ 7s ² 7p?			² P _{1/2} ?	
104	Rf	Rutherfordium	(Rn) 5f ¹⁴ 6d ² 7s ² ?			³ F ₂ ?	6.0?