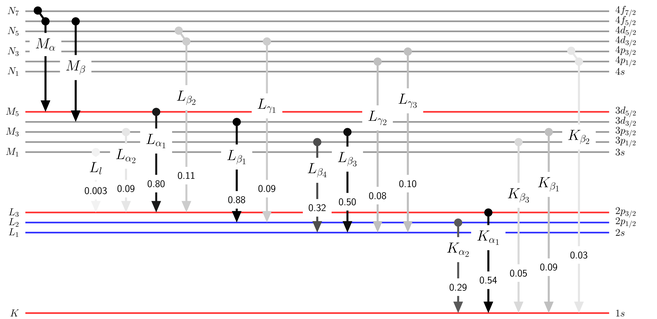
X-ray Absorption and Emission Energies of the Elements



Atomic Data and Energies from
W. T. Elam, B. D. Ravel and J. R. Sieber,
Radiation Physics and Chemistry **63**, pp 121-128 (2002)

Common oxidation states from wikipedia.org, after
N. N. Greenwood and A. Earnshaw,
Chemistry of the Elements, 2nd ed. (1997).

All energies in eV.
Emission line strengths are approximate, and vary with element.

Symbol	Z
name	
K edge	K_{α_1} K_{β_3}
L_1 edge	L_{β_3} L_{β_4}
L_2 edge	L_{β_1} L_{γ_1}
L_3 edge	L_{α_1} L_{β_2}
M_5 edge	M_α M_β
Mass	oxidation states

H 1 hydrogen
14
1.0079 +1

He 2 helium
25
4.0026

Li 3 lithium
55
5
6.941 +1

Be 4 beryllium
112 109
8
3
3
9.0122 +2

B 5 boron
188 183
13
5
5
10.81 +3

C 6 carbon
284 277
18
7
7
12.011 -4, -3, . . . , +2, +3, +4

N 7 nitrogen
410 392
37
18
18
14.0067 -3, +3, +5

O 8 oxygen
543 525
42
18
18
15.9994 -2

F 9 fluorine
697 677
45
20
20
18.9984 -1

Ne 10 neon
870 849
49
22
22
20.179

Na 11 sodium
1071 1040
64
30
31
22.9898 +1

Mg 12 magnesium
1303 1254 1302
89 88 88
50
49
24.305 +2

Al 13 aluminum
1559 1487 1557
118 116 116
73
73
26.9815 +3

Si 14 silicon
1839 1740 1837
150 148 148
100
99
28.0855 -4, +4

P 15 phosphorus
2146 2011 2140
189 183 182
136
135
30.9738 -3, +3, +5

S 16 sulfur
2472 2310 2465
231 224 223
164
163
32.06 -2, +2, +4, +6

Cl 17 chlorine
2822 2622 2812
270 260 260
202
200
35.453 -1, +1, +3, +5, +7

Ar 18 argon
3206 2958 3190
326 311 310
251
248
39.948

K 19 potassium
3608 3314 3590
379 360 360
297
295
39.0983 +1

Ca 20 calcium
4039 3692 4013
438 413 413
350
346
40.08 +2

Sc 21 scandium
4492 4093 4464
498 470 470
404
399
44.9559 +3

Ti 22 titanium
4966 4512 4933
561 528 528
460 458
454 452
2
47.88 +3, +4

V 23 vanadium
5465 4953 5428
627 590 590
520 518
512 510
2
50.9415 +2, +3, +4, +5

Cr 24 chromium
5989 5415 5947
696 654 654
584 582
574 572
2
51.996 +2, +3, +6

Mn 25 manganese
6539 5900 6492
769 722 722
650 648
639 637
2
54.938 +2, +3, +4, +7

Fe 26 iron
7112 6405 7059
845 792 792
720 718
707 705
2
55.847 +2, +3

Co 27 cobalt
7709 6931 7649
925 865 866
793 790
778 775
3
58.9332 +2, +3

Ni 28 nickel
8333 7480 8267
1009 942 941
870 866
853 849
4
58.69 +2

Cu 29 copper
8979 8046 8904
1097 1022 1019
952 947
933 928
5
63.546 +1, +2

Zn 30 zinc
9659 8637 9570
1196 1108 1105
1045 1035
1022 1012
10
65.38 +2

Ga 31 gallium
10367 9251 10267
1299 1199 1196
1143 1125
1116 1098
19
69.72 +3

Ge 32 germanium
11103 9886 10982
1415 1294 1290
1248 1218
1217 1188
29
72.59 -4, +2, +4

As 33 arsenic
11867 10543 11726
1527 1386 1381
1359 1317
1324 1282
42
74.9216 -3, +3, +5

Se 34 selenium
12658 11224 12497
1652 1491 1486
1474 1419
1434 1379
55
78.96 -2, +2, +4, +6

Br 35 bromine
13474 11924 13292
1782 1600 1593
1596 1526
1550 1481
69
79.904 -1, +1, +3, +5

Kr 36 krypton
14326 12648 14112
1921 1707 1699
1731 1636
1678 1585
94
83.8

Rb 37 rubidium
15200 13396 14961
2065 1826 1816
1864 1751
1804 1692
112
85.4678 +1

Sr 38 strontium
16105 14165 15835
2216 1946 1936
2007 1871
1940 1806
134
87.62 +2

Y 39 yttrium
17038 14958 16739
2373 2074 2062
2156 1998
2080 1924
156
88.9059 +3

Zr 40 zirconium
17998 15775 17668
2532 2202 2189
2307 2126
2223 2044
179
91.22 +4

Nb 41 niobium
18986 16615 18625
2698 2337 2322
2465 2260
2371 2169
202
92.9064 +4, +5

Mo 42 molybdenum
20000 17480 19606
2866 2472 2454
2625 2394
2520 2292
228
95.94 +3, +4, +6

Tc 43 technetium
21044 18367 20626
3043 2625 2595
2793 2535
2677 2423
254
97.907 +4, +7

Ru 44 ruthenium
22117 19279 21656
3224 2763 2741
2967 2683
2838 2558
280
101.07 +3, +4, +6

Rh 45 rhodium
23220 20216 22724
3412 2916 2891
3146 2834 3144
3004 2697 3002
307
102.906 +2, +3, +4

Pd 46 palladium
24350 21177 23818
3604 3072 3044
3330 2990 3328
3173 2838 3171
335
106.42 +2, +4

Ag 47 silver
25514 22163 24941
3806 3233 3202
3524 3150 3520
3351 2983 3347
368
107.868 +1

Cd 48 cadmium
26711 23173 26093
4018 3400 3365
3727 3315 3715
3538 3133 3526
405
112.41 +2

In 49 indium
27940 24210 27275
4238 3573 3535
3938 3487 3920
3730 3286 3712
444
114.82 +3

Sn 50 tin
29200 25271 28485
4465 3750 3709
4156 3663 4131
3929 3444 3904
485
118.69 -4, +2, +4

Sb 51 antimony
30491 26359 29725
4698 3932 3885
4380 3843 4347
4132 3604 4099
528 528 538
121.75 -3, +3, +5

Te 52 tellurium
31814 27473 30993
4939 4118 4068
4612 4029 4570
4341 3768 4299
573 573 583
127.6 -2, +2, +4, +6

I 53 iodine
33169 28612 32294
5188 4313 4257
4852 4221 4801
4557 3938 4506
619 619 631
126.905 -1, +1, +3, +5, +7

Xe 54 xenon
34561 29775 33620
5453 4512 4451
5107 4418 5038
4786 4110 4717
676 676 689
131.29

Cs 55 cesium
35985 30973 34982
5714 4711 4643
5359 4619 5279
5012 4285 4932
727 727 741
132.905 +1

Ba 56 barium
37441 32194 36378
5989 4926 4852
5624 4828 5531
5247 4467 5154
781 781 796
137.33 +2

La 57 lanthanum
38925 33442 37797
6266 5138 5057
5891 5038 5786
5483 4647 5378
836 836 853
138.906 +3

Hf 72 hafnium
65351 55790 63244
11271 9164 8906
10739 9023 10519
9561 7899 9341
1662 1646 1700
178.49 +4

Ta 73 tantalum
67416 57535 65222
11682 9488 9213
11136 9343 10898
9881 8146 9643
1735 1712 1770
180.948 +5

W 74 tungsten
69525 59318 67244
12100 9819 9525
11544 9672 11288
10207 8398 9951
1809 1775 1838
183.85 +4, +6

Re 75 rhenium
71676 61141 69309
12527 10160 9845
11959 10010 11685
10535 8652 10261
1883 1840 1906
186.207 +4

Os 76 osmium
73871 63000 71414
12968 10511 10176
12385 10354 12092
10871 8911 10578
1960 1907 1978
190.2 +4

Ir 77 iridium
76111 64896 73560
13419 10868 10510
12824 10708 12512
11215 9175 10903
2040 1976 2052
192.22 +3, +4

Pt 78 platinum
78395 66831 75750
13880 11235 10853
13273 11071 12941
11564 9442 11232
2122 2048 2128
195.08 +2, +4

Au 79 gold
80725 68806 77982
14353 11610 11205
13734 11443 13381
11919 9713 11566
2206 2118 2203
196.967 +1, +3

Hg 80 mercury
83102 70818 80255
14839 11992 11560
14209 11824 13831
12284 9989 11906
2295 2191 2281
200.59 +1, +2

Tl 81 thallium
85530 72872 82573
15347 12390 11931
14698 12213 14292
12658 10269 12252
2389 2267 2363
204.383 +1, +3

Pb 82 lead
88005 74970 84939
15861 12795 12307
15200 12614 14766
13035 10551 12601
2484 2342 2444
207.2 +2, +4

Bi 83 bismuth
90526 77107 87349
16388 13211 12692
15711 13023 15247
13419 10839 12955
2580 2418 2526
208.98 +3, +5

Po 84 polonium
93105 79291 89803
16939 13637 13085
16244 13446 15744
13814 11131 13314
2683 2499 2614
208.982 -2, +2, +4

At 85 astatine
95730 81516 92304
17493 14067 13485
16785 13876 16252
14214 11427 13681
2787 2577 2699
209.987 -1, +1

Rn 86 radon
98404 83785 94866
18049 14511 13890
17337 14315 16770
14619 11727 14052
2892 2654 2784
222.018

Fr 87 francium
101137 86106 97474
18639 14976 14312
17907 14771 17304
15031 12031 14428
3000 2732 2868
223.02 +1

Ra 88 radium
103922 88478 100130
19237 15445 14747
18484 15236 17848
15444 12339 14808
3105 2806 2949
226.025 +2

Ac 89 actinium
106755 90884 102846
19840 15931 15184
19083 15713 18408
15871 12652 15196
3219 2900 3051
227.028 +3

Ce 58 cerium
40443 34720 39256
6548 5361 5274
6164 5262 6055
5723 4839 5614
884 884 902
140.12 +3, +4

Pr 59 praseodymium
41991 36027 40749
6835 5593 5498
6440 5492 6325
5964 5035 5849
929 927 946
140.908 +3, +4

Nd 60 neodymium
43569 37361 42272
7126 5829 5723
6722 5719 6602
6208 5228 6088
980 979 1002
144.24 +3

Pm 61 promethium
45184 38725 43827
7428 6071 5957
7013 5961 6893
6459 5432 6339
1027 1023 1048
144.913 +3

Sm 62 samarium
46834 40118 45414
7737 6317 6196
7312 6201 7183
6716 5633 6587
1083 1078 1106
150.36 +3

Eu 63 europium
48519 41542 47038
8052 6571 6438
7617 6458 7484
6977 5850 6844
1128 1122 1153
151.96 +2, +3

Gd 64 gadolinium
50239 42996 48695
8376 6832 6688
7930 6708 7787
7243 6053 7100
1190 1181 1213
157.25 +3

Tb 65 terbium
51996 44482 50385
8708 7097 6940
8252 6975 8102
7514 6273 7364
1241 1233 1269
158.925 +3, +4

Dy 66 dysprosium
53789 45999 52113
9046 7370 7204
8581 7248 8427
7790 6498 7636
1292 1284 1325
162.5 +3

Ho 67 holmium
55618 47547 53877
9394 7653 7471
8918 7526 8758
8071 6720 7911
1351 1342 1383
164.93 +3

Er 68 erbium
57486 49128 55674
9751 7939 7745
9264 7811 9096
8358 6949 8190
1409 1404 1448
167.26 +3

Tm 69 thulium
59390 50742 57505
10116 8231 8026
9617 8102 9442
8648 7180 8473
1468 1463 1510
168.934 +3

Yb 70 ytterbium
61332 52388 59382
10486 8536 8313
9978 8402 9787
8944 7416 8753
1528 1526 1574
173.04 +3

Lu 71 lutetium
63314 54070 61290
10870 8846 8606
10349 8710 10143
9244 7655 9038
1589 1580 1630
174.967 +3

Th 90 thorium
109651 93351 105605
20472 16426 15642
19693 16202 18981
16300 12968 15588
3332 2990 3149
232.038 +4

Pa 91 protactinium
112601 95868 108427
21105 16931 16104
20314 16703 19571
16733 13291 15990
3442 3071 3240
231.036 +5

U 92 uranium
115606 98440 111303
21757 17454 16575
20948 17220 20170
17166 13614 16388
3552 3164 3340
238.051 +4, +6

Np 93 neptunium
118669 101059 114234
22427 17992 17061
21600 17751 20784
17610 13946 16794
3664 3250 3435
237.048 +3, +4, +5

Pu 94 plutonium
121791 103734 117228
23104 18541 17557
22266 18296 21420
18057 14282 17211
3775 3339 3534
239.052 +3, +4, +5

Am 95 americium
124982 106472 120284
23808 19110 18069
22952 18856 22072
18510 14620 17630
3890 3429 3635
243.061 +3, +4, +5

Cm 96 curium
128241 109271 123403
24526 19688 18589
23651 19427 22735
18970 14961 18054
4009 3525 3740
247.07 +3

Bk 97 berkelium
131556 112121 126580
25256 20280 19118
24371 20018 23416
19435 15308 18480
4127 3616 3842
247.07 +3, +4

Cf 98 californium
134939 115032 129823
26010 20894 19665
25108 20624 24117
19907 15660 18916
4247 3709 3946
251.08 +3

Es 99 einsteinium

Fm 100 fermium

Md 101 mendelevium

No 102 nobelium

Lr 103 lawrencium


Henry Moseley

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