# IONIZATION POTENTIALS OF ATOMS AND ATOMIC IONS

The ionization potentials of neutral and partially ionized atoms are listed in this table. Data were obtained from the compilations cited below, supplemented by results from the recent research literature. All values have been corrected to the currently recommended value of the conversion factor from wave number to energy, namely 1 eV = 8065.541 $cm^{-1}$ (Reference 5). Values are given in eV.

Following the traditional spectroscopic notation, columns are headed I, II, III, etc. up to XXX, where I indicates the neutral atom, II the singly ionized atom, III the doubly ionized atom, etc. The first section of the table includes spectra I to VIII of all the elements; subsequent sections cover higher spectra (ionization stages) for those elements for which data are available.

## REFERENCES


1. Moore, C. E., *Ionization Potentials and Ionization Limits Derived from the Analysis of Optical Spectra*, Natl. Stand. Ref. Data Ser. — Natl. Bur. Stand. (U.S.) No. 34, 1970.
2. Martin, W. C., Zalubas, R., and Hagan, L., *Atomic Energy Levels — The Rare Earth Elements*, Natl. Stand. Ref. Data Ser. — Natl. Bur. Stand. (U.S.), No. 60, 1978.
3. Sugar, J. and Corliss, C., *Atomic Energy Levels of the Iron Period Elements: Potassium through Nickel, J. Phys. Chem. Ref. Data*, Vol.14, Suppl. 2, 1985.
4. References to papers in *J. Phys. Chem. Ref. Data*, in the period 1973—91 covering other elements may be found in the cumulative index to that journal.
5. Cohen, E. R. and Taylor, B. N., *J. Phys. Chem. Ref. Data*, 17, 1795, 1988.
6. Martin, W.C., and Wiese, W.L., in *Atomic, Molecular, and Optical Physics Handbook*, Drake, G.W.F., Ed., AIP Press, New York, 1996.


### Neutral Atoms to +7 Ions

| *Z* | Element | I | II | III | IV | V | VI | VII | VIII |
|---|---|---|---|---|---|---|---|---|---|
| 1 | H | 13.59844 | | | | | | | |
| 2 | He | 24.58741 | 54.41778 | | | | | | |
| 3 | Li | 5.39172 | 75.64018 | 122.45429 | | | | | |
| 4 | Be | 9.3227 | 18.21116 | 153.89661 | 217.71865 | | | | |
| 5 | B | 8.29803 | 25.15484 | 37.93064 | 259.37521 | 340.22580 | | | |
| 6 | C | 11.26030 | 24.38332 | 47.8878 | 64.4939 | 392.087 | 489.99334 | | |
| 7 | N | 14.53414 | 29.6013 | 47.44924 | 77.4735 | 97.8902 | 552.0718 | 667.046 | |
| 8 | O | 13.61806 | 35.11730 | 54.9355 | 77.41353 | 113.8990 | 138.1197 | 739.29 | 871.4101 |
| 9 | F | 17.42282 | 34.97082 | 62.7084 | 87.1398 | 114.2428 | 157.1651 | 185.186 | 953.9112 |
| 10 | Ne | 21.5646 | 40.96328 | 63.45 | 97.12 | 126.21 | 157.93 | 207.2759 | 239.0989 |
| 11 | Na | 5.13908 | 47.2864 | 71.6200 | 98.91 | 138.40 | 172.18 | 208.50 | 264.25 |
| 12 | Mg | 7.64624 | 15.03528 | 80.1437 | 109.2655 | 141.27 | 186.76 | 225.02 | 265.96 |
| 13 | Al | 5.98577 | 18.82856 | 28.44765 | 119.992 | 153.825 | 190.49 | 241.76 | 284.66 |
| 14 | Si | 8.15169 | 16.34585 | 33.49302 | 45.14181 | 166.767 | 205.27 | 246.5 | 303.54 |
| 15 | P | 10.48669 | 19.7694 | 30.2027 | 51.4439 | 65.0251 | 220.421 | 263.57 | 309.60 |
| 16 | S | 10.36001 | 23.3379 | 34.79 | 47.222 | 72.5945 | 88.0530 | 280.948 | 328.75 |
| 17 | Cl | 12.96764 | 23.814 | 39.61 | 53.4652 | 67.8 | 97.03 | 114.1958 | 348.28 |
| 18 | Ar | 15.75962 | 27.62967 | 40.74 | 59.81 | 75.02 | 91.009 | 124.323 | 143.460 |
| 19 | K | 4.34066 | 31.63 | 45.806 | 60.91 | 82.66 | 99.4 | 117.56 | 154.88 |
| 20 | Ca | 6.11316 | 11.87172 | 50.9131 | 67.27 | 84.50 | 108.78 | 127.2 | 147.24 |
| 21 | Sc | 6.5615 | 12.79967 | 24.75666 | 73.4894 | 91.65 | 110.68 | 138.0 | 158.1 |
| 22 | Ti | 6.8281 | 13.5755 | 27.4917 | 43.2672 | 99.30 | 119.53 | 140.8 | 170.4 |
| 23 | V | 6.7463 | 14.66 | 29.311 | 46.709 | 65.2817 | 128.13 | 150.6 | 173.4 |
| 24 | Cr | 6.7665 | 16.4857 | 30.96 | 49.16 | 69.46 | 90.6349 | 160.18 | 184.7 |
| 25 | Mn | 7.43402 | 15.63999 | 33.668 | 51.2 | 72.4 | 95.6 | 119.203 | 194.5 |
| 26 | Fe | 7.9024 | 16.1878 | 30.652 | 54.8 | 75.0 | 99.1 | 124.98 | 151.06 |
| 27 | Co | 7.8810 | 17.083 | 33.50 | 51.3 | 79.5 | 102.0 | 128.9 | 157.8 |
| 28 | Ni | 7.6398 | 18.16884 | 35.19 | 54.9 | 76.06 | 108 | 133 | 162 |
| 29 | Cu | 7.72638 | 20.29240 | 36.841 | 57.38 | 79.8 | 103 | 139 | 166 |
| 30 | Zn | 9.3942 | 17.96440 | 39.723 | 59.4 | 82.6 | 108 | 134 | 174 |
| 31 | Ga | 5.99930 | 20.5142 | 30.71 | 64 | | | | |
| 32 | Ge | 7.8994 | 15.93462 | 34.2241 | 45.7131 | 93.5 | | | |
| 33 | As | 9.7886 | 18.633 | 28.351 | 50.13 | 62.63 | 127.6 | | |
| 34 | Se | 9.75238 | 21.19 | 30.8204 | 42.9450 | 68.3 | 81.7 | 155.4 | |
| 35 | Br | 11.81381 | 21.8 | 36 | 47.3 | 59.7 | 88.6 | 103.0 | 192.8 |
| 36 | Kr | 13.99961 | 24.35985 | 36.950 | 52.5 | 64.7 | 78.5 | 111.0 | 125.802 |
| 37 | Rb | 4.17713 | 27.285 | 40 | 52.6 | 71.0 | 84.4 | 99.2 | 136 |
| 38 | Sr | 5.6949 | 11.03013 | 42.89 | 57 | 71.6 | 90.8 | 106 | 122.3 |
| 39 | Y | 6.2171 | 12.24 | 20.52 | 60.597 | 77.0 | 93.0 | 116 | 129 |
| 40 | Zr | 6.63390 | 13.13 | 22.99 | 34.34 | 80.348 | | | |
| 41 | Nb | 6.75885 | 14.32 | 25.04 | 38.3 | 50.55 | 102.057 | 125 | |

## IONIZATION POTENTIALS OF ATOMS AND ATOMIC IONS (continued)

| *Z* | Element | I | II | III | IV | V | VI | VII | VIII |
|---|---|---|---|---|---|---|---|---|---|
| 42 | Mo | 7.09243 | 16.16 | 27.13 | 46.4 | 54.49 | 68.8276 | 125.664 | 143.6 |
| 43 | Tc | 7.28 | 15.26 | 29.54 | | | | | |
| 44 | Ru | 7.36050 | 16.76 | 28.47 | | | | | |
| 45 | Rh | 7.45890 | 18.08 | 31.06 | | | | | |
| 46 | Pd | 8.3369 | 19.43 | 32.93 | | | | | |
| 47 | Ag | 7.5763 | 21.49 | 34.83 | | | | | |
| 48 | Cd | 8.9938 | 16.90832 | 37.48 | | | | | |
| 49 | In | 5.78636 | 18.8698 | 28.03 | 54 | | | | |
| 50 | Sn | 7.3439 | 14.63225 | 30.50260 | 40.73502 | 72.28 | | | |
| 51 | Sb | 8.6084 | 16.53051 | 25.3 | 44.2 | 56 | 108 | | |
| 52 | Te | 9.0096 | 18.6 | 27.96 | 37.41 | 58.75 | 70.7 | 137 | |
| 53 | I | 10.45126 | 19.1313 | 33 | | | | | |
| 54 | Xe | 12.1298 | 21.20979 | 32.1230 | | | | | |
| 55 | Cs | 3.89390 | 23.15745 | | | | | | |
| 56 | Ba | 5.21170 | 10.00390 | | | | | | |
| 57 | La | 5.5770 | 11.060 | 19.1773 | 49.95 | 61.6 | | | |
| 58 | Ce | 5.5387 | 10.85 | 20.198 | 36.758 | 65.55 | 77.6 | | |
| 59 | Pr | 5.464 | 10.55 | 21.624 | 38.98 | 57.53 | | | |
| 60 | Nd | 5.5250 | 10.73 | 22.1 | 40.41 | | | | |
| 61 | Pm | 5.58 | 10.90 | 22.3 | 41.1 | | | | |
| 62 | Sm | 5.6436 | 11.07 | 23.4 | 41.4 | | | | |
| 63 | Eu | 5.6704 | 11.241 | 24.92 | 42.7 | | | | |
| 64 | Gd | 6.1501 | 12.09 | 20.63 | 44.0 | | | | |
| 65 | Tb | 5.8638 | 11.52 | 21.91 | 39.79 | | | | |
| 66 | Dy | 5.9389 | 11.67 | 22.8 | 41.47 | | | | |
| 67 | Ho | 6.0215 | 11.80 | 22.84 | 42.5 | | | | |
| 68 | Er | 6.1077 | 11.93 | 22.74 | 42.7 | | | | |
| 69 | Tm | 6.18431 | 12.05 | 23.68 | 42.7 | | | | |
| 70 | Yb | 6.25416 | 12.1761 | 25.05 | 43.56 | | | | |
| 71 | Lu | 5.4259 | 13.9 | 20.9594 | 45.25 | 66.8 | | | |
| 72 | Hf | 6.82507 | 14.9 | 23.3 | 33.33 | | | | |
| 73 | Ta | 7.5496 | | | | | | | |
| 74 | W | 7.8640 | | | | | | | |
| 75 | Re | 7.8335 | | | | | | | |
| 76 | Os | 8.4382 | | | | | | | |
| 77 | Ir | 8.9670 | | | | | | | |
| 78 | Pt | 8.9587 | 18.563 | | | | | | |
| 79 | Au | 9.2255 | 20.5 | | | | | | |
| 80 | Hg | 10.43750 | 18.756 | 34.2 | | | | | |
| 81 | Tl | 6.1082 | 20.428 | 29.83 | | | | | |
| 82 | Pb | 7.41666 | 15.0322 | 31.9373 | 42.32 | 68.8 | | | |
| 83 | Bi | 7.2856 | 16.69 | 25.56 | 45.3 | 56.0 | 88.3 | | |
| 84 | Po | 8.41671 | | | | | | | |
| 85 | At | | | | | | | | |
| 86 | Rn | 10.74850 | | | | | | | |
| 87 | Fr | 4.0727 | | | | | | | |
| 88 | Ra | 5.2784 | 10.14716 | | | | | | |
| 89 | Ac | 5.17 | 12.1 | | | | | | |
| 90 | Th | 6.3067 | 11.5 | 20.0 | 28.8 | | | | |
| 91 | Pa | 5.89 | | | | | | | |
| 92 | U | 6.19405 | | | | | | | |
| 93 | Np | 6.2657 | | | | | | | |
| 94 | Pu | 6.0262 | | | | | | | |
| 95 | Am | 5.9738 | | | | | | | |
| 96 | Cm | 6.02 | | | | | | | |
| 97 | Bk | 6.23 | | | | | | | |
| 98 | Cf | 6.30 | | | | | | | |
| 99 | Es | 6.42 | | | | | | | |
| 100 | Fm | 6.50 | | | | | | | |
| 101 | Md | 6.58 | | | | | | | |
| 102 | No | 6.65 | | | | | | | |

# IONIZATION POTENTIALS OF ATOMS AND ATOMIC IONS (continued)

## +8 Ions to +15 Ions

| *Z* | Element | IX | X | XI | XII | XIII | XIV | XV | XVI |
|---|---|---|---|---|---|---|---|---|---|
| 9 | F | 1103.1176 | | | | | | | |
| 10 | Ne | 1195.8286 | 1362.1995 | | | | | | |
| 11 | Na | 299.864 | 1465.121 | 1648.702 | | | | | |
| 12 | Mg | 328.06 | 367.50 | 1761.805 | 1962.6650 | | | | |
| 13 | Al | 330.13 | 398.75 | 442.00 | 2085.98 | 2304.1410 | | | |
| 14 | Si | 351.12 | 401.37 | 476.36 | 523.42 | 2437.63 | 2673.182 | | |
| 15 | P | 372.13 | 424.4 | 479.46 | 560.8 | 611.74 | 2816.91 | 3069.842 | |
| 16 | S | 379.55 | 447.5 | 504.8 | 564.44 | 652.2 | 707.01 | 3223.78 | 3494.1892 |
| 17 | Cl | 400.06 | 455.63 | 529.28 | 591.99 | 656.71 | 749.76 | 809.40 | 3658.521 |
| 18 | Ar | 422.45 | 478.69 | 538.96 | 618.26 | 686.10 | 755.74 | 854.77 | 918.03 |
| 19 | K | 175.8174 | 503.8 | 564.7 | 629.4 | 714.6 | 786.6 | 861.1 | 968 |
| 20 | Ca | 188.54 | 211.275 | 591.9 | 657.2 | 726.6 | 817.6 | 894.5 | 974 |
| 21 | Sc | 180.03 | 225.18 | 249.798 | 687.36 | 756.7 | 830.8 | 927.5 | 1009 |
| 22 | Ti | 192.1 | 215.92 | 265.07 | 291.500 | 787.84 | 863.1 | 941.9 | 1044 |
| 23 | V | 205.8 | 230.5 | 255.7 | 308.1 | 336.277 | 896.0 | 976 | 1060 |
| 24 | Cr | 209.3 | 244.4 | 270.8 | 298.0 | 354.8 | 384.168 | 1010.6 | 1097 |
| 25 | Mn | 221.8 | 248.3 | 286.0 | 314.4 | 343.6 | 403.0 | 435.163 | 1134.7 |
| 26 | Fe | 233.6 | 262.1 | 290.2 | 330.8 | 361.0 | 392.2 | 457 | 489.256 |
| 27 | Co | 186.13 | 275.4 | 305 | 336 | 379 | 411 | 444 | 511.96 |
| 28 | Ni | 193 | 224.6 | 321.0 | 352 | 384 | 430 | 464 | 499 |
| 29 | Cu | 199 | 232 | 265.3 | 369 | 401 | 435 | 484 | 520 |
| 30 | Zn | 203 | 238 | 274 | 310.8 | 419.7 | 454 | 490 | 542 |
| 36 | Kr | 230.85 | 268.2 | 308 | 350 | 391 | 447 | 492 | 541 |
| 37 | Rb | 150 | 277.1 | | | | | | |
| 38 | Sr | 162 | 177 | 324.1 | | | | | |
| 39 | Y | 146.2 | 191 | 206 | 374.0 | | | | |
| 42 | Mo | 164.12 | 186.4 | 209.3 | 230.28 | 279.1 | 302.60 | 544.0 | 570 |

## +16 Ions to +23 Ions

| *Z* | Element | XVII | XVIII | XIX | XX | XXI | XXII | XXIII | XXIV |
|---|---|---|---|---|---|---|---|---|---|
| 17 | Cl | 3946.2960 | | | | | | | |
| 18 | Ar | 4120.8857 | 4426.2296 | | | | | | |
| 19 | K | 1033.4 | 4610.8 | 4934.046 | | | | | |
| 20 | Ca | 1087 | 1157.8 | 5128.8 | 5469.864 | | | | |
| 21 | Sc | 1094 | 1213 | 1287.97 | 5674.8 | 6033.712 | | | |
| 22 | Ti | 1131 | 1221 | 1346 | 1425.4 | 6249.0 | 6625.82 | | |
| 23 | V | 1168 | 1260 | 1355 | 1486 | 1569.6 | 6851.3 | 7246.12 | |
| 24 | Cr | 1185 | 1299 | 1396 | 1496 | 1634 | 1721.4 | 7481.7 | 7894.81 |
| 25 | Mn | 1224 | 1317 | 1437 | 1539 | 1644 | 1788 | 1879.9 | 8140.6 |
| 26 | Fe | 1266 | 1358 | 1456 | 1582 | 1689 | 1799 | 1950 | 2023 |
| 27 | Co | 546.58 | 1397.2 | 1504.6 | 1603 | 1735 | 1846 | 1962 | 2119 |
| 28 | Ni | 571.08 | 607.06 | 1541 | 1648 | 1756 | 1894 | 2011 | 2131 |
| 29 | Cu | 557 | 633 | 670.588 | 1697 | 1804 | 1916 | 2060 | 2182 |
| 30 | Zn | 579 | 619 | 698 | 738 | 1856 | | | |
| 36 | Kr | 592 | 641 | 786 | 833 | 884 | 937 | 998 | 1051 |
| 42 | Mo | 636 | 702 | 767 | 833 | 902 | 968 | 1020 | 1082 |

## +24 Ions to +29 Ions

| *Z* | Element | XXV | XXVI | XXVII | XXVIII | XXIX | XXX |
|---|---|---|---|---|---|---|---|
| 25 | Mn | 8571.94 | | | | | |
| 26 | Fe | 8828 | 9277.69 | | | | |
| 27 | Co | 2219.0 | 9544.1 | 10012.12 | | | |
| 28 | Ni | 2295 | 2399.2 | 10288.8 | 10775.40 | | |
| 29 | Cu | 2308 | 2478 | 2587.5 | 11062.38 | 11567.617 | |
| 36 | Kr | 1151 | 1205.3 | 2928 | 3070 | 3227 | 3381 |
| 42 | Mo | 1263 | 1323 | 1387 | 1449 | 1535 | 1601 |