# Empirically derived set of atomic sensitivity factors for XPS

The following empirically derived set of atomic sensitivity factors, relative to F 1s= 1.00, is obtained from a combination of data from the Varian IEE and Physical Electronics (Perkin Elmer) 550 spectrometers. These spectrometers utilize scanning by varying the retarding voltage applied to the emitted electrons, with the analyser operated at constant-pass energy. This gives a transmission function for the spectrometer varying with the inverse of the electron kinetic energy. The factors therefore should be applicable to other spectrometers with the same transmission characteristics (cf. M. P. Seah, Surf. Interface Anal., 2, 222, 1980), but will not be applicable to those operating in a different mode.

These data appeared originally in C. D. Wagner, L. E. Davis, M. V. Zeller, J. A. Taylor, R. M. Raymond and L. H. Gale, Surf. Interface Anal., 3. 211 (1981) and are reproduced here from Appendix 6 of "Practical Surface Analysis", Vol. 1., 2nd Edition, by C. D. Wagner, eds. D. Briggs and M.P. Seah, Published by J. Wiley and Sons in 1990, ISBN 0-471-92081-9 by kind permission of the Authors and publishers.

| | Strong Line | | Secondary Line ++ | |
|---|---|---|---|---|
| | Area 1s | Height 1s+ | Area 2s | Height 2s |
| Li | 0.02 | 0.02 | | |
| Be | 0 059 | 0 059 | | |
| B | 0.13 | 0.13 | | |
| C | 0.25 | 0.25 | | |
| N | 0.42 | 0.42 | | |
| O | 0.66 | 0.66 | 0.025 | 0.025 |
| F | 1 | 1 | 0.04 | 0.04 |
| Ne | 1.5 | 1.5 | 0.07 | 0 07 |
| Na | 2.3 | 2.3 | 0.13 | 0.12 |
| Mg | 3.5 $ | 3.3 | 0.2 | 0.15 |

| | Strong Line | | | Secondary line ++ | |
|---|---|---|---|---|---|
| | Area | | Height + | Area | Height + |
| | 2p3/2 | 2p | 2p3/2 | 2s | 2s |
| Mg | | 0.12 | 0.12 | 0.2 | 0.15 |
| Al | | 0.185 | 0.18 | 0.23 | 0.17 |
| Si | | 0.27 | 0.25 | 0.26 | 0.19 |
| P | | 0.39 | 0.36 | 0.29 | 0.21 |
| S | | 0.54 | 0.49 | 0.33 | 0.24 |
| Cl | | 0.73 | 0.61 | 0.37 | 0.25 |
| Ar | | 0.96 | 0.75 | 0.4 | 0.26 |
| K | 0.83 | 1.24 | 0.83 | 0.43 | 0.26 |
| Ca | 1.05 | 1.58 | 1.05 | 0.47 | 0.26 |
| Sc | -1.1 | -1.65 | -1.1 | 0.5 | 0.26 |
| Ti | -1.2 | -1.8 | -1.2 | 0.54 | 0.26 |

| | Strong Lines | | | Secondary line ++ | |
|---|---|---|---|---|---|
| | Area | | Height + | Area | Height + |
| | 2p3/2 | 2p | 2p3/2 | 3p | 3p |
| Ti | (1.2) * | -1.8 | -1.2 | 0.21 | 0.15 |
| V | -1.3 | -1.95 | -1.3 | 0.21 | 0.16 |
| Cr | -1.5 | -2.3 | -1.5 | -0.21 | -0.17 |
| Mn | -1.7 | -2.6 | -1.7 | -0.22 | -0.19 |
| Fe | -2 | -3 | -2 | (0.26) | -0.21 |
| Co | -2.5 | -3.8 | -2.5 | -0.35 | -0.25 |
| Ni | -3 | -4.5 | -3 | -0.5 | (0 3) |
| Cu | -4.2 | -6.3 | -4.2 | -0.65 | -0.4 |
| Zn | 4.8 | | 4.8 | 0.75 | 0.4 |
| Ga | 5.4 | | 5.4 | 0.84 | 0.4 |
| Ge | 6.1 * | | 6.0* | 0.92 | 0.4 |
| As | 6.8* | | 6.8* | 1 | 0.43 |

| | Strong Lines | | | Secondary line ++ | | |
|---|---|---|---|---|---|---|
| | Area | | Height | Area | | Height |
| | 3d5/2 | 3d | 3d5/2 | 3p3/2 | 3p | 3p3/2 |
| Ga | | 0.31 | 0.31 | | 0.84 | 0.4 |
| Ge | | 0.38 | 0.37 | | 0.91 | 0.4 |
| As | | 0.53 | 0.51 | | 0.97 | 0.42 |
| Se | | 0.67 | 0.64 | | 1.05 | 0.48 |
| Br | | 0.83 | 0.77 | | 0.14 | 0.54 |
| Kr | | 1.02 | 0.91 | 0.82 | 1.23 & | 0.6 |
| Rb | | 1.23 | 1.07 | 0.87 | 1.3 | 0.67 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Sr | | 1.48 | 1.24 | 0.92 | 1.38 | 0 69 |
| Y | | 1.76 | 1.37 | 0.98 | 1.47 | 0 71 |
| Zr | | 2.1 | 1.5 | 1.04 | 1.56 | 0.72 |
| Nb | 1.44 | 2.4 | 1.57 | 1.1 | | 0.72 |
| Mo | 1.66 | 2.75 | 1.74 | 1.17 | | 0.73 |
| Tc | 1.89 | 3.15 | 1.92 | 1.24 | | 0.73 |
| Ru | 2.15 | 3.6 | 2.15 | 1.3 | | 0.73 |
| Rh | 2.4 | 4.1 | 2.4 | 1.38 | | 0.74 |
| Pd | 2.7 | 4.6 | 2.7 | 1.43 | | 0.74 |
| Ag | 3.1 | 5.2 | 3.1 | 1.52 | | 0.75 |
| Cd | 3.5 | | 3.5 | 1.6 | | 0.75 |
| In | 3.9 | | 3.9 | 1.68 | | 0.75 |
| Sn | 4.3 | | 4.3 | 1 77 | | 0.75 |

| | Strong line | | | Secondary line ++ | |
|---|---|---|---|---|---|
| | Area | | Height | Area | Height |
| | 3d5/2 | 3d | 3d5/2 | 4d | 4d |
| Sb | 4.8 | | 4.8 | 1 | 0.86 |
| Te | 5.4 | | 5.4 | 1.23 | 0.97 |
| I | 6 | | 6 | 1.44 | 1.08 |
| Xe | 6.6 | | 6.6 | 1.72 | 1.16 |
| Cs | 7.2 | | 7 | 2 | 1.25 |
| Ba | 7.9 | | 7.5 | 2.35 | 1.35 |
| La | | (10) * | | -2 | |
| Ce | | -10 | | -2 | |
| Pr | | -9 | | -2 | |
| Nd | | -7 | | -2 | |
| Pm | | -6 | | -2 | |
| Sm | | -5 | | -2 | |
| Eu | | -5 | | -2 | |
| Gd | (3)* | | | -2 | |
| Tb | (3)* | | | -2 | |

| | Strong line | Secondary line ++ |
|---|---|---|
| | Area 4d | Area 4p3/2 |
| Dy | (2) * | (0.6) * |
| Ho | -2 | -0.6 |
| Er | -2 | -0.6 |
| Tm | -2 | -0.6 |
| Yb | -2 | -0.6 |
| Lu | -2 | -0.6 |

| | Strong Line | | | Secondary Line ++ | | |
|---|---|---|---|---|---|---|
| | Area | | Height | Area | | Height |
| | 4f7/2 | 4f | 4f7/2 | 4d5/2 | 4d | 4d5/2 |
| Hf | | 2.05 | 1.7 | 1.42 | 2.35 | 0.9 |
| Ta | | 2.4 | 1.89 | 1.5 | 2.5 | 0.9 |
| W | | 2.75 | 2 | 1.57 | 2.6 | 0.9 |
| Re | | 3.1 | 2.1 | 1.66 | 2.75 | 0.9 |
| Os | | 3.5 | 2.2 | 1.75 | 2.9 | 0.9 |
| Ir | 2.25 | 3.95 | 2.4 | 1.84 | | 0.9 |
| Pt | 2.55 | 4.4 | 2.55 | 1.92 | | 0.9 |
| Au | 2.8 | 4.95 | 2.8 | 2.05 | | 0.9 |
| Hg | 3.15 | 5.5 | 3.15 | 2.15 | | 0.95 |

| | Strong Line | | | Secondary Line | | | | |
| | Area | | Height | Area | Height | Area | | Height |
| | 4f7/2 | 4f | 4f7/2 | 4d5/2 | 4d5/2 | 5d5/2 | 5d | 5d5/2 |
|---|---|---|---|---|---|---|---|---|
| Tl | 3.5 | 6.15 | 3.5 | 2.25 | 0.95 | | 0.9 | 0.55 |
| Pb | 3.85 | 6.7 | 3.82 | 2.35 | 1 | | 1 | 0.6 |
| Bi | 4.25 | 7.4 | 4.25 | 2.5 | 1 | | 1.1 | 0.65 |
| Th | 7.8 | | 7.8 | 3.5 | 1.2 | 0.9 | 1.5 | 0.9 |
| U | 9 | | 9 | 3.85 | 1.3 | 1 | 1.6 | 1 |

**Notes:**

+ Height sensitivity factors based on line widths for strong lines of 3.1eV. typical of lines obtained in survey spectra on insulating samples. When spin doublets are unresolved, data are for the convoluted peak height.

++ Factors for the strong lines are insensitive to the radiation source (magnesium or aluminium). Factors for the secondary lines (2s,3p,4d and 5d) are dependent to an extent upon the photon energy. Values shown are average for aluminium and magnesium. For more accurate results, multiply the factors by 0.9 when magnesium radiation is used and by 1.1 when aluminium radiation is used.

$ Starred data are for peaks obtained only by using aluminium X-rays.

* Data in parentheses indicate great variability with chemical state, because of the prevalence of multielectron processes. Data shown for the series titanium-copper are for diamagnetic forms; data for paramagnetic forms will be lower in general. Data for the rare earths are based on few experimental points and should be regarded only as a rough approximation.

& Many of the area data are supplied for spin doublets for 3p and 4d because of the considerable width of many of those lines. Data for combined spin doublets in the 2p series for transition metals and the 3d for the rare earths are supplied because of the prevalence of shake-up lines, which make it desirable to deal with the doublet as a whole.