CEM 924 (Spring 2001) - Problem Set #3

(1) (a) (5 points) XPS is usually performed using soft x-ray radiation from either a Mg or Al anode. What are the characteristic photon energies of the $K\alpha_{1,2}$ lines from these materials?

(b) (5 points) The Mg $K\alpha_{1,2}$ line is really an unresolved doublet in which the $K\alpha_1$ line is more intense than the $K\alpha_2$ line. Which atomic transition is associated with each of these lines? From what you know about spin-orbit splitting, will the $K\alpha_1$ or $K\alpha_2$ line have the highest photon energy?

(c) (10 points) Write down the atomic and x-ray notation for the expected spin-orbit split levels corresponding to a subshell with quantum numbers $n = 4$, and $l = 3$.

(d) (10 points) Using Mg $K\alpha_{1,2}$ radiation, photoelectrons with kinetic energies of 1165.5 eV and 1161.9 eV are observed from a pure metal. Assuming the workfunction φ of this metal is 4.3 eV, what are the binding energies of these peaks? What kinetic and binding energies would be measured using Al $K\alpha_{1,2}$ radiation?

(e) (5 points) The two peaks in part (d) above form a doublet and have experimentally measured peak areas of 1023 and 766 counts$\cdot s^{-1}\cdot$eV. From what subshell (1s, 2s, 2p etc.) do these peaks originate?

(f) (5 points) Would you expect the binding energy of the doublet in part (e) to be higher or lower in an element with higher atomic number Z? Explain. Would you expect the spin-orbit splitting (the separation between the doublet peaks) to be larger or smaller in an element with higher Z? Explain.

(2) (a) (10 points) A thin film of Ag was deposited onto a clean Pt surface in a layer-by-layer fashion and the surface investigated by Al $K\alpha_{1,2}$ excited XPS. The intensity of the original Pt $4p_{1/2}$ (BE = 610 eV) peak was still observed but with only 25 % of the intensity of the original uncoated surface. If the electron energy analyzer was set to collect photoelectrons emitted at 30° from the surface normal, what was the thickness of the film? (You will have to estimate an inelastic mean free path, λ, for the photoelectrons)

(3) Briefly define (two or three sentences) the following terms:

(a) (2 points) X-ray satellite

(b) (2 points) Shake-up satellite

(c) (2 points) Electron energy analyzer pass energy

(d) (2 points) Sampling depth

(e) (2 points) Core level chemical shift

(4) (10 points) Using XPS analysis, I obtained the following 1s binding energies and component peak areas for an organic sample. No other peaks were observed. Using the abbreviated table of binding energies for organic samples given in the lecture notes (page

9.17), and the table of atomic sensitivity factors (page 9.35), suggest a reasonable structure for the material based on a calculated stoichiometry.

Peak Binding Energy (eV)	Area (counts·s^{-1}·eV)
285.0	102,945
289.0	24,998
293.5	25,770
532.2	79,195
532.8	80,044
690.0	366,330

You do not need the identity of the 690.0 eV peak but can you suggest an identity?

Total 70 points