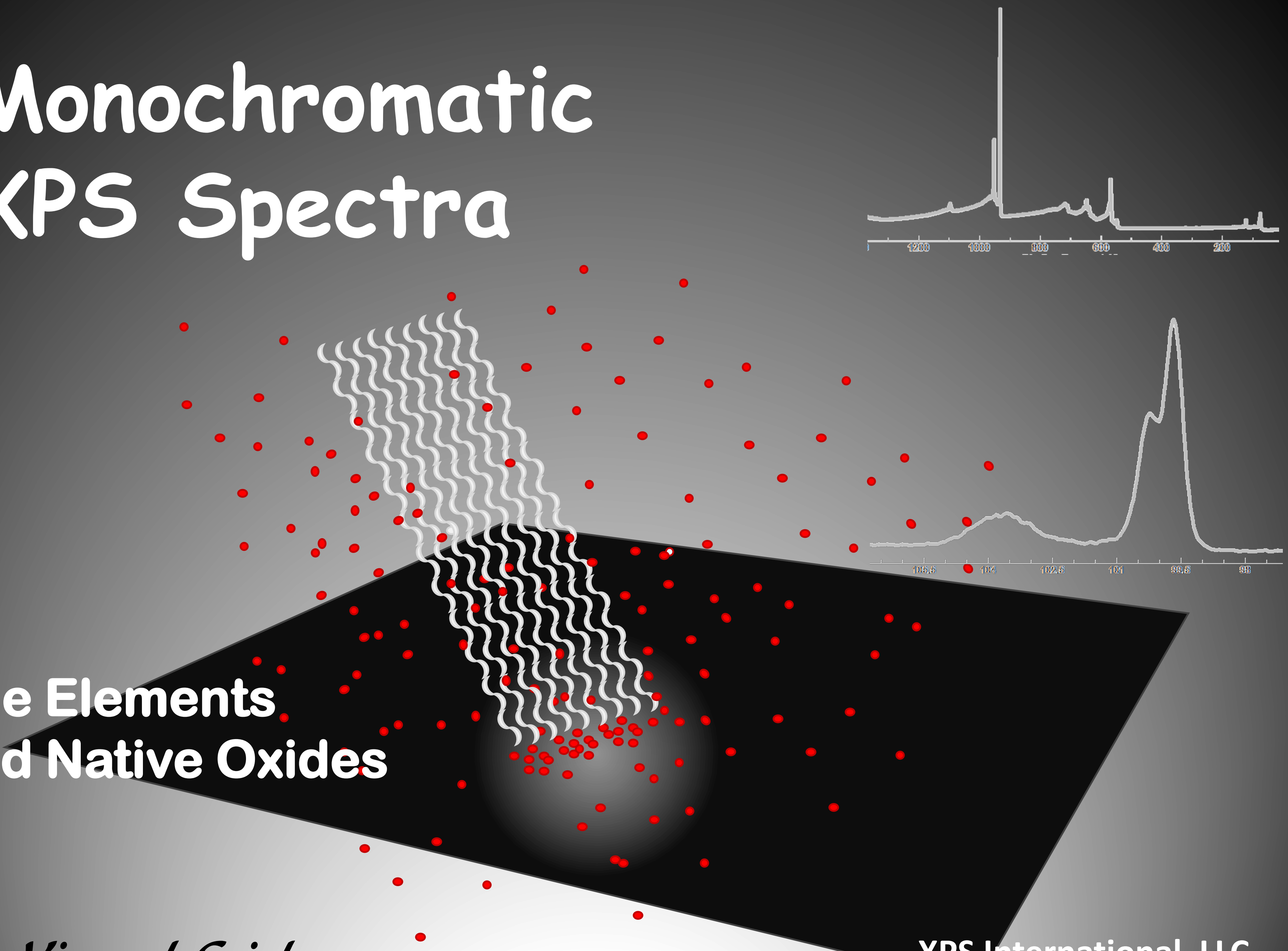
Monochromatic XPS Spectra



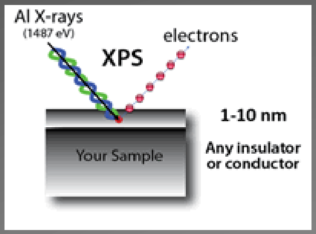
The Elements and Native Oxides

B. Vincent Crist

XPS International, LLC
https://xpslibrary.com

Monochromatic XPS Spectra

The Elements and Native Oxides



1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H 1s H_2° LiH																	2 He 1s He^+/Be He^+/C
3 Li 1s LiOH Li_2O 54.9 55.6 (1.65) (1.6) 285.0 285.0 531.8 530.8 (1.6) (1.5)	4 Be 1s Be° BeO* 111.8 113.6 (0.79) (1.73) 286.2 285.0 111.88 531.2 (0.69) (1.71)											5 B 1s B° B_2O_3 187.5 193.7 (0.92) (1.30) 285.2 285.0 187.8 533.7 (1.03) (1.6)	6 C 1s HOPG Black 284.5 284.4 (0.42) (1.04)	7 N 1s Kapton BN 400.9 398.9 (1.31) (1.10) 285.0 285.0 191.3 (1.03)	8 O 1s CuO SiO_2 529.6 532.4 (0.98) (1.2.7) 284.7 285.0 934.0 103.1 (1.42) (1.19)	9 F 1s Teflon CaF_2 689.2 685.1 (1.8) (1.53) 285.0 285.0 292.0 348.1 (1.6) (1.6)	10 Ne 1s Ne^+/Be Ne^+/C 863.1 (1.3)
11 Na 1s Na° Na_2O 1071.8 1072.6 (1.1) (1.78) 285.0 530.6 (1.44)	12 Mg 2p Mg° MgO* 49.7 49.5 (0.58) (1.25) 286.5 285.0 49.77 529.9 (0.60) (1.38)											13 Al 2p Al° Al_2O_3* 72.9 74.4 (0.62) (1.39) 284.9 285.0 72.82 530.8 (0.41) (1.60)	14 Si 2p3 Si° SiO_2* 99.8 103.1 (0.57) (1.19) 285.8 285.0 99.35 532.4 (0.45) (1.27)	15 P 2p3 P° InP 130.1 128.8 (0.67) (0.62) 285.0 285.5 444.7 (0.78)	16 S 2p S° MoS_2 164.0 162.7 (0.72) (0.39) 285.0 229.7 (0.80)	17 Cl 2p3 PVC NaCl 199.8 199.3 (1.7) (1.19) 285.0 285.0 1072.0 (1.40)	18 Ar 2p3 Ar^+/B Ar^+/HOPG 241.8 241.8 (1.4) (0.89) 285.2 284.5 188.1
19 K 2p3 K° K_2O 294.4 292.7 (0.9) (1.37) 285.0 531.0 (1.6)	20 Ca 2p3 Ca° $CaCO_3$ 346.5 346.4 (1.0) (1.67) 284.6 285.0 346.5 530.8 (1.07) (1.64)	21 Sc 2p3 Sc° Sc_2O_3* 398.5 401.9 (0.9) (1.27) 285.9 285.0 398.46 530.0 (0.69) (1.30)	22 Ti 2p3 Ti° TiO_2 453.8 458.8 (0.90) (1.02) 285.1 285.0 453.95 530.0 (0.62) (1.20)	23 V 2p3 V° V_2O_5 512.2 517.0 (0.79) (0.99) 285.0 284.8 512.22 530.0 (0.75) (1.33)	24 Cr 2p3 Cr° Cr_2O_3 574.2 575.6 (1.05) (1.10) 284.8 285.0 574.37 530.1 (0.89) (1.27)	25 Mn 2p3 Mn° MnO_2 638.7 641.4 (1.00) (1.12) 286.3 284.6 638.74 529.0 (0.89) (1.02)	26 Fe 2p3 Fe° a-Fe_2O_3 706.6 709.8 (0.90) (1.31) 285.0 285.0 706.78 529.9 (0.99) (1.04)	27 Co 2p3 Co° Co_3O_4* 778.1 779.5 (0.99) (1.51) 285.0 285.0 778.26 530.0 (0.85) (1.00)	28 Ni 2p3 Ni° NiO* 852.6 853.7 (1.14) (1.19) 284.7 284.8 852.65 529.3 (1.02) (1.06)	29 Cu 2p3 Cu° Cu_2O 932.7 932.7 (1.22) (1.16) 284.7 285.0 932.67 530.5 (0.92) (1.00)	30 Zn 2p3 Zn° ZnO* 1021.8 1021.7 (1.10) (1.43) 284.8 285.0 1021.76 530.5 (0.97) (1.15)	31 Ga 3d5 Ga° Ga_2O_3* 18.5 20.7 (0.70) (1.28) 285.6 285.0 18.5 531.4 (0.60) (1.51)	32 Ge 3d5 Ge° GeO_2* 29.3 32.9 (0.68) (1.28) 285.1 285.0 29.28 532.1 (0.64) (1.40)	33 As 3d5 As° As_2O_3 41.8 45.3 (0.65) (1.26) 284.8 285.0 41.69 532.0 (0.67) (1.71)	34 Se 3d5 Se° SeO_2 54.8 59.3 (0.76) (1.09) 284.2 284.6 54.90 532.6 (0.78)	35 Br 3d5 KBr 68.8 (0.92) 285.0 293.0 (1.31)	36 Kr 3d5 Kr^+/Be Kr^+/C 86.9 (0.88) 285.0
37 Rb 3d5 Rb° RbOAc 111.5 109.7 (0.8) (1.40) 285.0 530.6 (1.9)	38 Sr 3d5 Sr° $SrCO_3$ 134.3 133.4 (0.9) (1.56) 285.0 531.5 (1.9)	39 Y 3d5 Y° Y_2O_3* 155.9 158.0 (0.60) (1.18) 286.0 285.0 155.92 530.7 (0.62) (1.30)	40 Zr 3d5 Zr° ZrO_2* 178.9 182.5 (0.63) (1.20) 285.5 285.0 178.80 530.4 (0.63) (1.44)	41 Nb 3d5 Nb° Nb_2O_5 202.1 207.2 (0.78) (1.12) 285.0 285.0 202.35 530.3 (0.57) (1.34)	42 Mo 3d5 Mo° MoO_3 227.8 233.0 (0.66) (1.03) 285.1 284.9 227.94 530.9 (0.57) (1.23)	43 Tc 3d5 Tc° TcO_2 256.8	44 Ru 3d5 Ru° RuO_2 280.0 280.7 --- (0.77) 284.7 284.6 280.11 529.3 (0.59) (0.95)	45 Rh 3d5 Rh° Rh_2O_3 307.2 308.6 (0.73) (0.90) 284.6 284.7 307.21 530.2 (0.69) (1.09)	46 Pd 3d5 Pd° PdO* 335.1 336.9 (0.80) (0.98) 284.6 284.9 335.10 530.6 (0.77) (1.09)	47 Ag 3d5 Ag° Ag_2O* 368.2 367.6 (0.64) (1.00) 284.8 284.3 368.28 530.1 (0.62) (1.20)	48 Cd 3d5 Cd° CdO* 405.0 404.1 (0.80) (1.42) 285.0 285.0 405.04 528.6 (0.61) (1.28)	49 In 3d5 In° In_2O_3* 443.8 444.3 (1.08) (1.33) 285.0 285.0 443.87 529.8 (0.71) (1.19)	50 Sn 3d5 Sn° SnO_2 484.9 487.3 (0.81) (1.32) 284.9 285.5 485.01 531.1 (0.68) (1.14)	51 Sb 3d5 Sb° Sb_2O_5 528.1 532.4 (0.88) (1.6) 284.8 285.0 528.26 531.0 (0.80) (1.6)	52 Te 3d5 Te° TeO_2 572.7 576.6 (0.97) (1.48) 284.3 284.9 572.97 530.8 (0.83) (1.42)	53 I 3d5 KI 619.2 (1.30) 285.0 293.2 (1.11)	54 Xe 3d5 Xe^+/Be Xe^+/C 669.6 (1.13) 285.0
55 Cs 3d5 Cs° Cs_2O 726.4 724.7 (1.3) (2.00) 285.0 198.9	56 Ba 3d5 Ba° $BaCO_3$ 780.6 779.9 (1.4) (2.07) 285.0 531.4 (1.77)	57 La 3d5 La° La_2O_3 835.8 834.4 (1.3) (2.5) 285.0 529.0 (1.66)	72 Hf 4f7 Hf° HfO_2* 14.4 17.2 (0.63) (1.31) 285.7 285.0 14.32 529.9 (0.62) (1.71)	73 Ta 4f7 Ta° Ta_2O_5* 21.8 26.3 (0.72) (1.11) 285.1 285.0 21.78 530.4 (0.56) (1.47)	74 W 4f7 W° WO_3 31.4 35.8 (0.58) (1.02) 285.1 285.1 31.38 530.6 (0.53) (1.28)	75 Re 4f7 Re° Re_2O_7 40.3 46.9 (0.67) (1.47) 285.0 285.0 40.30 532.2 (0.54) (1.49)	76 Os 4f7 Os° OsO_2 50.7 53.8 (1.2)	77 Ir 4f7 Ir° IrO_2 60.8 61.7 (0.80) (0.84) 284.5 284.8 60.88 530.0 (0.82) (0.99)	78 Pt 4f7 Pt° PtO_2 71.1 75.1 (0.96) (1.09) 284.4 284.9 71.15 531.3 (0.88) (1.52)	79 Au 4f7 Au° Au_2O_3 84.0 85.1 (0.66) (1.37) 284.1 285.1 83.98 530.2 (0.68) (1.13)	80 Hg 4f Hg° HgO 99.8 100.9 --- (1.07) 285.0 285.0 99.81 530.0 (0.65) (1.00)	81 Tl 4f7 Tl° Tl_2O_3* 117.8 118.1 (0.97) (1.1) 285.2 284.8 117.77 528.6 (0.66) (1.07)	82 Pb 4f7 Pb° PbO* 136.9 137.5 (0.67) (1.17) 285.0 285.0 136.95 528.9 (0.63) (1.09)	83 Bi 4f7 Bi° Bi_2O_3* 157.0 158.9 (0.73) (1.37) 284.9 285.0 157.05 529.6 (0.62) (1.52)	84 Po 4f7 Radioactive	85 At 4f7 Radioactive	86 Rn 4f7 Radioactive
87 Fr 4f7 Radioactive	88 Ra 4f7 Radioactive	89 Ac 4f7 Radioactive															

58 Ce 3d5 Ce° CeO_2 883.8 882.1 (3.2) (2.0) 285.0 529.6 (2.00)	59 Pr 3d5 Pr° Pr_2O_3 929.4 928.8 (2.96) (3.2) 285.0 528.5 (1.2)	60 Nd 3d5 Nd° Nd_2O_3 980.8 983.2 (2.9) (2.7) 285.6 285.0 530.8 (1.3)	61 Pm 4d5 Pm° Pm_2O_3 Radioactive	62 Sm 4d5 Sm° Sm_2O_3 1081.1 1083.8 --- (4.3) --- 285.0 128.7 529.9 (2.5) (1.6)	63 Eu 4d5 Eu° Eu_2O_3 128.2 136.2 --- (3.6) 284.3 285.0 128.18 530.5 (1.08) (1.4)	64 Gd 4d5 Gd° Gd_2O_3 140.2 (1187.5) --- (5.4) 281.4 285.0 140.31 529.3 (1.05) (1.5)	65 Tb 4d5 Tb° Tb_2O_3 145.9 (149.5) --- (?) --- 285.0 145.95 529.7 (1.16) (1.5)	66 Dy 4d5 Dy° Dy_2O_3 152.4 (153.5) --- (1.9) --- 285.0 152.34 529.4 (0.90) (1.7)	67 Ho 4d5 Ho° Ho_2O_3 159.8 160.9 --- (2.0) --- 285.0 159.58 529.3 (0.98) (1.6)	68 Er 4d5 Er° Er_2O_3 167.7 168.5 --- (1.9) --- 285.0 167.25 529.7 (1.00) (1.5)	69 Tm 4d5 Tm° Tm_2O_3 175.3 176.3 --- (1.1) 285.3 285.0 175.37 529.6 (1.06) (1.6)	70 Yb 4d5 Yb° Yb_2O_3 182.4 185.0 --- (2.7) 285.6 285.0 182.39 529.2 (0.61) (1.5)	71 Lu 4f7 Lu° Lu_2O_3* 7.1 8.0 (0.46) (2.5) 284.6 285.0 7.10 529.5 (0.69) (1.4)
90 Th 4d5 Th° ThO_2 333.2 334.5 (1.7) (1.6)	91 Pa 4d5 Radioactive	92 U 4f7 U° UO_3 377.3 381.7 (1.4) Radioactive	93 Np Radioactive	94 Pu Radioactive	95 Am Radioactive	96 Cm Radioactive	97 Bk Radioactive	98 Cf Radioactive	99 Es Radioactive	100 Fm Radioactive	101 Md Radioactive	102 No Radioactive	103 Lr Radioactive

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Handbooks of Monochromatic XPS Spectra

Volume 1 - *The Elements and Native Oxides*

by

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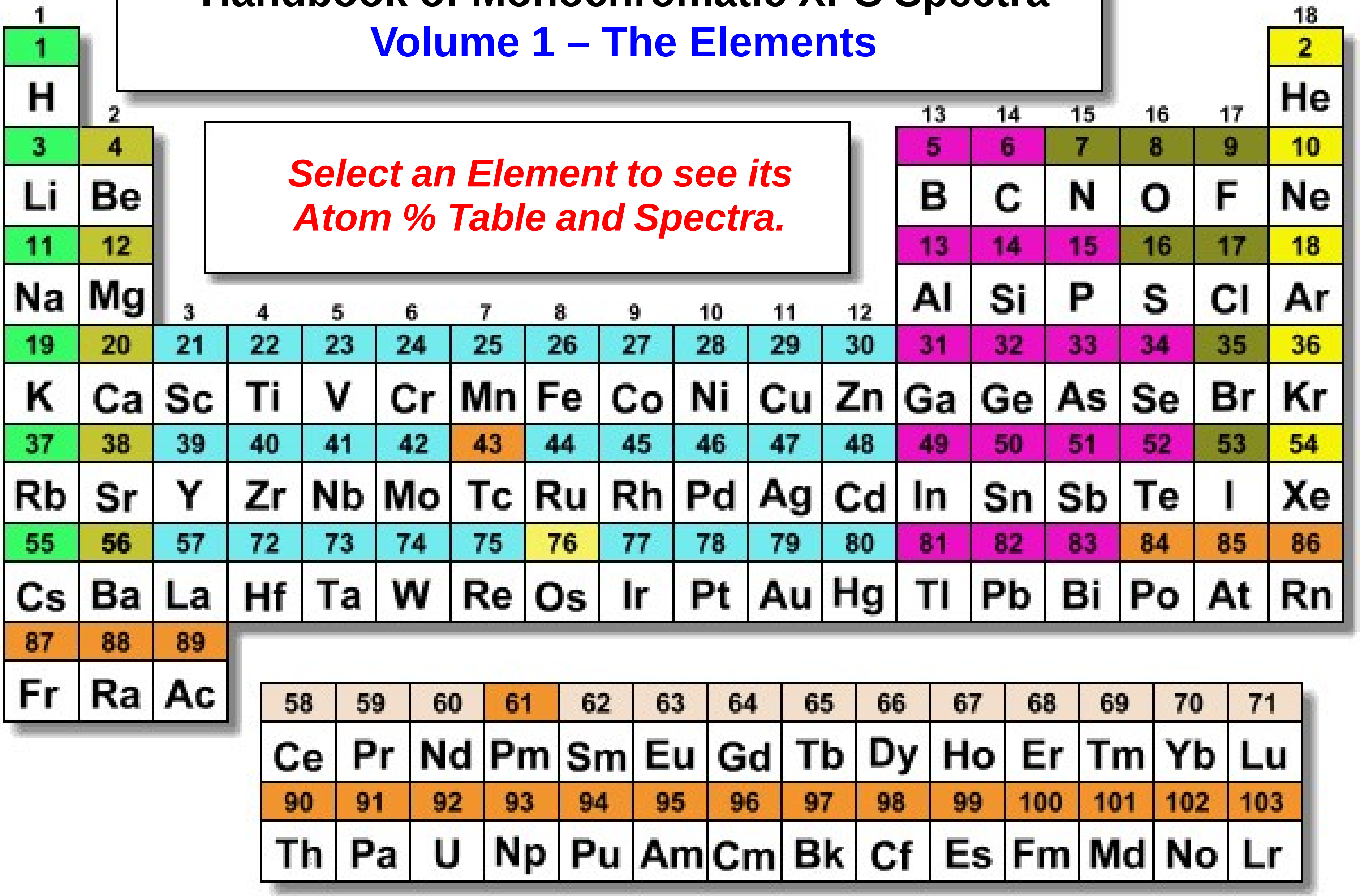
Handbook of Monochromatic XPS Spectra

Volume 1 – The Elements

C (1s) BE = 285.0 eV
Charge Referencing

Select an Element to see its Atom % Table and Spectra.



1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1																	2
H																	He
3	4											5	6	7	8	9	10
Li	Be											B	C	N	O	F	Ne
11	12											13	14	15	16	17	18
Na	Mg											Al	Si	P	S	Cl	Ar
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
87	88	89															
Fr	Ra	Ac															

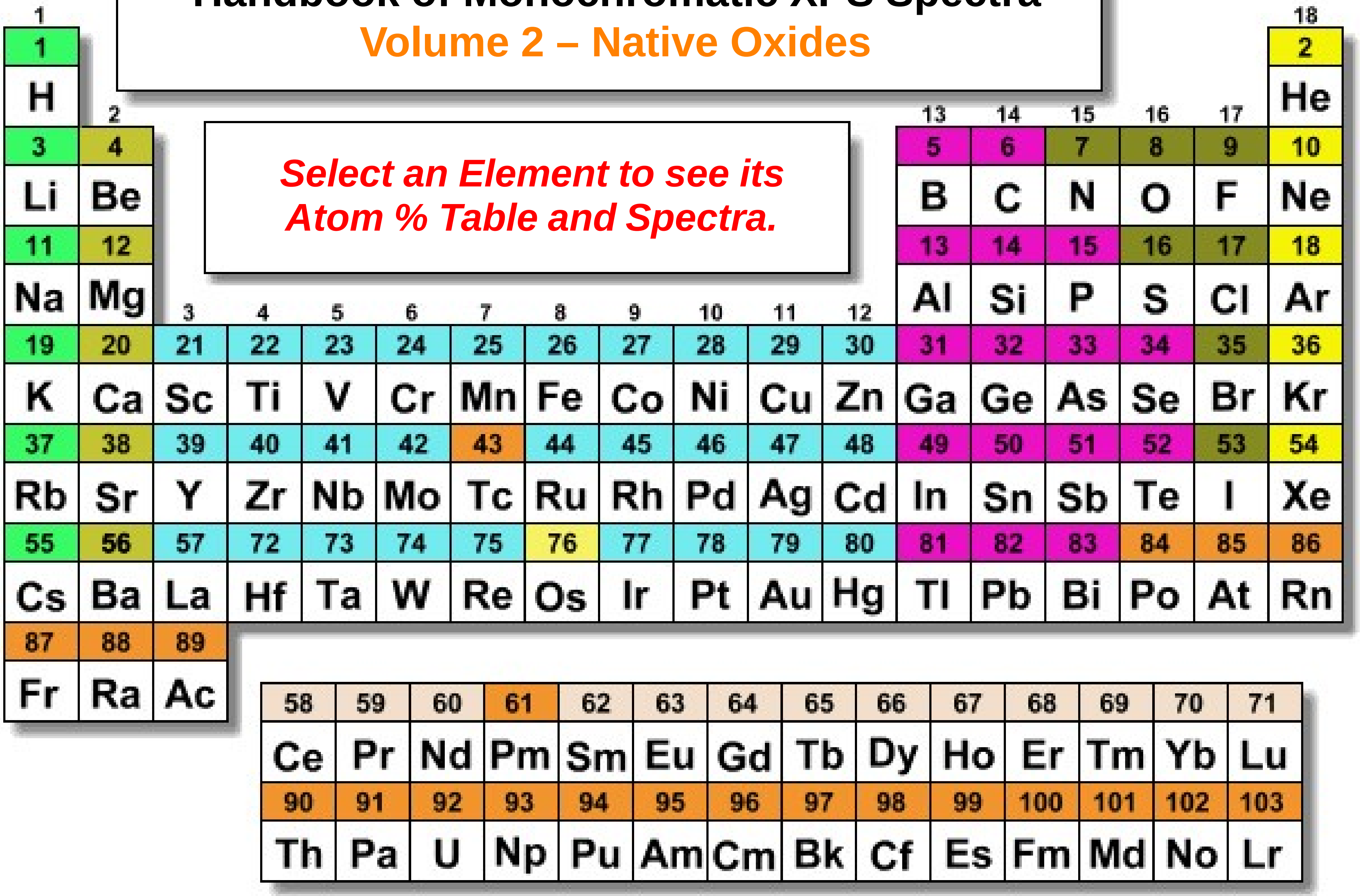
58	59	60	61	62	63	64	65	66	67	68	69	70	71
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
90	91	92	93	94	95	96	97	98	99	100	101	102	103
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

Handbook of Monochromatic XPS Spectra

Volume 2 – Native Oxides

Charge Neutralizer OFF

Select an Element to see its Atom % Table and Spectra.



1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac															

58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

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Monochromatic XPS Spectra of The Elements and Native Oxides

THE ELEMENTS

THE ELEMENTS (continued)

THE ELEMENTS (continued)

THE ELEMENTS (continued)

NATIVE OXIDES

NATIVE OXIDES (continued)

INTRODUCTION

This handbook contains wide scan spectra and narrows scan spectra from the elements and native oxides of the elements. The elements have been analyzed under conditions that have maximized the accuracy of the binding energies. The binding energies for the pure elements are referenced to the reference energies recommended by the National Physical Laboratory in the UK. Please refer to section "F" (Energy Scale Reference Energies and Calibration Details) for more details about calibration.

“The Elements” Section:

Includes wide scan survey spectra , high energy resolution spectra, and valence band spectra for the elements Ag, Al, Ar(+),
As, Au, B, Ba(+), Be, Bi, Br(-), C, Ca(2+), Cd, Ce(4+), Cl(-), Co, Cr, Cs (+), Cu, Dy, Er, Eu, F(-), Fe,
Ga, Gd, Ge, Hf, Hg, Ho, I(-), In, Ir, K(+), La(3+), Li(+), Lu, Mg, Mn, Mo, N(3-), Na(+), Nb, Nd, Ni, O(2-), P, Pb,
Pd, Pr, Pt, Rb(+), Re, Rh, Ru, S, Sb, Sc, Se, Si, Sm, Sn, Sr(2+), Ta, Tb, Te, Ti, Tl, Tm. V, W, Y, Yb, Zn, and Zr.
If the element is part of insulating chemical compound, then a C (1s) spectrum is also provided to allow the user to correct for sample charging. All narrow scan spectra are peak-fitted to reveal FWHM, peak asymmetry, and peak separation for spin-orbit pairs. The strong signals observed in the wide scan survey spectra are labeled and tabulated together with rough BE values of those strong signals. The details of the experimental protocol used to produce each these spectra are provided in the "Instrument and Analysis Details" section. All pure elements, except for Silicon and Selenium, were ion etched prior to analysis.

The “Native Oxides” Section:

Includes wide scan survey spectra, high energy resolution spectra for principal signals of each element, carbon (1s) high energy resolution spectra, and oxygen (1s) high energy resolution spectra found in/on naturally formed native oxides of the elements Ag, Al, As, B, Be, Bi, Cd, Co, Cu, Fe, Ga, Ge, Hf, In, Ir, Mg, Mn, Mo, Nb, Ni, Pb, Pd, Pt, Re, Rh, Ru, Sb, Sc, Se, Sn, Ta, Te, Ti, Tl, V, W, Y, Zn, and Zr. Atomic percentage based tables of surface composition, which reveal the natural oxidative tendencies of the elements and the tendencies of these elements to capture various gases from the air and/or various contaminants introduced to the surface from handling by the original chemical producers. To enhance traceability and to try to determine chemical shifts it was deemed essential to observe the pure metal signal for a set of spectra to be included in this Native Oxide section. The samples used for these measurements were, in general, naturally formed native oxides that were analyzed as received without any treatment of any kind. All of these samples had been stored in a set of drawers which were not air-tight and so the samples were exposed to the normal atmosphere of a laboratory for many months or years.

Note: Most of the native oxides are naturally formed native oxides, but a few of the native oxides are actually “freshly formed” native oxides that were produced by scraping the surface of the oxidized metal with a clean knife and exposing the freshly cleaned surface to the normal atmosphere of the laboratory for a time period between 5 minutes and several days. This scraping was done because the naturally formed native oxide or carbonate film was thick enough to hide the pure metal signal when the samples were analyzed by XPS. This method produces freshly formed native oxides which have probably not reached a thermodynamically stable state.

ORGANIZATION AND DETAILS OF SPECTRAL SETS

Organization of Spectra

A set of spectra for a particular chemical is located by looking for the chemical formula abbreviation written in the upper right hand corner of each page. For the element called “aluminium (Al)" the user will find its chemical abbreviation “Al" in the upper right corner of the pages that belong to that set of data and spectra. The spectra are organized by using the chemical abbreviation. This means that spectra for "antimony (Sb)" can be found by looking for the chemical formula: “Sb".

Contents of Each Set of Spectra

The spectra are presented exactly as printed by the Spectral Data Processor software which is provided in each XI SpecMaster Data-Base system. The first page of a set includes the “Detailed Surface Composition Table” which reports the peak assignments, binding energies, relative sensitivity factors, and Atom % abundance of each major signal contained in the wide scan survey spectrum for that chemical. In the title line of this first page the user will find the full chemical name along with other basic information about the chemical, such as Formula Weight, Chemical Abstract Services number, common name, and the Latin language name of the element if available.

The second page of each set is the wide scan survey spectrum with peak labels for each of the strong signals.

Detailed information about the operating capabilities of the SSI systems and the instrument and analysis conditions used to collect these data are presented in the "Instrument and Analysis Details" section of this book.

The remaining pages of each set are the high energy resolution narrow scan spectra which were obtained by measuring the strongest signals found in the wide scan survey spectrum. These spectra include detailed peak-fit results in a table and display the actual peak-fit results for each spectrum. The binding energies of insulating materials are reported in both raw and corrected form. Based on our research we have used a 285.0 eV value for the C (1s) signal of hydrocarbons for charge referencing spectra. The FWHM values for each peak of a high energy resolution spectrum is adjacent to the binding energy for that peak. The percentage numbers given for each peak is a relative percentage that is based on the intensity of that signal only (It is not an atom % value).

Philosophy of Data Collection Methods

Our philosophy is to collect spectra under analysis conditions that are practical, readily reproduced, and typically used in laboratories that use monochromatic X-ray sources and work under real world practical analysis conditions. We have assumed that the most XPS laboratories need practical reference spectra and will not spend the time or money to produce and to analyze pure, clean surfaces under ultimate energy resolution conditions.

However, we did spend extra time to collect data with above average signal to noise (S/N) ratios which reveal the presence of minor components that might otherwise be missed. In the production of these spectra we did not attempt to clean the surfaces of the native oxides or the insultors which would make charge referencing a difficult task. For practical reasons we used the C (1s) spectra from the naturally formed layer of adventitious hydrocarbons because that signal is the “de facto” standard for charge referencing insulating materials.

The spectral data contained within these handbooks are designed to assist engineers, scientists, analysts, theoreticians, and teachers who use XPS on an everyday basis under practical working conditions. We believe that these spectra will help XPS users to analyze industrial problems, gather reference data, perform basic research, test theories, and teach others. These spectra are designed to be practical tools for everyday use and were obtained under practical working conditions. No attempt was made to produce research grade spectra, but many of the spectra are actually research grade spectra because of the self-consistent methods used.

In the production of some spectra no attempt to produce a pure, clean surface, but some effort was made to produce surfaces with a minimum amount of natural surface contamination if needed. When ion etching was used to clean a material that contained more than one element, then ion etching was done with conditions that should minimize preferential sputtering. For the spectra of pure elements, the surface was strongly ion etched.

Peak-Fitting (Curve-Fitting) of High Energy Resolution Spectra

Peak-fitting was performed by using the software provided with the Surface Science Instruments XPS system. That software allows the user to control the full width at half maxima (FWHM) value of any peak, the binding energy (BE) of any peak, peak areas, the ratio of two peak areas, the energy difference between two peak maxima, the shape of a peak as a sum-function of Gaussian and Lorentzian peak shapes in any peak, and the percentage of asymmetry in any peak.

By empirically peak-fitting the spectra from large sets of closely related materials in a trial and error method and analyzing the trends, it was possible to recognize several fundamental peak-shape and peak-fitting parameters for pure elements, binary oxides, polymers, and semiconductors. We used those empirical results to guide our efforts to peak-fit many of the spectra which had complicated peak shapes. In some cases we used the theoretical ratio of spin-orbit coupled signals to assist the peak-fitting of some spectra and also the energy interval between spin-orbit coupled signals that were derived from pure element spectra. No attempt was made to fit the spectra
in accordance with theoretical expectations or calculations.

A reduced “chi-squared” value, which indicates the goodness of a peak-fit, was used to determine if a peak-fit was reasonable or not. Based on practical experience a “chi-squared” value between 1 and 2 implies a relatively good peak-fit. A “chi-squared” value between 2 and 4 implies that the fit has not yet been optimized. A “chi- squared” value larger than 4 implies that one or more signals may be missing from the peak-fit effort.

A Shirley-type baseline was used for all peak-fits. Peak shapes for the main XPS signals obtained from chemical compounds (e.g. oxides, halides, etc.) were typically optimized by using a Gaussian:Lorentzian ratio between 80:20 and 90:10. For pure metals, the Gaussian:Lorentzian ratio for the main XPS signals was normally between

50:50 and 70:30. The main XPS signals for semi-conductor materials usually required a Gaussian:Lorentzian peakshpae between 70:30 and 80:20.

From the peak-fitting of the binary oxides, we have observed that FWHM for the C (1s), O (1s) and the main metal signal from the binary oxide are usually in range 1.0-1.4 eV. This trend helped us to decide if we had good charge compensation.

Charge Compensation of Insulating Materials

Charge compensation of insulating materials was normally handled by using the patented SSI mesh-screen together with a low voltage flood gun of electrons which used an acceleration voltage that was adjusted to 3-4 eV for optimum results. The mesh-screen device uses a 90% transmission electro-formed mesh made of nickel metal that is supported above the surface of the sample by mounting the mesh on a conductive metal frame that is grounded to the sample mount. To achieve good charge compensation the mesh-screen is positioned so that the distance between the mesh and the surface of the sample is between 0.5 - 1.0 mm. When the distance between the mesh-screen and the surface of the sample is greater than 1.2 mm, the usefulness of the mesh screen flood gun system was normally null.

The mesh-screen is understood to function as an electron cut-off lense with some tendency to allow incoming flood gun electrons to focus onto the area being irradiated with monochromatic X-ray beam. This occurs because the X-ray beam does not have a uniform flux density over the area of the beam. In effect, the mesh-screen produces a nearly uniform electric potential at the surface of the sample and allows incoming flood-gun electrons to pass through whenever they are needed (on demand).

The mesh-screen was used on every insulating material except for a few materials that were analyzed before the flood gun mesh-screen method was developed.

Abbreviations Used

Due to the limited space provided to describe each sample in each electronic data-file, it was necessary to use various abbreviations. The abbreviations are:

scr = screen used for charge compensation
scrn = screen used for charge compensation
TOA = take-off-angle for the electrons
Aldr = Aldrich Chemical Co.
RMC = Rare Metallics Co.
SPP = Scientific Polymer Products Co. MS
Co. = Metal Samples Company
FG = flood gun,
mesh = mesh-screen used for charge control,
1mm=1 mm height used for the mesh-screen,
semi-con = semi-conductive behavior
conduc, = conductive behavior
Tech = technical grade purity,
pellet = sample pressed into pellet form by pellet press used to make Infrared KBr pellets,
plt = pellet
pel = pellet

INSTRUMENT AND ANALYSIS DETAILS USED TO MAKE XPS SPECTRA

A. Instrument Details (ref 1)

Manufacturer: Surface Science Instruments (SSI)
Model: X-Probe
S-Probe (upgraded from M-Probe model 2703)
Software Version; 1.36.05 (Compiled in MS-DOS "C" version 6.0)
Analyzer Type: Fixed Analyzer Transmission (FAT)
Fixed Pass Energy = Constant Analyser Energy (CAE)
180° Hemi-spherical (truncated)
Input Lens Field of View: 30° for sample normal to lens axis (1" diameter port)
(always larger than X-ray beam; retarding potential scanned)
X-ray Type: Al° monochromatic (one 2 " diameter thin natural SiO2 crystal wafer glued onto Zerodur substrate heated to 65° C)
X-ray kV and mA Emission: 10 KV, 1.5-22.0 mA (depending on spot size used)
X-ray Energy Defined as: 1486.7 eV (8.3393 Å), Bragg Angle=78.5°
Excitation Source Window: 0.6 µ aluminum in S-Probe (10µ mylar in X-Probe)
Angle of X-ray Incidence: α = 71° (relative to sample normal)
Electron Emission Angle: β = 0° (relative to sample normal)
Angle Between X-ray Axis and Electron Analyzer Axis: ϕ =71° (fixed, non-variable)

Pass Energy of Analyzer:	150 V for Resolution 4 setting 100 V for Resolution 3 setting 50 V for Resolution 2 setting 25 V for Resolution 1 setting
Type & Size of Input Slit:	Fixed (2 mm X 35 mm); magnetic compression
Type & Size of Output Slit:	None (dispersion limited by hemisphere voltages)
Electron Collection Lens	
Field of View:	~ 1 mm^2 for a take off angle = 0° at 1000 eV KE
Electron Collection Lens Efficiency:	7% over 2π steradians
Sample Surface to Tip of Electron Collection Lens Distance:	~33 mm
Crystal to Sample Surface Distance:	~190 mm
Crystal to X-ray Anode Distance:	~190 mm
True Background Count of Noise:	<10 electrons/second at -50 eV (shot noise limited)
Detector Type:	SSI Position Sensitive Detector (PSD), resistive anode, 40 mm X 40 mm, electronically defined as 128 active channels with a maximum electron count rate of 1,000,000
Dead Time:	zero (unless ion etching pure element while collecting data)
Base Pressure:	4.0×10^{-10} torr
Normal Operating Pressure:	1.6×10^{-9} torr
FWHM Diffracted by Natural SiO2:	~0.25 eV

Power Settings: 200 Watts in a 250 x1100 µ X-ray beam
100 Watts in a 150 x 800 µ X-ray beam
45 Watts in a 80 x 350 µ X-ray beam
15 Watts in a 40 x 250 µ X-ray Beam
X-ray Induced Current: 1.1 x 10^{-9} amps for a 600 µ spot in X-Probe
Approximate True X-ray Power : ~6 x 10^{-6} W in a 600 µ spot
Approximate True X-ray Irradiance: ~8 W/m^2
Approximate True X-ray Photon Flux: ~7 x 10^9 photons/sec

B. Experimental Details

Electron Take-Off-Angle: 90° relative to sample surface (unless otherwise reported)
Pass Energies Used: Wide scans were done at PE = 150 eV
Narrow scans were normally done at PE = 50 eV
Valence band scans were done at PE=150 eV
X-ray Beam Size Used: (for S-Probe)
Wide scans: 250 x 1500 µ ellipse (at 90° TOA)
250 x 1100 µ ellipse (at 35° TOA)
Narrow Scans: 250 x 1500 µ ellipse (at 90° TOA)
150 x 1000 µ ellipse (at 90° TOA)
SSI Mesh-Screen: A 85% transmission (20 µ diameter wire with 200 µ spacing) nickel metal mesh screen was adhered to a small 25 mm x 25 mm x 1.5 mm (W x L x H) aluminum plate over a 20 mm x 20 mm aperture.

The mesh-screen was placed over all oxide samples so that the distance between the sample surface and the mesh-screen was <1.0 mm but >0.3 mm.

Dwell Time (counting time):	200 milliseconds/channel (usual setting)
Data Transfer Time:	4 milliseconds
Max. Number of Channels:	5000 (channels = data points)
Scan Time for One Wide Scan:	~ 3.5 minutes (using 1024 data points)
Scan Time for One Narrow Scan:	~100 seconds (using 256 data points)
Energy Range:	-100 to +1400 eV (BE range)
Typical Step Size:	0.1 eV/step (i.e. 0.1 eV/data point)

C. Data Processing Details

Baseline Subtraction:	None, unless S/BG gave a small display. When the baseline was removed, the intensity of the lowest point was subtracted from all points.
Data Smoothing:	None
Energy Shifting:	None

D. Sample Details (for Volumes 1-5)

The "Description" given on each XPS spectrum reports the empirical elemental formula for the oxide, purity, source, production lot number, a note, if appropriate, about being conductive or semi- conductive, the abbreviation "scrn" which means that the SSI mesh-screen was used, and a number, and “90”: which means that a 90^{o} electron take-off-angle used to collect the data for that sample.

Abbreviations used in the description and their full meaning include: Aldr = Aldrich Chemical Co., RMC = Rare Metallics Co., semi-con = semi-conductive behavior, scrn = SSI mesh-screen used, TOA = electron Take-Off-Angle, Tech = technical grade purity, pellet = sample pressed into pellet form, plt = pellet, pel = pellet, MS Co. = Metal Samples Company in Munford, Alabama USA (Tel 205-358- 4202), SPP = Scientific Polymer Products Inc. in Ontario, New York state, USA (Tel 716-265-0413)

Sources of Elements and Chemical Compounds (for Volume 1)

The pure element samples were obtained from various sources without any specific information about sample purity so pure element samples must be assumed to be pure at the 99%+ level. The "halide" salts used to produce spectra from gaseous or highly reactive elements were also obtained from various sources. These halide samples were obtained as crystalline "windows" which are normally used in Infrared spectroscopy and have purities at the 99% level. The Boron Nitride (BN) sample was a white ceramic electrical standoff which was fractured in air. The copper foil material, which was always used to determine reference energies, were obtained as 99% pure foil which was designed as a multiple purpose foil for use around the home. The gold ingot material, which was also used to determine reference energies was obtained as a 99.999% pure sample from Aldrich Chem. Co..

Source of Polymer Materials (for Volume 4)

A special kit (#205) of the 100 polymer materials was obtained from Scientific Polymer Products, Inc. which is located at 6265 Dean Parkway, Ontario, New York, USA 13519 (Tel 716-265-0413).

Source of Alloys (for Volume 6)

A special kit of 54 metallic alloys was obtained from the Metal Samples Co., which is located at Route #1, Box 152, Munford, Alabama, USA, 36268 (Tel 205-358-4202). This kit includes a materials analysis report on each alloy in weight percents. The National Research Institute for Metals (NRIM) in Tsukuba, Japan has provided a series of various binary alloys made of AuCu and CoNi alloys.

Sources of Semi-Conductor Materials (for Volume 3)

Over the course of many years, many people in the Japanese semi-conductor business have given samples of various semi-conductor materials in crystalline wafer form. Various samples were donated by the Oki Electric Company, Mitsubishi Materials, Canon, and various universities. The source of each material is included with the individual sample descriptions whenever that information was provided.

Sources of Commercially Pure Binary Oxide Samples (for Volume 2)

Most of the commercially pure binary oxides were purchased from the Aldrich Chem. Co.. The packages from the Aldrich Chemical Co. included an "Analytical Information" sheet which described an ICP or AA analysis summary, a production lot number, the Aldrich product number, sample purity number (e.g. 99+%), sample appearance (color and physical form), date of chemical analysis, formula weight and a label on the bottle that reports the melting point, toxicity, Chemical Abstracts registry number and density. The samples from Aldrich were generally quite pure at the surface. Other oxide samples were obtained from either Cerac Inc. (USA) or Rare Metallics Co., Ltd. (Japan). The packages from Cerac Inc. included a "Certificate of Analysis" with an ICP or AA analysis summary, a production lot number, a product number, purity (e.g. 99+%),and mesh size. The packages from Rare Metallics Co. did not include analytical data reports, but instead had stock numbers and a purity statement. Two samples (i.e. SiO2 natural crystal and Al2O3 fused plate) were obtained from in-house sources and do not have any purity reports.

Powdered Samples Pressed into 3mm Diameter Pellet

Until analyzed, all finely powdered samples were kept stored in their original glass or plastic containers, which were packaged inside of plastic-lined aluminum bags. Just prior to XPS analysis, each bottle was opened in the normal air of the room where the XPS system was kept, and a small 50- 100 mg portion of the sample was removed via a clean nichrome spatula and placed in the compression chamber of a hand-operated, stainless steel pellet press. All finely powdered samples were compressed without any chemical treatments, which, if done, may have introduced unusual contamination or produced some change in the samples. The resulting pellets varied in thickness from 0.3 - 0.8 mm.

To avoid iron and /or chromium contamination from the anvil, a thin sheet of paper was placed over the sample in the compression chamber. Any powders, which were clumped together, were very gently pressed into a powder just prior to compression. To avoid unnecessary heat-induced oxidation, those samples which were hard and granular were very gently ground into a fine powder in a agate marble mortar and pestle. As soon as each sample was removed from the compression chamber, it was mounted onto silver (Ag°) paint inside of a 5mm wide round brass boat which was 1.3 mm in height.

Silver paint was used so that conductive oxides could behave as true conductors thereby providing true electron binding energies for those oxides that were indeed conductive. In general, each oxide was exposed to room air for <15 min..

Benefits of Pressing Powders into Pellets
(increased counts and simple charge control)

A comparison of the electron counts obtained from powdered samples pressed onto double-sided adhesive tape and positioned at a 35° electron take-off-angle with the electron counts obtained from hand-pressed glossy or semi-glossy pellets positioned at a 90° electron take-off-angle (TOA) revealed that a pellet at a 90° electron TOA produces 3-5 times higher electron counts than a powdered sample pressed onto double-sided tape at a 35° electron TOA.

By pressing the finely powdered oxides into pellets, it was also found the surface charging behavior of these glossy or semi-glossy samples was very easy to control by using the mesh-screen electron flood-gun combination with the flood gun set to 4-6 eV acceleration energy and approximately 0.5 mA filament current.

Problems Caused by Pressing Samples into Pellets

By pressing the finely powdered oxides into pellets, the surface of the resulting samples were usually smooth enough to appear glossy or semi-glossy, but some samples had iron or chromium contamination which indicated that the oxide had undergone a pressure induced reaction with the stainless steel anvil. Very strong hand pressure caused some oxides to react with the stainless steel anvil, but medium hand pressure usually did not produce undesired iron and chromium contamination. All analyses that showed any unexpected contamination were repeated. Other forms of accidental contamination (chlorine or previously analyzed oxides) were caused by insufficient cleaning of the stainless steel anvil, which was normally cleaned with a metal polishing solution (Pikal) and rinsed with distilled water and isopropanol. All analyses that showed any unexpected contamination were repeated.

Solution to Pressure Induced Contamination of Pellets

Experiments on ways to avoid the pressure-induced iron or chromium contamination, produced pellets with semi-smooth non-glossy surfaces which required more effort to produce good charge control.
These non-glossy surfaces also gave electron count rates that were about 10-50% lower than the glossy or semi-glossy surfaces. As a result, it appears that very smooth surfaces, which appear glossy or semi-glossy, greatly simplify efforts to control surface charging under the charge-control mesh-screen and also enhance the electron count rate by 10-50% more than a pellet that has a semi-rough non- glossy appearance.

Extensive experiments on different methods to avoid contamination of the pellets revealed that contamination is minimized or avoided by using freshly cleaned aluminum foil as a "buffer" between the oxide powders and the metals in the steel anvil components. The aluminum foil, which is sold as a kitchen wrap material, is cleaned with 100% isopropanol (isopropyl alcohol) just prior to use. The foil is cut to a size that is readily useful with the pellet press device after it is cleaned. Alternately, we have also used a type of "glycine" paper which is commonly used to as a paper to hold powders when weighing a powdered sample. This "weighing" paper is common in many chemical laboratories and can be substituted for the aluminum foil whenever the pressing results with the aluminum foil produce undesired binding results. The glycine paper method sometimes introduces very small amounts of contaminants which produce a N (1s) and C (1s) signals. The amount of these contaminants is much smaller than the amount of contaminants that occur by simply pressing the powder without any sort of paper or aluminum foil buffers.

Source of Pellet Press Equipment

"Qwik Handi-Press" from Barnes Analytical Division, Spectra-Tech, Inc.652 Glenbrook Road, Stamford, Connecticut, 06906 (FAX 203-357-0609) Kit: Part # 0016-111 to 0016-121 contains 1,3, and 7 mm die sets. Originally purchased through Aldrich Chem. Co. in 1989.

E. Energy Resolution Details

Table 1: Experimentally Observed Relation Between Energy Resolution

Element (XPS signal)	Resulting FWHM	Resolution Setting	Pass Energy	X-ray Spot Size
Si ($2p_{3/2}$) crystal - fractured edge	0.38 eV	5	10 eV	40 x 250µ
Si ($2p_{3/2}$) crystal - fractured edge	0.43 eV	1	25 eV	80 x 350µ
Au ($4f_{7/2}$) foil - ion etched clean	0.64 eV	5	10 eV	250 x 1000µ
Au ($4f_{7/2}$) foil - ion etched clean	0.79 eV	1	25 eV	250 x 1000µ
Au ($4f_{7/2}$) foil - ion etched clean	0.86 eV	2	50 eV	250 x 1000µ
Au ($4f_{7/2}$) foil - ion etched clean	1.40 eV	4	150 eV	250 x 1000µ
Ag ($3d_{5/2}$) foil - ion etched clean	0.42 eV	5	10 eV	40 x 250µ
Ag ($3d_{5/2}$) foil - ion etched clean	0.64 eV	1	25 eV	40 x 250µ
Ag ($3d_{5/2}$) foil - ion etched clean	0.75 eV	2	50 eV	40 x 250µ
Ag ($3d_{5/2}$) foil - ion etched clean	1.00 eV	3	100 eV	40 x 250µ
Ag ($3d_{5/2}$) foil - ion etched clean	1.30 eV	4	150 eV	40 x 250µ
Cu ($2p_{3/2}$) foil - ion etched clean	0.85 eV	5	10 eV	250 x 1000µ
Cu ($2p_{3/2}$) foil - ion etched clean	0.94 eV	1	25 eV	250 x 1000µ
Cu ($2p_{3/2}$) foil - ion etched clean	1.06 eV	2	50 eV	250 x 1000µ

Cu (2p$_{3/2}$) foil - ion etched clean	1.60 eV	4	150 eV	250 x 1000μ
Cu (2p$_{3/2}$) foil - ion etched clean	0.85 eV	5	10 eV	150 x 800μ
Cu (2p$_{3/2}$) foil - ion etched clean	0.96 eV	1	25 eV	150 x 800μ
Cu (2p$_{3/2}$) foil - ion etched clean	1.05 eV	2	50 eV	150 x 800μ
Cu (3s) foil - ion etched clean	2.35 eV	2	50 eV	250 x 1000μ

Table 2: Theoretical Analyzer Resolution versus Pass Energy Settings

Theoretical Analyser Resolution	Pass Energy	Effective Detector Width
0.25 eV	25.0 eV	3.5 eV
0.50	50	7.0
1.00	100	14.0
1.50	150	21.0

F. Energy Scale Reference Energies and Calibration Details (ref. 8)

From May 1986 to January 1993

Energy Scale Reference Energies: 932.47 eV for Cu ($2p_{3/2}$) signal
122.39 eV for Cu (3s) signal
83.96 eV for Au ($4f_{7/2}$) signal
Binding Energy Uncertainty: less than ±0.08 eV
Digital-to-Analog (DAC) Conversion Setting: 163.88

After January 1993 (Based on NPL reference energies published in 1990)

Energy Scale Reference Energies: 932.67 <±0.05 eV for Cu ($2p_{3/2}$) signal
122.45 <±0.05 eV for Cu (3s) signal
83.98 <±0.05 eV for Au ($4f_{7/2}$) signal
Observed Reference Energy: 75.01 <±0.05 eV for Cu (3p3) signal
Binding Energy Uncertainty: less than ±0.08 eV
Digital-to-Analog (DAC) Conversion Setting: 163.87

Note: NPL has recently revised reference energies to be 932.62 eV for Cu (2p3) and 83.96 eV for Au (4f7) for monochromatic systems using an electron take-off-angles of 45°

Reference Energies of Adventitious Hydrocarbon Contaminants

From May 1986 to January 1993 the electron binding energy of adventitious hydrocarbons was assumed to occur at 284.6 eV based on SSI and C. D. Wagner's research and recommendations.

Publications by P. Swift (Surface and Interface Analysis **4**, 47 (1982), S. Kohiki and K. Oki (J. Electron Spectrosc. Related Phenom. 33, 375-380 (1984), and G. Barth, R. Linder and C. E. Bryson, III (Surface and Interface Analysis **11**, 307-311 (1988) have shown that the electron binding energy for various hydrocarbon contaminants and polymers is not necessarily a constant number. Research by this author indicates that the electron binding energy for adventitious hydrocarbons lies somewhere between 284.4 and 287.0 eV depending on the underlying (oxide) materials. By taking a simple average of all available binding energies, the author has found that 285.0 eV is preferred for hydrocarbons on ion etched metals where the hydrocarbon is many hours old. For naturally-formed native oxides the preferred binding energy is 285.2 eV. Oxide based materials at the far left of the periodic element table (columns 1-4) tend to have higher values (285.2-287.0 eV, while most of the transition metal oxides center around 285.0 eV. Near the far right of the periodic table, the binding energy seems to rise to a 285.2-286.5 eV range (columns 12-14) when the native oxides of those elements are analyzed.

In routine practice, this author prefers to use the 285.0 eV number. Some potential factors that may cause this rather large range of electron binding energies for adventitious hydrocarbon contamination includes the dipole moment at the surface of the oxide material, which is expected to be much stronger than the dipole moment of a pure metal, and also, in the case of naturally formed native oxide films, the thickness of the native oxide, any physical or chemical treatments, the thickness of the adventitious hydrocarbon layer, and the type of instrument used to analyze the sample. The type of instrument being used may cause different shifts in the observed binding energy of the adventitious hydrocarbon contamination because the source may or may not generate different amounts of low energy secondary electrons from the window that protects the X-ray source. The heat from the source and contamination that degases from a just turned on source may also influence the observed binding energy. Electron flood guns and implanted ions may or may not influence the binding energy of semiconductive materials.

Instrument Stability and Long Term Calibration

Initially each of the two SSI systems, that we have used, was calibrated 2-3 times per week because its ability to maintain accurate voltage settings was unknown. Once it was determined that the systems could maintain reliable voltage settings for 1-3 months, it was decided that good calibration could be maintained by checking and, if necessary, correcting the pass energies of the system on a 2-4 week basis. Each of the two SSI XPS instruments, that we have used, have been calibrated on a routine basis every 2-4 weeks by using SSI's reference energies. By using this method over several years time, it was found that the maximum uncertainty (error in pass energies) was normally <±0.10 eV, but a few times rose to ±0.15 eV or less. In a very rare case, the uncertainty rose to 0.20 eV. Long term use of the SSI systems has shown that the DAC circuit does not change enough to be observed unless the room temperature changes by more than 10 degrees Centigrade. If the room temperature changes within a few hours time by more than 10 degrees or the temperature of the DAC chip is changed by more than 10 degrees, then a >0.1 eV shift, which is much smaller than the reliability of almost all literature BEs, can be observed. Variables, which seem to cause pass energy settings to change slightly, include building line-voltages, ion etching conditions, and the addition or removal of some electrical device.

G. Electron Counting and Instrument Response Function Details

Instrument Response Functions (for the X-Probe System only) (ref 3, 4, 5)

Instrument Response Function: $Q(E)=E^{+0.27}$ for 150 eV PE **(ref.3)**
Instrument Response Function: $Q(E)=E^{+1.0}$ for 50 eV PE **(ref.3)**

Signal/Background (S/BG) Ratios for Ion Etched Silver using a 250x1000 μ Spot*

Pass Energy	25 eV	50 eV	100 eV	150 eV
S/BG ratio**	>140	>110	>70	>50

* Using a 90° electron take-off-angle and a smooth Ag°/mylar film.

** The S/BG ratio is a simple numerical ratio of electrons counts at the peak maximum relative to the average electron counts observed at approximately 10 eV lower BE.

Lens Voltage Settings Available via Software under Instrument Calibration

Pass Energy*	29.6-29.8	54.7-54.9	105.1-105.3	155.9-156.2
Detector Widths	3.743	7.486	14.954	22.297
Sensitivity Exponent	-0.1	0.3	0.7	1.1
V1 Offset	30	55	105	155
V1 Slope	0.600	0.611	0.676	0.709

* These pass energies include corrections for instrument work function. True pass energies were set to 25, 50, 100, and 150 eV ±0.1 eV.

H. Effects of Poorly Focussing the Distance between the Sample and the Electron Lens

If the focus distance between the sample surface and the electron collection lens is poorly adjusted, then the number of electron counts drops very quickly. A 0.5 mm error in focus produces a >300% decrease in counts, but does not produce any observable error in binding energies, which is a common problem with many XPS instruments. A 0.1 mm error in focus produces a 15% decrease in peak area counts and is easily observed as a horizontal displacement in the static (un-scanned mode) XPS signal as observed on the standard CRT display of the detector response. Such a decrease in signal intensity generally urges the operator to correct the focus error so as to maximize the electron count rate. In this manner, the operator has avoided any chance of obtaining false BE readings and has accurately reproduced a nearly absolute focus point which greatly increases the quantitative accuracy of any unknown sample. Experiments with the Bragg angle alignment of the crystal indicated that the maximum error due to an unusual bad alignment of the crystal would be <0.1 eV. To observe an error greater than 0.1 eV, the electron counts were found to decrease by >50%.

I. Quantitation Details and Choice of "Sensitivity Exponents" (ref 2, 4, 5)

By default, the SSI software uses a 0.7 number as the sensitivity exponent factor for each pass energy setting which are used in an equation that modifies theoretically calculated atomic photo-ionization cross-sections (John H. Scofield, Ph.D.) to generate relative sensitivity factors that are valid for this XPS systems and which can be used to generate valid atomic percentages. The 0.7 value produces a ±10% accuracy in quantitative results for XPS signals obtained by using a 150 eV pass energy and occur within the 0-700 eV BE range. For signals that occur at higher BEs, it is generally necessary to change the sensitivity exponent factor to a 1.1 or higher value (1.4). To measure signals obtained by using other pass energies for quantitation, it is necessary to use other sensitivity exponent factors, if the user desires to maximize quantitative accuracy.

To determine useful sensitivity exponents, it is useful to use freshly ion etched poly-crystalline copper foil to test the validity of the sensitivity exponent for larger BE ranges and different pass energies. By integrating the peak areas of the Cu (2p1), Cu (2p3), Cu (3s), Cu (3p) and Cu (3d) signals with a modest amount of attention to baseline end points, it is possible to perform trial and error choices of the sensitivity exponents until a useful number is determined. Once a useful number has been entered into the computer software routine, then the software can generate "fictional" atomic percentages for each of the integrated copper signals which will generate 20 atom % values with a uncertainty of ±1-2 atom %. If the exponent factor is severely wrong then the atomic percentages will generate numbers such as 10%, 11%, 26%, 24%, and 29% or perhaps 31%, 28%, 14%, 13%, and 14%.

This trial-and-error approach may require 1-2 hours time and can be done on either wide scan data or more preferably narrow scan data for each of the 4-5 pass energies. This method, in effect, assumes that all five of the relative sensitivity factors for copper are reasonably correct. If wide scan data are used, then this method requires a little extra effort to avoid the satellites of the Cu (2p) signals.

This method, in effect, pretends that the pure copper sample is a standard material that is composed of 5 components which are present in 20 atomic % concentration. The objective is to change the sensitivity exponent until the software generates a 20 atom % result for each of the five copper signals. After useful sensitivity exponents are found, they are tested by analyzing freshly exposed bulk regions of crystalline materials such as SiO_2, Al_2O_3, and NaCl. The high and low BE signals of the NaCl crystal are especially useful to test the validity of the sensitivity exponents.

As further checks, the freshly exposed bulk of common polymers (e.g. mylar or PMMA) or a thin film of high purity silicone oil can also be analyzed. Teflon has repeatedly given a slightly larger than desirable error by comparison to the other materials listed above. For that reason Teflon seems to be a less desirable material to determine useful sensitivity exponent values.

J. Crude Tests of the Reliability of Relative Sensitivity Factors

Crude testing of Scofield's numbers are included in atomic percentage composition tables that give atomic percentages for only one element. This testing used the software's automatic peak area integration software that is reasonably accurate. The results indicate that some of the relative sensitivity factors for some of the weaker signals are less reliable. If, however, all factors are taken into account, then Scofield's numbers are reliable to a 95% accuracy level for truly homogeneous materials. These results are available when using the Spectral Data Processor software.

K. Traceability Details

The definition of traceability reported by Martin P. Seah and Cedric J. Powell in the J. Vac. Soc. Technol. Vol 8, p.736 (1990) publication is: "The property of a result of a measurement whereby it can be related to appropriate standards, generally international or national standards, through an unbroken chain of comparisons." Based on this definition, the following correlations were envisioned.

Traceability of Reference Binding Energies (Calibration)

At this time, there are no international standards for binding energies or reference energies. Numbers which are considered to be standard binding energies (BE), which would lead to traceability in BEs, include (a) those provided by Martin P. Seah at the National Physical Laboratory (NPL) in the United Kingdom (England), and (b) those provided by the ASTM in the USA "Standard Practice for Checking the Operating Characteristics of XPS Spectrometers" designated as "E 902-88". Other nations also have similar national standards, which tend to imitate those set by the USA and the UK. Recently, many people in the world have been using NPL's reference energies, which have become "de facto" standards but have not yet been accepted by the International Standards Organization (ISO).

There are still many workers and researchers using various numbers provided by the instrument makers. The author of this book was using Surface Science Instruments (SSI) Co. reference energies until December 1992 and then switched to NPL BEs in January 1993. SSI reference energies came from Hewlett-Packard (HP). SSI and HP both used high precision voltage meters from HP to calibrate their ESCA machines (i.e. X, M, and S-Probe and HP-5950 A-type and B-type, resp.). Hewlett Packard was the first company to offer a commercial ESCA system, which used reference energies developed in cooperation with Kai Siegbahn at Uppsala, who effectively developed ESCA into a useful science and received the Nobel Prize.

In a recent effort to improve the accuracy of BEs obtained from pure elements, the S-Probe pass energies were checked and corrected, if needed, almost every work-day for two months to obtain high precision and high accuracy BEs for the pure elements that are metals. This study used the NPL reference energies with Cu (2p3) at 932.67 eV with +/- 0.02 uncertainty and Au (4f7) 83.98 eV with +/-0.02 uncertainty by using 0.02 eV/pt. steps for the calibrations. To determine the "true" BE of each of the pure elements, which were scraped clean in air and then ion etched in vacuum, a 0.05 eV/pt. step was used. A repetitive ion etching (depth profile) style was used to collect wide scan, valence (Fermi edge) band, and narrow scans of the main signals for each metal at 50, 25 and 10 eV pass energies. Each repetitive experiment run lasted about 4 hours. Therefore, if NPL's BE numbers are accepted as "de facto" international standards, then the ultimate traceability of BEs in this data collection can be related to NPL BE numbers for Cu (2p3) and Au (4f7). In a different, but similar manner, the BEs used to calibrate the S-Probe are traceable to Siegbahn's work and the high precision, high voltage meters produced by the Hewlett Packard Company.

Traceability Transfer from Pure Metals to Non-conductive Binary Oxides

A question that should be posed is traceability to the oxide BEs. Traceability begins with NPL's BEs for pure copper and gold as state above. Traceability then transfers to pure element BEs which are based on NPL reference BEs. Traceability then transfers to pure element BEs based on SSI's reference BEs, and then the naturally formed native oxide data published in Volume 2 of our XPS Spectral Handbook series where BEs were measured from pure element signals and also the naturally formed native oxide signals.

Naturally formed native oxides typically have thin oxide films (10-80Å) which, in general, behave as good or true electrical conductors, which allows a direct measure of the true binding energy of many, but not all, binary oxides. To determine if traceability can indeed be transferred to true binary oxides, it was necessary to study the behavior of the naturally formed native oxides by applying various flood gun settings with the samples grounded and insulated. The results from that study can be used to transfer traceability to the experimentally observed BEs of pure binary oxides. The most difficult transfer of traceability occurs for the naturally formed native oxide systems. If the flood gun study was not done, then it is difficult to transfer traceability in a reliable manner from a conductive metal to one of its corresponding non-conductive binary oxides.

Traceability of Instrument Response Function

Copper, gold and silver data obtained from the X-Probe system were submitted to Martin P. Seah at the NPL for a round robin test on transmission function; the results of which were published in Surface and Interface Analysis, p.243 (1993). In that publication, X-Probe data, which we contributed, were attributed to group #35. That paper reported that instrument has a $Q(E) = E^{0.27}$ for Rex 4 pass energy (PE=150 V)and a $Q(E) = E^{1.0}$ for the Res 2 pass energy (PE=50 V). If the NPL method is accepted as a "de-facto" standard, even though it is not an internationally recognized standard, then the transmission function and quantitation results of the S-Probe system are traceable to the "metrology spectrometer" at NPL.

Traceability of Relative Sensitivity Factors (RSFs) used for Quantitation

Scofield's theoretically calculated photo-ionization cross-sections are internationally used as the "de- facto" standard theoretical numbers, except in Russia and a few other places, where Band's numbers are preferred but are almost identical to Scofields. The SSI system uses a very simple equation that modifies Scofield's numbers to generate relative sensitivity factors that are used by the SSI software to calculate atom %s. That equation corrects for pass energy differences, transmission function differences, and inelastic mean free path versus kinetic energy dependency. The SSI system relies on Scofield numbers and that simple equation. Other instrument makers prefer to blend Scofield's numbers and experimentally determined numbers.

Traceability of Sample Purity

The purity of the commercially pure (99+%) binary oxides can be traced to Aldrich's ICP or AA analyses performed by Aldrich. Copies of their results are included in the handbook at the beginning of each group of spectra. Similar data sheets were also obtained for samples bought from Cerac. A set of gold, copper, and silver samples, i.e. "Reference Metal Samples SCAA90" set, kit #367, was obtained from the NPL and used to test the instrument response function of the M-Probe system. Binding energies obtained from those gold, copper, and silver samples were identical to binding energies obtained from our commonplace gold, copper, and silver samples within the expected uncertainty of ±0.08 eV used for routine instrument calibration.

L. Reference Papers Describing Capabilities of X-Probe, M-Probe, and S-Probe XPS Systems

1. Robert L. Chaney, *Surface and Interface Analysis*, **10,** 36-47 (1987) [re: X-Probe]
2. Noel H. Turner, *Surface and Interface Analysis*, **18,** 47-51 (1992) [re: Quantitation]
3. M. P. Seah, Surface and Interface Analysis, 20, 243-266 (1993) [re: Response Function]
4. L.T. Weng et al, *Surface and Interface Analysis*, **20,** 179-192 (1993) [re: Response Function]
5. L.T. Weng et al, *Surface and Interface Analysis*, **20,** 193-205 (1993) [re: Response Function]
6. B. Vincent Crist, *Surface Science Spectra*, **1**, 292-296 (1993) [re: KBr spectra]
7. B. Vincent Crist, *Surface Science Spectra*, **1**, 376-380 (1993) [re: Ar/C spectra]
8. M. P. Seah, I.S. Gilmore, and G. Beamson, *Surface and Interface Analysis*, **26,** 642-649 (1998)

The Elements

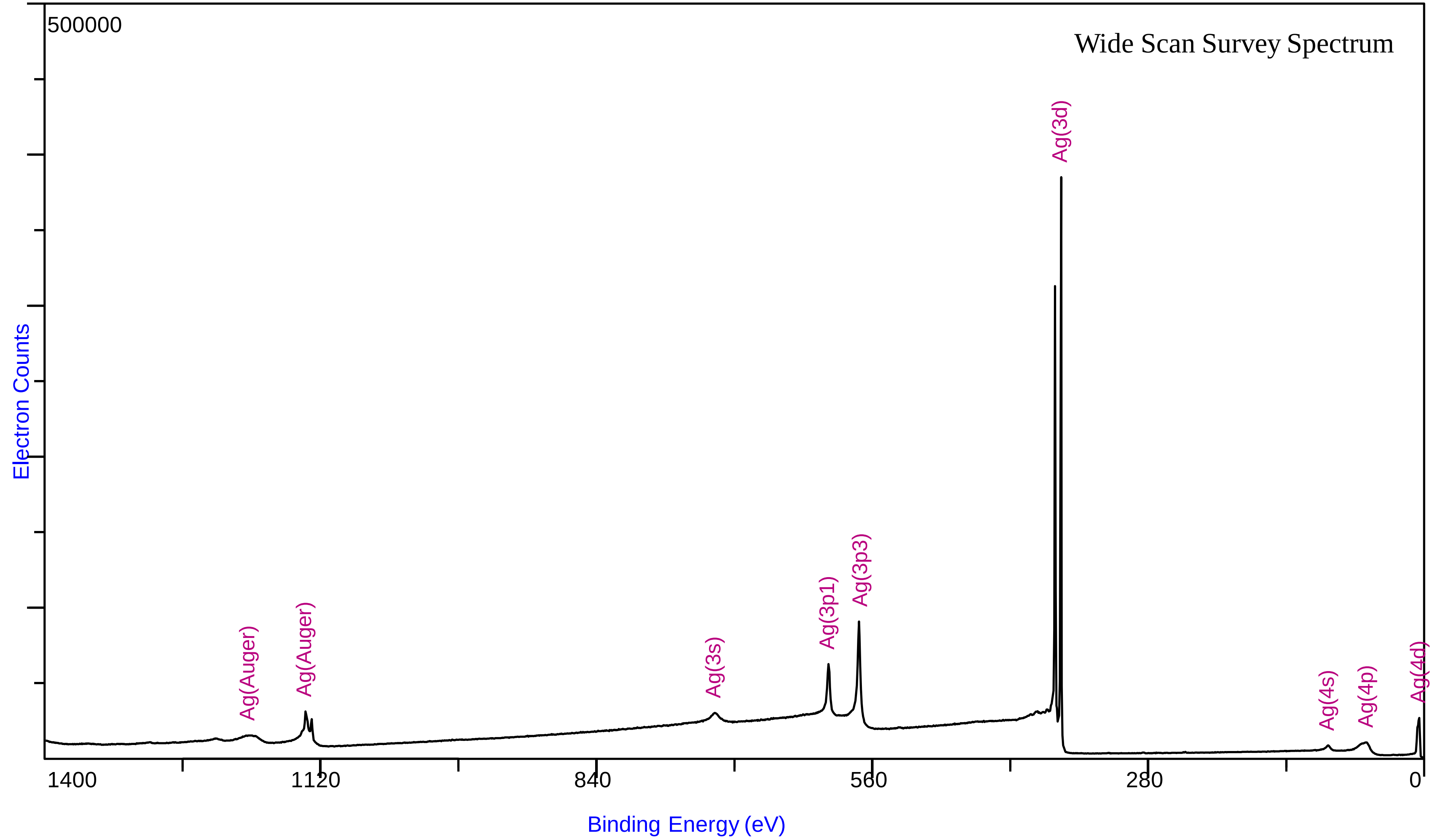
```
                Detailed Surface Composition Table


Description: Silver (Ag)  [Argentum => Ag]
             Sum of 15 individual spectra after repetitive ion etching
Date:        Tue Mar 1 1994

                     Corrected  Exper.   Sens        Norm   Relative
     Signal              BE        BE    Factor      Area     Area
       Ag Auger     1192.7    1192.7    0.00       56994  117296
       Ag Auger     1134.9    1134.9    0.00      123548       0
       Ag3s          719.6     719.6    2.68       43435   16218
       Ag3p1         604.0     604.0    3.79       98589   26023
       Ag3p3         573.6     573.6    5.87      186287   31709
       Ag3d          368.4     368.4   17.78      294202   16546
       Ar2s          319.6     319.6    1.96         599     306
       C 1s          284.5     284.5    1.00         910     910
       Ar2p          241.7     241.7    3.06        1404     459
       Ag4s           97.0      97.0    0.66       14200   21419
       Ag4p           58.6      58.6    2.13       59667   27983
       Ag4d            4.5       4.5    1.62       63425   39240
```

Silver Metal (Z=47) **Ag^0**

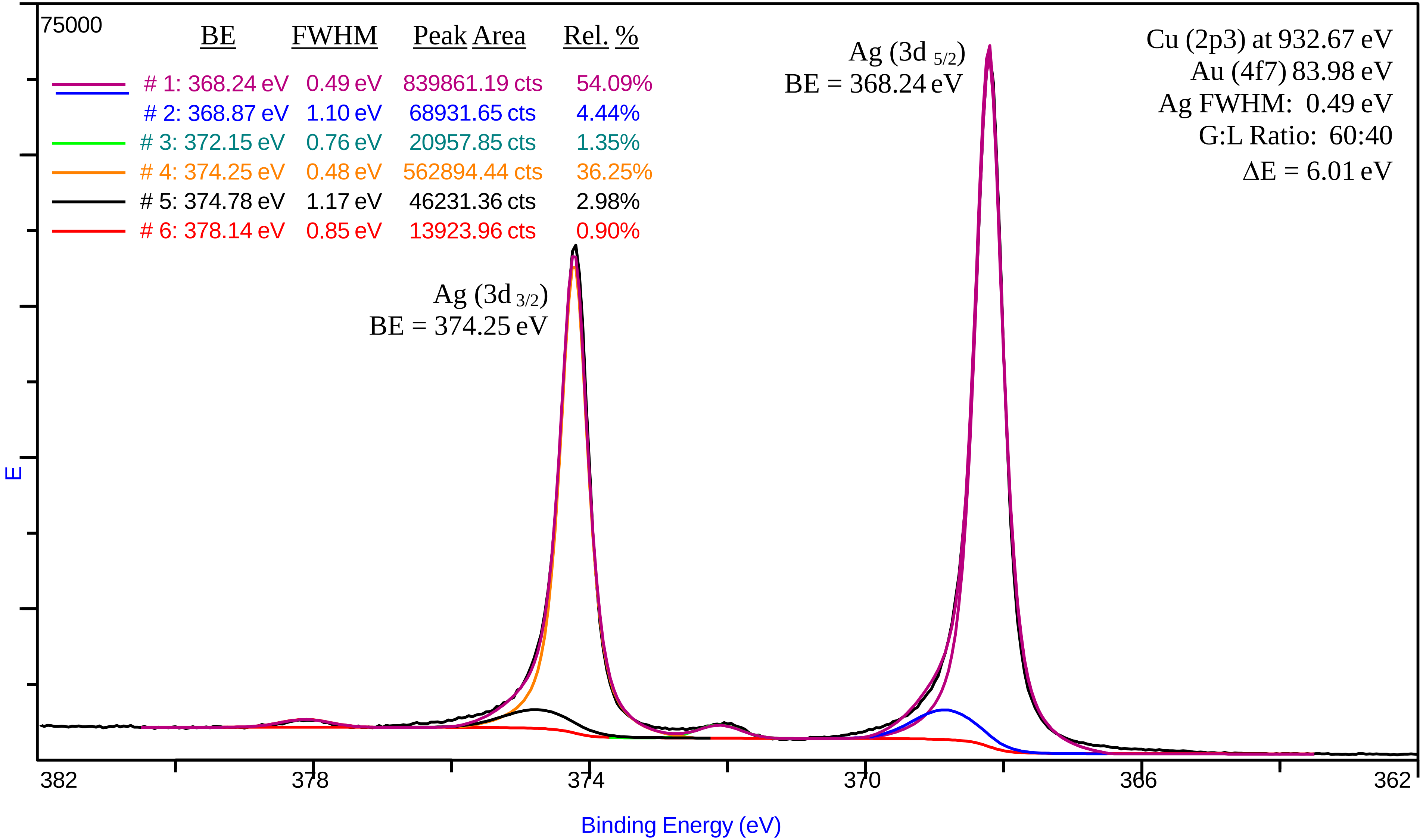
[CAS# 7440-22-4]



Silver Metal (Z=47)

Ag^0

[CAS# 7440-22-4]

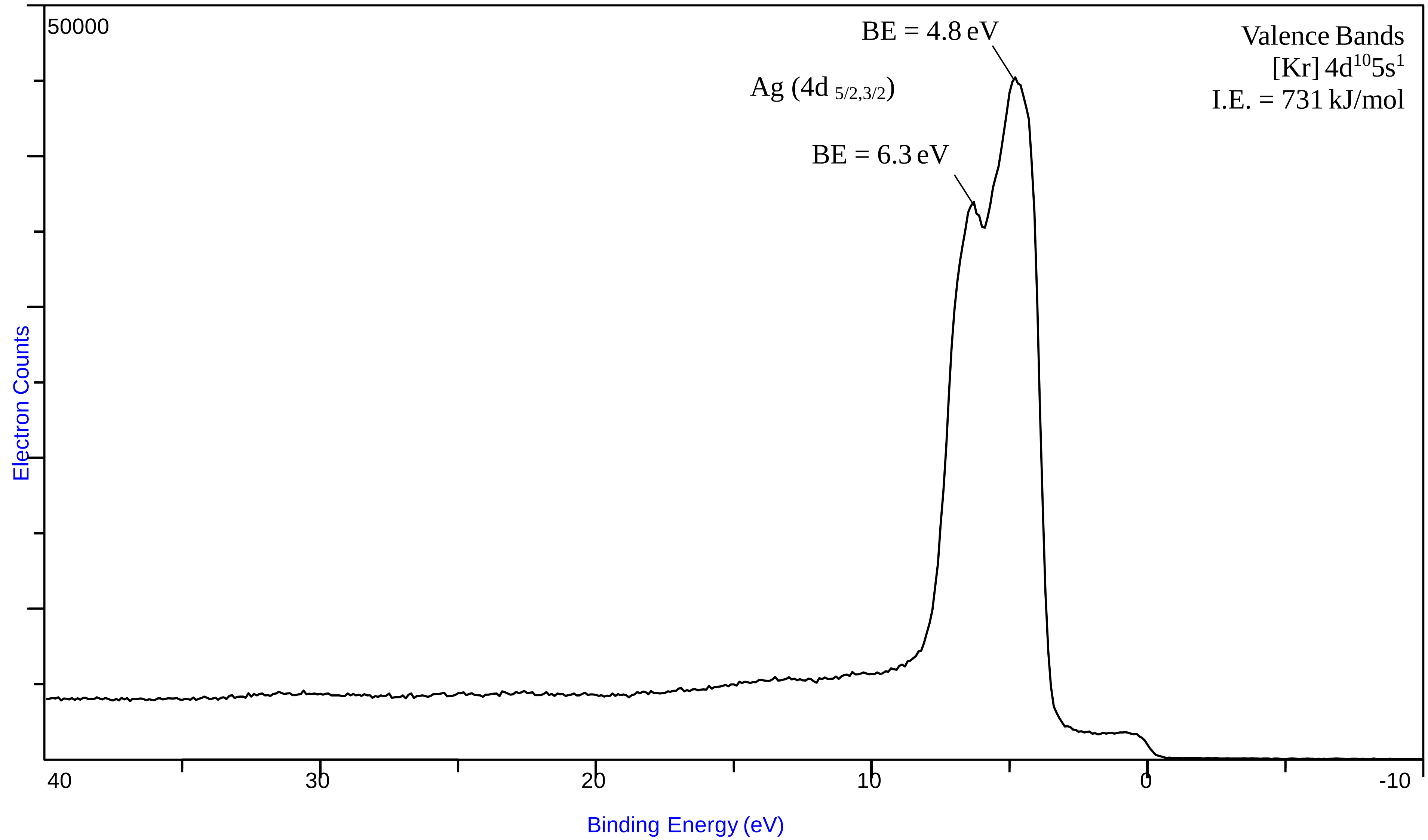


	BE	FWHM	Peak Area	Rel. %
# 1:	368.24 eV	0.49 eV	839861.19 cts	54.09%
# 2:	368.87 eV	1.10 eV	68931.65 cts	4.44%
# 3:	372.15 eV	0.76 eV	20957.85 cts	1.35%
# 4:	374.25 eV	0.48 eV	562894.44 cts	36.25%
# 5:	374.78 eV	1.17 eV	46231.36 cts	2.98%
# 6:	378.14 eV	0.85 eV	13923.96 cts	0.90%

Cu (2p3) at 932.67 eV
Au (4f7) 83.98 eV
Ag FWHM: 0.49 eV
G:L Ratio: 60:40
ΔE = 6.01 eV

Silver Metal (Z=47) **Ag^0**

[CAS# 7440-22-4]



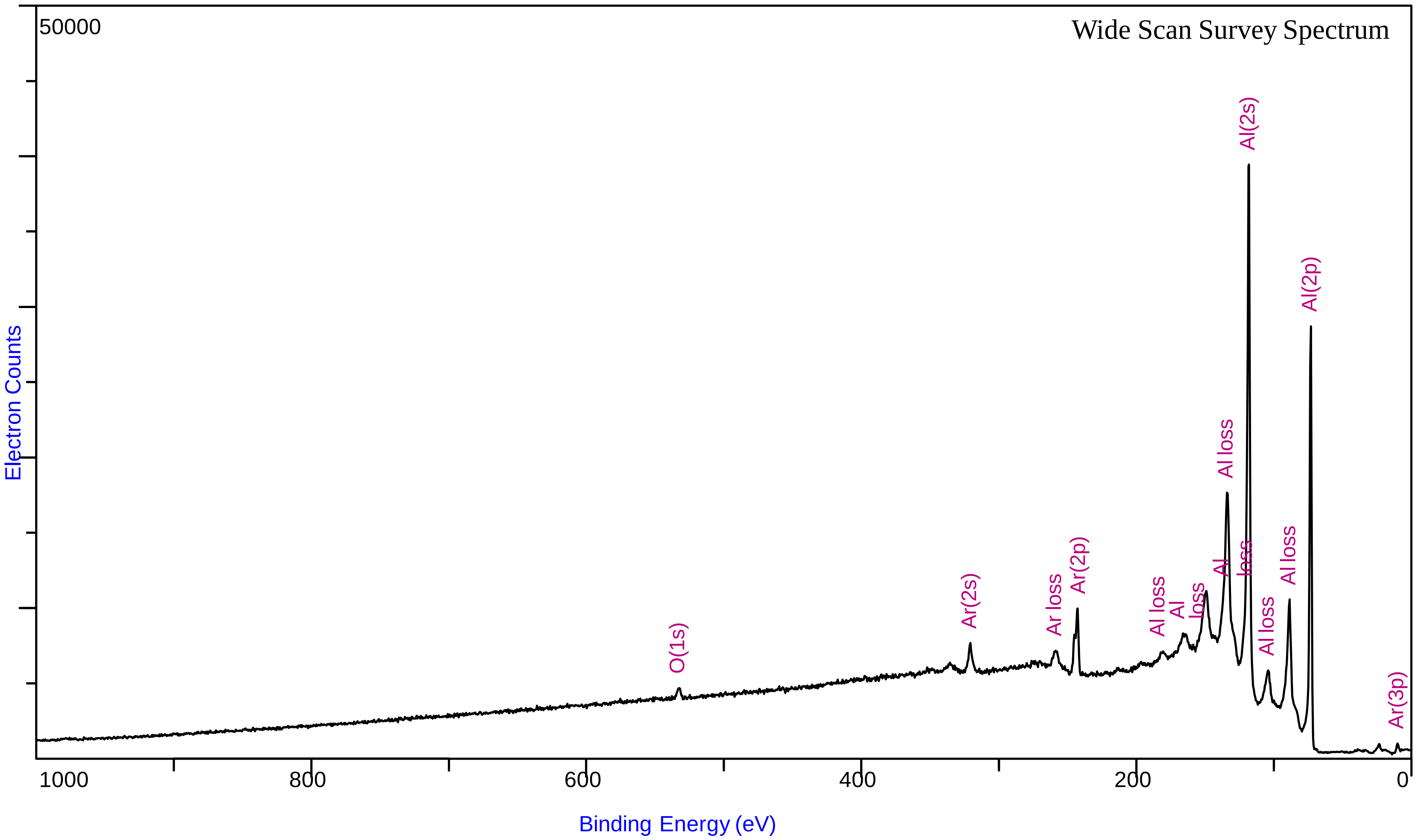
```
                  Detailed Surface Composition Table

      Description: Aluminium (Al) 90 deg TOA
                   Sum of 10 spectra from repetitive etch/scans
      Date:        Thu Mar 3 1994

                       Corrected   Exper.     Sens          Norm   Relative
            Signal        BE         BE      Factor         Area     Area
             O 1s       532.3      532.3      2.12          2859     1348
             Ar2s       320.5      320.5      1.89          6880     3644
              Ar loss   258.3      258.3      6.89          7355     1068
             Ar2p       242.5      242.5      3.19         13927     4366
              Al loss   180.1      180.1      0.00          3099        0
              Al loss   165.4      165.4      0.00          8634     1021
              Al loss   148.8      148.8      0.00         19410        0
              Al loss   133.4      133.4      0.00         49247        0
             Al2s       117.9      117.9      0.90         87391    96758
              Al loss   103.7      103.7      0.00         10757        0
              Al loss    88.2       88.2      0.00         31383        0
             Al2p        72.7       72.7      0.67         51411    76273
             Ar3p         9.5        9.5      0.32          1678     5196
```

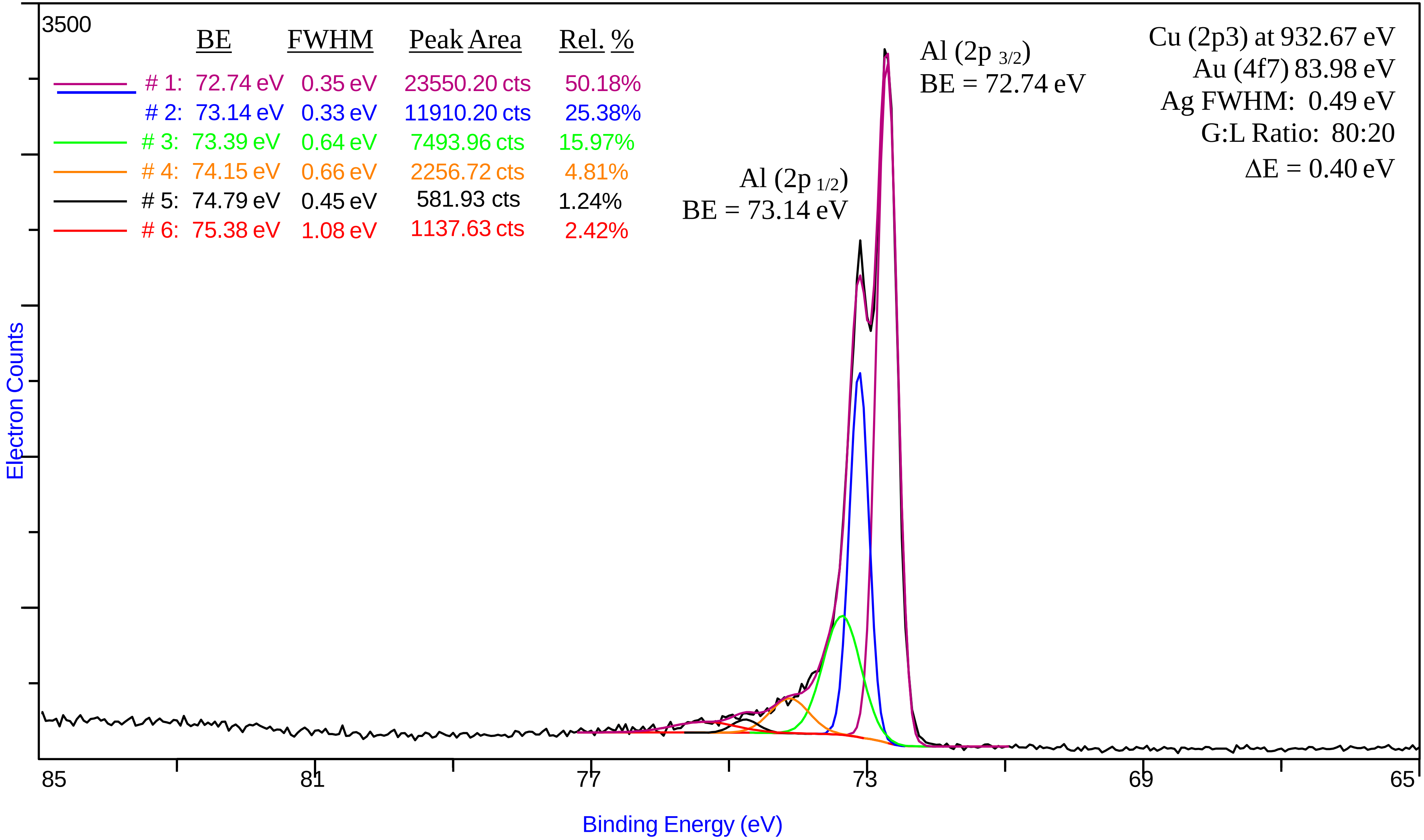
Aluminium Metal (Z=13) **Al^0**

[CAS# 7429-90-5]



Aluminium Metal (Z=13) **Al^0**

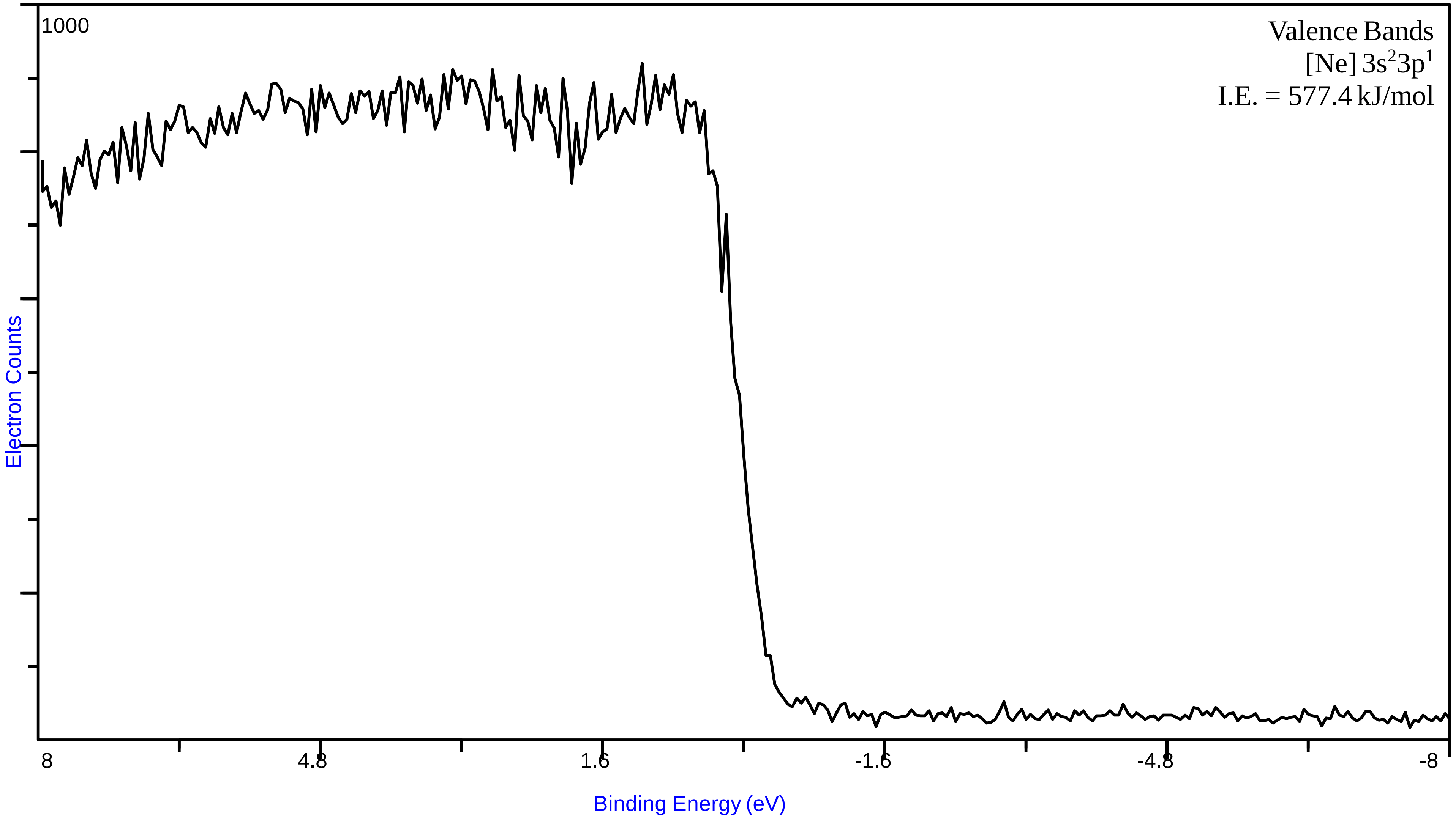
[CAS# 7429-90-5]



	BE	FWHM	Peak Area	Rel. %
# 1:	72.74 eV	0.35 eV	23550.20 cts	50.18%
# 2:	73.14 eV	0.33 eV	11910.20 cts	25.38%
# 3:	73.39 eV	0.64 eV	7493.96 cts	15.97%
# 4:	74.15 eV	0.66 eV	2256.72 cts	4.81%
# 5:	74.79 eV	0.45 eV	581.93 cts	1.24%
# 6:	75.38 eV	1.08 eV	1137.63 cts	2.42%

Aluminium Metal (Z=13) **Al^0**

[CAS# 7429-90-5]



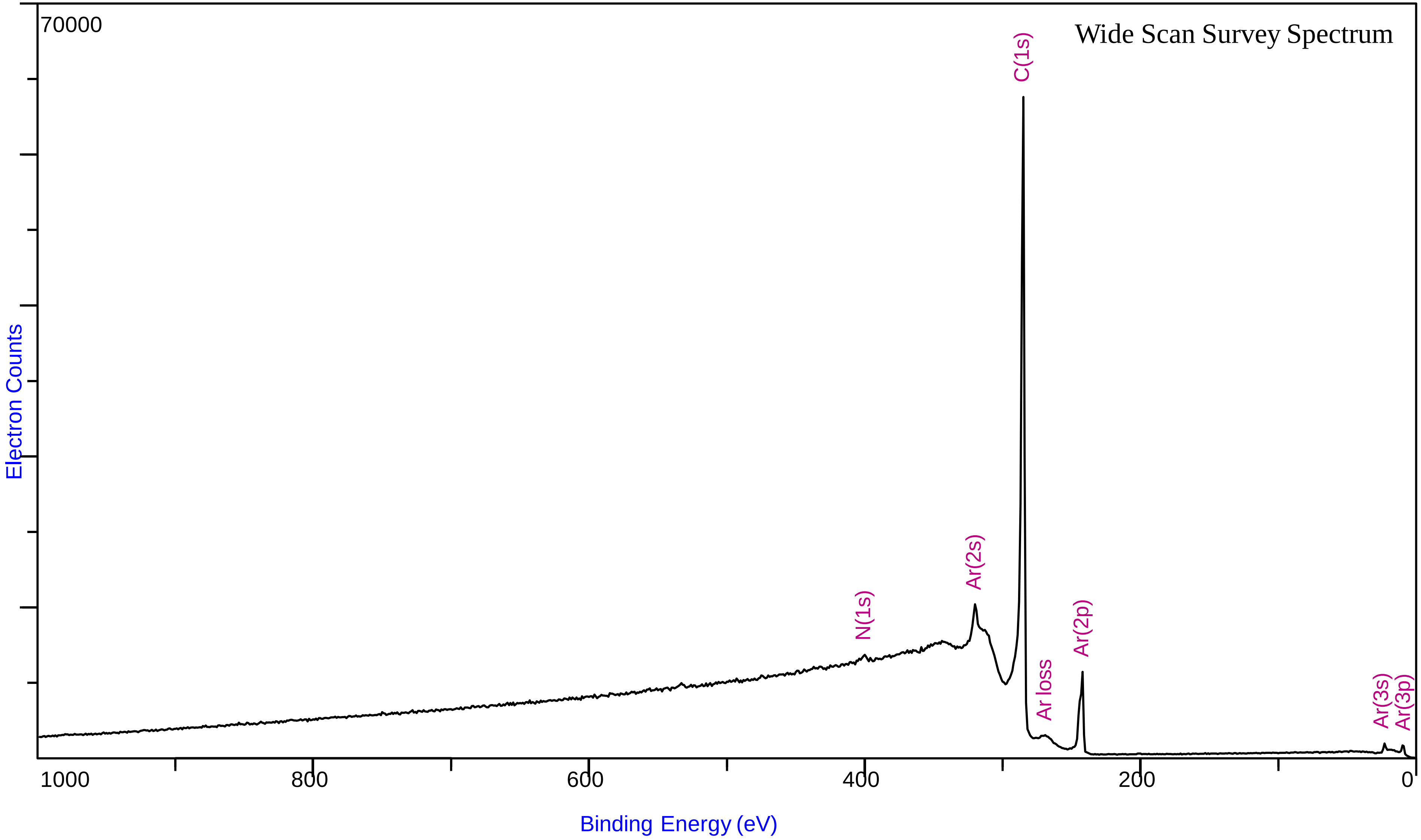
Detailed Surface Composition Table

```
Description: Argon Ions Implanted in Natural Graphite Crystal (90 TOA)    (Ref 7)
Date:        Tue Jan 12 1993

                  Corrected  Exper.   Sens         Norm   Relative
     Signal          BE        BE    Factor        Area     Area      Atom %
       Ar2s        319.5     319.2    1.90        30888    16239
     * C 1s        284.8     284.5    1.00       233917   233887      95.88
       Ar loss     268.8     268.5    0.00         7032        0
     * Ar2p        241.8     241.5    3.17        31861    10046       4.12
       Ar3s         22.3      21.9    0.29         3946    13713
       Ar3p          8.9       8.6    0.31         2352     7584
```

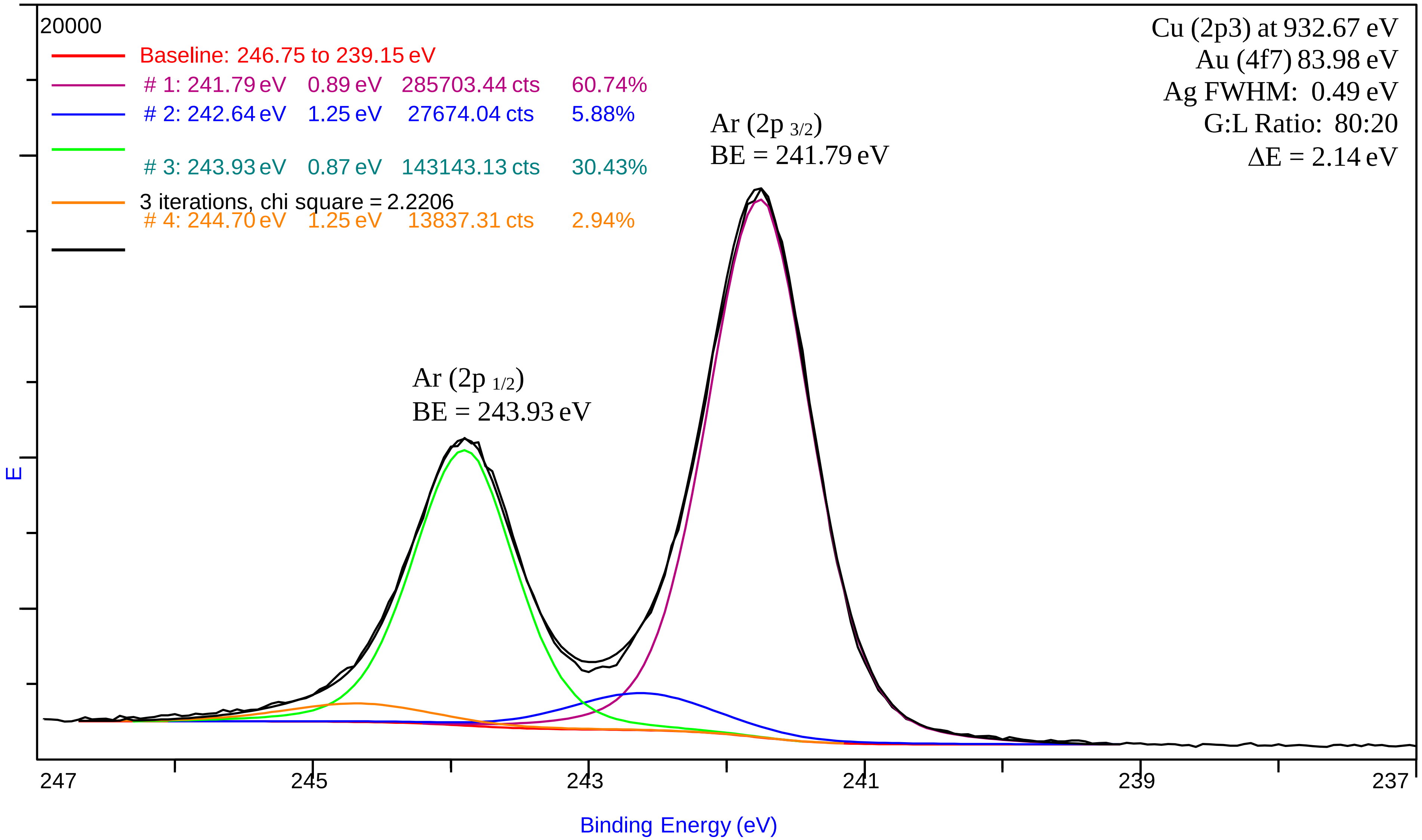
Ar^0 in C

[CAS# 7440-37-1]



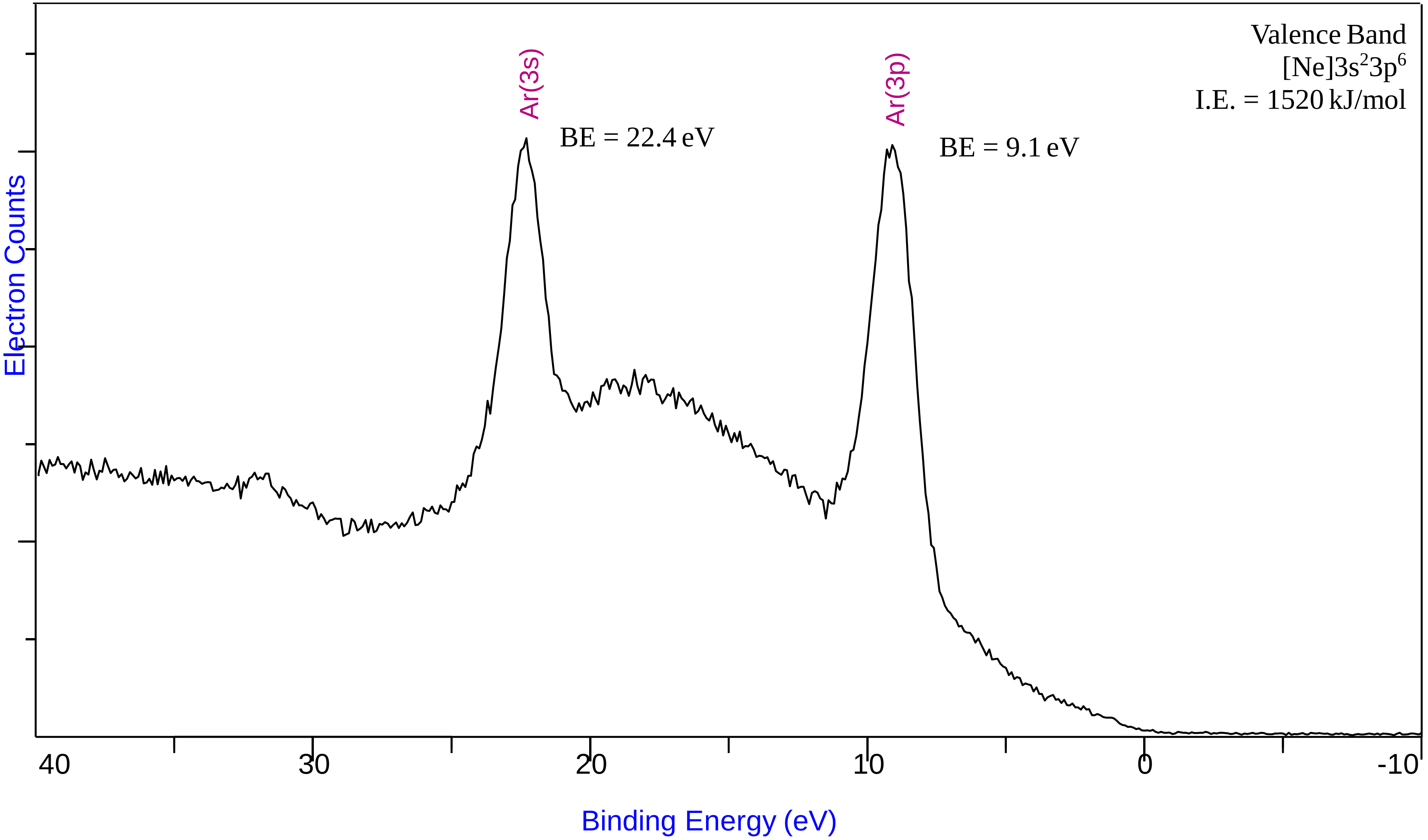
Ar^0 in C

[CAS# 7440-37-1]



Ar^0 in C

[CAS# 7440-37-1]



Detailed Surface Composition Table

Description: Arsenic (As)
Date: Thu Mar 10 1994

Signal	Corrected BE	Exper. BE	Sens Factor	Norm Area	Relative Area
As (2p1)	1359.5	1359.5	0.00	6333	0
As loss	1342.3	1342.3	0.00	2270	0
As (2p3)	1323.9	1323.9	0.00	16085	0
As Auger	519.0	519.0	0.00	1225	0
As Auger	467.8	467.8	0.00	1584	0
As Auger	457.7	457.7	0.00	2299	0
As Auger	425.5	425.5	0.00	720	0
As Auger	387.5	387.5	0.00	870	0
As Auger	371.2	371.2	0.00	7374	0
As Auger	359.6	359.6	0.00	5447	0
As Auger	335.0	335.0	0.00	4237	0
As Auger	327.0	327.0	0.00	792	0
As loss	279.1	279.1	1.00	7177	7178
As Auger	261.4	261.4	0.00	27159	0

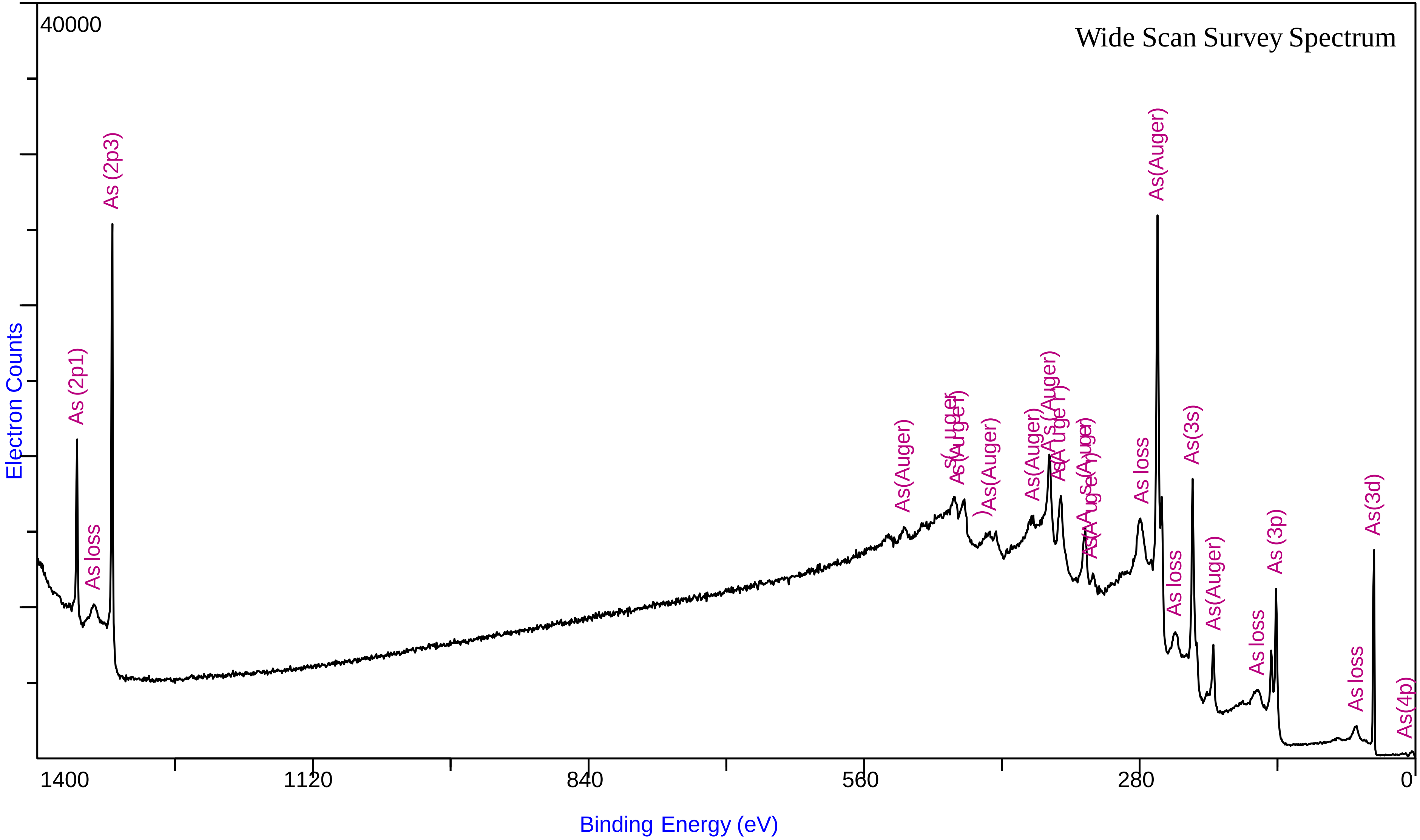
Detailed Surface Composition Table (continued)

Description: Arsenic (As)
Date: Thu Mar 10 1994

Signal	Corrected BE	Exper. BE	Sens Factor	Norm Area	Relative Area
As loss	243.4	243.4	0.00	2653	0
As3s	225.7	225.7	0.00	13349	109271
As Auger	204.7	204.7	1.34	2677	2002
As loss	159.1	159.1	0.00	1201	0
As (3p)	140.7	140.7	1.42	10842	7637
As loss	59.2	59.2	0.00	1677	0
As3d	41.5	41.5	1.89	5514	2920
As4p	9.1	9.1	0.13	225	1784

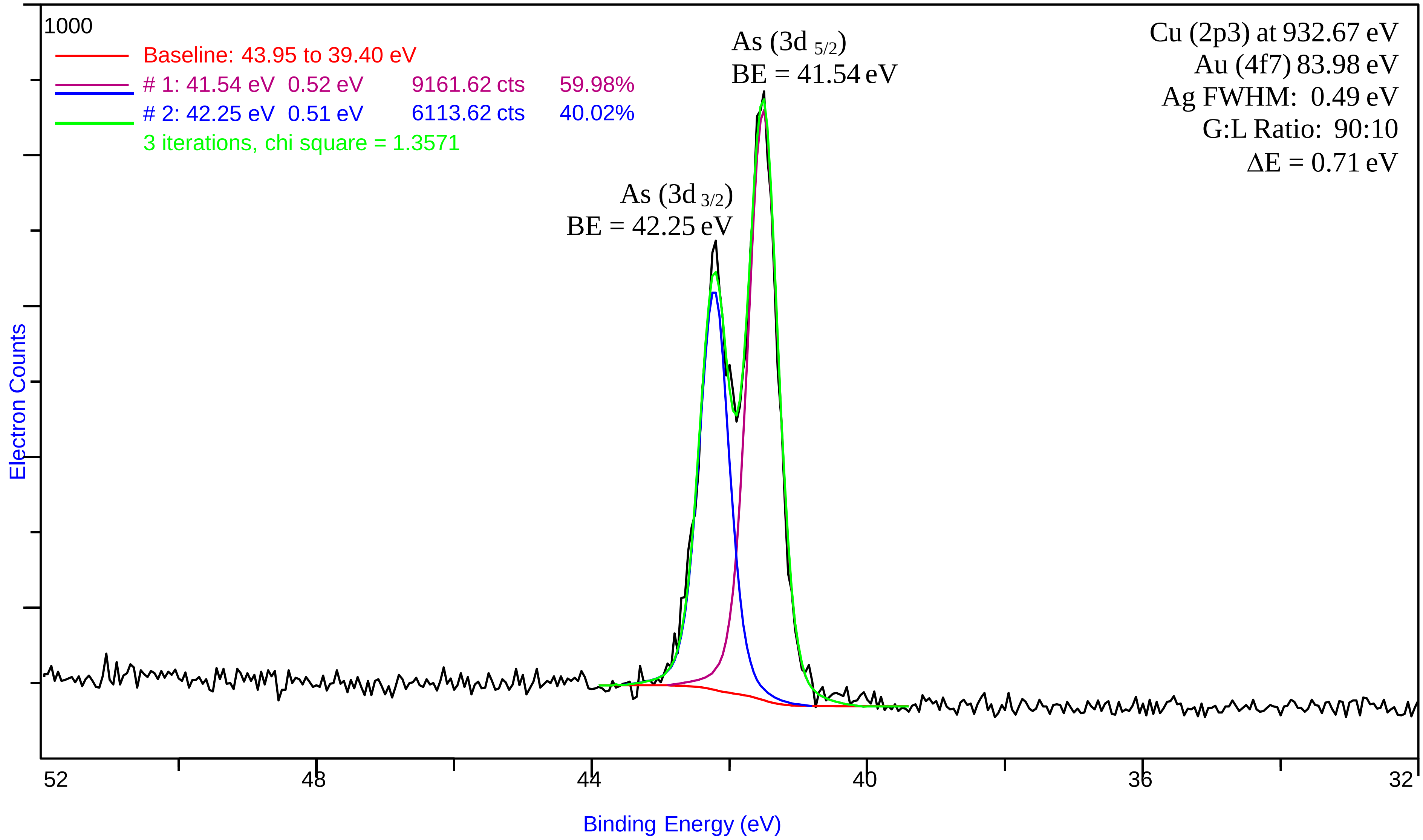
Arsenic Metal (Z=33) **As^0**

[CAS# 7440-38-2]



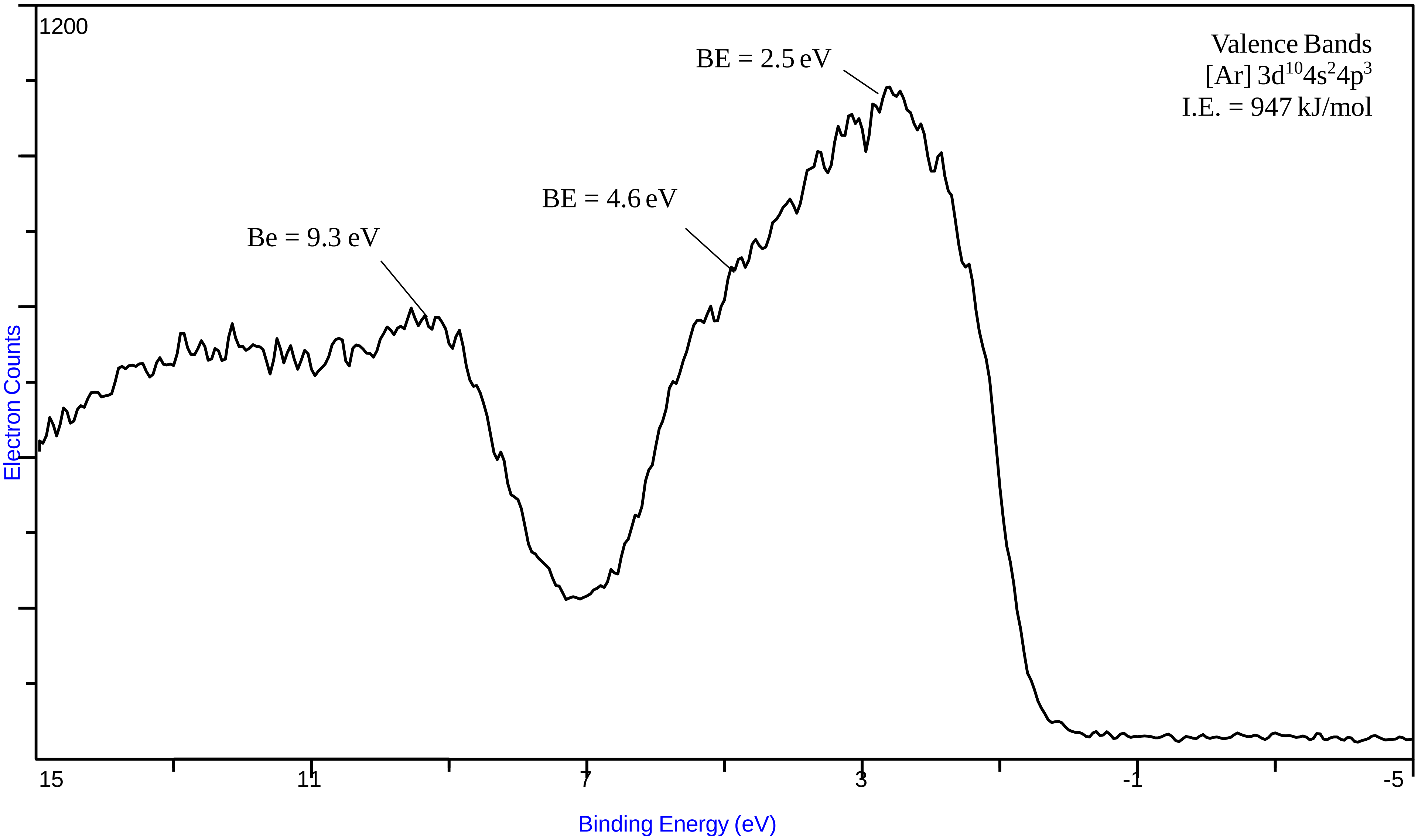
Arsenic Metal (Z=33) **As^0**

[CAS# 7440-38-2]



Arsenic Metal (Z=33) **As^0**

[CAS# 7440-38-2]



Gold Metal (Z=79) **Au^0**

[CAS# 7440-57-5]

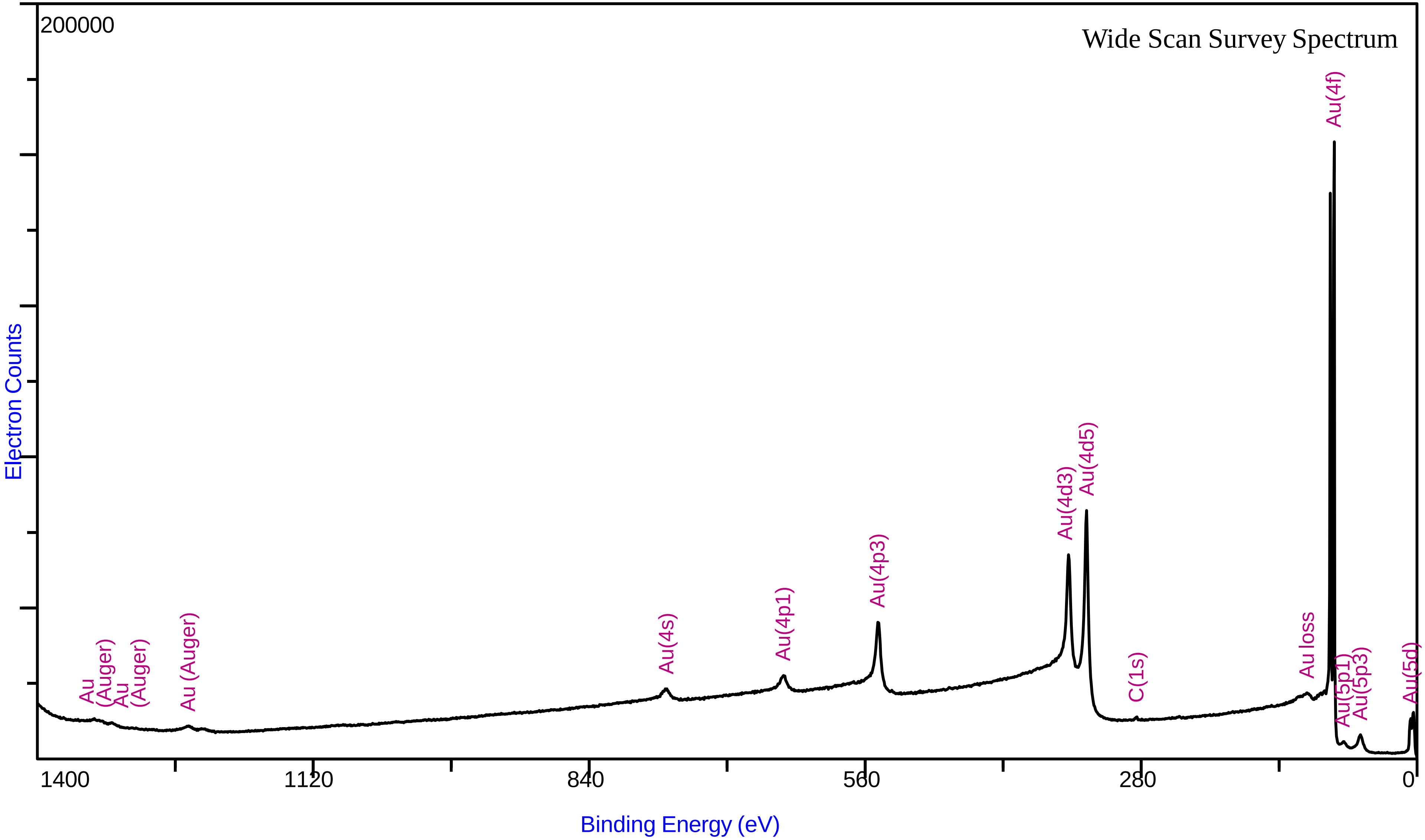
```
                    Detailed Surface Composition Table


Description: Gold (Au) 90 deg TOA  [Aurum = Au]
             Sum of 15 repetitive etch/scans
Date:        Fri Feb 25 1994

                   Corrected   Exper.    Sens       Norm   Relative
     Signal           BE         BE     Factor      Area     Area
       Au4s         761.2      761.2     1.74       9904     5706
       Au4p1        642.4      642.4     1.99      14742     7393
       Au4p3        546.3      546.3     5.61      51765     9231
       Au4d3        353.0      353.0     7.97      76555     9610
       Au4d5        335.0      335.0    11.64     103982     8933
       Au4f          83.6       83.6    17.66     208355    11797
       Au5p1         74.0       74.0     0.48       1956     4090
       Au5p3         56.8       56.8     1.14      11411    10020
       Au5d           5.8        5.8     1.89      24461    12977
```

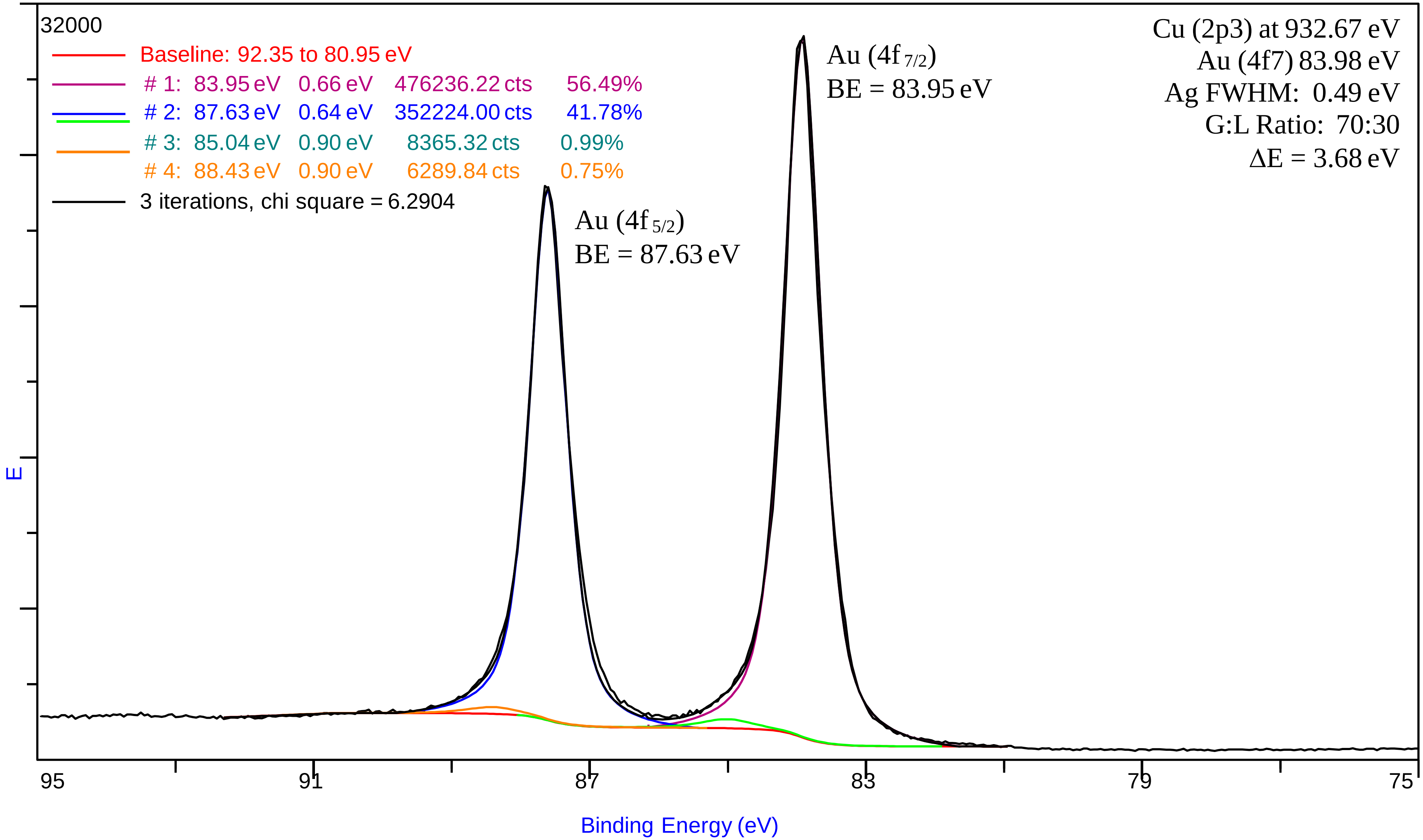
Gold Metal (Z=79) **Au^0**

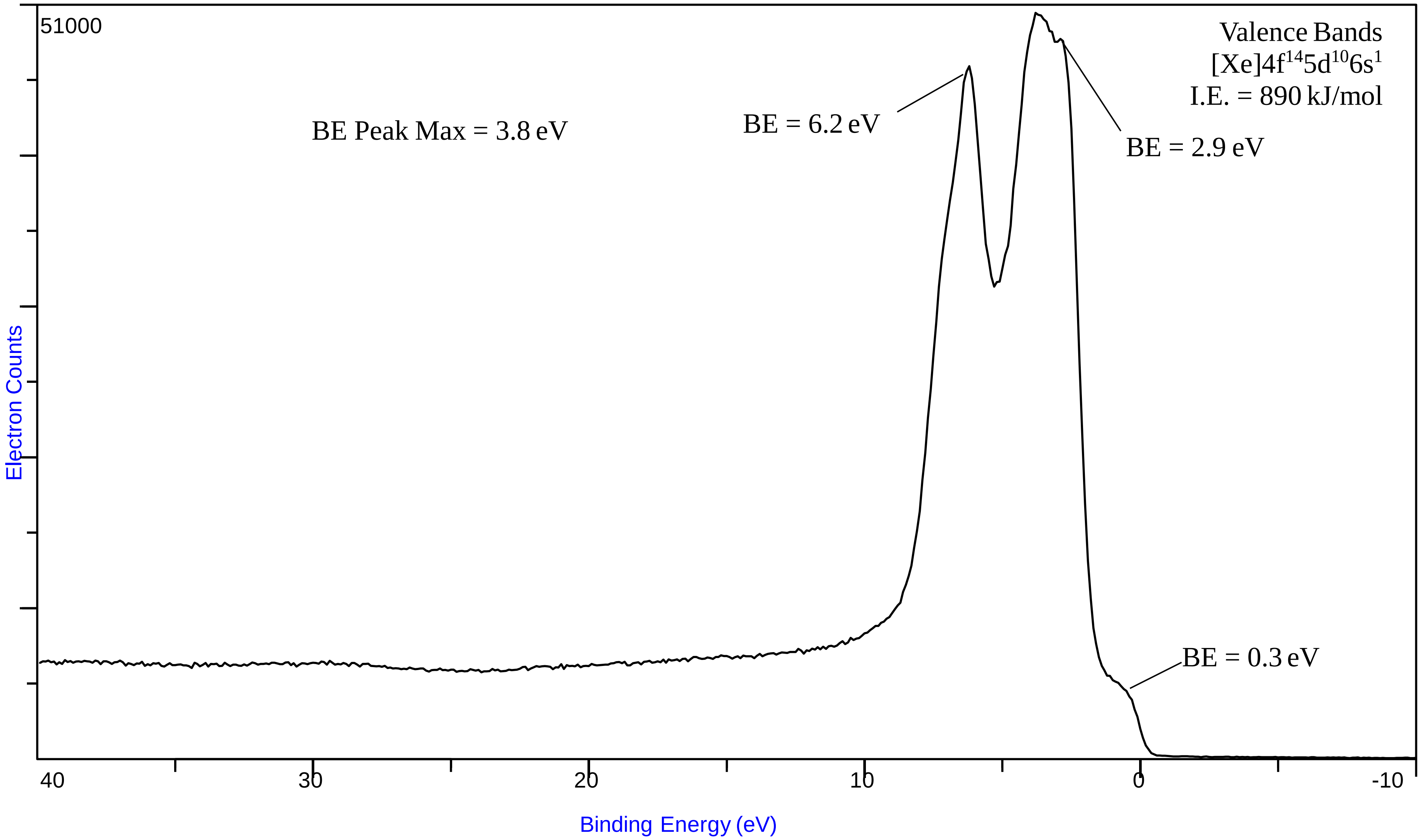
[CAS# 7440-57-5]



Gold Metal (Z=79) Au^0

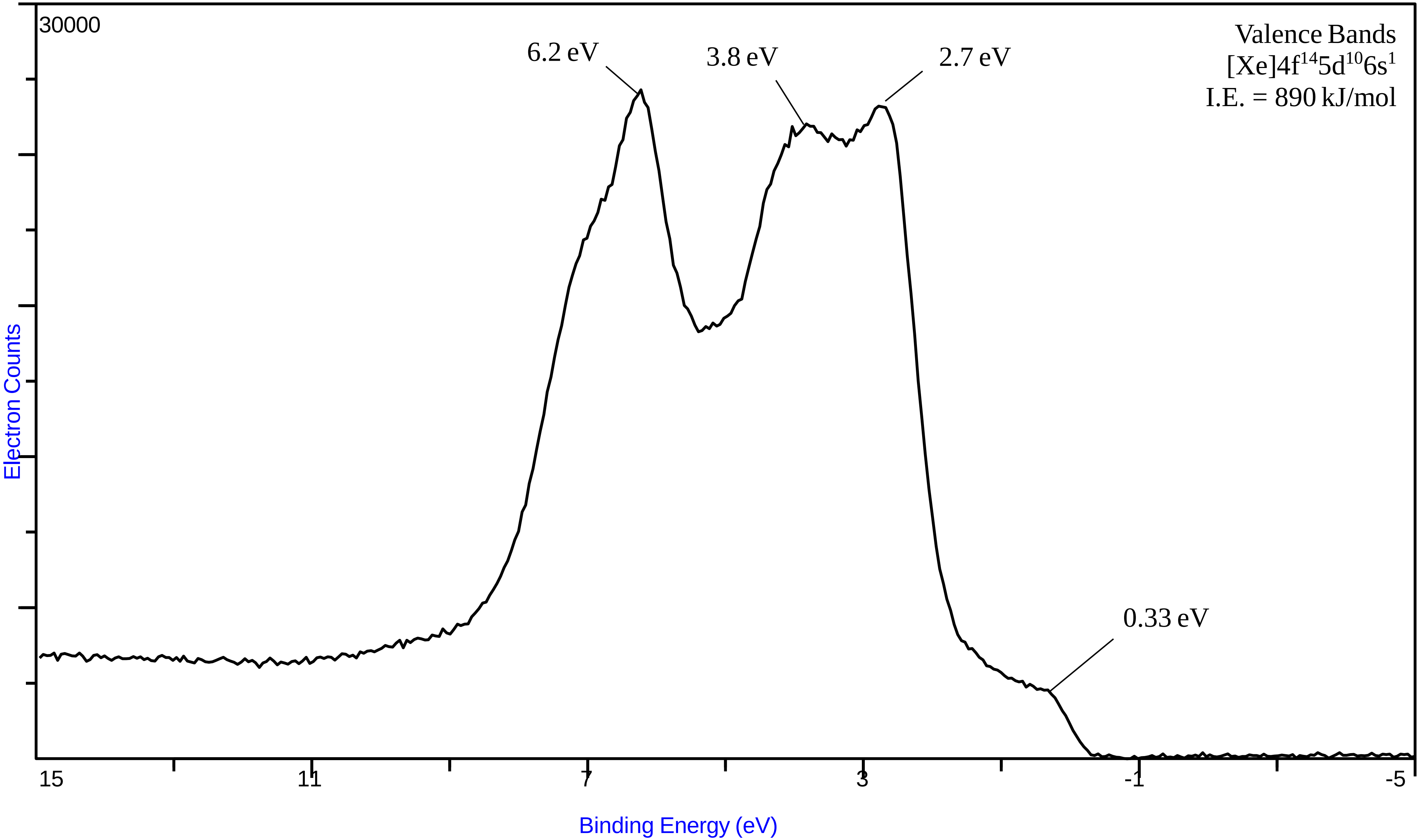
[CAS# 7440-57-5]




51000
Valence Bands
$[Xe]4f^{14}5d^{10}6s^1$
I.E. = 890 kJ/mol
BE Peak Max = 3.8 eV
BE = 6.2 eV
BE = 2.9 eV
BE = 0.3 eV
Electron Counts
40
30
20
10
0
-10
Binding Energy (eV)

Gold Metal (Z=79) on PET Film **Au^0**

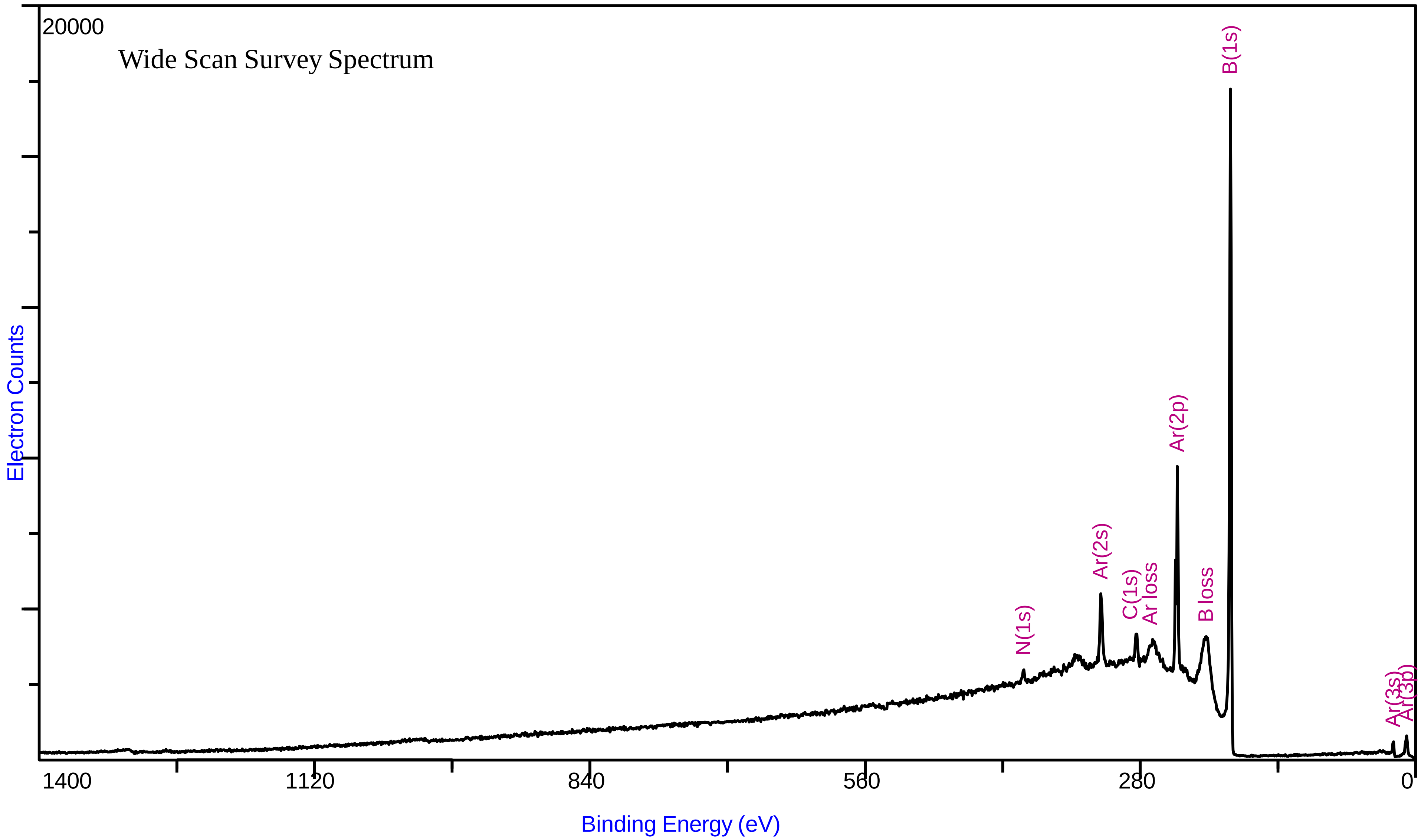
[CAS# 7440-57-5]



Detailed Surface Composition Table

Description: Boron (B): Ion etched clean, 90 TOA
Date: Thu Feb 24 1994

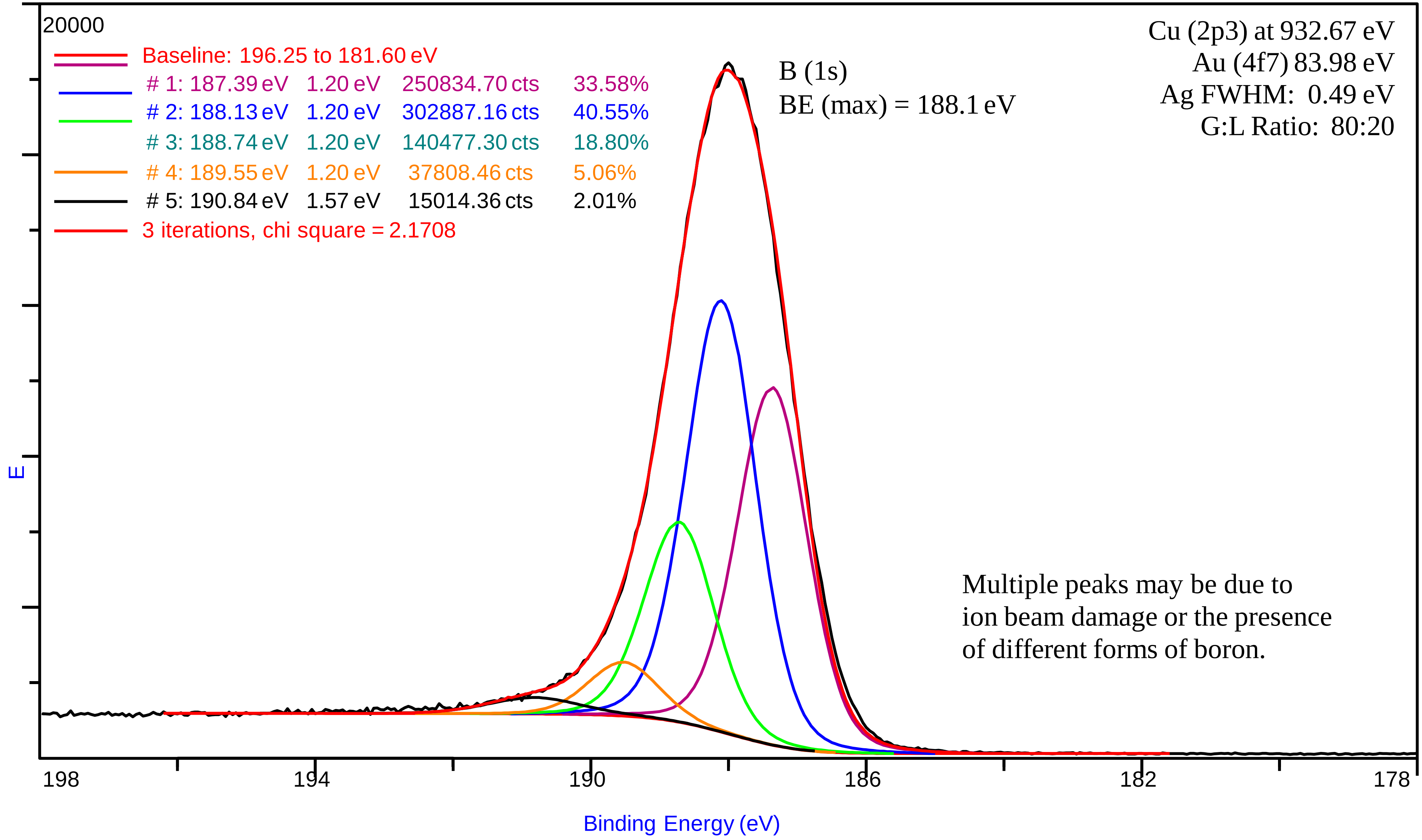
Signal	Corrected BE	Exper. BE	Sens Factor	Norm Area	Relative Area
N 1s	398.2	398.2	1.76	583	331
Ar2s	319.4	319.4	1.96	4312	2202
C 1s	283.4	283.4	1.00	1302	1302
Ar loss	266.9	266.9	0.00	1506	0
Ar2p	241.6	241.6	3.06	8690	2839
B loss	212.6	212.6	0.00	12364	0
B 1s	187.7	187.7	0.49	27345	55744
Ar3s	22.0	22.0	0.24	476	2016
Ar3p	8.5	8.5	0.25	1338	5305


20000
Wide Scan Survey Spectrum
Electron Counts
B(1s)
Ar(2p)
B loss
Ar loss
C(1s)
Ar(2s)
N(1s)
Ar(3s)
Ar(3p)
1400
1120
840
560
280
0
Binding Energy (eV)

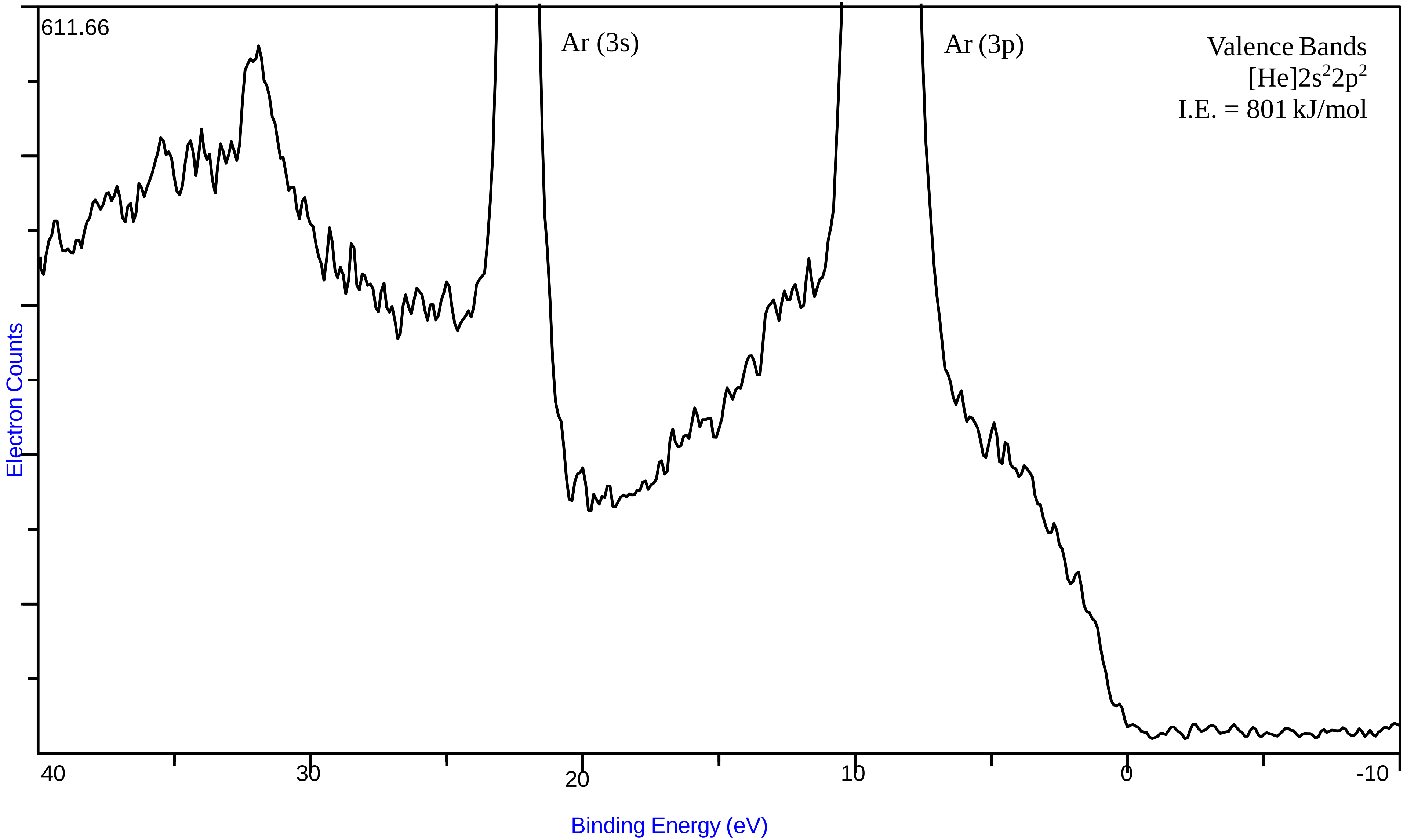
Boron (Z=5)

B^0

[CAS# 7440-42-8]



Multiple peaks may be due to ion beam damage or the presence of different forms of boron.


611.66
Ar (3s)
Ar (3p)
Valence Bands
[He]2s^{2}2p^2
I.E. = 801 kJ/mol
Electron Counts
40
30
20
10
0
-10
Binding Energy (eV)

Barium (Z=56) in Barium Carbonate (FW=197.35) **Ba : $BaCO_3$**

[CAS# 513-77-9]

Detailed Surface Composition Table

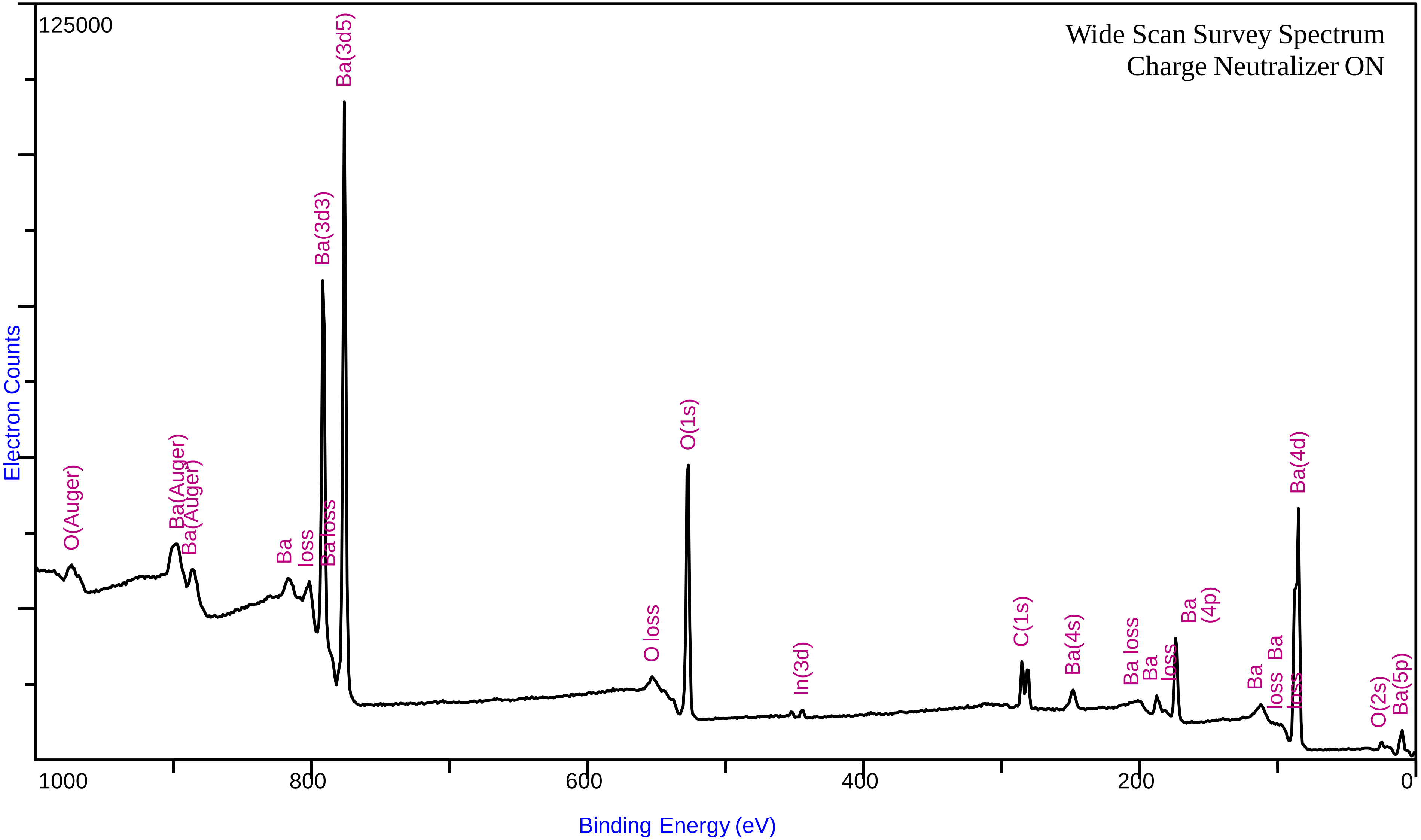
Description: BARIUM (Ba) CARBONATE (90 DEG TOA, Ion Etched Briefly at 4 KeV)
Date: Fri Jul 10 1987

Signal	Corrected BE	Exper. BE	Sens Factor	Norm Area	Relative Area	Atom %
O Auger	974.3	973.8	0.00	22438	0	
BaAuger	898.2	897.7	0.00	48775	0	
BaAuger	886.5	886.0	0.00	18189	0	
Ba loss	817.1	816.6	0.10	18322	182905	
Ba loss	801.8	801.3	0.00	23120	0	
Ba3d3	791.8	791.3	9.29	154697	16650	
* Ba3d5	776.4	775.9	13.75	217657	15828	17.19
O loss	553.2	552.7	0.00	47393	0	
* O 1s	527.3	526.8	2.24	99098	44309	48.11
* C 1s	285.0	284.5	1.00	31967	31963	34.71
Ba4s	248.1	247.6	1.17	13225	11285	
Ba loss	201.1	200.6	6.08	9596	1578	
Ba loss	187.3	186.8	8.86	11455	1292	
Ba (4p)	173.4	172.9	0.23	30989	134568	
Ba loss	111.9	111.4	0.23	22578	98009	
Ba loss	97.5	97.0	0.00	3773	0	
Ba4d	84.7	84.2	7.05	125295	17764	
O 2s	24.3	23.8	0.18	8226	46424	
Ba5p	9.5	9.0	0.77	12728	16503	

Barium (Z=56) in Barium Carbonate (FW=197.35)

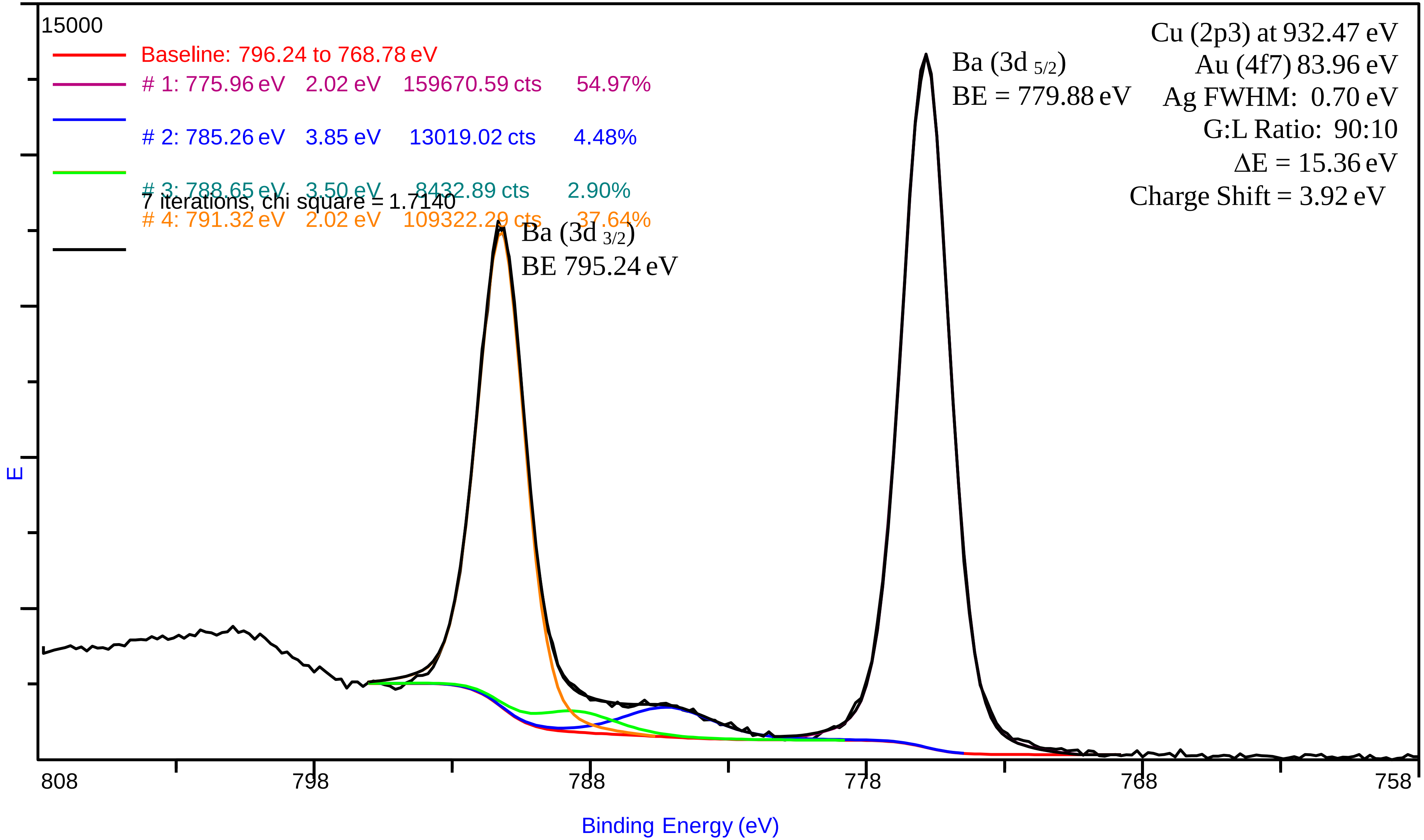
Ba : $BaCO_3$

[CAS# 513-77-9]



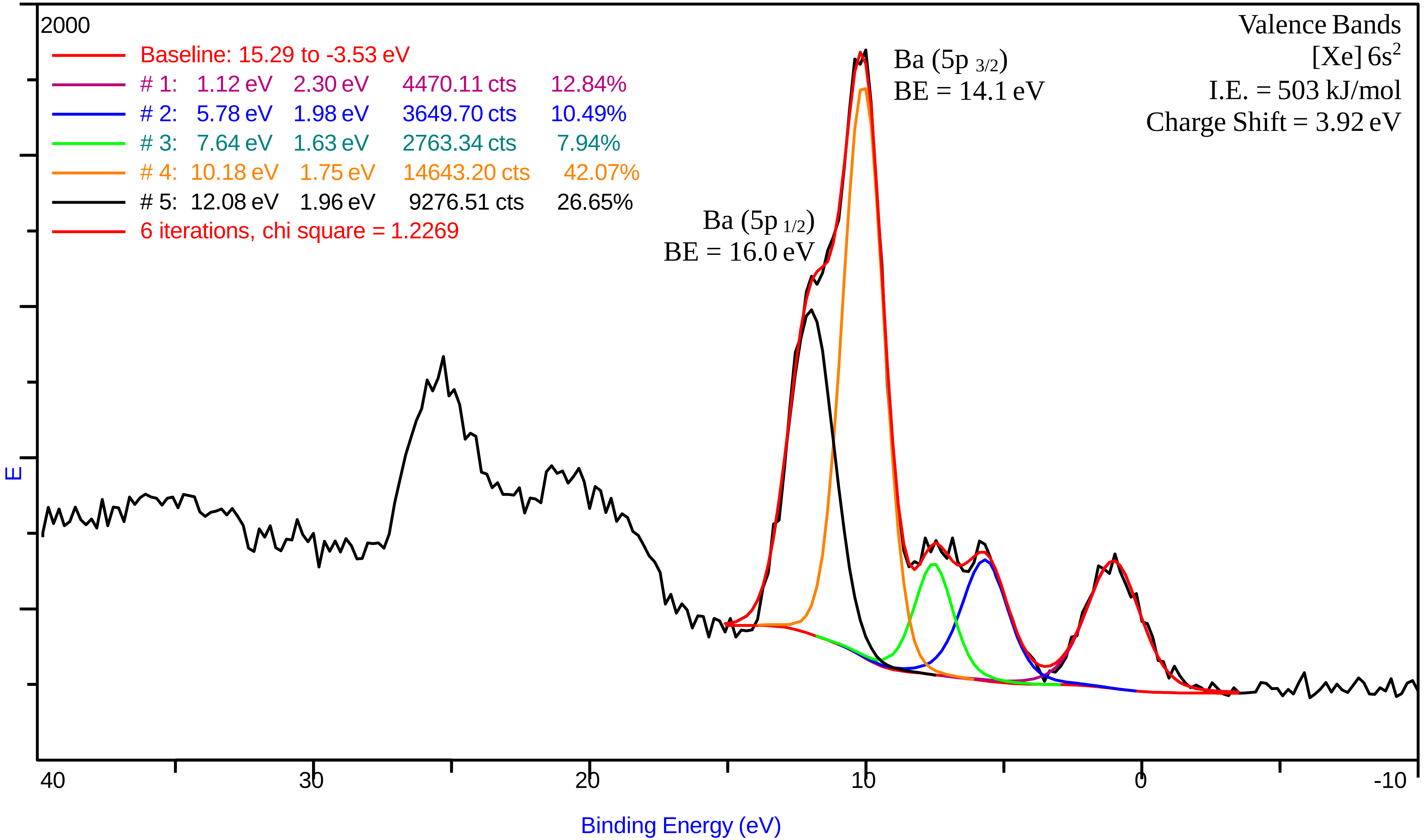
Barium (Z=56) in Barium Carbonate (FW=197.35) **Ba : BaCO$_3$**

[CAS# 513-77-9]



Barium (Z=56) in Barium Carbonate (FW=197.35) **Ba : BaCO$_3$**

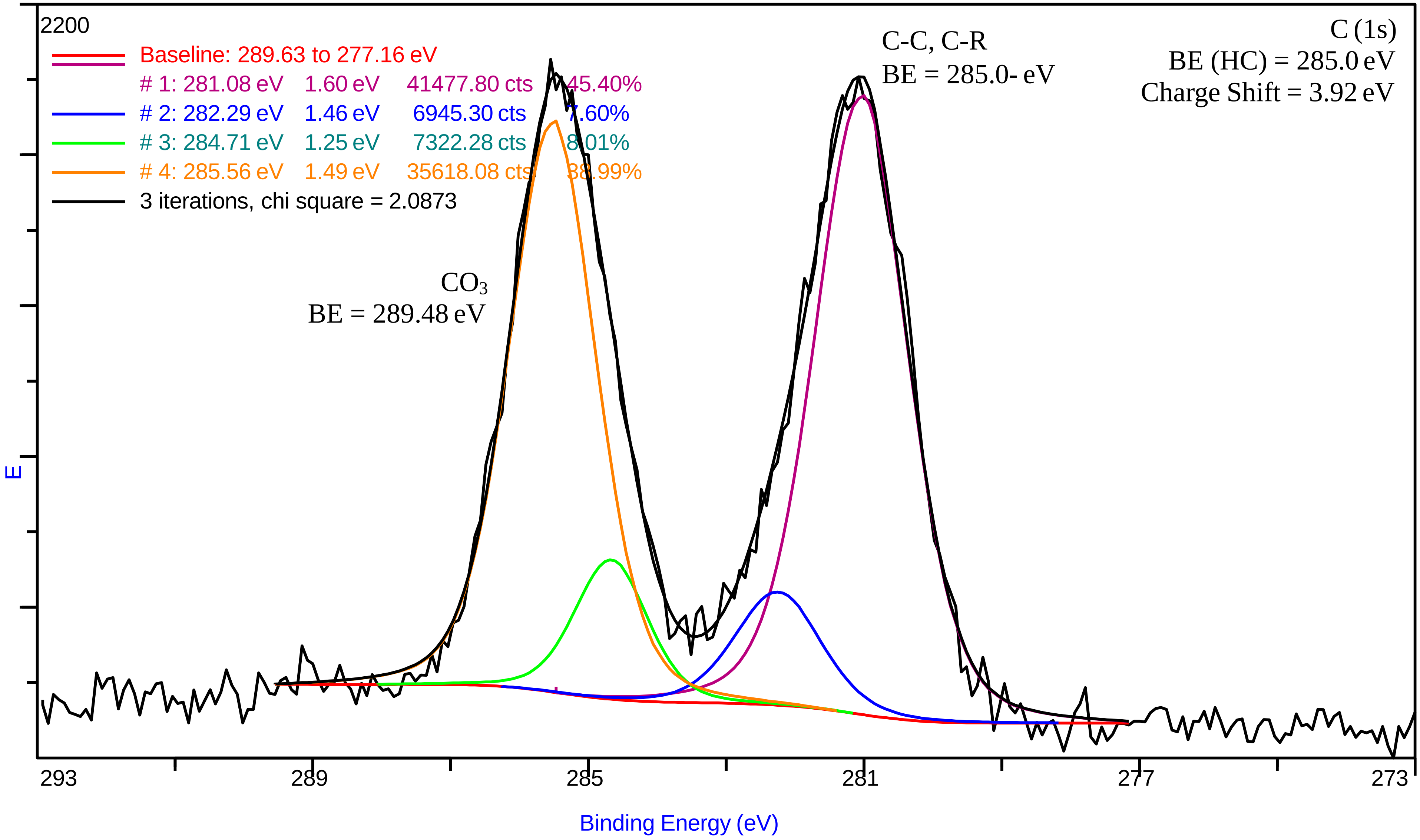
[CAS# 513-77-9]



Barium (Z=56) in Barium Carbonate (FW=197.35)

Ba : $BaCO_3$

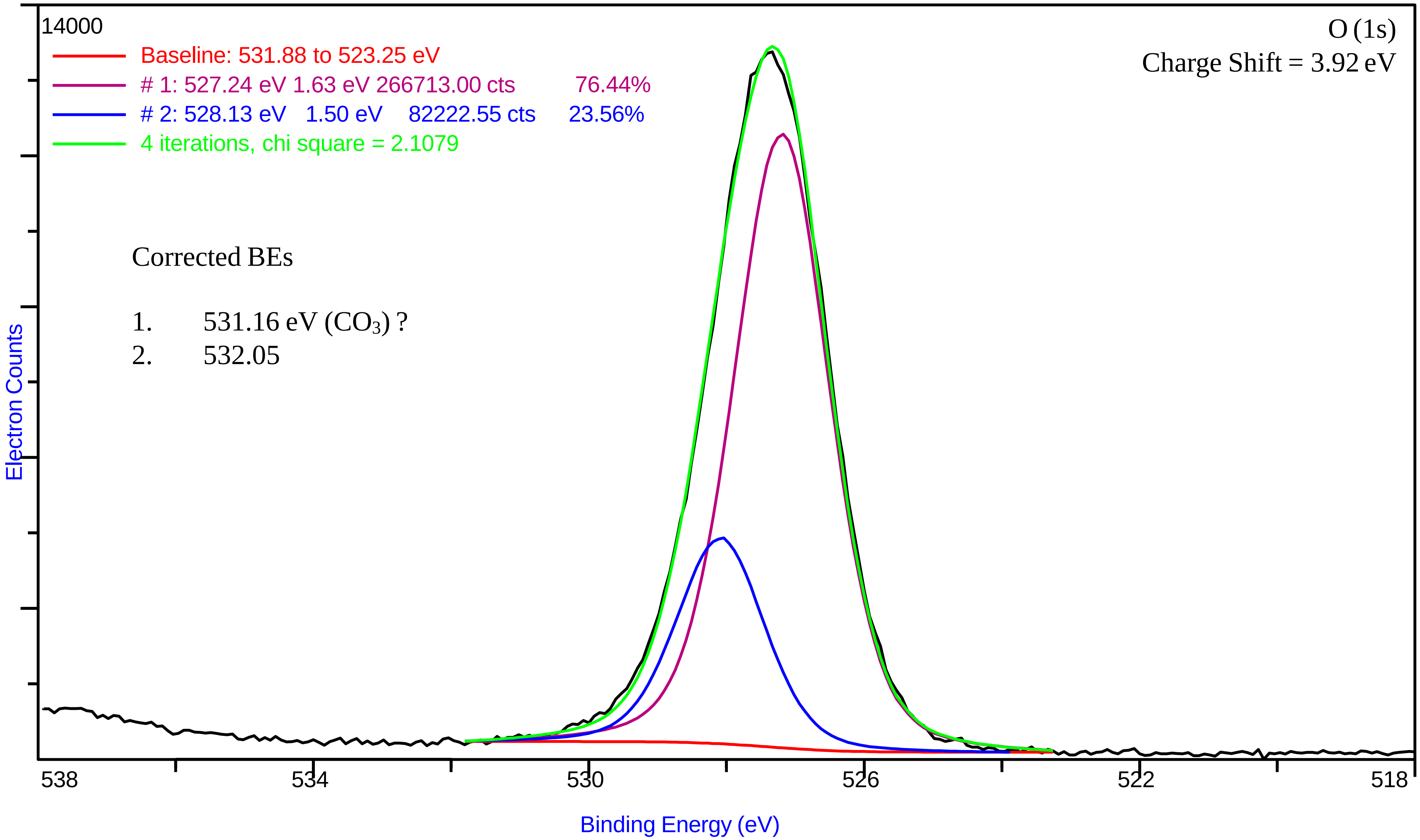
[CAS# 513-77-9]



Barium (Z=56) in Barium Carbonate (FW=197.35)

Ba : $BaCO_3$

[CAS# 513-77-9]



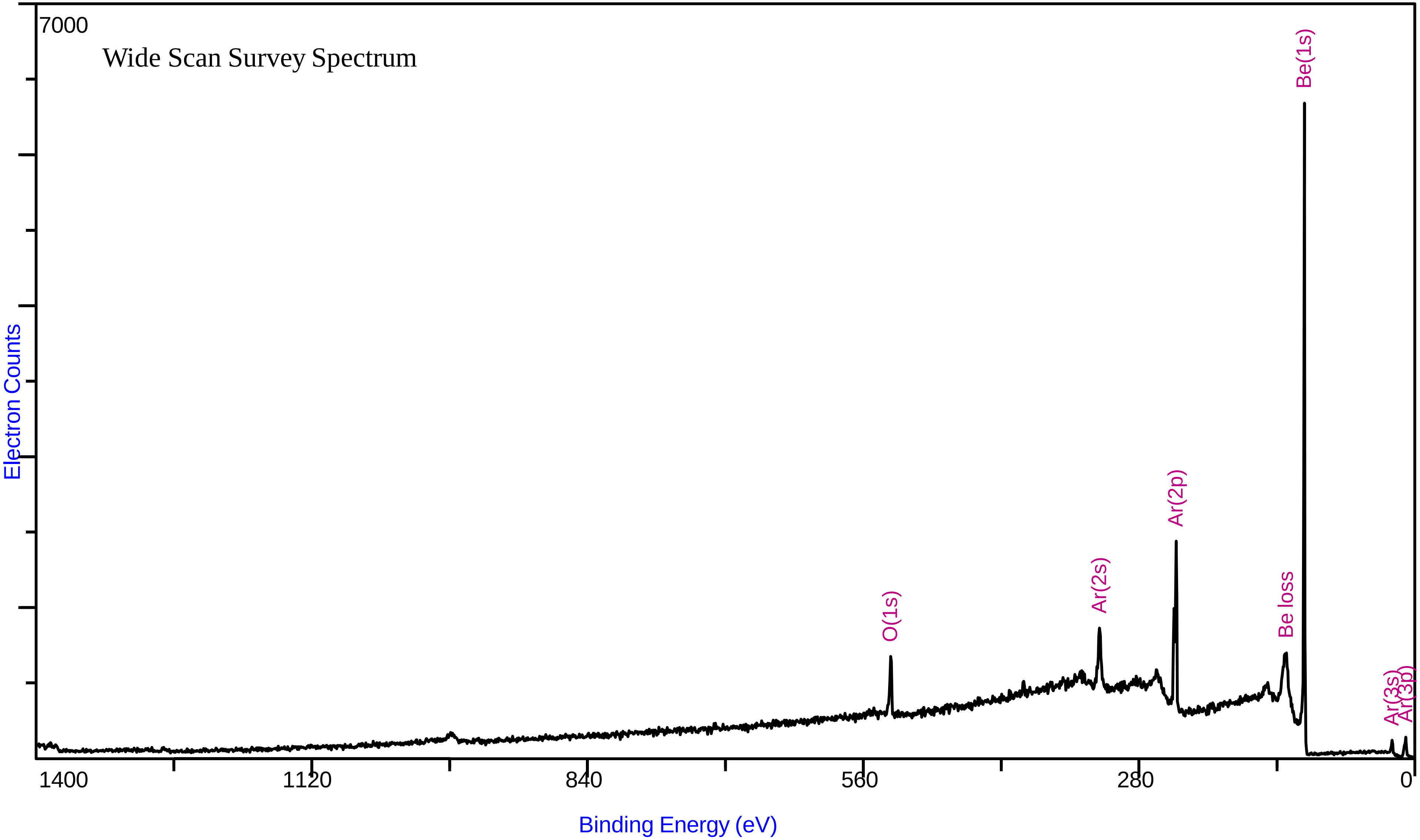
```
                     Detailed Surface Composition Table


        Description: Beryllium (Be)
        Date:        Mon Mar 7 1994

                        Corrected  Exper.   Sens        Norm   Relative
             Signal        BE        BE    Factor       Area     Area
               O 1s       531.6     531.6    2.80       1375      491
               Ar2s       319.5     319.5    1.96       2222     1135
               Ar2p       241.7     241.7    3.06       4162     1360
               Be loss    129.9     129.9    0.00       3989        0
               Be1s       111.5     111.5    0.20       8003    39951
               Ar3s        22.3      22.3    0.24        303     1283
               Ar3p         8.5       8.5    0.25        460     1824
```

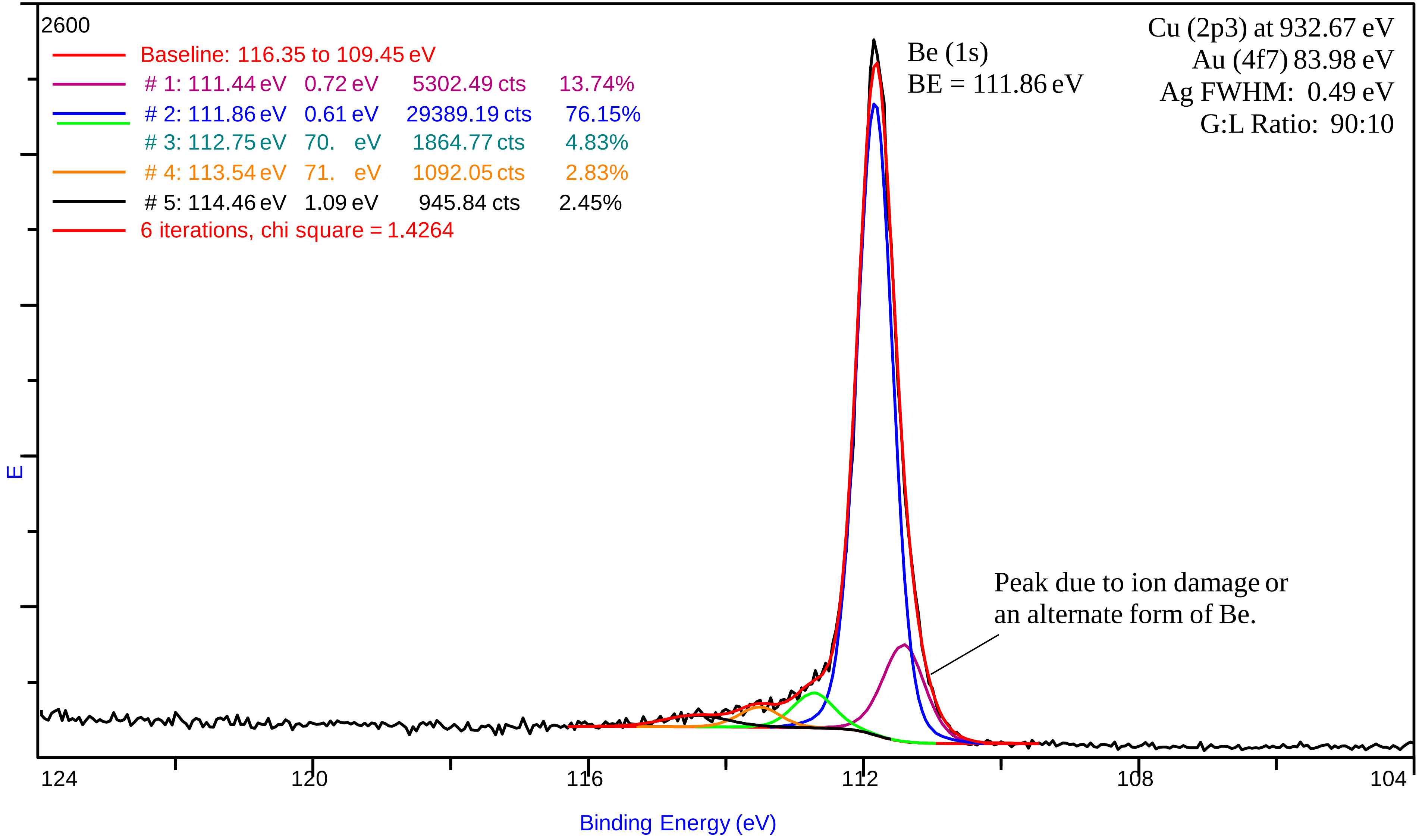
Beryllium Metal (Z=4) Be^0

[CAS# 7440-41-7]



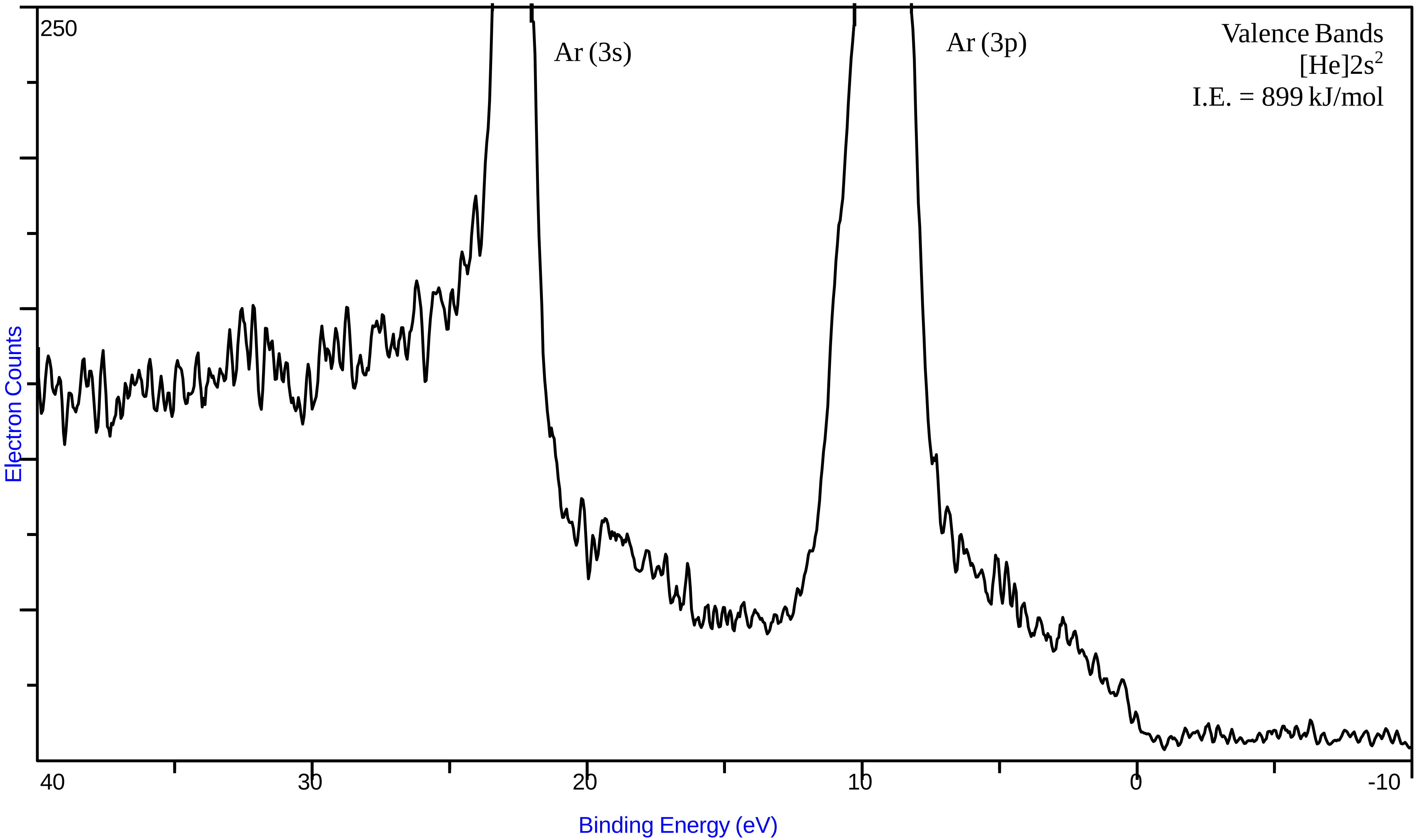
Beryllium Metal (Z=4) **Be^0**

[CAS# 7440-41-7]



Beryllium Metal (Z=4) **Be^0**

[CAS# 7440-41-7]



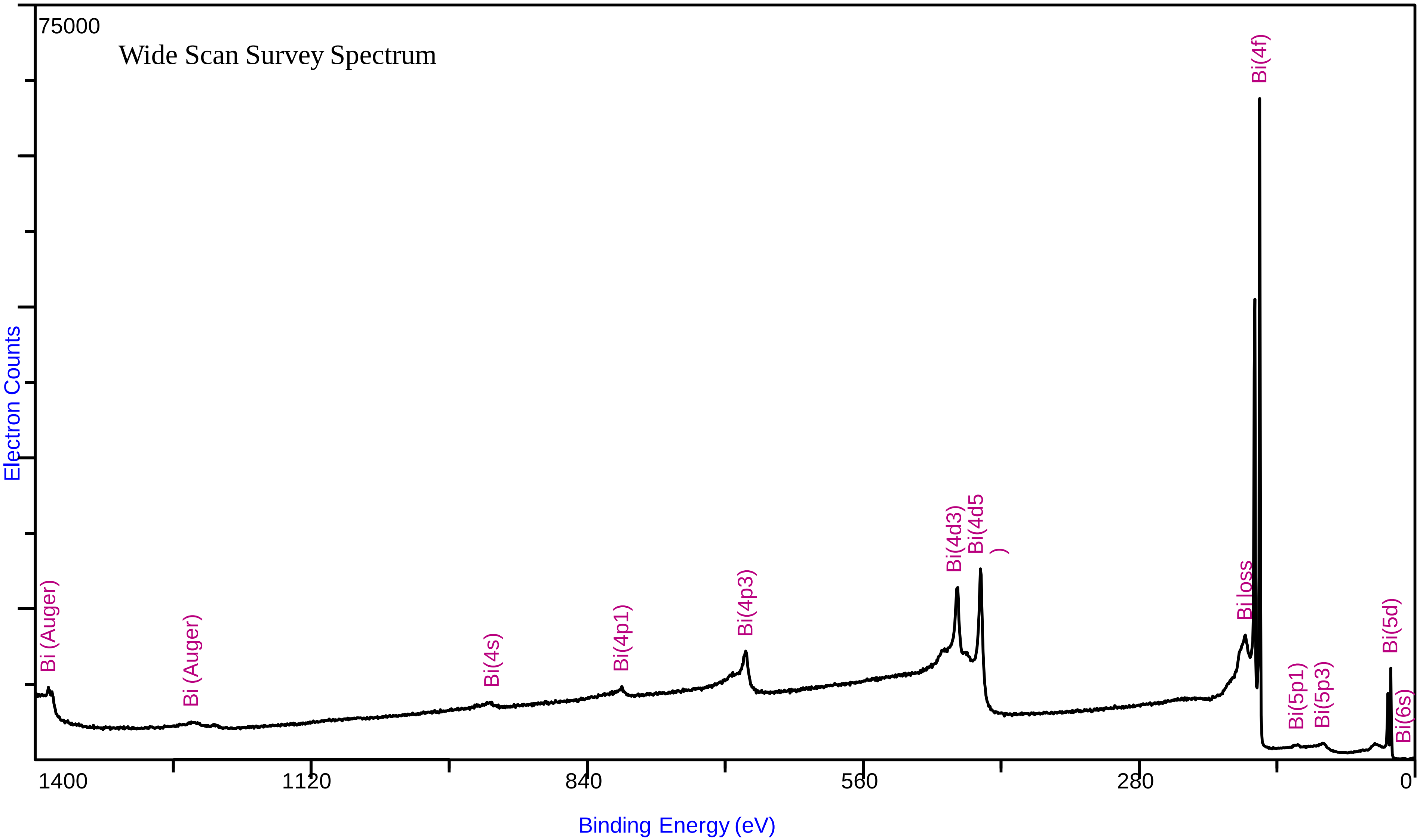
Detailed Surface Composition Table

Description: Bismuth (Bi)
Date: Mon Mar 7 1994

Signal	Corrected BE	Exper. BE	Sens Factor	Norm Area	Relative Area
Bi4s	936.6	936.6	1.68	3856	2300
Bi4p1	805.0	805.0	1.87	3434	1832
Bi4p3	678.7	678.7	5.99	10932	1827
Bi4d3	463.9	463.9	8.85	15819	1788
Bi4d5	440.3	440.3	13.07	28588	2187
Bi loss	171.8	171.8	0.00	11212	0
Bi4f	156.8	156.8	25.34	67957	2682
Bi5p1	118.2	118.2	0.56	706	1260
Bi5p3	92.8	92.8	1.45	1655	1140
Bi5d	23.8	23.8	3.12	9837	3153
Bi6s	10.5	10.5	0.09	174	1988

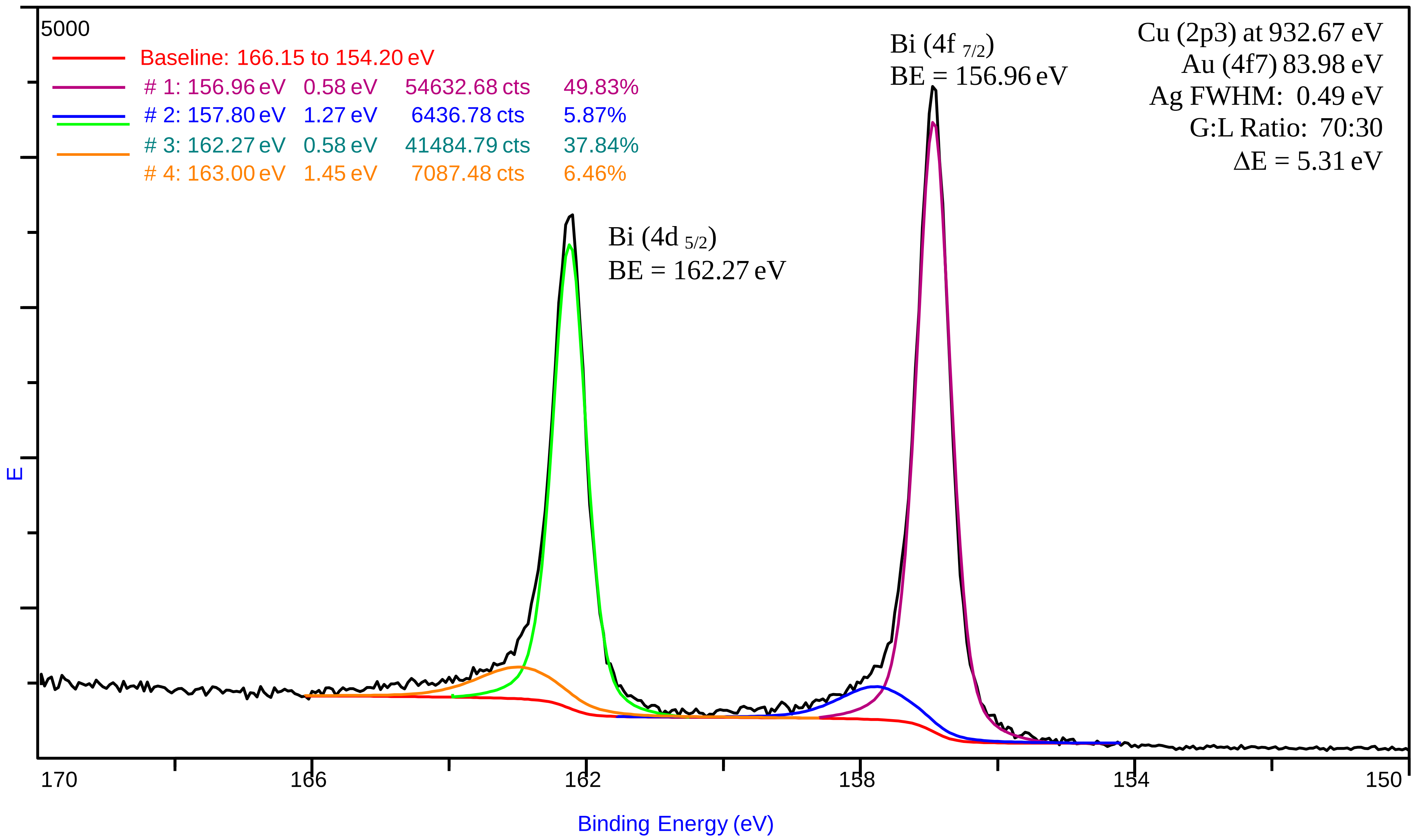
Bismuth Metal (Z=83) **Bi^0**

[CAS# 7440-69-9]



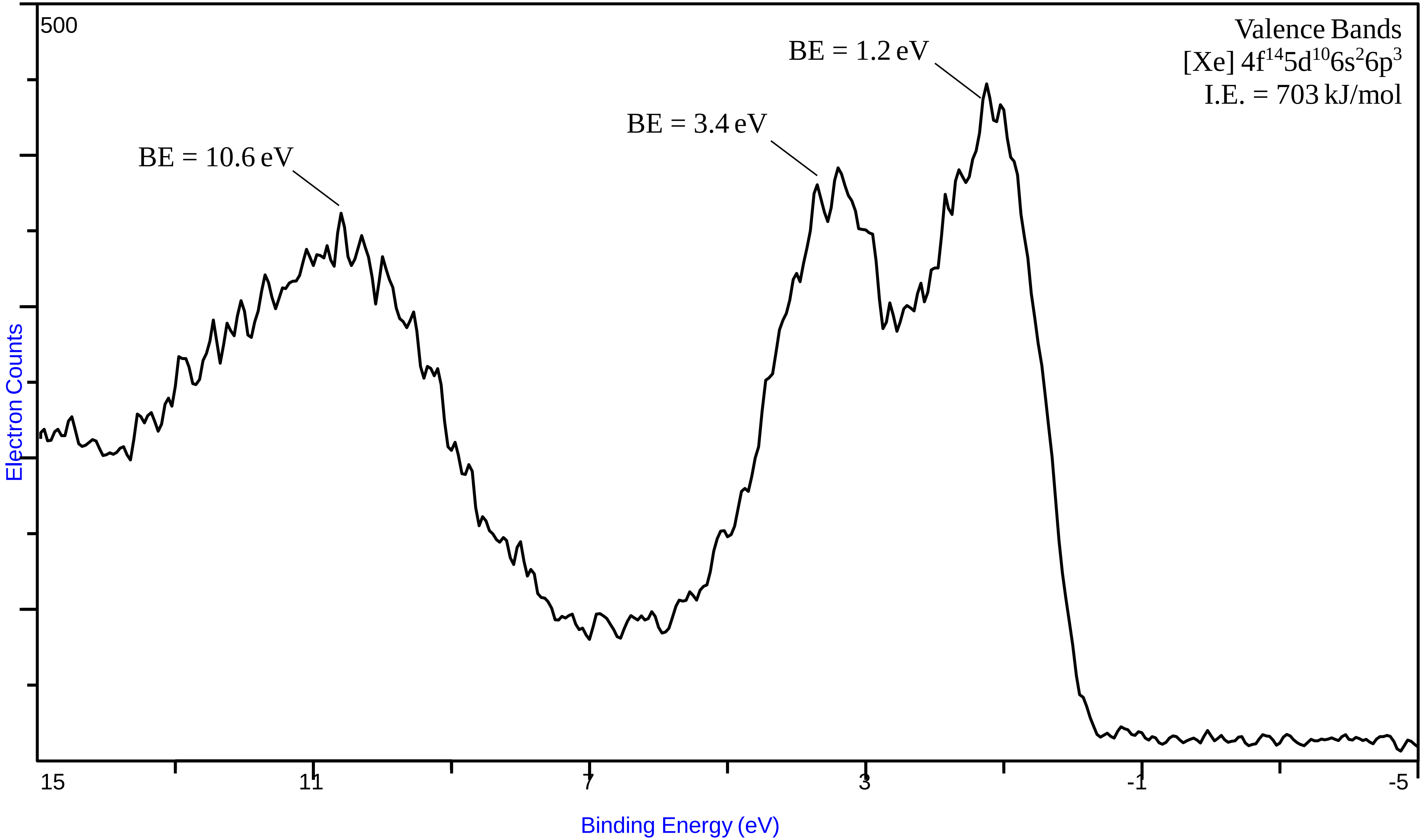
Bismuth Metal (Z=83) **Bi^0**

[CAS# 7440-69-9]



Bismuth Metal (Z=83) **Bi^0**

[CAS# 7440-69-9]



Bromine (Z=35) in Potassium Bromide (FW=119.01) **Br : KBr**

[CAS# 7758-02-3]

Detailed Surface Composition Table

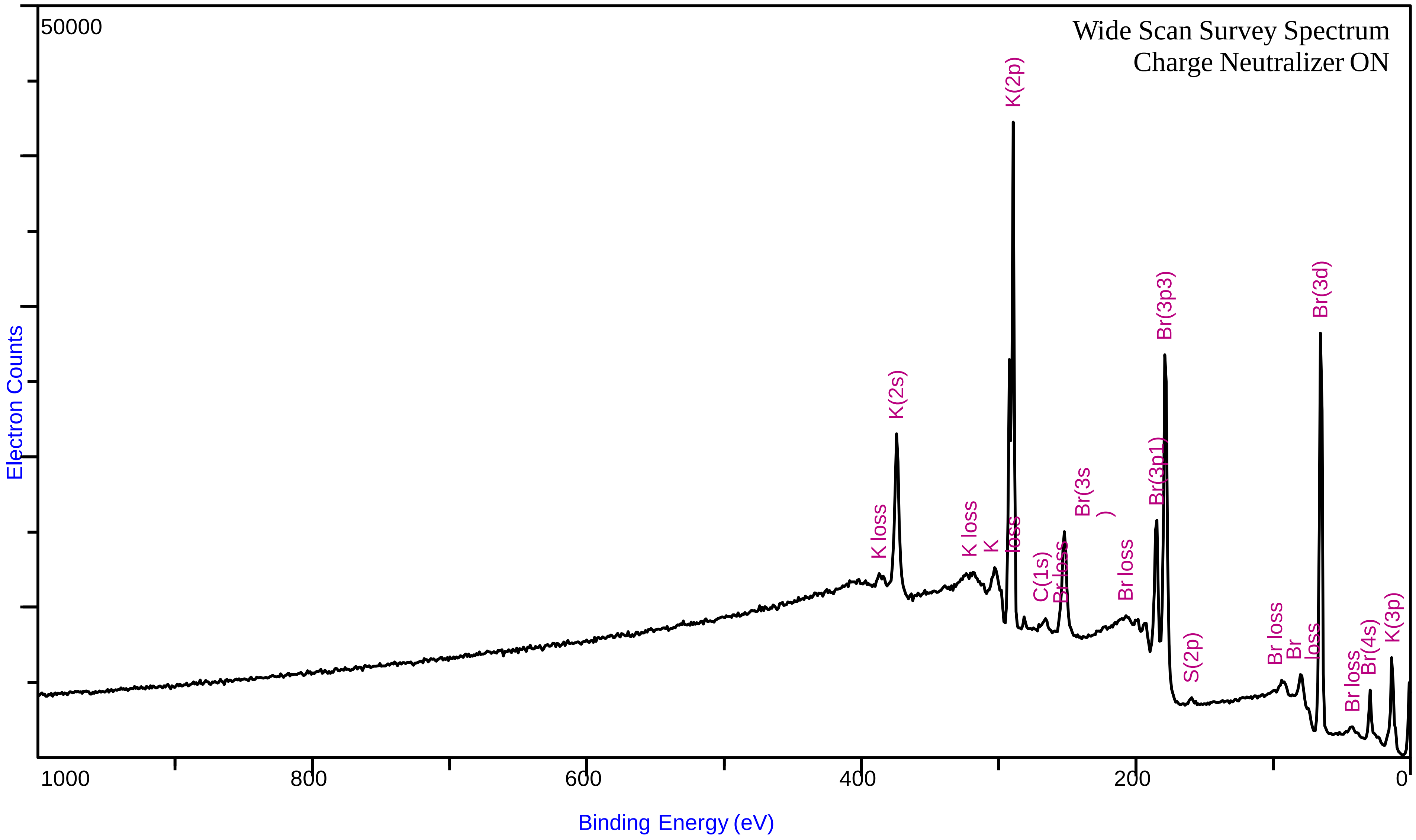
Description: POTASSIUM BROMIDE (KBr) CRYSTAL (17 HR IN VACUUM) **(Ref 6)**
Date: Mon Dec 15 1986

Signal	Corrected BE	Exper. BE	Sens Factor	Norm Area	Relative Area	Atom %
K loss	389.8	386.3	0.00	10051	0	
* K 2s	377.2	373.7	2.07	100049	48382	48.34
K loss	321.2	317.7	0.00	40521	0	
K loss	305.5	302.0	0.00	39599	0	
K 2p	292.2	288.7	3.95	242072	61227	
Br loss	268.7	265.2	0.00	9204	0	
Br3s	255.0	251.5	1.58	72740	46016	
Br loss	209.9	206.4	0.00	17984	0	
Br3p1	187.8	184.3	1.89	35873	18945	
Br3p3	181.2	177.7	3.67	140025	38194	
S 2p	162.2	158.7	1.89	4014	2124	
Br loss	96.3	92.8	0.00	16072	0	
Br loss	82.4	78.9	0.00	39435	0	
* Br3d	67.9	64.4	3.48	169762	48779	48.74
Br loss	45.0	41.5	0.00	12360	0	
Br4s	32.0	28.5	0.23	24934	106317	
K 3p	16.0	12.5	0.46	45428	98510	
* C 1s	285.0	281.5	1.00	2936	2927	2.92

Bromine (Z=35) in Potassium Bromide (FW=119.01)

Br : KBr

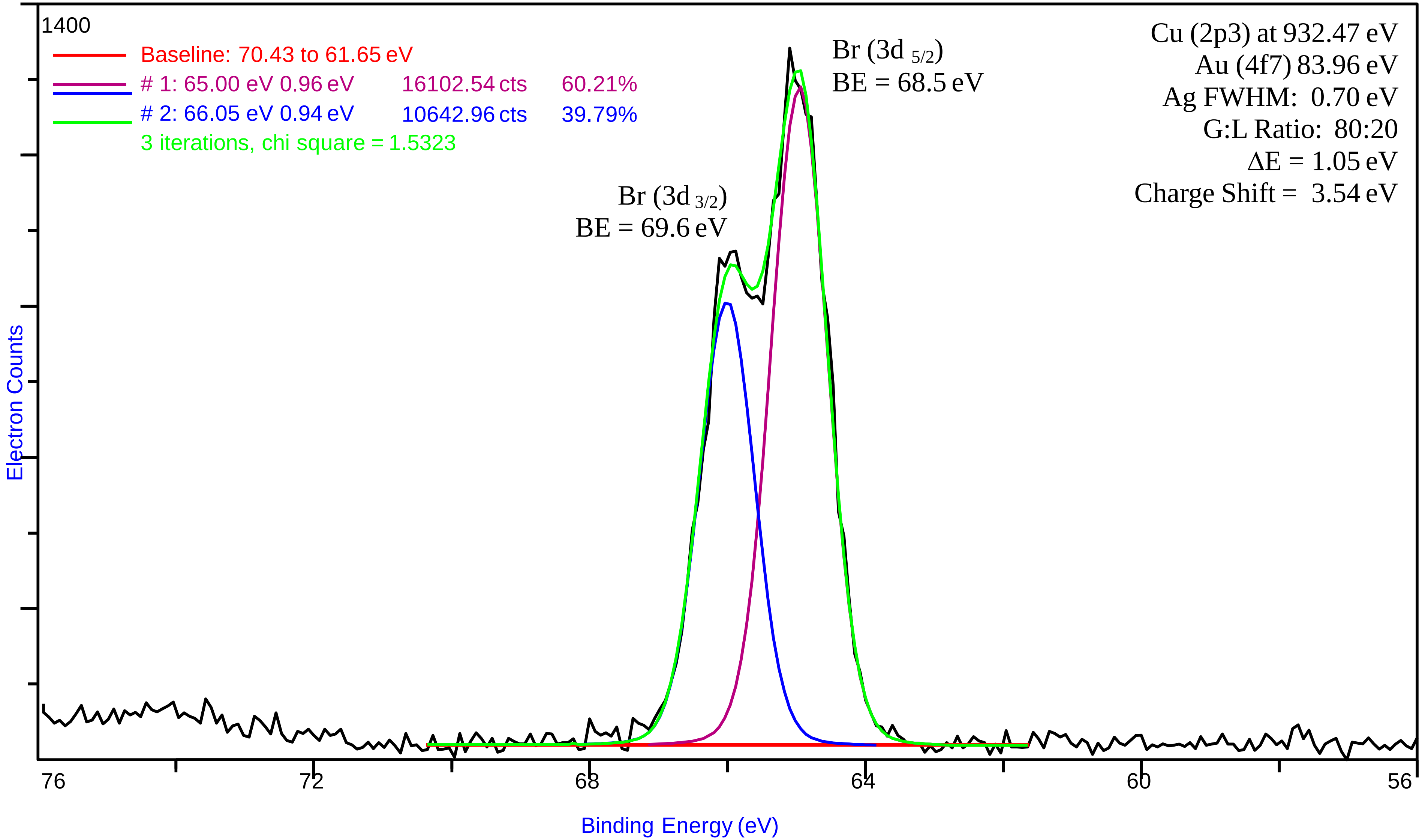
[CAS# 7758-02-3]



Bromine (Z=35) in Potassium Bromide (FW=119.01)

Br : KBr

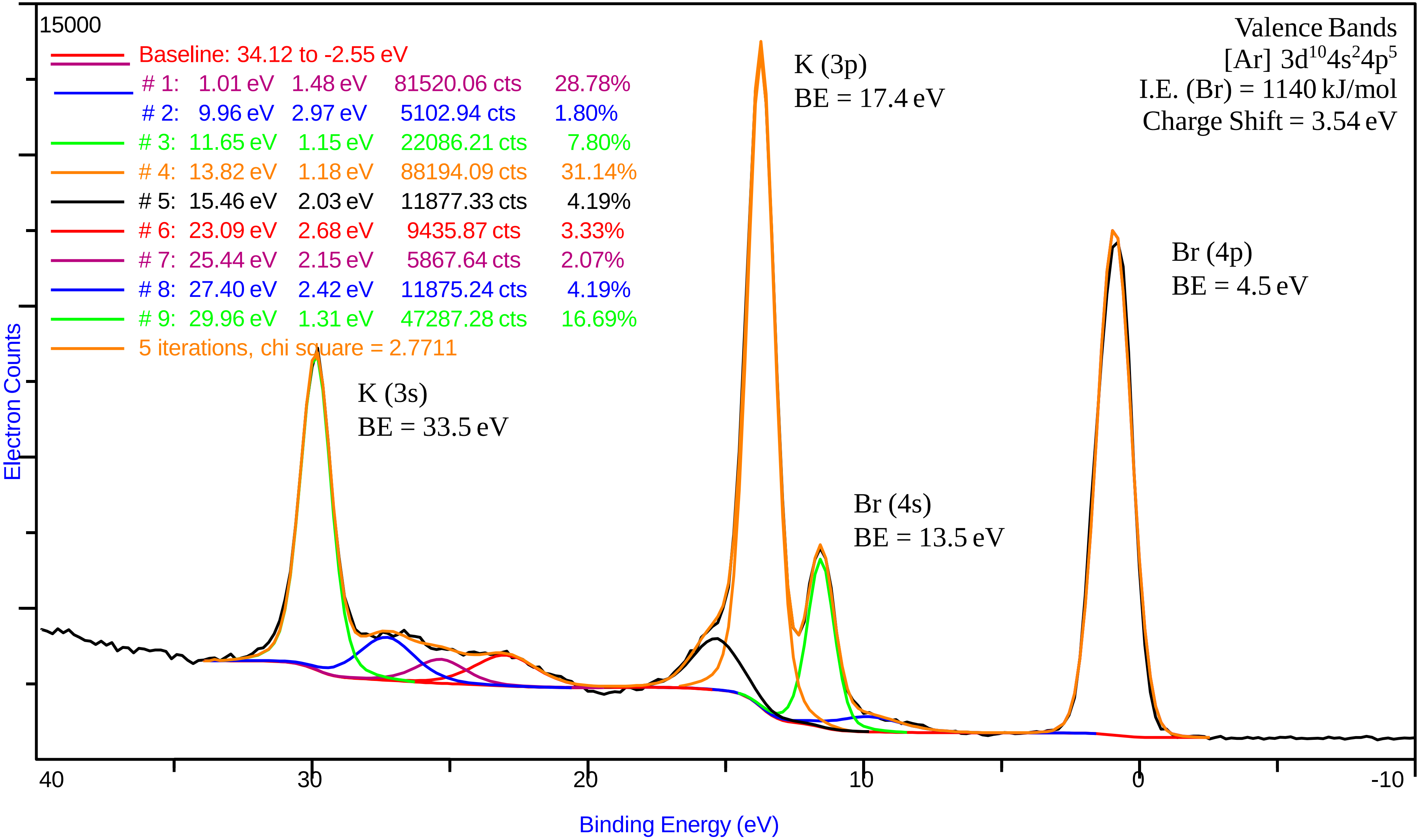
[CAS# 7758-02-3]



Bromine (Z=35) in Potassium Bromide (FW=119.01)

Br : KBr

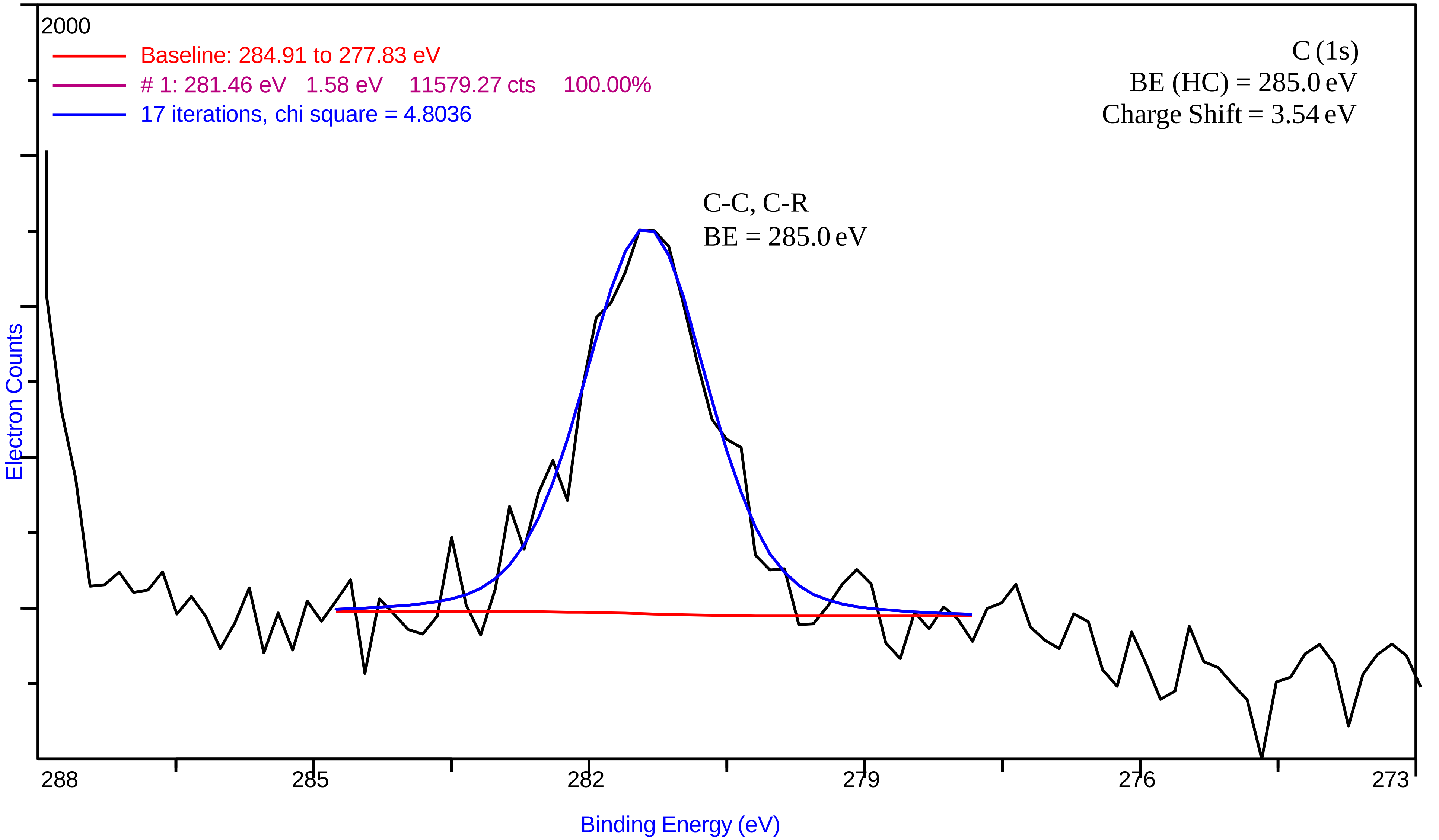
[CAS# 7758-02-3]



Bromine (Z=35) in Potassium Bromide (FW=119.01)

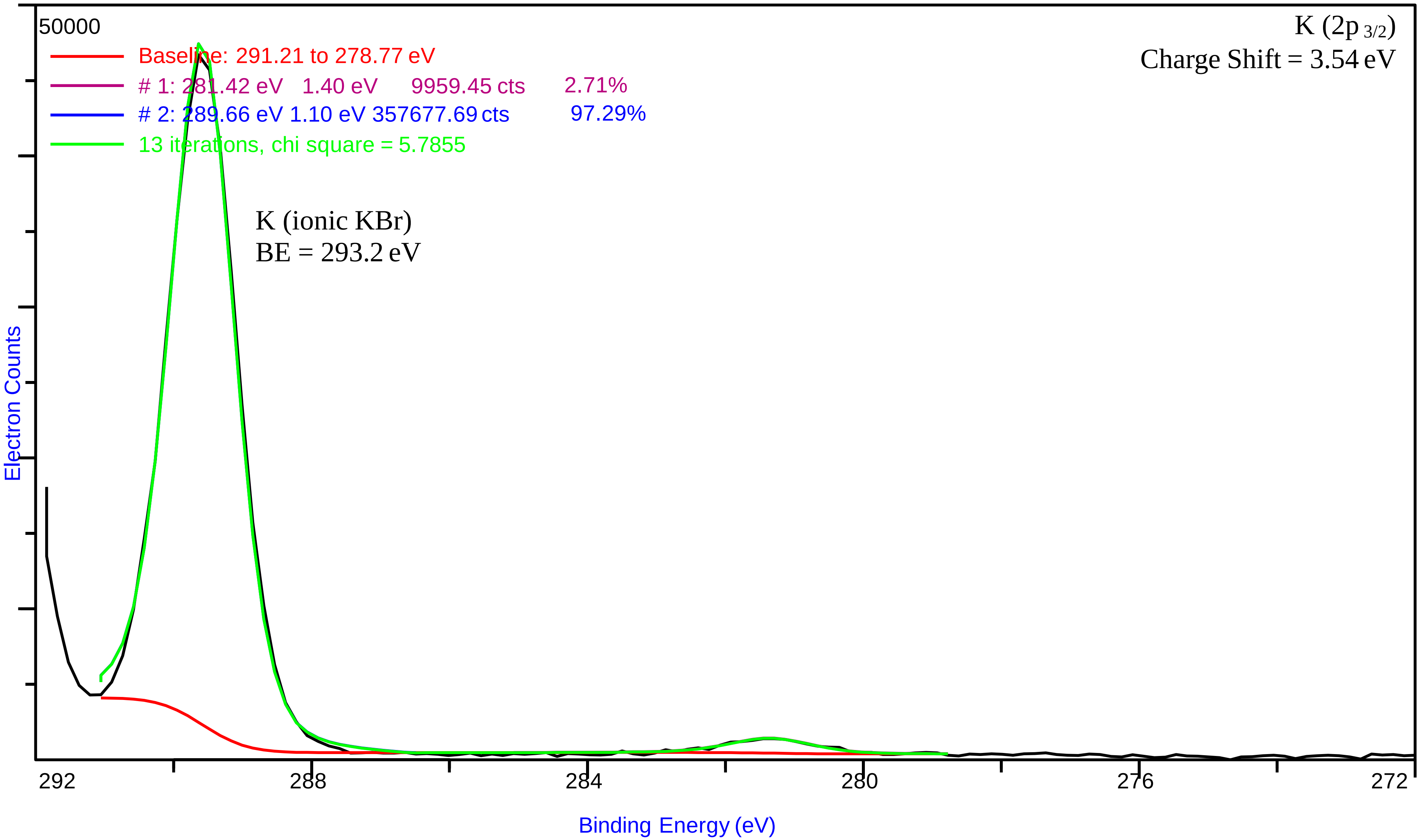
Br : KBr

[CAS# 7758-02-3]



Bromine (Z=35) in Potassium Bromide (FW=119.01) **Br : KBr**

[CAS# 7758-02-3]



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                    Detailed Surface Composition Table

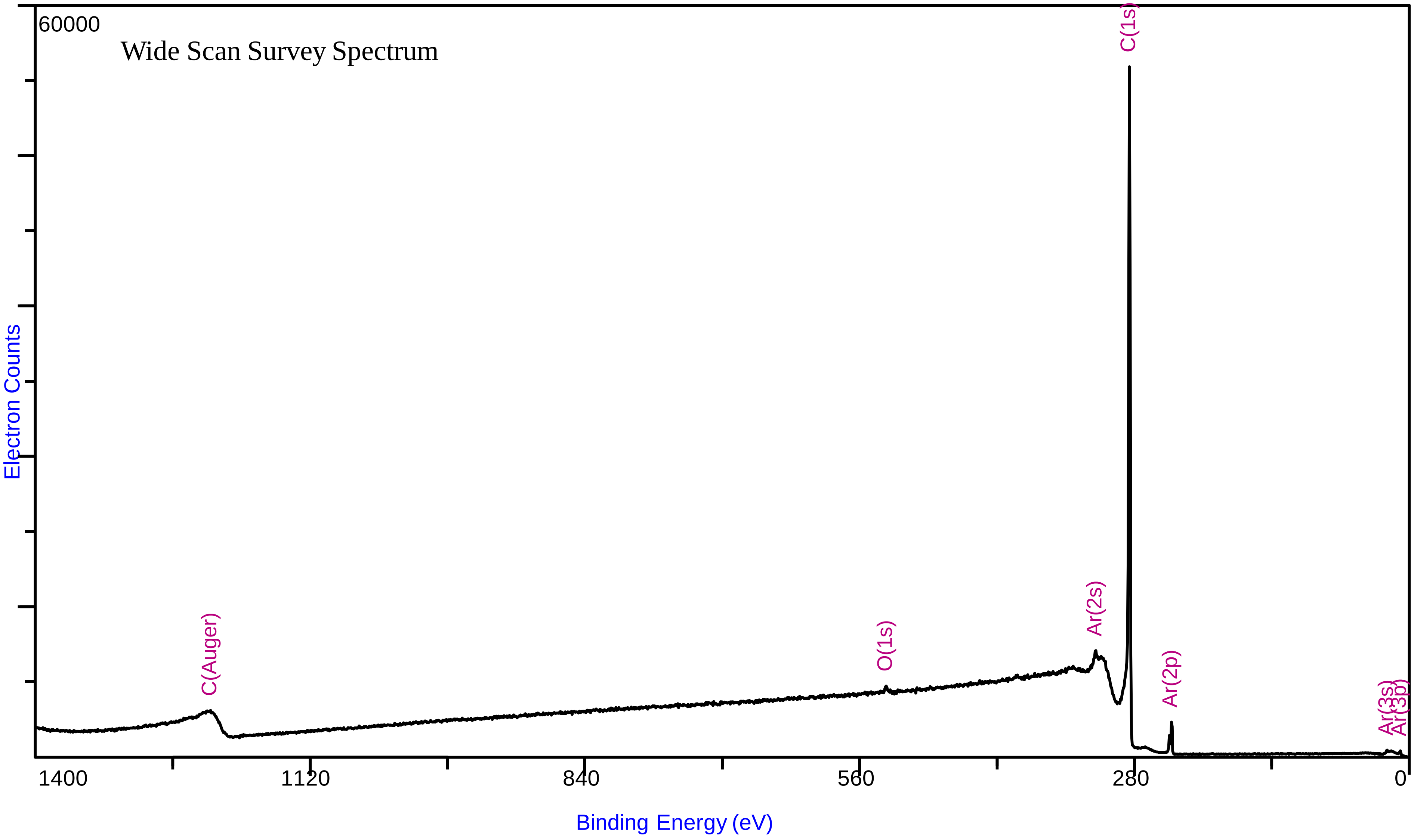
Description: Carbon (C) [amorphous]
Date:         Sun Mar 13 1994

               Corrected   Exper.   Sens        Norm   Relative
     Signal       BE         BE     Factor      Area     Area
     C Auger    1221.4    1221.4    0.00       11013        0
     O 1s        532.6     532.6    2.80         422      151
     Ar2s        319.1     319.1    1.96        1178      601
     C 1s        284.4     284.4    1.00       32524    32523
     Ar2p        241.5     241.5    3.06        1650      539
     Ar3s         21.9      21.9    0.24         514     2177
     Ar3p          8.5       8.5    0.25         101      400
```

Carbon (Z=6) Amorphous

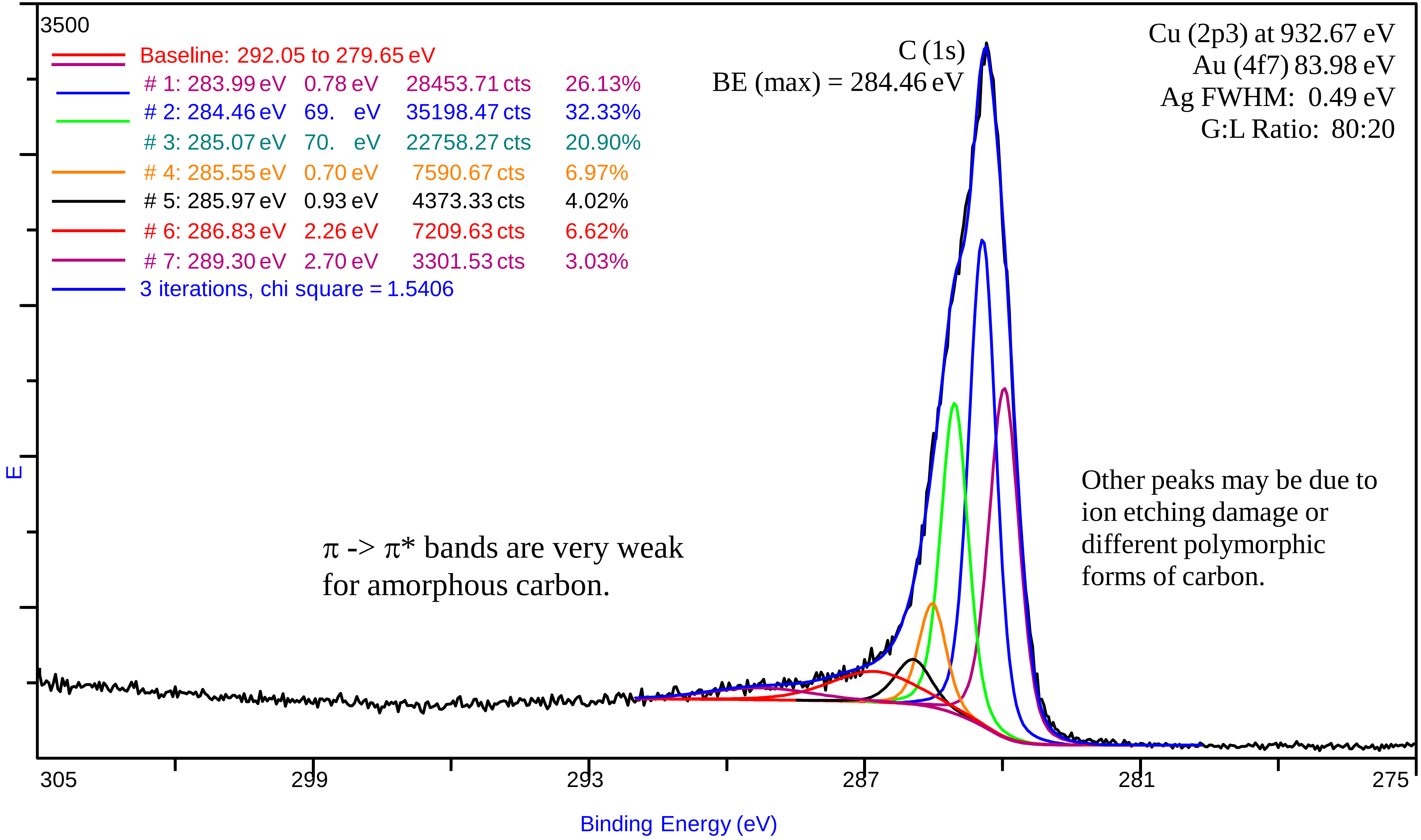
C^0

[CAS# 7440-44-0]



Carbon (Z=6) Amorphous C^0

[CAS# 7440-44-0]

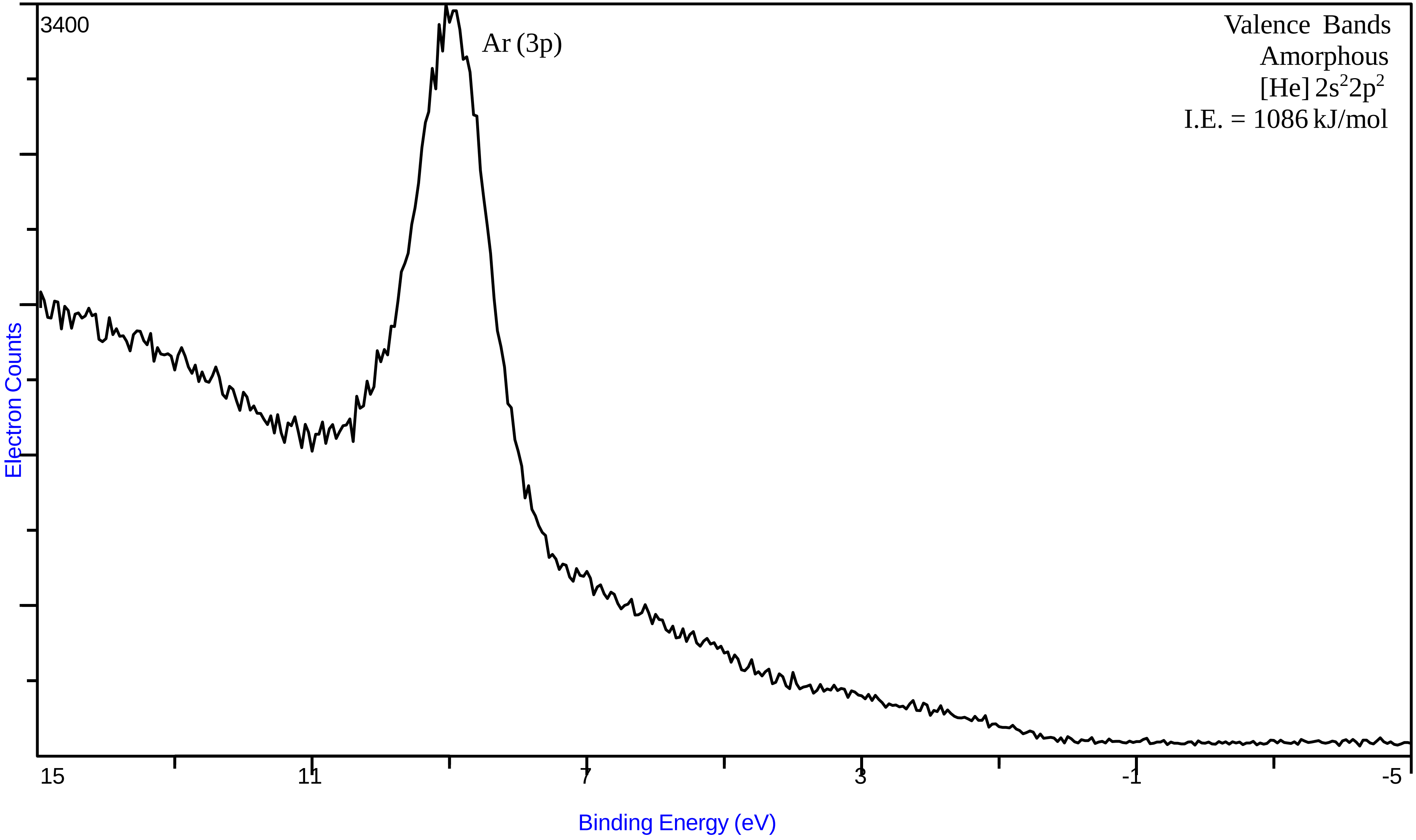


π -> π* bands are very weak for amorphous carbon.

Other peaks may be due to ion etching damage or different polymorphic forms of carbon.

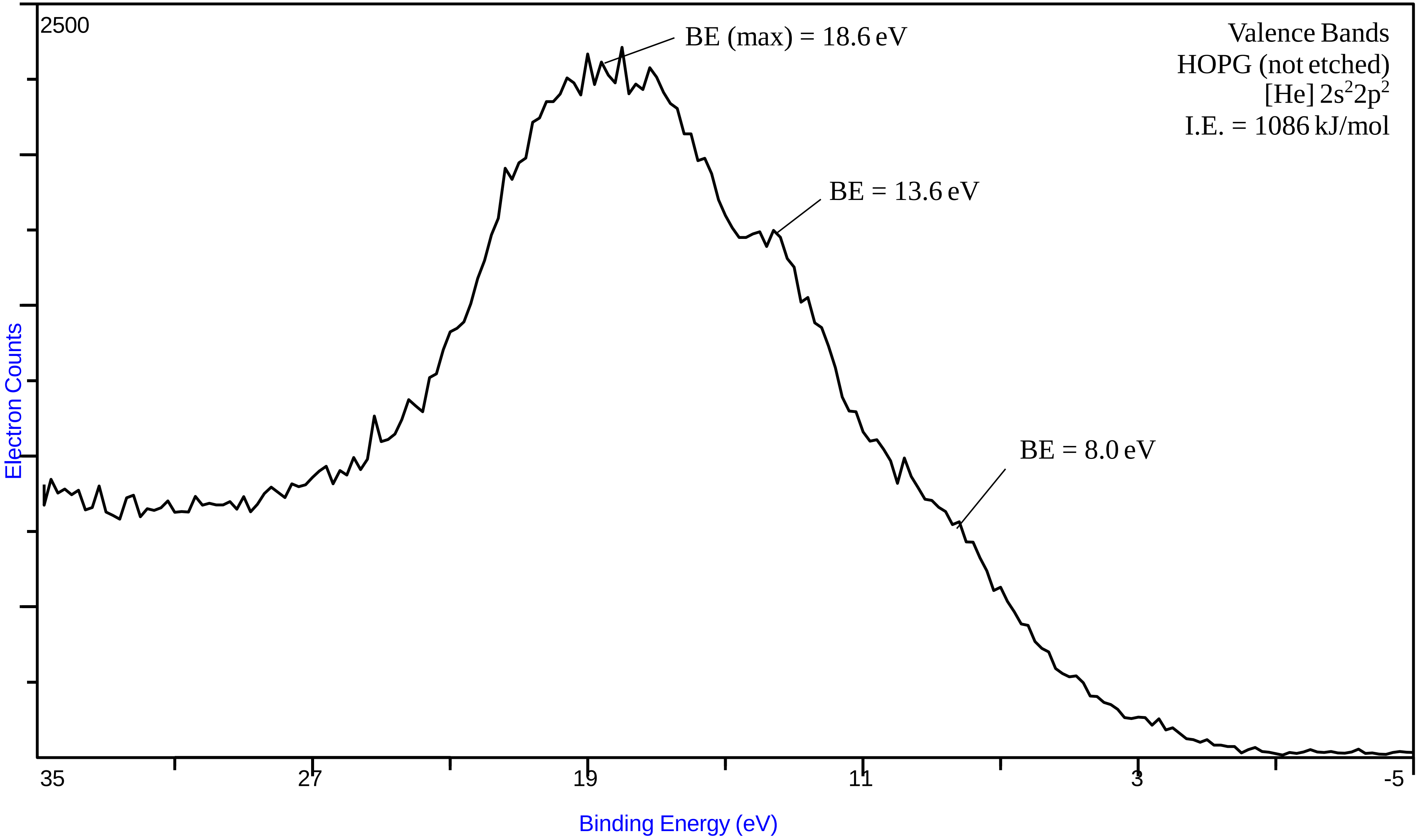
Carbon (Z=6)Amorphous **C^0**

[CAS# 7440-44-0]



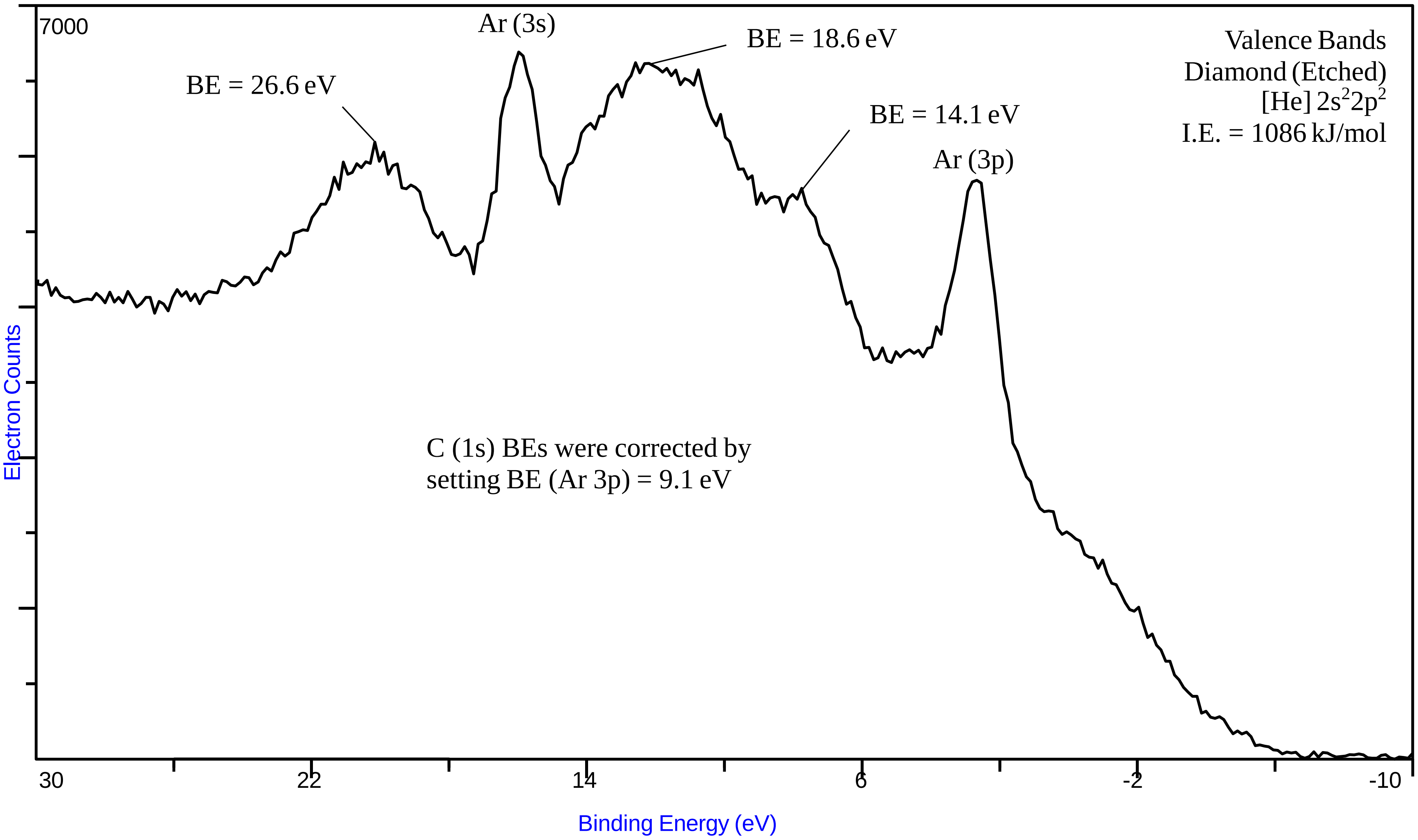
Carbon (Z=6) Highly Oriented Pyrolytic Graphite (HOPG) **C^0**

[CAS# 7440-44-0]



Carbon (Z=6) Argon Ion Etched Diamond Bulk **C^0**

[CAS# 7440-44-0]



C (1s) BEs were corrected by setting BE (Ar 3p) = 9.1 eV

BE Lookup Table for Signals from Elements and Common Chemical Species

1-82 eV

1.0	Bi	6p1	3.9	Pt	5d	10.0	P	3p	18.0	At	6s	24.0	Kr	4s	34.0	K	3s	44.0	Ra	6s	52.0	Tm	5s	65.7	V	3s
1.0	Ce	4f	4.0	Ir	5d	10.0	Ti	4s	18.0	Ce	5p	24.0	Sn	4d	35.0	Re	5p3	44.0	U	6s	52.3	Yb	5s	66.0	Ni	3p
1.0	Co	3d	4.0	Pm	4f	10.0	V	4s	18.0	Pr	5p	25.0	Th	6p1	35.2	Mo	4p	44.4	Y	4s	52.6	Fe	3p	66.0	Pt	5p1
1.0	Cr	3d	4.5	Ag	4d	10.0	Zr	5s	18.1	Hf	Ntv Ox	26.0	Bi	5d3	35.2	W	Na2WO4	1.	Ta	5p1	53.0	Sn	loss	67.8	Ta	5s
1.0	Fe	3d	4.8	Dy	5d	10.5	Bi	6s	18.2	C	2s	26.0	He	1s	35.3	Y	loss	2.	As	2O3	53.4	Os	4f5	68.0	Ra	5d
1.0	Ga	4p	5.0	B	2p	10.7	Cd	4d5	18.4	Sr	4p	26.0	Rn	6s	35.8	W	O3	45.5	As	Ntv Ox	54.0	Os	5p1	68.0	Tc	4s
1.0	Hf	5d	5.0	Br	4p	11.0	Kr	4p	18.7	Ga	3d5	26.1	Lu	5p	36.0	Ce	5s	45.7	Ge	loss	54.2	Se	CdSe	68.5	Br	3d5
1.0	In	5p	5.0	Ca	3d	11.0	Rn	6p	18.8	Ga	3d	26.8	Ta	2O5	36.0	Gd	5s	46.0	Re	5p1	54.5	Se	GeSe	68.5	Br	KBr
1.0	Na	3s	5.0	Er	4f	1.	Sc	4s	18.9	Ga	3d3	26.8	Zr	4p	36.6	Sr	4s	46.3	Ga	loss	54.9	Se	3d5	68.8	Cd	4p
1.0	Os	5d	5.0	Po	6p	2.	Cs	5p3	19.0	Eu	5p	27.0	Br	4s	36.7	V	3p	46.8	Re	2O7	54.9	Li	1s	69.0	Br	3d
1.0	Pb	6p	5.3	Se	4p	11.6	Cd	4d3	19.0	Nd	5p	28.2	Sc	3p	37.0	W	5p3	46.8	W	5p1	54.9	Li	OH	69.5	Br	3d3
1.0	Sn	5p	5.5	Cl	3p	12.0	Cs	5p	19.0	Pb	5d5	28.6	In	loss	37.5	Hf	5p1	47.0	Mn	3p	54.9	Se	3d	70.0	Re	loss
1.2	Yb	4f7	5.8	Au	5d	12.0	Po	6s	19.0	Ra	6p	28.8	Rb	4s	38.0	Pm	5s	47.0	Rh	4p	55.2	Se	GeSe2	71.0	Pt	4f7
1.4	Pd	4d	6.0	Ta	5d	12.0	Te	5s	19.0	Sm	5p	29.0	Dy	5p1	38.0	Pr	5s	47.9	Ru	4p	55.3	Li	CO3	71.8	Mg	loss
1.4	Rh	4d	6.0	Y	4d	12.0	Tl	5d5	19.1	Ga	Sb fract	29.0	Er	5p	38.3	Sn	loss	48.0	Dy	5s	55.6	Nb	4s	72.6	Pt	4f
2.0	Cd	5p	6.2	Hg	5d	12.6	Cs	5p1	19.4	Ga	AlAs etch	29.0	Lu	5p	39.0	Eu	5s	48.0	Rn	5d	55.7	Se	3d3	72.7	Al	2p3
2.0	Mg	3s	6.9	Eu	4f	13.0	Tl	5d	19.5	N	2s	29.1	Ge	3d5	39.0	Nd	5s	48.0	Sb	loss	56.8	Au	5p3	72.9	Al	2p
2.0	Mo	4d	7.0	O	2p	13.2	Rb	4p	19.7	Ga	P fract	29.2	F	2s	39.0	Tc	4p	48.5	I	4d	56.8	Lu	5s	73.1	Tl	5p3
2.0	Nb	4d	7.0	Sm	4f	13.2	Rb	4p	19.7	Ga	As fract	29.4	Ge	3d	39.5	Tm	5p	49.5	Ho	5s	57.4	Er	5s	73.2	Al	2p1
2.0	Nd	4f	7.0	Sn	5s	14.0	Ne	2p	20.0	U	6p	29.5	Ho	5p1	40.0	At	5d	5.	Mg	CO3	58.0	Ag	4p	73.8	Al	N
2.0	Ni	3d	1.	Xe	5p	14.0	Sc	3d	20.2	Zn	loss	29.7	Ge	3d3	40.0	Ba	5s	6.	Mg	(OH)2	58.0	Fr	5d	74.0	Au	5p1
2.0	Pr	4f	2.	Lu	4f7	14.2	Hf	4f7	20.5	Gd	5p	30.2	Ge	Se	40.0	In	loss	6.	Mg	2p3	58.0	Hg	5p3	74.2	Cr	3s
2.0	Sb	5p	7.1	Tb	4f	15.0	Fr	6p	20.7	Ga	2O3	30.3	Na	2p	40.0	Tb	5s	7.	Mg	O	58.1	W	loss	74.3	Al	2O3
2.0	Sc	4p	7.	Gd	4f	15.0	H	1s	21.0	Pb	5d3	30.9	Nb	4p	40.1	Te	4d	8.	Mg	2p	58.2	Ti	3s	74.3	Al	2O3-nH2O
2.0	Tc	4d	8.	Dy	4f	15.0	Hf	4f	21.6	Ta	4f7	30.9	Pb	loss	40.2	Re	4f7	9.	Mg	2p1	58.3	Te	loss	74.4	Pt	4f5
2.0	Ti	3d	8.0	At	6p	15.0	Rb	4p1	21.8	Tb	5p	31.0	Hf	5p3	41.0	Ne	2s	50.0	Mg	CO3	58.6	Ag	4p	74.4	Al	(OH)3
2.0	V	3d	8.0	S	3p	15.0	Tl	5d3	22.0	Dy	5p3	31.0	Po	5d	41.0	Sm	5s	50.0	Sr	loss	58.9	Y	loss	74.9	Cu	3p
2.0	Yb	4f	8.3	Ho	4f	15.7	Cl	3s	22.0	Pm	5p	31.3	W	4f7	41.2	Re	4f	3.	Zr	4s	59.0	Co	3p	74.9	Se	loss
2.0	Zr	4d	3.	Lu	5d	15.9	Hf	4f5	22.3	Ar	3s	31.5	Ge	Se2	41.4	Re	Ntv Ox	4.	Mg	NtvOx1	59.2	As	loss	75.0	Cs	4d5
5.	Yb	4f5	4.	Lu	2O3	15.9	I	5s	22.7	Ta	4f	31.7	Sb	4d	41.5	As	3d5	50.7	Os	4f7	60.8	Ir	4f7	75.1	Pt	O2-nH2O
6.	Te	5p	5.	Tm	4f7	16.0	K	3p	23.0	Cs	5s	32.1	Ga	loss	41.8	As	3d	50.7	Pd	4p	61.0	Mg	loss	75.1	W	5s
2.8	Cu	3d	6.	Lu	4f5	16.0	P	3s	23.1	O	2s	32.3	W	4f	42.0	As	S	50.7	Sc	3s	62.0	Ir	4f	75.5	Al	Ntv Ox
2.8	Mn	3d	8.9	Ar	3p	16.0	S	3s	23.3	Ho	5p3	32.4	Ti	3p	42.0	Th	6s	50.9	Mg	reoxid	62.0	Ir	O2	76.0	Cs	4d
2.8	Re	5d	9.0	F	2p	16.9	In	4d	23.3	Y	4p	32.6	Ta	5p3	42.1	Ca	3s	51.0	Ir	5p3	62.0	Ir	5p1	77.8	Ni	loss
2.8	Si	3p	9.0	Ru	4d	17.0	La	5p	23.4	Ta	S2	33.0	La	5s	42.1	Cr	3p	51.0	Mg	NtvOx2	62.0	Mo	4s	78.3	In	4p
2.8	W	5d	9.0	Sb	5s	17.0	Th	6p3	23.5	Ca	3p	33.2	Ge	O2	42.2	As	3d3	4.	Os	4f	62.0	Xe	4d	79.0	Cs	4d3
3.0	Ge	4p	1.	Si	3s	1.	Xe	5s	23.5	Yb	5p	33.4	Lu	5p	42.7	Re	4f5	5.	Pt	5p3	62.3	Hf	5s	80.0	Ru	4s
3.0	I	5p	2.	As	4p	2.	Hf	O2	23.8	Bi	5d	33.5	W	4f5	42.7	Ta	loss	51.5	Mg	reoxid	62.7	Ir	Ntv Ox	80.7	Rh	4s
3.0	Pb	6s	9.7	Zn	3d	17.7	Pb	5d	24.0	Ta	4f5	33.8	Ge	Ntv Ox	43.0	As	2S3	51.7	Re	loss	63.3	Na	2s	81.0	Hg	5p1
3.2	Bi	6p3	10.0	Ba	5p	17.9	Ga	InAs (ar)	24.0	Bi	5d5	34.0	Fr	6s	44.0	Os	5p3	51.9	Mg	NtvOx3	63.8	Ir	4f5	81.8	Re	5s

BE Lookup Table for Signals from Elements and Common Chemical Species

82-275 eV

82.0	Br	loss
82.0	Mn	3s
82.7	Pb	5p3
84.0	Au	4f7
84.0	Ba	4d3
84.7	Ba	4d
85.0	Au	4f
85.0	Th	5d5
86.0	Ba	4d5
86.9	Kr	3d5
87.2	Kr	3d
87.7	Au	4f5
1.	Al	loss
2.	Au	2O3
3.	Kr	3d3
2.	Pd	4s
3.	Zn	3p
1.	Os	5s
2.	Mg	2s
90.6	Sn	4p
91.0	Fe	3s
92.8	Bi	5p3
93.0	Th	5d3
94.0	U	5d5
94.6	Tl	5p1
95.2	Ir	5s
96.0	Br	loss
97.0	Ag	4s
98.7	Er	Auger
99.8	Si	2p3
8.	Mg	loss
9.	Hg	4f7
1.	Si	2p
2.	Si	O
100.4	Si	2p1
100.4	Si	C
6.	Sb	4p
7.	Hg	O
100.9	Co	3s
100.9	Hg	S
8.	Si	Almand.
9.	Hg	4f
102.0	Pt	5s
102.0	Si	3N4
102.6	Si	O
102.9	Zn	loss
103.0	Ga	3p
103.0	Ga	3p3
103.0	Pt	loss
103.0	Si	O2
103.0	U	5d3
103.5	Si	O2-nH2O
103.7	Al	loss
103.9	Hg	4f5
104.0	La	4d
104.0	Po	5p3
106.3	Pb	5p1
107.0	Ga	3p1
108.0	Au	5s
109.7	Rb	3d5
109.7	Rb	OAc
109.9	Cd	4s
110.0	Ce	4d
110.0	Rb	3d
5.	Ni	3s
6.	Mg	loss
111.2	Rb	3d3
111.8	Be	1s
112.6	Te	4p
113.6	Be	O
114.7	Be	Ntv Ox
115.0	At	5p3
115.0	Pr	4d
115.5	Se	Auger
116.2	Si	loss
117.7	Tl	4f7
117.9	Al	2s
118.0	Nd	4d
118.2	Bi	5p1
118.2	Tl	2O3
119.4	Ga	loss
119.4	Tl	CO3
120.0	Hg	5s
120.0	Tl	4f
1.	Pm	4d
2.	I	4p
3.	Ge	3p3
4.	Tl	4f5
122.4	Cu	3s
122.4	In	4s
127.0	Rn	5p3
2.	Eu	4d5
3.	Tl	loss
128.6	P	InP etch
129.0	Ge	3p1
129.0	P	InP etch
129.0	Sm	4d
129.3	P	GaP etch
130.0	Be	loss
1.	Ho	Auger
2.	P	2p3
130.6	P	2p
131.4	P	2p1
132.0	Po	5p1
132.7	Ga	loss
133.4	Al	loss
6.	Si	loss
7.	Sr	3d5
133.7	Sr	CO3
134.0	Sr	3d
134.9	Sm	2O3
5.	Sr	3d3
6.	Eu	2O3
136.8	Pb	O2
8.	Rb	loss
9.	Pb	4f7
1.	Tl	5s
2.	Sn	4s
5.	Pb	O
6.	Pb	3O4
137.8	Pb	2O3
137.8	Se	Auger
138.3	Pb	4f
138.5	Ge	loss
138.8	Pb	Ntv Ox
139.0	Pb	CO3
139.0	Xe	4p
139.5	Zn	3s
140.0	Fr	5p3
140.3	Gd	4d5
140.7	As	3p3
141.2	Gd	2O3
141.7	Pb	4f5
142.0	As	3p
145.9	Tb	4d5
146.0	Sr	loss
147.0	As	3p1
148.0	At	5p1
148.0	Pb	5s
148.5	Tb	F3
148.8	Al	loss
149.8	Pb	loss
149.9	P	loss
149.9	Tb	3O7
150.5	Si	2s
152.0	Zn	loss
152.3	Dy	4d5
152.9	Sb	4s
153.0	Ra	5p3
155.8	Y	3d5
156.1	Dy	2O3
156.6	Y	2O3
157.0	Bi	4f7
157.0	Bi	4f
157.0	Bi	loss
157.0	Y	3d
157.9	Y	3d3
158.5	Cs	4p3
158.8	Bi	2O3
158.9	Ga	3s
158.9	Y	2(CO3)3
159.2	Bi	Ntv Ox
159.6	Ho	4d5
160.0	Bi	5s
161.2	S	PbS
161.3	Ho	2O3
161.5	S	CuS, TaS2
161.7	Se	3p3
161.9	S	HgS
162.2	S	MoS2
162.3	Bi	4f5
162.4	S	Na2S2O3
162.6	S	FeS2
163.9	S	2p3
164.0	Rn	5p1
164.0	S	2p
164.0	Sr	loss
165.1	S	2p1
166.6	S	Na2SO3
167.3	Er	4d5
167.3	Se	3p1
167.6	Si	loss
168.5	Er	2O3
168.5	S	Na2SO4
168.5	S	Na2S2O3
168.6	P	loss
168.8	Y	loss
169.1	Te	4s
169.3	Er	4d3
173.0	Ba	4p
173.3	Ga	loss
175.4	Tm	4d
175.9	Tb	loss
176.3	Tm	2O3
177.0	Po	5s
177.0	Th	5p3
178.7	Se	Auger
178.7	Zr	3d5
179.9	Zr	3d
180.9	Cs	4p1
1.	Ge	3s
2.	Zr	3d3
3.	Br	3p3
182.0	Br	3p
1.	Fr	5p1
2.	Yb	4d5
182.4	Zr	O2
182.8	Er	Auger
183.7	Si	loss
184.0	Po	4f
184.9	Yb	2O3
185.3	S	loss
185.5	I	4s
8.	Br	3p1
9.	B	CrB
188.0	B	1s
1.	B	MoB, LaB6
2.	B	WB
3.	B	Ni3B
188.9	B	Ntv Ox
189.0	P	2s
189.2	Tm	Auger
8.	B	N
9.	Yb	4d3
194.0	B	2O3
195.0	At	5s
195.0	U	5p3
1.	Lu	4d5
2.	Zr	loss
197.0	La	4p3
197.5	Ge	Auger
198.4	Se	Auger
198.7	Cl	2p
198.9	Cl	2p3
198.9	Cl	MCl
199.8	Cl	C-Cl
200.0	Ra	5p1
200.5	Cl	2p1
201.4	Nb	3d
202.3	Nb	3d5
204.1	Nb	NbO
205.0	Nb	3d3
205.1	S	loss
205.8	Lu	4d3
206.1	Nb	NbO2
207.0	Ce	4p3
207.0	Xe	4s
207.3	P	loss
207.4	Nb	Nb2O5
207.4	Nb	Ntv Ox
208.0	Kr	3p3
210.0	At	4f
210.8	Hf	4d5
210.9	Dy	Auger
213.0	B	loss
213.0	La	4p1
214.0	Rn	5s
217.5	Cl	loss
218.0	Pr	4p3
220.5	Se	Auger
221.3	Hf	4d3
223.0	Ce	4p1
225.7	As	3s
226.1	Ta	4d5
228.0	Mo	3d5
228.0	Nd	4p3
229.0	S	2s
229.4	Mo	O2 (?)
229.5	Mo	3d
229.7	Mo	S2
229.9	Se	3s
230.0	As	Auger
231.1	Mo	3d3
232.6	Mo	Ntv Ox
232.9	Tb	Auger
233.0	Kr	3p1
233.1	Mo	O3
234.0	Fr	5s
234.0	Pr	4p1
234.0	Th	5p1
235.3	Mg	Auger
237.0	Pm	4p3
237.6	Ta	4d3
237.9	Rb	3p3
238.0	Cs	4s
238.0	Rn	4f
238.9	Mo	loss
241.8	Ar	2p3
242.0	Ar	2p
243.1	W	4d5
243.9	Ar	2p1
245.0	Nd	4p1
248.0	Ba	4s
248.0	Rb	3p1
249.6	S	loss
250.0	Sm	4p3
253.0	Mo	loss
253.0	Tc	3d
253.0	Tc	3d5
254.0	Ra	5s
255.0	Br	3s
255.0	Eu	4p3
255.0	Pm	4p1
255.1	Se	Auger
255.6	W	4d3
257.0	Tc	3d3
260.0	Re	4d5
260.0	U	5p1
261.0	As	Auger
261.5	Tb	Auger
264.3	Rb	loss
267.5	S	loss
267.7	W	loss
268.0	Fr	4f
268.4	Sr	3p3
270.0	Cl	2s
271.3	Gd	4p3
273.5	Re	4d3
274.5	Er	Auger
275.0	La	4s

BE Lookup Table for Signals from Elements and Common Chemical Species 278-609 eV

278.7	Sr	3p1
279.0	Os	4d5
280.1	Ru	3d5
281.0	Ru	Ntv Ox
281.1	Ru	O2
282.2	Ru	3d
282.6	C	VC
282.9	C	NbC
283.0	C	TaC
283.0	Sm	4p1
284.0	Tb	Auger
284.2	Ru	3d3
284.5	C	HOPG
284.5	Se	Auger
285.0	C	1s
285.4	C	C-OR
286.0	Cl	loss
286.0	Tb	4p3
287.0	C	C-Cl
287.8	C	C=O, C-F
288.9	C	COOR
289.0	Eu	4p1
289.0	Kr	3s
289.4	C	MCO3
290.0	Ce	4s
290.6	Gd	4p1
290.8	C	C-CO3, CF2
291.7	C	pi->pi*
292.7	C	CF3
292.9	K	2p3 KX
293.0	Os	4d3
294.0	Th	5s
295.0	K	2p
295.6	Dy	4p3
295.7	K	2p1
296.2	Ir	4d5
296.2	Se	Auger
299.0	Ra	4f
299.2	Y	3p3
300.6	Sr	loss
301.6	Mg	Auger
305.0	Pr	4s
305.5	K	loss
307.2	Rh	3d5
308.5	Rh	Ntv Ox
308.9	Rh	2O3
308.9	Sr	loss
309.4	Rh	3d
310.4	Ge	Auger
311.0	Tb	4p1
311.1	Y	3p1
311.9	Ir	4d3
311.9	Rh	3d3
312.5	Mg	Auger
313.0	C	loss
314.5	Pt	4d5
315.1	Se	Auger
315.2	Ho	4p3
319.5	Ar	2s
320.0	Nd	4s
320.8	Er	4p3
321.2	K	loss
321.8	Rb	3s
322.0	U	5s
323.6	Mg	Auger
326.8	Ge	Auger
329.4	Zr	3p3
331.0	Pm	4s
331.2	Pt	4d3
332.0	Dy	4p1
332.3	Tm	4p3
333.0	Th	4f7
333.1	Mg	Auger
334.0	Au	4d5
335.0	Pd	3d5
335.4	Pd	Ntv Ox
337.0	Pd	O
337.5	Pd	3d
339.0	As	Auger
339.8	Yb	4p3
340.3	Pd	3d3
341.4	Ge	Auger
342.0	Th	4f5
343.0	Ho	4p1
343.0	Zr	3p1
346.5	Pd	loss
346.6	Ca	2p
347.1	Ca	O
347.2	Mg	Auger
347.8	Ca	UHV Ox
349.0	Sm	4s
353.0	Au	4d3
357.2	Sr	3s
357.9	Ge	Auger
357.9	Mg	Auger
358.3	Hg	4d5
358.6	Se	Auger
359.0	As	Auger
359.2	Lu	4p3
359.3	Zr	loss
360.8	Nb	3p3
363.0	Eu	4s
363.6	Ga	Auger
363.7	Dy	Auger
366.0	Er	4p1
366.8	Ag	2S
367.7	Ag	O
368.2	Ag	Ag, Ag2O
368.5	Mg	Auger
370.0	Eu	Auger
371.0	Ag	3d
371.0	As	Auger
374.2	Ag	3d3
376.0	Gd	4s
376.2	Nb	3p1
377.2	K	2s
377.3	U	4f7
377.8	Hg	4d3
379.5	Hf	4p3
381.0	Mg	Auger
382.0	U	4f
384.9	Tl	4d5
386.0	Tm	4p1
388.0	U	4f5
388.3	Se	Auger
389.8	K	loss
390.3	Yb	4p1
391.7	Ga	Auger
391.7	Mg	Auger
393.8	Mo	3p3
393.8	Y	3s
395.6	Tb	4s
397.0	N	CrN
397.1	N	AlN
397.3	N	TiN
397.6	N	Si3N4
398.4	N	1s
398.4	N	BN
398.4	Sc	2p3
399.8	Se	Auger
399.9	Tm	Auger
400.6	Ta	4p3
401.0	Sc	2p
401.9	Sc	2O3
402.2	N	H4
403.2	Sc	2p1
404.1	Cd	O
405.0	Cd	3d5
405.1	Cd	Te
405.4	Cd	Se, CO3
405.5	Tl	4d3
406.7	Cd	(OH)2
407.2	N	O3
408.0	Cd	3d
411.0	Tb	Auger
411.3	Mo	3p1
411.7	Cd	3d3
412.0	Pb	4d5
412.3	Ge	Auger
412.6	Dy	4s
412.7	Lu	4p1
420.4	Ta	loss
421.6	Mo	loss
423.3	W	4p3
424.5	N	loss
425.0	As	Auger
425.0	Tc	3p3
425.5	Pb	loss
429.6	Zr	3s
433.0	Ge	Auger
434.3	Pb	4d3
436.0	Ho	4s
437.3	Hf	4p1
437.8	Ca	2s
440.0	Bi	4d5
443.6	Ge	Auger
443.8	In	3d5
444.3	In	2O3
444.4	In	Ntv Ox
444.8	In	P fract
444.9	In	GaAs
445.0	Tc	3p1
445.2	In	Ntv OH
445.9	In	Ntv CO3
446.4	Re	4p3
446.9	Pb	loss
447.3	Ga	Auger
448.0	In	3d
450.3	Er	4s
451.4	In	3d3
453.0	Se	Auger
453.9	Ti	2p3
454.3	Na	Auger
455.1	Ti	O
456.0	Ti	2p
457.4	Ti	2O3
458.0	As	Auger
458.2	Ti	CaTiO3
458.7	Ti	O2
460.0	Ti	2p1
460.2	Gd	Auger
462.5	Ta	4p1
463.1	In	loss
464.0	Bi	4d3
466.1	Ru	3p3
466.8	Nb	3s
468.0	As	Auger
468.5	Tm	4s
471.0	Os	4p3
471.5	Zn	Auger
473.0	Po	4d5
474.0	Se	Auger
474.7	In	loss
480.8	Yb	4s
484.9	Sn	3d5
486.3	Sn	O
486.4	Ga	Auger
487.3	Sn	O2
488.4	Ru	3p1
488.8	Ho	Auger
490.5	W	4p1
493.3	Sn	3d3
494.6	Zn	Auger
494.8	Ir	4p3
496.3	Rh	3p3
497.1	Se	Auger
497.2	Sn	3d
497.4	Na	Auger
498.0	Sc	2s
499.0	Sn	loss
500.0	Po	4d3
503.8	Ga	Auger
505.0	Mo	3s
507.0	At	4d5
507.5	Sn	loss
507.9	Lu	4s
512.1	V	2p3
513.2	Na	Auger
513.5	Ga	Auger
513.9	Dy	Auger
515.0	Eu	Auger
515.6	V	2p
515.9	V	2O3
517.1	V	2O5
517.3	V	O2
518.5	Re	4p1
519.0	As	Auger
519.6	Pt	4p3
519.7	V	2p1
521.3	Rh	3p1
524.0	Na	Auger
524.8	Ge	Auger
528.2	Sb	3d5
529.4	O	Ag2O, NiO
529.6	Sb	2O3
529.8	O	MgO
530.5	O	NaOH
531.1	O	Al2O3
531.1	Sb	2O5
531.8	O	1s LiOH
532.3	Pd	3p3
532.5	Ga	Auger
532.5	O	B2O3, SiO2
532.6	Sb	3d
532.9	O	HgO
533.0	At	4d3
533.8	Hf	4s
536.4	Na	Auger
537.6	Sb	3d3
541.0	Rn	4d5
544.0	Tc	3s
544.2	Sb	loss
546.3	Au	4p3
548.0	Os	4p1
548.1	Cu	Auger
552.4	Na	Auger
553.2	O	loss
553.3	Sb	loss
557.1	Tb	Auger
558.5	Zn	Auger
560.0	Pd	3p1
560.9	Ti	2s
562.8	Ta	4s
565.0	Na	Auger
567.0	Rn	4d3
568.1	Cu	Auger
570.9	Ga	Auger
572.5	Te	CdTe
572.9	Te	3d5
573.0	Zn	Auger
573.6	Ag	3p3
574.1	Cr	B
574.3	Cr	2p3
575.0	Cr	2p
575.5	Cr	Ntv Ox
575.6	Cr	2O3
576.5	Te	O2
576.6	Cr	Ntv Ox
577.0	Fr	4d5
577.0	Te	3d
577.2	Hg	4p3
577.7	Cr	Ntv Ox
578.2	Ir	4p1
579.5	Cr	O3
579.8	Ge	Auger
580.0	Cr	KCrO4
581.8	Zn	Auger
583.3	Te	3d3
583.5	Cr	2p1
586.2	Er	Auger
586.9	Tm	Auger
588.9	Ga	Auger
591.0	Ru	3s
593.6	W	4s
600.0	Gd	Auger
600.7	Te	loss
603.0	Fr	4d3
603.0	Ra	4d5
604.0	Ag	3p1
609.1	Pt	4p1

BE Lookup Table for Signals from Elements and Common Chemical Species 609-1395 eV

609.6	Tl	4p3
617.0	Cd	3p3
619.0	I	3d
619.2	I	3d5
619.2	I	KI
623.2	Ni	Auger
625.2	Re	4s
626.1	Ho	Auger
626.4	V	2s
627.8	Rh	3s
628.2	Cu	Auger
629.4	Ga	Auger
630.6	I	3d3
634.5	Er	Auger
635.0	Cu	Auger
636.0	Ra	4d3
638.7	Mn	2p3
4.	Ni	Auger
5.	Ga	Auger
640.9	Mn	Mn3O4
641.0	Mn	MnO
641.0	Mn	Mn2O3
641.6	Mn	MnO2
642.4	Au	4p1
5.	I	loss
6.	Pb	4p3
645.0	Mn	2p
647.5	Cu	Auger
649.7	Mn	2p1
651.0	Cd	3p1
652.2	Zn	Auger
655.0	Eu	Auger
655.7	Ga	Auger
657.2	I	loss
658.0	Os	4s
659.4	Zn	Auger
2.	In	3p3
3.	Ho	Auger
669.7	Xe	3d5
671.5	Pd	3s
675.0	Xe	3d
676.0	Th	4d5
676.7	In	loss
677.9	Tm	Auger
679.0	Bi	4p3
680.2	Hg	4p1
682.0	Sm	Auger
682.4	Xe	3d3
685.1	F	CaF2
685.7	F	1s
685.7	F	LiF
688.9	F	CF2
690.9	Ir	4s
695.7	Cr	2s
697.4	Co	Auger
700.3	Tb	Auger
702.0	Ne	Auger
703.1	In	3p1
703.5	F	loss
705.0	Po	4p3
705.2	Ni	Auger
706.7	Fe	2p3
707.2	Fe	S2
707.5	Ga	Auger
709.8	Fe	O
710.4	Fe	2O3-g
710.5	Fe	3O4
710.8	Fe	2O3-a
711.5	Fe	OOH
711.6	F	loss
712.2	Ni	Auger
713.0	Co	Auger
713.0	Th	4d3
714.1	In	loss
714.6	Sn	3p3
715.1	Er	Auger
719.5	Cu	Auger
719.6	Ag	3s
719.9	Fe	2p1
721.5	Tl	4p1
724.0	Pt	4s
724.8	Cs	3d5
724.8	Cs	Cl
724.9	Cs	2O:SiO2
736.0	U	4d5
740.0	At	4p3
740.0	Cs	3d3
748.0	Ho	Auger
749.0	Cs	loss
756.2	Sn	3p1
758.0	Nd	Auger
761.1	Pb	4p1
761.2	Au	4s
761.8	Cs	loss
763.4	Gd	Auger
766.4	Sb	3p3
768.0	Rn	4p3
768.6	Mn	2s
770.2	Sn	loss
772.8	Cd	3s
777.7	Ni	Auger
778.3	Co	2p3
779.0	U	4d3
779.2	Co	O
779.5	Co	3O4
780.0	Ba	3d5
780.0	Ba	CO3, OAc
780.6	Co	(OH)2
780.9	Co	Ntv Ox
782.2	Sb	loss
784.0	Fe	Auger
793.7	Co	2p1
795.2	Ba	3d3
797.0	Pr	Auger
802.0	Ba	loss
803.6	Hg	4s
805.0	Bi	4p1
808.9	Tb	Auger
810.0	Fr	4p3
812.6	Sb	3p1
817.0	Ba	loss
819.7	Te	3p3
826.0	In	3s
830.5	Co	Auger
833.0	Ce	Auger
833.0	F	Auger
835.2	La	2O3
836.0	La	3d5
836.5	Te	loss
837.2	La	B6
837.9	Co	Auger
841.1	Gd	Auger
844.2	Cs	Auger
846.0	Fe	Auger
846.7	Tl	4s
851.0	Po	4p1
851.6	Mn	Auger
852.6	Ni	2p3
852.9	Ni	B
853.0	La	3d3
853.8	Ni	O
854.3	Ni	Ntv Ox
855.4	Ni	(OH)2
859.0	F	Auger
863.0	Ne	1s
869.9	Ni	2p1
870.5	Cs	Auger
870.7	Te	3p1
875.0	I	3p3
878.1	F	Auger
879.0	Ra	4p3
882.0	Ce	O2
884.0	Ce	3d5
885.2	Sn	3s
886.0	At	4p1
886.5	Ba	Auger
888.0	Fe	Auger
888.4	Te	loss
891.7	Pb	4s
898.0	Ba	Auger
900.3	Mn	Auger
902.0	Ce	3d3
915.9	Cr	Auger
918.6	Cs	Auger
925.3	Co	2s
929.0	Rn	4p1
930.9	I	3p1
7.	Cu	Cl
8.	Pr	3d5
932.0	Cs	Auger
3.	Cu	S
4.	Cu	2O
932.6	Cu	2p3
932.9	Cu	2O
933.9	Cu	O
934.0	Xe	3p3
934.6	Cu	(OH)2
936.6	Bi	4s
940.7	Cu	CT
942.2	Cu	CT
943.8	Cu	CT
1.	Sb	3s
2.	Mn	Auger
945.5	Sb	Auger
952.2	Cu	2p1
952.2	Pr	3d3
952.5	Cs	Auger
959.5	Cr	Auger
959.9	Te	Auger
965.0	Th	4p3
969.3	Te	Auger
970.4	I	Auger
976.8	V	Auger
979.7	O	Auger
980.0	Fr	4p1
981.0	Nd	3d5
981.8	I	Auger
994.6	Te	Auger
995.0	Po	4s
995.0	Sb	Auger
996.0	Xe	3p1
997.3	Cr	Auger
998.0	Cs	3p3
999.0	O	Auger
1003.0	Nd	3d3
1003.6	Cr	Auger
1004.8	Te	3s
1008.7	Ni	2s
1013.0	O	Auger
1014.7	V	Auger
1020.3	Te	Auger
1021.7	Zn	O
1021.8	Zn	2p3
1022.3	Zn	S
1022.5	Sb	Auger
1027.0	Pm	3d5
1027.2	Cr	Auger
1031.0	Zn	loss
1031.9	Sb	Auger
1034.9	Ti	Auger
1042.0	At	4s
1043.0	U	4p3
1044.8	Zn	2p1
1049.6	Sn	Auger
1052.0	Pm	3d3
1055.3	V	Auger
1055.5	Zn	loss
1058.0	Ra	4p1
1058.0	Sn	Auger
1063.0	Ba	3p3
1067.7	Ti	Auger
1071.8	Na	2O-SiO2
1071.9	Na	OH
1072.0	I	3s
1072.0	Na	1s
1072.0	Na	Cl
1076.4	In	Auger
1081.0	Sm	3d5
1084.0	In	Auger
1092.5	Te	Auger
1097.0	Rn	4s
1097.2	Cu	2s
1102.8	Ti	Auger
1103.1	Cd	Auger
1107.0	N	Auger
1108.0	Sm	3d3
1109.8	Cd	Auger
1112.9	Sb	Auger
1116.6	Ga	2p3
1117.7	Sc	Auger
1126.0	Eu	3d5
1128.0	La	3p3
1128.9	Ag	Auger
1129.0	Sn	Auger
1131.8	Te	Auger
1135.0	Ag	Auger
1137.0	Ba	3p1
1141.0	Xe	3s
1143.4	Ga	2p1
1148.9	Sc	Auger
1151.0	In	Auger
1153.0	Fr	4s
1155.0	Eu	3d3
1159.4	Pd	Auger
1170.0	Th	4p1
1184.0	Ce	3p3
1185.5	Rh	Auger
1186.8	Gd	2O3
1186.9	Gd	3d5
1190.0	Ag	Auger
1194.0	Ca	Auger
1196.4	Zn	2s
1208.0	Ra	4s
1213.0	Pd	Auger
1217.0	Cs	3s
1217.0	Ge	2p3
1217.0	Ru	Auger
1219.6	Gd	3d3
1221.4	C	Auger
1225.0	Ag	Auger
1234.7	Rh	Auger
1234.8	Ge	loss
1235.0	K	Auger
1242.0	Pr	3p3
1242.1	Tb	3d5
1243.8	Pd	Auger
1245.9	Tl	Auger
1249.0	Ge	2p1
1250.8	Pt	Auger
1259.8	Ru	a
1264.2	Mo	Auger
1265.0	Rh	Auger
1265.8	Ge	loss
1272.0	Ce	3p1
1272.0	U	4p1
1275.7	Tb	3d3
1296.2	Dy	3d5
1298.6	Mo	Auger
1303.3	Mg	1s
1304.0	Cl	Auger
1307.0	Hf	Auger
1315.3	Mg	loss
1316.1	Pt	Auger
1318.0	Ta	Auger
1319.0	Nb	Auger
1321.6	Lu	Auger
1322.3	Re	Auger
1323.9	As	2p3
1324.5	Mo	Auger
1326.3	Mg	loss
1334.0	Pt	Auger
1335.1	Dy	3d3
1337.7	Zr	Auger
1352.9	Ho	3d5
1358.7	Er	3d5
1359.5	As	2p1
1363.6	Yb	Auger
1365.5	Mo	Auger
1367.1	Tm	Auger
1368.2	Zr	Auger
1373.3	Tb	3p3
1378.9	Gd	3p3
1390.9	Pb	Auger
1392.6	Zr	Auger
1393.3	Ho	3d3
1395.0	Si	Auger