Fundamental XPS Data from Pure Elements, Pure Oxides, and Chemical Compounds

C(1s) BE = 285.0 eV
Charge Referencing

13 Al 2p3	
Al°	Al2O3
72.9	74.3
(0.62)	(1.41)
284.7	285.0
72.82	531.1
(0.41)	(1.56)

Atomic Number of Element
Abbreviation for Element
Al (2p3) BE of Al° under Native Oxide
Al (2p3) FWHM of Al° under Native Oxide
C (1s) BE of Hydrocarbons Captured by Ion Etched Al°
Reliable Reference BE for Ion Etched, Pure Al°
Al (2p3) FWHM of Ion Etched , Pure Al°

Main XPS Signal for Element of Interest
Most Common Oxide or Chemical Compound of Element
Al (2p3) BE of Major Oxide Species in Pure Oxide
Al (2p3) FWHM of Major Oxide Species in Pure Oxide
C (1s) BE Defined to be at 285.0 eV
O (1s) BE of Major Oxygen Species in Pure Oxide
O (1s) FWHM of Major Oxygen Species in Pure Oxide

All non-conductive materials were referenced to adventitious hydrocarbon with C (1s) BE at 285.0eV.
Energy resolution settings for pure oxide data gave FWHM <0.75 eV for Ag (3d5) of ion etched Ag°.
All non-conductors were analyzed with the Flood-Gun Mesh-Screen 0.5-1.0 mm above the specimen.
C (1s) BEs for "hydrocarbons" on elements were collected from carbon captured by ion etched elements.
Carbon from the cryo-pumped vacuum (3x10(-9) torr) was analyzed >10 hours after ion etching.
Energy resolution settings for ion etched elements gave FWHM <0.50 eV forAg (3d5) of ion etched Ag°.
Calibration was: Cu (2p3) at 932.67 ±0.05 eV, Cu (3s) at 122.45 ±0.05 eV, and Au(4f7) at 83.98 eV.

The FWHM and BE values presented in this table were all obtained by one scientist using two SSI XPS systems, which yield a theoretical energy resolution limit of about 0.1 eV and were equipped with monochromatic Aluminum X-ray sources which have a theoretical energy resolution limit of about 0.16 eV. The BEs for the ion etched elements can be used as reliable secondary energy reference values within a standard deviation of 0.055. All other BE values are <±0.15 eV.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H 1s												5 B 1s	6 C 1s	7 N 1s	8 O 1s	9 F 1s	2 He 1s
H2°	LiH											B°	B2O3	Kapton	BN	CuO	SiO2	Teflon	CaF2	He+/Be	He+/C
												187.5	194.0	284.5	284.4	400.9	398.9	529.7	532.5	688.9	685.1		
												(0.87)	(2.40)	(0.42)	(1.04)	(1.31)	(1.10)	(0.98)	(1.40)	(1.8)	(1.53)		
												285.2	285.0			285.0	285.0	284.9	285.0	285.0	285.0		
												187.8	532.5				191.3	934.0	103.0	291.9	348.1		
												(1.03)	(2.22)				(1.03)	(1.42)	(1.14)	(1.6)	(1.6)		
3 Li 1s	4 Be 1s																
Li°	LiOH	Be°	BeO														
	54.9	111.9	113.6														
	(1.65)	(0.79)	(1.73)														
	285.0	286.1	285.0														
	531.8	111.88	531.3														
	(1.6)	(0.69)	(1.47)														
11 Na 1s	12 Mg 2p											13 Al 2p3	14 Si 2p3	15 P 2p3	16 S 2p3	17 Cl 2p3	18 Ar 2p3
Na°	NaCl	Mg°	MgO									Al°	Al2O3	Si°	SiO2	P°	InP	S°	MoS2	PVC	NaCl	Ar+/Be	Ar+/C
	1072.0	49.7	51.5									72.9	75.6	99.8	103.0	130.13	128.8	164.0	162.7	199.8	199.3		242.1
	(1.40)	(0.58)	(1.63)									(0.62)	(1.41)	(0.57)	(1.14)	(0.67)	(0.62)	(0.72)	(0.39)	(1.7)	(1.19)		(0.90)
	285.0	286.5	285.0									284.7	285.0	285.3	285.0	285.0	285.0	285.0		285.0	285.0		285.0
	199.3	49.77	529.8									72.82	531.1	99.35	532.5		444.7		229.7		1072.0		
	(1.19)	(0.60)	(1.99)									(0.41)	(1.56)	(0.45)	(1.40)		(0.78)		(0.80)		(1.40)		
19 K 2p3	20 Ca 2p3	21 Sc 2p3	22 Ti 2p3	23 V 2p3	24 Cr 2p3	25 Mn 2p3	26 Fe 2p3	27 Co 2p3	28 Ni 2p3	29 Cu 2p3	30 Zn 2p3	31 Ga 3d5	32 Ge 3d5	33 As 3d5	34 Se 3d5	35 Br 3d5	36 Kr 3d5
K°	KI	Ca°	CaO	Sc°	Sc2O3	Ti°	TiO2	V°	V2O5	Cr°	Cr2O3	Mn°	MnO2	Fe°	Fe2O3	Co°	Co3O4	Ni°	NiO	Cu°	Cu2O	Zn°	ZnO	Ga°	Ga2O3	Ge°	GeO2	As°	As2O3	Se°	SeOx	Br	KBr	Kr+/Be	Kr+/C
	293.2	346.5	347.1	398.6	401.9	453.8	458.7	512.2	517.3	574.2	575.7	638.7	641.5	706.6	709.8	778.1	779.5	852.6	853.8	932.7	932.5	1021.8	1021.7	18.7	20.7	29.3	33.2	41.8	45.1	54.8	59.3		68.8		86.94
	(1.11)	(?)	(1.81)	(0.9)	(1.27)	(0.90)	(1.09)	(0.79)	(1.32)	(1.05)	(1.20)	(1.00)	(1.12)	(0.90)	(1.32)	(0.99)	(1.39)	(1.14)	(1.42)	(1.22)	(1.10)	(1.10)	(1.50)	(0.70)	(1.37)	(0.68)	(1.49)	(0.67)	(1.26)	(0.76)	(1.09)		(0.92)		(0.79)
	285.0	284.6	285.0	285.8	285.0	285.2	285.0	285.0	285.0	284.6	285.0	286.4	285.0	284.9	285.0	284.9	285.0	284.8	285.0	284.6	285.0	284.8	285.0	285.0	285.0	285.0	285.0	284.5	285.0	284.2	285.0		285.0		285.0
	619.2	346.5	531.5	398.46	530.0	453.95	530.0	512.22	530.2	574.37	530.1	638.74	529.5	706.78	532.9	778.26	530.1	852.65	529.4	932.68	530.5	1021.76	530.5	18.5	531.3	29.28	532.2	41.69	532.0	54.90	532.6		293.0		
	(1.30)	(1.07)	(1.57)	(0.69)	(1.33)	(0.62)	(1.18)	(0.75)	(1.33)	(0.89)	(1.24)	(0.89)	(1.02)	(0.99)	(1.05)	(0.85)	(1.00)	(1.02)	(1.03)	(0.92)	(1.01)	(0.97)	(1.11)	(0.60)	(1.51)	(0.64)	(1.40)	(0.67)	(1.41)	(0.78)			(1.31)		
37 Rb 3d5	38 Sr 3d5	39 Y 3d5	40 Zr 3d5	41 Nb 3d5	42 Mo 3d5	43 Tc 3d5	44 Ru 3d5	45 Rh 3d5	46 Pd 3d5	47 Ag 3d5	48 Cd 3d5	49 In 3d5	50 Sn 3d5	51 Sb 3d5	52 Te 3d5	53 I 3d5	54 Xe 3d5
Rb°	RbOAc	Sr°	SrCO3	Y°	Y2O3	Zr°	ZrO2	Nb°	Nb2O5	Mo°	MoO3	Tc°	Ru°	RuO2	Rh°	Rh2O3	Pd°	PdO	Ag°	Ag2O	Cd°	CdO	In°	In2O3	Sn°	SnO2	Sb°	Sb2O5	Te°	TeO2	I	KI	Xe+/Be	Xe+/C
	109.7		133.7	155.9	156.6	179.0	182.4	202.1	207.4	227.8	233.1	Radioactive	280.0	281.1	307.2	308.9	335.1	337.0	368.2	367.5	405.0	404.0	443.8	444.3	484.9	487.3	528.2	530.4	572.8	576.5		619.2		669.6
	(1.40)		(1.63)	(0.80)	(1.25)	(0.90)	(1.18)	(0.78)	(1.14)	(0.66)	(1.05)		(0.67)	(0.79)	(0.73)	(0.80)	(0.86)	(0.97)	(0.64)	(1.00)	(0.90)	(1.38)	(1.08)	(1.26)	(0.81)	(1.28)	(1.0)	(1.10)	(1.12)	(1.27)		(1.30)		(1.13)
	285.0		285.0	286.0	285.0	285.3	285.0	285.0	285.0	285.4	285.0		---	285.0	284.05	285.0	284.5	285.0	284.7	285.0	285.0	285.0	284.9	285.0	284.7	285.0	284.6	285.0	284.2	285.0		285.0		285.0
	530.9		531.5	155.92	531.0	178.80	530.3	202.35	530.4	227.94	531.0		280.11	529.7	307.21	530.5	335.10	530.7	368.28	529.4	405.04	528.6	443.87	529.9	485.01	531.1	528.26	531.2	572.97	530.7		293.2		
	(1.6)		(1.9)	(0.62)	(1.30)	(0.63)	(1.39)	(0.57)	(1.36)	(0.57)	(1.20)		(0.59)	(0.95)	(0.69)	(1.05)	(0.77)	(1.35)	(0.62)	(0.97)	(0.61)	(1.28)	(0.71)	(1.19)	(0.68)	(1.29)	(0.80)	(0.86)	(0.83)	(1.39)		(1.11)		
55 Cs 3d5	56 Ba 3d5	57 La 3d5	72 Hf 4f7	73 Ta 4f7	74 W 4f7	75 Re 4f7	76 Os 4f7	77 Ir 4f7	78 Pt 4f7	79 Au 4f7	80 Hg 4f7	81 Tl 4f7	82 Pb 4f7	83 Bi 4f7	84 Po 4f7	85 At 4f7	86 Rn 4f7
Cs°	CsCl	Ba°	BaOAc	La°	La2O3	Hf°	HfO2	Ta°	Ta2O5	W°	WO3	Re°	Re2O7	Os°	OsO4	Ir°	IrO2	Pt°	PtO2	Au°	Au2O3	Hg°	HgO	Tl°	Tl2O3	Pb°	PbO	Bi°	Bi2O3						
	724.6		780.0		834.7	14.4	17.1	21.8	26.8	31.4	35.8	40.3	46.8		60.8	62.0	71.0	75.1	84.1	88.1	99.8	100.7	117.8	118.2	136.9	137.5	157.0	158.8	Radioactive	Radioactive	Radioactive
	(2.08)		(1.80)		(3.0)	(0.63)	(1.26)	(0.80)	(1.12)	(0.58)	(1.01)	(0.67)	(1.64)		(0.80)	(0.98)	(0.96)	(1.16)	(0.83)	(1.12)	---	(1.06)	(0.97)	(1.01)	(0.67)	(1.10)	(0.73)	(1.11)			
	285.0		285.0		285.0	285.7	285.0	285.0	285.0	285.3	285.0	285.3	285.0		284.4	285.0	284.3	285.0	284.1	285.0	285.0	(285.0)	285.1	285.0	284.9	285.0	284.6	285.0			
	199.2		531.4		529.2	14.32	530.5	21.78	531.0	31.38	530.6	40.30	532.1		60.88	530.2	71.15	531.3	83.98	531.6	99.81	532.9	117.77	528.8	136.95	528.9	157.05	529.6			
			(1.83)		(1.6)	(0.62)	(1.68)	(0.56)	(1.46)	(0.53)	(1.27)	(0.54)	(1.58)		(0.82)	(0.97)	(0.88)	(1.74)	(0.68)	(1.13)	(0.65)	(0.96)	(0.66)	(1.10)	(0.63)	(1.07)	(0.62)	(1.58)			
87 Fr 4f7	88 Ra 4f7	89 Ac 4f7																											
Radioactive	Radioactive	Radioactive																											

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B. Vincent Crist
Last Update 2-22-99

58 Ce 3d5	59 Pr 3d5	60 Nd 3d5	61 Pm 4d5	62 Sm 4d5	63 Eu 4d5	64 Gd 4d5	65 Tb 4d5	66 Dy 4d5	67 Ho 4d5	68 Er 4d5	69 Tm 4d5	70 Yb 4f7	71 Lu 4f7
Ce° CeO2	Pr° Pr2O5	Nd° Nd2O3	Pm° Pm2O3	Sm° Sm2O3	Eu° Eu2O3	Gd° Gd2O3	Tb° Tb3O7	Dy° Dy2O3	Ho° Ho2O3	Er° Er2O3	Tm° Tm2O3	Yb° Yb2O3	Lu° Lu2O3
882.1	(931.98) 933.1	(980.86)	Radioactive	--- (134.9)	128.2 135.6	140.2 (1186.8)	145.9 (149.9)	152.4 (156.1)	159.8 161.3	167.7 168.5	175.3 176.3	1.07 184.9	7.10 8.4
(2.0)	--- (4.4)	---		--- (10)	--- (3.7)	--- (5.4)	--- (?)	--- (?)	--- ((6.0)	--- (3.8)	--- (3.4)	--- (3.4)	--- (3.0)
285.0	--- 285.0	---		--- 285.0	284.3 285.0	281.4 285.0	--- 285.0	--- 285.0	--- 285.0	--- 285.0	285.3 285.0	285.6 285.0	284.6 285.0
529.6	111.2 528.2	118.0		123.2 531.7	128.18 529.2	140.33 529.0	146.02 529.5	152.30 529.2	159.58 529.3	167.25 529.2	175.37 529.6	(182.39) 529.4	7.1 529.6
(2.00)	(2.17) (1.4)	(1.80)		(2.5?) (2.4)	(1.08) (1.4)	(1.02) (1.7)	(1.33) (1.6)	(1.88) (1.7)	(1.50) (1.7)	(1.93) (1.9)	(1.92) (1.7)	(0.61) (2.0)	(0.69) (1.8)
90 Th 4f7	91 Pa 4f7	92 U 4f7	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr
Th° ThO2		U° U2O3											
	Radioactive		Radioactive	Radioactive	Radioactive	Radioactive	Radioactive	Radioactive	Radioactive	Radioactive	Radioactive	Radioactive	Radioactive