CANADIAN MINING INDUSTRY RESEARCH ORGANIZATION (CAMIRO) EXPLORATION DIVISION

CAMIRO PROJECT 10E01
Phase 1

Quality Control Assessment of Portable XRF Analyzers: Development of Standard Operating Procedures, Performance on Variable Media and Recommended Uses

APPENDIX 2b

Table 1_3 from
University of California X-Ray Data Booklet
Saved independently as pdf file (appendix_2b.pdf)

X-Ray Data Booklet Table 1-3. *Photon energies and relative intensities of K-, L-, and M-shell lines shown in Fig. 1-1, arranged by increasing energy. An intensity of 100 is assigned to the strongest line in each shell for each element.*

Energy (eV)	Element	Line	Relative intensity
54.3	3 Li	$K\alpha_{1,2}$	150
108.5	4 Be	$K\alpha_{1,2}$	150
183.3	5 B	$K\alpha_{1,2}$	151
277	6 C	$K\alpha_{1,2}$	147
348.3	21 Sc	Ll	21
392.4	7 N	$K\alpha_{1,2}$	150
395.3	22 Ti	Ll	46
395.4	21 Sc	$L\alpha_{1,2}$	111
399.6	21 Sc	$L\beta_1$	77
446.5	23 V	Ll	28
452.2	22 Ti	$L\alpha_{1,2}$	111
458.4	22 Ti	$L\beta_1$	79
500.3	24 Cr	Ll	17
511.3	23 V	$L\alpha_{1,2}$	111
519.2	23 V	$L\beta_1$	80
524.9	8 O	$K\alpha_{1,2}$	151
556.3	25 Mn	Ll	15
572.8	24 Cr	$L\alpha_{1,2}$	111
582.8	24 Cr	$L\beta_1$	79
615.2	26 Fe	Ll	10
637.4	25 Mn	$L\alpha_{1,2}$	111
648.8	25 Mn	$L\beta_1$	77
676.8	9 F	$K\alpha_{1,2}$	148
677.8	27 Co	Ll	10
705.0	26 Fe	$L\alpha_{1,2}$	111
718.5	26 Fe	$L\beta_1$	66
742.7	28 Ni	Ll	9
776.2	27 Co	$L\alpha_{1,2}$	111
791.4	27 Co	$L\beta_1$	76
811.1	29 Cu	Ll	8
833	57 La	$M\alpha_1$	100
848.6	10 Ne	$K\alpha_{1,2}$	150
851.5	28 Ni	$L\alpha_{1,2}$	111
868.8	28 Ni	$L\beta_1$	68
883	58 Ce	$M\alpha_1$	100
884	30 Zn	Ll	7
929.2	59 Pr	$M\alpha_1$	100
929.7	29 Cu	$L\alpha_{1,2}$	111
949.8	29 Cu	$L\beta_1$	65
957.2	31 Ga	Ll	7
978	60 Nd	$M\alpha_1$	100
1,011.7	30 Zn	$L\alpha_{1,2}$	111
1,034.7	30 Zn	$L\beta_1$	65
1,036.2	32 Ge	Ll	6
1,041.0	11 Na	$K\alpha_{1,2}$	150
1,081	62 Sm	$M\alpha_1$	100
1,097.9	31 Ga	$L\alpha_{1,2}$	111
1,120	33 As	Ll	6
1,124.8	31 Ga	$L\beta_1$	66

Table 1-3. *Energies and intensities of x-ray emission lines (continued).*

Energy (eV)	Element	Line	Relative intensity
1,131	63 Eu	$M\alpha_1$	100
1,185	64 Gd	$M\alpha_1$	100
1,188.0	32 Ge	$L\alpha_{1,2}$	111
1,204.4	34 Se	Ll	6
1,218.5	32 Ge	$L\beta_1$	60
1,240	65 Tb	$M\alpha_1$	100
1,253.6	12 Mg	$K\alpha_{1,2}$	150
1,282.0	33 As	$L\alpha_{1,2}$	111
1,293	66 Dy	$M\alpha_1$	100
1,293.5	35 Br	Ll	5
1,317.0	33 As	$L\beta_1$	60
1,348	67 Ho	$M\alpha_1$	100
1,379.1	34 Se	$L\alpha_{1,2}$	111
1,386	36 Kr	Ll	5
1,406	68 Er	$M\alpha_1$	100
1,419.2	34 Se	$L\beta_1$	59
1,462	69 Tm	$M\alpha_1$	100
1,480.4	35 Br	$L\alpha_{1,2}$	111
1,482.4	37 Rb	Ll	5
1,486.3	13 Al	$K\alpha_2$	50
1,486.7	13 Al	$K\alpha_1$	100
1,521.4	70 Yb	$M\alpha_1$	100
1,525.9	35 Br	$L\beta_1$	59
1,557.4	13 Al	$K\beta_1$	1
1,581.3	71 Lu	$M\alpha_1$	100
1,582.2	38 Sr	Ll	5
1,586.0	36 Kr	$L\alpha_{1,2}$	111
1,636.6	36 Kr	$L\beta_1$	57
1,644.6	72 Hf	$M\alpha_1$	100
1,685.4	39 Y	Ll	5
1,692.6	37 Rb	$L\alpha_2$	11
1,694.1	37 Rb	$L\alpha_1$	100
1,709.6	73 Ta	$M\alpha_1$	100
1,739.4	14 Si	$K\alpha_2$	50
1,740.0	14 Si	$K\alpha_1$	100
1,752.2	37 Rb	$L\beta_1$	58
1,775.4	74 W	$M\alpha_1$	100
1,792.0	40 Zr	Ll	5
1,804.7	38 Sr	$L\alpha_2$	11
1,806.6	38 Sr	$L\alpha_1$	100
1,835.9	14 Si	$K\beta_1$	2
1,842.5	75 Re	$M\alpha_1$	100
1,871.7	38 Sr	$L\beta_1$	58
1,902.2	41 Nb	Ll	5
1,910.2	76 Os	$M\alpha_1$	100
1,920.5	39 Y	$L\alpha_2$	11
1,922.6	39 Y	$L\alpha_1$	100
1,979.9	77 Ir	$M\alpha_1$	100
1,995.8	39 Y	$L\beta_1$	57
2,012.7	15 P	$K\alpha_2$	50
2,013.7	15 P	$K\alpha_1$	100
2,015.7	42 Mo	Ll	5

2,039.9	40 Zr	$L\alpha_2$	11
2,042.4	40 Zr	$L\alpha_1$	100
2,050.5	78 Pt	$M\alpha_1$	100
2,122	43 Tc	Ll	5
2,122.9	79 Au	$M\alpha_1$	100
2,124.4	40 Zr	$L\beta_1$	54
2,139.1	15 P	$K\beta_1$	3
2,163.0	41 Nb	$L\alpha_2$	11
2,165.9	41 Nb	$L\alpha_1$	100
2,195.3	80 Hg	$M\alpha_1$	100
2,219.4	40 Zr	$L\beta_{2,15}$	1
2,252.8	44 Ru	Ll	4
2,257.4	41 Nb	$L\beta_1$	52
2,270.6	81 Tl	$M\alpha_1$	100
2,289.8	42 Mo	$L\alpha_2$	11
2,293.2	42 Mo	$L\alpha_1$	100
2,302.7	40 Zr	$L\gamma_1$	2
2,306.6	16 S	$K\alpha_2$	50
2,307.8	16 S	$K\alpha_1$	100
2,345.5	82 Pb	$M\alpha_1$	100
2,367.0	41 Nb	$L\beta_{2,15}$	3
2,376.5	45 Rh	Ll	4
2,394.8	42 Mo	$L\beta_1$	53
2,420	43 Tc	$L\alpha_2$	11
2,422.6	83 Bi	$M\alpha_1$	100
2,424	43 Tc	$L\alpha_1$	100
2,461.8	41 Nb	$L\gamma_1$	2
2,464.0	16 S	$K\beta_1$	5
2,503.4	46 Pd	Ll	4
2,518.3	42 Mo	$L\beta_{2,15}$	5
2,538	43 Tc	$L\beta_1$	54
2,554.3	44 Ru	$L\alpha_2$	11
2,558.6	44 Ru	$L\alpha_1$	100
2,620.8	17 Cl	$K\alpha_2$	50
2,622.4	17 Cl	$K\alpha_1$	100
2,623.5	42 Mo	$L\gamma_1$	3
2,633.7	47 Ag	Ll	4
2,674	43 Tc	$L\beta_{2,15}$	7
2,683.2	44 Ru	$L\beta_1$	54
2,692.0	45 Rh	$L\alpha_2$	11
2,696.7	45 Rh	$L\alpha_1$	100
2,767.4	48 Cd	Ll	4
2,792	43 Tc	$L\gamma_1$	3
2,815.6	17 Cl	$K\beta_1$	6
2,833.3	46 Pd	$L\alpha_2$	11
2,834.4	45 Rh	$L\beta_1$	52
2,836.0	44 Ru	$L\beta_{2,15}$	10
2,838.6	46 Pd	$L\alpha_1$	100
2,904.4	49 In	Ll	4
2,955.6	18 Ar	$K\alpha_2$	50
2,957.7	18 Ar	$K\alpha_1$	100
2,964.5	44 Ru	$L\gamma_1$	4
2,978.2	47 Ag	$L\alpha_2$	11
2,984.3	47 Ag	$L\alpha_1$	100
2,990.2	46 Pd	$L\beta_1$	53
2,996.1	90 Th	$M\alpha_1$	100
3,001.3	45 Rh	$L\beta_{2,15}$	10
3,045.0	50 Sn	Ll	4
3,126.9	48 Cd	$L\alpha_2$	11
3,133.7	48 Cd	$L\alpha_1$	100

Table 1-3. *Energies and intensities of x-ray emission lines (continued).*

Energy (eV)	Element	Line	Relative intensity
3,143.8	45 Rh	$L\gamma_1$	5
3,150.9	47 Ag	$L\beta_1$	56
3,170.8	92 U	$M\alpha_1$	100
3,171.8	46 Pd	$L\beta_{2,15}$	12
3,188.6	51 Sb	Ll	4
3,190.5	18 Ar	$K\beta_{1,3}$	10
3,279.3	49 In	$L\alpha_2$	11
3,286.9	49 In	$L\alpha_1$	100
3,311.1	19 K	$K\alpha_2$	50
3,313.8	19 K	$K\alpha_1$	100
3,316.6	48 Cd	$L\beta_1$	58
3,328.7	46 Pd	$L\gamma_1$	6
3,335.6	52 Te	Ll	4
3,347.8	47 Ag	$L\beta_{2,15}$	13
3,435.4	50 Sn	$L\alpha_2$	11
3,444.0	50 Sn	$L\alpha_1$	100
3,485.0	53 I	Ll	4
3,487.2	49 In	$L\beta_1$	58
3,519.6	47 Ag	$L\gamma_1$	6
3,528.1	48 Cd	$L\beta_{2,15}$	15
3,589.6	19 K	$K\beta_{1,3}$	11
3,595.3	51 Sb	$L\alpha_2$	11
3,604.7	51 Sb	$L\alpha_1$	100
3,636	54 Xe	Ll	4
3,662.8	50 Sn	$L\beta_1$	60
3,688.1	20 Ca	$K\alpha_2$	50
3,691.7	20 Ca	$K\alpha_1$	100
3,713.8	49 In	$L\beta_{2,15}$	15
3,716.9	48 Cd	$L\gamma_1$	6
3,758.8	52 Te	$L\alpha_2$	11
3,769.3	52 Te	$L\alpha_1$	100
3,795.0	55 Cs	Ll	4
3,843.6	51 Sb	$L\beta_1$	61
3,904.9	50 Sn	$L\beta_{2,15}$	16
3,920.8	49 In	$L\gamma_1$	6
3,926.0	53 I	$L\alpha_2$	11
3,937.6	53 I	$L\alpha_1$	100
3,954.1	56 Ba	Ll	4
4,012.7	20 Ca	$K\beta_{1,3}$	13
4,029.6	52 Te	$L\beta_1$	61
4,086.1	21 Sc	$K\alpha_2$	50
4,090.6	21 Sc	$K\alpha_1$	100
4,093	54 Xe	$L\alpha_2$	11
4,100.8	51 Sb	$L\beta_{2,15}$	17
4,109.9	54 Xe	$L\alpha_1$	100
4,124	57 La	Ll	4
4,131.1	50 Sn	$L\gamma_1$	7
4,220.7	53 I	$L\beta_1$	61
4,272.2	55 Cs	$L\alpha_2$	11
4,286.5	55 Cs	$L\alpha_1$	100
4,287.5	58 Ce	Ll	4
4,301.7	52 Te	$L\beta_{2,15}$	18
4,347.8	51 Sb	$L\gamma_1$	8
4,414	54 Xe	$L\beta_1$	60
4,450.9	56 Ba	$L\alpha_2$	11

4,453.2	59 Pr	Ll	4
4,460.5	21 Sc	$K\beta_{1,3}$	15
4,466.3	56 Ba	$L\alpha_1$	100
4,504.9	22 Ti	$K\alpha_2$	50
4,507.5	53 I	$L\beta_{2,15}$	19
4,510.8	22 Ti	$K\alpha_1$	100
4,570.9	52 Te	$L\gamma_1$	8
4,619.8	55 Cs	$L\beta_1$	61
4,633.0	60 Nd	Ll	4
4,634.2	57 La	$L\alpha_2$	11
4,651.0	57 La	$L\alpha_1$	100
4,714	54 Xe	$L\beta_{2,15}$	20
4,800.9	53 I	$L\gamma_1$	8
4,809	61 Pm	Ll	4
4,823.0	58 Ce	$L\alpha_2$	11
4,827.5	56 Ba	$L\beta_1$	60
4,840.2	58 Ce	$L\alpha_1$	100
4,931.8	22 Ti	$K\beta_{1,3}$	15
4,935.9	55 Cs	$L\beta_{2,15}$	20
4,944.6	23 V	$K\alpha_2$	50

4,952.2	23 V	$K\alpha_1$	100
4,994.5	62 Sm	Ll	4
5,013.5	59 Pr	$L\alpha_2$	11
5,033.7	59 Pr	$L\alpha_1$	100
5,034	54 Xe	$L\gamma_1$	8
5,042.1	57 La	$L\beta_1$	60
5,156.5	56 Ba	$L\beta_{2,15}$	20
5,177.2	63 Eu	Ll	4
5,207.7	60 Nd	$L\alpha_2$	11
5,230.4	60 Nd	$L\alpha_1$	100
5,262.2	58 Ce	$L\beta_1$	61
5,280.4	55 Cs	$L\gamma_1$	8
5,362.1	64 Gd	Ll	4
5,383.5	57 La	$L\beta_{2,15}$	21
5,405.5	24 Cr	$K\alpha_2$	50
5,408	61 Pm	$L\alpha_2$	11
5,414.7	24 Cr	$K\alpha_1$	100
5,427.3	23 V	$K\beta_{1,3}$	15
5,432	61 Pm	$L\alpha_1$	100
5,488.9	59 Pr	$L\beta_1$	61

5,531.1	56 Ba	$L\gamma_1$	9
5,546.7	65 Tb	Ll	4
5,609.0	62 Sm	$L\alpha_2$	11
5,613.4	58 Ce	$L\beta_{2,15}$	21
5,636.1	62 Sm	$L\alpha_1$	100
5,721.6	60 Nd	$L\beta_1$	60
5,743.1	66 Dy	Ll	4
5,788.5	57 La	$L\gamma_1$	9
5,816.6	63 Eu	$L\alpha_2$	11
5,845.7	63 Eu	$L\alpha_1$	100
5,850	59 Pr	$L\beta_{2,15}$	21
5,887.6	25 Mn	$K\alpha_2$	50
5,898.8	25 Mn	$K\alpha_1$	100
5,943.4	67 Ho	Ll	4
5,946.7	24 Cr	$K\beta_{1,3}$	15
5,961	61 Pm	$L\beta_1$	61
6,025.0	64 Gd	$L\alpha_2$	11
6,052	58 Ce	$L\gamma_1$	9
6,057.2	64 Gd	$L\alpha_1$	100
6,089.4	60 Nd	$L\beta_{2,15}$	21

Table 1-3. *Energies and intensities of x-ray emission lines (continued).*

Energy (eV)	Element	Line	Relative intensity
6,152	68 Er	Ll	4
6,205.1	62 Sm	$L\beta_1$	61
6,238.0	65 Tb	$L\alpha_2$	11
6,272.8	65 Tb	$L\alpha_1$	100
6,322.1	59 Pr	$L\gamma_1$	9
6,339	61 Pm	$L\beta_2$	21
6,341.9	69 Tm	Ll	4
6,390.8	26 Fe	$K\alpha_2$	50
6,403.8	26 Fe	$K\alpha_1$	100
6,456.4	63 Eu	$L\beta_1$	62
6,457.7	66 Dy	$L\alpha_2$	11
6,490.4	25 Mn	$K\beta_{1,3}$	17
6,495.2	66 Dy	$L\alpha_1$	100
6,545.5	70 Yb	Ll	4
6,587.0	62 Sm	$L\beta_{2,15}$	21
6,602.1	60 Nd	$L\gamma_1$	10
6,679.5	67 Ho	$L\alpha_2$	11
6,713.2	64 Gd	$L\beta_1$	62
6,719.8	67 Ho	$L\alpha_1$	100
6,752.8	71 Lu	Ll	4
6,843.2	63 Eu	$L\beta_{2,15}$	21
6,892	61 Pm	$L\gamma_1$	10
6,905.0	68 Er	$L\alpha_2$	11
6,915.3	27 Co	$K\alpha_2$	51
6,930.3	27 Co	$K\alpha_1$	100
6,948.7	68 Er	$L\alpha_1$	100
6,959.6	72 Hf	Ll	5
6,978	65 Tb	$L\beta_1$	61
7,058.0	26 Fe	$K\beta_{1,3}$	17
7,102.8	64 Gd	$L\beta_{2,15}$	21
7,133.1	69 Tm	$L\alpha_2$	11
7,173.1	73 Ta	Ll	5
7,178.0	62 Sm	$L\gamma_1$	10
7,179.9	69 Tm	$L\alpha_1$	100
7,247.7	66 Dy	$L\beta_1$	62
7,366.7	65 Tb	$L\beta_{2,15}$	21
7,367.3	70 Yb	$L\alpha_2$	11
7,387.8	74 W	Ll	5
7,415.6	70 Yb	$L\alpha_1$	100
7,460.9	28 Ni	$K\alpha_2$	51
7,478.2	28 Ni	$K\alpha_1$	100
7,480.3	63 Eu	$L\gamma_1$	10
7,525.3	67 Ho	$L\beta_1$	64
7,603.6	75 Re	Ll	5
7,604.9	71 Lu	$L\alpha_2$	11
7,635.7	66 Dy	$L\beta_2$	20
7,649.4	27 Co	$K\beta_{1,3}$	17
7,655.5	71 Lu	$L\alpha_1$	100
7,785.8	64 Gd	$L\gamma_1$	11
7,810.9	68 Er	$L\beta_1$	64
7,822.2	76 Os	Ll	5
7,844.6	72 Hf	$L\alpha_2$	11
7,899.0	72 Hf	$L\alpha_1$	100
7,911	67 Ho	$L\beta_{2,15}$	20
8,027.8	29 Cu	$K\alpha_2$	51

8,045.8	77 Ir	Ll	5
8,047.8	29 Cu	$K\alpha_1$	100
8,087.9	73 Ta	$L\alpha_2$	11
8,101	69 Tm	$L\beta_1$	64
8,102	65 Tb	$L\gamma_1$	11
8,146.1	73 Ta	$L\alpha_1$	100
8,189.0	68 Er	$L\beta_{2,15}$	20
8,264.7	28 Ni	$K\beta_{1,3}$	17
8,268	78 Pt	Ll	5
8,335.2	74 W	$L\alpha_2$	11
8,397.6	74 W	$L\alpha_1$	100
8,401.8	70 Yb	$L\beta_1$	65
8,418.8	66 Dy	$L\gamma_1$	11
8,468	69 Tm	$L\beta_{2,15}$	20
8,493.9	79 Au	Ll	5
8,586.2	75 Re	$L\alpha_2$	11
8,615.8	30 Zn	$K\alpha_2$	51
8,638.9	30 Zn	$K\alpha_1$	100
8,652.5	75 Re	$L\alpha_1$	100
8,709.0	71 Lu	$L\beta_1$	66

8,721.0	80 Hg	Ll	5
8,747	67 Ho	$L\gamma_1$	11
8,758.8	70 Yb	$L\beta_{2,15}$	20
8,841.0	76 Os	$L\alpha_2$	11
8,905.3	29 Cu	$K\beta_{1,3}$	17
8,911.7	76 Os	$L\alpha_1$	100
8,953.2	81 Tl	Ll	6
9,022.7	72 Hf	$L\beta_1$	67
9,048.9	71 Lu	$L\beta_2$	19
9,089	68 Er	$L\gamma_1$	11
9,099.5	77 Ir	$L\alpha_2$	11
9,175.1	77 Ir	$L\alpha_1$	100
9,184.5	82 Pb	Ll	6
9,224.8	31 Ga	$K\alpha_2$	51
9,251.7	31 Ga	$K\alpha_1$	100
9,343.1	73 Ta	$L\beta_1$	67
9,347.3	72 Hf	$L\beta_2$	20
9,361.8	78 Pt	$L\alpha_2$	11
9,420.4	83 Bi	Ll	6
9,426	69 Tm	$L\gamma_1$	12

9,442.3	78 Pt	$L\alpha_1$	100
9,572.0	30 Zn	$K\beta_{1,3}$	17
9,628.0	79 Au	$L\alpha_2$	11
9,651.8	73 Ta	$L\beta_2$	20
9,672.4	74 W	$L\beta_1$	67
9,713.3	79 Au	$L\alpha_1$	100
9,780.1	70 Yb	$L\gamma_1$	12
9,855.3	32 Ge	$K\alpha_2$	51
9,886.4	32 Ge	$K\alpha_1$	100
9,897.6	80 Hg	$L\alpha_2$	11
9,961.5	74 W	$L\beta_2$	21
9,988.8	80 Hg	$L\alpha_1$	100
10,010.0	75 Re	$L\beta_1$	66
10,143.4	71 Lu	$L\gamma_1$	12
10,172.8	81 Tl	$L\alpha_2$	11
10,260.3	31 Ga	$K\beta_3$	5
10,264.2	31 Ga	$K\beta_1$	66
10,268.5	81 Tl	$L\alpha_1$	100
10,275.2	75 Re	$L\beta_2$	22
10,355.3	76 Os	$L\beta_1$	67

Table 1-3. *Energies and intensities of x-ray emission lines (continued).*

Energy (eV)	Element	Line	Relative intensity
10,449.5	82 Pb	$L\alpha_2$	11
10,508.0	33 As	$K\alpha_2$	51
10,515.8	72 Hf	$L\gamma_1$	12
10,543.7	33 As	$K\alpha_1$	100
10,551.5	82 Pb	$L\alpha_1$	100
10,598.5	76 Os	$L\beta_2$	22
10,708.3	77 Ir	$L\beta_1$	66
10,730.9	83 Bi	$L\alpha_2$	11
10,838.8	83 Bi	$L\alpha_1$	100
10,895.2	73 Ta	$L\gamma_1$	12
10,920.3	77 Ir	$L\beta_2$	22
10,978.0	32 Ge	$K\beta_3$	6
10,982.1	32 Ge	$K\beta_1$	60
11,070.7	78 Pt	$L\beta_1$	67
11,118.6	90 Th	Ll	6
11,181.4	34 Se	$K\alpha_2$	52
11,222.4	34 Se	$K\alpha_1$	100
11,250.5	78 Pt	$L\beta_2$	23
11,285.9	74 W	$L\gamma_1$	13
11,442.3	79 Au	$L\beta_1$	67
11,584.7	79 Au	$L\beta_2$	23
11,618.3	92 U	Ll	7
11,685.4	75 Re	$L\gamma_1$	13
11,720.3	33 As	$K\beta_3$	6
11,726.2	33 As	$K\beta_1$	13
11,822.6	80 Hg	$L\beta_1$	67
11,864	33 As	$K\beta_2$	1
11,877.6	35 Br	$K\alpha_2$	52
11,924.1	80 Hg	$L\beta_2$	24
11,924.2	35 Br	$K\alpha_1$	100
12,095.3	76 Os	$L\gamma_1$	13
12,213.3	81 Tl	$L\beta_1$	67
12,271.5	81 Tl	$L\beta_2$	25
12,489.6	34 Se	$K\beta_3$	6
12,495.9	34 Se	$K\beta_1$	13
12,512.6	77 Ir	$L\gamma_1$	13
12,598	36 Kr	$K\alpha_2$	52
12,613.7	82 Pb	$L\beta_1$	66
12,622.6	82 Pb	$L\beta_2$	25
12,649	36 Kr	$K\alpha_1$	100
12,652	34 Se	$K\beta_2$	1
12,809.6	90 Th	$L\alpha_2$	11
12,942.0	78 Pt	$L\gamma_1$	13
12,968.7	90 Th	$L\alpha_1$	100
12,979.9	83 Bi	$L\beta_2$	25
13,023.5	83 Bi	$L\beta_1$	67
13,284.5	35 Br	$K\beta_3$	7
13,291.4	35 Br	$K\beta_1$	14
13,335.8	37 Rb	$K\alpha_2$	52
13,381.7	79 Au	$L\gamma_1$	13
13,395.3	37 Rb	$K\alpha_1$	100
13,438.8	92 U	$L\alpha_2$	11
13,469.5	35 Br	$K\beta_2$	1
13,614.7	92 U	$L\alpha_1$	100
13,830.1	80 Hg	$L\gamma_1$	14

14,097.9	38 Sr	$K\alpha_2$	52
14,104	36 Kr	$K\beta_3$	7
14,112	36 Kr	$K\beta_1$	14
14,165.0	38 Sr	$K\alpha_1$	100
14,291.5	81 Tl	$L\gamma_1$	14
14,315	36 Kr	$K\beta_2$	2
14,764.4	82 Pb	$L\gamma_1$	14
14,882.9	39 Y	$K\alpha_2$	52
14,951.7	37 Rb	$K\beta_3$	7
14,958.4	39 Y	$K\alpha_1$	100
14,961.3	37 Rb	$K\beta_1$	14
15,185	37 Rb	$K\beta_2$	2
15,247.7	83 Bi	$L\gamma_1$	14
15,623.7	90 Th	$L\beta_2$	26
15,690.9	40 Zr	$K\alpha_2$	52
15,775.1	40 Zr	$K\alpha_1$	100
15,824.9	38 Sr	$K\beta_3$	7
15,835.7	38 Sr	$K\beta_1$	14
16,084.6	38 Sr	$K\beta_2$	3

16,202.2	90 Th	$L\beta_1$	69
16,428.3	92 U	$L\beta_2$	26
16,521.0	41 Nb	$K\alpha_2$	52
16,615.1	41 Nb	$K\alpha_1$	100
16,725.8	39 Y	$K\beta_3$	8
16,737.8	39 Y	$K\beta_1$	15
17,015.4	39 Y	$K\beta_2$	3
17,220.0	92 U	$L\beta_1$	61
17,374.3	42 Mo	$K\alpha_2$	52
17,479.3	42 Mo	$K\alpha_1$	100
17,654	40 Zr	$K\beta_3$	8
17,667.8	40 Zr	$K\beta_1$	15
17,970	40 Zr	$K\beta_2$	3
18,250.8	43 Tc	$K\alpha_2$	53
18,367.1	43 Tc	$K\alpha_1$	100
18,606.3	41 Nb	$K\beta_3$	8
18,622.5	41 Nb	$K\beta_1$	15
18,953	41 Nb	$K\beta_2$	3
18,982.5	90 Th	$L\gamma_1$	16

19,150.4	44 Ru	$K\alpha_2$	53
19,279.2	44 Ru	$K\alpha_1$	100
19,590.3	42 Mo	$K\beta_3$	8
19,608.3	42 Mo	$K\beta_1$	15
19,965.2	42 Mo	$K\beta_2$	3
20,073.7	45 Rh	$K\alpha_2$	53
20,167.1	92 U	$L\gamma_1$	15
20,216.1	45 Rh	$K\alpha_1$	100
20,599	43 Tc	$K\beta_3$	8
20,619	43 Tc	$K\beta_1$	16
21,005	43 Tc	$K\beta_2$	4
21,020.1	46 Pd	$K\alpha_2$	53
21,177.1	46 Pd	$K\alpha_1$	100
21,634.6	44 Ru	$K\beta_3$	8
21,656.8	44 Ru	$K\beta_1$	16
21,990.3	47 Ag	$K\alpha_2$	53
22,074	44 Ru	$K\beta_2$	4
22,162.9	47 Ag	$K\alpha_1$	100
22,698.9	45 Rh	$K\beta_3$	8

Table 1-3. *Energies and intensities of x-ray emission lines (continued).*

Energy (eV)	Element	Line	Relative intensity
22,723.6	45 Rh	$K\beta_1$	16
22,984.1	48 Cd	$K\alpha_2$	53
23,172.8	45 Rh	$K\beta_2$	4
23,173.6	48 Cd	$K\alpha_1$	100
23,791.1	46 Pd	$K\beta_3$	8
23,818.7	46 Pd	$K\beta_1$	16
24,002.0	49 In	$K\alpha_2$	53
24,209.7	49 In	$K\alpha_1$	100
24,299.1	46 Pd	$K\beta_2$	4
24,911.5	47 Ag	$K\beta_3$	9
24,942.4	47 Ag	$K\beta_1$	16
25,044.0	50 Sn	$K\alpha_2$	53
25,271.3	50 Sn	$K\alpha_1$	100
25,456.4	47 Ag	$K\beta_2$	4
26,061.2	48 Cd	$K\beta_3$	9
26,095.5	48 Cd	$K\beta_1$	17
26,110.8	51 Sb	$K\alpha_2$	54
26,359.1	51 Sb	$K\alpha_1$	100
26,643.8	48 Cd	$K\beta_2$	4
27,201.7	52 Te	$K\alpha_2$	54
27,237.7	49 In	$K\beta_3$	9
27,275.9	49 In	$K\beta_1$	17
27,472.3	52 Te	$K\alpha_1$	100
27,860.8	49 In	$K\beta_2$	5
28,317.2	53 I	$K\alpha_2$	54
28,444.0	50 Sn	$K\beta_3$	9
28,486.0	50 Sn	$K\beta_1$	17
28,612.0	53 I	$K\alpha_1$	100
29,109.3	50 Sn	$K\beta_2$	5
29,458	54 Xe	$K\alpha_2$	54
29,679.2	51 Sb	$K\beta_3$	9
29,725.6	51 Sb	$K\beta_1$	18
29,779	54 Xe	$K\alpha_1$	100
30,389.5	51 Sb	$K\beta_2$	5
30,625.1	55 Cs	$K\alpha_2$	54
30,944.3	52 Te	$K\beta_3$	9
30,972.8	55 Cs	$K\alpha_1$	100
30,995.7	52 Te	$K\beta_1$	18
31,700.4	52 Te	$K\beta_2$	5
31,817.1	56 Ba	$K\alpha_2$	54
32,193.6	56 Ba	$K\alpha_1$	100
32,239.4	53 I	$K\beta_3$	9
32,294.7	53 I	$K\beta_1$	18
33,034.1	57 La	$K\alpha_2$	54
33,042	53 I	$K\beta_2$	5
33,441.8	57 La	$K\alpha_1$	100
33,562	54 Xe	$K\beta_3$	9
33,624	54 Xe	$K\beta_1$	18
34,278.9	58 Ce	$K\alpha_2$	55
34,415	54 Xe	$K\beta_2$	5
34,719.7	58 Ce	$K\alpha_1$	100
34,919.4	55 Cs	$K\beta_3$	9
34,986.9	55 Cs	$K\beta_1$	18
35,550.2	59 Pr	$K\alpha_2$	55
35,822	55 Cs	$K\beta_2$	6

36,026.3	59 Pr	$K\alpha_1$	100
36,304.0	56 Ba	$K\beta_3$	10
36,378.2	56 Ba	$K\beta_1$	18
36,847.4	60 Nd	$K\alpha_2$	55
37,257	56 Ba	$K\beta_2$	6
37,361.0	60 Nd	$K\alpha_1$	100
37,720.2	57 La	$K\beta_3$	10
37,801.0	57 La	$K\beta_1$	19
38,171.2	61 Pm	$K\alpha_2$	55
38,724.7	61 Pm	$K\alpha_1$	100
38,729.9	57 La	$K\beta_2$	6
39,170.1	58 Ce	$K\beta_3$	10
39,257.3	58 Ce	$K\beta_1$	19
39,522.4	62 Sm	$K\alpha_2$	55
40,118.1	62 Sm	$K\alpha_1$	100
40,233	58 Ce	$K\beta_2$	6
40,652.9	59 Pr	$K\beta_3$	10
40,748.2	59 Pr	$K\beta_1$	19
40,901.9	63 Eu	$K\alpha_2$	56
41,542.2	63 Eu	$K\alpha_1$	100
41,773	59 Pr	$K\beta_2$	6
42,166.5	60 Nd	$K\beta_3$	10
42,271.3	60 Nd	$K\beta_1$	19
42,308.9	64 Gd	$K\alpha_2$	56
42,996.2	64 Gd	$K\alpha_1$	100
43,335	60 Nd	$K\beta_2$	6
43,713	61 Pm	$K\beta_3$	10
43,744.1	65 Tb	$K\alpha_2$	56
43,826	61 Pm	$K\beta_1$	19
44,481.6	65 Tb	$K\alpha_1$	100
44,942	61 Pm	$K\beta_2$	6
45,207.8	66 Dy	$K\alpha_2$	56
45,289	62 Sm	$K\beta_3$	10
45,413	62 Sm	$K\beta_1$	19
45,998.4	66 Dy	$K\alpha_1$	100
46,578	62 Sm	$K\beta_2$	6
46,699.7	67 Ho	$K\alpha_2$	56
46,903.6	63 Eu	$K\beta_3$	10
47,037.9	63 Eu	$K\beta_1$	19
47,546.7	67 Ho	$K\alpha_1$	100
48,221.1	68 Er	$K\alpha_2$	56
48,256	63 Eu	$K\beta_2$	6
48,555	64 Gd	$K\beta_3$	10
48,697	64 Gd	$K\beta_1$	20
49,127.7	68 Er	$K\alpha_1$	100
49,772.6	69 Tm	$K\alpha_2$	57
49,959	64 Gd	$K\beta_2$	7
50,229	65 Tb	$K\beta_3$	10
50,382	65 Tb	$K\beta_1$	20
50,741.6	69 Tm	$K\alpha_1$	100
51,354.0	70 Yb	$K\alpha_2$	57
51,698	65 Tb	$K\beta_2$	7
51,957	66 Dy	$K\beta_3$	10
52,119	66 Dy	$K\beta_1$	20
52,388.9	70 Yb	$K\alpha_1$	100
52,965.0	71 Lu	$K\alpha_2$	57
53,476	66 Dy	$K\beta_2$	7

Table 1-3. *Energies and intensities of x-ray emission lines (continued).*

Energy (eV)	Element	Line	Relative intensity
53,711	67 Ho	$K\beta_3$	11
53,877	67 Ho	$K\beta_1$	20
54,069.8	71 Lu	$K\alpha_1$	100
54,611.4	72 Hf	$K\alpha_2$	57
55,293	67 Ho	$K\beta_2$	7
55,494	68 Er	$K\beta_3$	11
55,681	68 Er	$K\beta_1$	21
55,790.2	72 Hf	$K\alpha_1$	100
56,277	73 Ta	$K\alpha_2$	57
57,210	68 Er	$K\beta_2$	7
57,304	69 Tm	$K\beta_3$	11
57,517	69 Tm	$K\beta_1$	21
57,532	73 Ta	$K\alpha_1$	100
57,981.7	74 W	$K\alpha_2$	58
59,090	69 Tm	$K\beta_2$	7
59,140	70 Yb	$K\beta_3$	11
59,318.2	74 W	$K\alpha_1$	100
59,370	70 Yb	$K\beta_1$	21
59,717.9	75 Re	$K\alpha_2$	58
60,980	70 Yb	$K\beta_2$	7
61,050	71 Lu	$K\beta_3$	11
61,140.3	75 Re	$K\alpha_1$	100
61,283	71 Lu	$K\beta_1$	21
61,486.7	76 Os	$K\alpha_2$	58
62,970	71 Lu	$K\beta_2$	7
62,980	72 Hf	$K\beta_3$	11
63,000.5	76 Os	$K\alpha_1$	100
63,234	72 Hf	$K\beta_1$	22
63,286.7	77 Ir	$K\alpha_2$	58
64,895.6	77 Ir	$K\alpha_1$	100
64,948.8	73 Ta	$K\beta_3$	11
64,980	72 Hf	$K\beta_2$	7
65,112	78 Pt	$K\alpha_2$	58
65,223	73 Ta	$K\beta_1$	22
66,832	78 Pt	$K\alpha_1$	100
66,951.4	74 W	$K\beta_3$	11
66,989.5	79 Au	$K\alpha_2$	59
66,990	73 Ta	$K\beta_2$	7
67,244.3	74 W	$K\beta_1$	22
68,803.7	79 Au	$K\alpha_1$	100
68,895	80 Hg	$K\alpha_2$	59
68,994	75 Re	$K\beta_3$	12
69,067	74 W	$K\beta_2$	8
69,310	75 Re	$K\beta_1$	22
70,819	80 Hg	$K\alpha_1$	100
70,831.9	81 Tl	$K\alpha_2$	60
71,077	76 Os	$K\beta_3$	12
71,232	75 Re	$K\beta_2$	8
71,413	76 Os	$K\beta_1$	23
72,804.2	82 Pb	$K\alpha_2$	60
72,871.5	81 Tl	$K\alpha_1$	100
73,202.7	77 Ir	$K\beta_3$	12
73,363	76 Os	$K\beta_2$	8
73,560.8	77 Ir	$K\beta_1$	23
74,814.8	83 Bi	$K\alpha_2$	60

74,969.4	82 Pb	$K\alpha_1$	100
75,368	78 Pt	$K\beta_3$	12
75,575	77 Ir	$K\beta_2$	8
75,748	78 Pt	$K\beta_1$	23
77,107.9	83 Bi	$K\alpha_1$	100
77,580	79 Au	$K\beta_3$	12
77,850	78 Pt	$K\beta_2$	8
77,984	79 Au	$K\beta_1$	23
79,822	80 Hg	$K\beta_3$	12
80,150	79 Au	$K\beta_2$	8
80,253	80 Hg	$K\beta_1$	23

82,118	81 Tl	$K\beta_3$	12
82,515	80 Hg	$K\beta_2$	8
82,576	81 Tl	$K\beta_1$	23
84,450	82 Pb	$K\beta_3$	12
84,910	81 Tl	$K\beta_2$	8
84,936	82 Pb	$K\beta_1$	23
86,834	83 Bi	$K\beta_3$	12
87,320	82 Pb	$K\beta_2$	8
87,343	83 Bi	$K\beta_1$	23
89,830	83 Bi	$K\beta_2$	9

89,953	90 Th	$K\alpha_2$	62
93,350	90 Th	$K\alpha_1$	100
94,665	92 U	$K\alpha_2$	62
98,439	92 U	$K\alpha_1$	100
104,831	90 Th	$K\beta_3$	12
105,609	90 Th	$K\beta_1$	24
108,640	90 Th	$K\beta_2$	9
110,406	92 U	$K\beta_3$	13
111,300	92 U	$K\beta_1$	24
114,530	92 U	$K\beta_2$	9