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DE #0544-4

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Analytical Approximations for X-Ray Cross Sections III

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Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550
for the United States Department of Energy
under Contract DE-AC04-76DP00789

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SF2900Q(8-81)

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Printed in the United States of America
Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

NTIS price codes
Printed copy: A07
Microfiche copy: A01

SAND87—0070
Unlimited Release
Printed August 1988

Distribution
Category UC—~~??~~ 700

SAND--87-0070

DE88 015366

Analytical Approximations for X-Ray Cross Sections III

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Abstract

This report updates our previous work that provided analytical approximations to cross sections for both photoelectric absorption of photons by atoms and incoherent scattering of photons by atoms. This representation is convenient for use in programmable calculators and in computer programs to evaluate these cross sections numerically. The results apply to atoms of atomic numbers between 1 and 100 and for photon energies $\geq$10 eV. The photoelectric cross sections are again approximated by four-term polynomials in reciprocal powers of the photon energy. There are now more fitting intervals, however, than were used previously. The incoherent-scattering cross sections are based on the Klein-Nishina relation, but use simpler approximate equations for efficient computer evaluation. We describe the averaging scheme for applying these atomic results to any composite material. The fitting coefficients are included in tables, and the cross sections are shown graphically.

Acknowledgments

We take this opportunity to thank all the people who have given us helpful suggestions over the years. This will be the last revision by this combination of authors because Ruth Lighthill has retired. Frank Biggs joins the rest of the user community in thanking Ruth for her valuable efforts in this activity and in wishing her a happy retirement.

Preface

The authors have enjoyed the interactions with many users of this representation of photon cross sections, starting with the original publication in February of 1967 and continuing through a revision in December 1971. As always, we sincerely appreciate user feedback.

Contents

Analytical Approximations for X-Ray Cross Sections III

1. Introduction

This report updates our earlier analytical representation of cross sections for both photoelectric absorption of photons by atoms and Klein-Nishina scattering of photons from atoms.[1] We updated the photoelectric cross sections to include new data that have become available in the last 15 years. The largest changes occur at photon energies below 1 keV.

There is now greater interest in the user community for convenient computer approximations for cross sections at higher photon energies than existed before. Therefore, we have added analytical representations for the Klein-Nishina cross sections that apply at higher photon energies than we included in our earlier report.

We tried to keep this document reasonably self-contained. This means that some material is reproduced here that also appears in our earlier publications.[1-2]

This document is more likely to be used as a reference that is referred to periodically than read only one time from cover to cover. We constructed the Contents with this in mind so it can easily be used to locate topics of interest. The graphs are expected to get the most use; they are at the end of the document, with the element name and corresponding atomic number across the top of the page for easy reference. As in previous revisions, the values of the absorption edges are printed on the graphs.

This new compilation has been used here at Sandia for over a year to help check it for errors. Therefore, any new results that became available during this time were not included in the fitting.

The report is organized as follows. Section 2 gives the physical constants used in the report, defines units, provides some definitions, and gives a few notations. In Section 3 we discuss the form of the analytical representation for the photoelectric cross sections. Section 4 discusses the Klein-Nishina relations and our approximation to them. In Section 5 the combined cross sections show the result of adding the incoherent cross sections to the photoelectric cross sections, and we describe the application to composite materials. The parameter table in Appendix A gives the fitting parameters used in the analytical approximations for the photoelectric cross sections. Finally, the cross-section plots are provided in Appendix B. References are provided after the appendixes.

2. Physical Constants, Units, and Notations

2.1 Fundamental Constants

We provide the values of the physical constants to be used in this document here for convenient reference.

$$N_0 = 6.02205 \times 10^{23}/\text{mole (Avogadro's number)}$$

$$r = 2.81794 \times 10^{-13}\ \text{cm (electron radius)}$$

$$m = 9.10953 \times 10^{-28}\ \text{g (electron mass)}$$

$$c = 2.99792 \times 10^{10}\ \text{cm/s (speed of light)}$$

The numerical values of these constants are taken from Reference 3. Not all of these constants are used here to as many significant places as they are provided in the reference, but they are adequate for their use here.

A quantity that is used in the Klein-Nishina equations is

$$L = \frac{8}{3}\pi r^2 N_0 = 0.40061\ \text{cm}^2/\text{mole}\,. \qquad (1)$$

2.2 Units

We will express atomic and composite-material cross sections in units of centimeters squared per gram. This is consistent with our earlier versions of this representation and is convenient for compatibility with existing computer codes that use this representation.

Although our final cross sections for any element or composite material are in units of centimeters squared per gram, it is convenient to first express the Klein-Nishina cross sections in units of centimeters squared per mole of electrons. Then, to get the Klein-Nishina approximation to the scattering cross section for an element of atomic number Z and atomic weight A, we simply multiply by the ratio Z/A. This provides the corresponding atomic cross section in units of centimeters squared per gram.

In the Klein-Nishina equations and related results, the following substitution is used:

$$X = \frac{E(\mathrm{keV})}{511.004}\,(\text{photon energy in } mc^2 \text{ units})\,. \tag{2}$$

Further substitutions used in developing the Klein-Nishina results include

$$\omega = \frac{1}{(1 + 2X)} \tag{3}$$

and

$$\eta = \frac{1}{2X}\,. \tag{4}$$

There are some constants appearing in this document that depend on the atomic weights of the elements. We tabulate these in Table 1. Note that this table is divided into two sides, with 50 elements in each part. The atomic number Z appears in the first column, the element symbol is given next in the El column, and the atomic weights are in the A column. The quantities in the Conv column are the multiplication factors needed for changing the units of photon cross sections from centimeters squared per gram to barns/atom $[10^{24}/(N_0/A) = A/0.602205]$. These conversions are also given for convenience below the plots of the photoelectric cross sections. Finally, the ratios of atomic number (Z) to the atomic weight (A) are listed in the Z/A columns. These numbers also appear in the fitting parameters table. The atomic weights given in Table 1 are from page B-3 of Reference 3. There have been improvements of a few percent in the accuracy of some of these atomic weights since our last revision was published in 1971.

Table 1. Atomic Weights, Unit Conversions, and Z/A Ratios for the Elements

Z	El	A	Conv	Z/A	Z	El	A	Conv	Z/A
1	H	1.00794	1.67	0.9921	51	Sb	121.75	202.17	0.4189
2	He	4.00260	6.65	0.4997	52	Te	127.60	211.89	0.4075
3	Li	6.941	11.53	0.4322	53	I	126.9045	210.73	0.4176
4	Be	9.01218	14.97	0.4438	54	Xe	131.29	218.02	0.4113
5	B	10.81	17.95	0.4625	55	Cs	132.9054	220.70	0.4138
6	C	12.011	19.95	0.4995	56	Ba	137.33	228.05	0.4078
7	N	14.0067	23.26	0.4998	57	La	138.9055	230.66	0.4104
8	O	15.9994	26.57	0.5000	58	Ce	140.12	232.68	0.4139
9	F	18.99840	31.55	0.4737	59	Pr	140.9077	233.99	0.4187
10	Ne	20.179	33.51	0.4956	60	Nd	144.24	239.52	0.4160
11	Na	22.98977	38.18	0.4785	61	Pm	145.	240.78	0.4207
12	Mg	24.305	40.36	0.4937	62	Sm	150.36	249.68	0.4123
13	Al	26.98154	44.80	0.4818	63	Eu	151.96	252.34	0.4146
14	Si	28.0855	46.64	0.4985	64	Gd	157.25	261.12	0.4070
15	P	30.97376	51.43	0.4843	65	Tb	158.9254	263.91	0.4090
16	S	32.06	53.24	0.4991	66	Dy	162.50	269.84	0.4062
17	Cl	35.453	58.87	0.4795	67	Ho	164.9304	273.88	0.4062
18	Ar	39.948	66.34	0.4506	68	Er	167.26	277.75	0.4066
19	K	39.0983	64.93	0.4860	69	Tm	168.9342	280.53	0.4084
20	Ca	40.08	66.56	0.4990	70	Yb	173.04	287.34	0.4045
21	Sc	44.9559	74.65	0.4671	71	Lu	174.967	290.54	0.4058
22	Ti	47.88	79.51	0.4595	72	Hf	178.49	296.39	0.4034
23	V	50.9415	84.59	0.4515	73	Ta	180.9479	300.48	0.4034
24	Cr	51.996	86.34	0.4616	74	W	183.85	305.29	0.4025
25	Mn	54.9380	91.23	0.4551	75	Re	186.207	309.21	0.4028
26	Fe	55.847	92.74	0.4656	76	Os	190.2	315.84	0.3996
27	Co	58.9332	97.86	0.4581	77	Ir	192.22	319.19	0.4006
28	Ni	58.69	97.46	0.4771	78	Pt	195.08	323.94	0.3998
29	Cu	63.546	105.52	0.4564	79	Au	196.9665	327.08	0.4011
30	Zn	65.38	108.57	0.4589	80	Hg	200.59	333.09	0.3988
31	Ga	69.72	115.77	0.4446	81	Tl	204.383	339.39	0.3963
32	Ge	72.59	120.54	0.4408	82	Pb	207.2	344.07	0.3958
33	As	74.9216	124.41	0.4405	83	Bi	208.9804	347.03	0.3972
34	Se	78.96	131.12	0.4306	84	Po	209.	347.06	0.4019
35	Br	79.904	132.69	0.4380	85	At	210.	348.72	0.4048
36	Kr	83.80	139.16	0.4296	86	Rn	222.	368.65	0.3874
37	Rb	85.4678	141.92	0.4329	87	Fr	223.	370.31	0.3901
38	Sr	87.62	145.50	0.4337	88	Ra	226.0254	375.33	0.3893
39	Y	88.9059	147.63	0.4387	89	Ac	227.0278	376.99	0.3920
40	Zr	91.22	151.48	0.4385	90	Th	232.0381	385.31	0.3879
41	Nb	92.9064	154.28	0.4413	91	Pa	231.0359	383.65	0.3939
42	Mo	95.94	159.31	0.4378	92	U	238.0289	395.26	0.3865
43	Tc	98.	162.74	0.4388	93	Np	237.0482	393.6	0.3923
44	Ru	101.07	167.83	0.4353	94	Pu	244.	405.18	0.3852
45	Rh	102.9055	170.88	0.4373	95	Am	243.	403.52	0.3909
46	Pd	106.42	176.72	0.4322	96	Cm	247.	410.16	0.3887
47	Ag	107.8682	179.12	0.4357	97	Bk	247.	410.16	0.3927
48	Cd	112.41	186.66	0.4270	98	Cf	251.	416.80	0.3904
49	In	114.82	190.67	0.4268	99	Es	252.	418.46	0.3929
50	Sn	118.69	197.09	0.4213	100	Fm	257.	426.77	0.3891

2.3 Notations

We use the subscript i to denote atomic number and f_i to denote the mass fraction of element i in a composite material. The index j is used to denote the j-th energy interval for fitting the photoelectric cross sections. We use a subscript c to denote a composite material.

3. Photoelectric Cross Sections

The representation for the photoelectric cross section in interval j of element i is the linear combination of reciprocal powers of the photon energy E (E in keV).

$$\mu_{ij} = \frac{A_{ij1}}{E} + \frac{A_{ij2}}{E^2} + \frac{A_{ij3}}{E^3} + \frac{A_{ij4}}{E^4} \; ,$$

$$i = 1, \ldots, 100; \quad j = 1, \ldots, m_i \; , \tag{5}$$

where m_i is the number of fitting intervals used for element i. The units are centimeters squared per gram for the photoelectric cross section μ. The fitting parameters A_{ijk} are tabulated in Appendix A.3.

The fitting of these parameters to source data is discussed in Appendix B, where the cross-section plots are presented.

4. Klein-Nishina Cross Sections

4.1 General

The Klein-Nishina relations are used in this representation to estimate incoherent scattering. The equations used here are based on the theory developed in Evans.[4]

The Klein-Nishina model applies to free stationary electrons. Of course, atomic electrons are neither free nor stationary. However, the corrections for these effects are small compared to the sum of the photoelectric plus incoherent cross sections. For example, at small photon energies where electron binding effects are important, photoelectric effects dominate the total photon cross section. On the other hand, at high energies where the photoeffect is a small part of the total, the atomic binding effects become negligible compared to the energy of the incident photon.

In this section we first treat the total Klein-Nishina cross sections; then we discuss the Klein-Nishina energy-transfer cross sections. In each case the equations are given first, followed by graphs of the equations and a table of numerical results.

When discussing Klein-Nishina cross sections as applied to electrons, we use units of centimeters squared per mole (6.02205×10^{23}) of electrons. Constants and variable changes X, ω, and η are defined in Section 2.2 by Eqs (2), (3), and (4).

4.2 Equations for Total Cross Sections

The theoretical result for the total Klein-Nishina cross section is

$$R = \frac{3}{4} L \left[\left(\frac{2 + 2X - X^2}{2X^3} \right) \ln\omega + 2\omega \frac{(1 + X)^2}{X^2} - \omega^2 (1 + 3X) \right] . \tag{6}$$

The power-series expansion of this is sometimes a useful approximation at small photon energies and shows the form of the low-energy limit of the equation

$$R \approx L \left(1 - 2X + \frac{26}{5} X^2 - \frac{133}{10} X^3 + \frac{1144}{35} X^4 - \ldots \right) . \tag{7}$$

It is convenient to have a simple approximation to R that can be evaluated adequately in single precision on a 32-bit computer and that will use less machine time than the full equation for R. One such approximation for R is the following rational function that was used in our earlier compilations.

$$R \approx L \left(\frac{1 + 1.148X + 0.06141X^2}{1 + 3.171X + 0.9328X^2 + 0.02572X^3} \right) . \tag{8}$$

This is a good approximation to the Klein-Nishina equation for photon energies below 10 MeV.

An approximation for R valid at large values of X is

$$R \approx \frac{3}{8} L\eta \left[2(1 - 4\eta - 8\eta^2) \ln(1 + 2X) + 1 + 16\eta - \eta^2 \right] . \tag{9}$$

We recommend using this approximation to evaluate scattering cross sections for photons with energies above 10 MeV.

4.3 Total Cross-Sections Graph

Figure 1 shows a graph of the total Klein-Nishina cross section in units of centimeters squared per mole of electrons versus photon energy in kiloelectronvolts. The solid curve shows R of Eq (6), the rational fraction of Eq (8) by the short-dashed curve, the high-energy approximation of Eq (9) by the long-dashed curve, and the power series expansion of Eq (7) by the dash-dot-dot-dot curve as indicated in the legend of the figure. Note that the rational function approximation falls below the true value above about 10 MeV. However, the high-energy approximation is very good in this interval.

Of course, one could just use the complete Klein-Nishina equation at all energies, but it requires multiple precision word-length evaluation at low values of photon energies and is slower to evaluate than are the approximations. We recommend using the rational function (Eq (8)) for photon energies up to 10 MeV and the high-energy approximation (Eq (9)) for photon energies above 10 MeV.

4.4 Numerical Results for Total Cross Sections

The purpose of Table 2 is to give values of the total Klein-Nishina cross sections more accurately than can be read from a graph and to extend the evaluations to higher photon energies. Also, the relative errors of the corresponding approximations are provided. The values of the Klein-Nishina cross sections in units of centimeters squared per mole of electrons are given versus photon energy in kiloelectronvolts in the R column of Table 2 as determined by the multiple-precision evaluation of Eq (6). The Rea column gives the relative (fractional) error of the rational function approximation of R by Eq (8), and the Rel column gives the relative errors for the large energy approximation of R by Eq (9). The relative errors in the series expansion using the number of terms shown in Eq (7) are given in the last column.

Note that when a relative error exceeds 100%, we simply designate this by the entry "large," and when it is $<10^{-6}$ we indicate it by the entry "small." The exact values of the errors in these approximations are not of interest whenever they are extremely small or large enough to render the approximation useless.

As stated previously, we recommend using Eq (8) to approximate the total Klein-Nishina cross sections for photon energies below 10 MeV and using Eq (9) for photon energies above 10 MeV.

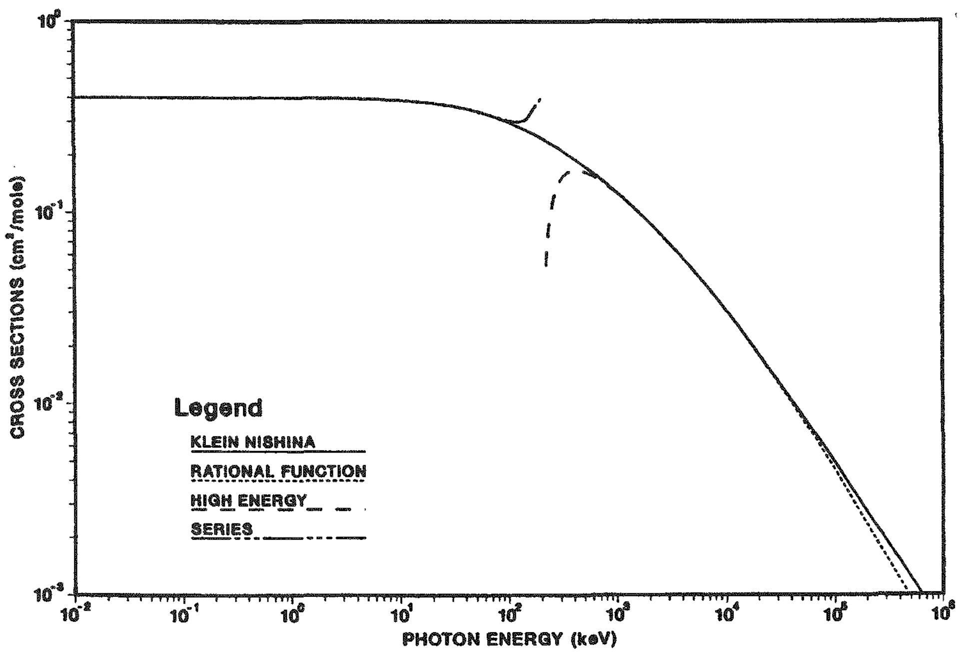


Figure 1. Klein-Nishina Total Cross Sections

Table 2. Values R of Eq (6) and Relative Errors Rea of Eq (8), Rel of Eq (9), and Res of Eq (7) vs Photon Energy E

E (keV)	R	Rea	Rel	Res
1×10^{-2}	4.006×10^{-1}	small	large	small
4×10^{-2}	4.005×10^{-1}	small	large	small
6×10^{-2}	4.005×10^{-1}	small	large	small
1×10^{-1}	4.004×10^{-1}	-4.5×10^{-6}	large	small
4×10^{-1}	4.000×10^{-1}	-1.8×10^{-5}	large	small
6×10^{-1}	3.997×10^{-1}	-2.7×10^{-5}	large	small
1×10^{0}	3.990×10^{-1}	-4.4×10^{-5}	large	small
4×10^{0}	3.945×10^{-1}	-1.6×10^{-4}	large	small
6×10^{0}	3.915×10^{-1}	-2.3×10^{-4}	large	small
1×10^{1}	3.857×10^{-1}	-3.5×10^{-4}	large	2.1^{-6}
4×10^{1}	3.485×10^{-1}	-5.9×10^{-4}	large	2.1^{-4}
6×10^{1}	3.286×10^{-1}	-4.4×10^{-4}	large	1.7^{-3}
1×10^{2}	2.967×10^{-1}	5.2×10^{-5}	large	2.1^{-2}
1×10^{2}	1.907×10^{-1}	3.4×10^{-4}	large	large
6×10^{2}	1.611×10^{-1}	-2×10^{-4}	-3.4×10^{-1}	large
1×10^{3}	1.272×10^{-1}	-3.6×10^{-4}	-5.8×10^{-2}	large
4×10^{3}	6.931×10^{-2}	-1.3×10^{-4}	-5.1×10^{-4}	large
6×10^{3}	4.410×10^{-2}	-1.1×10^{-4}	-1.3×10^{-4}	large
1×10^{4}	2.071×10^{-2}	-7.5×10^{-4}	small	large
4×10^{4}	1.052×10^{-2}	-2.8×10^{-2}	small	large
6×10^{4}	7.553×10^{-3}	-5×10^{-2}	small	large
1×10^{5}	4.937×10^{-3}	-8.7×10^{-2}	small	large
4×10^{5}	1.505×10^{-3}	-2.1×10^{-1}	small	large
6×10^{5}	1.056×10^{-3}	-2.4×10^{-1}	small	large
1×10^{6}	6.729×10^{-4}	-2.8×10^{-1}	small	large
4×10^{6}	1.949×10^{-4}	-3.7×10^{-1}	small	large
6×10^{6}	1.351×10^{-5}	-4×10^{-1}	small	large
1×10^{7}	8.501×10^{-5}	-4.3×10^{-1}	small	large
4×10^{7}	2.391×10^{-5}	-4.9×10^{-1}	small	large
6×10^{7}	1.646×10^{-5}	-5.1×10^{-1}	small	large
1×10^{8}	1.027×10^{-5}	-5.2×10^{-1}	small	large

4.5 Atomic Cross Sections

The incoherent scattering cross section, in units of centimeters squared per gram for an element of atomic number i (using the Klein-Nishina approximation) is

$$\eta_i = \left(\frac{Z}{A}\right)_i R \tag{10}$$

where Z is the atomic number and A is the atomic weight of element i. The Z /A ratios are tabulated in Table 1, and R should be used from Eq (8) or Eq (9).

4.6 Composite Materials

The total incoherent scattering cross section in units of centimeters squared per gram for a composite material consisting of N elements is

$$\eta_c = \sum_{i=1}^{N} f_i \eta_i = \left(\frac{Z}{A}\right)_c R \tag{11}$$

where

$$\left(\frac{Z}{A}\right)_c = \sum_{i=1}^{N} f_i \left(\frac{Z}{A}\right)_i \ . \tag{12}$$

The parameter f_i is the fraction (by mass) of element i in the composite material.

4.7 Equations for Energy-Transfer Cross Sections

The Klein-Nishina cross section for transferring energy to the scattering electrons is

$$S = \frac{3}{4} L \left\{ \frac{3 + 2X - X^2}{2X^3} \ln\omega + \frac{2\omega(1 + X)^2}{X^2} - \omega^2 \left[(1 + 3X) + \frac{(1+X)\,(2X^2 - 2X - 1)}{X^2} \right] - \frac{4}{3} X^2 \omega^3 \right\} , \tag{13}$$

where X is the photon in energy in mc^2 units (see Eq (2)), the constant L is defined by Eq (1), and the change in variable ω is defined by Eq (3).

The power-series expansion for S is

$$S \approx L \left(X - \frac{42}{10} X^2 + \frac{147}{10} X^3 - \frac{1616}{35} X^4 + ... \right) . \tag{14}$$

A useful rational function approximation for photon <10 MeV is the one used in our earlier work.

$$S \approx L \left(\frac{X + 0.825X^2 + 0.03234X^3}{1 + 5.393X + 5.212X^2 + 0.8783X^3 + 0.01599X^4} \right) . \tag{15}$$

However, at photon energies higher than 10 MeV we recommend the use of the following approximation:

$$S \approx \frac{3}{8} L\eta \left[2(1 - 4\eta - 12\eta^2) \ln(1 + 2X) - \frac{5}{3} + 22\eta + \eta^2 \right] , \tag{16}$$

where η is defined in Section 2.2 above by Eq (4).

4.8 Graphs of Energy-Transfer Approximations

Figure 2 shows the Klein-Nishina energy-transfer cross section Eq (13) in units of centimeters squared per mole of electrons versus photon energy in kiloelectronvolts by the solid curve. The approximations discussed above are also shown as indicated in the legend of the figure. Note that the rational-function approximation Eq (15) falls below the correct value above about $E=10^4$ keV. However, the high-energy approximation (Eq (16)) is good in this interval.

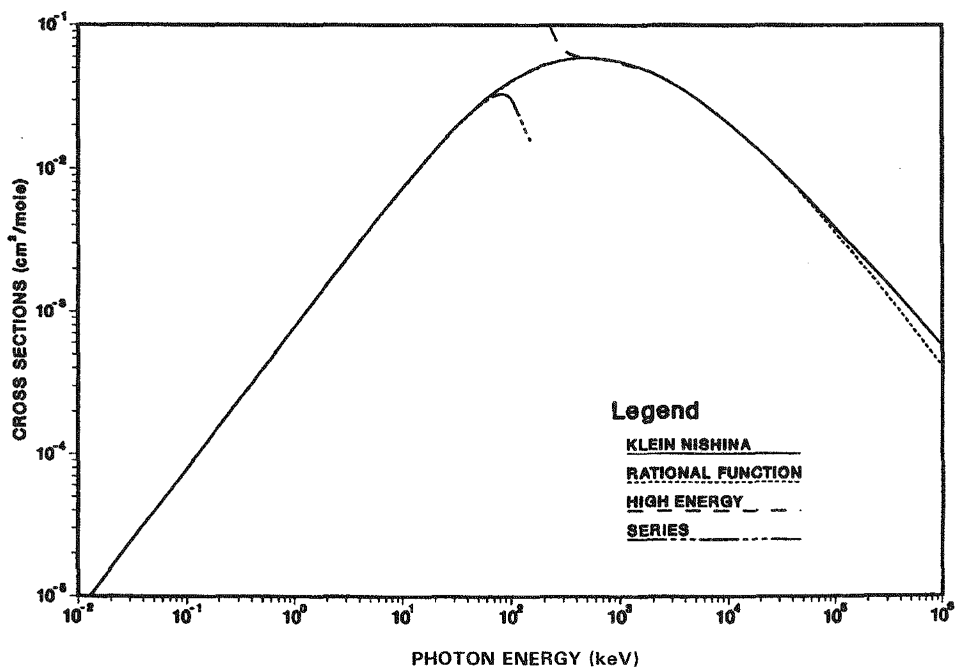


Figure 2. Klein-Nishina Energy-Transfer Cross Sections

4.9 Numerical Results for Energy-Transfer Approximations

The purpose of Table 3 is to provide some values of the Klein-Nishina cross sections more accurately than can be read from a graph, to tabulate the relative errors in the corresponding approximations, and to extend the evaluations to higher photon energies. The values of the Klein-Nishina energy-transfer cross sections in units of centimeters squared per mole of electrons appear in column S versus the photon energy kiloelectronvolts given in the first column as obtained by multiple precision evaluation of Eq (13). The relative (fractional) errors in the rational-fraction approximation (Eq (15)) are given in the Rea column, the relative errors in the high-energy approximation (Eq (16)) are given in the Rel column, and the relative errors in the power-series expansion of Eq (14) appear in the last column.

When a relative error in Table 3 exceeds 100%, we designate it by the entry "large" and when it is $<10^{-6}$ by the entry "small." Again, we recommend using Eq (15) as an approximation for the Klein-Nishina energy-transfer cross sections for photon energies below 10 MeV and using Eq (16) for photon energies $\geq$10 MeV.

Table 3. Values S of Eq (12), Relative Errors Rea of Eq (14), Rel of Eq (15), and Res of Eq (13) vs Photon Energy E

E(keV)	S	Rea	Rel	Res
1×10^{-2}	7.839×10^{-6}	small	large	small
4×10^{-2}	3.135×10^{-5}	small	large	small
6×10^{-2}	4.701×10^{-5}	small	large	small
1×10^{-1}	7.833×10^{-5}	-7.2×10^{-5}	large	small
4×10^{-1}	3.126×10^{-4}	-2.8×10^{-4}	large	small
6×10^{-1}	4.681×10^{-4}	-4.3×10^{-4}	large	small
1×10^{0}	7.775×10^{-4}	-7.1×10^{-4}	large	small
4×10^{0}	3.035×10^{-3}	-2.7×10^{-3}	large	small
6×10^{0}	4.481×10^{-3}	-3.9×10^{-3}	large	small
1×10^{1}	7.237×10^{-3}	-6.1×10^{-3}	large	-2.0×10^{-5}
4×10^{1}	2.331×10^{-2}	-1.5×10^{-2}	large	-5.6×10^{-3}
6×10^{1}	3.076×10^{-2}	-1.7×10^{-2}	large	-2.9×10^{-2}
1×10^{2}	4.095×10^{-2}	-1.6×10^{-2}	large	-2.4×10^{-1}
4×10^{2}	5.905×10^{-2}	3.8×10^{-4}	3.7×10^{-2}	large
6×10^{2}	5.920×10^{-2}	1.6×10^{-3}	-1.7×10^{-3}	large
1×10^{3}	5.597×10^{-2}	6.8×10^{-4}	-2.0×10^{-3}	large
4×10^{3}	3.508×10^{-2}	-1.4×10^{-5}	-3.5×10^{-5}	large
6×10^{3}	2.840×10^{-2}	-2.4×10^{-5}	-9.3×10^{-6}	large
1×10^{4}	2.099×10^{-2}	-8.1×10^{-6}	small	large
4×10^{4}	7.993×10^{-3}	-1.8×10^{-2}	small	large
6×10^{4}	5.863×10^{-3}	-3.8×10^{-2}	small	large
1×10^{5}	3.919×10^{-3}	-7.3×10^{-2}	small	large
4×10^{5}	1.250×10^{-3}	-2.0×10^{-1}	small	large
6×10^{5}	8.854×10^{-4}	-2.4×10^{-1}	small	large
1×10^{6}	5.706×10^{-4}	-2.9×10^{-1}	small	large
4×10^{6}	1.693×10^{-4}	-3.9×10^{-1}	small	large
6×10^{6}	1.181×10^{-4}	-4.2×10^{-1}	small	large
1×10^{7}	7.476×10^{-5}	-4.5×10^{-1}	small	large
4×10^{7}	2.136×10^{-5}	-5.2×10^{-1}	small	large
6×10^{7}	1.476×10^{-5}	-5.3×10^{-1}	small	large
1×10^{8}	9.246×10^{-6}	-5.5×10^{-1}	small	large

4.10 Atomic-Energy-Transfer Cross Sections

The cross section in units of centimeters squared per gram for transfer of energy to an element of atomic number i of the scattering medium is

$$\sigma_i = \left(\frac{Z}{A}\right)_i S \tag{17}$$

where the ratio Z/A is given in Table 1 and S is approximated by Eq (15) or Eq (16).

4.11 Composite Materials

For an N-element composite material

$$\sigma_c = \sum_{i=1}^{N} f_i \sigma_i = \left(\frac{Z}{A}\right)_c S \tag{18}$$

where again f_i is the mass fraction of element i in the composite.

5. Combined Cross Sections

5.1 Atomic Total

The total cross section consists of the sum of the scattering cross section and the photoelectric cross section. Using the Klein-Nishina approximation for the scattering cross section gives

$$\tilde{\mu}_{ij} = \mu_{ij} + \eta_i \tag{19}$$

for the total cross section in interval j of element i.

5.2 Composite Total

For a composite material of N elements, the constituent atomic cross sections are averaged over the elements of the composite to get the cross section for the composite material.

$$(\tilde{\mu}_j)_c = \sum_{i=1}^{N} f_i \mu_{ij} + \sum_{i=1}^{N} f_i \eta_i \tag{20}$$

The weighting factor f_i in this average is the fraction (by mass) of element i occurring in the composite material.

5.3 Atomic-Energy-Transfer Cross Section

The energy-transfer cross section for interval j of element i is

$$\hat{\mu}_{ij} = \mu_{ij} + \sigma_i \ . \tag{21}$$

5.4 Composite-Energy-Transfer Cross Section

Again, for a composite material the atomic cross sections are averaged over the elements of the composite,

$$(\hat{\mu}_j)_c = \sum_{i=1}^{N} f_i \mu_{ij} + \sum_{i=1}^{N} f_i \sigma_i \ , \tag{22}$$

where again f_i is the fraction (by mass) of element i occurring in the composite material.

APPENDIX A

Parameter Table

A.1 Disk File

As discussed in Section 3, there are four fitting parameters in each of several intervals for each element as written in Eq (5). These fitting parameters are stored on a disk file named FRANK5.DAT. In this Appendix we describe the file containing the photoelectric fitting parameters. The format for reading this file is as follows: The first record contains only the integer −1, and the second record contains only the integer 4. These numbers are used by some of our existing codes. The third and fourth records identify the cross sections with the report number and date.

Record 5 begins the parameter table. There are several records (one for each fitting interval j) for each element for atomic number i between 1 and 100. The atomic number is an integer and appears in the first three fields. The number of the fitting interval for a given element is an integer and appears in fields 4 through 6; this is the index j of Eq (5). Fields 7 through 14 contain the lower boundary of the fitting interval j, fields 15 through 22 contain the upper boundary of fitting interval j, and fields 23 through 32 contain the atomic number to atomic weight ratio Z/A. Fields 33 through 45 contain the first fitting coefficient, fields 45 through 56 contain the second coefficient, fields 57 through 67 contain the third coefficient, and fields 68 through 78 contain the fourth and last of the photoelectric fitting parameters for element i and interval j. The format for these records is: [FORMAT(2I3,2F8.0,E10.3,2X,4E11.3)].

A.2 Description of Table

The representation scheme for computer evaluation of photoelectric cross sections involves the use of four fitting parameters in each of several intervals for each of 100 elements. These are the parameters contained in Eq (5) of Section 3. Note that the subscripts of the fitting parameters of Eq (5) are written in parentheses in the column headings of the parameter table. The first index I refers to the atomic number, which is written at the beginning of each subsection of the table just before the element name. The interval number j appears in the first column of the table. The interval identification column is designated by INT IDENT and gives the interval boundaries in kiloelectronvolts. Some of the interval boundaries correspond to absorption edges. The RMS column gives the relative (fractional) root-mean-square error obtained when fitting Eq (5) to the source data. The entry NA is used in this column when the fitting was done without enough source data to make an adequate estimate of the fitting error. This occurs in some of the low-photon-energy intervals where data are scarce. The last column indicates whether or not a refitting was done in the corresponding intervals for this revision (update) by using Y(yes) and N(no) entries. Note that the ratio of atomic number to atomic weight Z/A is also shown for each element. This multiplier is needed to multiply the Klein-Nishina results of Section 4 to obtain the scattering cross section for the corresponding atom in units of centimeters squared per gram. Since these constants are also given in Table 1 of Section II, it is less important than it was in the earlier versions of this compilation to provide them here in the Parameter Table. However, we felt that we should keep the format the same for the convenience of users already familiar with earlier versions.

A.3 Table

The parameter table is given on the next 16 pages.

1 HYDROGEN Z/A = 9.921E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--K	.01	.014	NA	1.000E-08	0.	0.	0.	Y
2	K--.1	.014	.1	2.3-3	-6.383E+01	-6.446E+00	1.317E+01	-5.045E-02	N
3	.1--.8	.1	.8	6.3-3	3.051E+00	-7.818E+00	1.144E+01	6.959E-02	N
4	.8--4.	.8	4.	4.6-3	7.636E-02	-9.406E-01	6.144E+00	1.425E+00	N
5	4.--20.	4.	20.	5.3-3	1.180E-03	-8.236E-02	2.886E+00	5.534E+00	N
6	20.--100.	20.	100.	4.6-3	1.620E-05	-5.610E-03	1.214E+00	1.761E+01	N
7	100.--500.	100.	500.	2.2-3	1.034E-06	-4.114E-04	6.287E-01	3.927E+01	N
8	500.--INF	500.	INF	2.5-2	4.599E-07	5.006E-04	-1.425E-02	1.960E+02	Y
2 HELIUM	Z/A = 4.997E-01								
1	.01--K	.01	.025	NA	1.000E-08	0.	0.	0.	Y
2	K--.15	.025	.15	2.5-3	-1.196E+03	4.759E+02	1.979E+01	-3.540E-01	Y
3	.15--.8	.15	.8	7.5-2	1.857E+01	-4.079E+01	8.609E+01	-2.618E+00	N
4	.8--4.	.8	4.	2.2-2	1.606E+00	-1.726E+01	8.101E+01	-4.928E+00	N
5	4.--20.	4.	20.	1.2-2	3.663E-03	-3.782E-01	2.288E+01	6.006E+01	N
6	20.--100.	20.	100.	3.1+1	5.934E-04	-1.109E-01	1.388E+01	1.680E+02	Y
7	100.--500.	100.	500.	3.1+1	1.120E-05	-3.894E-03	6.136E+00	4.354E+02	Y
8	500.--INF	500.	INF	5.1+1	4.921E-06	1.493E-03	4.725E+00	7.128E+02	Y
3 LITHIUM	Z/A = 4.322E-01								
1	.01--K	.01	.055	1.5-2	-2.418E+02	3.530E+01	-2.699E-01	5.580E-04	N
2	K--.8	.055	.8	4.8-2	-1.474E+02	1.578E+02	2.036E+02	-8.521E+00	Y
3	.8--4.	.8	4.	9.3-3	4.375E+00	-5.094E+01	3.053E+02	-3.064E+01	N
4	4.--20.	4.	20.	6.3-3	4.040E-02	-2.930E+00	1.293E+02	1.828E+02	N
5	20.--100.	20.	100.	2.4+1	3.139E-03	-6.107E-01	7.342E+01	6.652E+02	Y
6	100.--500.	100.	500.	2.6+1	4.823E-05	-1.161E-02	2.898E+01	2.129E+03	Y
7	500.--INF	500.	INF	3.7+1	2.128E-05	1.951E-02	1.009E+01	7.144E+03	Y
4 BERRYLLIUM	Z/A = 4.438E-01								
1	.01--K	.01	.111	1.4-2	-2.785E+02	1.252E+02	-1.912E+00	8.371E-03	Y
2	K--.8	.111	.8	4.8-2	-4.798E+02	6.302E+02	4.187E+02	-2.783E+01	Y
3	.8--4.	.8	4.	6.4-2	1.037E+01	-1.280E+02	8.807E+02	-1.646E+02	N
4	4.--20.	4.	20.	5.0-3	1.018E-01	-8.264E+00	4.158E+02	4.366E+02	N
5	20.--100.	20.	100.	6.6-3	5.693E-03	-1.595E+00	2.644E+02	1.566E+03	N
6	100.--500.	100.	500.	1.7-1	2.129E-04	-7.972E-02	1.155E+02	6.065E+03	Y
7	500.--INF	500.	INF	2.5-1	7.797E-05	7.695E-02	3.396E+01	2.439E+04	Y
5 BORON	Z/A = 4.625E-01								
1	.01--K	.01	.188	2.1-1	-3.387E+02	1.923E+02	-2.742E+00	1.204E-02	N
2	K--.8	.188	.8	3.9-2	-9.943E+02	1.816E+03	3.939E+02	-1.755E+01	N
3	.8--4.	.8	4.	6.4-3	3.689E+00	-8.834E+01	1.525E+03	-2.145E+02	N
4	4.--20.	4.	20.	1.8-2	6.447E-01	-3.953E+01	1.281E+03	1.768E+02	N
5	20.--100.	20.	100.	2.3-2	1.852E-03	-1.356E+00	5.252E+02	5.160E+03	N
6	100.--500.	100.	500.	9.0-2	4.282E-04	-1.297E-01	2.892E+02	1.601E+04	Y
7	500.--INF	500.	INF	1.9-1	1.965E-04	1.947E-01	1.001E+02	5.902E+04	Y
6 CARBON	Z/A = 4.995E-01								
1	.01--.0457	.01	.0457	NA	5.704E+03	0.	0.	0.	Y
2	.0457--K	.0457	.284	4.7-2	-3.935E+02	3.219E+02	-6.549E+00	2.086E-01	Y
3	K--.8	.284	.8	1.9-1	-9.022E+02	1.760E+03	1.549E+03	-2.280E+02	Y
4	.8--4.	.8	4.	6.3-2	-7.363E+00	-1.537E+01	2.672E+03	-4.482E+02	Y
5	4.--20.	4.	20.	2.4-2	1.640E+00	-9.428E+01	2.872E+03	-5.583E+02	N
6	20.--100.	20.	100.	1.2-1	-3.742E-03	-1.232E+00	9.489E+02	1.406E+04	Y
7	100.--500.	100.	500.	3.1-2	6.760E-04	-1.164E-01	6.566E+02	2.739E+04	Y
8	500.--INF	500.	INF	1.4-1	4.503E-04	4.692E-01	2.183E+02	1.308E+05	Y
7 NITROGEN	Z/A = 4.998E-01								
1	.01--.0404	.01	.0404	NA	1.010E+04	0.	0.	0.	Y
2	.0404--K	.0404	.4016	1.4-2	-3.622E+02	3.873E+02	1.244E+01	-4.452E-01	Y
3	K--.8	.4016	.8	2.9-2	-2.338E+03	5.732E+03	-2.082E+02	1.482E+02	N
4	.8--4.	.8	4.	1.6-2	-4.940E+00	-8.442E+01	4.620E+03	-1.186E+03	N
5	4.--20.	4.	20.	1.7-2	2.019E+00	-1.249E+02	4.609E+03	-9.421E+02	N
6	20.--100.	20.	100.	1.4-2	1.709E-02	-8.196E+00	2.345E+03	1.369E+04	N
7	100.--500.	100.	500.	2.9-2	1.872E-03	-6.732E-01	1.282E+03	5.700E+04	Y
8	500.--INF	500.	INF	1.4-1	8.122E-04	8.364E-01	4.410E+02	2.358E+05	Y
8 OXYGEN	Z/A = 5.000E-01								
1	.01--.0483	.01	.0483	NA	1.144E+04	0.	0.	0.	Y
2	.0483--K	.0483	.532	1.8-2	-2.863E+02	4.085E+02	4.436E+01	-1.782E+00	Y
3	K--4.	.532	4.	2.3-2	-7.181E+01	4.748E+02	5.542E+03	-1.363E+03	N
4	4.--20.	4.	20.	1.1-2	2.745E+00	-1.747E+02	7.159E+03	-2.213E+03	N
5	20.--100.	20.	100.	1.0-2	3.774E-02	-1.559E+01	4.045E+03	1.810E+04	N
6	100.--500.	100.	500.	4.4-2	3.169E-03	-1.146E+00	2.194E+03	9.131E+04	Y
7	500.--INF	500.	INF	1.2-1	1.367E-03	1.473E+00	7.214E+02	4.048E+05	Y

9 FLUORINE Z/A = 4.737E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.0724	.01	.0724	NA	1.129E+04	0.	0.	0.	Y
2	.0724--K	.0724	.687	1.2-2	-2.676E+02	4.767E+02	8.767E+01	-4.504E+00	Y
3	K--4.	.687	4.	1.5-2	-8.907E+01	6.850E+02	7.217E+03	-2.022E+03	N
4	4.--20.	4.	20.	6.3-3	2.813E+00	-2.020E+02	9.903E+03	-4.454E+03	N
5	20.--100.	20.	100.	5.4-3	6.097E-02	-2.435E+01	6.099E+03	2.258E+04	N
6	100.--500.	100.	500.	4.4-2	4.857E-03	-1.805E+00	3.335E+03	1.285E+05	Y
7	500.--INF	500.	INF	9.7-2	2.041E-03	2.257E+00	1.084E+03	5.997E+05	Y

10 NEON Z/A = 4.956E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--L3	.01	.0183	NA	1.000E-06	0.	0.	0.	Y
2	L3--L1	.0183	.045	NA	8.235E+03	0.	0.	0.	Y
3	L1--.124	.045	.124	3.2-2	-6.059E+03	3.242E+03	-1.796E+02	3.141E+00	Y
4	.124--K	.124	.867	1.6-2	-1.940E+02	4.340E+02	2.357E+02	-1.666E+01	Y
5	K--4.	.867	4.	1.1-2	-8.680E+01	7.434E+02	1.077E+04	-3.822E+03	N
6	4.--20.	4.	20.	4.5-3	3.167E+00	-2.491E+02	1.439E+04	-8.187E+03	N
7	20.--100.	20.	100.	4.6-3	1.288E-01	-4.471E+01	9.862E+03	2.497E+04	N
8	100.--500.	100.	500.	3.3-2	5.202E-03	7.337E-02	4.614E+03	2.256E+05	N
9	500.--INF	500.	INF	7.7-2	3.087E-03	3.402E+00	1.569E+03	1.147E+06	Y

11 SODIUM Z/A = 4.785E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--L3	.01	.031	NA	5.429E+01	0.	0.	0.	Y
2	L3--L1	.031	.063	NA	8.874E+03	0.	0.	0.	Y
3	L1--K	.063	1.073	5.5-2	-5.565E+02	1.088E+03	1.062E+02	-6.845E+00	Y
4	K--20.	1.073	20.	1.4-2	1.732E+00	-1.853E+02	1.712E+04	-8.415E+03	N
5	20.--100.	20.	100.	8.1-3	2.726E-01	-8.218E+01	1.475E+04	9.467E+03	N
6	100.--500.	100.	500.	3.4-2	2.083E-03	4.548E+00	5.521E+03	3.358E+05	N
7	500.--INF	500.	INF	4.8-2	4.199E-03	4.808E+00	1.793E+03	1.898E+06	Y

12 MAGNESIUM Z/A = 4.937E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--L3	.01	.051	2.5-1	-5.574E+02	8.687E+01	-1.493E+00	8.660E-03	Y
2	L3--.123	.051	.123	6.9-2	-2.726E+04	9.700E+03	-6.921E+02	1.445E+01	Y
3	.123--K	.123	1.305	9.2-2	-6.179E+02	1.379E+03	2.321E+02	-2.291E+01	Y
4	K--20.	1.305	20.	9.6-3	-6.648E-01	-1.084E+02	2.219E+04	-1.241E+04	N
5	20.--100.	20.	100.	1.1-2	4.080E-01	-1.205E+02	2.139E+04	-1.143E+02	N
6	100.--500.	100.	500.	3.5-2	8.338E-03	2.236E+00	8.819E+03	4.284E+05	N
7	500.--INF	500.	INF	4.9-2	6.233E-03	7.344E+00	2.662E+03	2.460E+06	Y

13 ALUMINUM Z/A = 4.818E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.0159	.01	.0159	1.8-1	-1.654E+04	1.585E+02	3.907E+00	-3.383E-02	Y
2	.0159--L3	.0159	.073	1.8-1	1.122E+03	-4.015E+01	6.623E-01	-2.813E-03	Y
3	L3--L1	.073	.1177	1.2-1	2.390E+04	-6.953E+02	-7.978E+01	1.974E+00	Y
4	L1--K	.1177	1.560	1.5-1	-5.284E+02	1.399E+03	4.360E+02	-4.747E+01	Y
5	K--20.	1.560	20.	1.0-2	-3.674E+00	-1.622E+01	2.732E+04	-1.752E+04	N
6	20.--100.	20.	100.	1.3-2	4.158E-01	-1.351E+02	2.716E+04	3.723E+02	N
7	100.--500.	100.	500.	3.4-2	1.125E-02	2.747E+00	1.174E+04	5.695E+05	N
8	500.--INF	500.	INF	8.2-2	8.505E-03	1.049E+01	4.429E+03	2.431E+06	Y

14 SILICON Z/A = 4.985E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.0305	.01	.0305	NA	4.575E+02	0.	0.	0.	Y
2	.0305--L3	.0305	.099	2.2-6	-1.168E+02	1.269E+02	-5.506E+00	6.616E-02	Y
3	L3--K	.099	1.839	1.4-1	-6.451E+02	1.836E+03	5.350E+02	-6.436E+01	Y
4	K--20.	1.839	20.	5.6-3	-4.056E+00	-1.089E+01	3.544E+04	-2.595E+04	N
5	20.--100.	20.	100.	1.1-2	4.945E-01	-1.682E+02	3.627E+04	-1.605E+04	N
6	100.--500.	100.	500.	3.1-2	2.716E-02	-5.428E+00	1.775E+04	6.765E+05	N
7	500.--INF	500.	INF	4.7-2	1.127E-02	1.376E+01	4.871E+03	4.477E+06	Y

15 PHOSPHORUS Z/A = 4.843E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.0306	.01	.0306	NA	4.728E+02	0.	0.	0.	Y
2	.0306--L3	.0306	.132	5.1-3	-2.227E+02	2.204E+02	-1.122E+01	1.569E-01	Y
3	L3--K	.132	2.144	6.5-2	-5.700E+02	1.909E+03	7.651E+02	-1.123E+02	Y
4	K--20.	2.144	20.	7.6-3	-6.098E+00	7.712E+01	4.196E+04	-3.437E+04	N
5	20.--100.	20.	100.	1.1-2	5.710E-01	-2.001E+02	4.505E+04	-3.853E+04	N
6	100.--500.	100.	500.	3.0-2	3.613E-02	-8.426E+00	2.277E+04	8.080E+05	N
7	500.--INF	500.	INF	4.4-2	1.421E-02	1.770E+01	6.221E+03	5.554E+06	Y

16 SULFUR Z/A = 4.991E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.0341	.01	.0341	NA	5.368E+02	0.	0.	0.	Y
2	.0341--L3	.0341	.165	1.0-2	-2.097E+02	3.174E+02	-1.815E+01	2.796E-01	Y
3	L3--K	.165	2.472	6.5-2	-4.885E+02	1.976E+03	1.206E+03	-1.934E+02	Y
4	K--20.	2.472	20.	8.1-3	-1.021E+01	2.346E+02	5.164E+04	-4.707E+04	N
5	20.--100.	20.	100.	1.0-2	7.467E-01	-2.534E+02	5.800E+04	-6.691E+04	N
6	100.--500.	100.	500.	4.2-2	6.338E-02	-3.443E+01	4.058E+04	2.233E+05	Y
7	500.--INF	500.	INF	4.6-2	1.857E-02	2.398E+01	6.706E+03	8.358E+06	Y

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
17 CHLORINE	Z/A = 4.795E-01								
1	.01--.0436	.01	.0436	NA	7.808E+02	0.	0.	0.	Y
2	.0436--L3	.0436	.200	1.8-1	-6.163E+01	3.934E+02	-2.563E+01	4.396E-01	Y
3	L3--K	.200	2.824	3.1-2	-2.147E+02	1.269E+03	2.099E+03	-3.705E+02	Y
4	K--20.	2.824	20.	7.5-3	-1.192E+01	3.253E+02	5.927E+04	-5.980E+04	N
5	20.--100.	20.	100.	1.1-2	8.789E-01	-2.920E+02	6.860E+04	-1.018E+05	N
6	100.--500.	100.	500.	3.1-2	6.556E-02	-2.175E+01	3.895E+04	9.737E+05	N
7	500.--INF	500.	INF	4.3-2	2.236E-02	2.884E+01	9.717E+03	9.001E+06	Y
18 ARGON	Z/A = 4.506E-01								
1	.01--.0302	.01	.0302	NA	1.275E+04	0.	0.	0.	Y
2	.0302--L3	.0302	.245	4.1-2	-1.674E+03	1.047E+03	-9.010E+01	2.166E+00	Y
3	L3--K	.245	3.203	1.3-1	-2.244E+02	1.388E+03	2.571E+03	-5.113E+02	Y
4	K--20.	3.203	20.	5.3-3	-1.446E+01	4.359E+02	6.578E+04	-7.284E+04	N
5	20.--100.	20.	100.	8.5-3	8.786E-01	-3.001E+02	7.682E+04	-1.219E+05	N
6	100.--500.	100.	500.	2.5-2	6.779E-02	-2.695E+01	5.069E+04	5.281E+05	Y
7	500.--INF	500.	INF	3.9-2	2.598E-02	3.454E+01	1.059E+04	1.068E+07	Y
19 POTASSIUM	Z/A = 4.860E-01								
1	.01--.0305	.01	.0305	NA	3.111E+03	0.	0.	0.	Y
2	.0305--L3	.0305	.294	2.4-2	6.162E+01	5.770E+02	-4.497E+01	9.218E-01	Y
3	L3--K	.294	3.607	6.8-2	-3.601E+02	2.287E+03	2.513E+03	-4.591E+02	Y
4	K--20.	3.607	20.	4.2-3	-2.113E+01	7.161E+02	8.183E+04	-9.859E+04	N
5	20.--100.	20.	100.	8.7-3	1.048E+00	-3.644E+02	9.844E+04	-1.760E+05	N
6	100.--500.	100.	500.	2.9-2	1.040E-01	-3.553E+01	6.096E+04	1.226E+06	N
7	500.--INF	500.	INF	2.7-2	3.453E-02	4.621E+01	1.669E+04	1.238E+07	Y
20 CALCIUM	Z/A = 4.990E-01								
1	.01--.0305	.01	.0305	NA	3.029E+03	0.	0.	0.	Y
2	.0305--L3	.0305	.346	2.5-2	3.816E+02	5.887E+02	-4.888E+01	1.019E+00	Y
3	L3--K	.346	4.037	2.3-2	-1.054E+02	1.120E+03	5.115E+03	-1.325E+03	Y
4	K--20.	4.037	20.	4.1-3	-3.015E+01	1.141E+03	9.459E+04	-1.195E+05	N
5	20.--100.	20.	100.	8.4-3	1.408E+00	-4.553E+02	1.206E+05	-2.531E+05	N
6	100.--500.	100.	500.	4.8-2	1.204E-01	-5.356E+01	8.779E+04	6.252E+05	Y
7	500.--INF	500.	INF	5.2-2	4.178E-02	5.761E+01	1.377E+04	2.019E+07	Y
21 SCANDIUM	Z/A = 4.671E-01								
1	.01--M3	.01	.032	6.0-3	1.121E+03	7.413E+00	-3.020E-01	1.510E-03	Y
2	M3--L3	.032	.402	4.6-2	2.970E+02	6.359E+02	-4.935E+01	1.044E+00	Y
3	L3--K	.402	4.491	5.4-2	-1.507E+02	1.501E+03	5.139E+03	-1.442E+03	N
4	K--100.	4.491	100.	8.3-3	4.615E-01	-2.614E+02	1.217E+05	-2.057E+05	N
5	100.--500.	100.	500.	6.2-3	1.509E-01	-6.913E+01	9.253E+04	1.096E+06	N
6	500.--INF	500.	INF	3.0-2	4.833E-02	6.881E+01	2.762E+04	1.290E+07	Y
22 TITANIUM	Z/A = 4.595E-01								
1	.01--.1	.01	.1	8.6-2	3.596E+03	-6.877E+01	9.609E-01	-4.754E-03	Y
2	.1--L3	.1	.456	1.1-2	-3.132E+02	1.024E+03	-1.008E+02	3.096E+00	Y
3	L3--K	.456	4.966	2.4-2	-4.626E+01	8.678E+02	7.308E+03	-2.383E+03	N
4	K--100.	4.966	100.	8.3-3	2.074E-01	-2.292E+02	1.371E+05	-2.489E+05	N
5	100.--500.	100.	500.	1.2-2	1.972E-01	-9.550E+01	1.106E+05	1.067E+06	N
6	500.--INF	500.	INF	4.6-2	5.606E-02	8.140E+01	3.106E+04	1.567E+07	Y
23 VANADIUM	Z/A = 4.515E-01								
1	.01--.12	.01	.12	1.3-1	4.117E+03	-1.054E+02	1.531E+00	-7.725E-03	Y
2	.12--L3	.12	.513	1.1-2	-4.052E+02	1.169E+03	-1.212E+02	4.148E+00	Y
3	L3--L1	.513	.628	4.1-2	9.968E+03	-1.796E+03	-1.204E+03	1.481E+03	Y
4	L1--K	.628	5.465	2.4-2	-1.429E+02	1.632E+03	7.203E+03	-2.283E+03	Y
5	K--100.	5.465	100.	8.2-3	3.940E-01	-2.733E+02	1.564E+05	-3.184E+05	N
6	100.--500.	100.	500.	7.2-3	2.007E-01	-8.911E+01	1.254E+05	1.137E+06	N
7	500.--INF	500.	INF	6.6-2	6.449E-02	9.483E+01	3.584E+04	1.821E+07	Y
24 CHROMIUM	Z/A = 4.616E-01								
1	.01--.106	.01	.106	1.2-1	5.069E+03	-7.968E+01	8.395E-01	-4.494E-03	Y
2	.106--L3	.106	.575	1.2-2	-4.404E+02	1.301E+03	-1.166E+02	3.481E+00	Y
3	L3--K	.575	5.989	4.9-2	3.932E+01	1.537E+02	1.228E+04	-4.984E+03	N
4	K--100.	5.989	100.	8.4-2	2.740E-01	-2.665E+02	1.818E+05	-3.997E+05	N
5	100.--500.	100.	500.	9.9-3	2.727E-01	-1.288E+02	1.543E+05	9.755E+05	N
6	500.--INF	500.	INF	7.2-2	7.660E-02	1.142E+02	4.290E+04	2.161E+07	Y
25 MANGANESE	Z/A = 4.551E-01								
1	.01--.1	.01	.1	6.1-2	5.692E+03	-1.278E+02	1.150E+00	-3.774E-03	Y
2	.1--L3	.1	.640	1.0-2	-4.901E+02	1.450E+03	-1.365E+02	4.134E+00	Y
3	L3--K	.640	6.539	3.0-2	-3.065E+01	7.209E+02	1.275E+04	-5.462E+03	Y
4	K--100.	6.539	100.	7.1-3	2.930E-01	-2.703E+02	2.034E+05	-4.886E+05	N
5	100.--500.	100.	500.	9.3-3	2.940E-01	-1.342E+02	1.761E+05	8.747E+05	N
6	500.--INF	500.	INF	6.2-2	8.736E-02	1.322E+02	4.952E+04	2.436E+07	Y

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
26 IRON	Z/A = 4.656E-01								
1	.01--.024	.01	.024	3.9-2	-3.328E+03	2.590E+02	-3.812E+00	1.679E-02	Y
2	.024--.12	.024	.12	1.6-1	4.132E+03	3.963E+02	-2.505E+01	3.437E-01	Y
3	.12--L3	.12	.708	5.6-2	-2.683E+01	1.250E+03	-7.321E+01	1.137E+00	Y
4	L3--K	.708	7.112	2.0-2	-8.128E+00	6.550E+02	1.511E+04	-7.079E+03	N
5	K--100	7.112	100.	5.4-3	2.151E-01	-2.680E+02	2.341E+05	-6.063E+05	N
6	100.--500.	100.	500.	7.0-3	3.511E-01	-1.633E+02	2.090E+05	7.131E+05	N
7	500.--INF	500.	INF	6.4-2	1.026E-01	1.572E+02	5.901E+04	2.806E+07	Y
27 COBALT	Z/A = 4.581E-01								
1	.01--.0308	.01	.0308	NA	2.074E+03	0.	0.	0.	Y
2	.0308--.093	.0308	.093	1.9-2	6.932E+03	-6.765E-02	-9.182E+00	1.413E-01	Y
3	.093--L3	.093	.779	5.1-2	-8.228E+02	1.982E+03	-1.782E+02	4.937E+00	Y
4	L3--K	.779	7.709	3.0-2	2.092E+01	3.311E+02	1.820E+04	-9.303E+03	N
5	K--100.	7.709	100.	6.9-3	4.947E-02	-2.478E+02	2.586E+05	-7.185E+05	N
6	100.--500.	100.	500.	6.3-3	3.588E-01	-1.492E+02	2.296E+05	8.856E+05	N
7	500.--INF	500.	INF	4.0-2	1.154E-01	1.796E+02	6.740E+04	3.100E+07	Y
28 NICKEL	Z/A = 4.771E-01								
1	.01--.1	.01	.1	6.6-2	8.515E+03	-2.121E+02	2.132E+00	-7.667E-03	Y
2	.1--L3	.1	.854	4.4-2	-1.021E+03	2.388E+03	-2.361E+02	7.261E+00	Y
3	L3--L2	.854	.871	0.	0.	6.600E+03	0.	0.	N
4	L2--L1	.871	1.008	0.	0.	9.810E+03	0.	0.	N
5	L1--K	1.008	8.332	9.6-3	-1.175E+02	2.171E+03	1.514E+04	-6.042E+03	N
6	K--100.	8.332	100.	5.4-3	1.685E-02	-2.522E+02	3.005E+05	-9.000E+05	N
7	100.--500.	100.	500.	5.5-3	4.681E-01	-2.085E+02	2.782E+05	4.399E+05	N
8	500.--INF	500.	INF	4.7-2	1.364E-01	2.148E+02	8.039E+04	3.626E+07	Y
29 COPPER	Z/A = 4.564E-01								
1	.01--.1	.01	.1	1.5-1	9.992E+03	-3.780E+02	5.657E+00	-2.788E-02	Y
2	.1--L3	.1	.933	6.5-2	-8.896E+02	2.391E+03	-1.986E+02	3.649E+00	Y
3	L3--L1	.933	1.096	7.4-7	-5.089E+02	4.139E+03	7.468E+03	-6.981E+02	N
4	L1--K	1.096	8.981	1.1-2	-9.173E+01	1.862E+03	1.777E+04	-8.202E+03	N
5	K--100.	8.981	100.	5.6-3	7.440E-03	-2.371E+02	3.202E+05	-1.028E+06	N
6	100.--500.	100.	500.	7.0-3	4.729E-01	-2.055E+02	3.000E+05	2.182E+05	N
7	500.--INF	500.	INF	6.5-2	1.472E-01	2.345E+02	8.644E+04	3.990E+07	Y
30 ZINC	Z/A = 4.589E-01								
1	.01--.0307	.01	.0307	NA	1.479E+03	0.	0.	0.	Y
2	.0307--.109	.0307	.109	2.4-2	1.325E+04	-6.762E+02	1.188E+01	-6.785E-02	Y
3	.109--L3	.109	1.020	6.3-2	-1.330E+03	3.104E+03	-3.092E+02	8.946E+00	Y
4	L3--L2	1.020	1.043	5.4-7	-2.807E+04	1.091E+05	-1.511E+05	7.897E+04	N
5	L2--L1	1.043	1.193	4.5-3	-3.057E+03	1.385E+04	3.780E+02	-2.163E+02	N
6	L1--K	1.193	9.659	1.2-2	-8.018E+01	1.794E+03	2.095E+04	-1.070E+04	N
7	K--100.	9.659	100.	3.7-3	-1.158E+00	-3.871E+01	3.499E+05	-1.154E+06	N
8	100.--500.	100.	500.	9.8-3	4.820E-01	-1.832E+02	3.296E+05	6.802E+05	N
9	500.--INF	500.	INF	3.8-2	1.669E-01	2.696E+02	1.000E+05	4.382E+07	Y
31 GALLIUM	Z/A = 4.446E-01								
1	.01--.0278	.01	.0278	NA	1.479E+03	0.	0.	0.	Y
2	.0278--.076	.0278	.076	3.0-2	1.211E+04	-7.144E+02	1.535E+01	-1.030E-01	Y
3	.076--L3	.076	1.115	3.5-2	-1.199E+03	3.215E+03	-3.594E+02	1.152E+01	Y
4	L3--L2	1.115	1.142	3.6-7	-1.457E+04	6.363E+04	-1.011E+05	6.416E+04	N
5	L2--L1	1.142	1.298	6.3-3	3.470E+03	-8.674E+03	2.548E+04	-8.411E+03	N
6	L1--K	1.298	10.367	1.3-2	-9.431E+01	2.078E+03	2.172E+04	-1.101E+04	N
7	K--100.	10.367	100.	6.8-3	-1.253E+00	-2.897E+01	3.783E+05	-1.357E+06	N
8	100.--500.	100.	500.	9.3-3	5.591E-01	-2.217E+02	3.625E+05	3.392E+05	N
9	500.--INF	500.	INF	1.8-2	1.949E-01	2.371E+02	1.767E+05	2.400E+07	N
32 GERMANIUM	Z/A = 4.408E-01								
1	.01--.0305	.01	.0305	NA	4.941E+03	0.	0.	0.	Y
2	.0305--.1	.0305	.1	7.9-3	1.269E+04	-9.339E+02	2.767E+01	-1.952E-01	Y
3	.1--L3	.1	1.217	3.4-2	-1.358E+03	3.695E+03	-4.569E+02	1.599E+01	Y
4	L3--L2	1.217	1.248	2.2-7	-7.402E+03	3.636E+04	-6.670E+04	5.346E+04	N
5	L2--L1	1.248	1.413	2.1-6	-3.400E+02	3.232E+03	1.163E+04	-1.089E+03	N
6	L1--K	1.413	11.104	1.1-2	-5.940E+01	1.646E+03	2.621E+04	-1.507E+04	N
7	K--100.	11.104	100.	5.7-3	-2.025E+00	1.283E+02	4.069E+05	-1.510E+06	N
8	100.--500.	100.	500.	9.1-3	6.478E-01	-2.603E+02	4.045E+05	-5.153E+04	N
9	500.--INF	500.	INF	1.9-2	2.155E-01	2.609E+02	2.074E+05	2.220E+07	N

33 ARSENIC Z/A = 4.405E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.0371	.01	.0371	NA	2.547E+03	0.	0.	0.	Y
2	.0371--.1	.0371	.1	4.6-2	2.402E+04	-3.110E+03	1.364E+02	-1.877E+00	Y
3	.1--L3	.1	1.323	3.7-2	-1.536E+03	4.198E+03	-5.497E+02	1.920E+01	Y
4	L3--L2	1.323	1.359	1.7-7	-4.525E+03	2.468E+04	-5.133E+04	5.102E+04	N
5	L2--L1	1.359	1.529	1.4-6	-3.858E+02	1.013E+04	3.603E+03	-7.657E+02	N
6	L1--K	1.529	11.867	1.2-2	-5.339E+01	1.649E+03	2.950E+04	-1.800E+04	N
7	K--100.	11.867	100.	6.4-3	-1.655E+00	8.588E+01	4.504E+05	-1.795E+06	N
8	100.--500.	100.	500.	6.7-3	7.880E-01	-3.490E+02	4.641E+05	-1.258E+06	N
9	500.--INF	500.	INF	1.8-2	2.393E-01	2.906E+02	2.360E+05	2.145E+07	N
34 SELENIUM Z/A = 4.306E-01									
1	.01--.0371	.01	.0371	NA	1.577E+03	0.	0.	0.	Y
2	.0371--.114	.0371	.114	2.4-2	1.806E+04	-2.230E+03	9.408E+01	-1.263E+00	Y
3	.114--L3	.114	1.434	3.6-2	-1.610E+03	4.614E+03	-6.392E+02	2.252E+01	Y
4	L3--L2	1.434	1.475	2.7-8	-6.637E+02	4.194E+03	-1.104E+04	2.806E+04	N
5	L2--L1	1.475	1.652	1.4-6	-4.265E+02	9.660E+03	5.343E+03	-1.174E+03	N
6	L1--K	1.652	12.658	1.1-2	-3.968E+01	1.459E+03	3.327E+04	-2.228E+04	N
7	K--100.	12.658	100.	7.9-3	-3.461E+00	4.401E+02	4.690E+05	-1.943E+06	N
8	100.--500.	100.	500.	1.0-2	8.564E-01	-3.723E+02	5.020E+05	-1.430E+06	N
9	500.--INF	500.	INF	1.9-2	2.590E-01	3.237E+02	2.541E+05	2.321E+07	N
35 BROMINE Z/A = 4.380E-01									
1	.01--.035	.01	.035	NA	2.129E+03	0.	0.	0.	Y
2	.035--.1	.035	.1	4.4-6	1.451E+04	-1.941E+03	8.744E+01	-1.214E+00	Y
3	.1--.5	.1	.5	2.9-2	-3.534E+03	6.788E+03	-1.134E+03	5.165E+01	Y
4	.5--L3	.5	1.551	9.5-3	-3.347E+02	2.195E+03	1.033E+03	-2.839E+02	Y
5	L3--L2	1.551	1.597	6.3-9	1.461E+02	-1.050E+03	3.457E+03	2.000E+04	N
6	L2--L1	1.597	1.782	1.3-6	-4.318E+02	1.007E+04	6.548E+03	-1.535E+03	N
7	L1--K	1.782	13.474	1.2-2	-4.033E+01	1.607E+03	3.681E+04	-2.478E+04	N
8	K--100.	13.474	100.	5.9-3	-3.955E+00	5.482E+02	5.202E+05	-2.262E+06	N
9	100.--500.	100.	500.	9.2-3	9.718E-01	-4.209E+02	5.662E+05	-2.099E+06	N
10	500.--INF	500.	INF	1.5-2	2.907E-01	3.653E+02	2.908E+05	2.417E+07	N
36 KRYPTON Z/A = 4.296E-01									
1	.01--.0305	.01	.0305	NA	3.691E+03	0.	0.	0.	Y
2	.0305--.097	.0305	.097	9.7-7	2.024E+03	-2.083E+02	4.439E+00	1.056E-01	Y
3	.097--.3	.097	.3	8.5-2	7.648E+02	5.257E+03	-9.960E+02	4.686E+01	Y
4	.3--L3	.3	1.675	1.3-1	-2.451E+02	2.199E+03	1.217E+03	-3.120E+02	Y
5	L3--L2	1.675	1.727	1.8-8	3.611E+02	-2.974E+03	1.308E+04	1.268E+04	N
6	L2--L1	1.727	1.921	1.2-6	-4.163E+02	1.017E+04	7.535E+03	-1.891E+03	N
7	L1--K	1.921	14.323	7.5-3	-9.924E-01	8.455E+02	4.446E+04	-3.490E+04	N
8	K--100.	14.323	100.	5.2-3	-3.076E+00	4.257E+02	5.613E+05	-2.587E+06	N
9	100.--500.	100.	500.	6.8-3	1.050E+00	-4.435E+02	6.114E+05	-3.028E+06	N
10	500.--INF	500.	INF	1.9-2	3.136E-01	3.952E+02	3.252E+05	2.248E+07	N
37 RUBIDIUM Z/A = 4.329E-01									
1	.01--.0305	.01	.0305	NA	4.606E+03	0.	0.	0.	Y
2	.0305--M5	.0305	.111	1.4-1	1.441E+03	-1.761E+02	6.821E+00	4.470E-02	Y
3	M5--.3	.111	.3	1.1-1	-6.763E+02	6.772E+03	-1.372E+03	7.035E+01	Y
4	.3--L3	.3	1.805	1.2-1	-3.457E+02	2.591E+03	1.242E+03	-3.481E+02	Y
5	L3--L2	1.805	1.863	2.0-8	3.524E+02	-3.194E+03	1.657E+04	1.224E+04	N
6	L2--L1	1.863	2.065	1.0-6	-4.025E+02	1.067E+04	8.396E+03	-2.275E+03	N
7	L1--K	2.065	15.200	6.8-3	5.234E+00	7.494E+02	5.033E+04	-4.276E+04	N
8	K--100.	15.200	100.	6.3-3	-2.207E+00	2.653E+02	6.269E+05	-3.163E+06	N
9	100.--500.	100.	500.	5.6-3	1.101E+00	-4.280E+02	6.664E+05	-3.481E+06	N
10	500.--INF	500.	INF	1.6-2	3.467E-01	4.515E+02	3.525E+05	2.783E+07	N
38 STRONTIUM Z/A = 4.337E-01									
1	.01--.0307	.01	.0307	NA	4.850E+03	0.	0.	0.	Y
2	.0307--M5	.0307	.133	1.8-1	7.854E+02	-6.513E+01	2.134E+00	1.138E-01	Y
3	M5--.3	.133	.3	7.5-2	-2.484E+03	8.950E+03	-2.019E+03	1.171E+02	Y
4	.3--L3	.3	1.94	1.2-1	-3.209E+02	2.818E+03	1.344E+03	-3.984E+02	Y
5	L3--L2	1.94	2.007	1.9-8	2.746E+02	-2.830E+03	2.149E+04	7.655E+03	N
6	L2--L1	2.007	2.216	9.8-7	-4.181E+02	1.025E+04	1.159E+04	-3.199E+03	N
7	L1--K	2.216	16.105	6.9-3	-4.367E+01	1.966E+03	4.835E+04	-3.788E+04	N
8	K--100.	16.105	100.	4.6-3	-5.177E-01	-2.546E+01	6.941E+05	-3.733E+06	N
9	100.--500.	100.	500.	2.6-3	1.296E+00	-5.192E+02	7.384E+05	-5.043E+06	N
10	500.--INF	500.	INF	1.8-2	3.800E-01	4.950E+02	4.111E+05	1.955E+07	N

39 YTTRIUM Z/A = 4.387E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.0232	.01	.0232	8.6-2	3.854E+04	-1.366E+03	1.672E+01	-6.795E-02	Y
2	.0232--.1677	.0232	.1677	9.7-2	2.849E+03	-2.828E+02	1.529E+01	-1.723E-01	Y
3	.1677--.8	.1677	.8	9.2-2	-6.721E+03	1.290E+04	-3.111E+03	1.985E+02	Y
4	.8--L3	.8	2.079	1.2-2	3.585E+02	-4.223E+02	6.620E+03	-2.706E+03	N
5	L3--L2	2.079	2.155	6.5-9	-8.813E+01	1.184E+03	2.198E+04	-1.440E+03	N
6	L2--L1	2.155	2.373	9.1-7	-4.141E+02	1.043E+04	1.385E+04	-4.020E+03	N
7	L1--K	2.373	17.038	6.9-3	-1.282E+01	1.204E+03	6.028E+04	-5.752E+04	N
8	K--100.	17.038	100.	6.2-3	4.265E-01	-1.646E+02	7.684E+05	-4.421E+06	N
9	100.--500.	100.	500.	5.8-3	1.334E+00	-4.917E+02	8.066E+05	-5.879E+06	N
10	500.--INF	500.	INF	2.2-2	4.194E-01	5.651E+02	4.353E+05	2.981E+07	N

40 ZIRCONIUM Z/A = 4.385E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--M5	.01	.18	2.6-1	2.993E+02	1.449E+02	-3.012E+00	1.713E-02	Y
2	M5--.5	.18	.5	1.1-1	-7.040E+03	1.434E+04	-3.926E+03	2.887E+02	Y
3	.5--L3	.5	2.223	1.3-1	-1.647E+02	2.296E+03	3.166E+03	-1.127E+03	Y
4	L3--L2	2.223	2.307	1.7-8	-2.164E+02	3.512E+03	2.053E+04	-3.382E+03	N
5	L2--L1	2.307	2.533	8.1-7	-3.996E+02	1.064E+04	1.548E+04	-4.776E+03	N
6	L1--K	2.533	17.998	3.5-3	-3.011E+01	1.794E+03	6.153E+04	-5.699E+04	N
7	K--100.	17.998	100.	4.6-3	-5.900E-01	1.945E+02	8.031E+05	-4.579E+06	N
8	100.--500.	100.	500.	4.4-3	1.474E+00	-5.530E+02	8.907E+05	-7.927E+06	N
9	500.--INF	500.	INF	2.0-2	4.562E-01	6.248E+02	4.760E+05	3.216E+07	N

41 NIOBIUM Z/A = 4.413E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.0297	.01	.0297	1.4-1	3.251E+03	-6.844E+01	1.575E+00	-1.094E-02	Y
2	.0297--.2083	.0297	.2083	3.0-2	2.754E+03	-4.897E+02	4.237E+01	-8.372E-01	Y
3	.2083--.9	.2083	.9	1.0-1	-2.018E+03	8.543E+03	-1.769E+03	2.770E+01	Y
4	.9--L3	.9	2.370	3.1-2	2.150E+02	4.490E+02	6.409E+03	-2.429E+03	Y
5	L3--L2	2.370	2.464	2.6-8	-2.981E+02	6.188E+03	1.735E+04	-4.420E+03	N
6	L2--L1	2.464	2.698	7.2-7	-3.923E+02	1.102E+04	1.751E+04	-5.733E+03	N
7	L1--K	2.698	18.986	1.0-2	-1.658E+01	1.435E+03	7.050E+04	-7.037E+04	N
8	K--100.	18.986	100.	3.8-3	-2.292E+00	5.516E+02	8.555E+05	-5.018E+06	N
9	100.--500.	100.	500.	4.6-3	1.599E+00	-5.764E+02	9.643E+05	-8.517E+06	N
10	500.--INF	500.	INF	2.2-1	4.986E-01	7.224E+02	4.910E+05	4.104E+07	N

42 MOLYBDENUM Z/A = 4.378E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.03	.01	.03	2.2-1	-3.508E+03	3.050E+02	-4.620E+00	1.998E-02	Y
2	.03--M5	.03	.229	6.2-2	3.053E+03	-6.192E+02	5.104E+01	-9.955E-01	Y
3	M5--.8	.229	.8	9.0-2	-7.786E+03	1.722E+04	-5.215E+03	3.992E+02	Y
4	.8--L3	.8	2.521	3.0-2	-1.114E+02	1.895E+03	5.405E+03	-2.261E+03	N
5	L3--L2	2.521	2.625	3.0-8	-3.027E+02	7.576E+03	1.570E+04	-4.795E+03	N
6	L2--L1	2.625	2.867	6.5-7	-3.784E+02	1.099E+04	1.983E+04	-6.801E+03	N
7	L1--K	2.867	20.	6.2-3	-1.840E+01	1.552E+03	7.635E+04	-8.181E+04	N
8	K--100.	20.	100.	3.6-3	-2.560E+00	7.317E+02	9.005E+05	-5.349E+06	N
9	100.--500.	100.	500.	3.1-3	1.540E+00	-4.834E+02	1.021E+06	-9.300E+06	N
10	500.--INF	500.	INF	2.3-2	5.359E-01	7.662E+02	5.243E+05	5.200E+07	N

43 TECHNETIUM Z/A = 4.388E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.068	.01	.068	NA	2.680E+03	0.	0.	0.	Y
2	.068--M5	.068	.253	9.3-2	-7.592E+02	8.677E+02	-1.346E+02	6.198E+00	Y
3	M5--M3	.253	.425	2.4-2	-3.269E+04	4.110E+04	-1.328E+04	1.384E+03	Y
4	M3--L3	.425	2.677	3.0-2	-3.863E+02	3.458E+03	3.500E+03	-1.341E+03	Y
5	L3--L2	2.677	2.793	3.7-8	-2.871E+02	7.198E+03	1.867E+04	-5.767E+03	N
6	L2--L1	2.793	3.043	1.3-7	-1.101E+02	1.635E+04	3.183E+03	-1.491E+03	N
7	L1--K	3.043	21.044	4.1-3	-2.936E+01	1.924E+03	7.955E+04	-8.669E+04	N
8	K--100.	21.044	100.	5.8-3	5.721E-01	7.164E+01	1.004E+06	-6.678E+06	N
9	100.--500.	100.	500.	4.5-3	1.769E+00	-5.691E+02	1.097E+06	-1.069E+07	N
10	500.--INF	500.	INF	2.4-2	5.748E-01	8.119E+02	6.113E+05	3.605E+07	N

44 RUTHENIUM Z/A = 4.353E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.0716	.01	.0716	1.5-1	2.116E+03	1.001E+02	-2.614E+00	1.466E-02	Y
2	.0716--M5	.0716	.2794	8.2-2	1.947E+02	7.270E+02	-1.490E+02	8.002E+00	Y
3	M5--M3	.2794	.4606	2.0-2	-2.141E+04	2.872E+04	-8.592E+03	8.312E+02	Y
4	M3--L3	.4606	2.838	3.5-2	-2.430E+02	2.793E+03	5.237E+03	-2.042E+03	Y
5	L3--L2	2.838	2.967	4.4-8	-2.831E+02	7.880E+03	1.913E+04	-6.518E+03	N
6	L2--L1	2.967	3.224	5.3-7	-3.547E+02	1.093E+04	2.575E+04	-9.586E+03	N
7	L1--K	3.224	22.117	5.1-3	-1.311E+01	1.428E+03	9.237E+04	-1.148E+05	N
8	K--100.	22.117	100.	6.2-3	1.007E-02	1.277E+02	1.086E+06	-7.755E+06	N
9	100.--500.	100.	500.	1.2-2	1.633E+00	-4.030E+02	1.144E+06	-9.817E+06	N
10	500.--INF	500.	INF	2.5-2	6.218E-01	9.117E+02	5.873E+05	6.614E+07	N

45 RHODIUM Z/A = 4.373E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.072	.01	.072	2.1-1	2.535E+03	1.329E+02	-3.193E+00	1.648E-02	Y
2	.072--M5	.072	.307	7.2-2	-1.037E+03	1.357E+03	-2.412E+02	1.212E+01	Y
3	M5--M3	.307	.4962	1.3-2	1.155E+03	3.456E+03	8.529E+02	-3.075E+02	Y
4	M3--L3	.4962	3.004	3.6-2	-4.773E+02	3.678E+03	5.261E+03	-2.225E+03	Y
5	L3--L2	3.004	3.146	5.2-8	-2.665E+02	7.197E+03	2.390E+04	-7.946E+03	N
6	L2--L1	3.146	3.412	4.9-7	-3.285E+02	9.342E+03	3.454E+04	-1.203E+04	N
7	L1--K	3.412	23.220	4.3-3	-2.532E+01	2.009E+03	9.447E+04	-1.115E+05	N
8	K--100.	23.220	100.	2.9-3	-3.043E+00	9.079E+02	1.126E+06	-8.086E+06	N
9	100.--500.	100.	500.	3.8-3	1.870E+00	-4.570E+02	1.251E+06	-1.191E+07	N
10	500.--INF	500.	INF	2.4-2	6.726E-01	9.644E+02	7.281E+05	4.409E+07	N

46 PALLADIUM Z/A = 4.322E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.07	.01	.07	2.3-1	1.095E+04	-2.552E+02	1.914E+00	-3.916E-03	Y
2	.07--M5	.07	.335	5.3-1	2.418E+03	9.664E+01	-1.050E+02	9.047E+00	Y
3	M5--M3	.335	.5315	2.5-2	-1.605E+04	3.107E+04	-1.240E+04	1.658E+03	Y
4	M3--L3	.5315	3.174	4.1-2	-4.705E+02	3.846E+03	5.959E+03	-2.639E+03	Y
5	L3--L2	3.174	3.33	6.5-8	-2.530E+02	7.129E+03	2.620E+04	-9.068E+03	N
6	L2--L1	3.33	3.605	4.3-7	-3.225E+02	1.001E+04	3.550E+04	-1.354E+04	N
7	L1--K	3.605	24.35	8.4-3	1.642E+01	4.603E+02	1.181E+05	-1.737E+05	N
8	K--100.	24.35	100.	3.9-3	-2.888E+00	8.714E+02	1.203E+06	-9.306E+06	N
9	100.--500.	100.	500.	2.6-3	1.857E+00	-3.662E+02	1.308E+06	-1.219E+07	N
10	500.--INF	500.	INF	2.2-2	7.151E-01	1.066E+03	7.318E+05	6.061E+07	N

47 SILVER Z/A = 4.357E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.086	.01	.086	1.0-1	1.054E+04	-1.973E+02	1.033E+00	-6.574E-04	Y
2	.086--M5	.086	.367	1.2-1	-4.089E+03	3.916E+03	-8.005E+02	4.841E+01	Y
3	M5--M3	.367	.5714	4.8-7	-2.951E+03	6.256E+03	1.909E+03	-8.620E+02	Y
4	M3--L3	.5714	3.351	4.1-2	-2.321E+01	1.892E+03	9.451E+03	-4.150E+03	Y
5	L3--L2	3.351	3.524	7.3-8	-2.547E+02	7.851E+03	2.733E+04	-1.038E+04	N
6	L2--L1	3.524	3.806	4.0-7	-3.170E+02	1.045E+04	3.850E+04	-1.560E+04	N
7	L1--K	3.806	25.514	4.1-3	-1.817E+00	1.265E+03	1.192E+05	-1.684E+05	N
8	K--100.	25.514	100.	3.3-3	-4.061E+00	1.339E+03	1.260E+06	-9.752E+06	N
9	100.--500.	100.	500.	2.7-3	2.065E+00	-4.444E+02	1.433E+06	-1.533E+07	N
10	500.--INF	500.	INF	2.3-2	7.734E-01	1.157E+03	8.006E+05	6.214E+07	N

48 CADMIUM Z/A = 4.270E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.03	.01	.03	NA	1.876E+03	0.	0.	0.	Y
2	.03--.098	.03	.098	6.1-2	8.550E+03	-2.785E+02	2.021E+00	1.032E-02	Y
3	.098--M5	.098	.404	2.6+0	4.933E+02	1.167E+03	-3.452E+02	2.759E+01	Y
4	M5--M3	.404	.6165	9.7-3	2.088E+03	3.036E+03	1.247E+03	-2.691E+02	Y
5	M3--L3	.6165	3.537	6.5-2	7.508E+00	2.031E+03	1.014E+04	-4.621E+03	Y
6	L3--L2	3.537	3.727	8.5-8	-2.454E+02	8.162E+03	2.822E+04	-1.156E+04	N
7	L2--L1	3.727	4.018	3.4-7	-2.677E+02	8.244E+03	4.935E+04	-1.791E+04	N
8	L1--K	4.018	26.711	3.4-3	-2.306E+01	2.129E+03	1.161E+05	-1.547E+05	N
9	K--100.	26.711	100.	2.6-3	-8.206E+00	2.269E+03	1.268E+06	-9.746E+06	N
10	100.--500.	100.	500.	9.7-3	2.254E+00	-4.904E+02	1.506E+06	-1.642E+07	N
11	500.--INF	500.	INF	2.4-2	8.123E-01	1.229E+03	8.686E+05	5.293E+07	N

49 INDIUM Z/A = 4.268E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.031	.01	.031	NA	1.702E+03	0.	0.	0.	Y
2	.031--.103	.031	.103	1.3-1	2.333E+04	-1.510E+03	3.498E+01	-2.775E-01	Y
3	.103--M5	.103	.443	2.0+0	-4.354E+03	4.933E+03	-1.221E+03	9.073E+01	Y
4	M5--M2	.443	.702	9.6-3	-2.048E+03	9.964E+03	-2.857E+03	7.223E+02	Y
5	M2--L3	.702	3.730	5.7-2	-1.763E+02	3.053E+03	9.756E+03	-4.718E+03	Y
6	L3--L2	3.730	3.938	9.8-8	-2.324E+02	7.725E+03	3.333E+04	-1.361E+04	N
7	L2--L1	3.938	4.238	3.2-7	-2.675E+02	8.828E+03	5.249E+04	-2.065E+04	N
8	L1--K	4.238	27.94	2.9-3	-2.149E+01	2.143E+03	1.256E+05	-1.775E+05	N
9	K--100.	27.94	100.	4.1-3	-2.097E+00	1.045E+03	1.428E+06	-1.216E+07	N
10	100.--500.	100.	500.	5.5-3	2.233E+00	-3.526E+02	1.578E+06	-1.747E+07	N
11	500.--INF	500.	INF	2.4-2	8.685E-01	1.331E+03	9.171E+05	6.234E+07	N

50 TIN Z/A = 4.213E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.0318	.01	.0318	NA	1.857E+03	0.	0.	0.	Y
2	.0318--.093	.0318	.093	5.6-2	3.071E+04	-2.069E+03	4.886E+01	-3.894E-01	Y
3	.093--M5	.093	.485	2.6+0	6.119E+01	1.769E+03	-5.287E+02	4.438E+01	Y
4	M5--M3	.485	.714	8.5-3	2.325E+03	2.905E+03	1.395E+03	-1.160E+02	Y
5	M3--L3	.714	3.929	8.7-2	-8.411E+02	7.174E+03	3.429E+03	-1.945E+03	N
6	L3--L2	3.929	4.156	1.1-7	-2.078E+02	6.795E+03	3.953E+04	-1.546E+04	N
7	L2--L1	4.156	4.465	3.0-7	-2.735E+02	1.006E+04	5.154E+04	-2.316E+04	N
8	L1--K	4.465	29.2	1.1-2	1.409E+01	5.245E+02	1.554E+05	-2.738E+05	N
9	K--100.	29.2	100.	3.0-3	-6.053E+00	2.152E+03	1.430E+06	-1.218E+07	N
10	100.--500.	100.	500.	2.2-3	2.434E+00	-4.441E+02	1.694E+06	-2.116E+07	N
11	500.--INF	500.	INF	2.0-2	9.156E-01	1.438E+03	9.506E+05	6.990E+07	N

51 ANTIMONY Z/A = 4.189E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.0304	.01	.0304	NA	7.076E+02	0.	0.	0.	Y
2	.0304--.096	.0304	.096	4.9-2	2.538E+04	-2.014E+03	5.518E+01	-5.093E-01	Y
3	.096--M5	.096	.528	2.6-1	-2.763E+03	3.809E+03	-9.187E+02	6.404E+01	Y
4	M5--M3	.528	.766	8.7-3	4.191E+03	1.201E+03	6.138E+02	8.057E+02	Y
5	M3--L3	.766	4.132	6.4-2	9.566E+01	1.292E+03	1.534E+04	-8.151E+03	Y
6	L3--L2	4.132	4.381	1.3-7	-2.154E+02	7.884E+03	3.884E+04	-1.742E+04	N
7	L2--L1	4.381	4.698	2.5-7	-2.413E+02	8.640E+03	6.267E+04	-2.629E+04	N
8	L1--K	4.698	30.491	2.8-3	-2.300E+01	2.351E+03	1.410E+05	-2.130E+05	N
9	K--100.	30.491	100.	6.7-4	-9.816E+00	3.157E+03	1.443E+06	-1.193E+07	N
10	100.--500.	100.	500.	8.7-3	2.470E+00	-3.671E+02	1.779E+06	-2.260E+07	N
11	500.--INF	500.	INF	2.3-2	9.713E-01	1.520E+03	1.016E+06	7.466E+07	N

52 TELLURIUM Z/A = 4.075E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.0528	.01	.0528	NA	9.416E+02	0.	0.	0.	Y
2	.0528--.106	.0528	.106	1.0-1	-5.818E+04	1.470E+04	-1.039E+03	2.257E+01	Y
3	.106--M5	.106	.572	2.5+0	-2.734E+03	3.947E+03	-9.985E+02	7.313E+01	Y
4	M5--M1	.572	1.006	5.9-2	-1.058E+05	2.917E+05	-2.491E+05	7.124E+04	Y
5	M1--L3	1.006	4.341	4.7-2	-4.397E+01	2.059E+03	1.571E+04	-9.021E+03	N
6	L3--L2	4.341	4.612	1.5-7	-1.946E+02	7.129E+03	4.399E+04	-1.939E+04	N
7	L2--L1	4.612	4.939	2.4-7	-2.372E+02	9.166E+03	6.308E+04	-2.911E+04	N
8	L1--K	4.939	31.814	9.8-3	1.086E+00	1.149E+03	1.640E+05	-2.950E+05	N
9	K--100.	31.814	100.	2.2-3	-3.401E+00	1.832E+03	1.571E+06	-1.426E+07	N
10	100.--500.	100.	500.	5.1-3	2.389E+00	-1.733E+02	1.798E+06	-2.273E+07	N
11	500.--INF	500.	INF	2.2-2	1.007E+00	1.586E+03	1.076E+06	7.154E+07	N

53 IODINE Z/A = 4.176E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.034	.01	.034	NA	7.020E+02	0.	0.	0.	Y
2	.034--.103	.034	.103	1.8-1	2.410E+04	-2.114E+03	6.324E+01	-6.266E-01	Y
3	.103--M5	.103	.619	1.4+0	-2.554E+03	4.115E+03	-1.059E+03	7.800E+01	Y
4	M5--M2	.619	.931	9.7-3	-4.564E+04	1.181E+05	-9.050E+04	2.490E+04	Y
5	M2--M1	.931	1.072	9.5-2	1.940E+04	-1.268E+04	-1.443E+04	1.681E+04	Y
6	M1--L3	1.072	4.557	1.6-1	-1.016E+03	1.150E+04	-8.332E+03	1.024E+04	Y
7	L3--L2	4.557	4.852	1.6-7	-1.833E+02	6.763E+03	5.201E+04	-2.240E+04	N
8	L2--L1	4.852	5.188	2.1-7	-2.150E+02	8.275E+03	7.525E+04	-3.297E+04	N
9	L1--K	5.188	33.17	3.5-3	-2.566E+01	2.615E+03	1.595E+05	-2.557E+05	N
10	K--100.	33.17	100.	2.9-3	-3.670E+00	1.872E+03	1.719E+06	-1.646E+07	N
11	100.--500.	100.	500.	4.7-3	2.225E+00	1.829E+02	1.881E+06	-2.157E+07	N
12	500.--INF	500.	INF	2.3-2	1.098E+00	1.755E+03	1.154E+06	8.971E+07	N

54 XENON Z/A = 4.113E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.0515	.01	.0515	NA	6.262E+02	0.	0.	0.	Y
2	.0515--.1073	.0515	.1073	1.8-1	7.578E+04	-1.206E+04	6.503E+02	-1.177E+01	Y
3	.1073--M5	.1073	.672	9.2-1	-1.456E+03	3.607E+03	-1.050E+03	8.562E+01	Y
4	M5--M3	.672	.936	4.6-2	5.494E+04	-4.316E+04	-3.353E+04	3.122E+04	Y
5	M3--M1	.936	1.143	5.0-2	-2.422E+04	6.454E+04	-3.914E+04	8.599E+03	N
6	M1--L3	1.143	4.782	1.9-2	-6.606E+02	7.269E+03	6.119E+03	-3.383E+03	N
7	L3--L2	4.782	5.102	1.7-7	-1.565E+02	5.749E+03	5.985E+04	-2.396E+04	N
8	L2--L1	5.102	5.445	1.9-7	-2.236E+02	9.444E+03	7.463E+04	-3.742E+04	N
9	L1--K	5.445	34.561	5.1-3	-2.010E+01	2.400E+03	1.720E+05	-2.977E+05	N
10	K--100.	34.561	100.	2.2-3	-1.622E+00	1.830E+03	1.780E+06	-1.721E+07	N
11	100.-- 500.	100.	500.	5.1-3	2.082E+00	3.625E+02	1.962E+06	-2.448E+07	N
12	500.--INF	500.	INF	2.1-2	1.148E+00	1.892E+03	1.133E+06	1.244E+08	N

55 CESIUM Z/A = 4.138E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.0704	.01	.0704	NA	6.813E+02	0.	0.	0.	Y
2	.0704--.111	.0704	.111	5.8-2	1.642E+05	-2.922E+04	1.724E+03	-3.361E+01	Y
3	.111--M5	.111	.726	1.6+0	-2.400E+03	4.936E+03	-1.531E+03	1.354E+02	Y
4	M5--M2	.726	1.065	7.5-3	1.295E+04	-7.423E+03	-6.620E+03	9.125E+03	Y
5	M2--L3	1.065	5.012	1.6-1	6.121E+02	-1.572E+03	2.712E+04	-1.563E+04	Y
6	L3--L2	5.012	5.36	1.2-7	-8.402E+01	2.872E+03	7.699E+04	-1.853E+04	N
7	L2--L1	5.36	5.713	1.8-7	-2.254E+02	1.015E+04	7.940E+04	-4.284E+04	N
8	L1--K	5.713	35.985	8.3-3	-1.987E+00	1.400E+03	2.040E+05	-4.166E+05	N
9	K--100.	35.985	100.	2.5-3	-4.238E+00	2.444E+03	1.873E+06	-1.899E+07	N
10	100.-- 500.	100.	500.	5.6-3	2.278E+00	4.044E+02	2.085E+06	-2.635E+07	N
11	500.--INF	500.	INF	2.2-2	1.226E+00	2.030E+03	1.249E+06	1.169E+08	N

56 BARIUM Z/A = 4.078E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.0305	.01	.0305	NA	5.765E+03	0.	0.	0.	Y
2	.0305--N5	.0305	.090	2.5-2	1.759E+03	-2.331E+02	9.598E+00	3.960E-02	Y
3	N5--M5	.090	.780	1.0+0	-4.276E+02	2.995E+03	-9.837E+02	8.771E+01	Y
4	M5--M2	.780	1.135	5.9-2	6.154E+03	1.190E+03	-2.858E+02	1.593E+03	Y
5	M2--L3	1.135	5.247	5.5-2	2.420E+02	-4.033E+02	3.138E+04	-2.304E+04	Y
6	L3--L2	5.247	5.623	1.7-7	-1.084E+02	4.043E+03	7.718E+04	-2.532E+04	N
7	L2--L1	5.623	5.987	1.5-7	-1.836E+02	7.952E+03	9.545E+04	-4.532E+04	N
8	L1--K	5.987	37.441	1.3-2	8.708E+00	7.581E+02	2.258E+05	-5.011E+05	N
9	K--100.	37.441	100.	2.6-3	-5.846E+00	3.162E+03	1.902E+06	-1.948E+07	N
10	100.--500.	100.	500.	4.4-3	2.590E+00	2.297E+02	2.236E+06	-3.193E+07	N
11	500.--INF	500.	INF	2.2-2	1.281E+00	2.144E+03	1.303E+06	1.193E+08	N

57 LANTHANUM Z/A = 4.104E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.04	.01	.04	NA	4.514E+03	0.	0.	0.	Y
2	.04--.13	.04	.13	1.7-1	2.741E+04	-4.218E+03	2.117E+02	-3.183E+00	Y
3	.13--M5	.13	.832	2.2+0	-1.231E+03	4.053E+03	-1.329E+03	1.203E+02	Y
4	M5--M3	.832	1.124	2.2-2	2.431E+03	3.780E+03	2.792E+03	-2.167E+02	Y
5	M3--M2	1.124	1.204	1.5-7	-4.024E+02	8.837E+03	2.398E+03	-4.154E+02	N
6	M2--L3	1.204	5.484	8.5-2	-2.694E+02	4.549E+03	1.944E+04	-1.264E+04	Y
7	L3--L2	5.484	5.891	1.7-7	-9.085E+01	3.459E+03	8.639E+04	-2.558E+04	N
8	L2--L1	5.891	6.266	1.2-7	-1.485E+02	6.357E+03	1.121E+05	-4.626E+04	N
9	L1--K	6.266	38.925	6.6-3	-6.527E+00	1.901E+03	2.209E+05	-4.602E+05	N
10	K--100.	38.925	100.	3.6-3	-7.588E+00	3.685E+03	1.991E+06	-2.054E+07	N
11	100.--500.	100.	500.	4.5-3	2.727E+00	3.137E+02	2.356E+06	-3.362E+07	N
12	500.--INF	500.	INF	2.2-2	1.365E+00	2.298E+03	1.393E+06	1.220E+08	N

58 CERIUM Z/A = 4.139E-01

1	.01--.053	.01	.053	NA	1.542E+03	0.	0.	0.	Y
2	.053--N5	.053	.110	6.4-2	2.448E+04	-5.012E+03	3.411E+02	-7.413E+00	Y
3	N5--M5	.110	.883	3.2-1	-1.622E+03	4.662E+03	-1.505E+03	1.385E+02	Y
4	M5--M3	.883	1.185	8.5-2	5.551E+04	-1.769E+05	2.024E+05	-7.125E+04	N
5	M3--M2	1.185	1.273	5.3-6	4.656E+03	6.580E+03	-3.256E+03	8.079E+02	N
6	M2--M1	1.273	1.435	9.7-7	-2.828E+02	1.019E+04	2.005E+03	-4.180E+02	N
7	M1--L3	1.435	5.723	5.7-2	3.264E+02	-7.440E+02	3.609E+04	-2.685E+04	Y
8	L3--L2	5.723	6.164	1.7-7	-7.263E+01	2.822E+03	9.606E+04	-2.458E+04	N
9	L2--L1	6.164	6.549	1.3-7	-1.695E+02	7.899E+03	1.139E+05	-5.644E+04	N
10	L1--K	6.549	40.443	1.3-2	1.939E+01	3.799E+02	2.661E+05	-6.583E+05	N
11	K--100.	40.443	100.	7.6-4	-1.029E+01	4.409E+03	2.101E+06	-2.280E+07	N
12	100.-- 500.	100.	500.	6.3-3	2.723E+00	4.916E+02	2.494E+06	-3.595E+07	N
13	500.--INF	500.	INF	2.6-2	1.464E+00	2.444E+03	1.486E+06	1.376E+08	N

59 PRASEODYMIUM Z/A = 4.187E-01

1	.01--.04	.01	.04	NA	3.935E+03	0.	0.	0.	Y
2	.04--N5	.04	.113	9.1-2	5.885E+01	5.060E+01	1.142E+01	-2.858E-01	Y
3	N5--M5	.113	.931	3.2+0	-2.475E+03	6.072E+03	-2.077E+03	2.099E+02	Y
4	M5--M3	.931	1.242	8.1-2	-6.489E+03	2.485E+04	-1.060E+04	2.589E+03	N
5	M3--M2	1.242	1.337	3.0-7	-5.349E+02	8.049E+03	5.499E+03	-9.313E+02	N
6	M2--M1	1.337	1.505	1.3-6	-3.829E+02	1.003E+04	3.437E+03	-7.202E+02	N
7	M1--L3	1.505	5.964	6.3-2	1.158E+02	1.754E+03	2.978E+04	-2.081E+04	Y
8	L3--L2	5.964	6.44	1.2-7	-4.523E+01	1.773E+03	1.075E+05	-1.884E+04	N
9	L2--L1	6.44	6.835	1.0-7	-1.401E+02	6.504E+03	1.315E+05	-5.758E+04	N
10	L1--K	6.835	41.991	1.1-2	8.492E+00	8.664E+02	2.819E+05	-7.256E+05	N
11	K--100.	41.991	100.	3.2-4	-9.126E+00	4.223E+03	2.290E+06	-2.709E+07	N
12	100.--500.	100.	500.	6.0-3	3.207E+00	3.424E+02	2.697E+06	-4.123E+07	N
13	500.--INF	500.	INF	2.4-2	1.557E+00	2.710E+03	1.566E+06	1.383E+08	N

60 NEODYMIUM Z/A = 4.160E-01

1	.01--.0305	.01	.0305	NA	2.269E+03	0.	0.	0.	Y
2	.0305--N5	.0305	.117	8.1-2	-1.142E+03	4.035E+02	-1.726E+01	2.479E-01	Y
3	N5--M5	.117	.978	1.5+0	-4.138E+02	3.657E+03	-1.265E+03	1.287E+02	Y
4	M5--M3	.978	1.298	8.4-2	1.241E+04	-6.608E+03	-8.545E+03	1.174E+04	Y
5	M3--M1	1.298	1.575	4.3-6	2.239E+02	1.199E+04	-1.181E+03	2.855E+02	N
6	M1--L3	1.575	6.208	6.8-2	-3.530E+02	6.609E+03	1.641E+04	-7.462E+03	Y
7	L3--L2	6.208	6.722	2.1-7	-6.644E+01	2.796E+03	1.098E+05	-2.924E+04	N
8	L2--L1	6.722	7.128	8.2-8	-1.114E+02	5.206E+03	1.457E+05	-5.559E+04	N
9	L1--K	7.128	43.569	7.6-3	8.287E+00	9.600E+02	2.935E+05	-7.637E+05	N
10	K--100.	43.569	100.	2.1-4	-9.944E+00	4.886E+03	2.320E+06	-2.702E+07	N
11	100.--500.	100.	500.	6.5-4	3.820E+00	8.492E+01	2.868E+06	-4.750E+07	N
12	500.--INF	500.	INF	2.3-2	1.633E+00	2.833E+03	1.759E+06	9.295E+07	N

61 PROMETHIUM Z/A = 4.207E-01

1	.01--.0305	.01	.0305	NA	2.285E+03	0.	0.	0.	Y
2	.0305--N5	.0305	.122	1.2-1	3.175E+03	-4.311E+02	2.911E+01	-5.124E-01	Y
3	N5--M5	.122	1.027	1.2+0	-7.108E+02	4.102E+03	-1.397E+03	1.482E+02	Y
4	M5--M3	1.027	1.357	4.2-5	-5.546E+02	7.912E+03	4.958E+03	-7.606E+02	N
5	M3--M2	1.357	1.471	4.2-7	-5.157E+02	8.937E+03	6.066E+03	-1.148E+03	N
6	M2--M1	1.471	1.648	1.5-6	-4.607E+02	9.760E+03	6.028E+03	-1.298E+03	N
7	M1--L3	1.648	6.459	2.2-3	-1.912E+02	5.138E+03	2.120E+04	-1.345E+04	N
8	L3--L2	6.459	7.013	2.6-7	-7.165E+01	3.169E+03	1.166E+05	-3.499E+04	N
9	L2--L1	7.013	7.428	3.0-7	-2.589E+02	8.215E+03	-1.102E+05	1.824E+06	N
10	L1--K	7.428	45.184	8.2-3	-4.251E+01	4.740E+03	2.377E+05	-4.279E+05	N
11	K--100.	45.184	100.	9.7-4	9.003E-02	2.739E+03	2.641E+06	-3.336E+07	N
12	100.--500.	100.	500.	5.3-3	2.857E+00	1.090E+03	2.888E+06	-4.432E+07	N
13	500.--INF	500.	INF	2.4-2	1.742E+00	3.069E+03	1.744E+06	1.719E+08	N

62 SAMARIUM Z/A = 4.123E-Ø1

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.Ø1--.Ø3Ø5	.Ø1	.Ø3Ø5	NA	1.754E+Ø3	Ø.	Ø.	Ø.	Y
2	.Ø3Ø5--N5	.Ø3Ø5	.128	5.1-2	1.174E+Ø3	1.37ØE+Ø2	-4.815E+ØØ	3.574E-Ø2	Y
3	N5--M5	.128	1.Ø78	2.3+Ø	-1.315E+Ø3	5.218E+Ø3	-1.9ØØE+Ø3	2.181E+Ø2	Y
4	M5--M3	1.Ø78	1.419	4.Ø-5	-5.499E+Ø2	7.881E+Ø3	5.664E+Ø3	-8.952E+Ø2	N
5	M3--L3	1.419	6.716	1.Ø-1	-1.126E+Ø2	3.912E+Ø3	3.23ØE+Ø4	-2.774E+Ø4	Y
6	L3--L2	6.716	7.312	1.6-7	-3.58ØE+Ø1	1.576E+Ø3	1.29ØE+Ø5	-2.2Ø1E+Ø4	N
7	L2--L1	7.312	7.736	4.4-8	-6.4ØØE+Ø1	3.Ø84E+Ø3	1.751E+Ø5	-4.595E+Ø4	N
8	L1--K	7.736	46.834	7.7-3	7.Ø96E+ØØ	1.Ø71E+Ø3	3.267E+Ø5	-9.193E+Ø5	N
9	K--1ØØ.	46.834	1ØØ.	1.3-3	-1.Ø82E+Ø1	5.919E+Ø3	2.475E+Ø6	-2.997E+Ø7	N
1Ø	1ØØ.--5ØØ.	1ØØ.	5ØØ.	7.2-3	3.844E+ØØ	4.Ø77E+Ø2	3.137E+Ø6	-5.576E+Ø7	N
11	5ØØ.--INF	5ØØ.	INF	2.4-2	1.799E+ØØ	3.181E+Ø3	1.898E+Ø6	1.263E+Ø8	N

63 EUROPIUM Z/A = 4.146E-Ø1

1	.Ø1--.Ø3Ø5	.Ø1	.Ø3Ø5	NA	2.Ø47E+Ø3	Ø.	Ø.	Ø.	Y
2	.Ø3Ø5--N5	.Ø3Ø5	.134	9.2-2	4.276E+Ø3	-4.382E+Ø2	2.276E+Ø1	-3.499E-Ø1	Y
3	N5--M5	.134	1.131	5.1-1	-4.678E+Ø2	4.Ø34E+Ø3	-1.326E+Ø3	1.388E+Ø2	Y
4	M5--M3	1.131	1.481	3.7-5	-5.5Ø7E+Ø2	7.936E+Ø3	6.518E+Ø3	-1.Ø58E+Ø3	N
5	M3--M2	1.481	1.614	4.7-7	-4.589E+Ø2	1.Ø19E+Ø4	5.669E+Ø3	-1.234E+Ø3	N
6	M2--M1	1.614	1.8ØØ	1.5-6	-4.913E+Ø2	8.74ØE+Ø3	1.Ø16E+Ø4	-2.142E+Ø3	N
7	M1--L3	1.8ØØ	6.977	3.5-3	-2.288E+Ø2	5.934E+Ø3	2.154E+Ø4	-1.326E+Ø4	N
8	L3--L2	6.977	7.618	1.3-7	-2.466E+Ø1	1.115E+Ø3	1.4ØØE+Ø5	-1.768E+Ø4	N
9	L2--L1	7.618	8.Ø52	4.1-8	-6.266E+Ø1	3.143E+Ø3	1.878E+Ø5	-5.Ø89E+Ø4	N
1Ø	L1--K	8.Ø52	48.519	3.9-3	-4.3Ø6E+ØØ	2.Ø26E+Ø3	3.28ØE+Ø5	-9.Ø12E+Ø5	N
11	K--1ØØ.	48.519	1ØØ.	2.6-3	-7.61ØE+ØØ	5.488E+Ø3	2.642E+Ø6	-3.287E+Ø7	N
12	1ØØ.--5ØØ.	1ØØ.	5ØØ.	4.9-3	3.783E+ØØ	7.655E+Ø2	3.245E+Ø6	-5.731E+Ø7	N
13	5ØØ.--INF	5ØØ.	INF	2.4-2	1.9Ø4E+ØØ	3.4ØØE+Ø3	2.Ø2ØE+Ø6	1.315E+Ø8	N

64 GADOLINIUM Z/A = 4.Ø7ØE-Ø1

1	.Ø1--.Ø3Ø5	.Ø1	.Ø3Ø5	NA	1.62ØE+Ø3	Ø.	Ø.	Ø.	Y
2	.Ø3Ø5--N5	.Ø3Ø5	.14Ø	7.2-2	1.627E+Ø3	8.32ØE+Ø1	-5.112E+ØØ	7.828E-Ø2	Y
3	N5--M5	.14Ø	1.185	1.2+Ø	-2.4Ø4E+Ø3	7.22ØE+Ø3	-2.684E+Ø3	2.976E+Ø2	Y
4	M5--M3	1.185	1.544	3.5-5	-5.394E+Ø2	7.849E+Ø3	7.295E+Ø3	-1.216E+Ø3	N
5	M3--M2	1.544	1.688	3.5-7	-4.486E+Ø2	1.Ø29E+Ø4	6.Ø91E+Ø3	-1.38ØE+Ø3	N
6	M2--M1	1.688	1.881	1.4-6	-4.679E+Ø2	9.424E+Ø3	9.571E+Ø3	-2.2Ø1E+Ø3	N
7	M1--L3	1.881	7.243	2.9-3	-3.Ø17E+Ø2	6.938E+Ø3	1.944E+Ø4	-1.1Ø4E+Ø4	N
8	L3--L2	7.243	7.93	3.4-7	-5.768E+Ø1	2.841E+Ø3	1.366E+Ø5	-4.131E+Ø4	N
9	L2--L1	7.93	8.375	2.2-8	-3.358E+Ø1	1.7Ø1E+Ø3	2.Ø29E+Ø5	-3.312E+Ø4	N
1Ø	L1--K	8.375	5Ø.239	3.3-3	-8.668E+ØØ	2.379E+Ø3	3.331E+Ø5	-9.285E+Ø5	N
11	K--5ØØ.	5Ø.239	5ØØ.	4.9-3	3.2Ø9E+ØØ	1.579E+Ø3	3.144E+Ø6	-4.8Ø4E+Ø7	N
12	5ØØ.--INF	5ØØ.	INF	2.4-2	1.966E+ØØ	3.553E+Ø3	2.1Ø3E+Ø6	1.345E+Ø8	N

65 TERBIUM Z/A = 4.Ø9ØE-Ø1

1	.Ø1--.Ø3Ø5	.Ø1	.Ø3Ø5	NA	1.879E+Ø3	Ø.	Ø.	Ø.	Y
2	.Ø3Ø5--N5	.Ø3Ø5	.147	9.9-2	3.Ø21E+Ø3	-1.618E+Ø2	9.979E+ØØ	-1.862E-Ø1	Y
3	N5--M5	.147	1.24	4.5-1	-1.4Ø6E+Ø3	5.621E+Ø3	-1.912E+Ø3	2.Ø75E+Ø2	Y
4	M5--M3	1.24	1.61	3.3-5	-5.345E+Ø2	7.632E+Ø3	8.66ØE+Ø3	-1.449E+Ø3	N
5	M3--M2	1.61	1.765	7.5-7	-4.988E+Ø2	9.4Ø1E+Ø3	9.226E+Ø3	-2.ØØØE+Ø3	N
6	M2--M1	1.765	1.963	1.4-6	-4.7ØØE+Ø2	9.391E+Ø3	1.117E+Ø4	-2.613E+Ø3	N
7	M1--L3	1.963	7.514	1.4-3	-1.9Ø2E+Ø2	5.724E+Ø3	2.615E+Ø4	-1.782E+Ø4	N
8	L3--L2	7.514	8.252	8.7-7	-1.568E+Ø2	1.116E+Ø4	8.757E+Ø4	-7.647E+Ø4	N
9	L2--L1	8.252	8.7Ø8	2.8-8	-4.533E+Ø1	2.421E+Ø3	2.126E+Ø5	-4.859E+Ø4	N
1Ø	L1--K	8.7Ø8	51.996	5.3-3	-4.721E+ØØ	2.127E+Ø3	3.644E+Ø5	-1.1Ø9E+Ø6	N
11	K--5ØØ.	51.996	5ØØ.	4.1-3	3.9Ø3E+ØØ	1.25ØE+Ø3	3.4Ø5E+Ø6	-5.637E+Ø7	N
12	5ØØ.--INF	5ØØ.	INF	2.4-2	2.Ø77E+ØØ	3.763E+Ø3	2.261E+Ø6	1.155E+Ø8	N

66 DYSPROSIUM Z/A = 4.Ø62E-Ø1

1	.Ø1--.Ø3Ø5	.Ø1	.Ø3Ø5	NA	3.294E+Ø3	Ø.	Ø.	Ø.	Y
2	.Ø3Ø5--N5	.Ø3Ø5	.154	1.Ø-1	3.167E+Ø3	-4.242E+Ø1	5.269E+ØØ	-1.178E-Ø1	Y
3	N5--M5	.154	1.295	2.8-1	-1.1Ø9E+Ø3	5.234E+Ø3	-1.65ØE+Ø3	1.694E+Ø2	Y
4	M5--M3	1.295	1.676	3.1-5	-5.242E+Ø2	7.751E+Ø3	9.341E+Ø3	-1.624E+Ø3	N
5	M3--M2	1.676	1.842	7.5-7	-4.635E+Ø2	1.Ø5ØE+Ø4	8.Ø66E+Ø3	-1.93ØE+Ø3	N
6	M2--M1	1.842	2.Ø46	1.3-6	-4.6Ø8E+Ø2	9.448E+Ø3	1.216E+Ø4	-2.942E+Ø3	N
7	M1--L3	2.Ø46	7.79	2.Ø-3	-1.Ø77E+Ø2	4.675E+Ø3	3.253E+Ø4	-2.519E+Ø4	N
8	L3--L2	7.79	8.58	5.Ø-7	-6.326E+Ø1	3.4Ø7E+Ø3	1.499E+Ø5	-5.526E+Ø4	N
9	L2--L1	8.58	9.Ø46	4.2-8	-7.262E+Ø1	4.176E+Ø3	2.13ØE+Ø5	-8.Ø26E+Ø4	N
1Ø	L1--K	9.Ø46	53.788	4.3-3	-1.8ØØE+Ø1	3.374E+Ø3	3.526E+Ø5	-9.982E+Ø5	N
11	K--5ØØ.	53.788	5ØØ.	4.8-3	4.112E+ØØ	1.344E+Ø3	3.52ØE+Ø6	-5.867E+Ø7	N
12	5ØØ.--INF	5ØØ.	INF	2.4-2	2.166E+ØØ	3.928E+Ø3	2.396E+Ø6	1.ØØ7E+Ø8	N

67 HOLMIUM Z/A = 4.062E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.0426	.01	.0426	NA	1.647E+03	0.	0.	0.	Y
2	.0426--N5	.0426	.161	1.4-1	2.949E+03	-5.473E+01	-1.313E+00	5.447E-02	Y
3	N5--M5	.161	1.351	3.1-1	-1.961E+03	6.859E+03	-2.353E+03	2.538E+02	Y
4	M5--M3	1.351	1.743	2.8-5	-5.221E+02	8.169E+03	9.852E+03	-1.807E+03	N
5	M3--M2	1.743	1.923	1.0-6	-4.878E+02	9.589E+03	1.119E+04	-2.580E+03	N
6	M2--M1	1.923	2.13	1.2-6	-4.549E+02	9.349E+03	1.378E+04	-3.393E+03	N
7	M1--L3	2.13	8.072	4.0-3	-1.379E+02	5.032E+03	3.428E+04	-2.787E+04	N
8	L3--L2	8.072	8.918	4.5-7	-4.939E+01	2.705E+03	1.628E+05	-5.056E+04	N
9	L2--L1	8.918	9.394	2.5-8	-4.426E+01	2.555E+03	2.349E+05	-5.948E+04	N
10	L1--K	9.394	55.618	5.4-3	-2.988E+00	2.094E+03	4.072E+05	-1.335E+06	N
11	K--500.	55.618	500.	2.2-2	5.131E+00	5.023E+02	4.000E+06	-7.974E+07	N
12	500.--INF	500.	INF	2.4-2	2.274E+00	4.258E+03	2.387E+06	1.450E+08	N

68 ERBIUM Z/A = 4.066E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.0322	.01	.0322	NA	2.419E+03	0.	0.	0.	Y
2	.0322--N5	.0322	.169	8.6-2	3.178E+03	-8.940E+01	5.741E+00	-1.173E-01	Y
3	N5--M5	.169	1.409	1.6-2	-1.598E+03	6.371E+03	-2.015E+03	1.951E+02	Y
4	M5--M3	1.409	1.812	2.6-5	-5.148E+02	8.464E+03	1.038E+04	-1.998E+03	N
5	M3--M2	1.812	2.006	1.2-6	-4.781E+02	8.546E+03	1.463E+04	-3.195E+03	N
6	M2--M1	2.006	2.217	1.1-6	-4.470E+02	9.490E+03	1.489E+04	-3.799E+03	N
7	M1--L3	2.217	8.358	3.6-3	-2.279E+02	6.501E+03	3.083E+04	-2.363E+04	N
8	L3--L2	8.358	9.264	5.5-7	-5.162E+01	2.947E+03	1.710E+05	-5.828E+04	N
9	L2--L1	9.264	9.752	2.9-8	-5.360E+01	3.254E+03	2.449E+05	-7.821E+04	N
10	L1--K	9.752	57.486	1.1-2	6.456E+00	1.211E+03	4.583E+05	-1.684E+06	N
11	K--500.	57.486	500.	6.0-3	4.025E+00	2.031E+03	3.795E+06	-6.651E+07	N
12	500.--INF	500.	INF	2.3-2	2.386E+00	4.497E+03	2.558E+06	1.403E+08	N

69 THULIUM Z/A = 4.084E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.031	.01	.031	NA	1.729E+03	0.	0.	0.	Y
2	.031--N5	.031	.180	8.6-2	5.004E+03	-3.383E+02	1.358E+01	-1.932E-01	Y
3	N5--M5	.180	1.468	5.4-2	-1.721E+03	6.821E+03	-2.191E+03	2.162E+02	Y
4	M5--M3	1.468	1.881	2.4-5	-5.074E+02	8.420E+03	1.161E+04	-2.277E+03	N
5	M3--L3	1.881	8.648	8.0-2	4.504E+02	-4.717E+03	9.421E+04	-1.104E+05	Y
6	L3--L2	8.648	9.617	6.3-7	-5.189E+01	3.077E+03	1.808E+05	-6.499E+04	N
7	L2--L1	9.617	10.116	2.9-8	-5.311E+01	3.348E+03	2.598E+05	-8.657E+04	N
8	L1--K	10.116	59.39	9.4-3	-3.887E+00	2.132E+03	4.637E+05	-1.723E+06	N
9	K--500.	59.39	500.	6.4-3	4.124E+00	2.299E+03	3.956E+06	-7.043E+07	N
10	500.--INF	500.	INF	2.4-2	2.512E+00	4.774E+03	2.690E+06	1.454E+08	N

70 YTTERBIUM Z/A = 4.045E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.075	.01	.075	NA	2.440E+03	0.	0.	0.	Y
2	.075--N5	.075	.185	6.2-2	5.923E+03	-5.235E+02	2.450E+01	-3.644E-01	Y
3	N5--M5	.185	1.528	4.5-2	-1.402E+03	6.524E+03	-1.996E+03	1.849E+02	Y
4	M5--M3	1.528	1.95	2.4-5	-4.609E+02	1.046E+04	8.110E+03	-1.884E+03	N
5	M3--L3	1.95	8.943	7.8-2	3.077E+02	-2.145E+03	8.374E+04	-9.504E+04	Y
6	L3--L2	8.943	9.978	7.5-7	-5.328E+01	3.291E+03	1.869E+05	-7.332E+04	N
7	L2--L1	9.978	10.489	3.7-8	-7.311E+01	4.929E+03	2.602E+05	-1.239E+05	N
8	L1--K	10.489	61.332	3.8-3	-2.434E+01	4.269E+03	4.243E+05	-1.379E+06	N
9	K--500.	61.332	500.	5.1-3	4.575E+00	2.312E+03	4.086E+06	-7.562E+07	N
10	500.--INF	500.	INF	2.3-2	2.606E+00	4.980E+03	2.895E+06	9.923E+07	N

71 LUTETIUM Z/A = 4.058E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.09	.01	.09	NA	2.123E+03	0.	0.	0.	Y
2	.09--N5	.09	.195	5.2-2	8.368E+03	-1.105E+03	5.971E+01	-9.746E-01	Y
3	N5--M5	.195	1.588	4.1-2	-1.536E+03	7.063E+03	-2.291E+03	2.250E+02	Y
4	M5--M3	1.588	2.024	2.1-5	-4.936E+02	9.095E+03	1.255E+04	-2.717E+03	N
5	M3--L3	2.024	9.245	7.2-2	2.304E+02	-1.379E+03	8.594E+04	-1.012E+05	Y
6	L3--L2	9.245	10.349	8.5-7	-5.213E+01	3.333E+03	1.974E+05	-7.977E+04	N
7	L2--L1	10.349	10.874	2.6-8	-5.333E+01	3.627E+03	2.858E+05	-1.071E+05	N
8	L1--K	10.874	63.316	1.0-2	3.726E+00	1.486E+03	5.352E+05	-2.222E+06	N
9	K--500.	63.316	500.	4.2-3	5.266E+00	2.137E+03	4.329E+06	-8.327E+07	N
10	500.--INF	500.	INF	2.4-2	2.736E+00	5.209E+03	3.153E+06	5.239E+07	N

72 HAFNIUM Z/A = 4.034E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	
1	.01--.0512	.01	.0512	7.5-2	5.463E+03	-2.212E+02	3.566E+00	-1.819E-02	Y
2	.0512--N5	.0512	.213	3.0-2	9.488E+03	-1.416E+03	8.076E+01	-1.382E+00	Y
3	N5--M5	.213	1.662	4.2-2	-1.796E+03	7.903E+03	-2.748E+03	2.932E+02	Y
4	M5--M3	1.662	2.108	2.0-5	-4.835E+02	9.549E+03	1.284E+04	-2.957E+03	N
5	M3--L3	2.108	9.560	7.0-2	3.480E+02	-3.031E+03	9.762E+04	-1.203E+05	Y
6	L3--L2	9.560	10.739	1.1-6	-6.090E+01	4.112E+03	2.015E+05	-9.934E+04	N
7	L2--L1	10.739	11.272	3.3-8	-7.386E+01	5.387E+03	2.859E+05	-1.536E+05	N
8	L1--K	11.272	65.345	3.1-3	-1.873E+01	4.102E+03	4.698E+05	-1.572E+06	N
9	K--500.	65.345	500.	3.5-3	4.753E+00	2.673E+03	4.462E+06	-8.960E+07	N
10	500.--INF	500.	INF	2.5-2	2.845E+00	5.554E+03	3.013E+06	1.535E+08	N

73 TANTALUM Z/A = 4.034E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	
1	.01--.0233	.01	.0233	7.3-2	-9.358E+03	4.382E+02	-5.661E+00	2.301E-02	Y
2	.0233--.0428	.0233	.0428	3.3-2	3.537E+04	-2.591E+03	6.585E+01	-5.643E-01	Y
3	.0428--N5	.0428	.229	1.2-1	9.080E+03	-1.376E+03	8.354E+01	-1.487E+00	Y
4	N5--M5	.229	1.735	4.2-2	-1.944E+03	8.490E+03	-3.040E+03	3.330E+02	Y
5	M5--M3	1.735	2.194	1.8-5	-4.771E+02	1.003E+04	1.338E+04	-3.254E+03	N
6	M3--L3	2.194	9.880	5.9-2	1.047E+02	6.524E+02	8.380E+04	-1.025E+05	Y
7	L3--L2	9.880	11.136	1.2-6	-5.521E+01	3.828E+03	2.145E+05	-1.019E+05	N
8	L2--L1	11.136	11.68	2.2-8	-4.987E+01	3.641E+03	3.160E+05	-1.250E+05	N
9	L1--K	11.68	67.416	9.7-3	-2.176E+00	2.172E+03	5.708E+05	-2.482E+06	N
10	K--500.	67.416	500.	3.2-3	5.194E+00	2.794E+03	4.645E+06	-9.648E+07	N
11	500.--INF	500.	INF	2.2-8	2.973E+00	5.785E+03	3.320E+06	9.608E+07	N

74 TUNGSTEN Z/A = 4.025E-01

1	.01--.031	.01	.031	1.2-1	-2.084E+03	1.834E+02	-2.686E+00	1.131E-02	Y
2	.031--.0493	.031	.0493	2.1-2	-1.398E+04	2.451E+03	-1.057E+02	1.381E+00	Y
3	.0493--N5	.0493	.245	2.0-1	9.985E+03	-1.816E+03	1.301E+02	-2.747E+00	Y
4	N5--M5	.245	1.809	3.8-2	-1.825E+03	8.623E+03	-3.114E+03	3.432E+02	Y
5	M5--M3	1.809	2.281	1.6-5	-4.666E+02	1.057E+04	1.355E+04	-3.503E+03	N
6	M3--L3	2.281	10.204	3.8-2	1.412E+02	2.762E+02	8.940E+04	-1.129E+05	Y
7	L3--L2	10.204	11.541	1.5-6	-6.206E+01	4.525E+03	2.194E+05	-1.223E+05	N
8	L2--L1	11.541	12.098	4.9-8	-1.211E+02	1.058E+04	2.701E+05	-2.556E+05	N
9	L1--K	12.098	69.525	2.6-3	-2.105E+01	4.623E+03	5.109E+05	-1.835E+06	N
10	K--500.	69.525	500.	2.6-3	5.276E+00	2.999E+03	4.828E+06	-1.030E+08	N
11	500.--INF	500.	INF	2.5-2	3.099E+00	6.112E+03	3.348E+06	1.310E+08	N

75 RHENIUM Z/A = 4.028E-01

1	.01--.0384	.01	.0384	1.1-1	-5.759E+03	4.019E+02	-6.479E+00	3.113E-02	Y
2	.0384--N5	.0384	.260	4.2-1	1.235E+04	-2.571E+03	1.879E+02	-4.072E+00	Y
3	N5--M5	.260	1.883	1.1-1	-1.846E+03	9.196E+03	-3.553E+03	4.261E+02	Y
4	M5--M3	1.883	2.368	1.4-5	-4.438E+02	1.148E+04	1.253E+04	-3.520E+03	N
5	M3--L3	2.368	10.534	4.7-2	1.961E+02	-3.585E+02	9.550E+04	-1.180E+05	Y
6	L3--L2	10.534	11.957	1.6-6	-5.721E+01	4.284E+03	2.331E+05	-1.270E+05	N
7	L2--L1	11.957	12.528	4.8-8	-1.192E+02	1.081E+04	2.828E+05	-2.788E+05	N
8	L1--K	12.528	71.676	5.2-3	-8.548E+00	3.122E+03	5.972E+05	-2.571E+06	N
9	K--500.	71.676	500.	3.5-3	4.901E+00	3.621E+03	4.969E+06	-1.085E+08	N
10	500.--INF	500.	INF	2.4-2	3.238E+00	6.600E+03	3.237E+06	2.204E+08	N

76 OSMIUM Z/A = 3.996E-01

1	.01--.0464	.01	.0464	1.4-1	5.189E+02	1.085E+02	-2.362E+00	1.285E-02	Y
2	.0464--N5	.0464	.272	3.8-1	9.943E+03	-1.964E+03	1.499E+02	-3.533E+00	Y
3	N5--M5	.272	1.960	4.1-2	-1.915E+03	9.625E+03	-3.819E+03	4.641E+02	Y
4	M5--M3	1.960	2.457	1.3-5	-4.312E+02	1.174E+04	1.298E+04	-3.813E+03	N
5	M3-L3	2.457	10.871	4.4-2	-7.620E+01	3.809E+03	8.189E+04	-1.090E+05	Y
6	L3--L2	10.871	12.385	1.9-6	-5.946E+01	4.643E+03	2.401E+05	-1.434E+05	N
7	L2--L1	12.385	12.969	4.1-8	-1.116E+02	1.035E+04	3.012E+05	-2.961E+05	N
8	L1--K	12.969	73.871	3.7-3	-1.803E+01	4.548E+03	5.700E+05	-2.246E+06	N
9	K--500.	73.871	500.	1.4-3	5.735E+00	3.318E+03	5.232E+06	-1.209E+08	N
10	500.--INF	500.	INF	2.4-2	3.351E+00	6.829E+03	3.509E+06	1.607E+08	N

77 IRIDIUM Z/A = 4.006E-01

1	.01--.048	.01	.048	1.8-1	-9.441E+01	1.284E+02	-2.563E+00	1.347E-02	Y
2	.048--N5	.048	.295	4.8-1	9.926E+03	-2.049E+03	1.630E+02	-4.025E+00	Y
3	N5--M5	.295	2.040	3.6-2	-2.391E+03	1.087E+04	-4.456E+03	5.612E+02	Y
4	M5--M3	2.040	2.551	1.3-5	-4.371E+02	1.150E+04	1.539E+04	-4.560E+03	N
5	M3--L3	2.551	11.215	5.1-2	1.540E+02	-7.160E+02	1.147E+05	-1.673E+05	Y
6	L3--L2	11.215	12.824	1.8-6	-5.153E+01	4.097E+03	2.582E+05	-1.419E+05	N
7	L2--L1	12.824	13.419	4.8-8	-1.366E+02	1.456E+04	2.707E+05	-3.461E+05	N
8	L1--K	13.419	76.111	1.4-2	-1.995E+01	4.906E+03	6.064E+05	-2.648E+06	N
9	K--500.	76.111	500.	2.4-3	6.213E+00	3.458E+03	5.442E+06	-1.286E+08	N
10	500.--INF	500.	INF	2.5-2	3.505E+00	7.126E+03	3.805E+06	1.114E+08	N

78 PLATINUM Z/A = 3.998E-01

1	.01--.0266	.01	.0226	6.1-2	1.220E+04	-3.768E+02	4.167E+00	-1.564E-02	Y
2	.0226--.0735	.0226	.0735	8.4-2	1.396E+04	-1.184E+03	3.650E+01	-3.548E-01	Y
3	.0735--N5	.0735	.313	7.9-1	1.172E+04	-2.752E+03	2.212E+02	-4.579E+00	Y
4	N5--M5	.313	2.122	3.7-2	-2.373E+03	1.129E+04	-4.739E+03	6.166E+02	Y
5	M5--M3	2.122	2.645	1.2-5	-4.333E+02	1.147E+04	1.710E+04	-5.181E+03	N
6	M3--L3	2.645	11.564	6.7-2	-7.755E+01	2.847E+03	1.047E+05	-1.599E+05	Y
7	L3--L2	11.564	13.273	2.7-6	-6.719E+01	5.737E+03	2.565E+05	-1.880E+05	N
8	L2--L1	13.273	13.88	4.6-8	-1.399E+02	1.605E+04	2.671E+05	-3.742E+05	N
9	L1--K	13.88	78.395	1.3-2	1.076E+01	9.617E+02	7.776E+05	-4.207E+06	N
10	K--500.	78.395	500.	3.4-3	6.088E+00	4.001E+03	5.552E+06	-1.300E+08	N
11	500.--INF	500.	INF	2.3-2	3.648E+00	7.453E+03	3.931E+06	1.226E+08	N

79 GOLD Z/A = 4.011E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.07	.01	.07	1.2-1	4.105E+03	2.410E+01	-1.837E+00	1.252E-02	Y
2	.07--N5	.07	.334	5.7-1	1.581E+04	-4.931E+03	5.197E+02	-1.822E+01	Y
3	N5--M5	.334	2.206	4.7-2	-2.231E+03	1.142E+04	-4.781E+03	6.012E+02	Y
4	M5--M3	2.206	2.743	1.1-5	-4.203E+02	1.212E+04	1.690E+04	-5.448E+03	N
5	M3--L3	2.743	11.919	3.7-2	1.443E+02	-4.096E+02	1.249E+05	-1.944E+05	Y
6	L3--L2	11.919	13.734	3.6-6	-8.194E+01	7.574E+03	2.506E+05	-2.318E+05	N
7	L2--L1	13.734	14.353	3.8-8	-1.134E+02	1.194E+04	3.355E+05	-3.921E+05	N
8	L1--K	14.353	80.725	4.4-3	-3.392E+00	3.070E+03	7.247E+05	-3.499E+06	N
9	K--500.	80.725	500.	9.6-4	7.917E+00	2.918E+03	6.095E+06	-1.596E+08	N
10	500.--INF	500.	INF	2.3-2	3.811E+00	7.846E+03	4.248E+06	4.571E+07	N

80 MERCURY Z/A = 3.988E-01

1	.01--.09	.01	.09	NA	5.142E+03	0.	0.	0.	Y
2	.09--N5	.09	.360	2.3+0	1.780E+04	-5.970E+03	6.765E+02	-2.176E+01	Y
3	N5--M5	.360	2.295	4.3-2	-2.317E+03	1.206E+04	-5.219E+03	7.004E+02	Y
4	M5--M3	2.295	2.847	9.5-6	-3.961E+02	1.286E+04	1.582E+04	-5.482E+03	N
5	M3--L3	2.847	12.283	3.9-2	2.241E+02	-2.195E+03	1.429E+05	-2.325E+05	Y
6	L3--L2	12.283	14.209	3.9-6	-7.533E+01	7.084E+03	2.675E+05	-2.412E+05	N
7	L2--L1	14.209	14.842	3.4-8	-1.288E+02	1.524E+04	3.090E+05	-4.397E+05	N
8	L1--K	14.842	83.102	9.0-3	4.681E-01	2.405E+03	7.958E+05	-4.232E+06	N
9	K--500.	83.102	500.	3.3-3	6.983E+00	4.309E+03	5.980E+06	-1.518E+08	N
10	500.--INF	500.	INF	2.4-2	3.946E+00	8.311E+03	4.256E+06	8.942E+07	N

81 THALLIUM Z/A = 3.963E-01

1	.01--.0313	.01	.0313	NA	1.823E+03	0.	0.	0.	Y
2	.0313--.0985	.0313	.0985	4.0-2	-1.010E+04	1.911E+03	-7.721E+01	9.111E-01	Y
3	.0985--.386	.0985	.386	9.7-1	1.488E+04	-4.878E+03	5.536E+02	-1.923E+01	Y
4	.386--M5	.386	2.389	4.1-2	-2.399E+03	1.271E+04	-5.745E+03	7.873E+02	Y
5	M5--M3	2.389	2.956	9.9-6	-4.087E+02	1.156E+04	2.169E+04	-7.188E+03	N
6	M3--L3	2.956	12.656	3.8-2	1.551E+02	-9.040E+02	1.404E+05	-2.314E+05	Y
7	L3--L2	12.656	14.697	3.9-6	-6.647E+01	6.324E+03	2.871E+05	-2.439E+05	N
8	L2--L1	14.697	15.346	3.9-8	-1.405E+02	2.137E+04	2.340E+05	-4.290E+05	N
9	L1--K	15.346	85.53	5.4-3	-1.053E+01	4.195E+03	7.543E+05	-3.747E+06	N
10	K--500.	85.53	500.	2.8-3	7.684E+00	4.048E+03	6.314E+06	-1.714E+08	N
11	500.--INF	500.	INF	2.4-2	4.082E+00	8.543E+03	4.521E+06	5.178E+07	N

82 LEAD Z/A = 3.958E-01

1	.01--.0311	.01	.0311	NA	1.569E+03	0.	0.	0.	Y
2	.0311--.095	.0311	.095	5.5-2	-9.651E+03	1.870E+03	-7.761E+01	9.425E-01	Y
3	.095--.413	.095	.413	6.7-1	1.609E+04	-5.855E+03	7.149E+02	-2.672E+01	Y
4	.413--M5	.413	2.484	4.2-2	-2.194E+03	1.239E+04	-5.418E+03	6.794E+02	Y
5	M5--M3	2.484	3.066	9.2-6	-4.016E+02	1.173E+04	2.316E+04	-7.955E+03	N
6	M3--L3	3.066	13.035	4.2-2	6.749E+01	6.789E+02	1.401E+05	-2.437E+05	Y
7	L3--L2	13.035	15.2	4.6-6	-7.125E+01	7.126E+03	2.931E+05	-2.779E+05	N
8	L2--L1	15.2	15.861	3.7-8	-1.363E+02	1.992E+04	2.721E+05	-4.887E+05	N
9	L1--K	15.861	88.004	5.4-3	-8.206E+00	4.058E+03	7.950E+05	-4.115E+06	N
10	K--500.	88.004	500.	4.6-4	7.595E+00	4.692E+03	6.429E+06	-1.747E+08	N
11	500.--INF	500.	INF	2.2-2	4.240E+00	8.883E+03	4.754E+06	3.448E+07	N

83 BISMUTH Z/A = 3.972E-01

1	.01--05	.01	.024	6.5-2	-4.395E+02	1.185E+01	2.207E-01	-1.865E-03	Y
2	05--04	.024	.026	1.0-2	4.586E+03	-1.052E+02	-2.706E+00	7.877E-02	Y
3	04--.0379	.026	.0379	1.8-2	1.118E+04	-3.159E+02	-9.250E+00	2.918E-01	Y
4	.0379--.1136	.0379	.1136	5.7-2	-1.578E+04	3.450E+03	-1.741E+02	2.596E+00	Y
5	.1136--.362	.1136	.362	7.2-1	2.124E+04	-8.884E+03	1.240E+03	-5.312E+01	Y
6	.362--M5	.362	2.581	1.2-1	-1.835E+03	1.188E+04	-5.123E+03	6.229E+02	Y
7	M5--M3	2.581	3.177	8.6-6	-3.943E+02	1.129E+04	2.671E+04	-9.164E+03	N
8	M3--L3	3.177	13.42	5.1-2	2.402E+02	-2.657E+03	1.637E+05	-2.867E+05	Y
9	L3--L2	13.42	15.714	5.1-6	-6.824E+01	7.005E+03	3.089E+05	-2.951E+05	N
10	L2--L1	15.714	16.391	3.7-8	-1.337E+02	1.999E+04	2.903E+05	-5.342E+05	N
11	L1--K	16.391	90.526	7.9-3	-1.411E+00	3.094E+03	8.901E+05	-5.203E+06	N
12	K--500.	90.526	500.	4.5-3	9.935E+00	3.289E+03	6.983E+06	-2.020E+08	N
13	500.--INF	500.	INF	2.3-2	4.425E+00	9.396E+03	5.008E+06	-5.280E+07	N

84 POLONIUM Z/A = 4.019E-01

1	.01--.0305	.01	.0305	NA	1.109E+03	0.	0.	0.	Y
2	.0305--.07	.0305	.07	2.0-2	1.939E+04	-1.380E+03	3.526E+01	-3.106E-01	Y
3	.07--.2415	.07	.2415	3.8-2	9.152E+03	-3.829E+03	5.535E+02	-2.106E+01	Y
4	.2415--M5	.2415	2.683	1.3-1	-1.131E+03	1.041E+04	-4.126E+03	4.235E+02	Y
5	M5--M3	2.683	3.302	8.0-6	-3.899E+02	1.134E+04	2.963E+04	-1.038E+04	N
6	M3--L3	3.302	13.814	3.7-2	4.918E+02	-1.053E+04	2.383E+05	-4.647E+05	Y
7	L3--L2	13.814	16.244	6.1-6	-7.471E+01	8.106E+03	3.143E+05	-3.397E+05	N
8	L2--L1	16.244	16.936	3.5-8	-1.335E+02	2.199E+04	2.786E+05	-5.569E+05	N
9	L1--K	16.936	93.105	1.0-2	7.789E+00	1.767E+03	1.003E+06	-6.443E+06	N
10	K--500.	93.105	500.	2.2-3	8.525E+00	5.102E+03	6.990E+06	-2.009E+08	N
11	500.--INF	500.	INF	2.2-2	4.633E+00	9.868E+03	5.142E+06	1.775E+07	N

85 ASTATINE Z/A = 4.048E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.0305	.01	.0305	NA	5.224E+02	0.	0.	0.	Y
2	.0305--.072	.0305	.072	6.4-2	2.744E+04	-2.310E+03	6.658E+01	-6.458E-01	Y
3	.072--.244	.072	.244	3.5+0	6.422E+03	-2.954E+03	4.933E+02	-2.019E+01	Y
4	.244--M5	.244	2.787	5.2-2	-1.933E+03	1.303E+04	-5.806E+03	6.870E+02	Y
5	M5--M3	2.787	3.426	7.5-6	-3.889E+02	1.171E+04	3.195E+04	-1.160E+04	N
6	M3--L3	3.426	14.214	7.8-2	3.129E+02	-6.378E+03	2.158E+05	-4.073E+05	Y
7	L3--L2	14.214	16.785	6.5-6	-6.880E+01	7.565E+03	3.411E+05	-3.547E+05	N
8	L2--L1	16.785	17.491	3.2-8	-1.280E+02	1.941E+04	3.508E+05	-6.556E+05	N
9	L1--K	17.491	95.73	4.5-3	-1.695E+00	3.621E+03	9.663E+05	-5.746E+06	N
10	K--500.	95.73	500.	2.9-3	9.913E+00	4.822E+03	7.370E+06	-2.163E+08	N
11	500.--INF	500.	INF	2.5-2	4.871E+00	1.062E+04	5.352E+06	-2.702E+07	N

86 RADON Z/A = 3.874E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.0466	.01	.0466	NA	1.284E+03	0.	0.	0.	Y
2	.0466--.093	.0466	.093	4.6-2	-7.912E+02	2.111E+03	-1.709E+02	3.589E+00	Y
3	.093--.305	.093	.305	3.4+0	1.243E+04	-6.150E+03	1.021E+03	-4.644E+01	Y
4	.305--M5	.305	2.892	4.7-2	-1.804E+03	1.279E+04	-5.624E+03	6.228E+02	Y
5	M5--M3	2.892	3.538	7.0-6	-3.616E+02	1.088E+04	3.423E+04	-1.248E+04	N
6	M3--L3	3.538	14.619	5.0-2	1.691E+02	-2.424E+03	1.954E+05	-4.008E+05	Y
7	L3--L2	14.619	17.337	7.3-6	-6.756E+01	7.739E+03	3.363E+05	-3.748E+05	N
8	L2--L1	17.337	18.055	3.1-8	-1.220E+02	1.976E+04	3.335E+05	-6.657E+05	N
9	L1--K	18.055	98.404	6.5-3	-5.899E-01	3.312E+03	9.833E+05	-6.258E+06	N
10	K--500.	98.404	500.	3.4-3	8.633E+00	5.888E+03	7.122E+06	-2.120E+08	N
11	500.--INF	500.	INF	2.2-2	4.841E+00	1.057E+04	5.286E+06	1.022E+07	N

87 FRANCIUM Z/A = 3.901E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.0494	.01	.0494	NA	1.287E+03	0.	0.	0.	Y
2	.0494--.196	.0494	.196	3.7-1	-9.129E+03	3.064E+03	-1.840E+02	2.869E+00	Y
3	.196--.525	.196	.525	7.8-1	1.217E+04	-1.865E+03	-1.031E+03	1.980E+02	Y
4	.525--M5	.525	3.00	2.4-1	-2.201E+03	1.461E+04	-7.082E+03	9.132E+02	Y
5	M5--M3	3.00	3.664	6.6-6	-3.615E+02	1.150E+04	3.541E+04	-1.363E+04	N
6	M3--L3	3.664	15.03	6.6-2	-5.769E+02	1.660E+04	5.526E+04	-7.044E+04	Y
7	L3--L2	15.03	17.904	7.6-6	-6.236E+01	7.249E+03	3.612E+05	-3.893E+05	N
8	L2--L1	17.904	18.639	3.1-8	-1.213E+02	2.052E+04	3.455E+05	-7.195E+05	N
9	L1--K	18.639	101.137	4.2-3	-8.453E+00	4.660E+03	9.757E+05	-6.010E+06	N
10	K--500.	101.137	500.	4.1-3	1.104E+01	4.630E+03	7.706E+06	-2.445E+08	N
11	500.--INF	500.	INF	2.4-2	5.063E+00	1.115E+04	5.666E+06	-1.082E+08	N

88 RADIUM Z/A = 3.893E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.0579	.01	.0579	NA	1.415E+03	0.	0.	0.	Y
2	.0579--.15	.0579	.15	2.6-2	-3.003E+04	8.875E+03	-6.798E+02	1.571E+01	Y
3	.15--.396	.15	.396	5.3-2	2.941E+04	-1.786E+04	3.591E+03	-2.242E+02	Y
4	.396--M5	.396	3.109	4.6-2	-1.852E+03	1.361E+04	-6.123E+03	6.294E+02	Y
5	M5--M3	3.109	3.791	6.2-6	-3.547E+02	1.164E+04	3.753E+04	-1.492E+04	N
6	M3--L3	3.791	15.446	4.4-2	2.933E+02	-6.829E+03	2.528E+05	-5.565E+05	Y
7	L3--L2	15.446	18.484	8.4-6	-6.085E+01	7.287E+03	3.762E+05	-4.161E+05	N
8	L2--L1	18.484	19.237	3.0-8	-1.192E+02	2.119E+04	3.500E+05	-7.644E+05	N
9	L1--K	19.237	103.922	3.8-3	-1.024E+01	5.310E+03	9.756E+05	-5.773E+06	N
10	K--500.	103.922	500.	6.3-3	1.241E+01	3.727E+03	8.307E+06	-2.833E+08	N
11	500.--INF	500.	INF	2.2-2	5.221E+00	1.168E+04	5.739E+06	-9.046E+07	N

89 ACTINIUM Z/A = 3.920E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--.0712	.01	.0712	NA	1.258E+03	0.	0.	0.	Y
2	.0712--.216	.0712	.216	3.0-2	-2.747E+03	3.975E+02	1.941E+02	-1.439E+01	Y
3	.216--.375	.216	.375	1.0+0	1.958E+04	-9.878E+03	1.388E+03	-1.778E+01	Y
4	.375--M5	.375	3.219	4.3-2	-2.098E+03	1.506E+04	-7.581E+03	9.825E+02	Y
5	M5--M3	3.219	3.909	5.8-6	-3.474E+02	1.153E+04	4.113E+04	-1.657E+04	N
6	M3--L3	3.909	15.870	4.7-2	5.789E+02	-1.507E+04	3.328E+05	-7.718E+05	Y
7	L3--L2	15.870	19.083	9.8-6	-6.339E+01	7.915E+03	3.884E+05	-4.637E+05	N
8	L2--L1	19.083	19.845	2.8-6	-1.182E+02	2.194E+04	3.621E+05	-8.244E+05	N
9	L1--K	19.845	106.759	6.1-3	8.142E+00	2.287E+03	1.185E+06	-8.493E+06	N
10	K--500.	106.759	500.	3.2-3	1.003E+01	6.690E+03	7.961E+06	-2.545E+08	N
11	500.INF	500.	INF	2.4-2	5.479E+00	1.217E+04	5.897E+06	-2.287E+07	N

90 THORIUM Z/A = 3.879E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--05	.01	.0879	NA	1.134E+03	0.	0.	0.	Y
2	05--N5	.0879	.676	1.9+0	1.398E+04	-6.113E+03	8.572E+02	-2.963E+01	Y
3	N5--M5	.676	3.332	5.5-2	-1.466E+03	1.349E+04	-6.743E+03	1.013E+03	Y
4	M5--M3	3.332	4.046	5.4-6	-3.308E+02	1.094E+04	4.517E+04	-1.812E+04	N
5	M3--L3	4.046	16.30	4.0-2	2.265E+02	-3.796E+03	2.424E+05	-5.526E+05	Y
6	L3--L2	16.30	19.693	1.1-5	-5.998E+01	7.669E+03	4.039E+05	-4.843E+05	N
7	L2--L1	19.693	20.466	2.6-8	-1.152E+02	2.229E+04	3.694E+05	-8.743E+05	N
8	L1--K	20.466	109.651	4.1-3	-1.965E+01	7.238E+03	9.916E+05	-5.869E+06	N
9	K--500.	109.651	500.	3.8-3	1.150E+01	6.085E+03	8.292E+06	-2.758E+08	N
10	500.--INF	500.	INF	2.4-2	5.620E+00	1.245E+04	6.338E+06	-1.549E+08	N

91 PROTACTINIUM Z/A = 3.939E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--O5	.01	.094	NA	2.194E+03	0.	0.	0.	Y
2	O5--.371	.094	.371	7.0-2	8.794E+03	-2.841E+03	2.038E+02	1.370E+01	Y
3	.371--M5	.371	3.442	5.2-1	-2.042E+03	1.581E+04	-8.451E+03	1.211E+03	Y
4	M5--M3	3.442	4.174	5.0-6	-3.240E+02	1.078E+04	5.022E+04	-2.015E+04	N
5	M3--L3	4.174	16.733	1.0-1	1.921E+03	-5.267E+04	6.573E+05	-1.562E+06	Y
6	L3--L2	16.733	20.314	1.3-5	-6.436E+01	8.617E+03	4.180E+05	-5.495E+05	N
7	L2--L1	20.314	21.105	2.5-8	-1.129E+02	2.138E+04	4.231E+05	-9.875E+05	N
8	L1--K	21.105	112.601	7.7-3	1.526E+01	1.356E+03	1.351E+06	-1.082E+07	N
9	K--500.	112.601	500.	3.0-3	1.254E+01	5.894E+03	8.877E+06	-3.120E+08	N
10	500.--INF	500.	INF	2.6-2	5.918E+00	1.306E+04	6.683E+06	-1.778E+08	N

92 URANIUM Z/A = 3.865E-01

1	.01--.0171	.01	.0171	1.4-1	4.400E+03	-1.564E+02	2.241E+00	-1.062E-02	Y
2	.0171--O5	.0171	.0963	5.2-1	-2.175E+03	4.327E+02	-1.164E+01	8.742E-02	Y
3	O5--.617	.0963	.617	1.8+0	1.528E+04	-7.106E+03	1.060E+03	-4.036E+01	Y
4	.617--M5	.617	3.552	6.0-2	-1.807E+03	1.483E+04	-7.405E+03	8.426E+02	Y
5	M5--M3	3.552	4.304	4.8-6	-3.148E+02	1.094E+04	5.041E+04	-2.121E+04	N
6	M3--L3	4.304	17.17	6.6-2	-1.100E+02	4.889E+03	1.908E+05	-4.810E+05	Y
7	L3--L2	17.17	20.948	1.5-5	-6.720E+01	9.489E+03	4.107E+05	-6.000E+05	N
8	L2--L1	20.948	21.759	2.3-8	-1.033E+02	1.864E+04	4.878E+05	-1.076E+06	N
9	L1--K	21.759	115.606	5.8-3	6.281E-01	3.792E+03	1.281E+06	-1.003E+07	N
10	K--500.	115.606	500.	1.5-3	1.146E+01	7.568E+03	8.699E+06	-3.106E+08	N
11	500.--INF	500.	INF	2.3-2	6.017E+00	1.327E+04	7.079E+06	-2.456E+08	N

93 NEPTUNIUM Z/A = 3.923E-01

1	.01--O5	.01	.1013	NA	2.522E+03	0.	0.	0.	Y
2	O5--.431	.1013	.431	6.4-2	1.668E+04	-8.606E+03	1.441E+03	-6.401E+01	Y
3	.431--M5	.431	3.664	4.5-2	-2.561E+03	1.858E+04	-1.101E+04	1.791E+03	Y
4	M5--M3	3.664	4.435	4.5-6	-3.232E+02	1.200E+04	5.096E+04	-2.302E+04	N
5	M3--L3	4.435	17.613	5.9-2	-4.467E+01	2.778E+03	2.204E+05	-5.257E+05	Y
6	L3--L2	17.613	21.60	1.6-5	-6.355E+01	9.093E+03	4.439E+05	-6.341E+05	N
7	L2--L1	21.60	22.427	2.2-8	-1.103E+02	2.501E+04	3.841E+05	-1.044E+06	N
8	L1--K	22.427	118.67	5.0-3	5.579E+00	3.489E+03	1.354E+06	-1.078E+07	N
9	K--500.	118.67	500.	2.7-3	1.272E+01	7.422E+03	9.191E+06	-3.336E+08	N
10	500.--INF	500.	INF	2.6-2	6.330E+00	1.392E+04	7.484E+06	-3.064E+08	N

94 PLUTONIUM Z/A = 3.852E-01

1	.01--.0306	.01	.0306	NA	3.508E+03	0.	0.	0.	Y
2	.0306--O5	.0306	.1054	1.8-2	-2.939E+03	8.224E+02	-3.576E+01	5.087E-01	Y
3	05--.405	.1054	.405	1.3-2	1.270E+04	-6.607E+03	1.093E+03	-3.674E+01	Y
4	.405--M5	.405	3.778	3.5-1	-2.063E+03	1.760E+04	-1.057E+04	1.695E+03	Y
5	M5--M3	3.778	4.556	4.3-6	-3.181E+02	1.245E+04	5.096E+04	-2.427E+04	N
6	M3--L3	4.556	18.063	4.1-2	3.925E+02	-1.022E+04	3.515E+05	-9.309E+05	Y
7	L3--L2	18.063	22.27	1.8-5	-6.367E+01	9.444E+03	4.539E+05	-6.824E+05	N
8	L2--L1	22.27	23.109	2.1-8	-1.065E+02	2.299E+04	4.461E+05	-1.181E+06	N
9	L1--K	23.109	121.797	4.5-3	-1.248E+01	6.703E+03	1.250E+06	-9.411E+06	N
10	K--500.	121.797	500.	2.5-3	1.781E+01	3.158E+03	1.075E+07	-4.693E+08	N
11	500.--INF	500.	INF	2.4-2	6.490E+00	1.422E+04	8.179E+06	-5.340E+08	N

95 AMERICIUM Z/A = 3.909E-01

1	.01--O5	.01	.103	NA	9.600E+02	0.	0.	0.	Y
2	O5--.498	.103	.498	2.1-1	3.669E+03	-1.927E+03	3.556E+02	-1.775E+01	Y
3	.498--N5	.498	.828	1.2-1	-8.806E+04	1.824E+05	-1.119E+05	2.150E+04	Y
4	N5--M5	.828	3.887	1.5-2	-8.786E+02	1.063E+04	-5.553E+02	-1.750E+03	N
5	M5--M3	3.887	4.667	4.0-6	-3.188E+02	1.325E+04	5.127E+04	-2.586E+04	N
6	M3--L3	4.667	18.519	5.2-2	3.232E+02	-9.027E+03	3.584E+05	-9.931E+05	Y
7	L3--L2	18.519	22.958	1.9-5	-6.201E+01	9.427E+03	4.778E+05	-7.281E+05	N
8	L2--L1	22.958	23.812	1.9-8	-9.199E+01	1.716E+04	6.101E+05	-1.350E+06	N
9	L1--K	23.812	124.99	2.8-3	-3.730E+00	5.425E+03	1.376E+06	-1.109E+07	N
10	K--500.	124.99	500.	3.6-3	1.966E+01	2.217E+03	1.154E+07	-5.298E+08	N
11	500.--INF	500.	INF	2.5-2	6.763E+00	1.479E+04	8.647E+06	-6.116E+08	N

96 CURIUM Z/A = 3.887E-01

1	.01--O5	.01	.1	NA	1.000E+03	0.	0.	0.	Y
2	O5--.498	.1	.498	1.9-1	3.148E+03	-1.605E+03	2.954E+02	-1.411E+01	Y
3	.498--N5	.498	.853	1.0-1	-7.979E+04	1.716E+05	-1.079E+05	2.118E+04	Y
4	N5--M5	.853	3.971	1.3-2	-8.139E+02	1.040E+04	4.547E+02	-2.530E+03	N
5	M5--M3	3.971	4.797	3.7-6	-3.144E+02	1.378E+04	5.160E+04	-2.733E+04	N
6	M3--L3	4.797	18.982	5.8-2	-2.912E+02	1.117E+04	1.679E+05	-4.469E+05	Y
7	L3--L2	18.982	23.663	2.1-5	-5.879E+01	9.126E+03	4.981E+05	-7.597E+05	N
8	L2--L1	23.663	24.535	2.0-8	-1.010E+02	2.212E+04	5.193E+05	-1.402E+06	N
9	L1--K	24.535	128.253	4.0-3	-1.147E+01	7.190E+03	1.327E+06	-1.016E+07	N
10	K--500.	128.253	500.	4.3-3	2.200E+01	1.083E+03	1.208E+07	-5.684E+08	N
11	500.--INF	500.	INF	2.9-2	7.017E+00	1.493E+04	9.471E+06	-8.527E+08	N

97 BERKELIUM Z/A = 3.927E-01

J	INT IDENT	START	FINISH	RMS	A(I,J,1)	A(I,J,2)	A(I,J,3)	A(I,J,4)	U
1	.01--05	.01	.1	NA	1.100E+03	0.	0.	0.	Y
2	05--.531	.1	.531	2.1-1	3.725E+03	-1.998E+03	3.728E+02	-1.783E+01	Y
3	.531--N5	.531	.877	5.3-2	-1.348E+05	2.867E+05	-1.865E+05	3.853E+04	Y
4	N5--M5	.877	4.132	1.7-2	-1.092E+03	1.257E+04	-3.090E+03	-6.861E+02	N
5	M5--M3	4.132	4.977	3.4-6	-3.108E+02	1.396E+04	5.452E+04	-2.964E+04	N
6	M3--L3	4.977	19.452	5.9-2	-8.536E+01	5.200E+03	2.278E+05	-6.067E+05	Y
7	L3--L2	19.452	24.385	2.4-5	-6.035E+01	9.752E+03	5.095E+05	-8.299E+05	N
8	L2--L1	24.385	25.275	1.8-8	-1.018E+02	2.538E+04	4.681E+05	-1.412E+06	N
9	L1--K	25.275	131.59	3.6-3	-1.308E+01	7.916E+03	1.354E+06	-1.049E+07	N
10	K--500.	131.59	500.	4.6-3	2.374E+01	1.750E+02	1.285E+07	-6.352E+08	N
11	500.--INF	500.	INF	2.8-2	7.219E+00	1.592E+04	9.491E+06	-8.283E+08	N

98 CALIFORNIUM Z/A = 3.904E-01

1	.01--05	.01	.1	NA	1.220E+03	0.	0.	0.	Y
2	05--.548	.1	.548	1.7-1	3.846E+03	-2.092E+03	3.854E+02	-1.758E+01	Y
3	.548--N5	.548	.902	1.3-1	-5.378E+04	1.380E+05	-9.898E+04	2.185E+04	Y
4	N5--M5	.902	4.254	1.6-2	-9.355E+02	1.168E+04	-4.663E+02	-2.379E+03	N
5	M5--M3	4.254	5.109	3.0-6	-3.044E+02	1.361E+04	6.013E+04	-3.273E+04	N
6	M3--L3	5.109	19.929	6.0-2	3.450E+02	-1.057E+04	4.170E+05	-1.248E+06	Y
7	L3--L2	19.929	25.125	2.6-5	-5.797E+01	9.571E+03	5.352E+05	-8.755E+05	N
8	L2--L1	25.125	26.03	1.7-8	-9.148E+01	1.942E+04	6.490E+05	-1.673E+06	N
9	L1--K	26.03	135.005	1.2-2	-5.416E+01	1.706E+04	8.630E+05	-1.792E+06	N
10	K--500.	135.005	500.	6.6-3	2.771E+01	-2.903E+03	1.419E+07	-7.456E+08	N
11	500.--INF	500.	INF	3.2-2	7.544E+00	1.589E+04	1.052E+07	-1.089E+09	N

99 EINSTEINIUM Z/A = 3.929E-01

1	.01--N5	.01	.927	NA	1.330E+03	0.	0.	0.	N
2	N5--M5	.927	4.378	1.4-2	-8.936E+02	1.145E+04	1.094E+03	-3.692E+03	N
3	M5--M4	4.378	4.630	1.3-7	-2.152E+02	7.720E+03	5.372E+04	-2.276E+04	N
4	M4--M3	4.630	5.259	2.7-6	-2.914E+02	1.268E+04	6.828E+04	-3.620E+04	N
5	M3--M2	5.259	6.574	2.7-5	-2.568E+02	1.341E+04	8.685E+04	-5.387E+04	N
6	M2--M1	6.574	6.977	1.2-7	-2.104E+02	1.155E+04	1.107E+05	-7.279E+04	N
7	M1--L3	6.977	20.414	4.4-3	1.088E+02	1.536E+03	2.458E+05	-6.005E+05	N
8	L3--L2	20.414	26.020	2.9-5	-5.691E+01	9.660E+03	5.556E+05	-9.320E+05	N
9	L2--L1	26.020	26.900	1.8-8	-9.167E+01	2.050E+04	6.520E+05	-1.784E+06	N
10	L1--K	26.900	139.490	4.5-3	9.687E-01	5.331E+03	1.646E+06	-1.518E+07	N
11	K--500.	139.490	500.	9.2-3	3.315E+01	-7.298E+03	1.587E+07	-8.866E+08	N
12	500.--INF	500.	INF	2.6-2	7.728E+00	1.675E+04	1.090E+07	-1.231E+09	N

100 FERMIUM Z/A = 3.891E-01

1	.01--N5	.01	.952	NA	1.460E+03	0.	0.	0.	N
2	N5--M5	.952	4.498	1.6-2	-1.082E+03	1.308E+04	-9.100E+02	-2.846E+03	N
3	M5--M4	4.498	4.766	1.4-7	-1.923E+02	6.709E+03	6.231E+04	-2.410E+04	N
4	M4--M3	4.766	5.397	2.2-6	-2.559E+02	1.024E+04	8.602E+04	-3.977E+04	N
5	M3--M2	5.397	6.793	2.9-5	-2.466E+02	1.276E+04	9.751E+04	-5.925E+04	N
6	M2--M1	6.793	7.205	1.1-7	-2.304E+02	1.518E+04	9.220E+04	-7.454E+04	N
7	M1--L3	7.205	20.907	2.1-3	8.675E+01	2.132E+03	2.568E+05	-6.538E+05	N
8	L3--L2	20.907	26.810	3.2-5	-5.793E+01	1.018E+04	5.793E+05	-1.018E+06	N
9	L2--L1	26.810	27.700	1.5-8	-8.637E+01	1.890E+04	7.445E+05	-1.949E+06	N
10	L1--K	27.700	143.090	5.2-3	5.556E-01	5.648E+03	1.738E+06	-1.662E+07	N
11	K--500.	143.090	500.	1.1-2	2.968E+01	-2.026E+03	1.484E+07	-7.825E+08	N
12	500.--INF	500.	INF	2.9-2	8.135E+00	1.726E+04	1.171E+07	-1.346E+09	N

APPENDIX B

Graphs

B.1 Discussion

Although the cross-section representations described in this report for Klein-Nishina and photoelectric cross sections apply for all photon energies above 0.01 keV, we will show the plots in this Appendix only in the interval 0.01 keV$\leq$E$\leq$1000 keV. The reason is that above 1000 keV, the photoelectric cross section becomes a smaller and smaller part of the total cross section. The total cross section is dominated by the scattering interaction, and the shape of this is shown in the Klein-Nishina plots given previously for photon energies up to 10^6 keV and tabulated to 10^8 keV. Also at high energies (>1.02 MeV) the pair production cross section increases in importance. We do not treat pair production in this document.

The photoelectric cross sections for each element were fitted to Eq (5) in several intervals. The boundaries for these intervals are given in the parameter table of Appendix A. The interval boundaries are often determined by absorption edges. The values of all the absorption edges that are used as interval boundaries are written on the plots and identified by name for your convenience.

The new fit to the photoelectric cross sections is given by the bottom solid curve of each plot. The old fit from our earlier compilation is shown by the dashed curve on each plot. The difference is most noticeable at low values of the photon energy.

The middle solid curve represents the energy-absorption cross section and is formed as the sum of the photoelectric cross section and the energy-transferred part of the Klein-Nishina cross section. The top solid curve is the total cross section and consists of the sum of the photoelectric cross section and the total Klein-Nishina cross section.

We did not refit the photoelectric cross sections in the intervals for which the existing fit was adequate for this update. The parameter table in Appendix A indicates whether or not a refit was done by showing a Y or N in the last column.

For most of the elements, only a part of the source data is shown on the plots because the symbols would overlap too much to be legible. The thinning was done automatically by the computer and in some cases caused the fit to appear worse than it really is.

The difference between the old fit and the new one is clear on the plots at photon energies below 1 keV, where much improved source data have become available during the last 15 years.

The high-energy limit behavior of the photoelectric cross section is governed by the coefficient of the 1/E term of Eq (5) for the highest energy interval. In our previous compilation, this coefficient was determined by theory for each element. In the current compilation it was necessary to use this coefficient in the fitting to adequately follow the cross-section source data at high photon energies. This resulted in a change of a few percent in these coefficients in some cases. This does not show on most of the plots because it usually occurs above the 1000 keV upper limit of the graphs. However, this difference can be seen on some of the plots just below E=1000 keV; look at neon (Z=10), for example.

The current compilation has more fitting intervals than the previous one. This was necessary to obtain adequate fitting accuracy. The root-mean-square fitting error for each interval is tabulated in the parameter table.

The fitting functions we are using (reciprocal powers of E) in Eq (5) are more compatible for fitting monotonically decreasing functional dependence as occurs between absorption edges generally above 1 keV. Below 1 keV the photoelectric cross-section behavior often has a more complicated behavior, as can be observed by looking at the plots. By using shorter intervals we have still achieved some success in following the source data in this region. We used judgment as to when to stop improving the fits (at a cost of more fitting intervals) at these low energies. Source data are still scarce at very low photon energies, and there is some variation between sources.

Another point to make about the fitting at low photon energies is that to get an increasing function using a linear combination of decreasing functions, a differencing of large numbers often occurs. This may cause more roundoff error at low photon energies than at higher energies.

Another factor is that the cross sections become more dependent on the state of the absorbing material, where such things as molecular binding energies start to become comparable to the photon energies.

On balance, we believe that we have represented the cross sections as well as the source data justify.

Another effect that should be mentioned is that the photoelectric cross section for a hydrogen atom would, strictly speaking, drop to zero below the K edge (E=0.014 keV). However, we allowed it to drop only to well below the Klein-Nishina cross sections for free electrons at these energies for convenience in plotting and in computing.

For elements of atomic numbers Z=96, 97, and 98, we estimated the values of the 0_V absorption edges. Values of the rest of the absorption edges were taken from a table in Reference 3, starting on page E-181.

B.2 Symbols and Sources of Data

The following table gives the sources of data used for fitting the parameters to the photoelectric cross sections. The symbols shown in this table are used throughout the 100 plots below. The superscripts in the Source of Data column refer to the corresponding references. Not all of these sources of data appear on every element. For example, the data from Smith *et al.* appear only for aluminum (Z=13). Some of these sources are compilations.

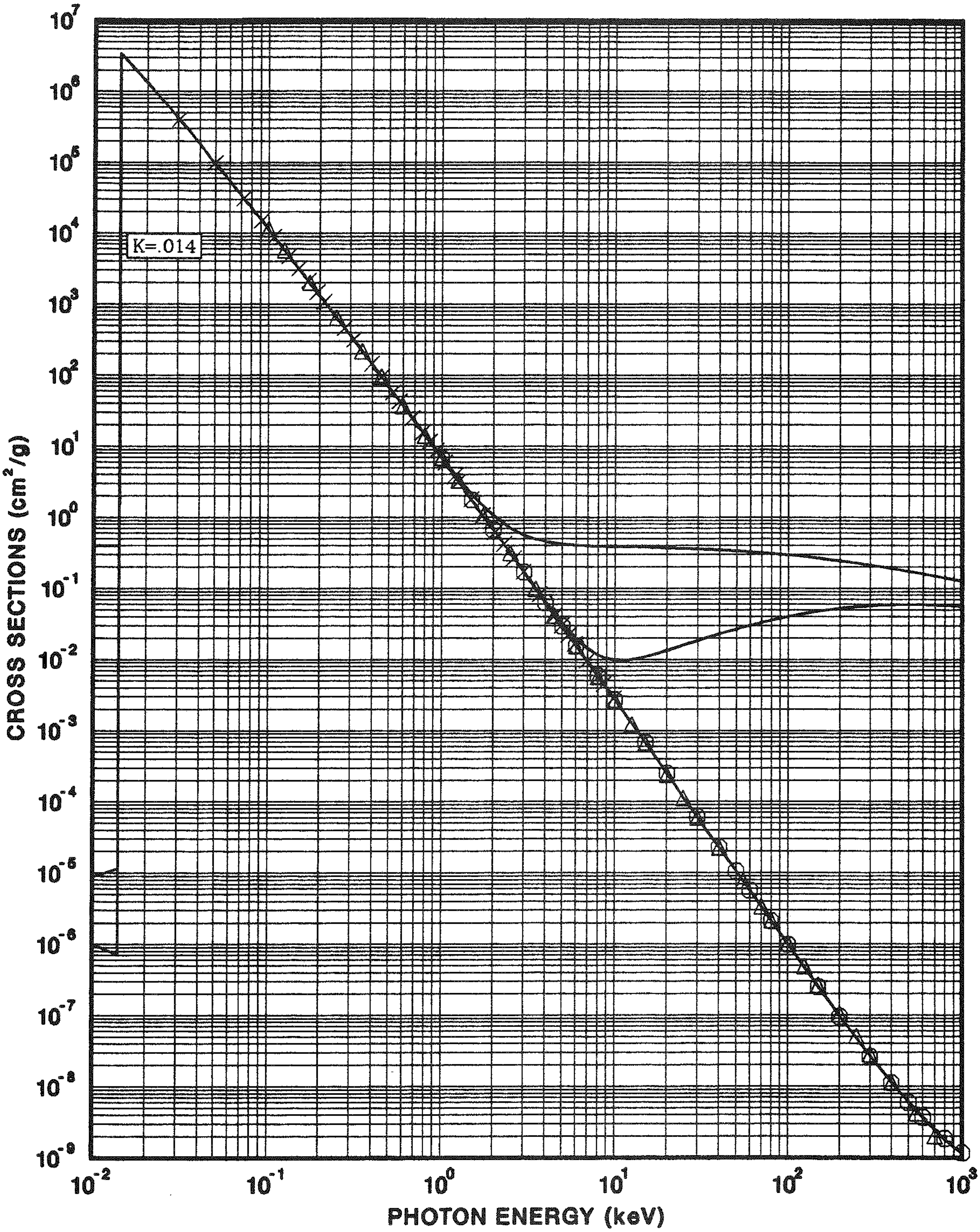
GRAPH SYMBOLS

Source of Data	Symbol
Henke, et al.[5]	×
LLNL[6]	△
ENDF/B-V[7]	⯃
DESY[8]	□
Physik Daten[9,10]	◇
Smith, et al.[11]	○

B.3 Graphs

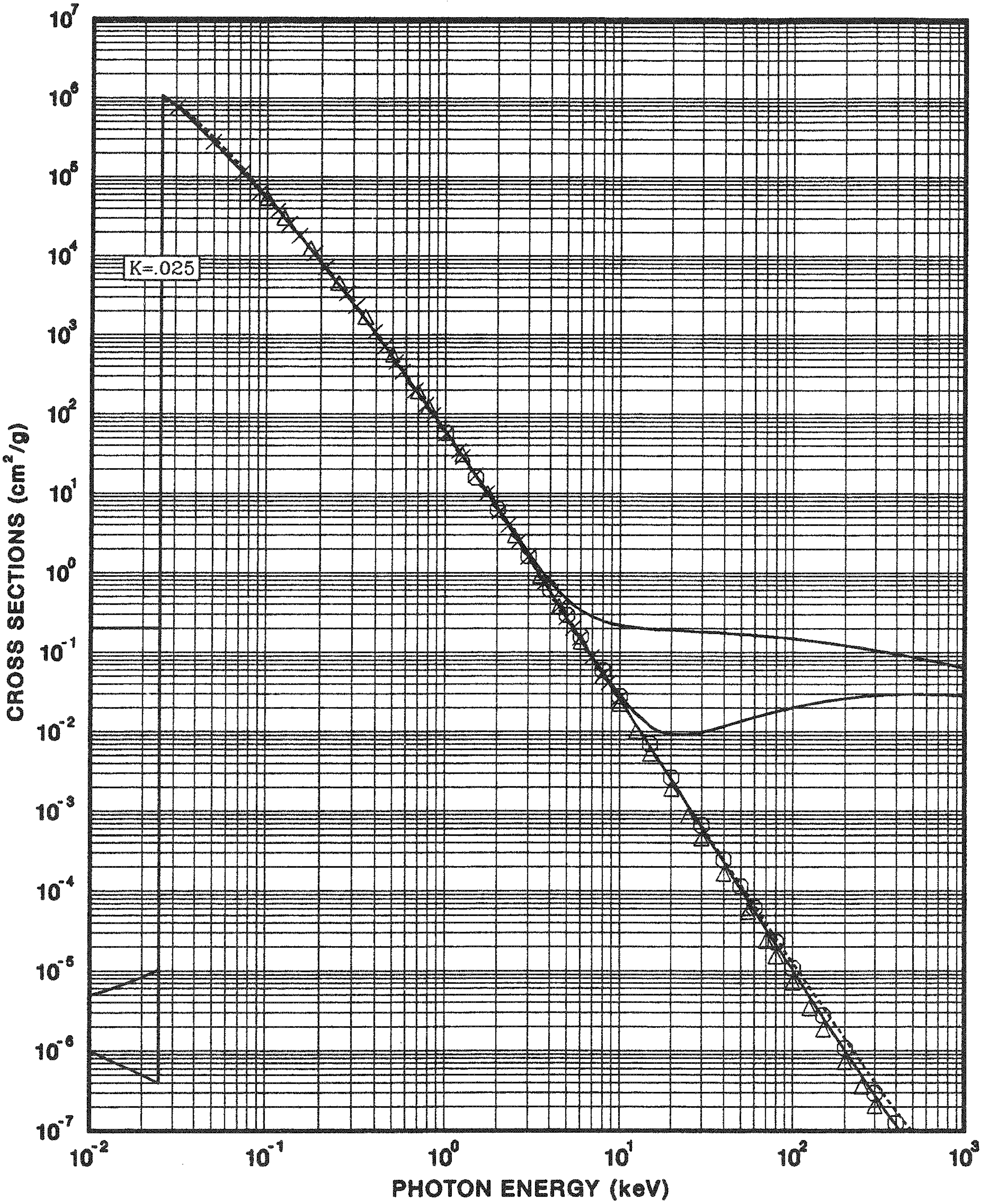
The graphs of the photon cross sections are contained on the next 100 pages.

HYDROGEN 1



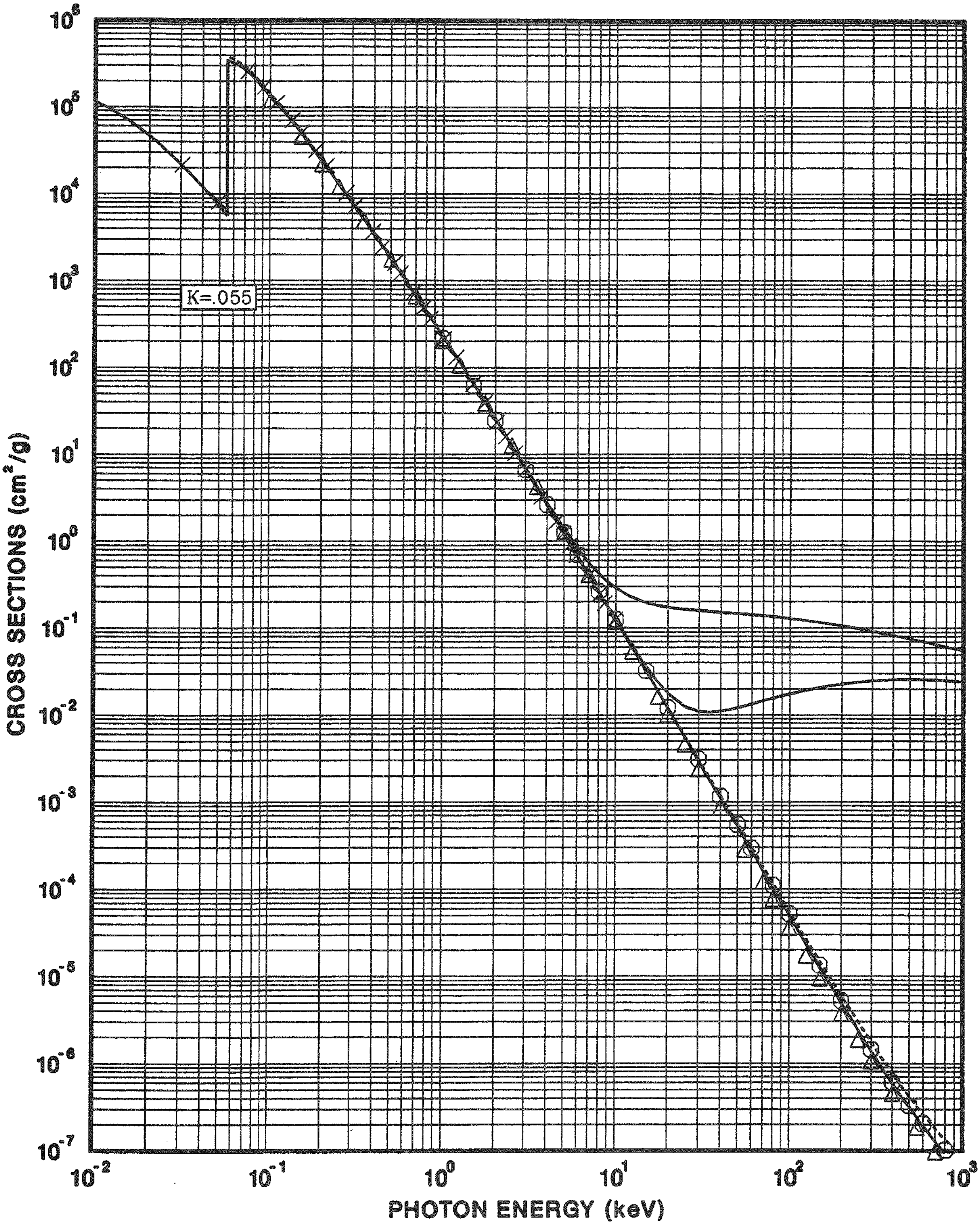
Barns/atom = 1.674 × cm^2/g

HELIUM 2



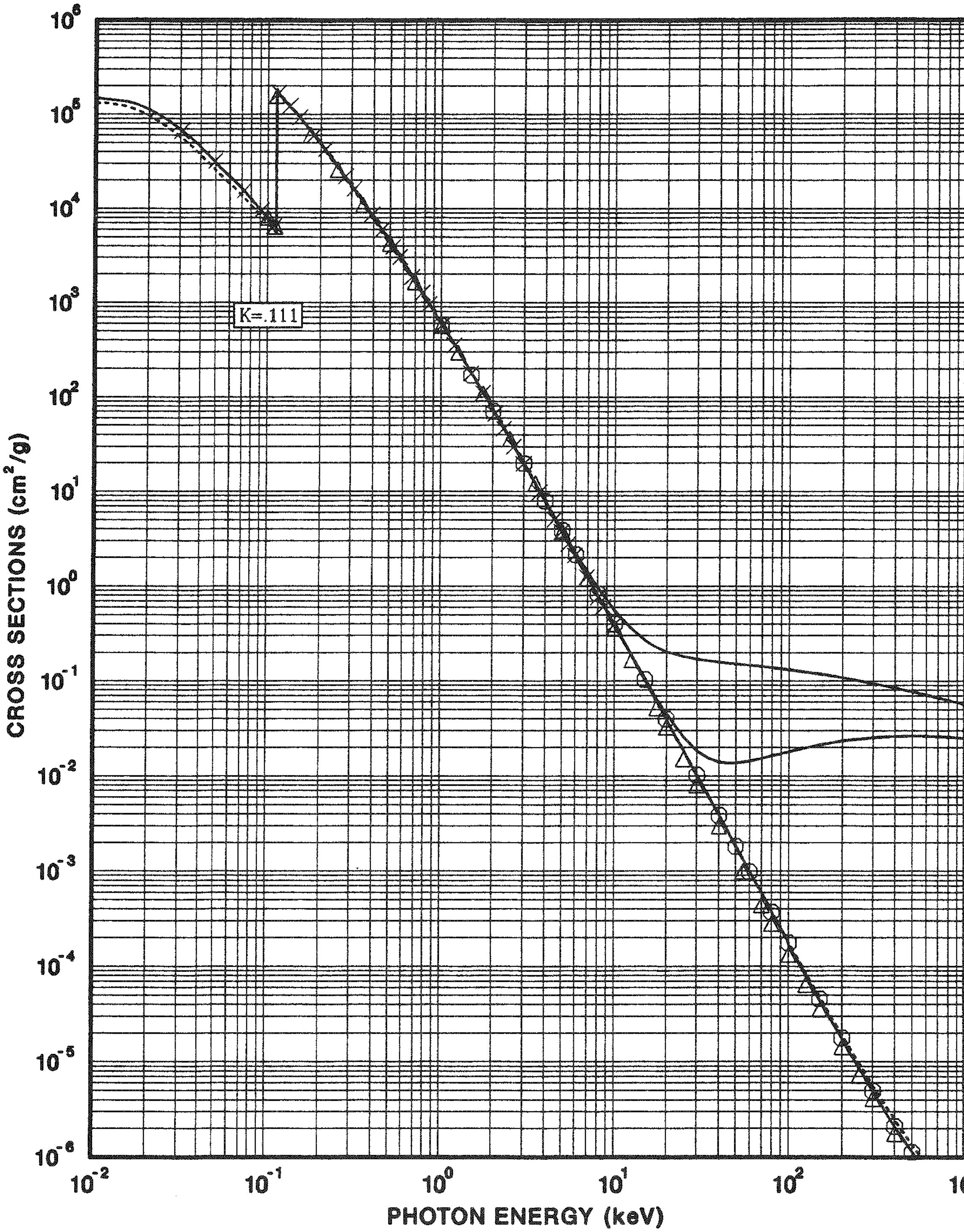
Barns/atom = 6.647 × cm^2/g

LITHIUM 3



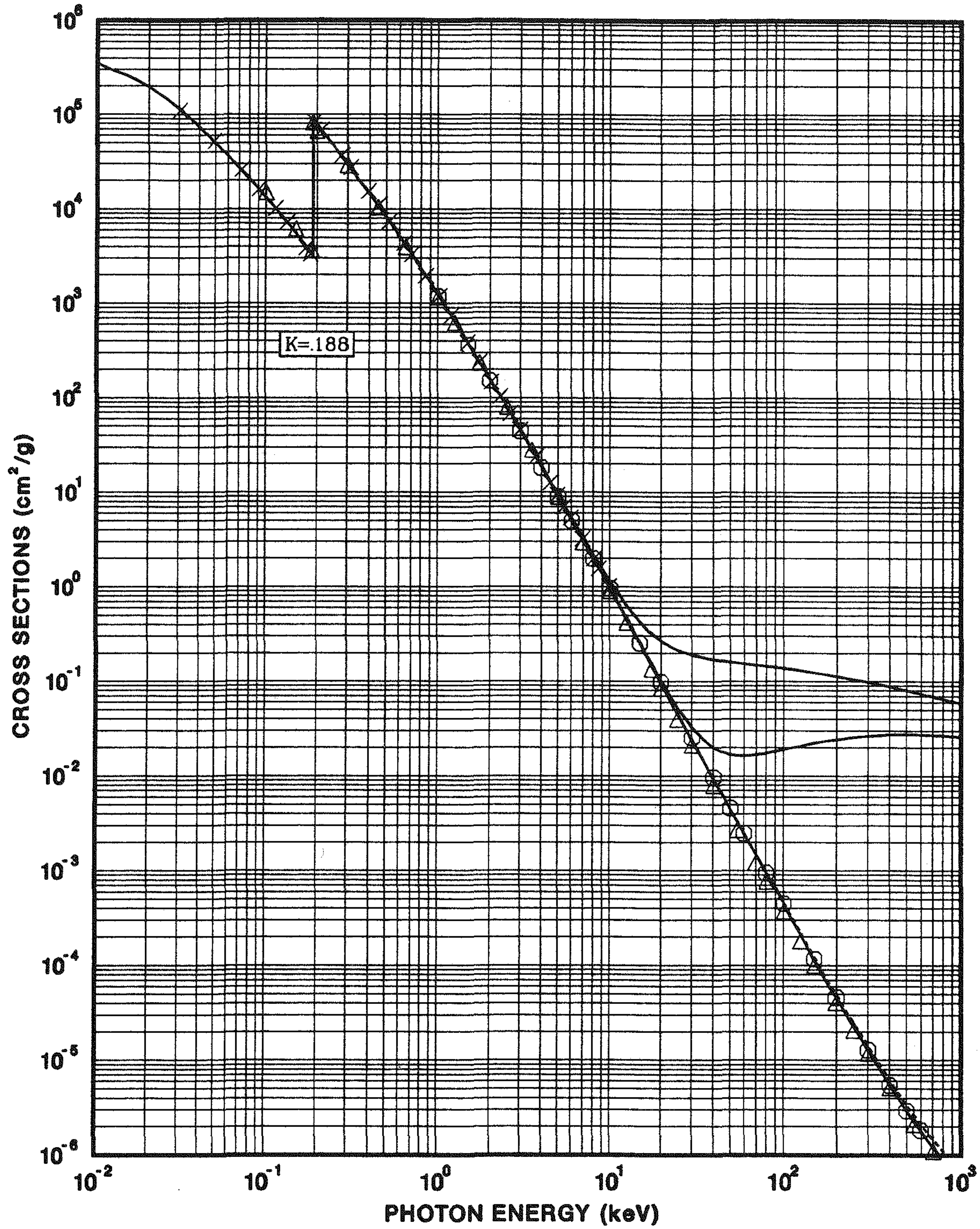
Barns/atom = 11.53 × cm^2/g

BERYLLIUM 4



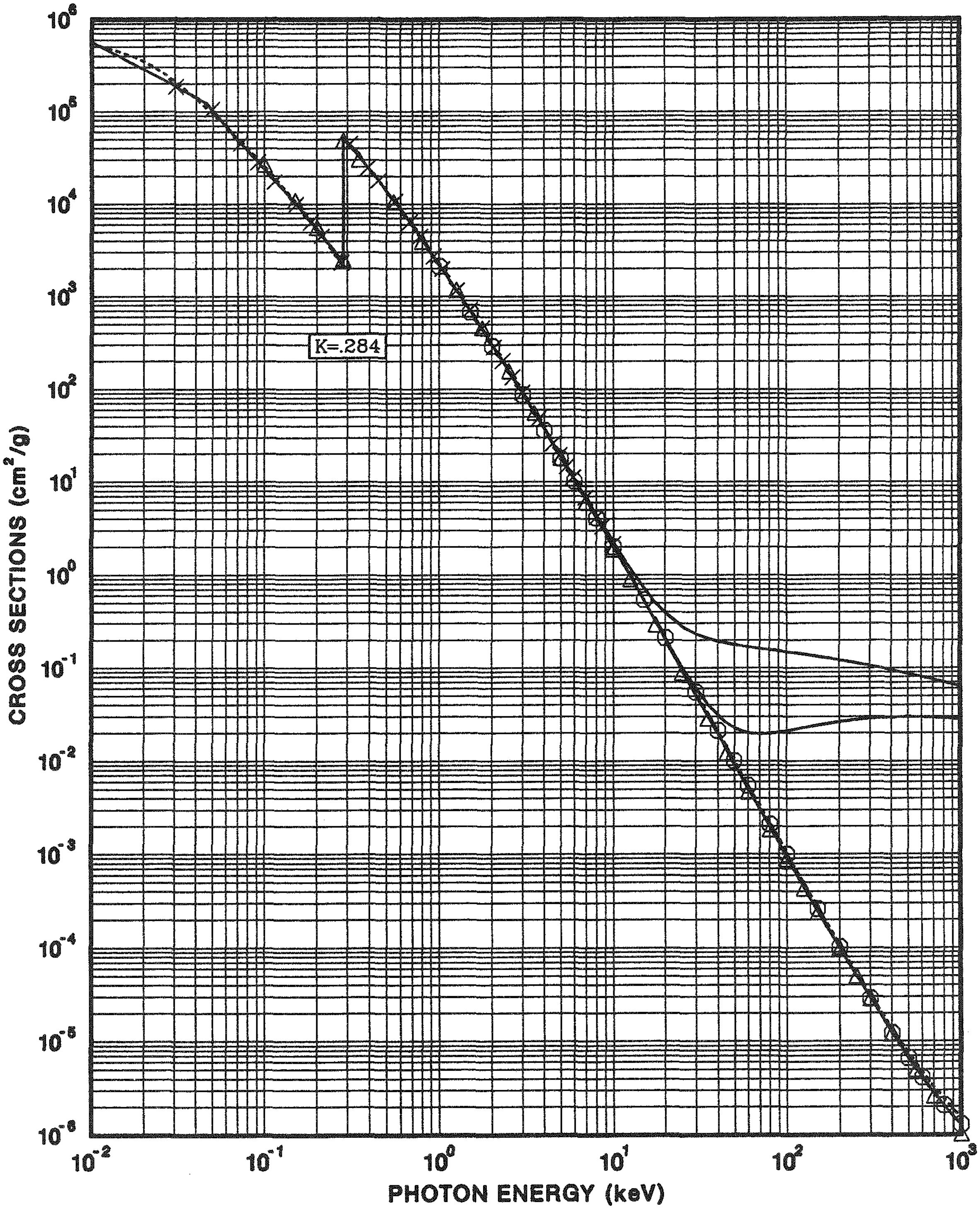
Barns/atom = 14.97 × cm^2/g

BORON 5



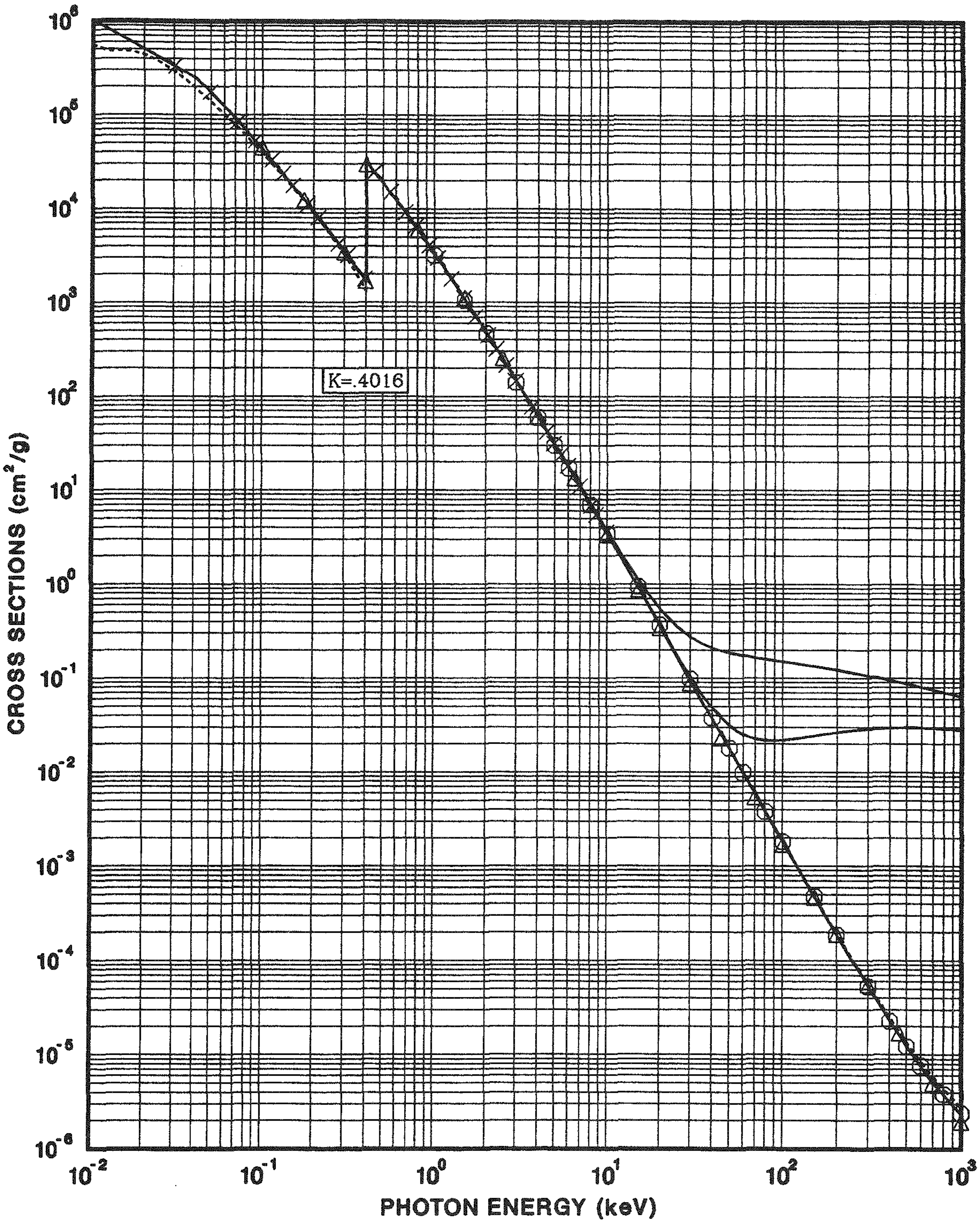
Barns/atom = 17.95 × cm^2/g

CARBON 6



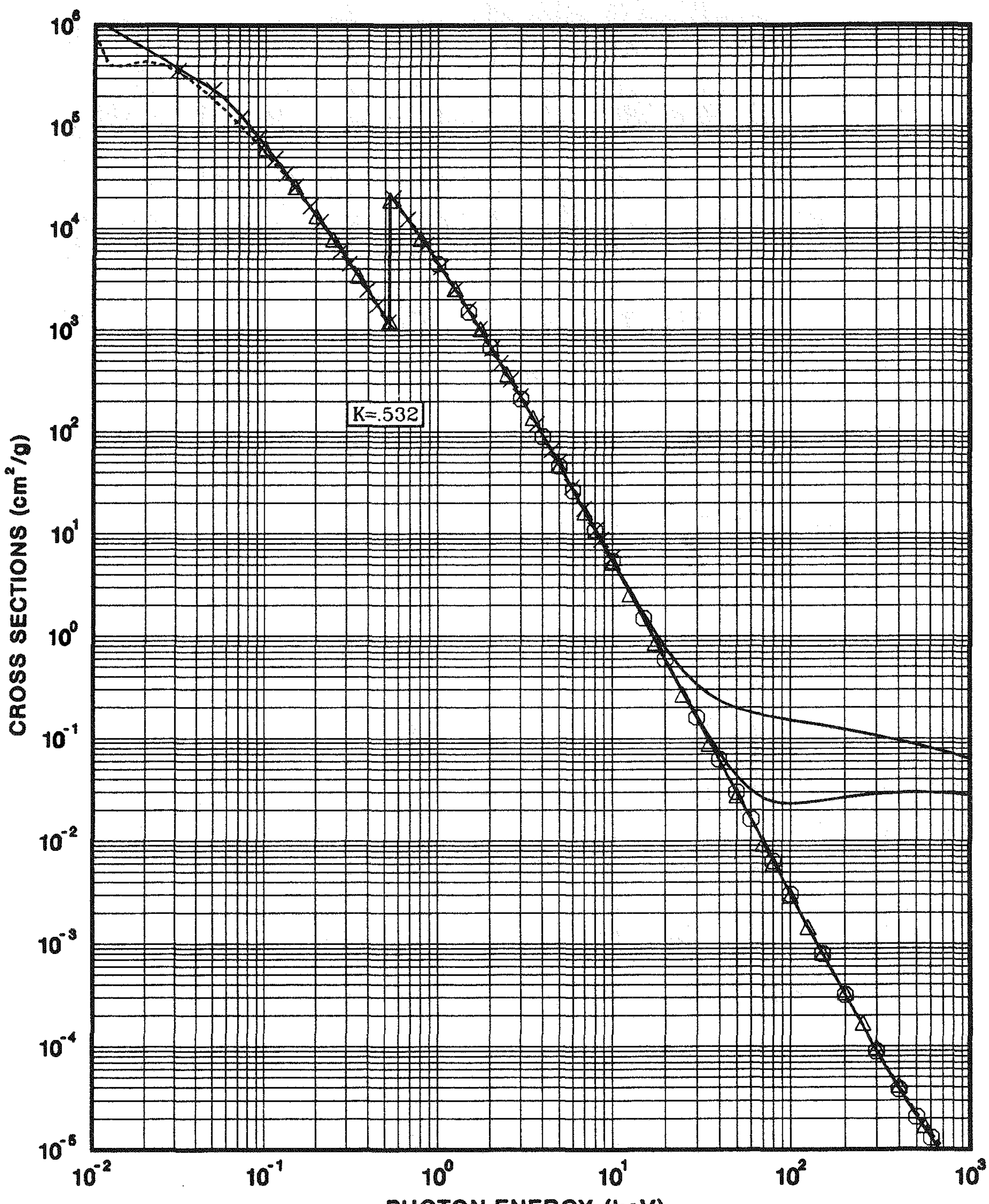
Barns/atom = 19.95 × cm^2/g

NITROGEN 7



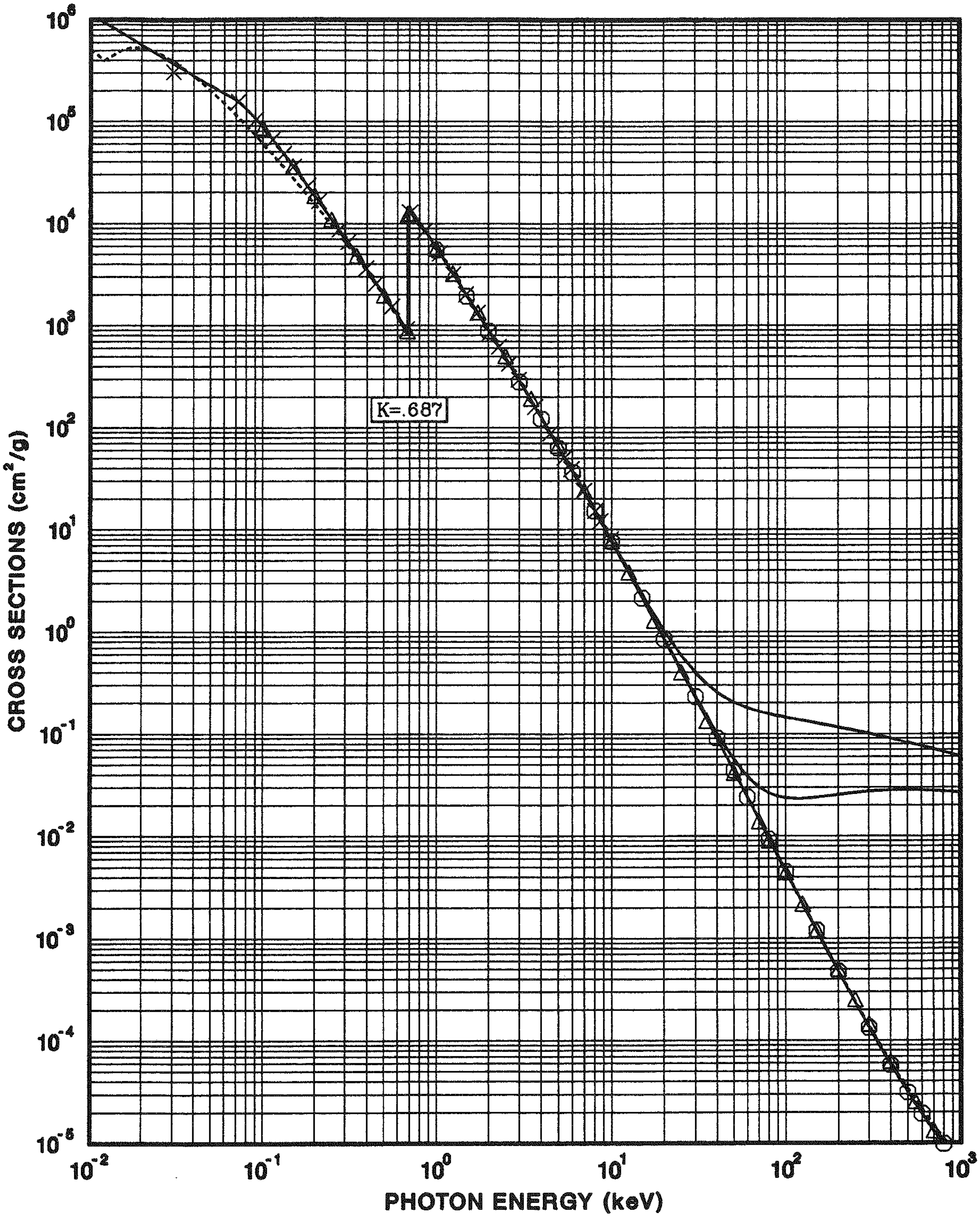
Barns/atom = 23.26 × cm^2/g

OXYGEN 8



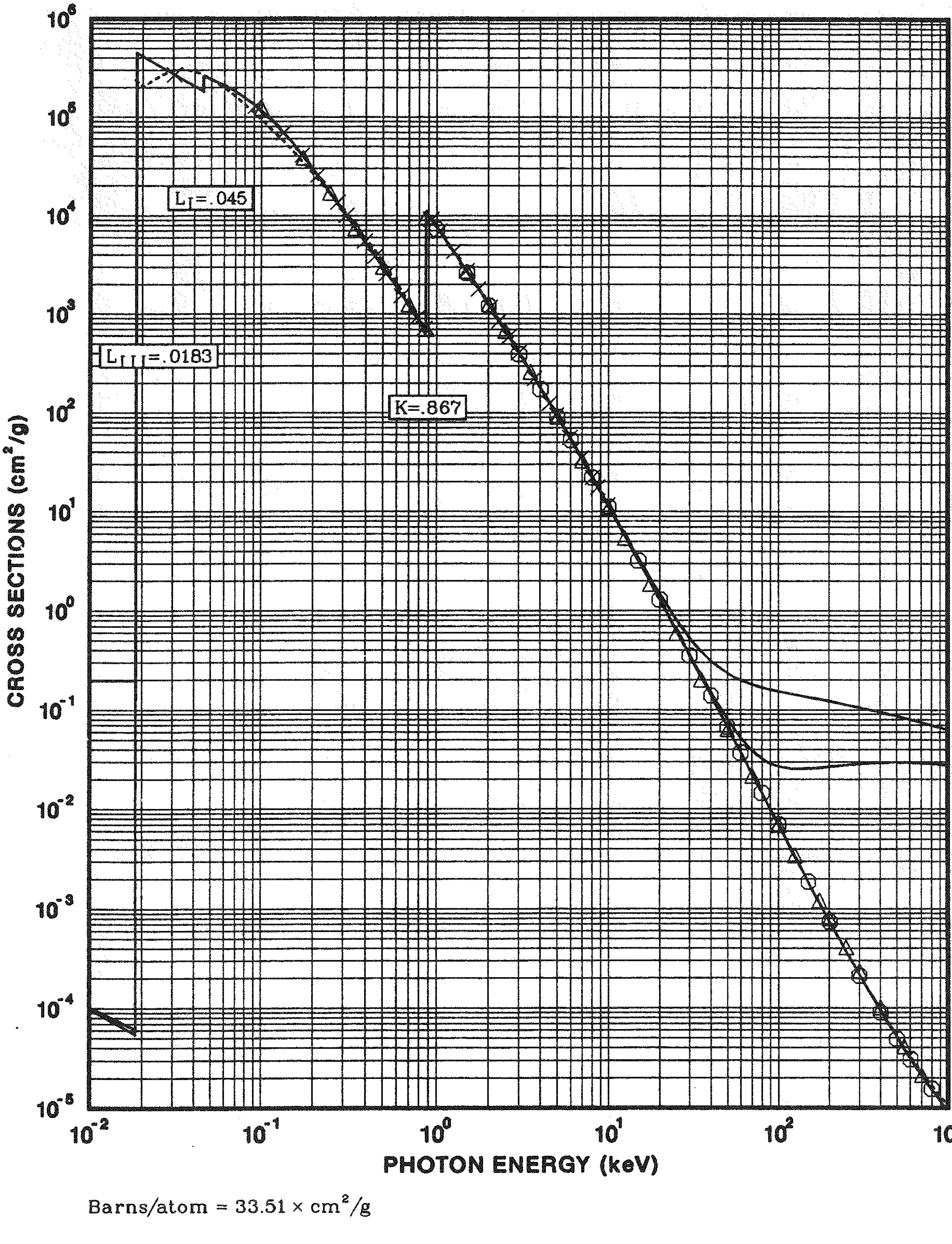
Barns/atom = 26.57 × cm^2/g

FLUORINE 9



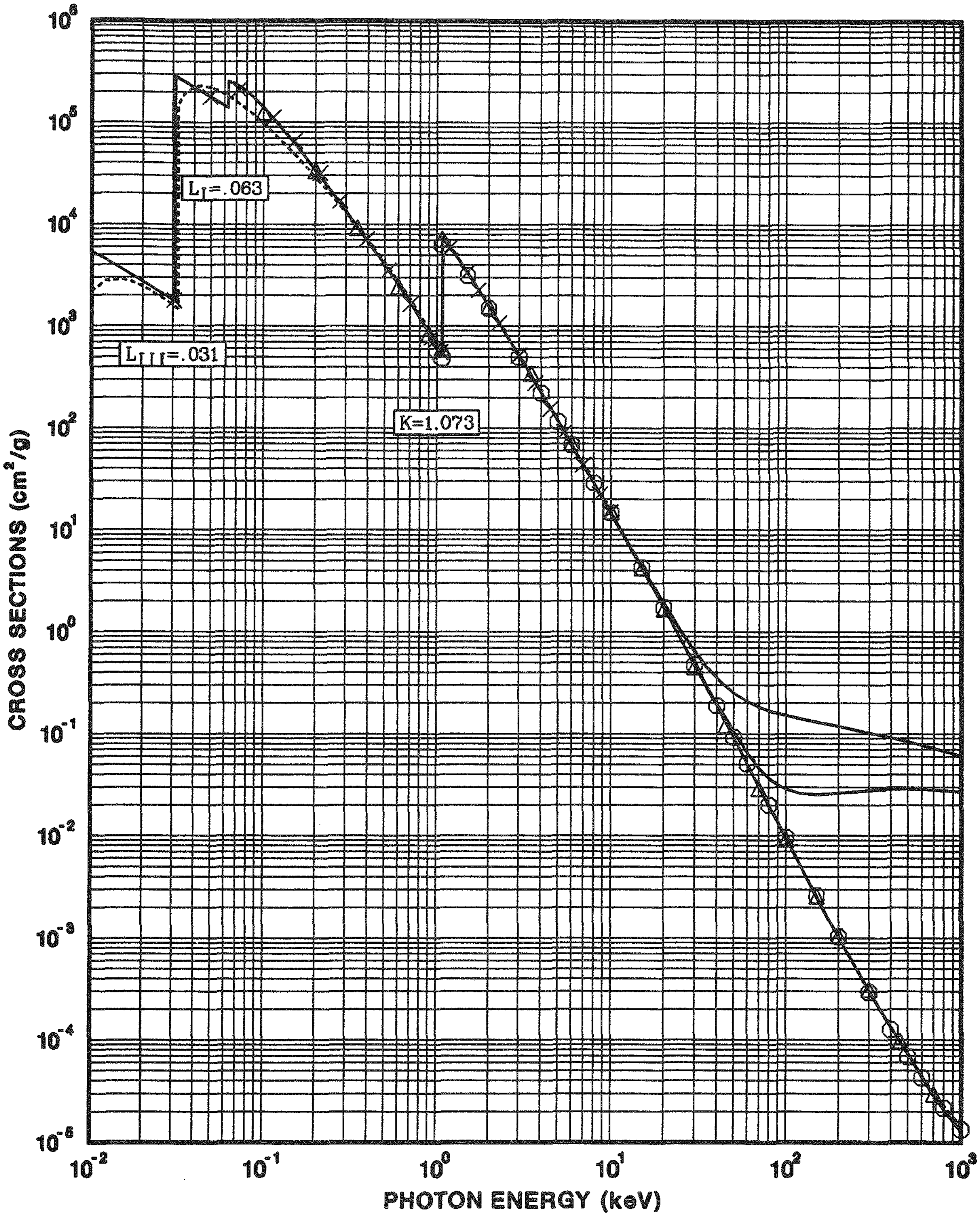
Barns/atom = 31.55 × cm^2/g

NEON 10



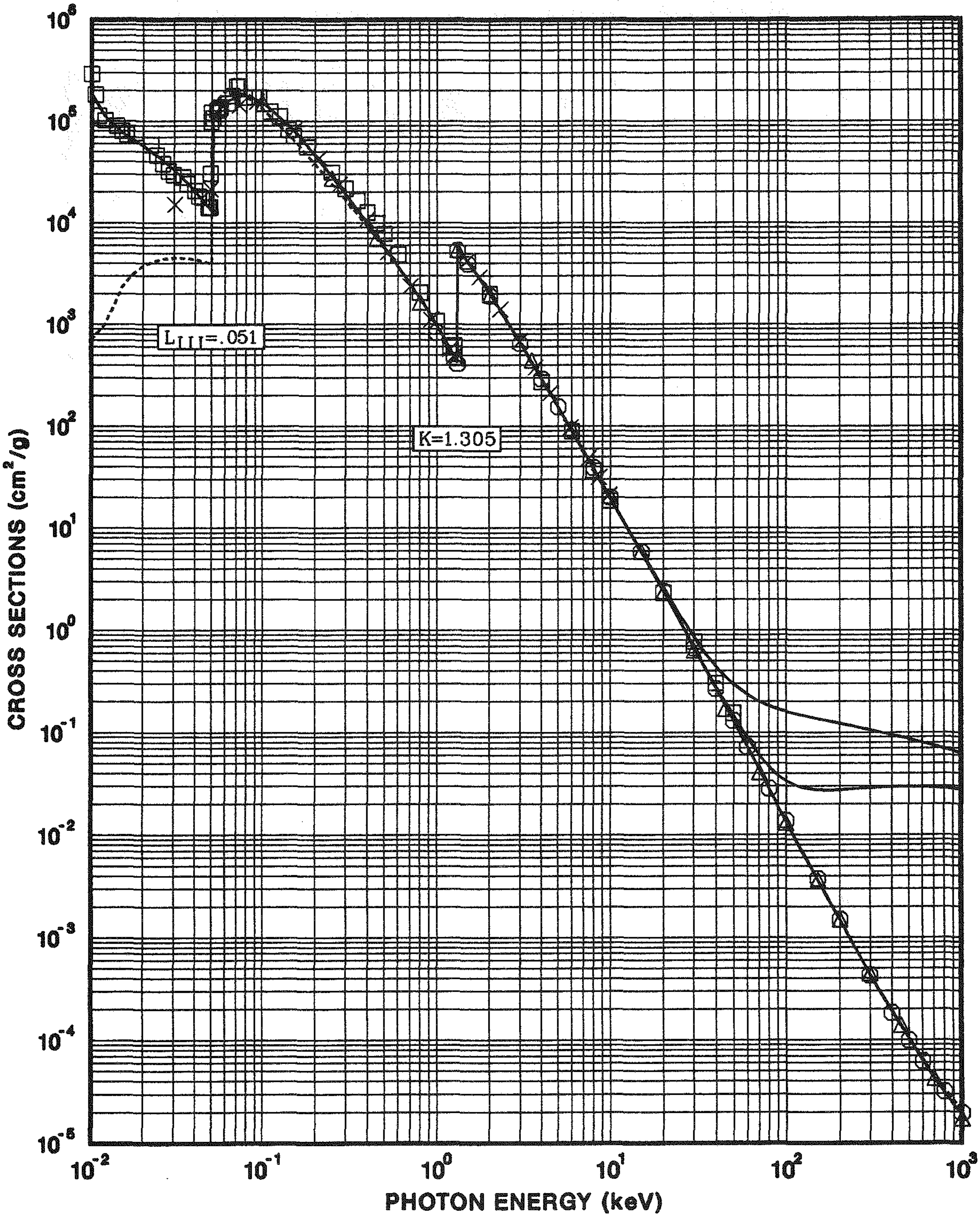
Barns/atom = 33.51 × cm^2/g

SODIUM 11



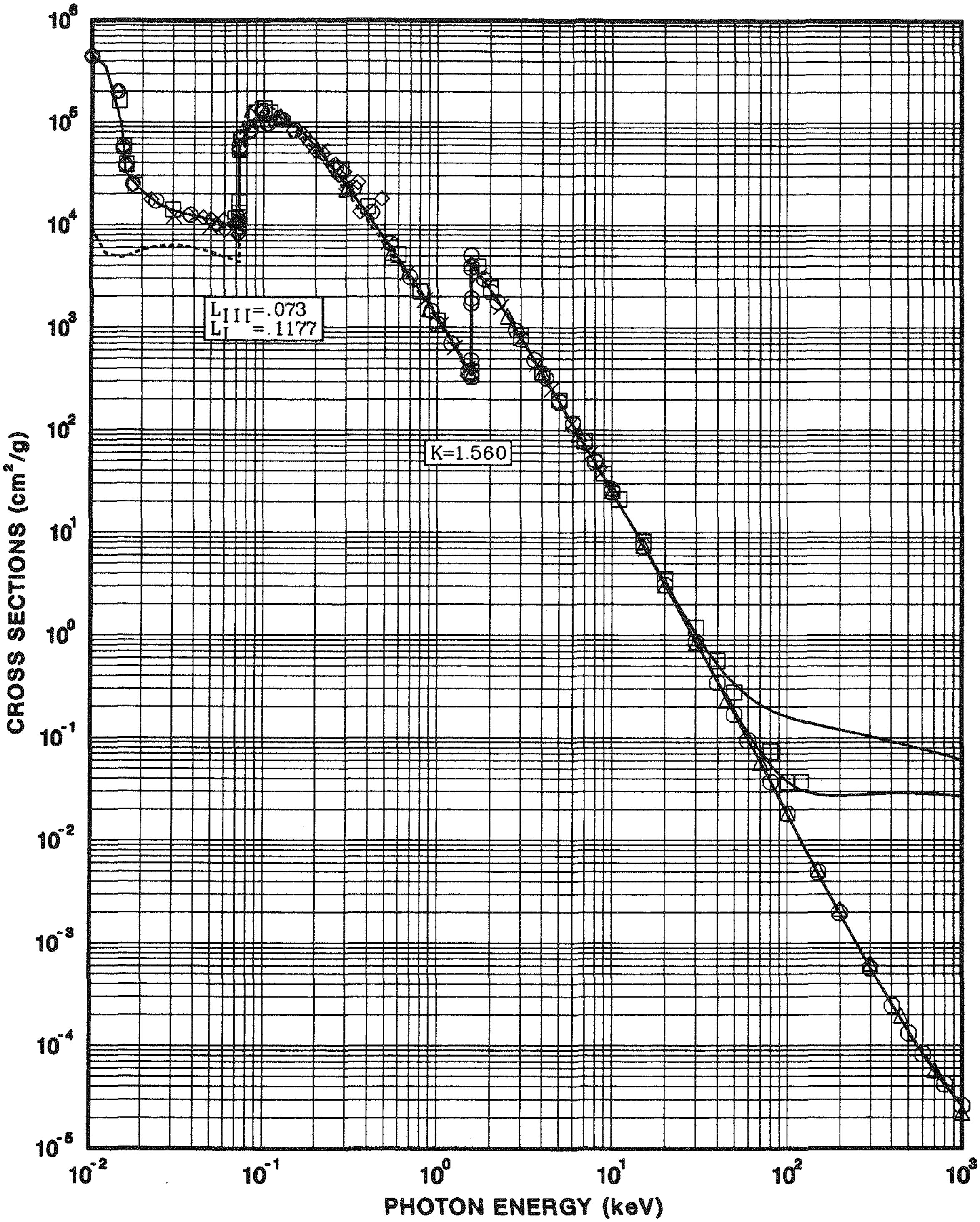
Barns/atom = 38.18 × cm^2/g

MAGNESIUM 12



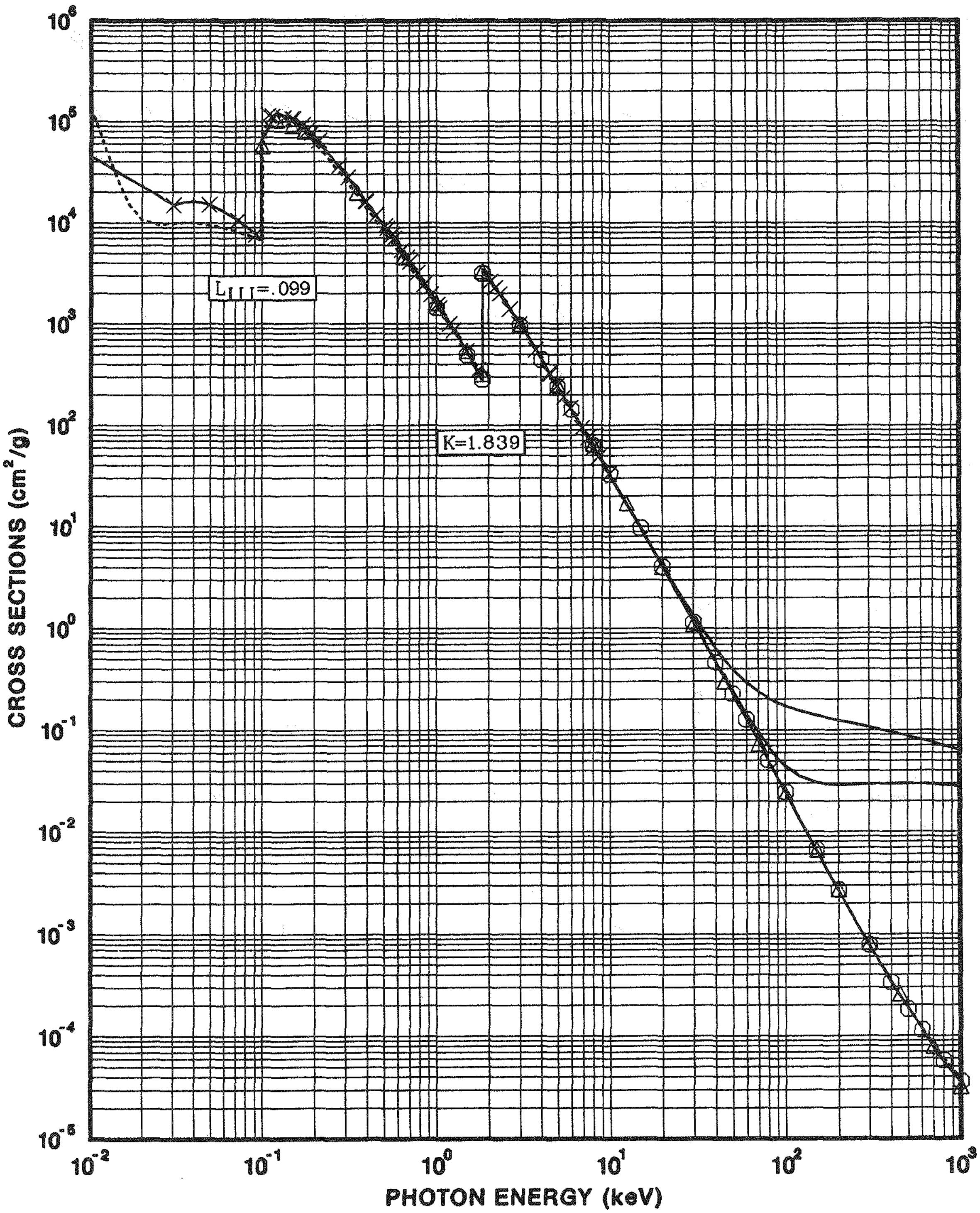
Barns/atom = 40.36 × cm^2/g

ALUMINUM 13



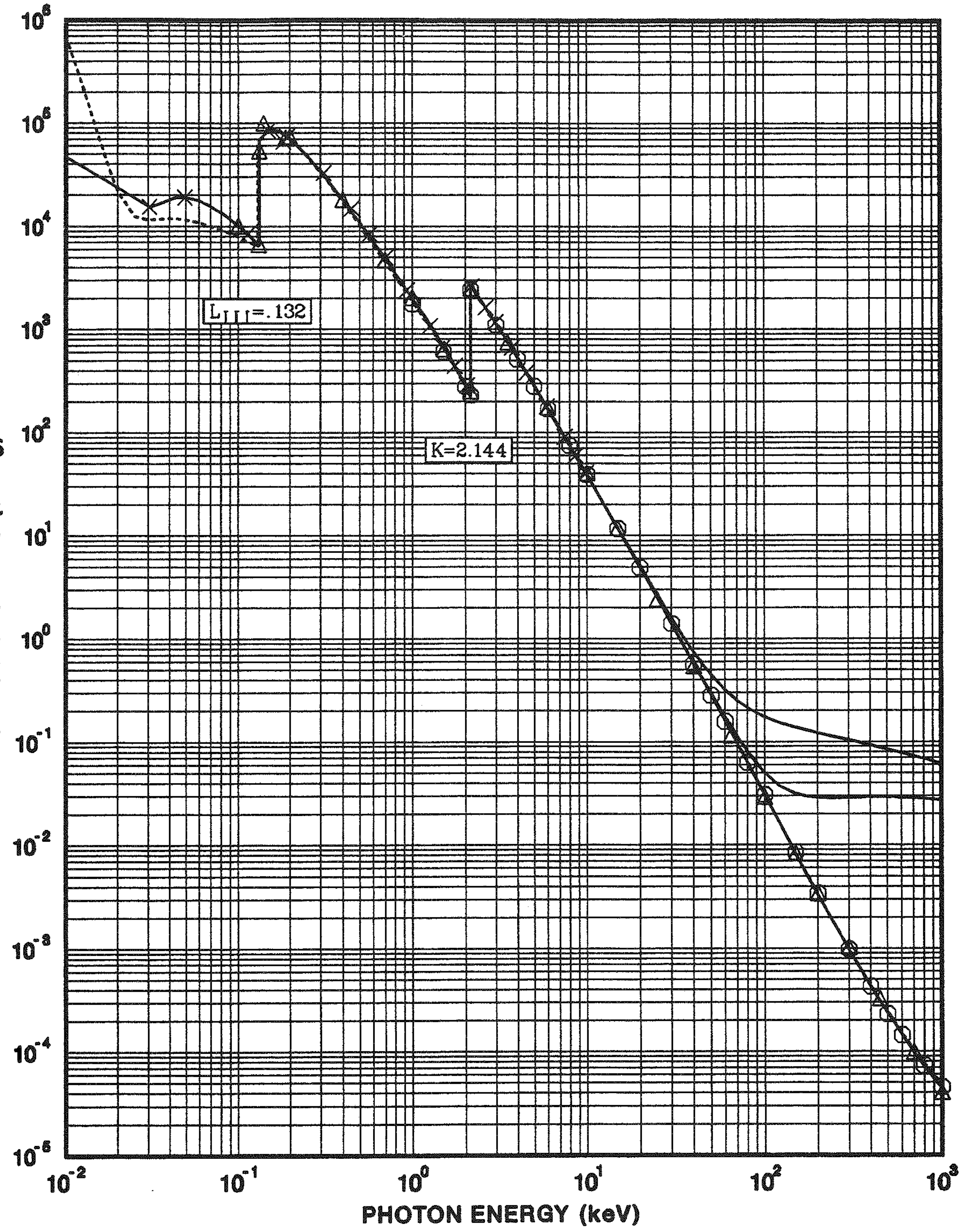
Barns/atom = 44.80 × cm^2/g

SILICON 14



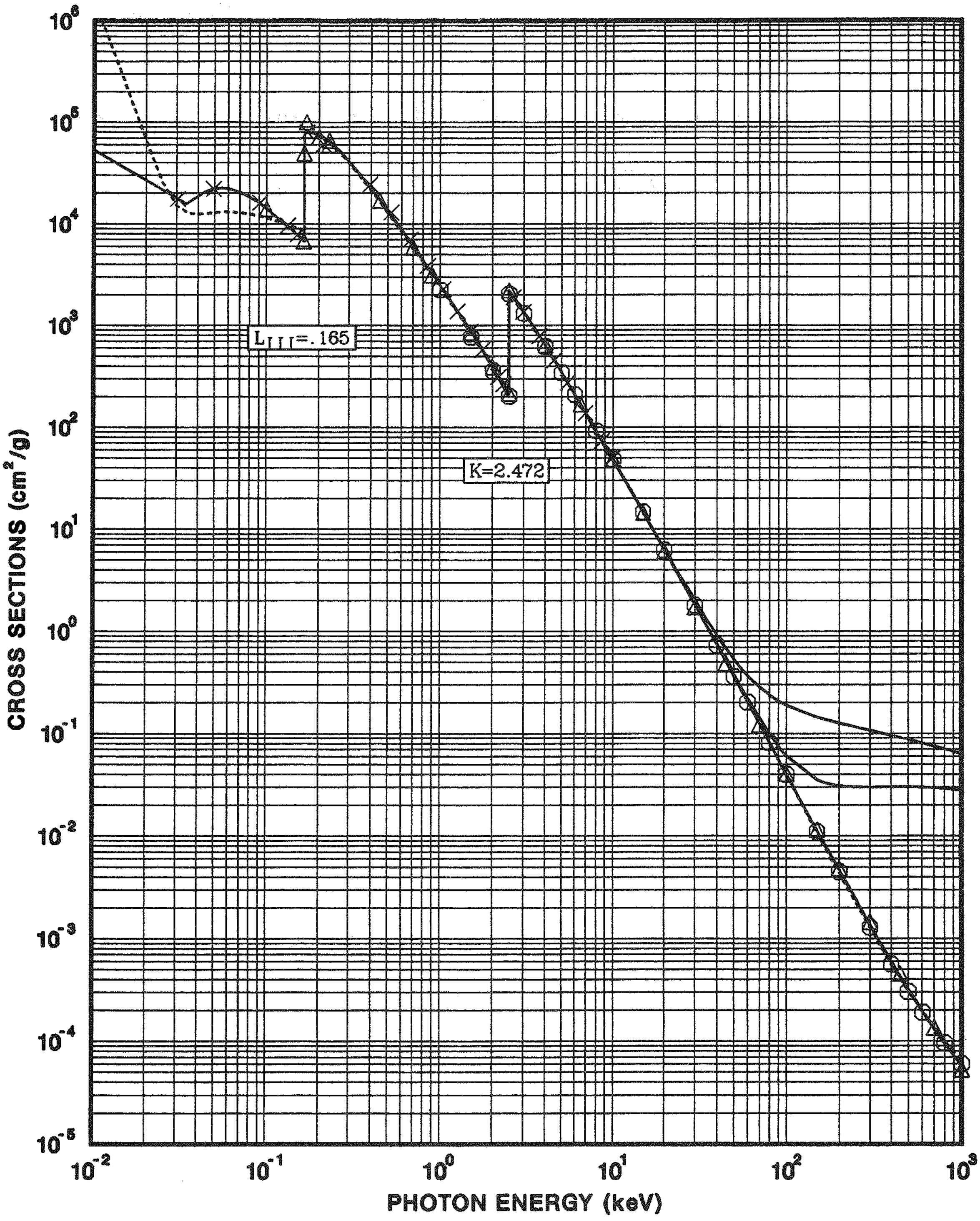
Barns/atom = 46.64 × cm^2/g

PHOSPHORUS 15



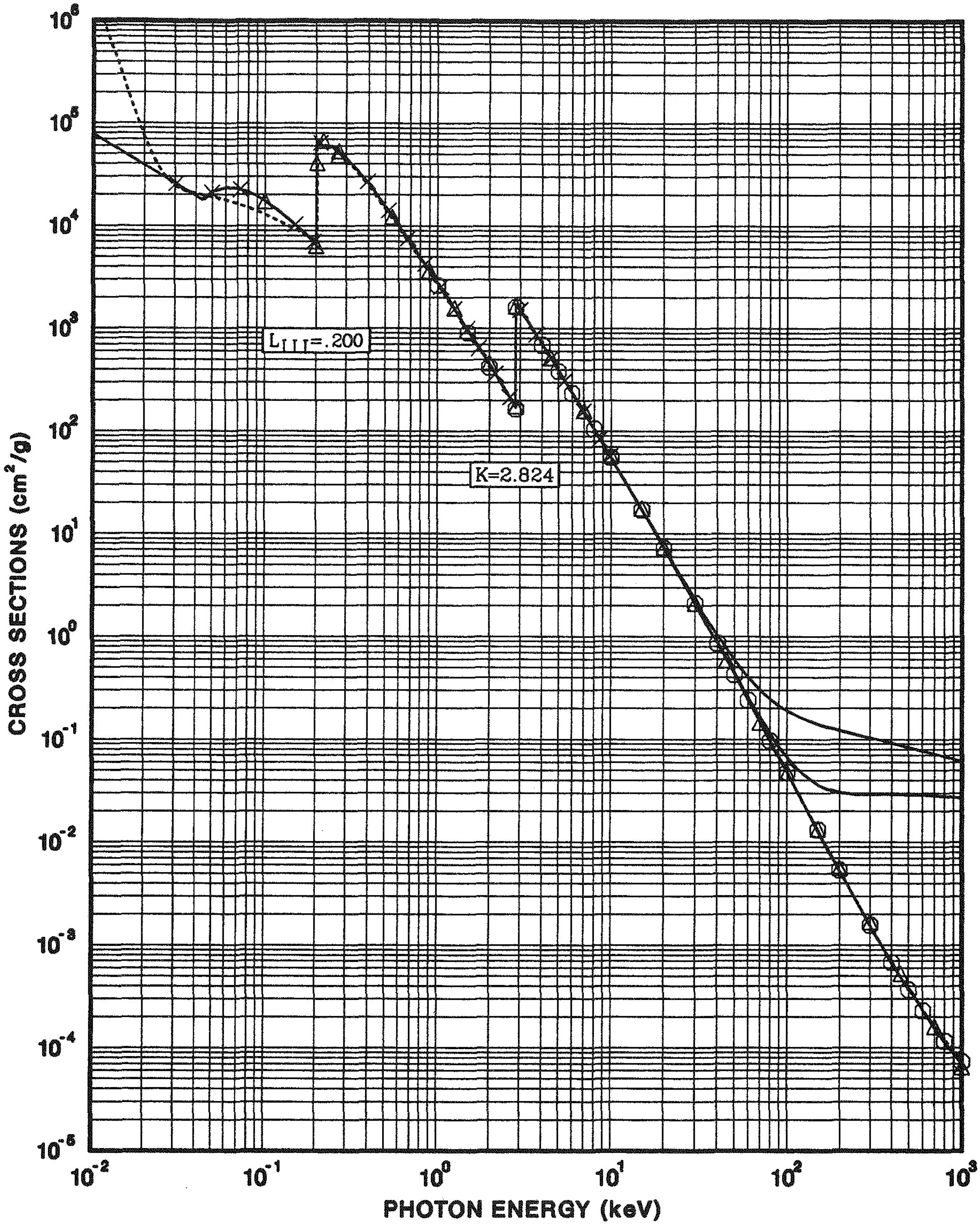
Barns/atom = 51.43 × cm^2/g

SULFUR 16



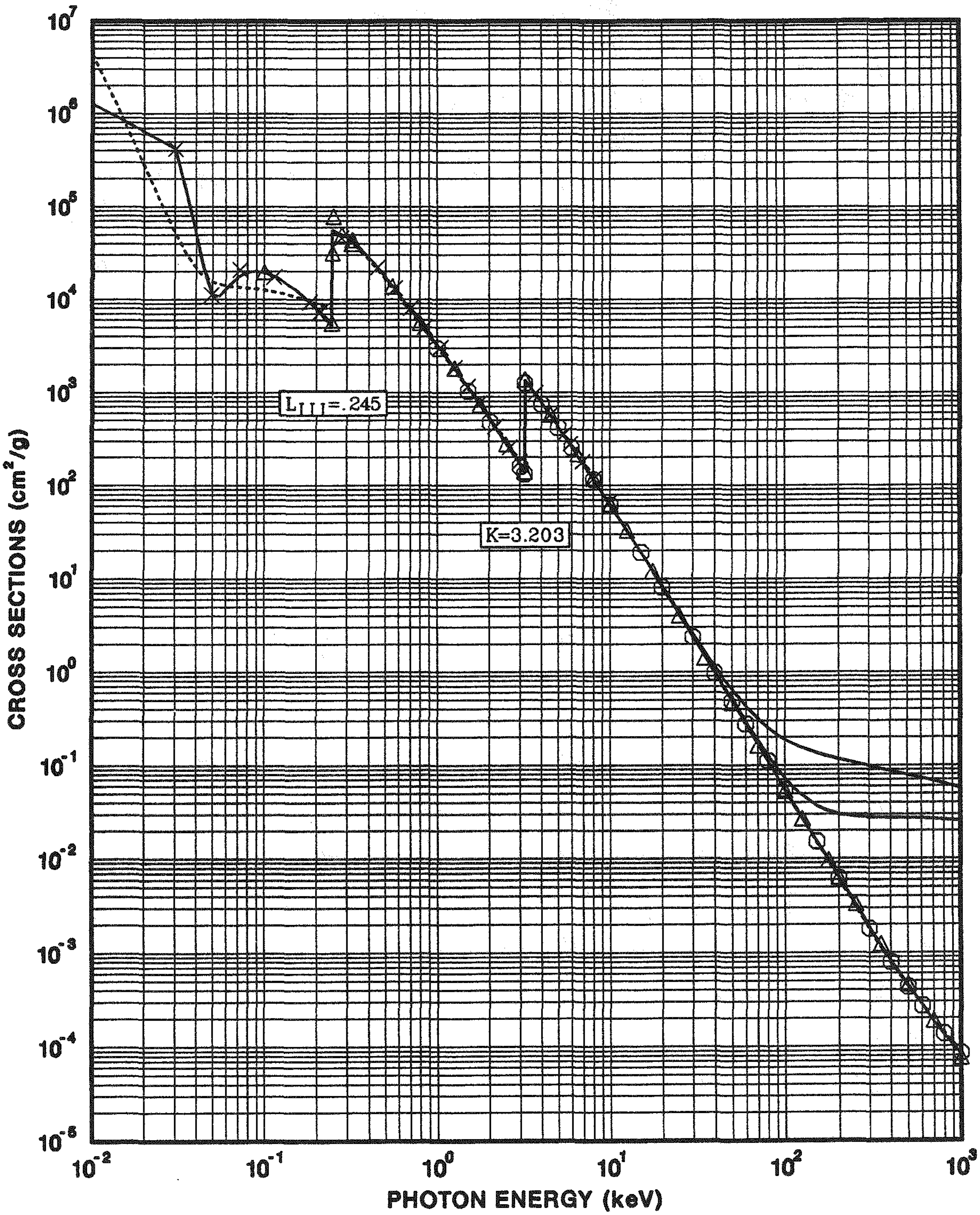
Barns/atom = 53.24 × cm^2/g

CHLORINE 17



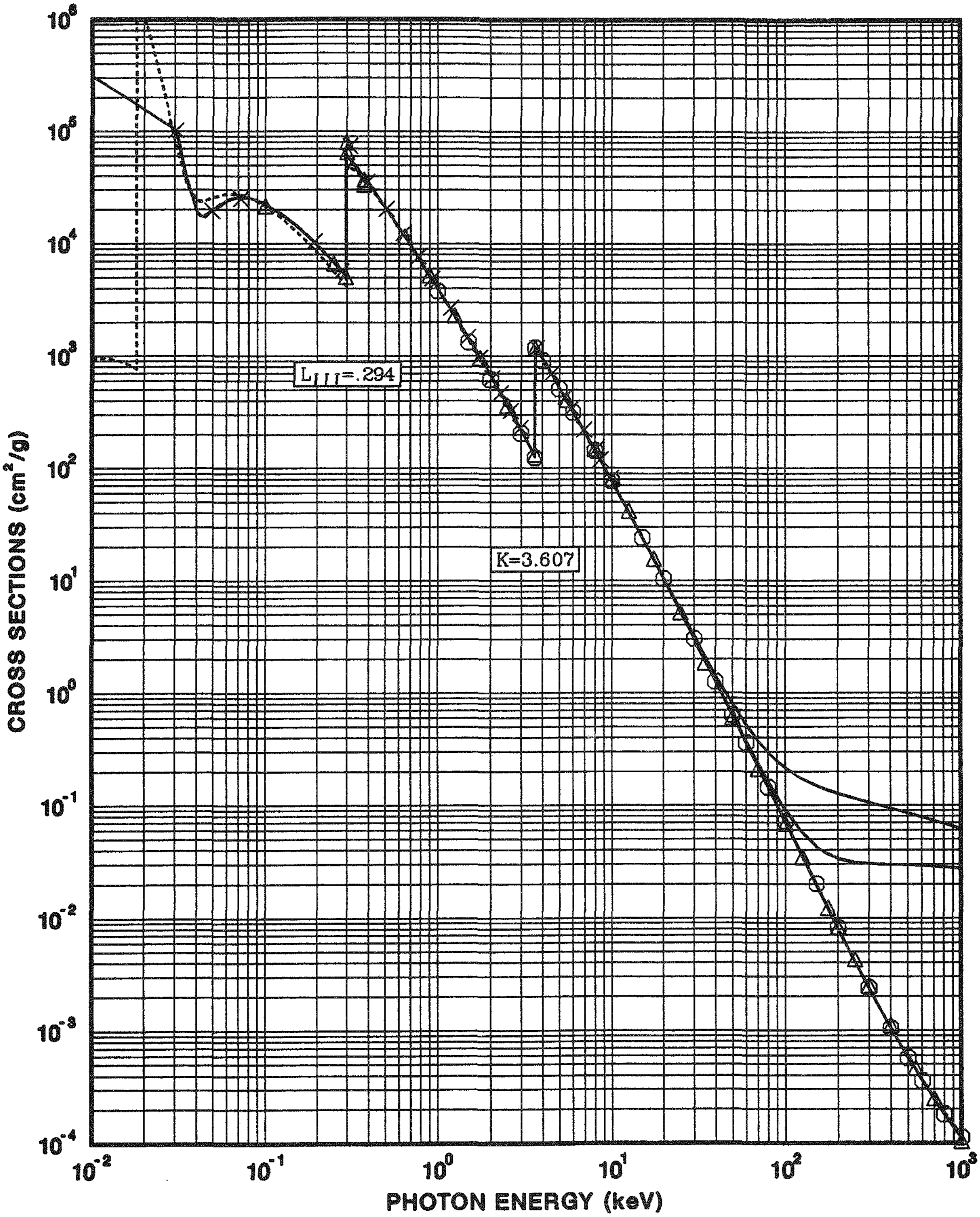
Barns/atom = 58.87 × cm^2/g

ARGON 18



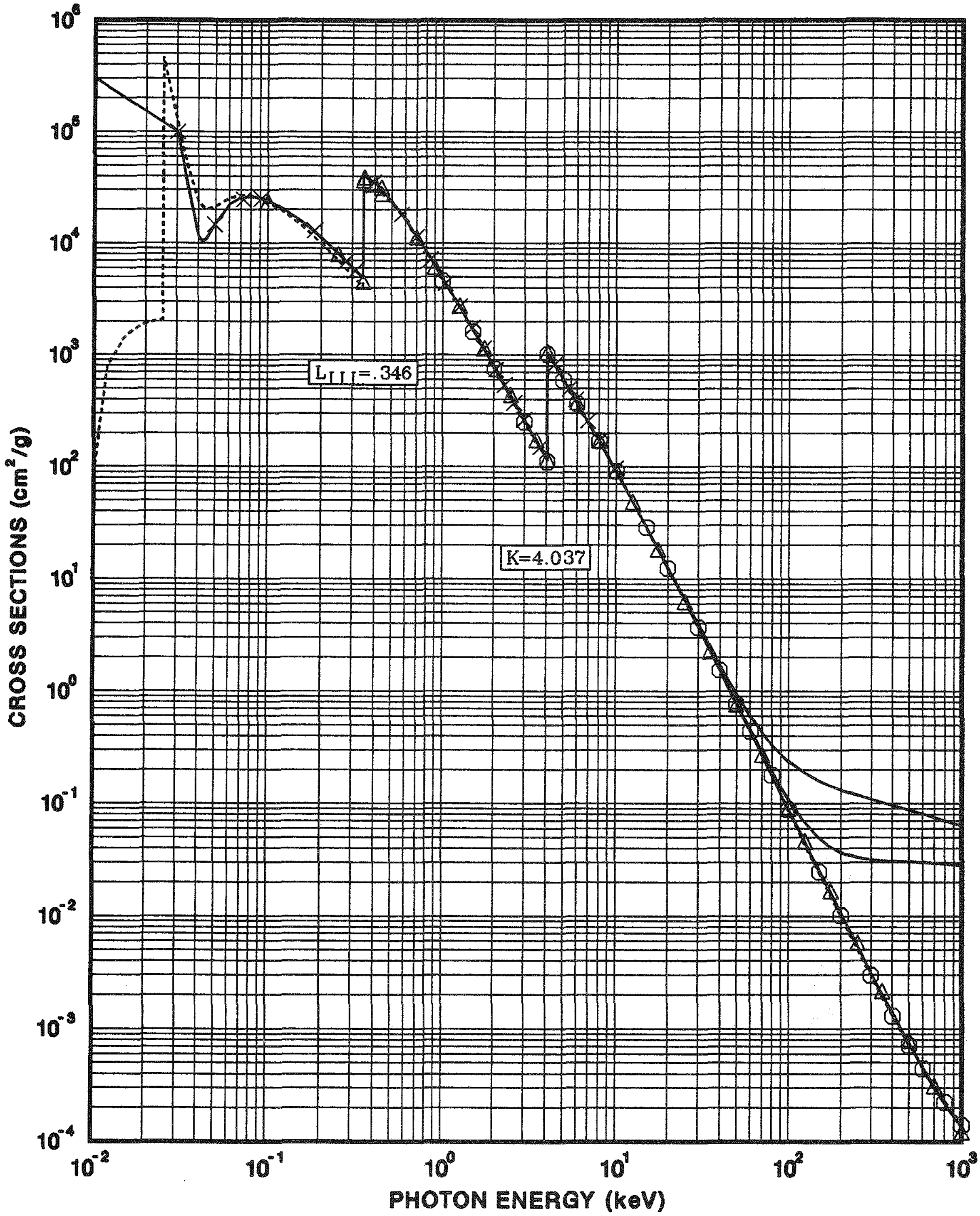
Barns/atom = 66.34 × cm^2/g

POTASSIUM 19



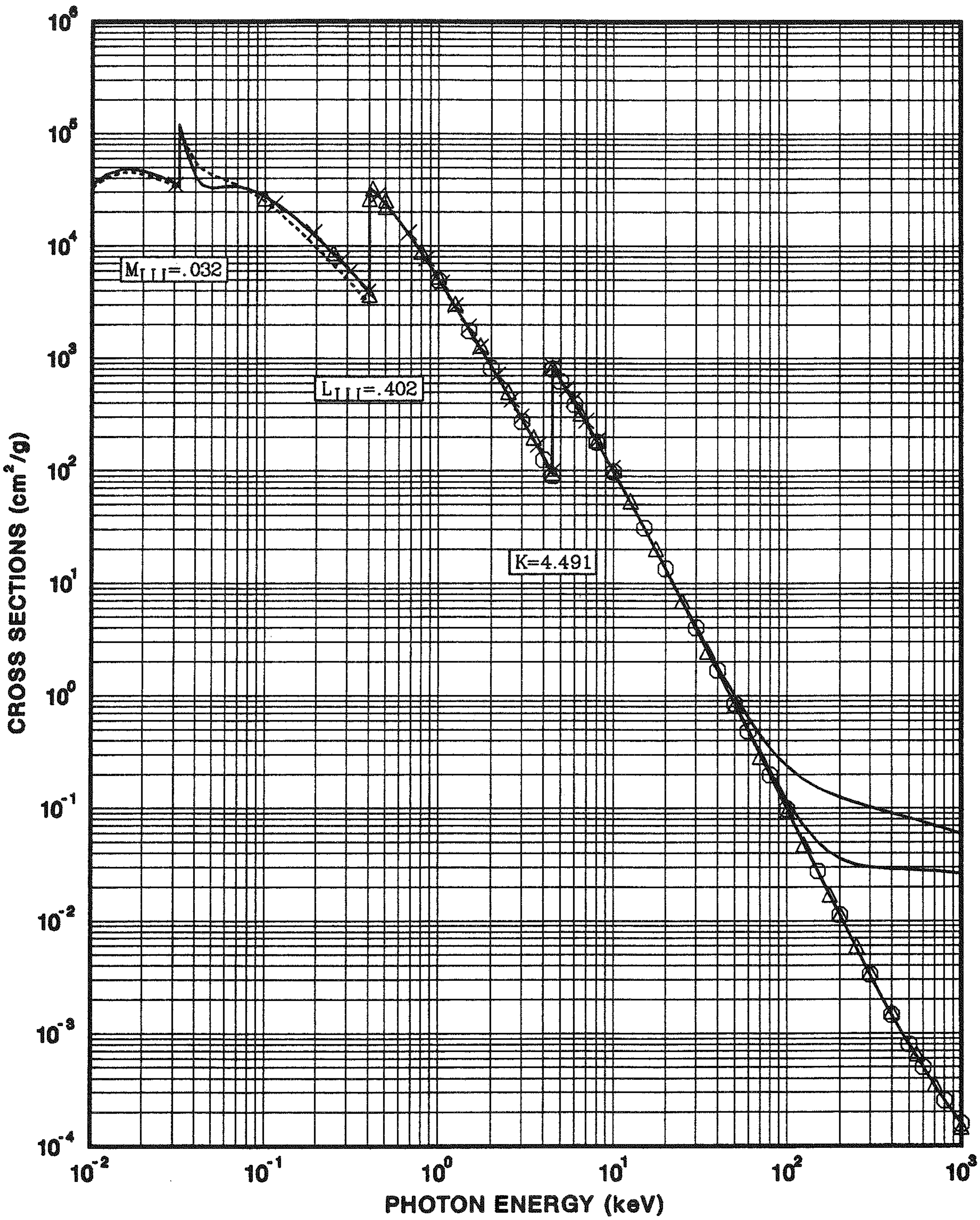
Barns/atom = 64.93 × cm^2/g

CALCIUM 20



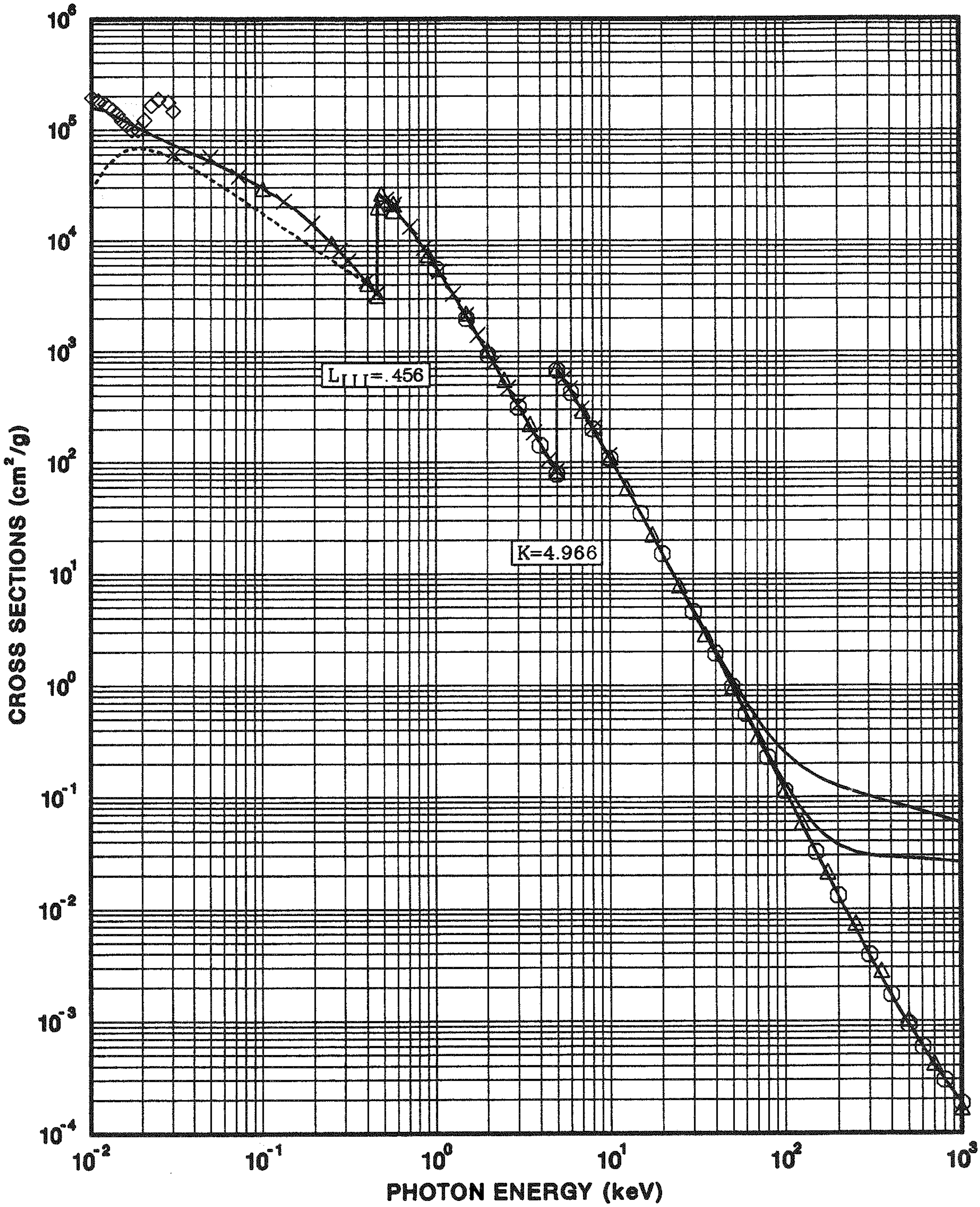
Barns/atom = 66.56 × cm^2/g

SCANDIUM 21



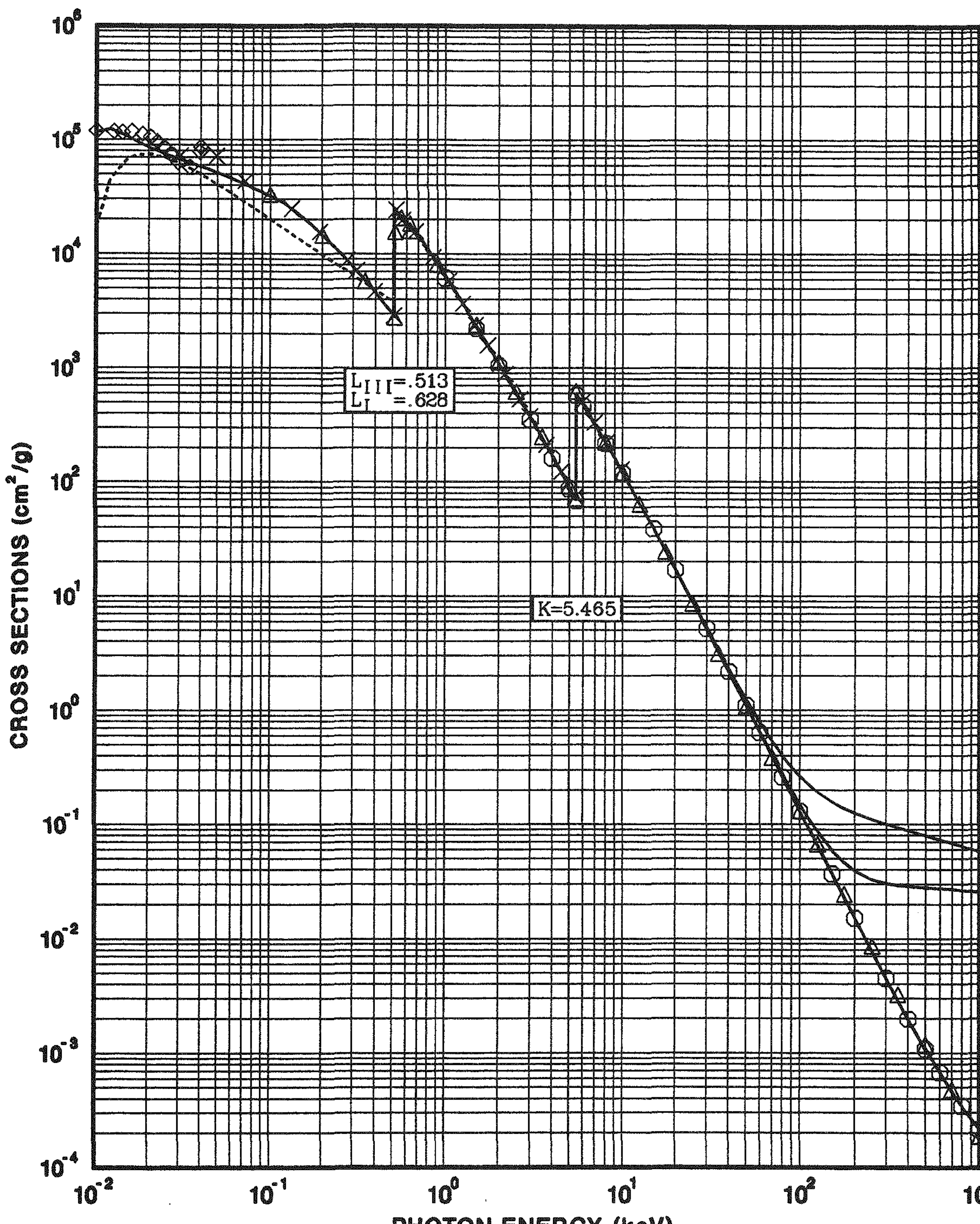
Barns/atom = 74.65 × cm^2/g

TITANIUM 22



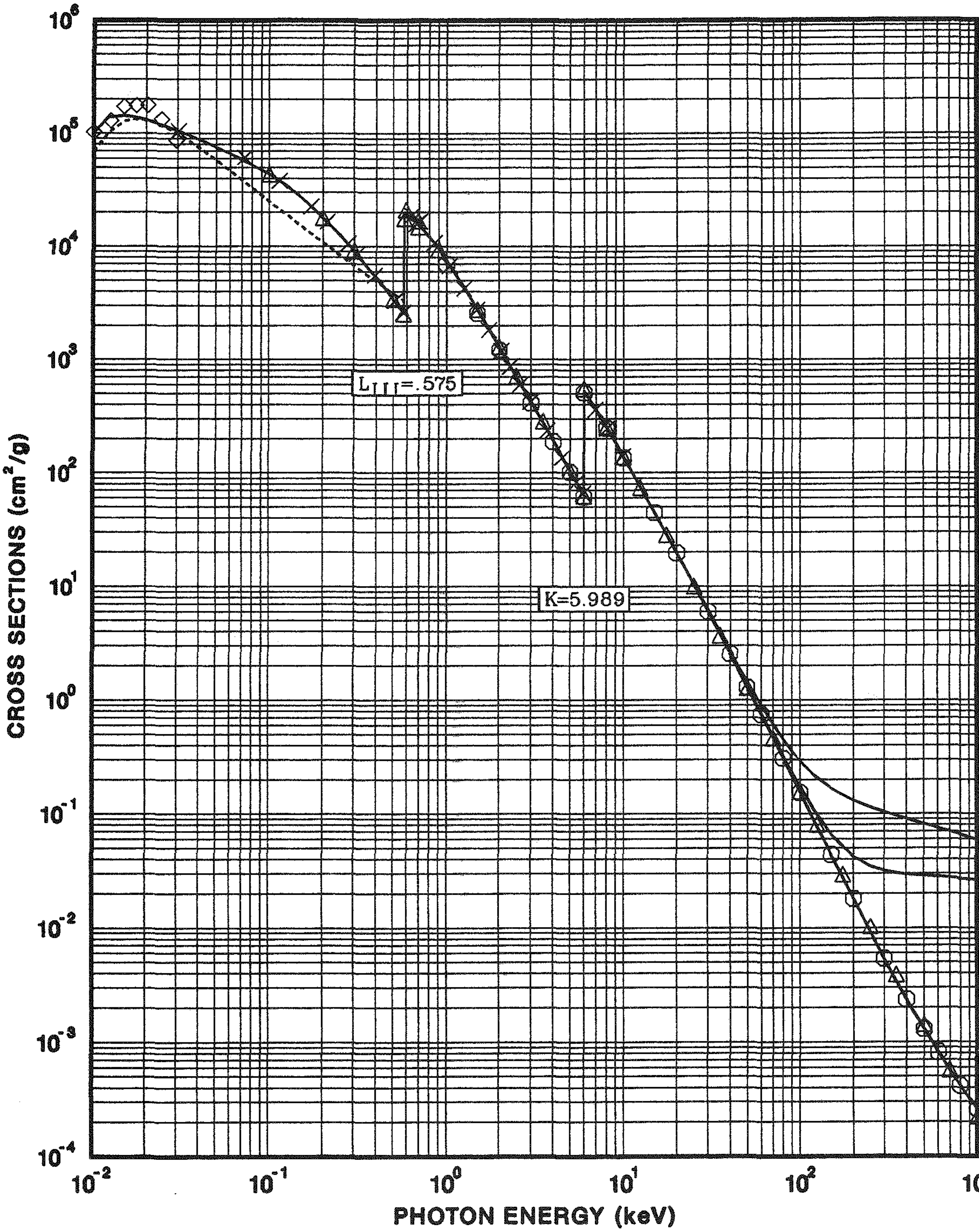
Barns/atom = 79.51 × cm^2/g

VANADIUM 23



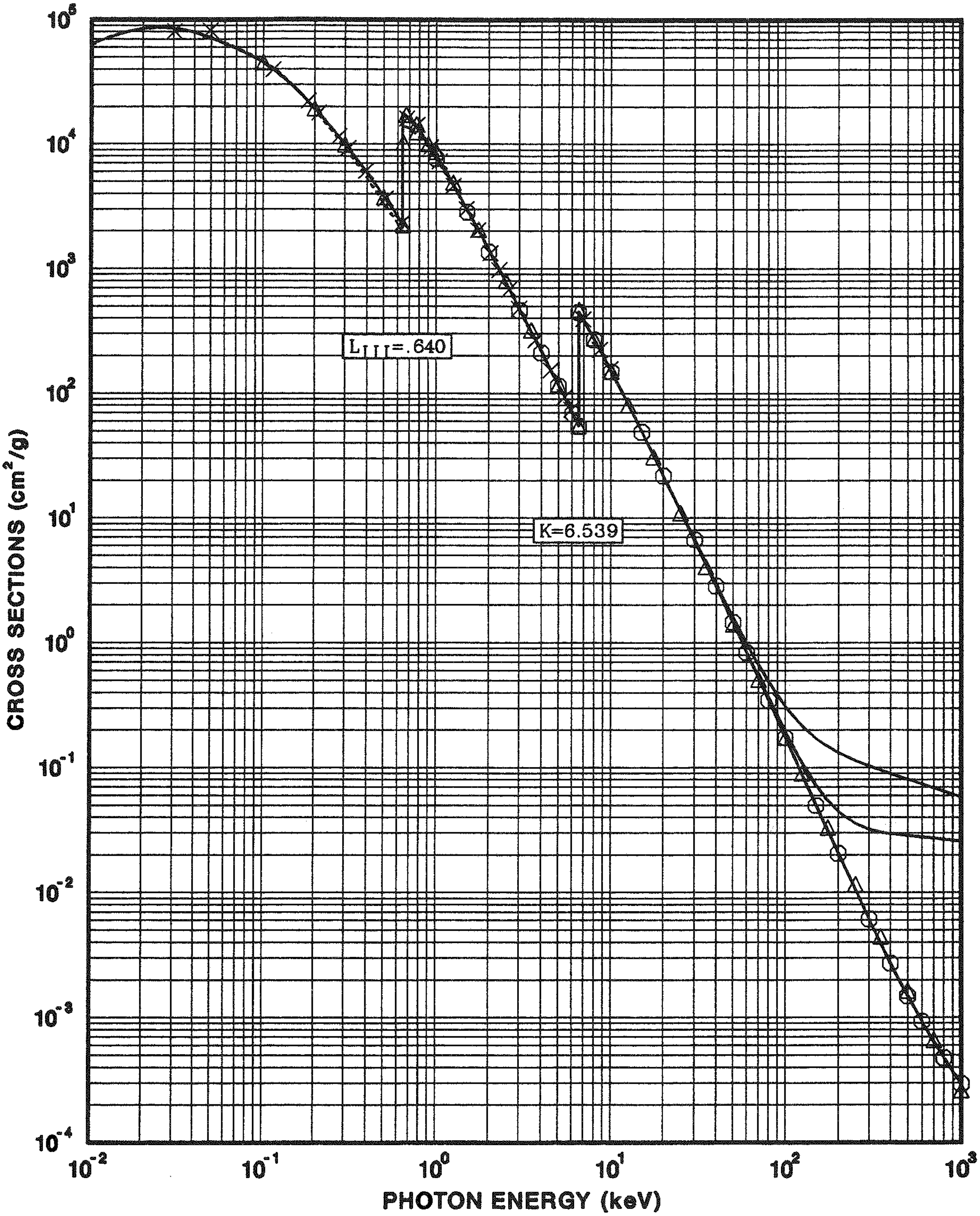
Barns/atom = 84.59 × cm^2/g

CHROMIUM 24



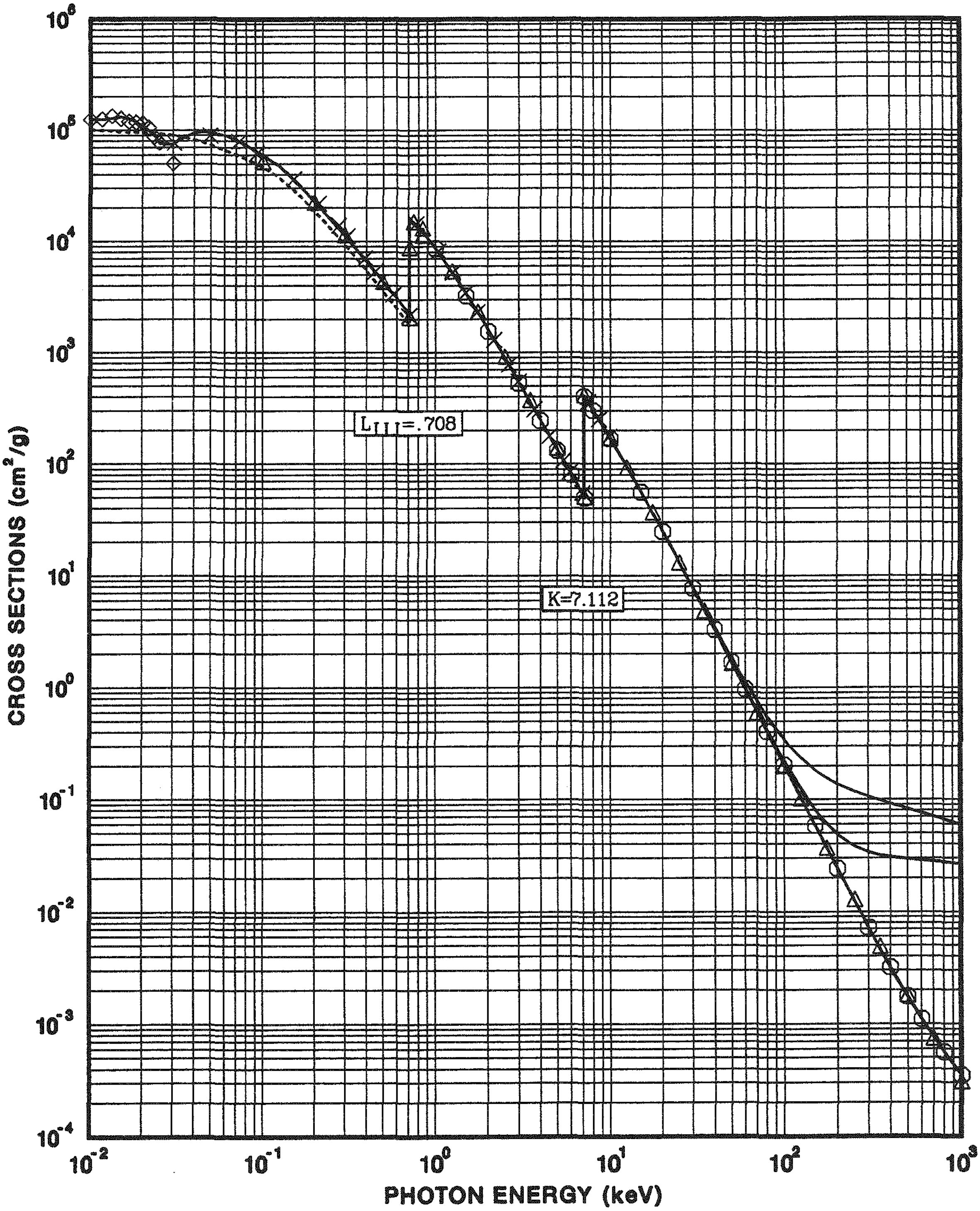
Barns/atom = 86.34 × cm^2/g

MANGANESE 25



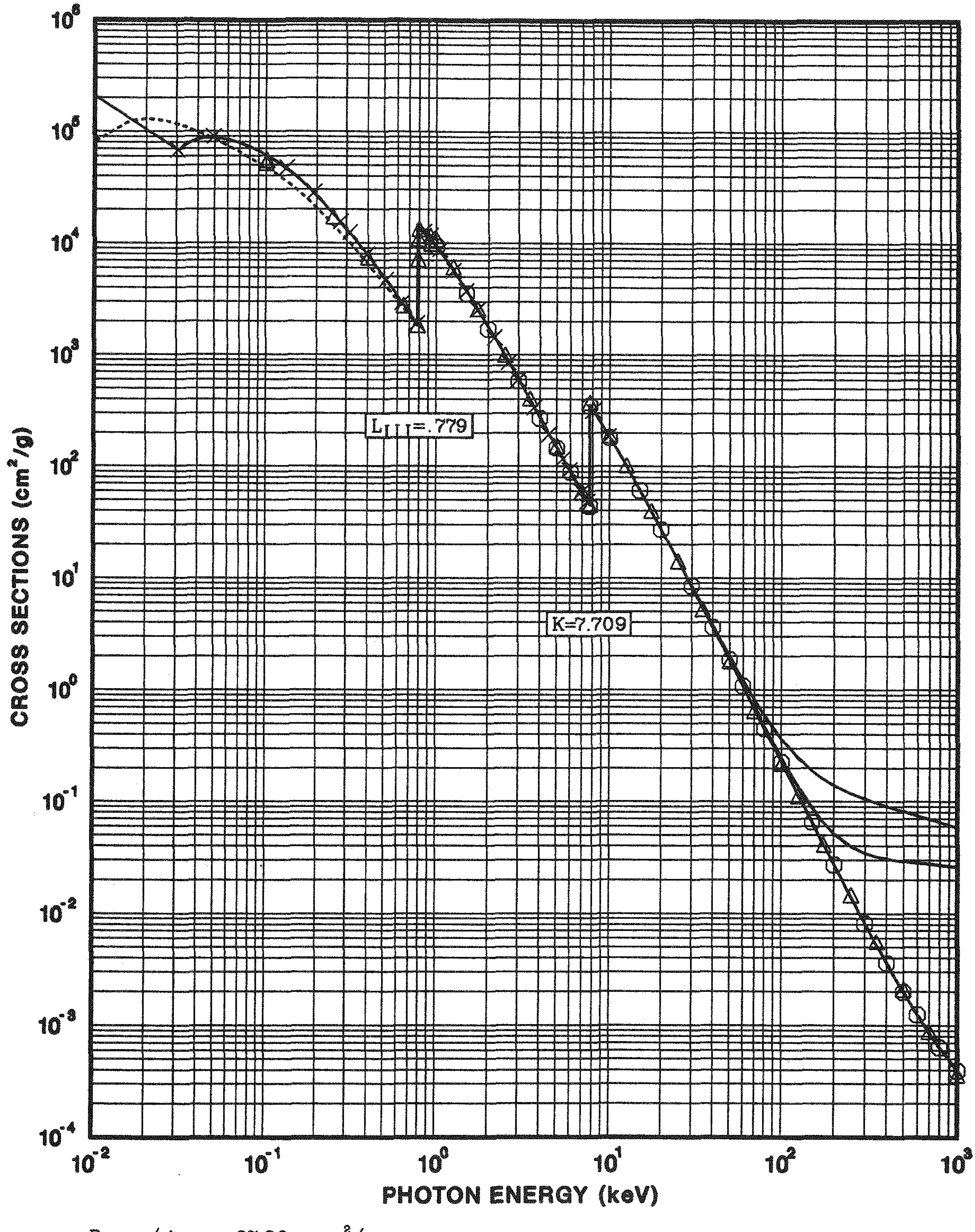
Barns/atom = 91.23 × cm^2/g

IRON 26



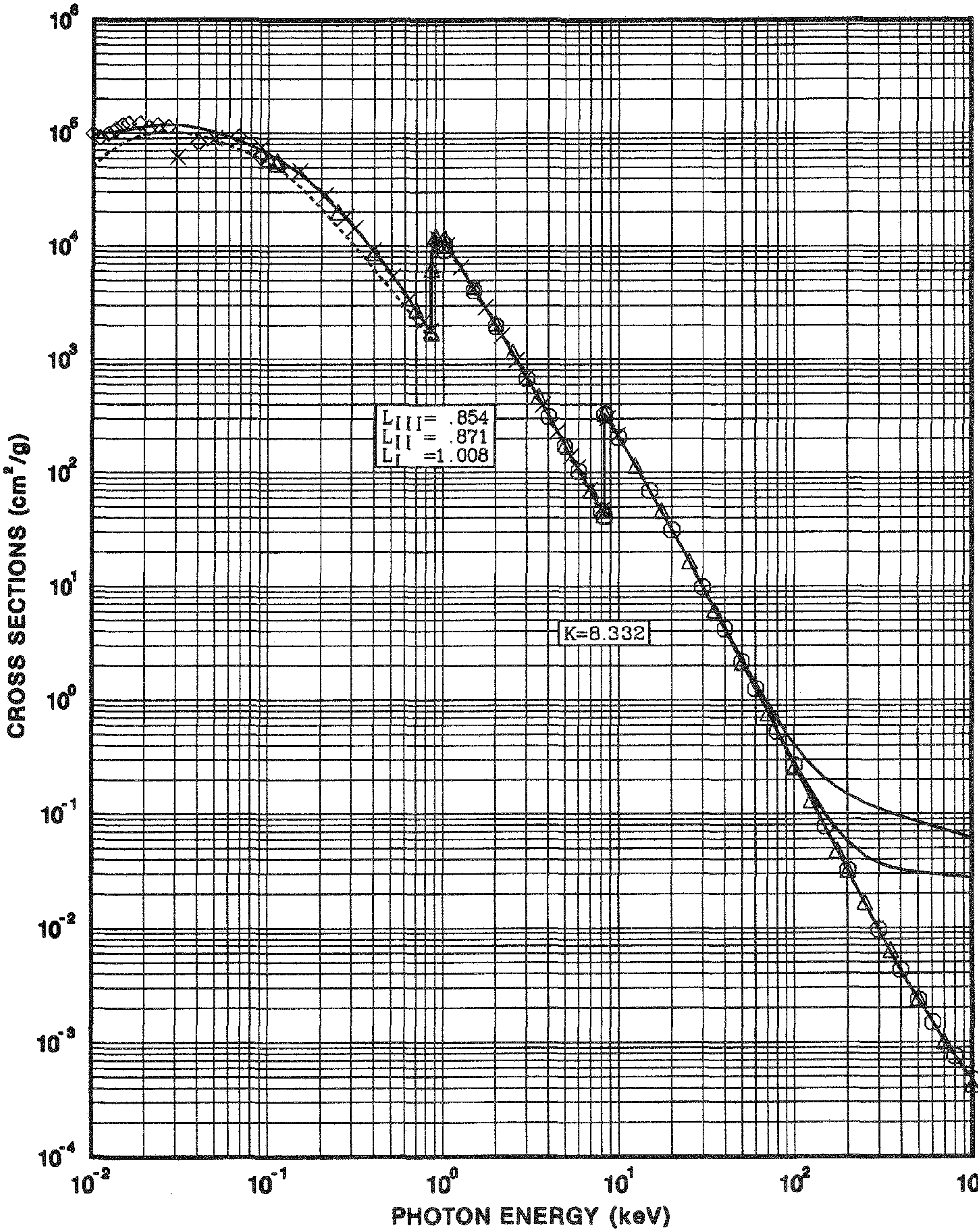
Barns/atom = 92.74 × cm²/g

COBALT 27



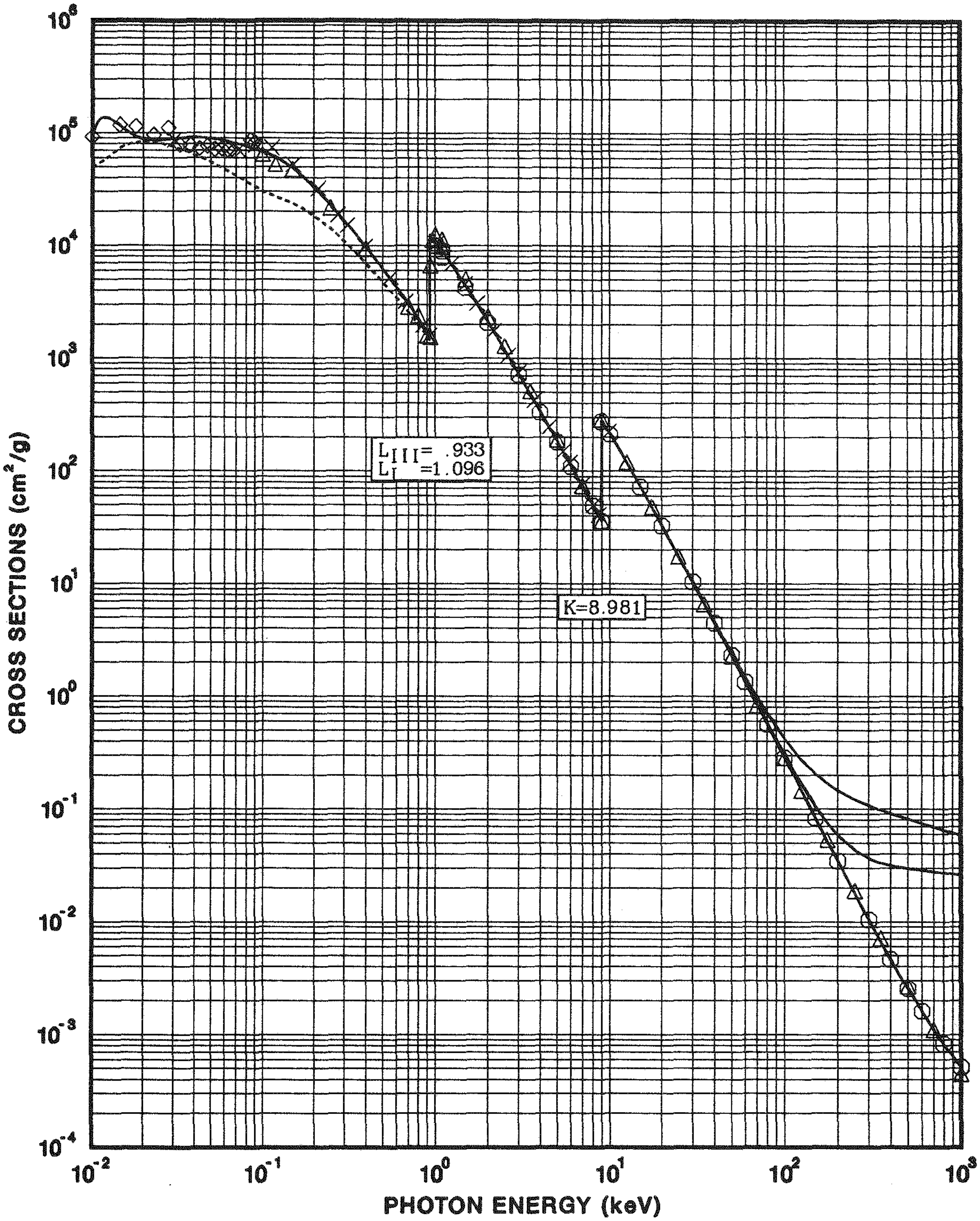
Barns/atom = 97.86 × cm^2/g

NICKEL 28



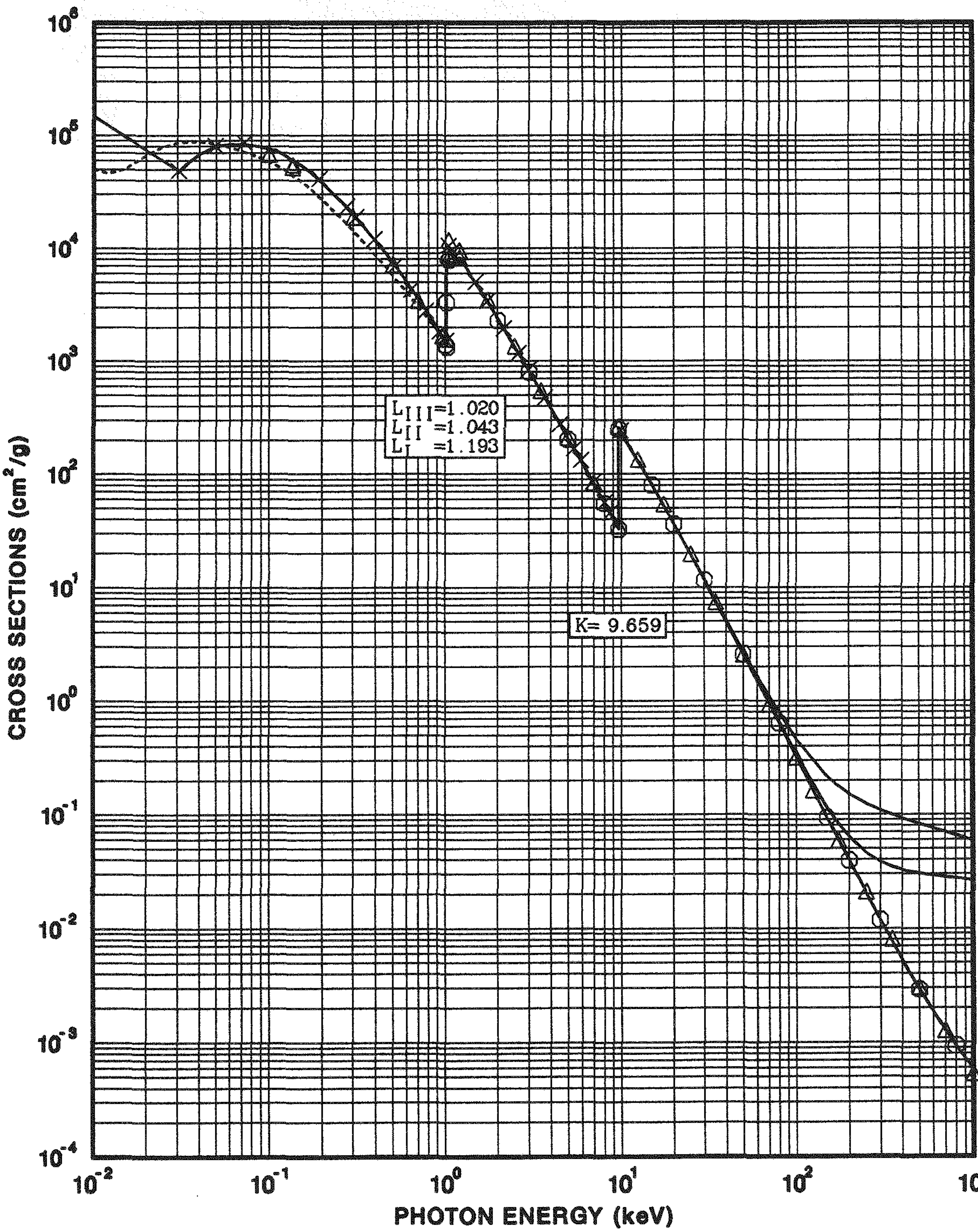
Barns/atom = 97.46 × cm²/g

COPPER 29



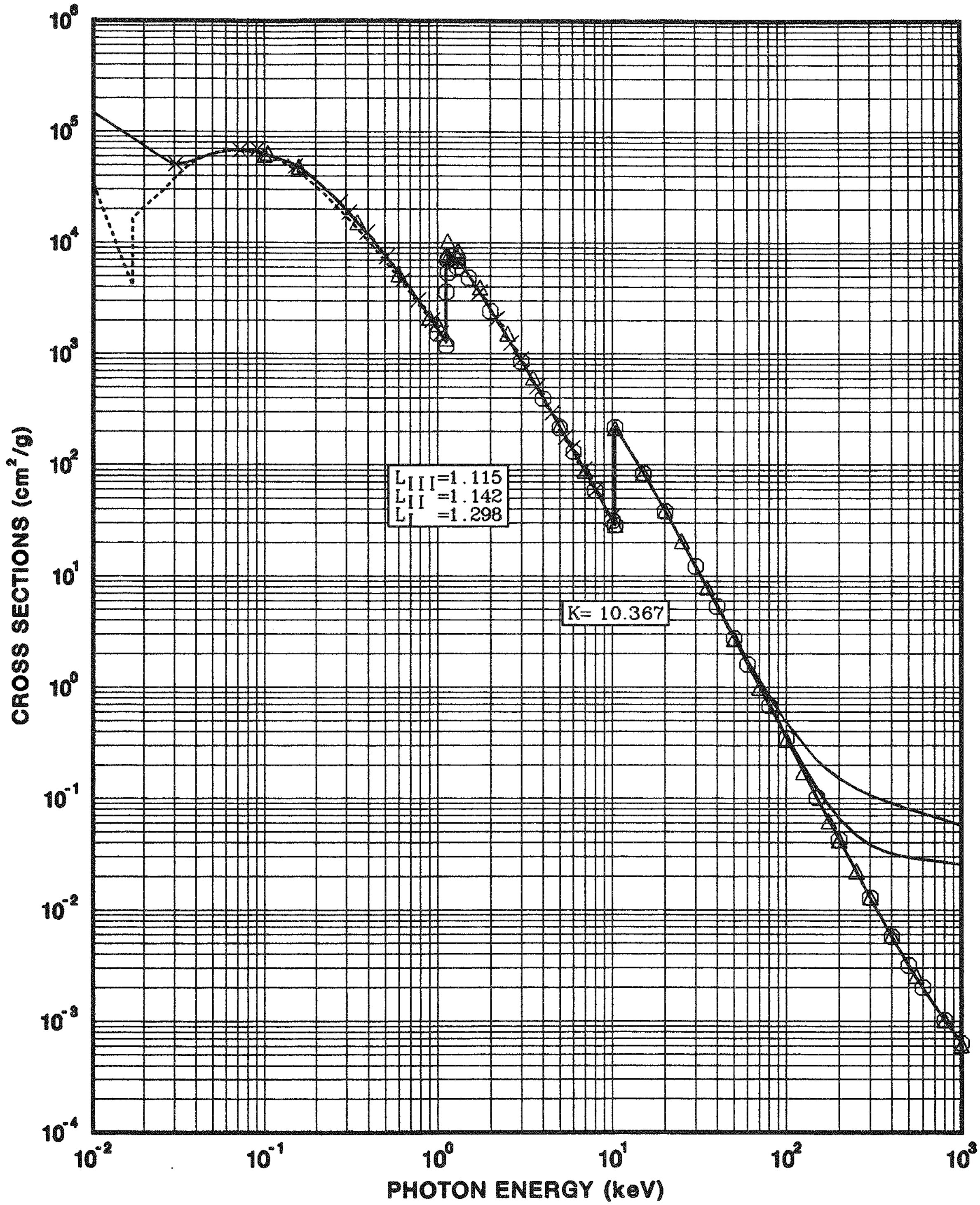
Barns/atom = 105.5 × cm^2/g

ZINC 30



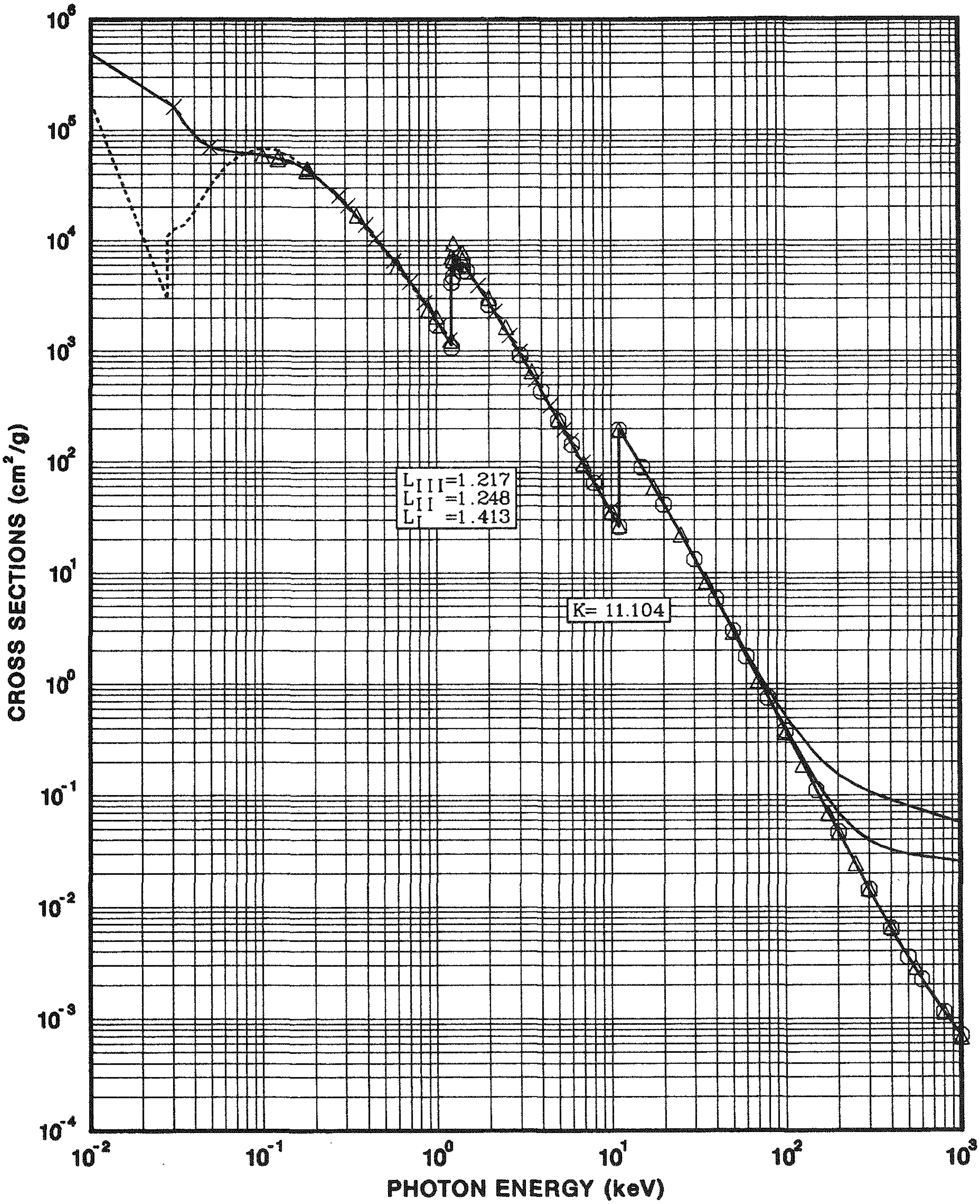
Barns/atom = 108.6 × cm^2/g

GALLIUM 31



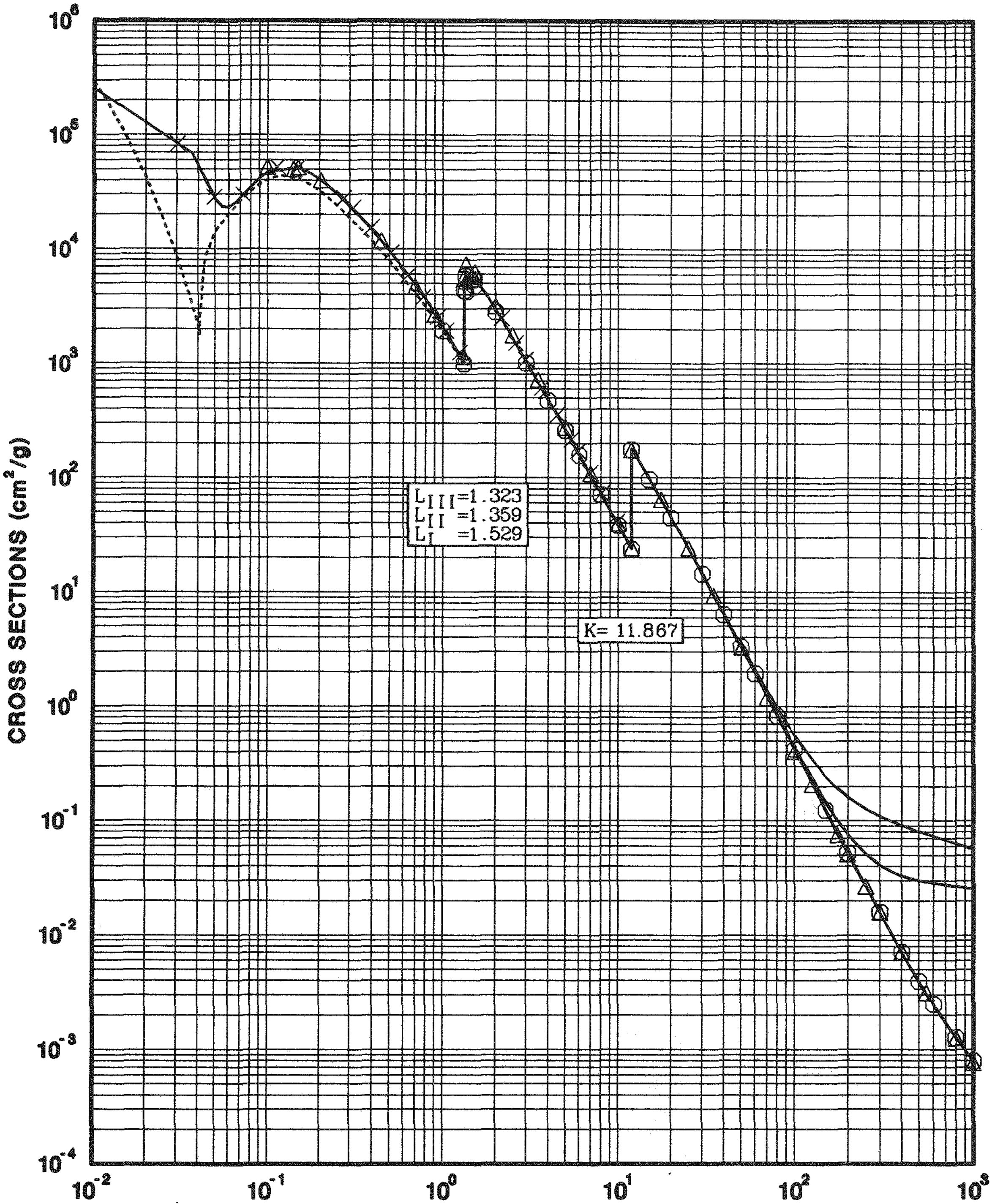
Barns/atom = 115.8 × cm^2/g

GERMANIUM 32



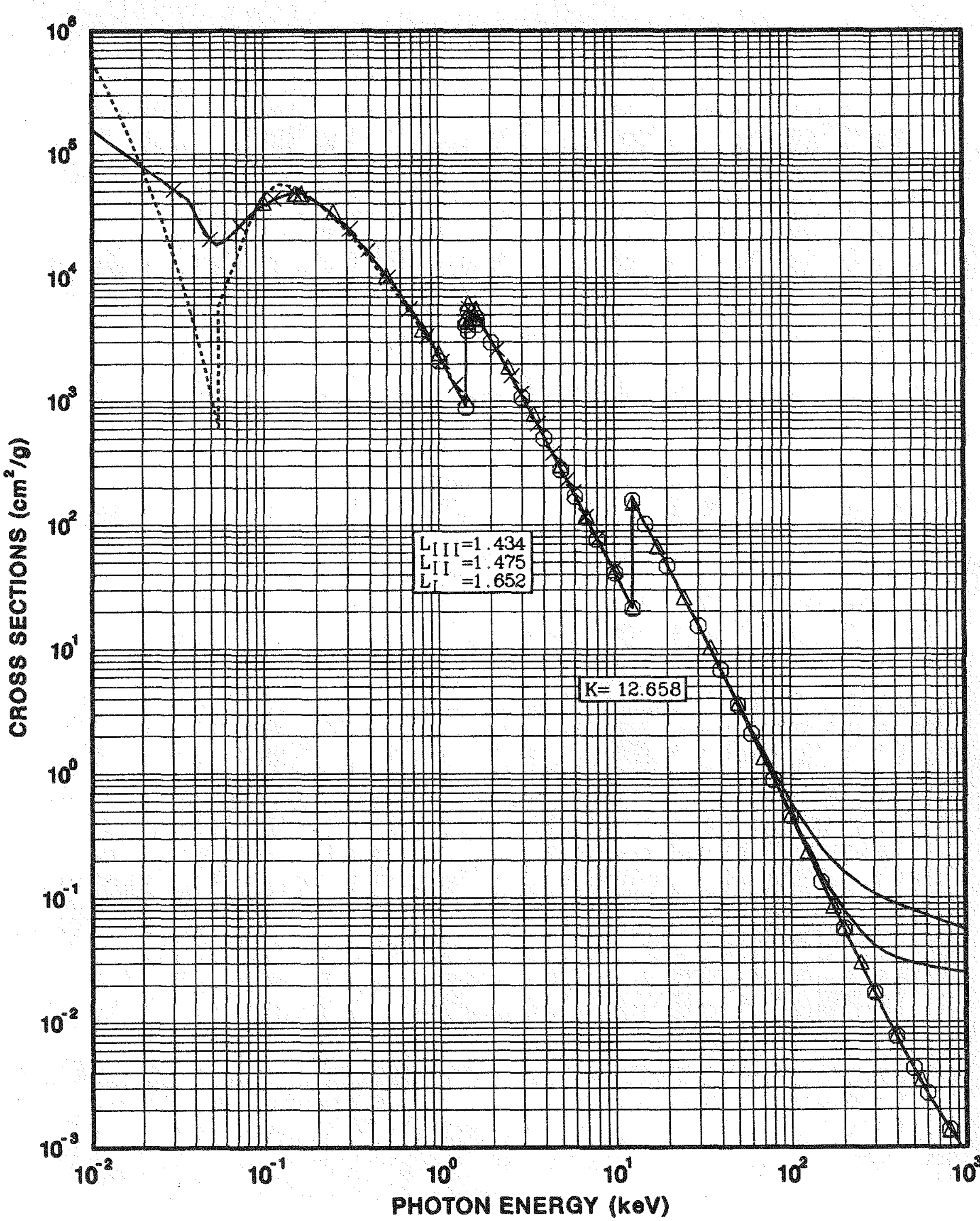
Barns/atom = 120.5 × cm^2/g

ARSENIC 33



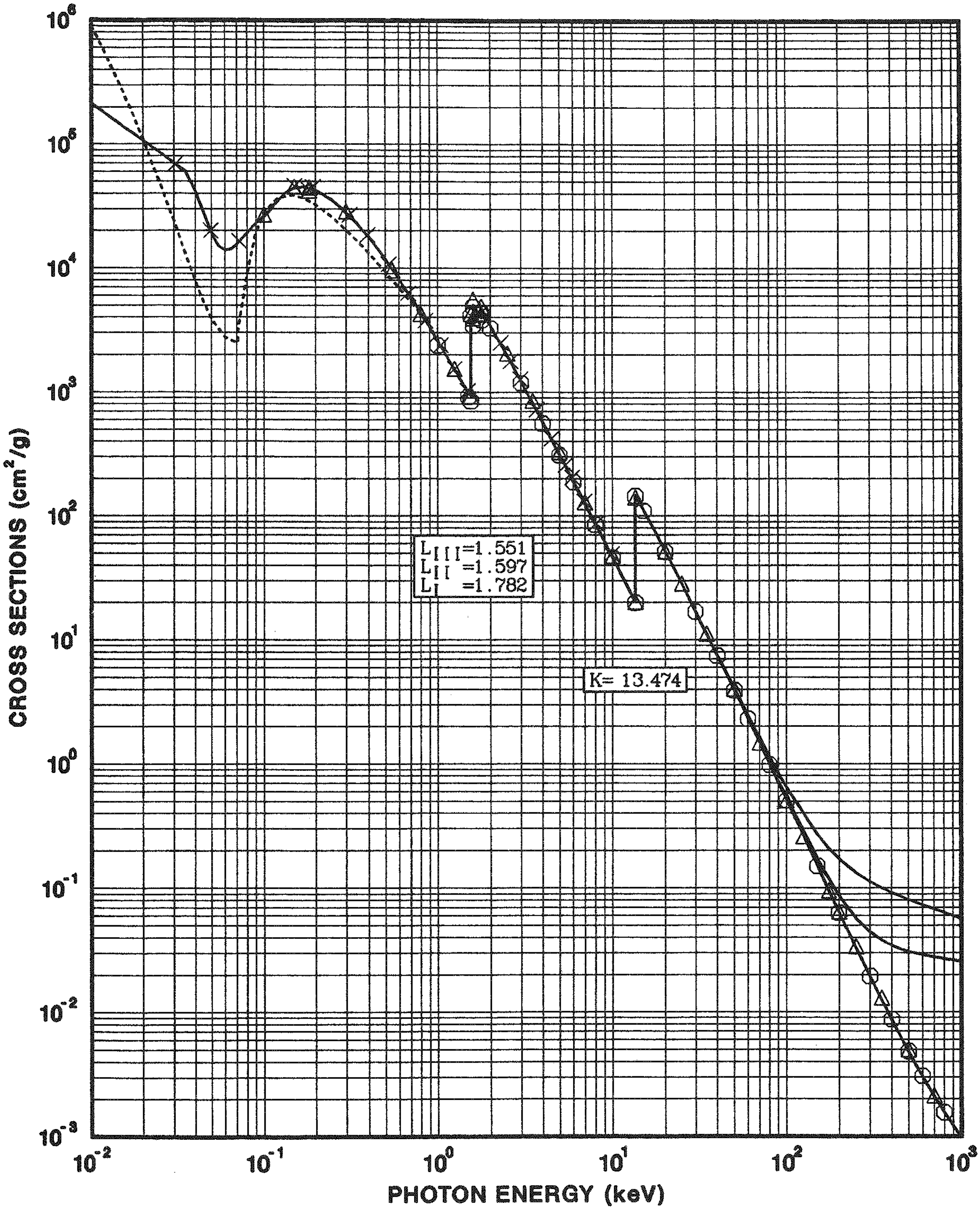
Barns/atom = 124.4 × cm^2/g

SELENIUM 34



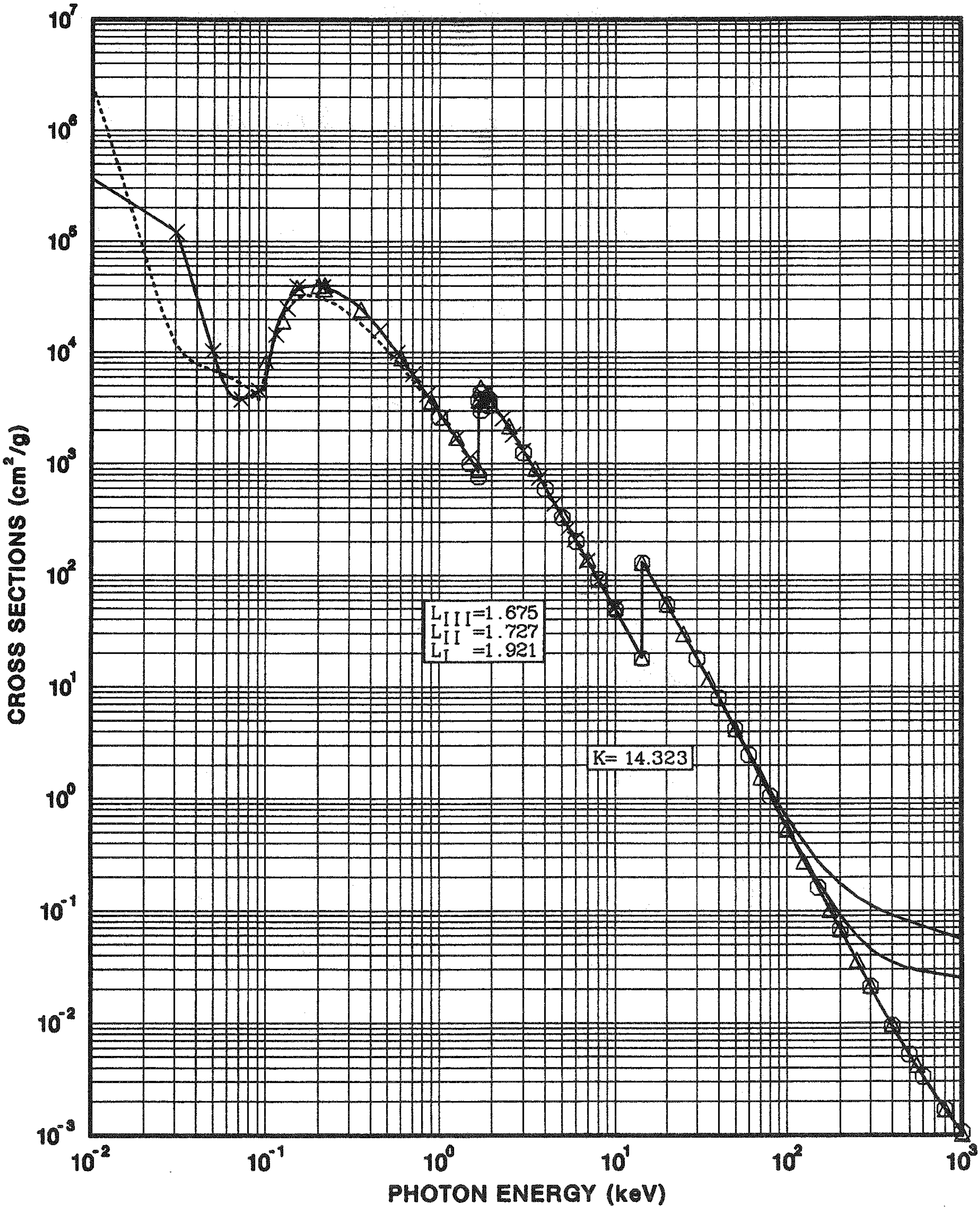
Barns/atom = 131.1 × cm^2/g

BROMINE 35



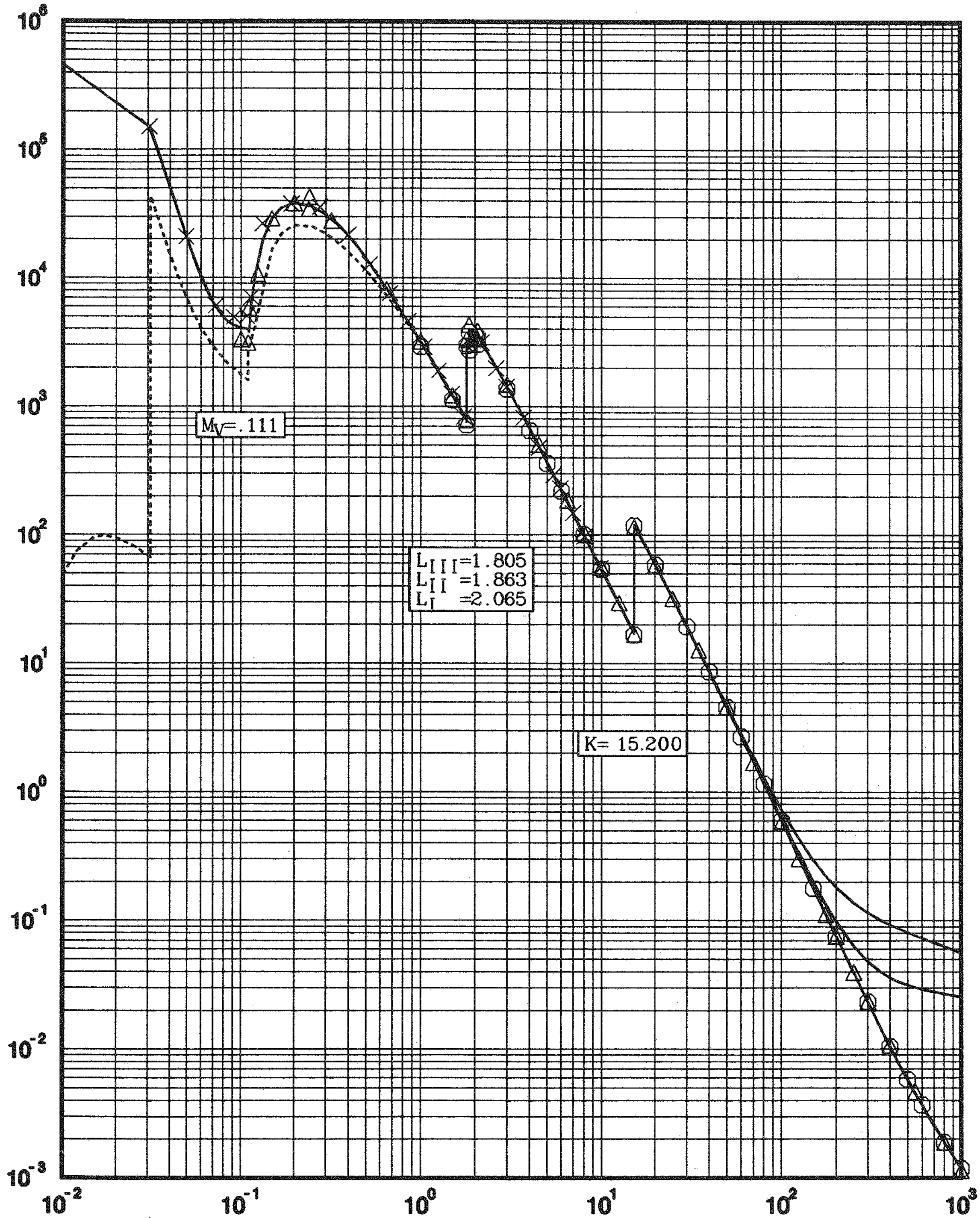
Barns/atom = 132.7 × cm²/g

KRYPTON 36



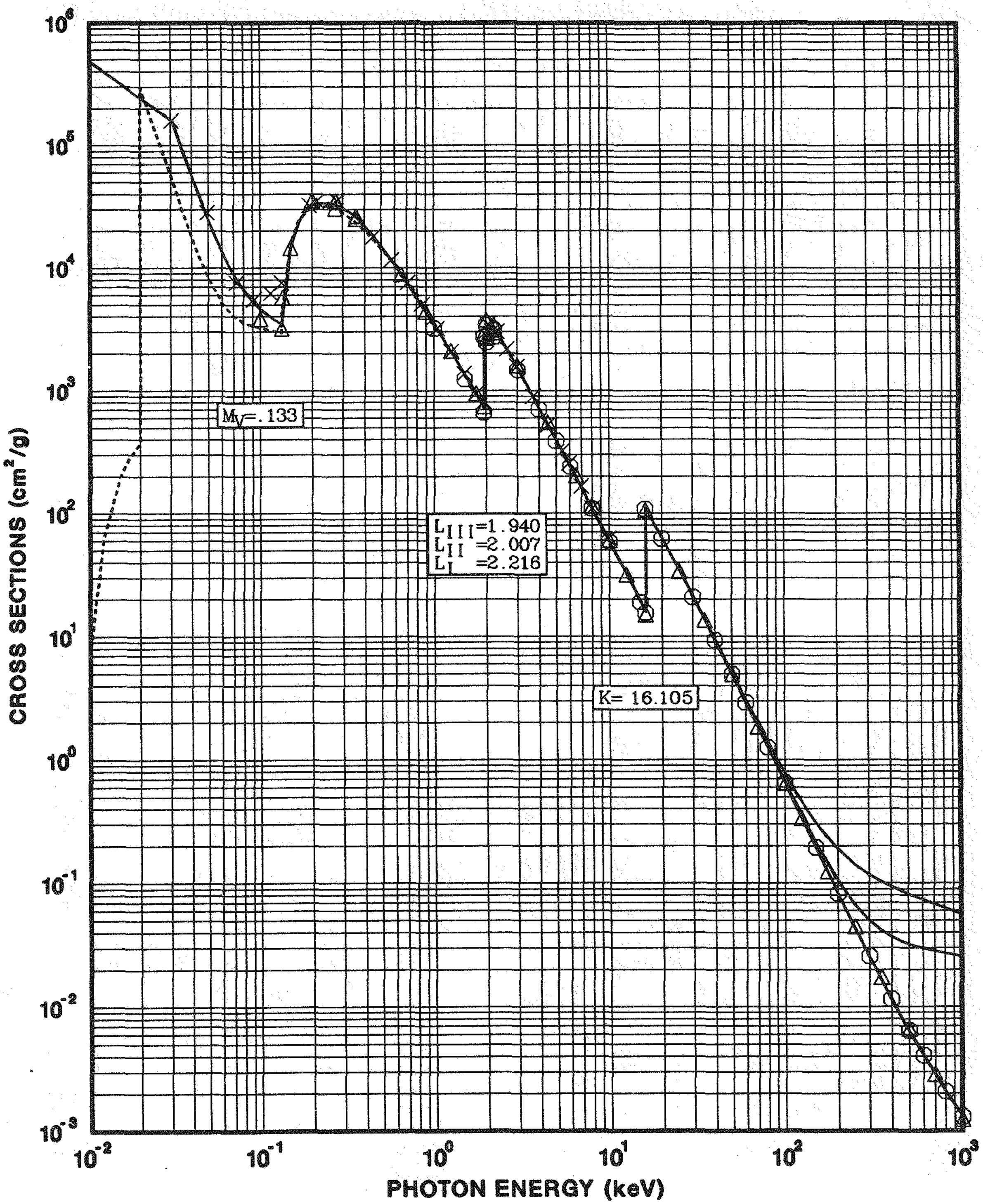
Barns/atom = 139.2 × cm²/g

RUBIDIUM 37



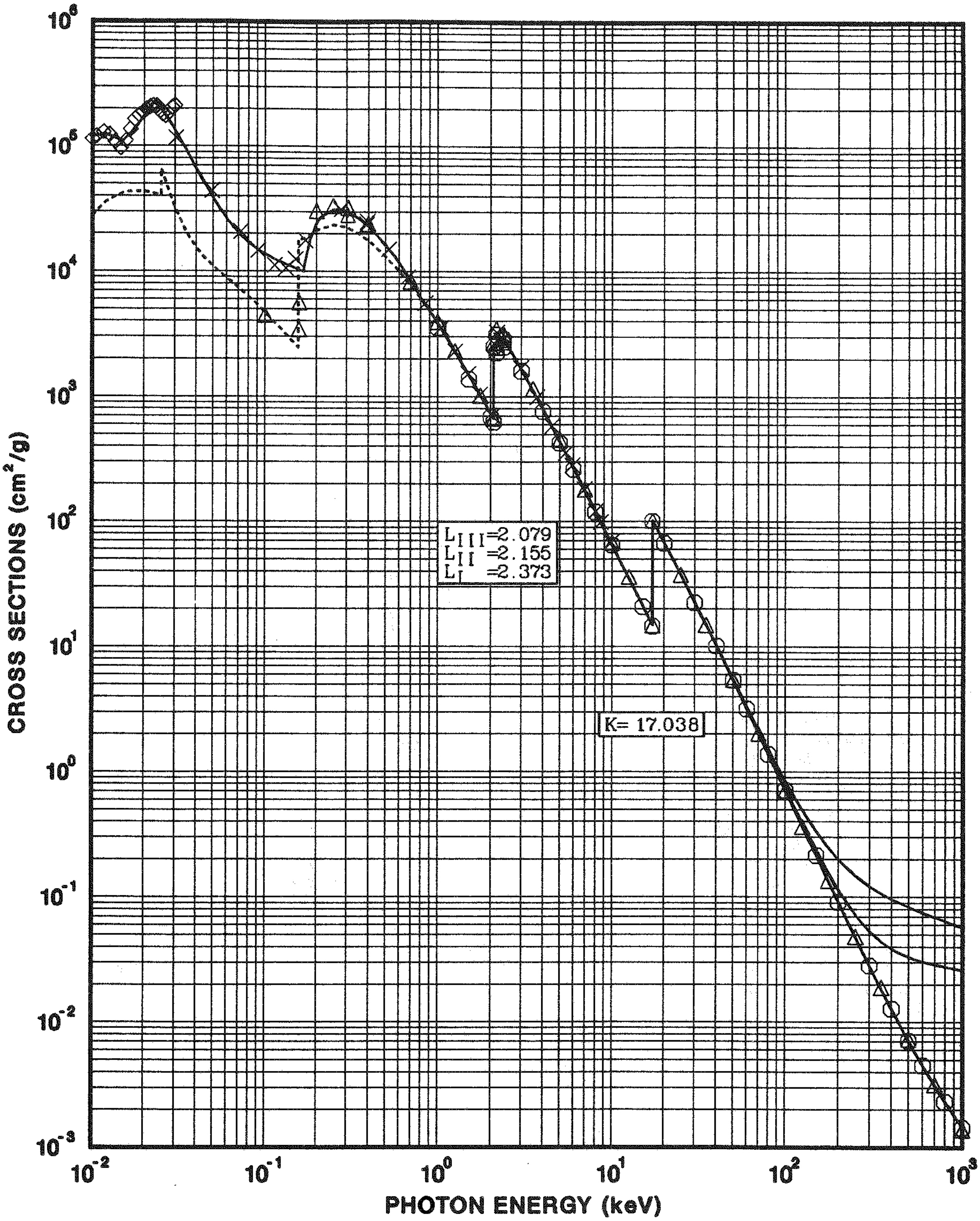
Barns/atom = 141.9 × cm²/g

STRONTIUM 38



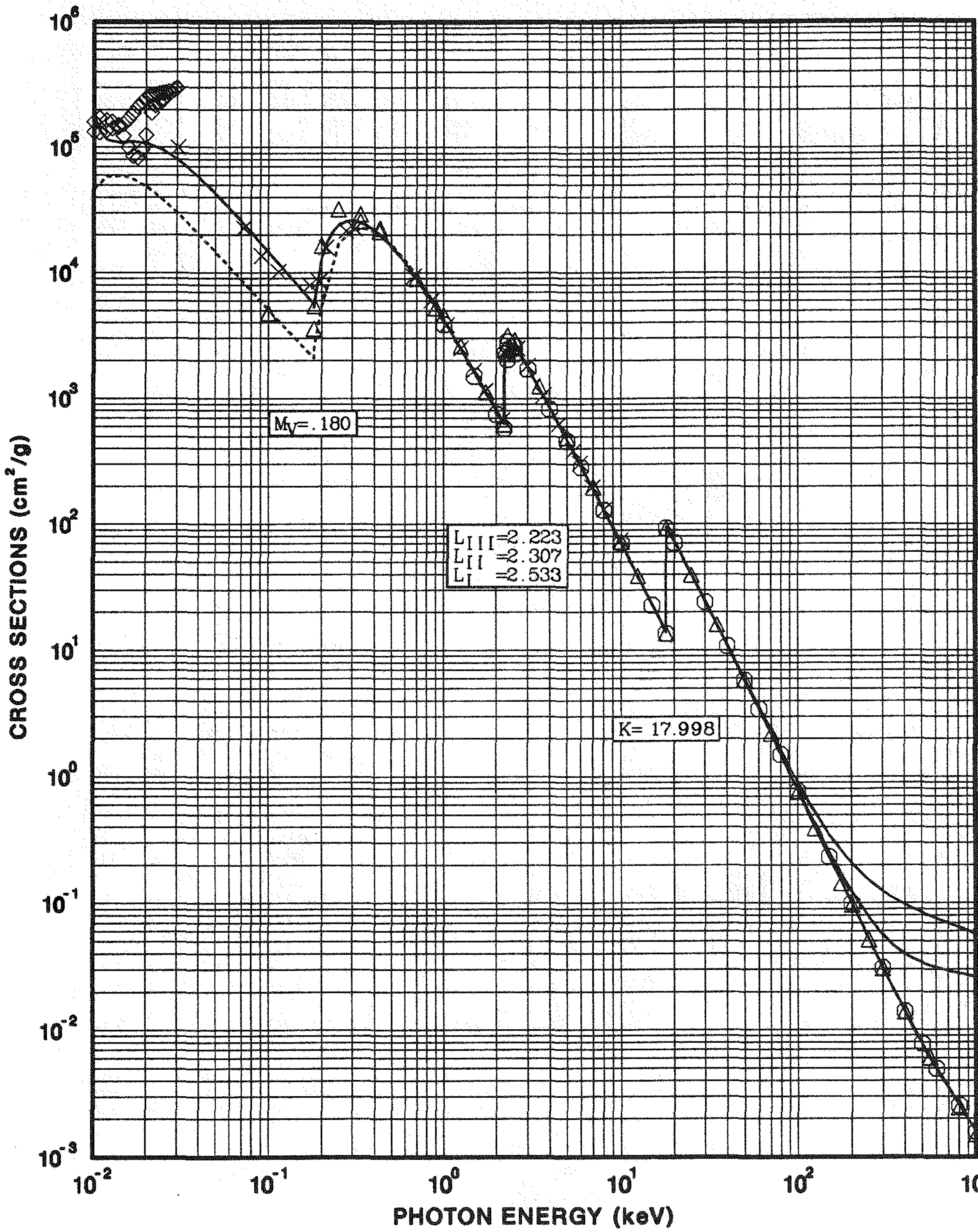
Barns/atom = 145.5 × cm^2/g

YTTRIUM 39



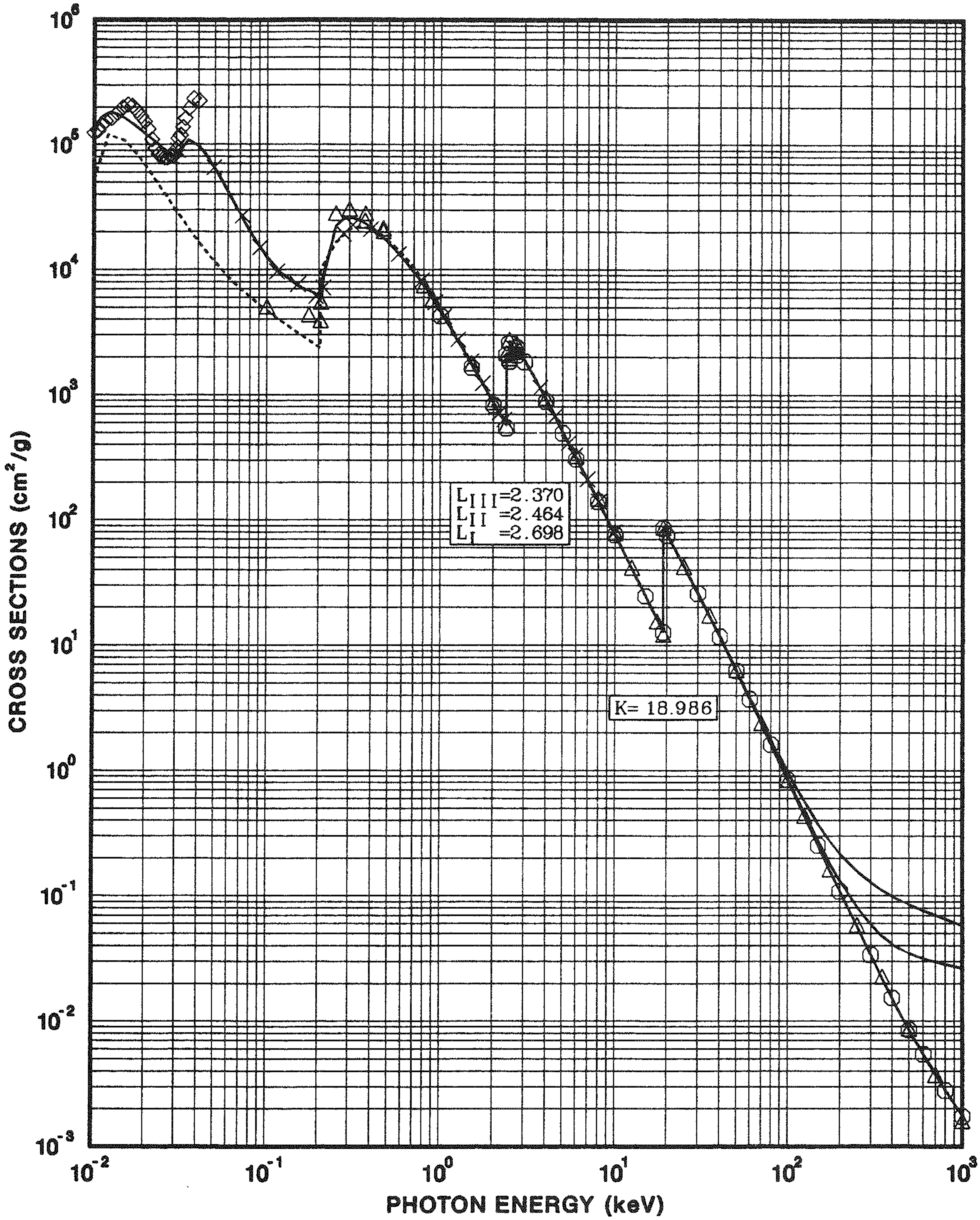
Barns/atom = 147.6 × cm^2/g

ZIRCONIUM 40



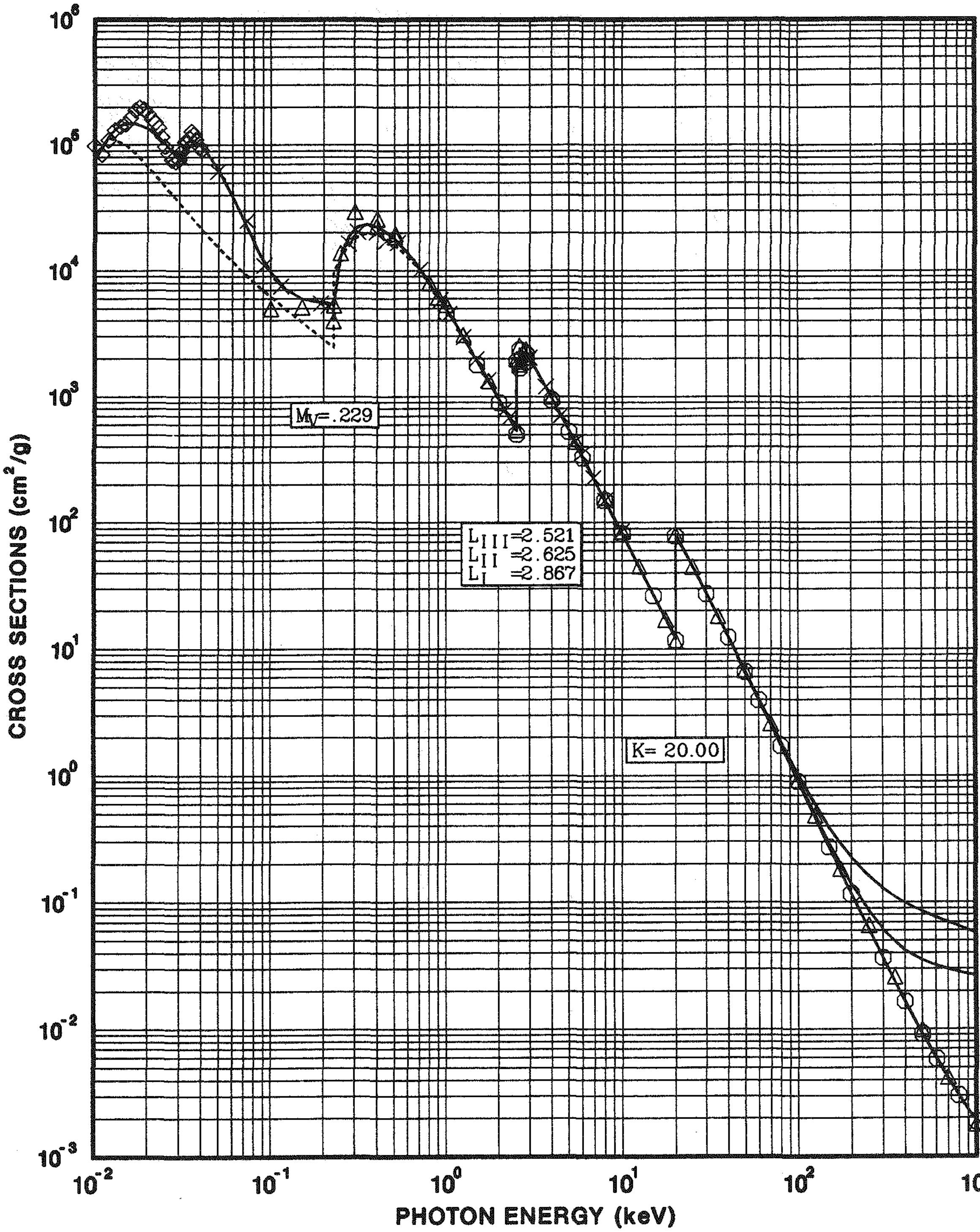
Barns/atom = 151.5 × cm^2/g

NIOBIUM 41



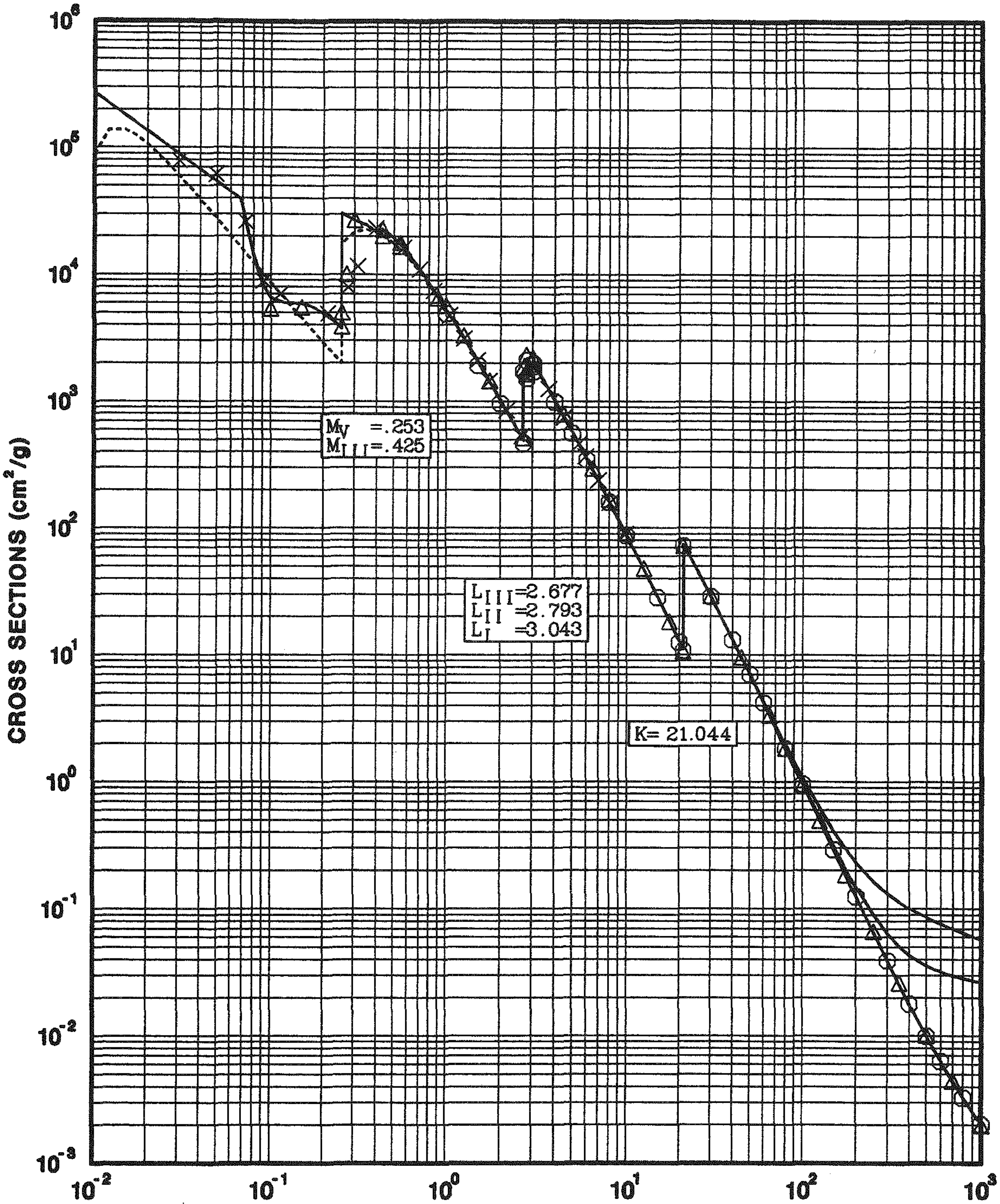
Barns/atom = 154.3 × cm^2/g

MOLYBDENUM 42



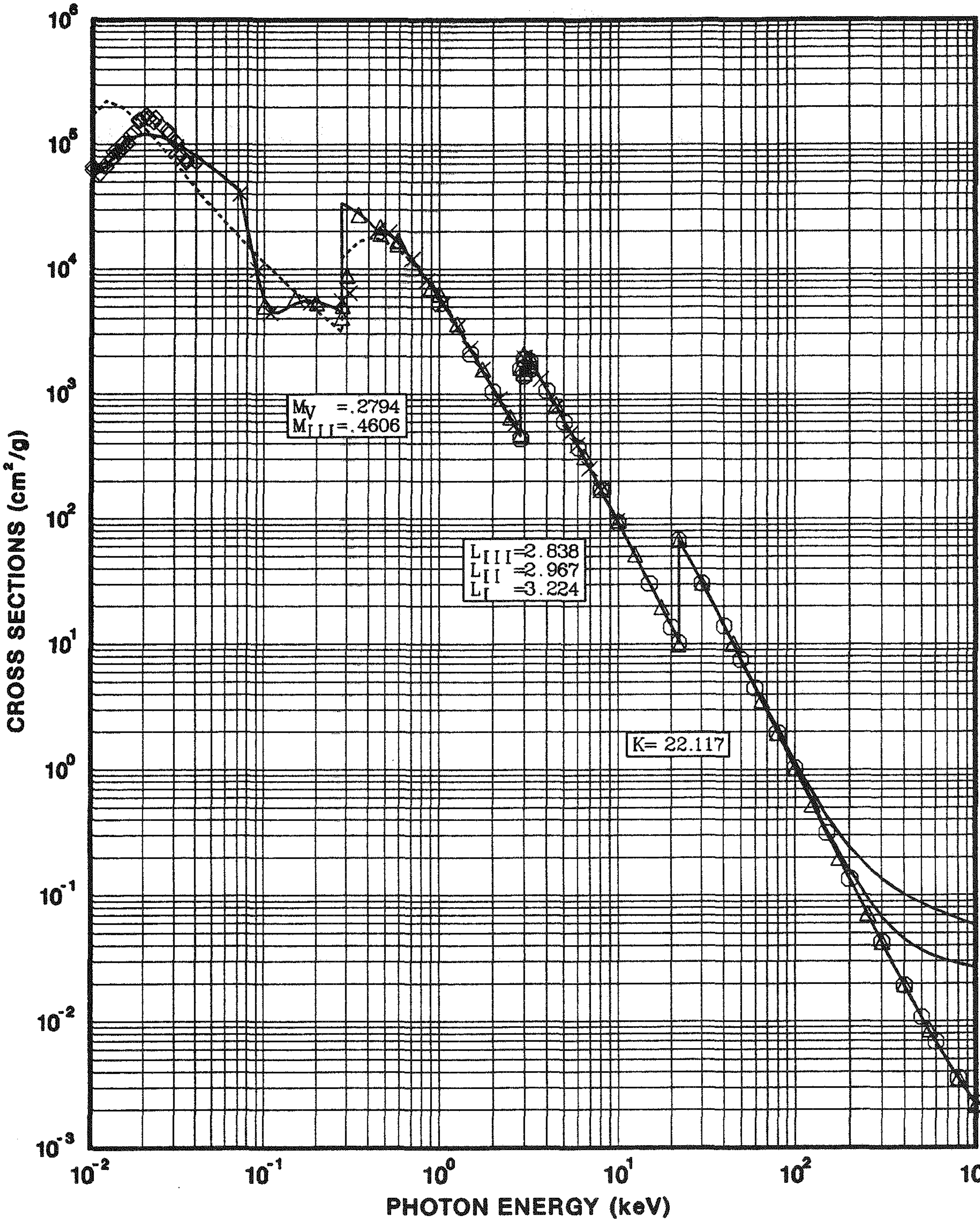
Barns/atom = 159.3 × cm^2/g

TECHNETIUM 43



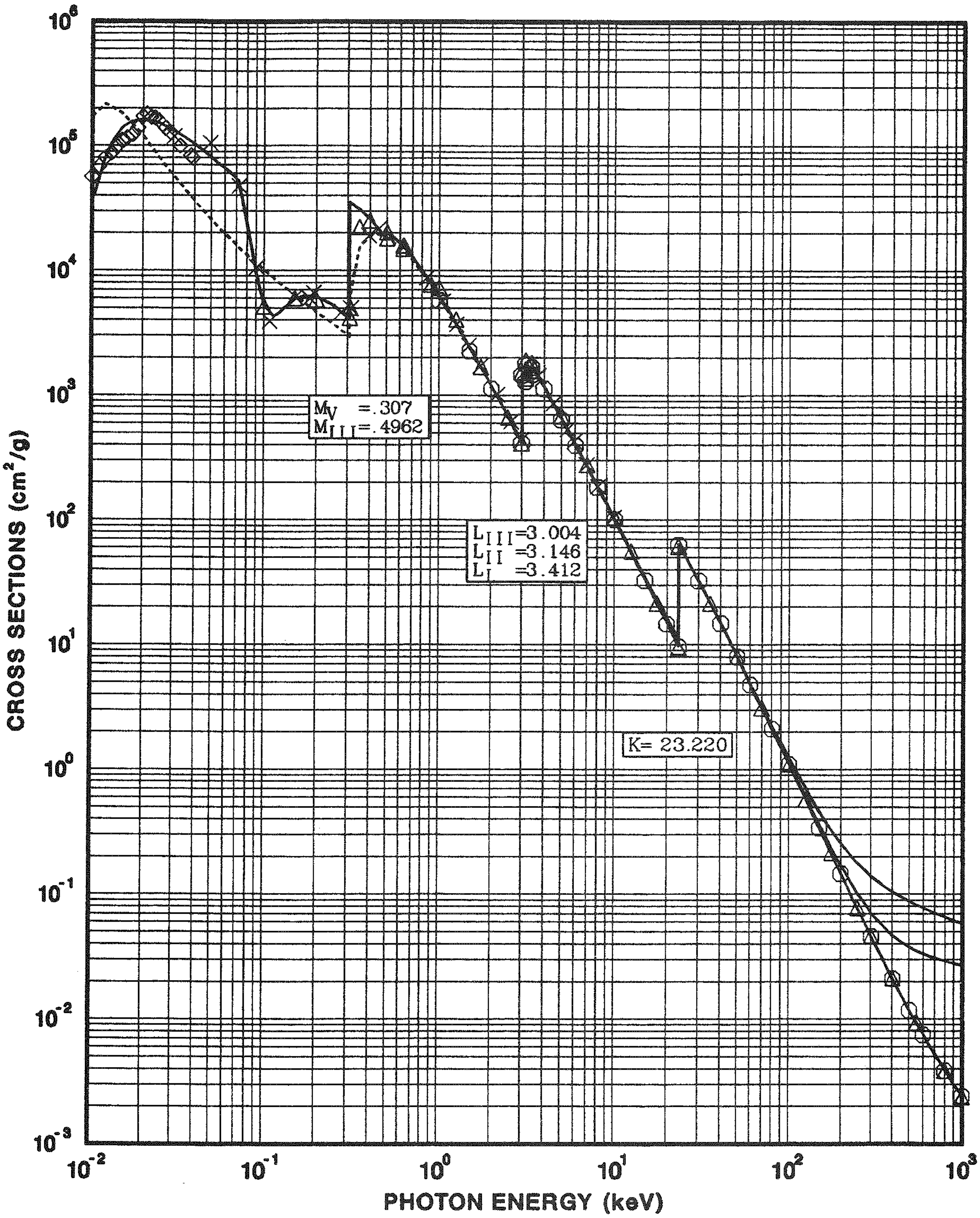
Barns/atom = 162.7 × cm^2/g

RUTHENIUM 44



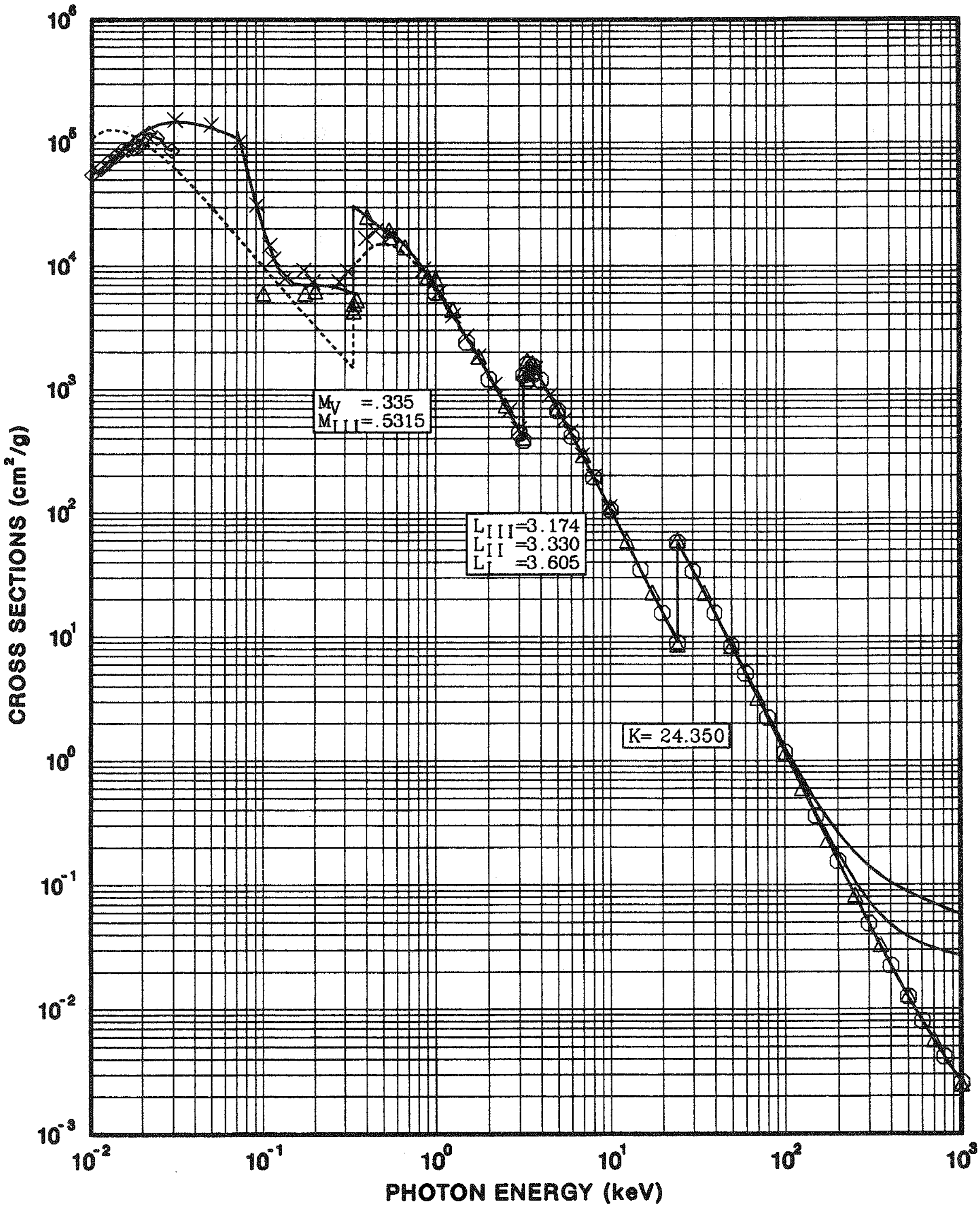
Barns/atom = 167.8 × cm^2/g

RHODIUM 45



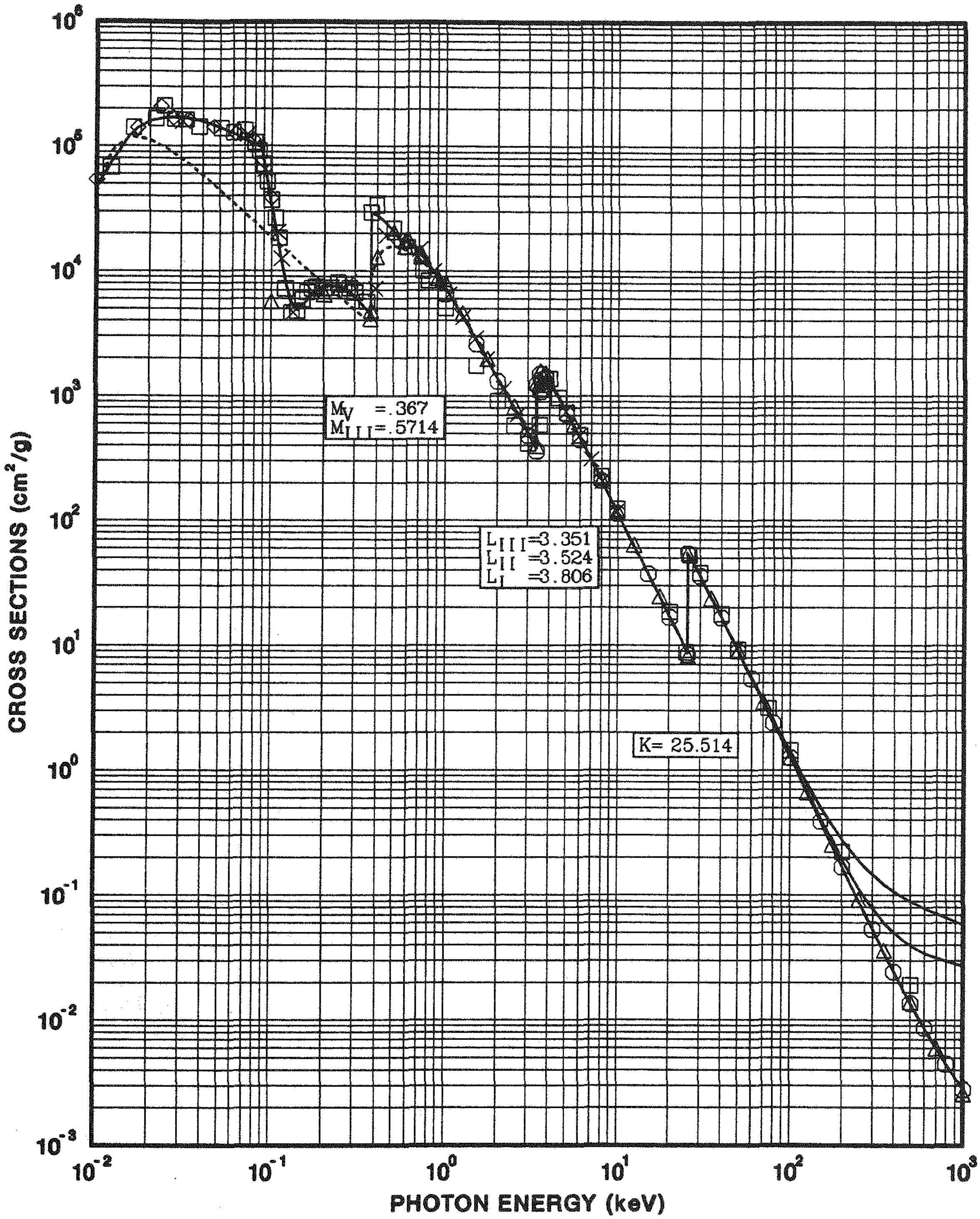
Barns/atom = 170.9 × cm^2/g

PALLADIUM 46



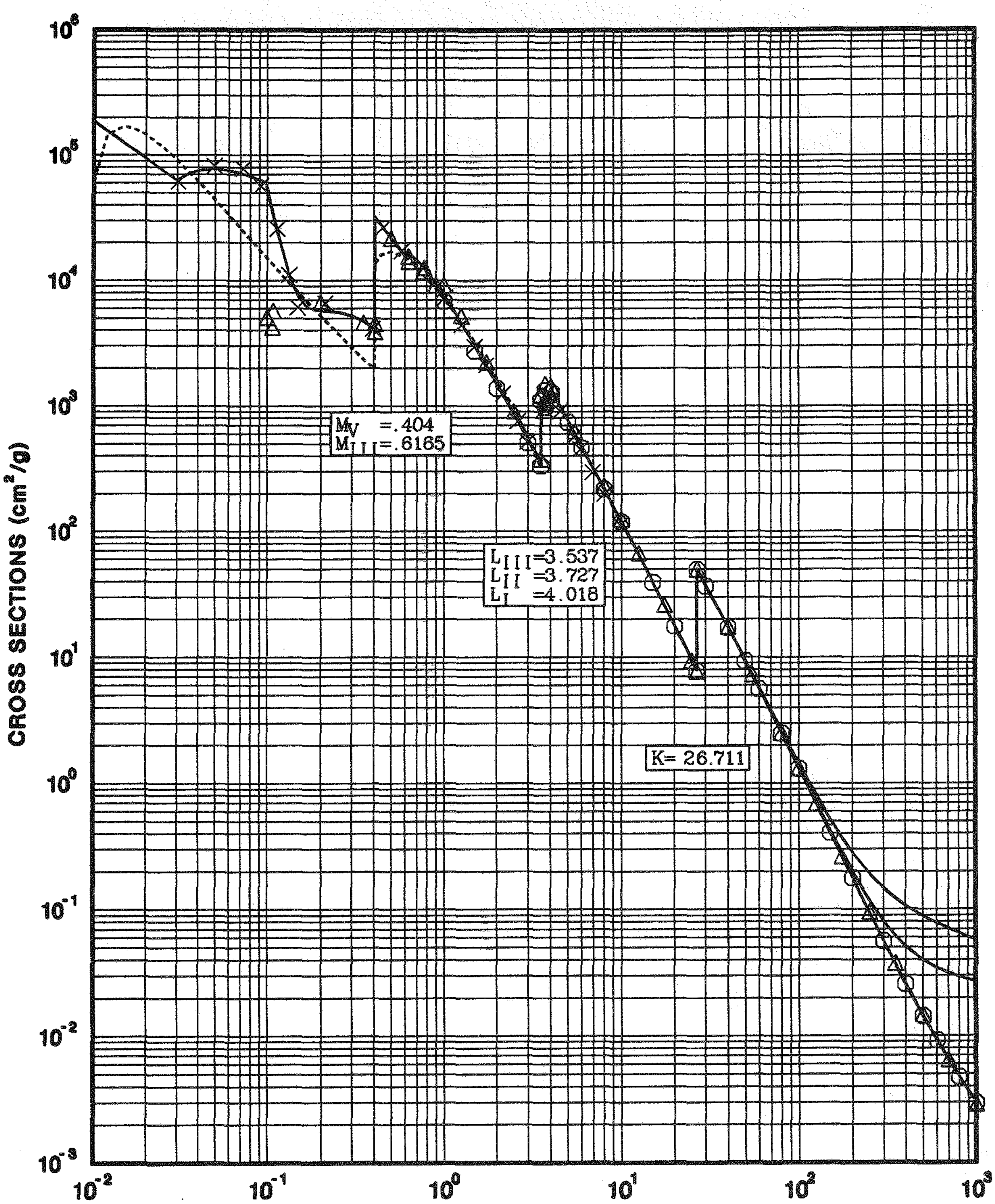
Barns/atom = 176.7 × cm^2/g

SILVER 47



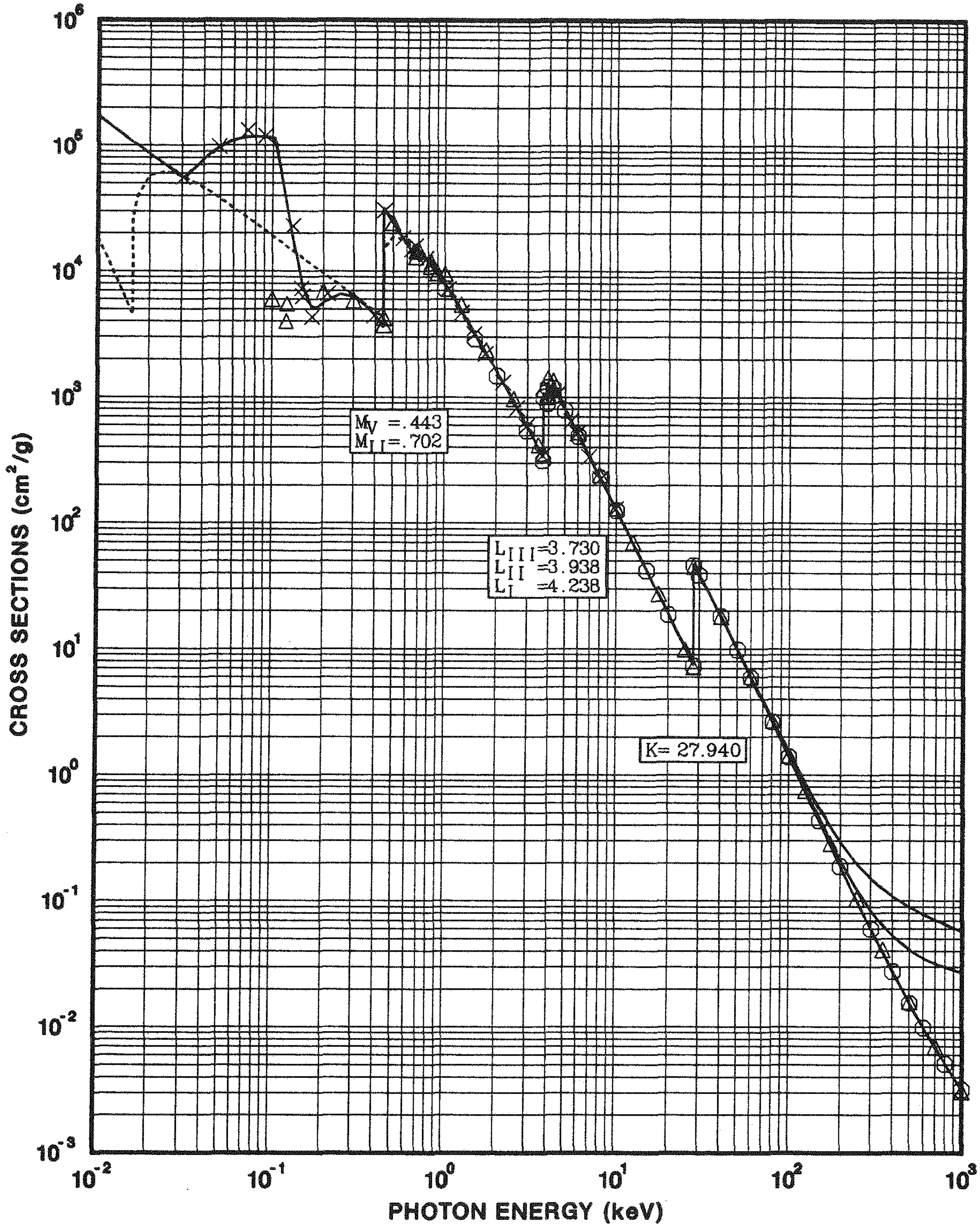
Barns/atom = 179.1 × cm^2/g

CADMIUM 48



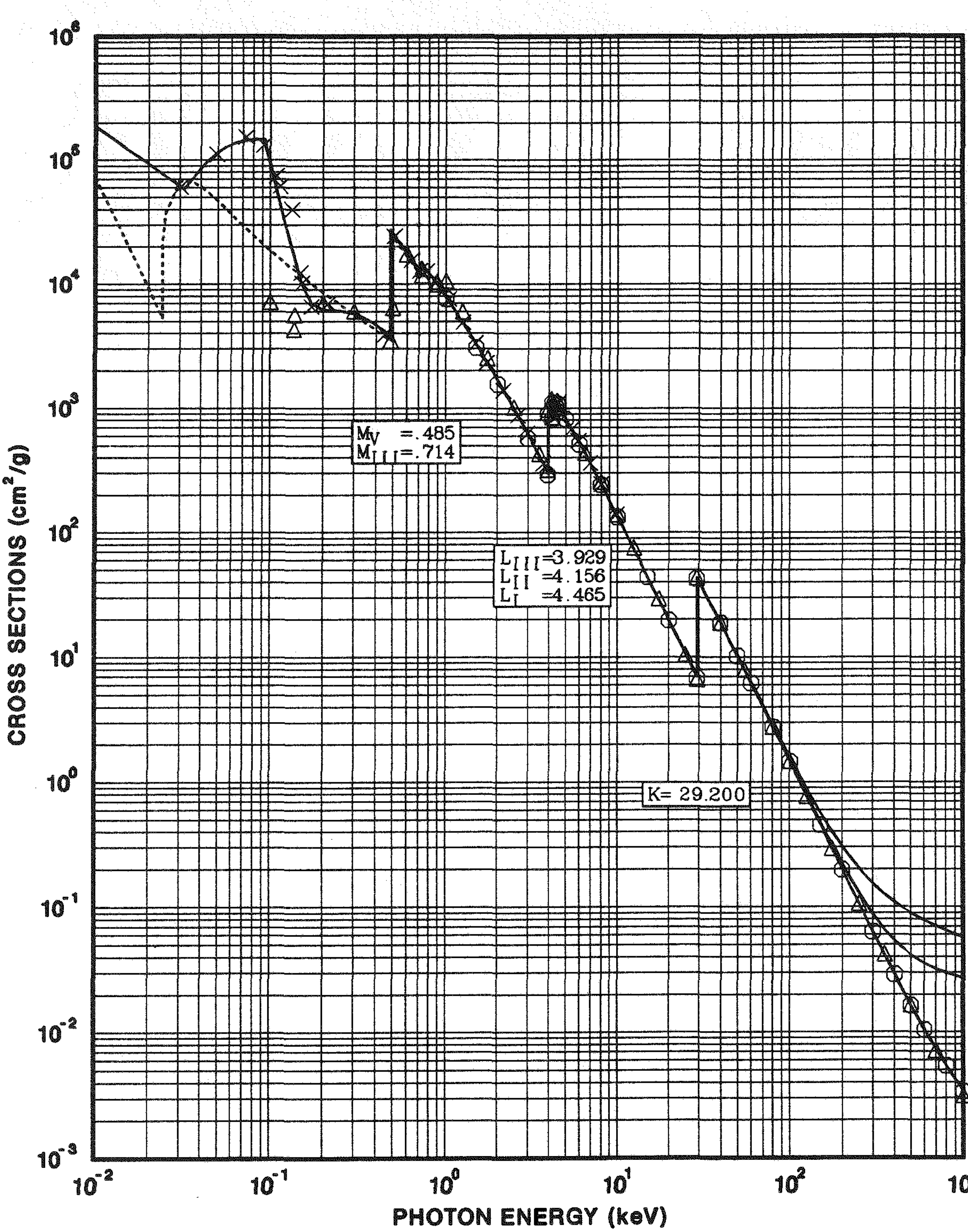
Barns/atom = 186.7 × cm^2/g

INDIUM 49



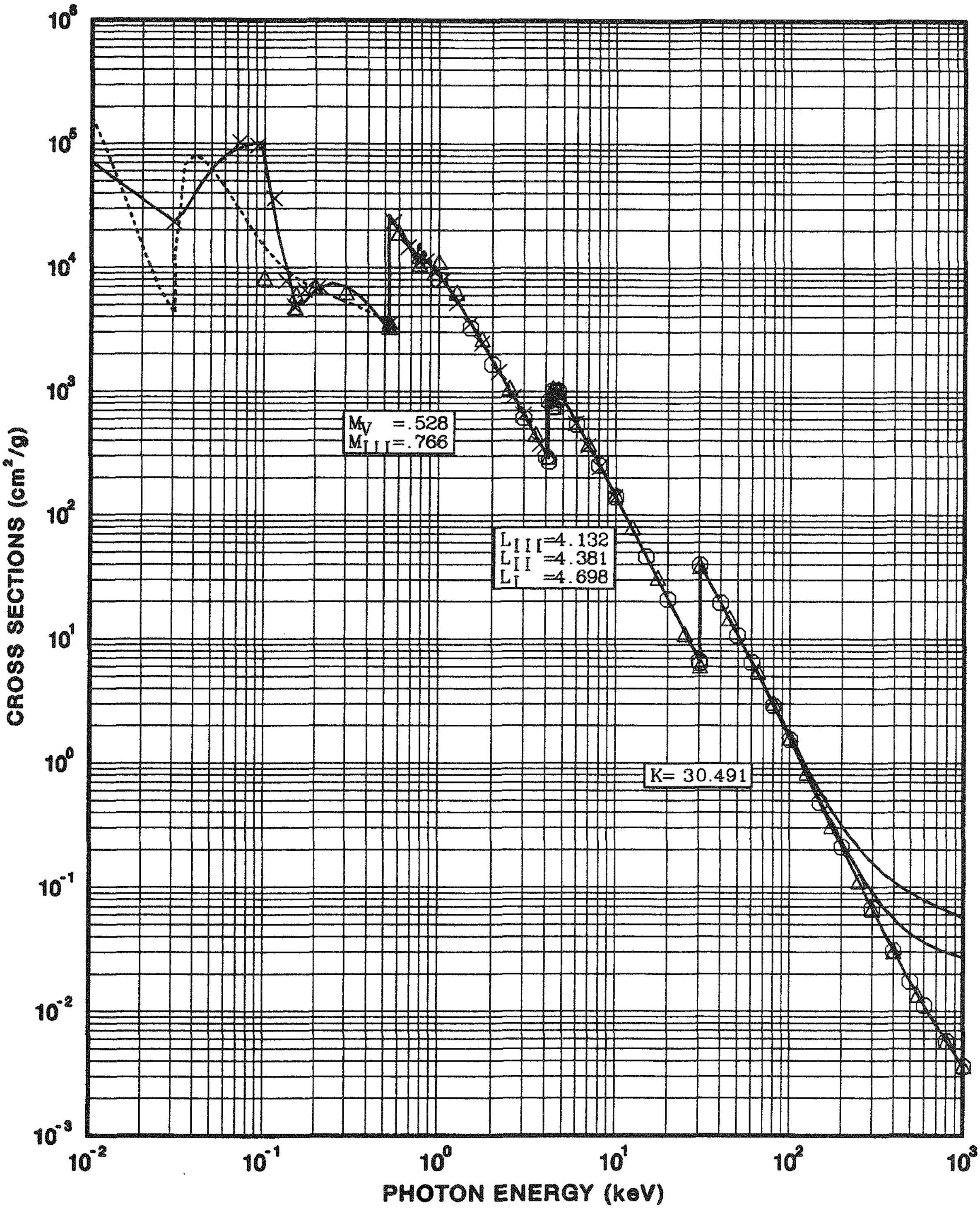
Barns/atom = 190.7 × cm^2/g

TIN 50



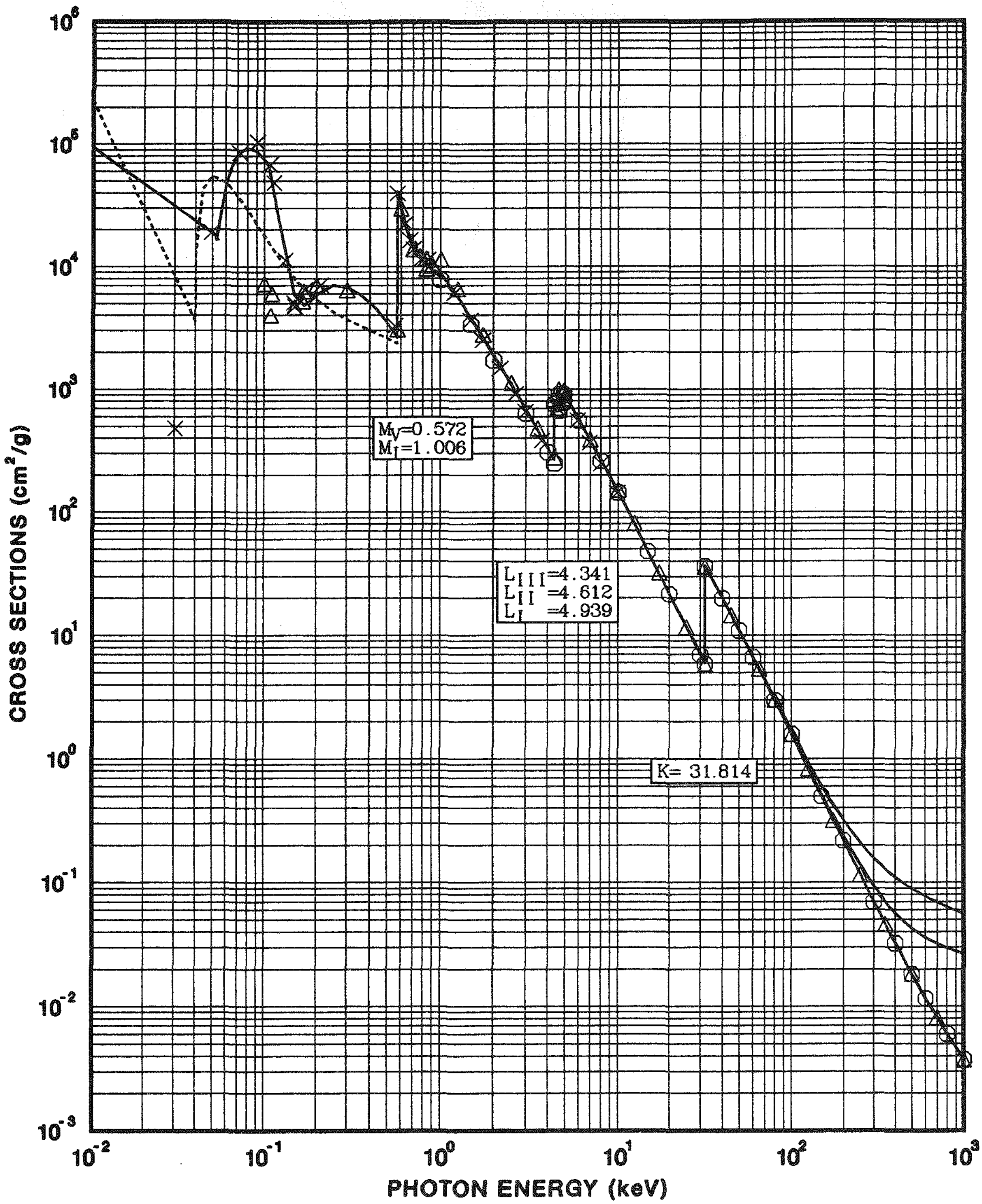
Barns/atom = 197.1 × cm^2/g

ANTIMONY 51



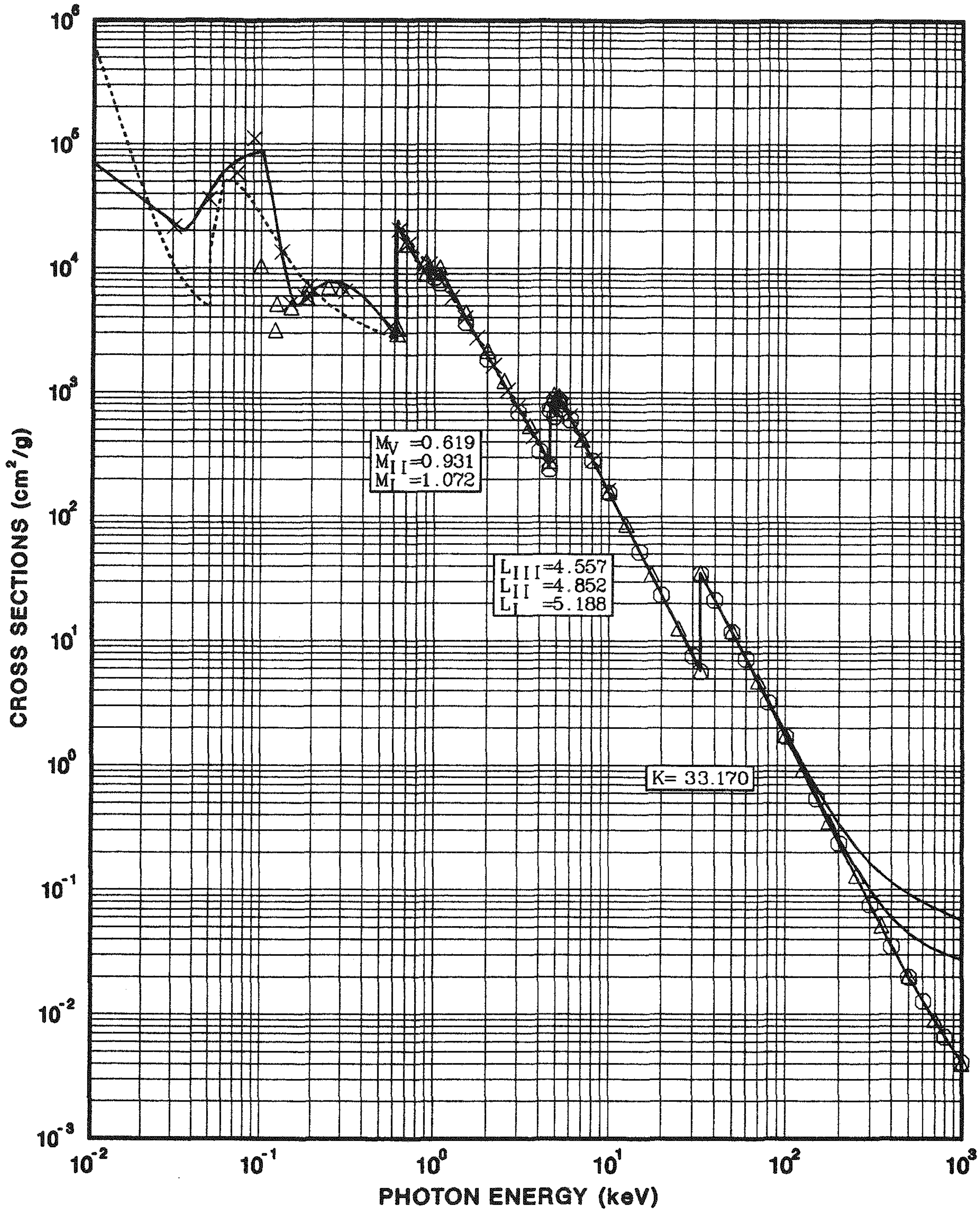
Barns/atom = 202.2 × cm²/g

TELLURIUM 52



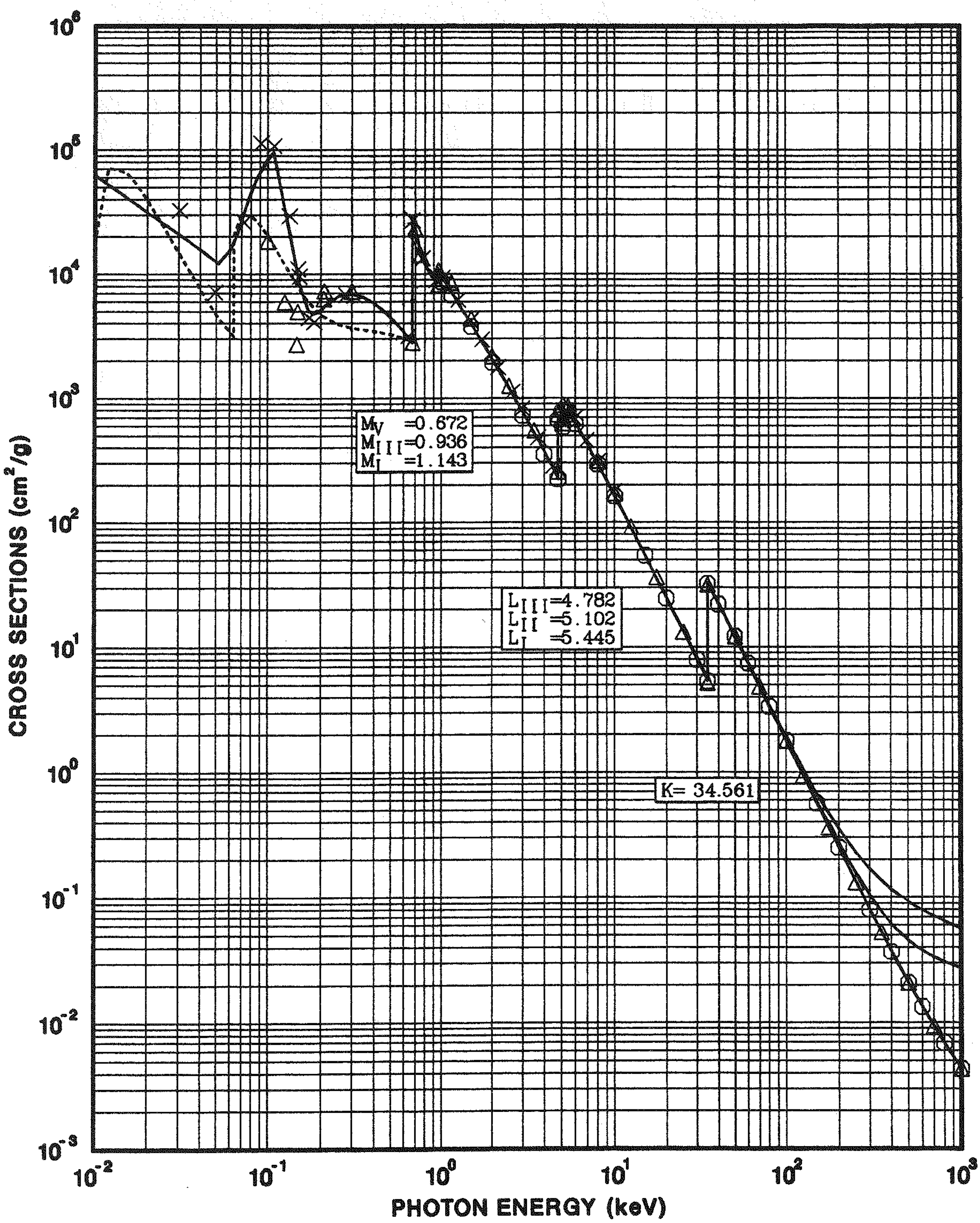
Barns/atom = 211.9 × cm^2/g

IODINE 53



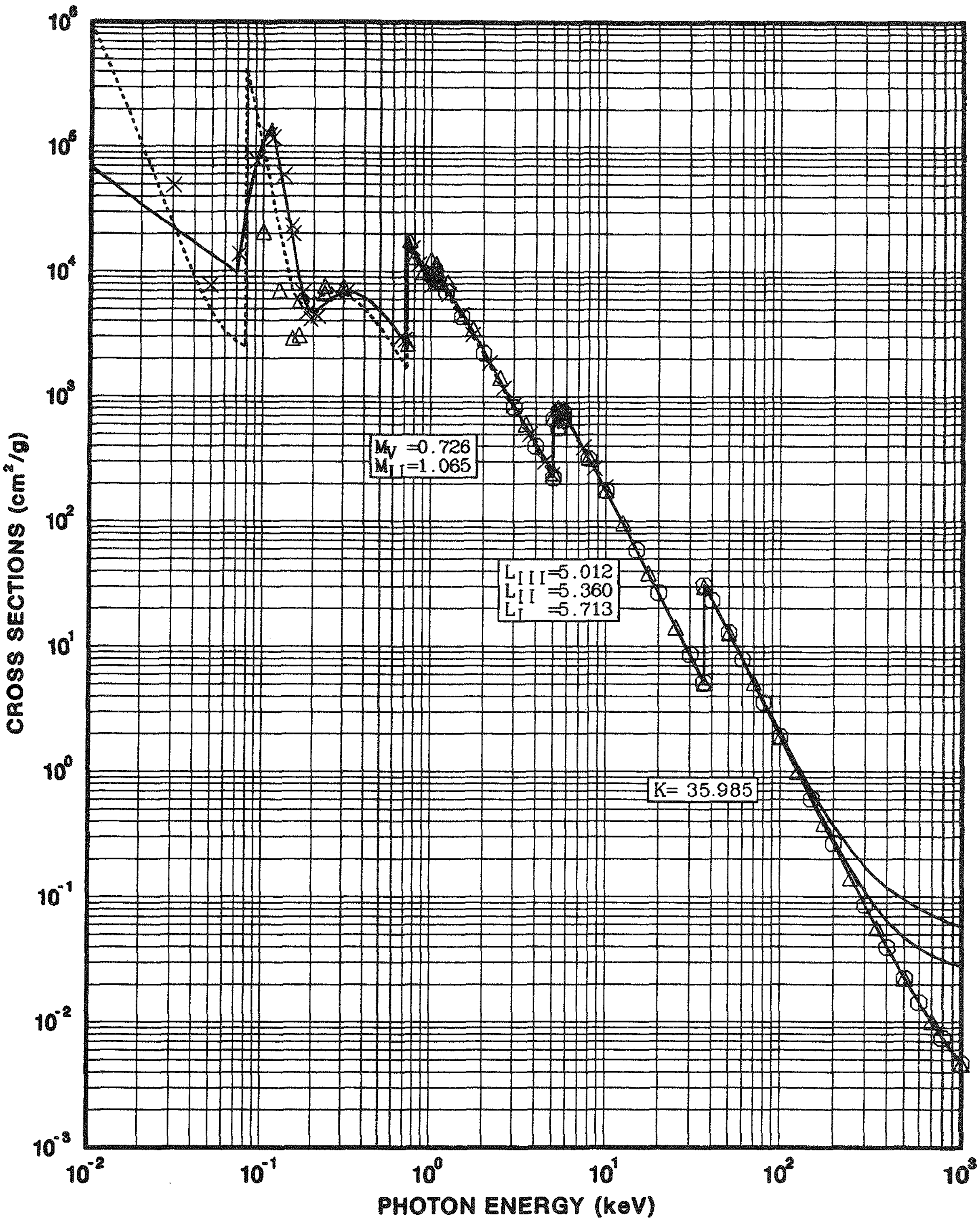
Barns/atom = 210.7 × cm^2/g

XENON 54



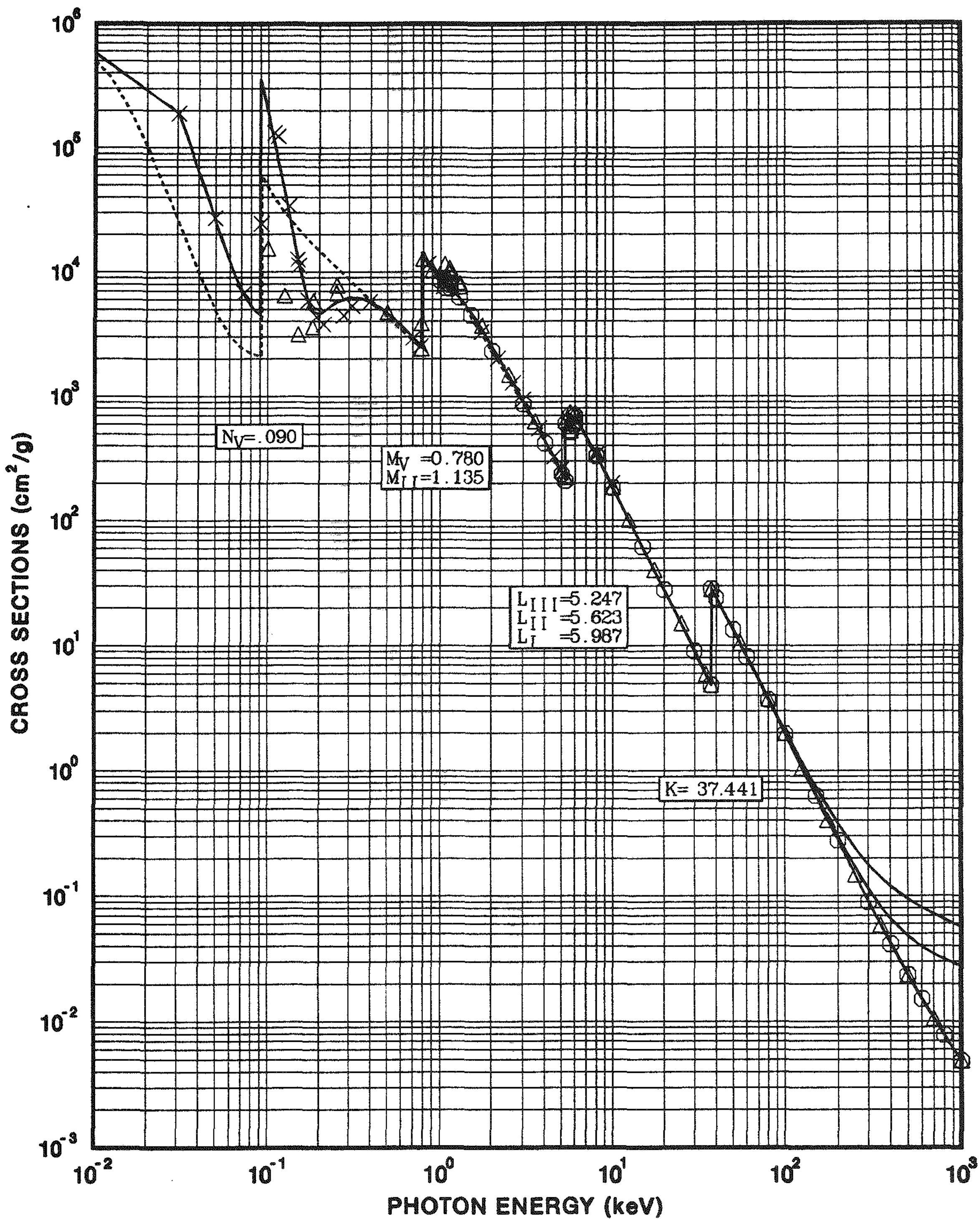
Barns/atom = 218.0 × cm²/g

CESIUM 55



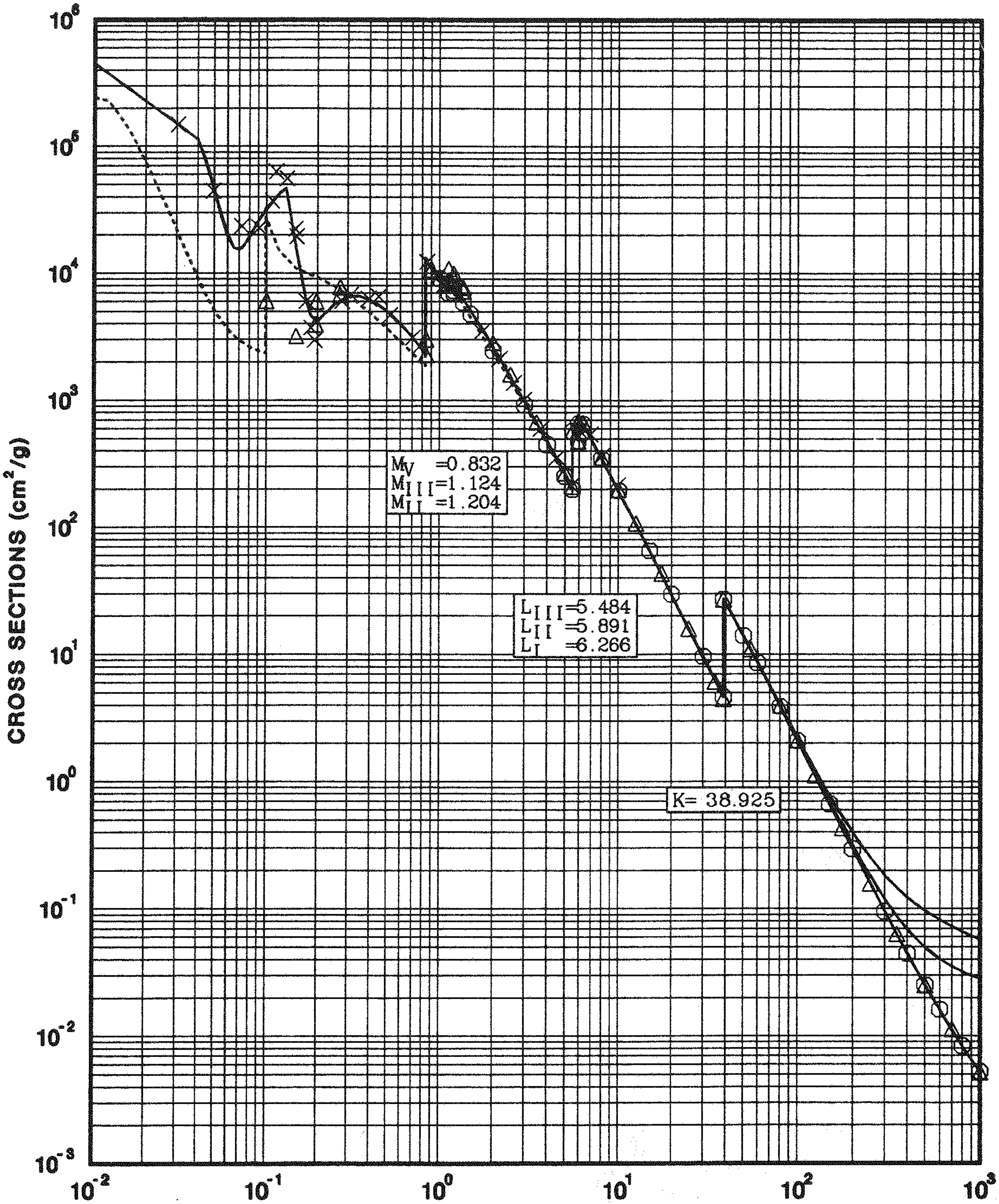
Barns/atom = 220.7 × cm^2/g

BARIUM 56



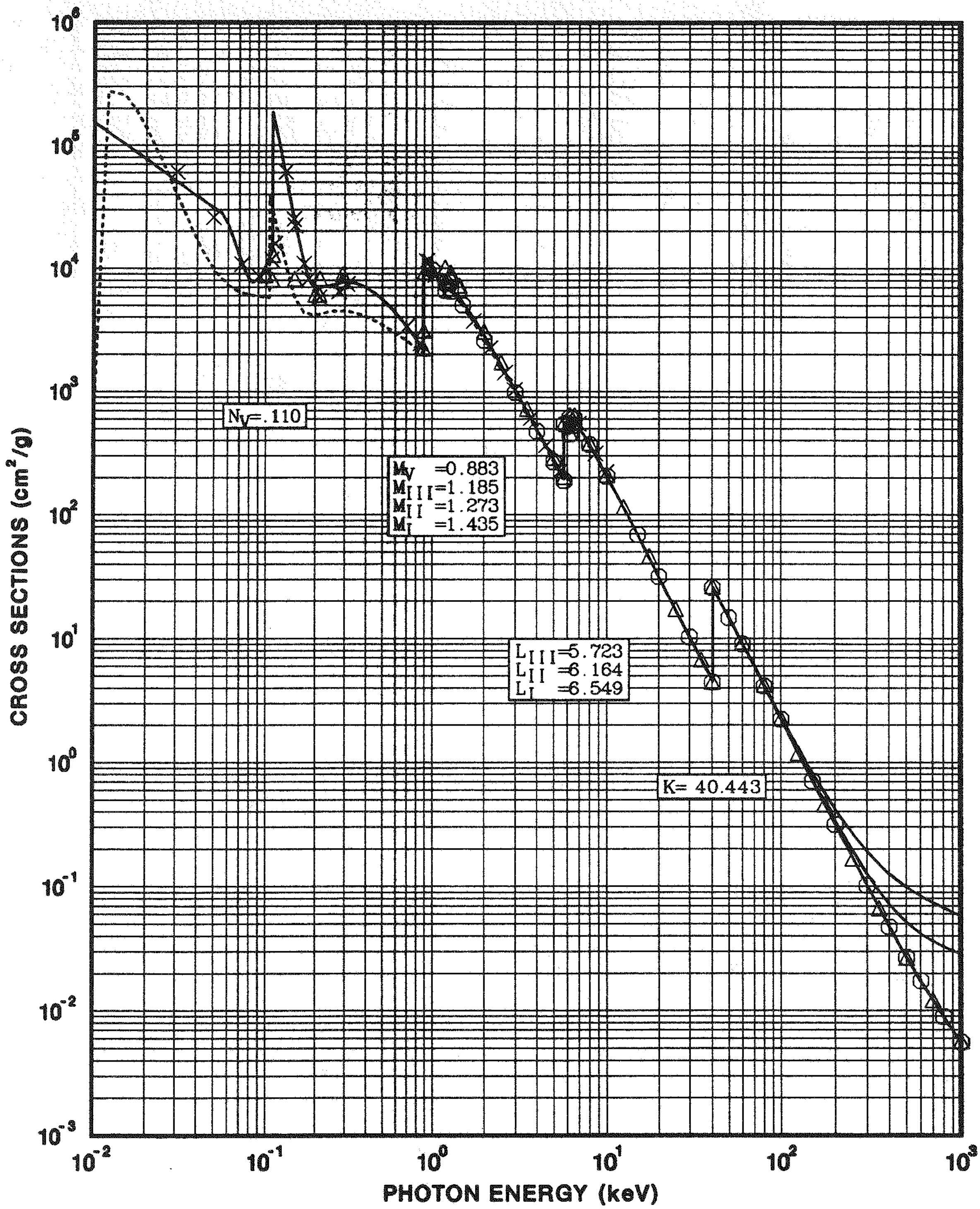
Barns/atom = 228.0 × cm^2/g

LANTHANUM 57



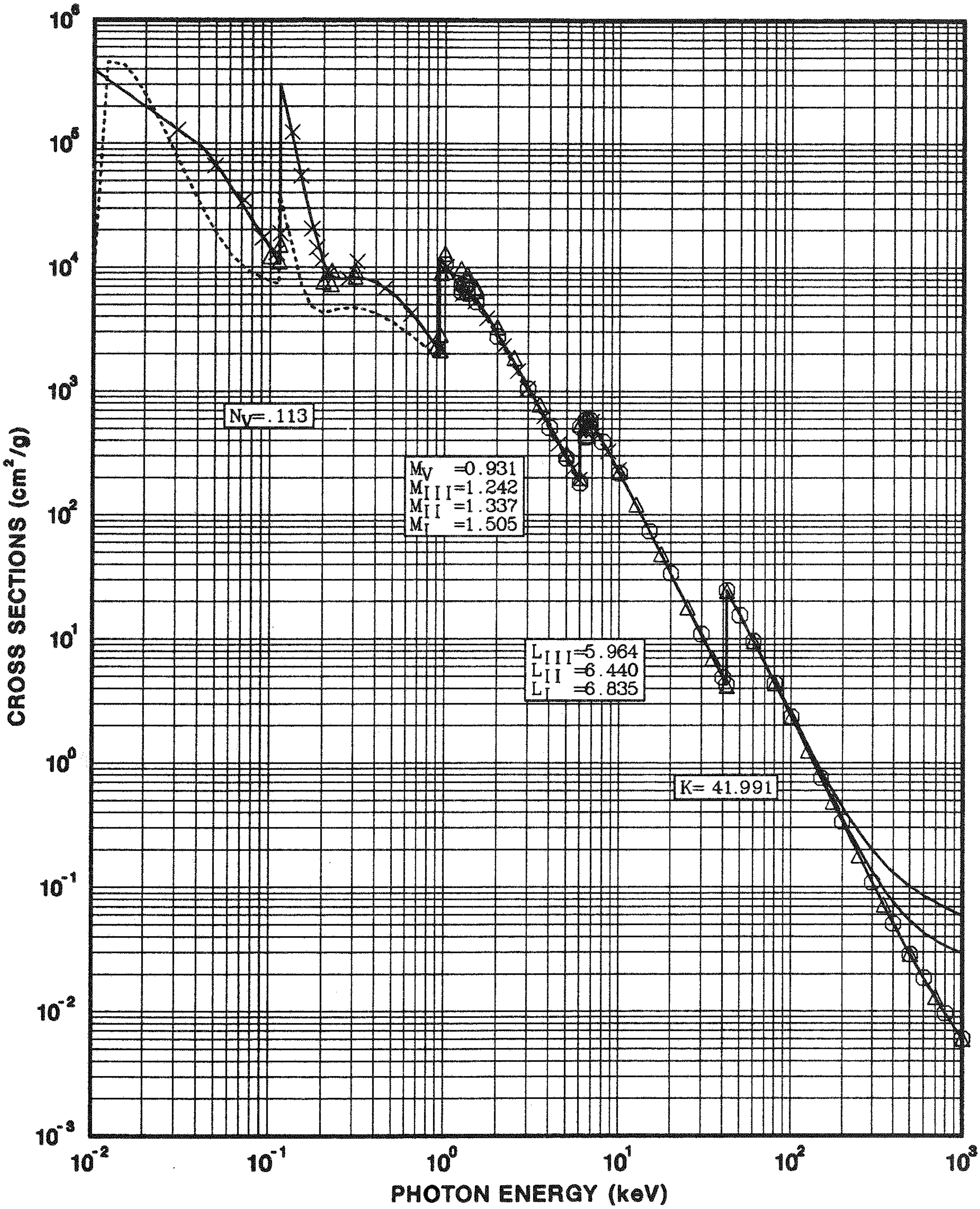
Barns/atom = 230.7 × cm^2/g

CERIUM 58



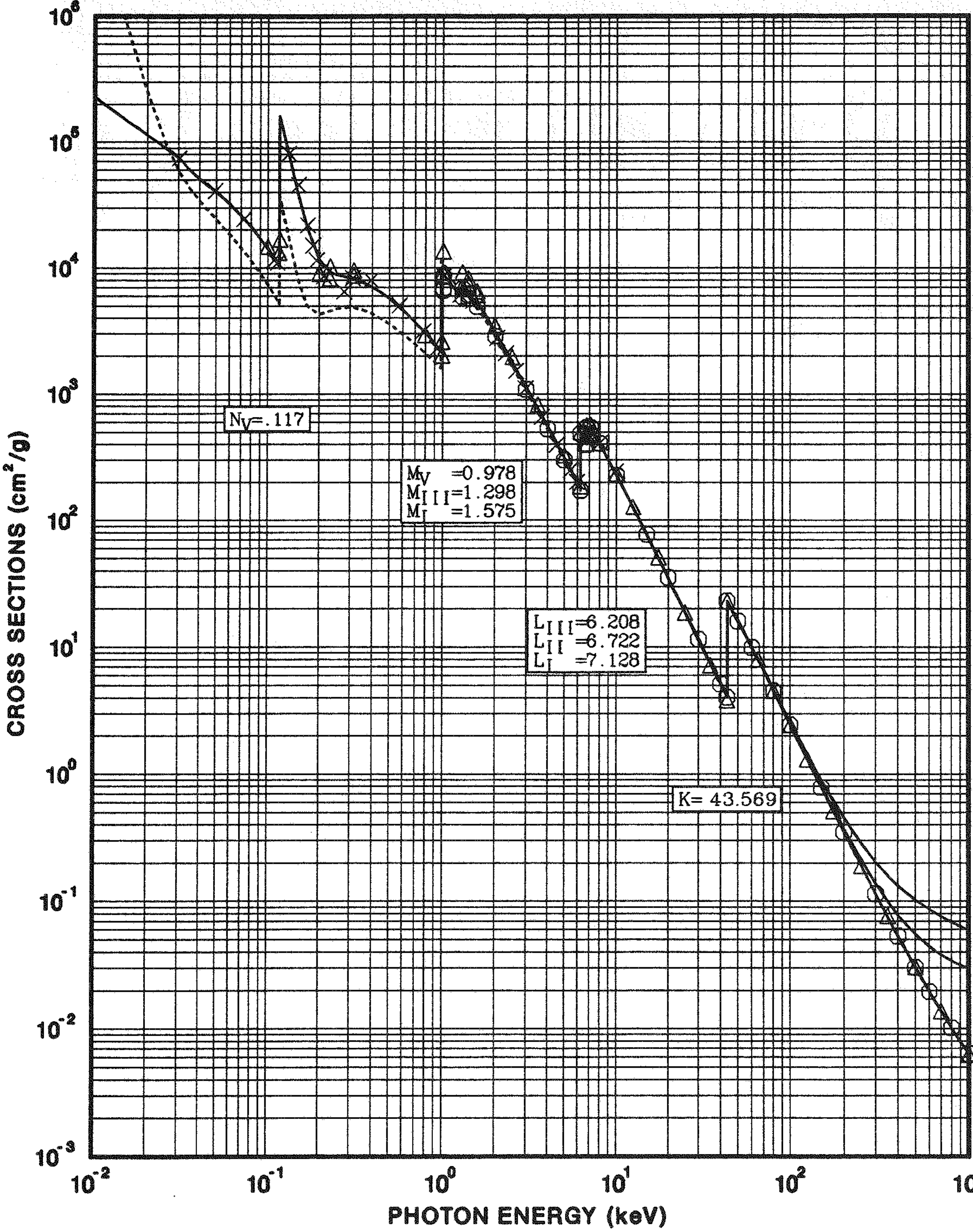
Barns/atom = 232.7 × cm^2/g

PRASEODYMIUM 59



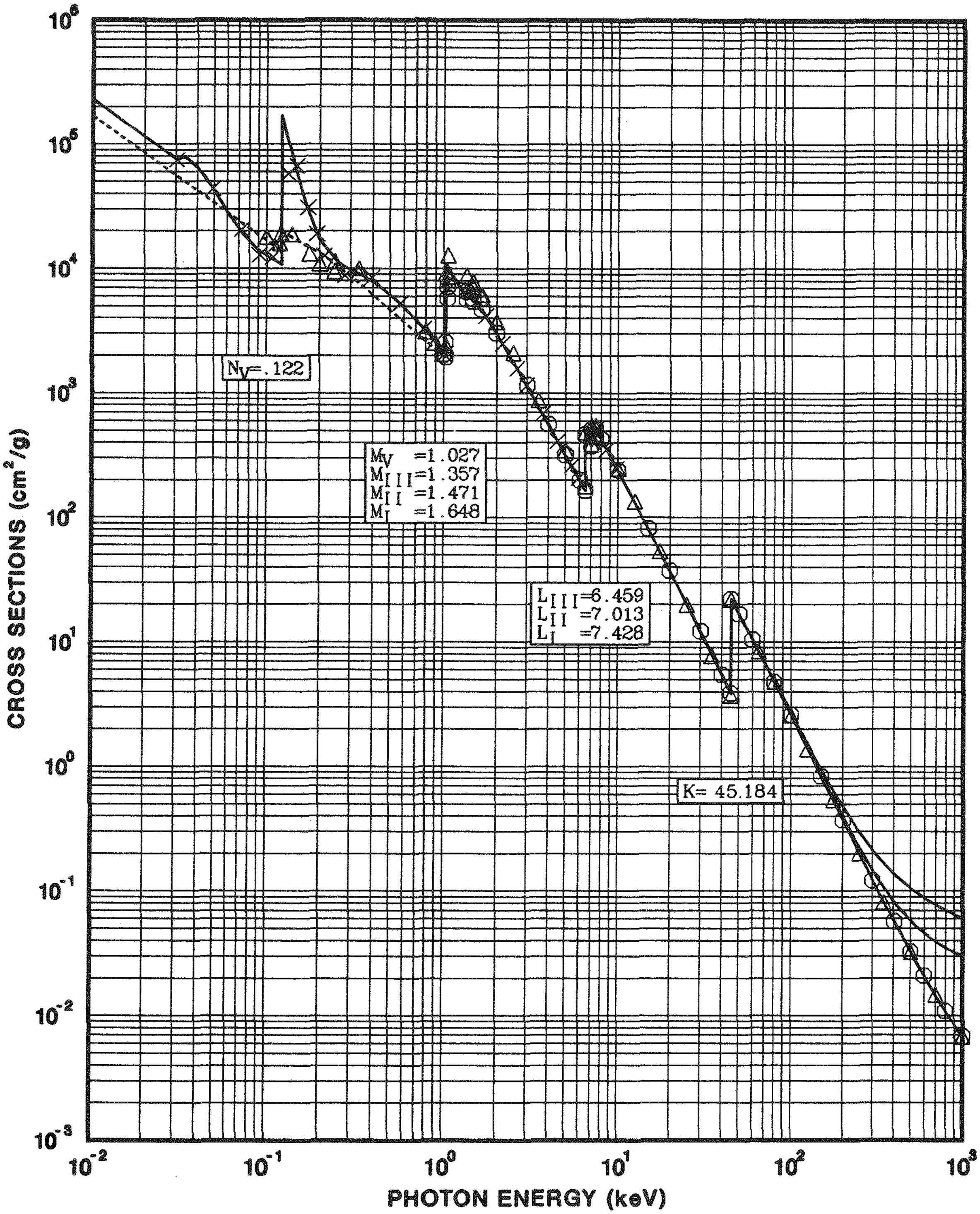
Barns/atom = 234.0 × cm^2/g

NEODYMIUM 60



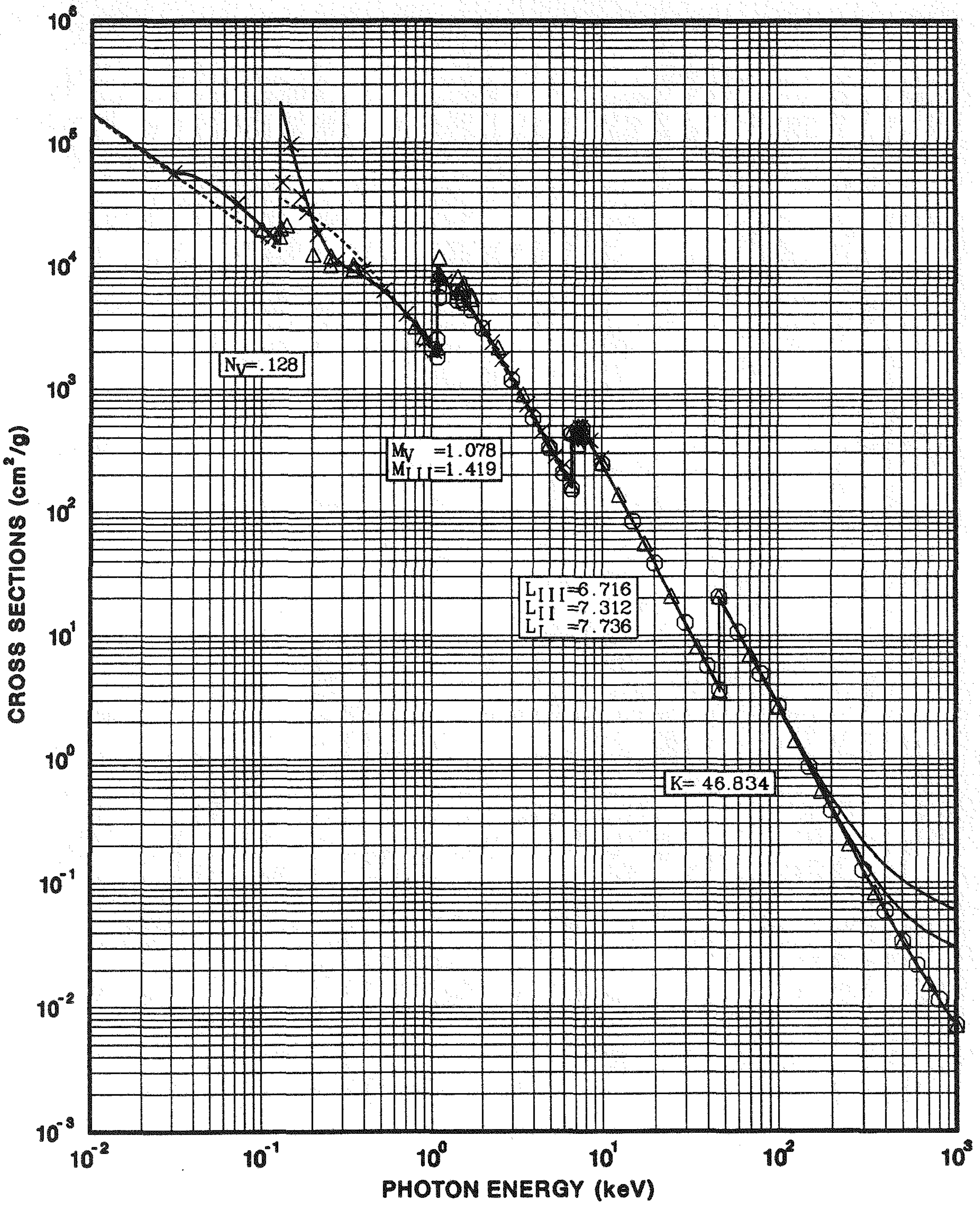
Barns/atom = 239.5 × cm^2/g

PROMETHIUM 61



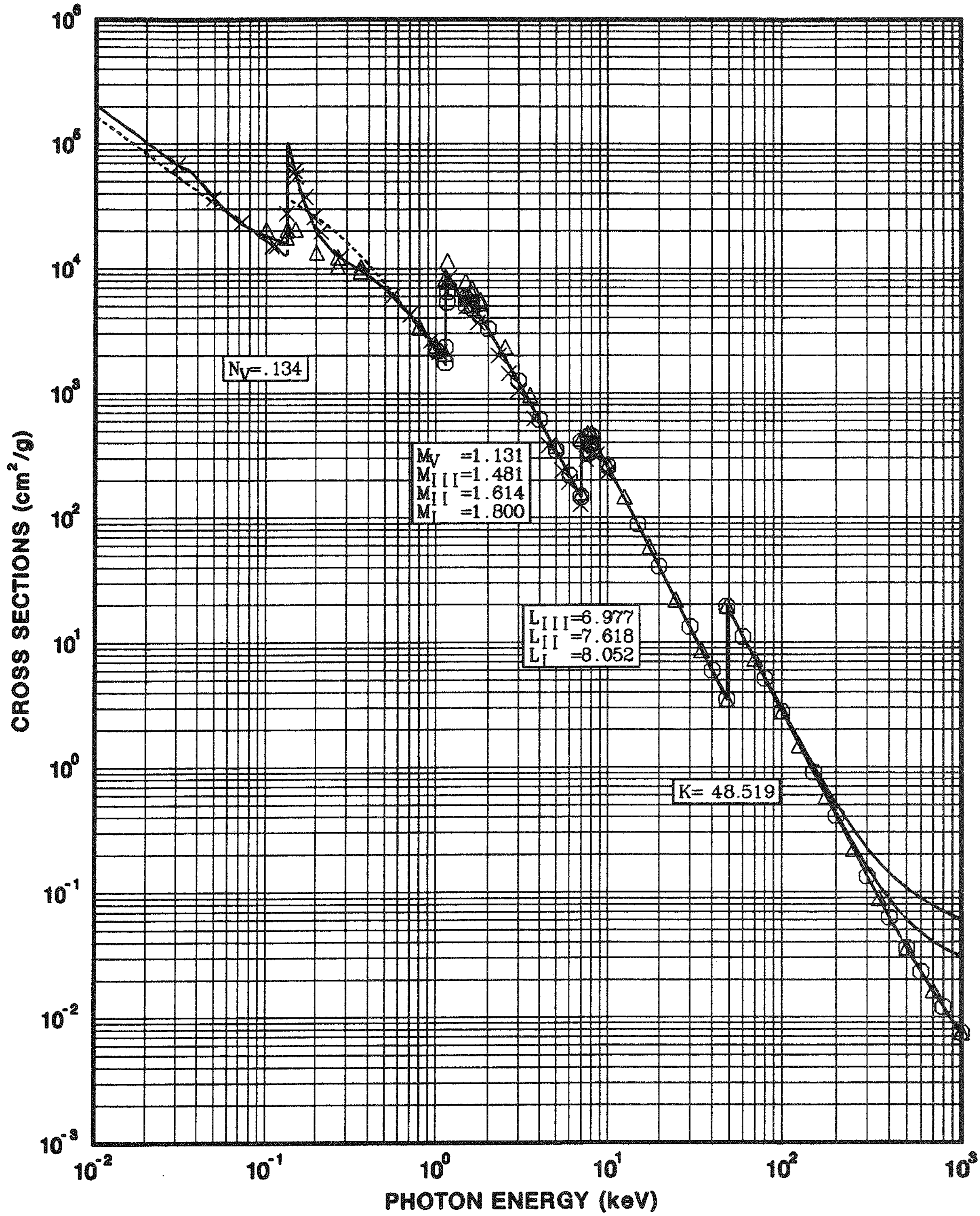
Barns/atom = 240.8 × cm^2/g

SAMARIUM 62



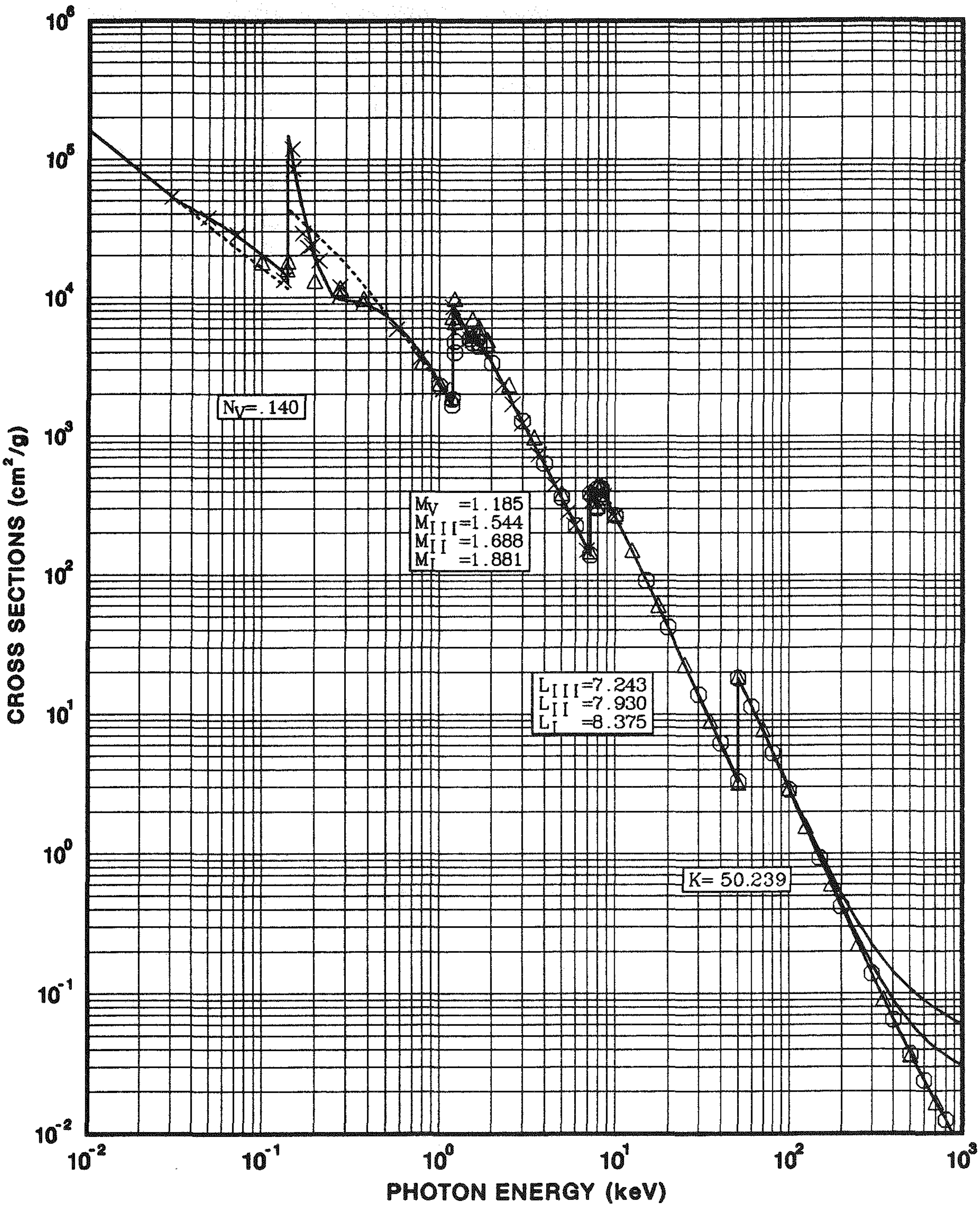
Barns/atom = 249.7 × cm^2/g

EUROPIUM 63



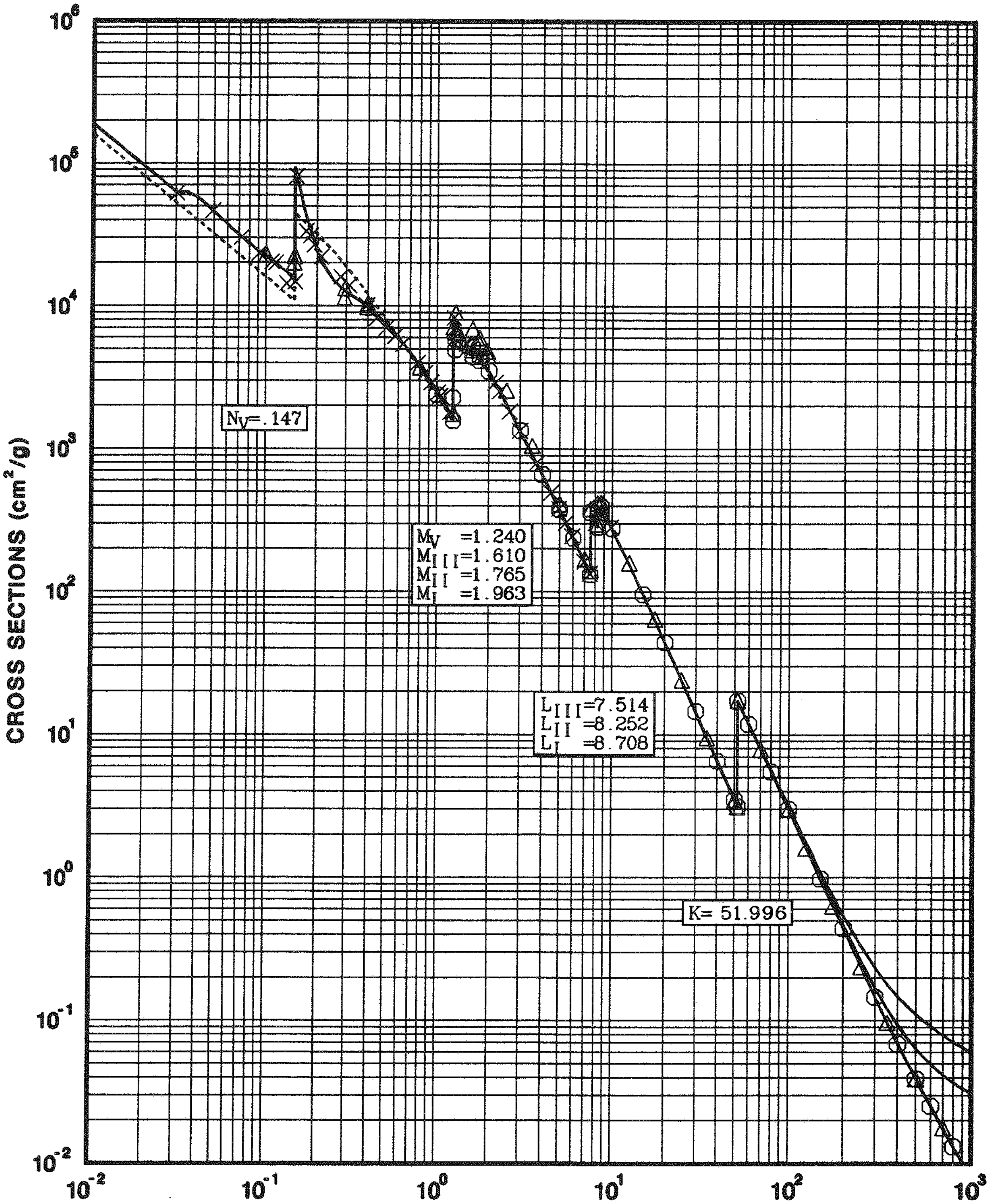
Barns/atom = 252.3 × cm²/g

GADOLINIUM 64



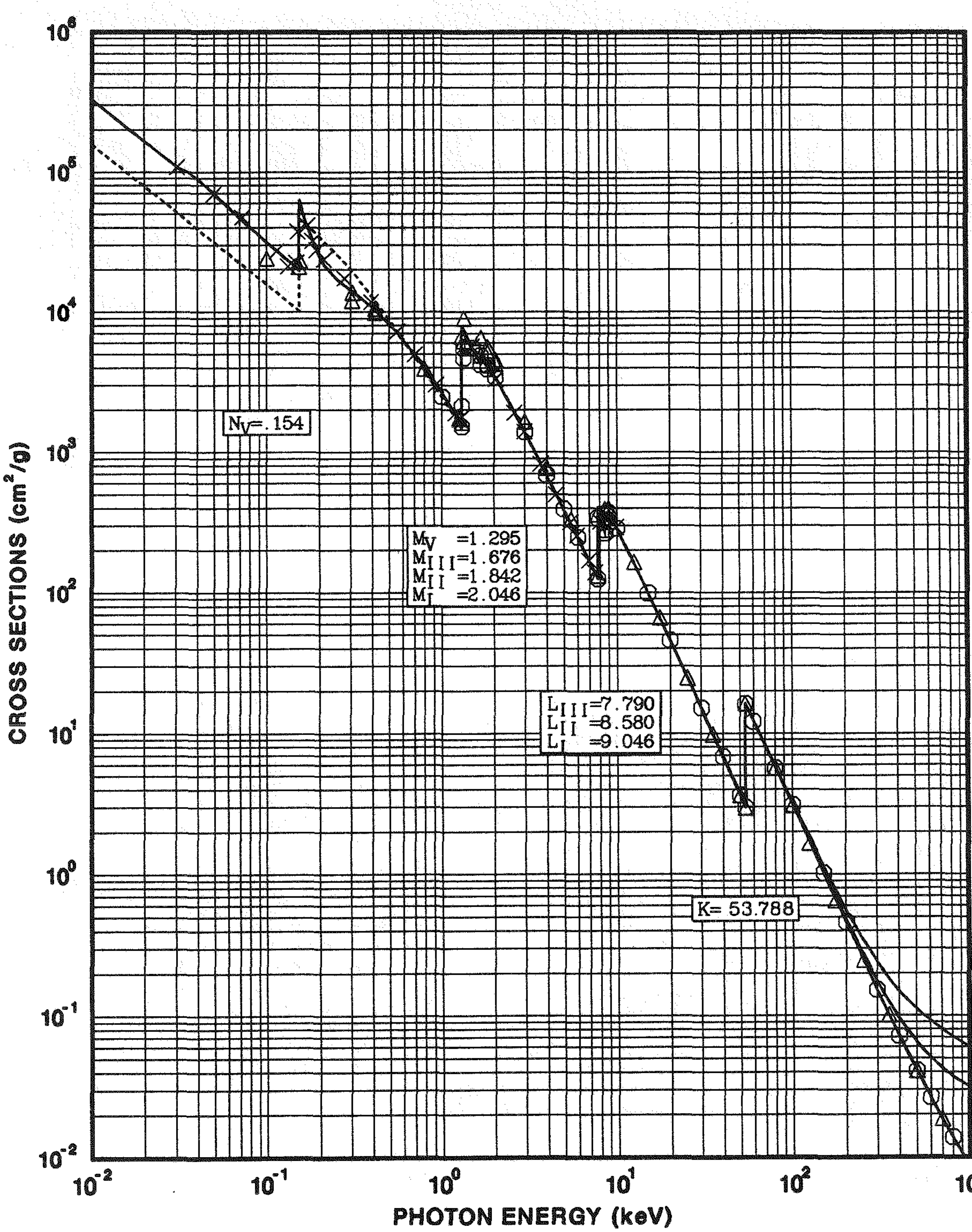
Barns/atom = 261.1 × cm^2/g

TERBIUM 65



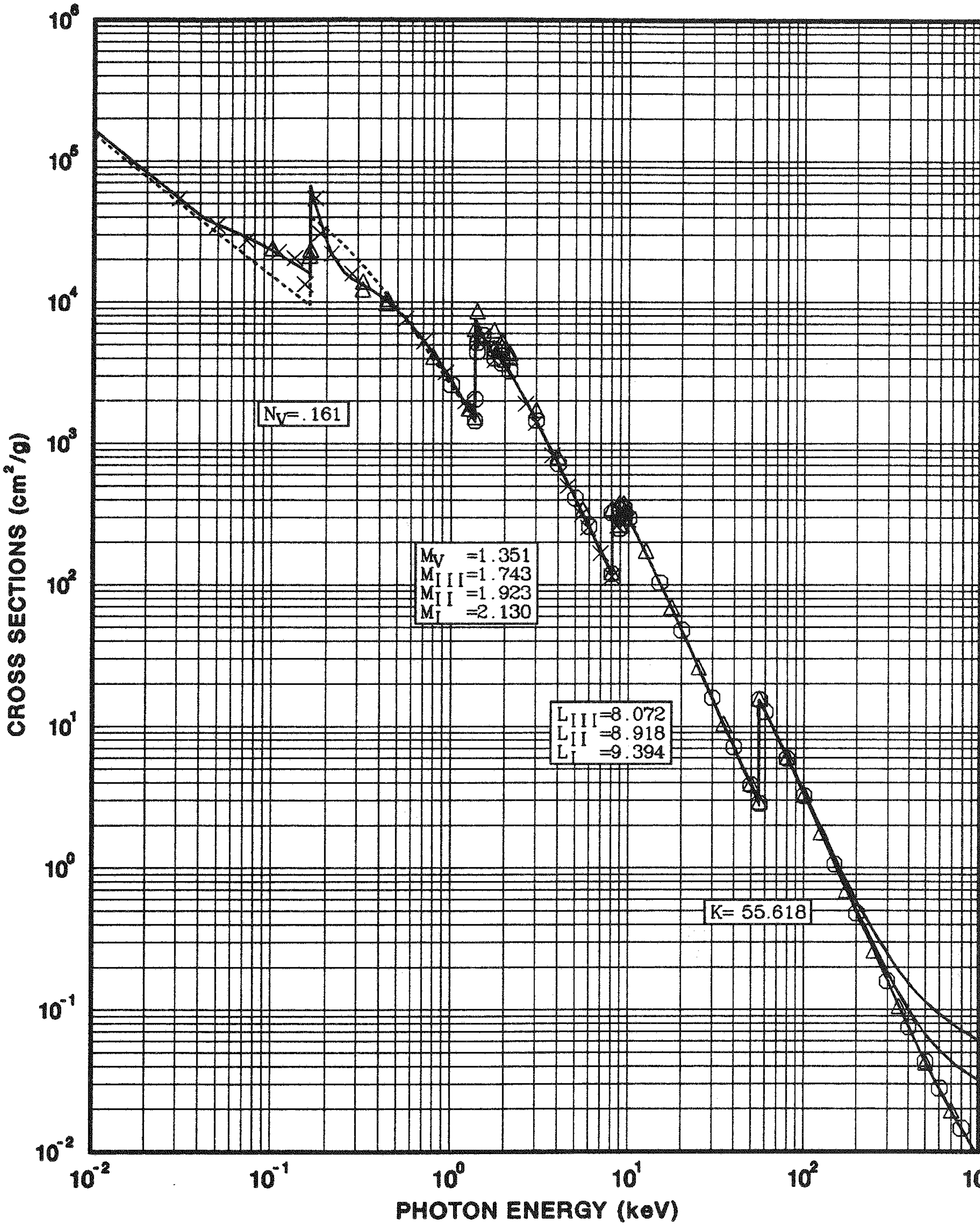
Barns/atom = 263.9 × cm^2/g

DYSPROSIUM 66



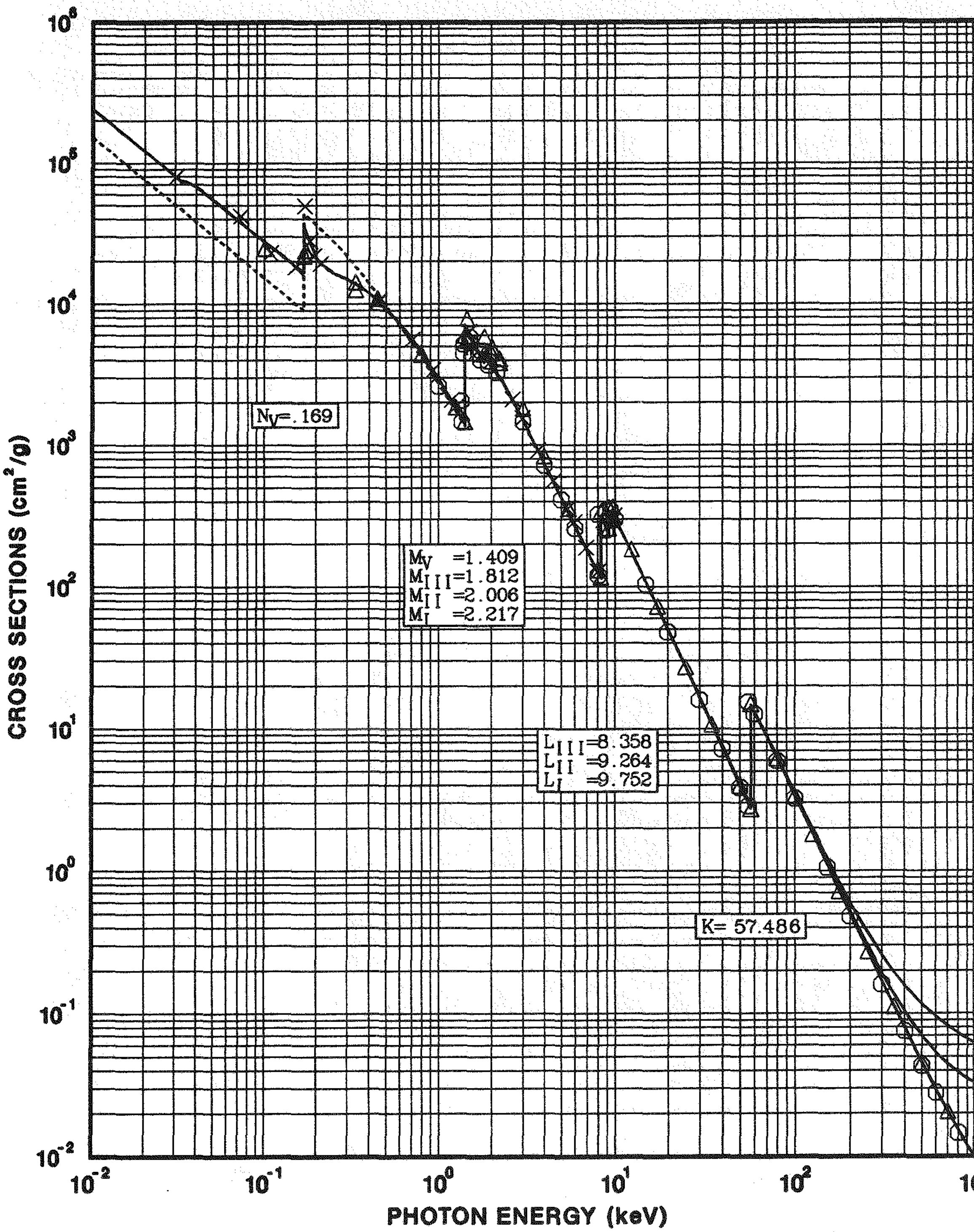
Barns/atom = 269.8 × cm^2/g

HOLMIUM 67



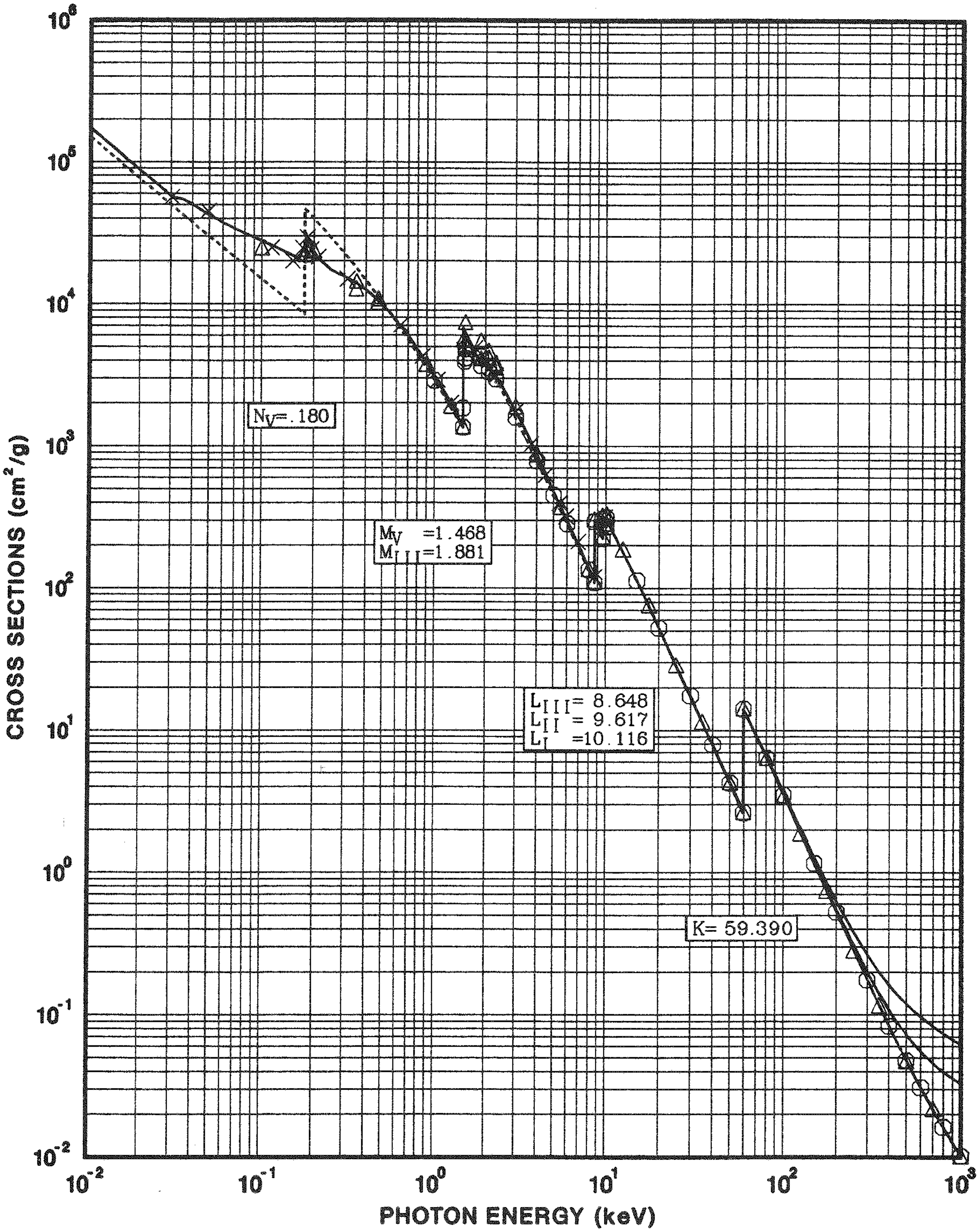
Barns/atom = 273.9 × cm^2/g

ERBIUM 68



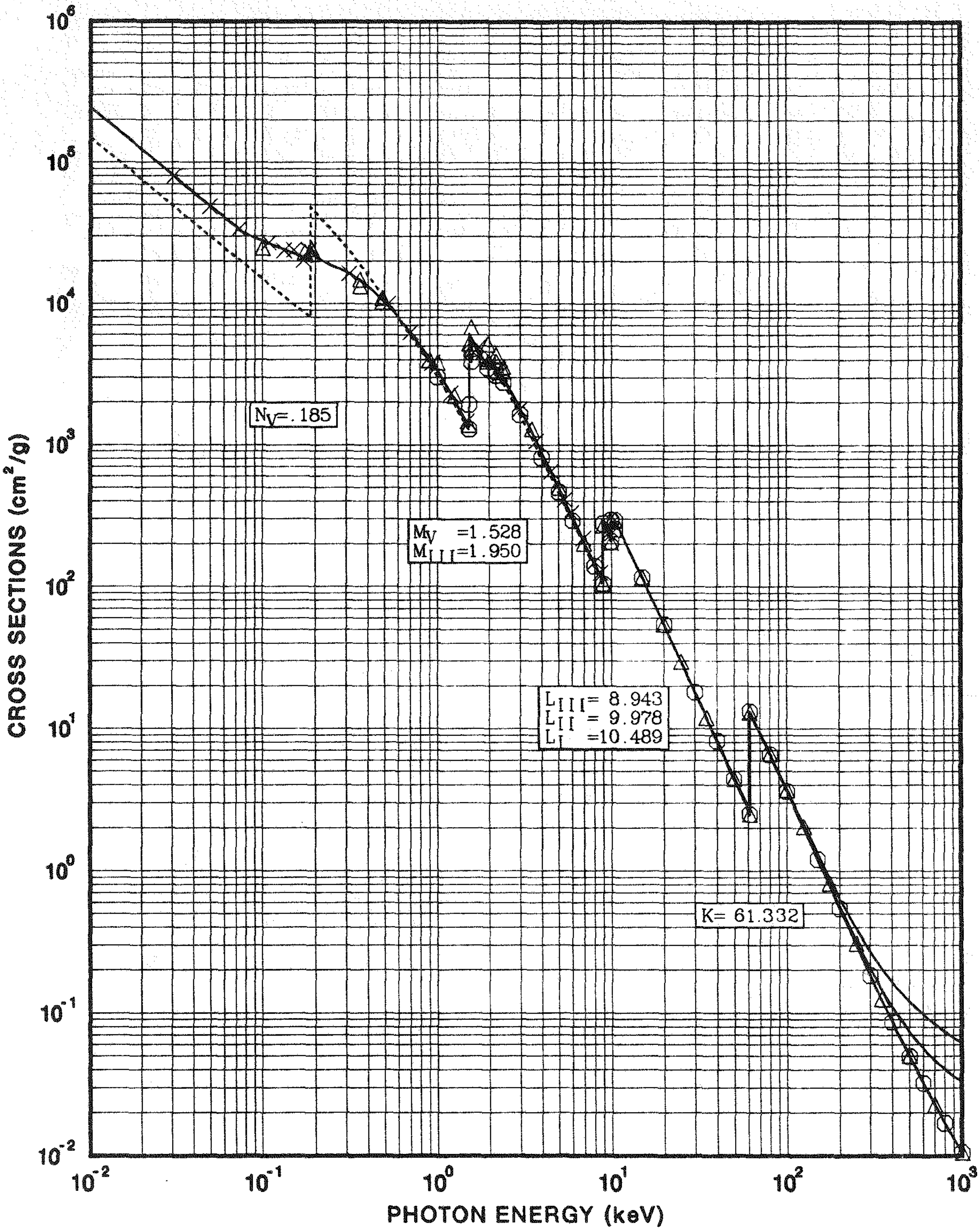
Barns/atom = 277.7 × cm^2/g

THULIUM 69



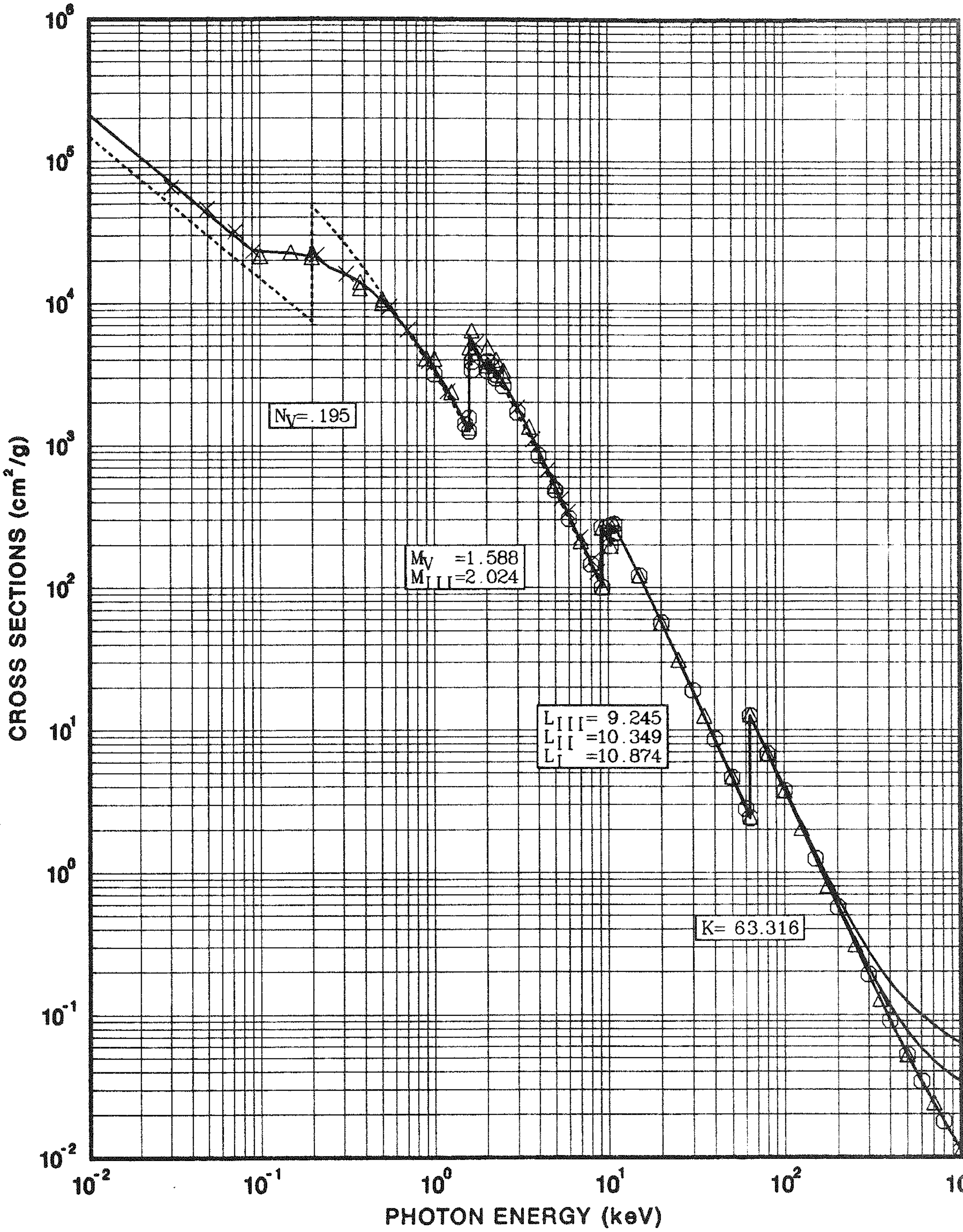
Barns/atom = 280.5 × cm^2/g

YTTERBIUM 70



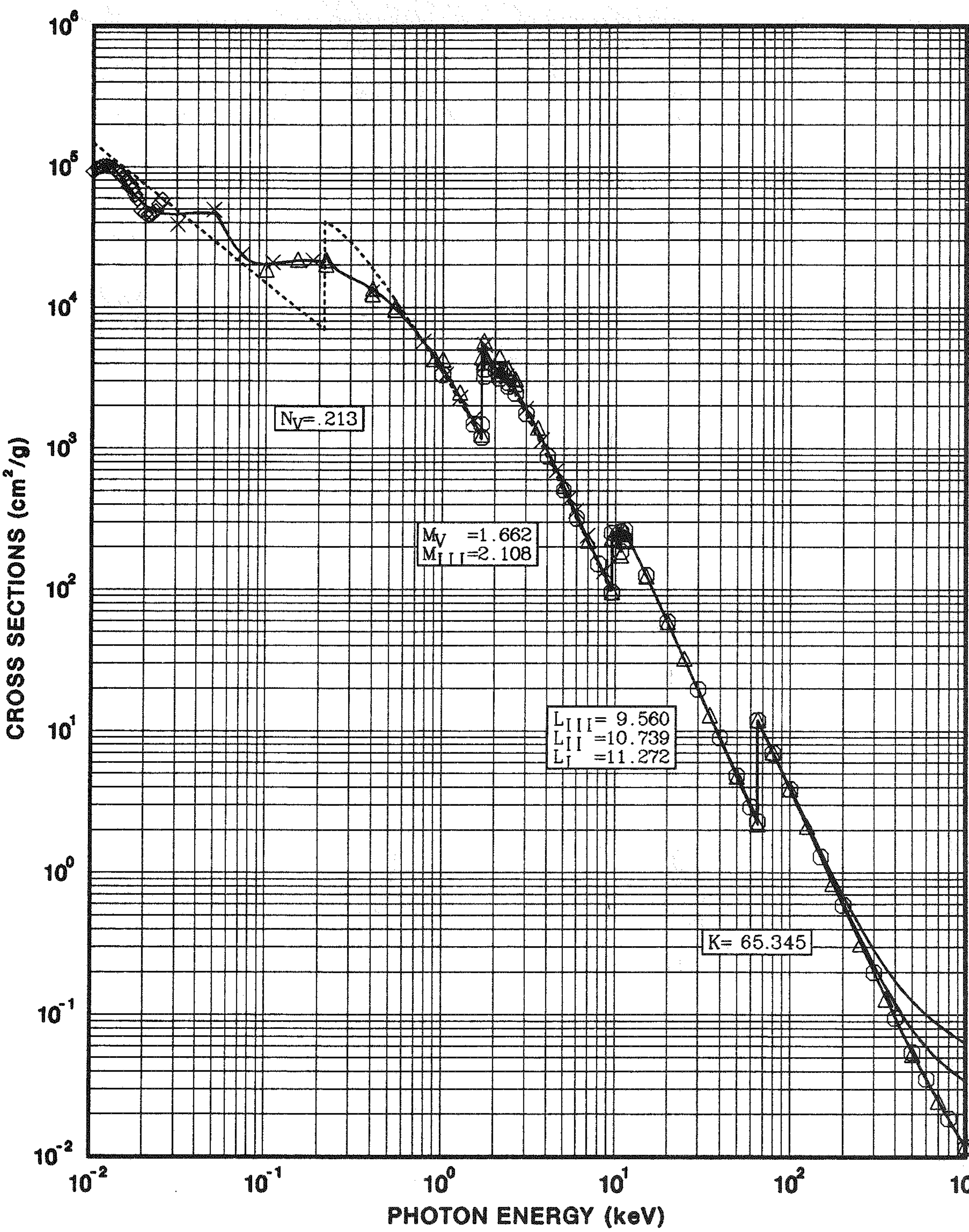
Barns/atom = 287.3 × cm^2/g

LUTETIUM 71



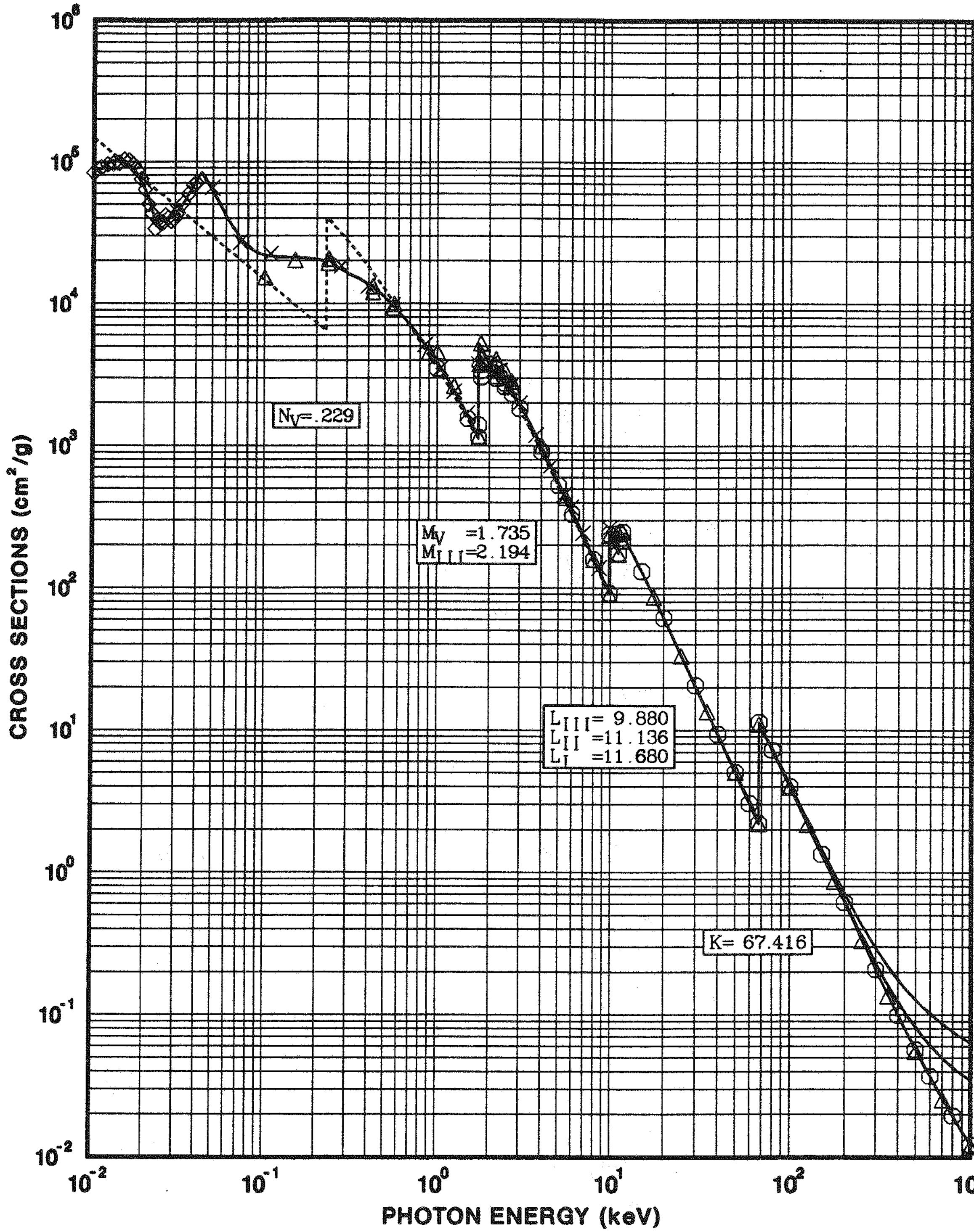
Barns/atom = 290.5 × cm^2/g

HAFNIUM 72



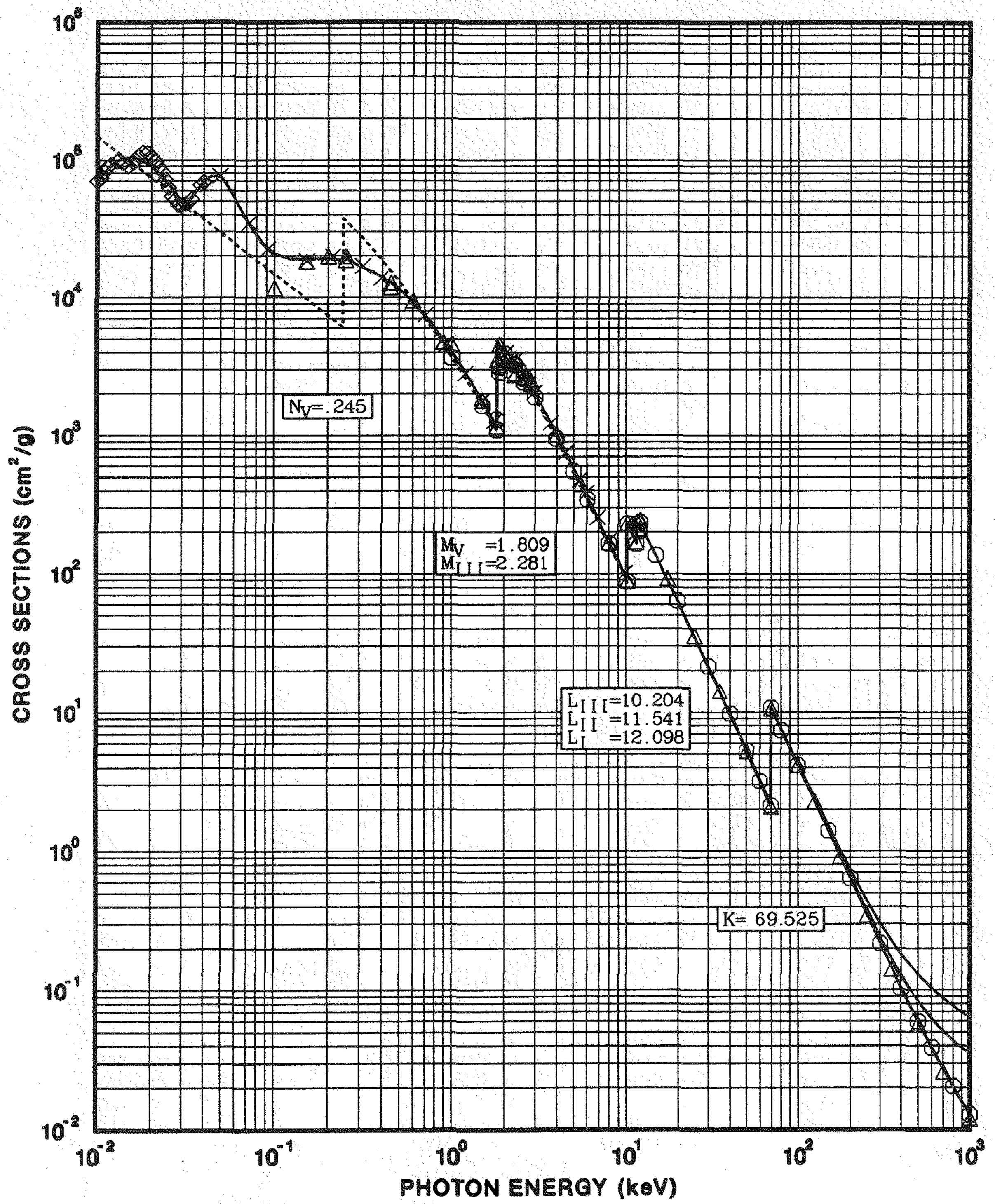
Barns/atom = 296.4 × cm^2/g

TANTALUM 73



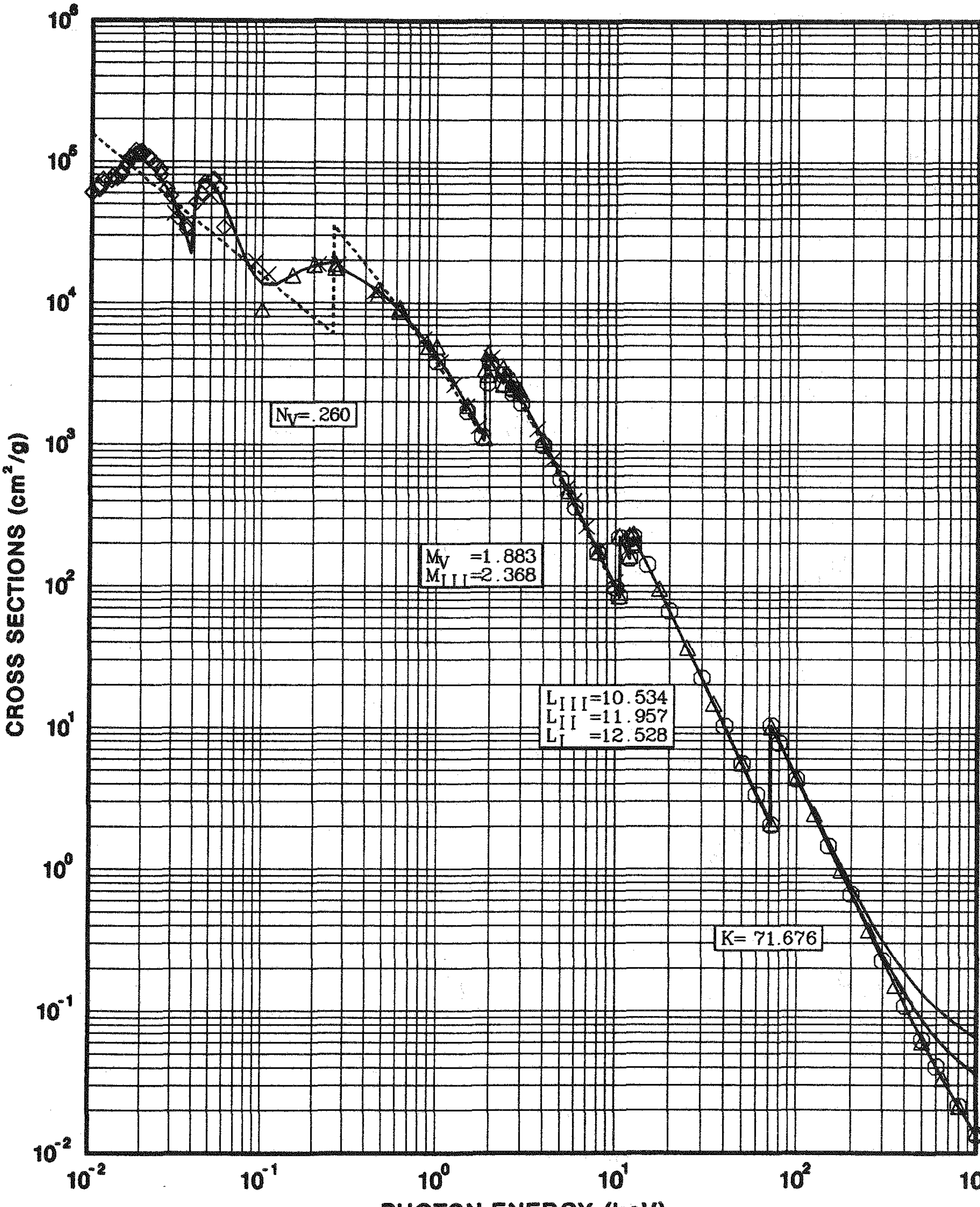
Barns/atom = 300.5 × cm²/g

TUNGSTEN 74



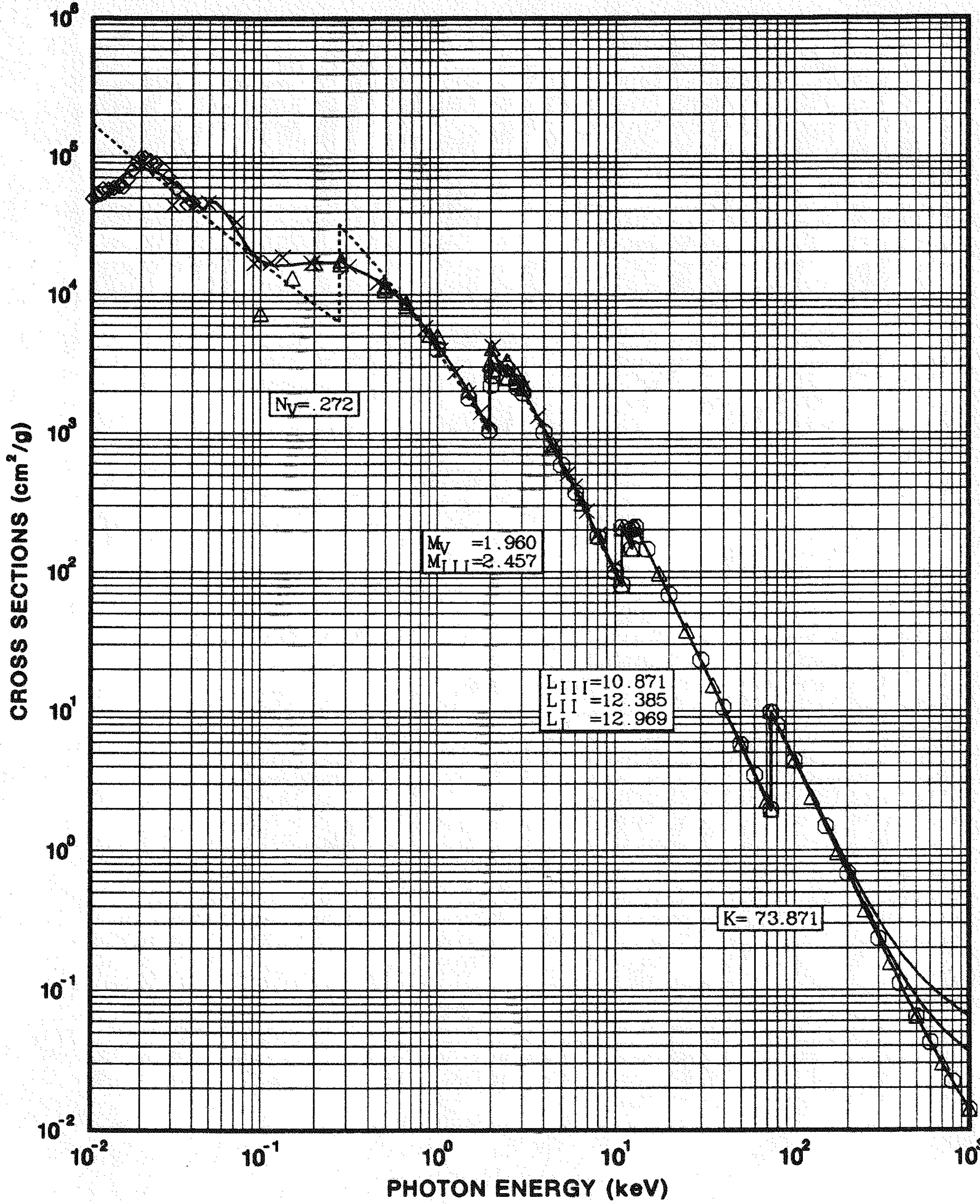
Barns/atom = 305.3 × cm²/g

RHENIUM 75



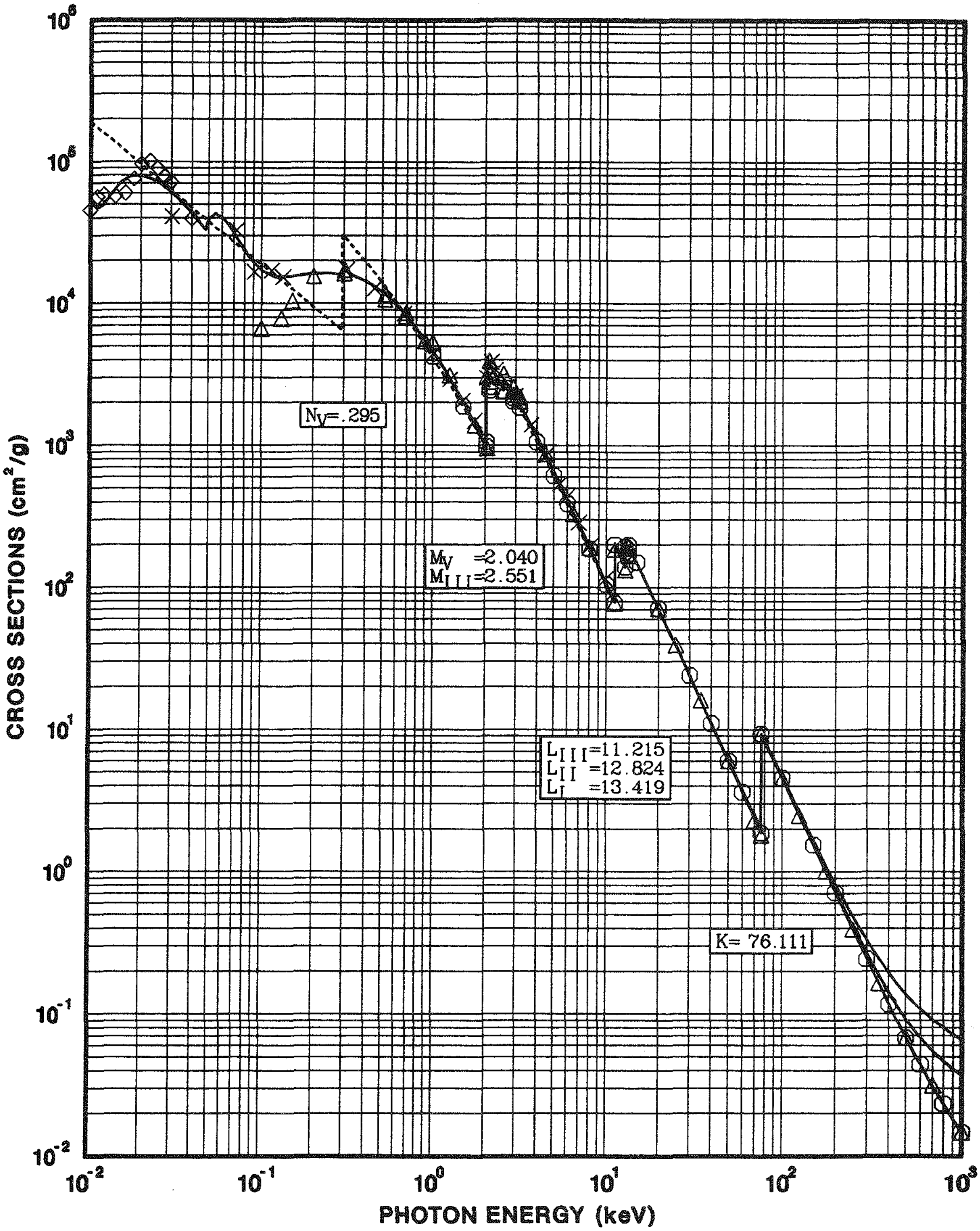
Barns/atom = 309.2 × cm^2/g

OSMIUM 76



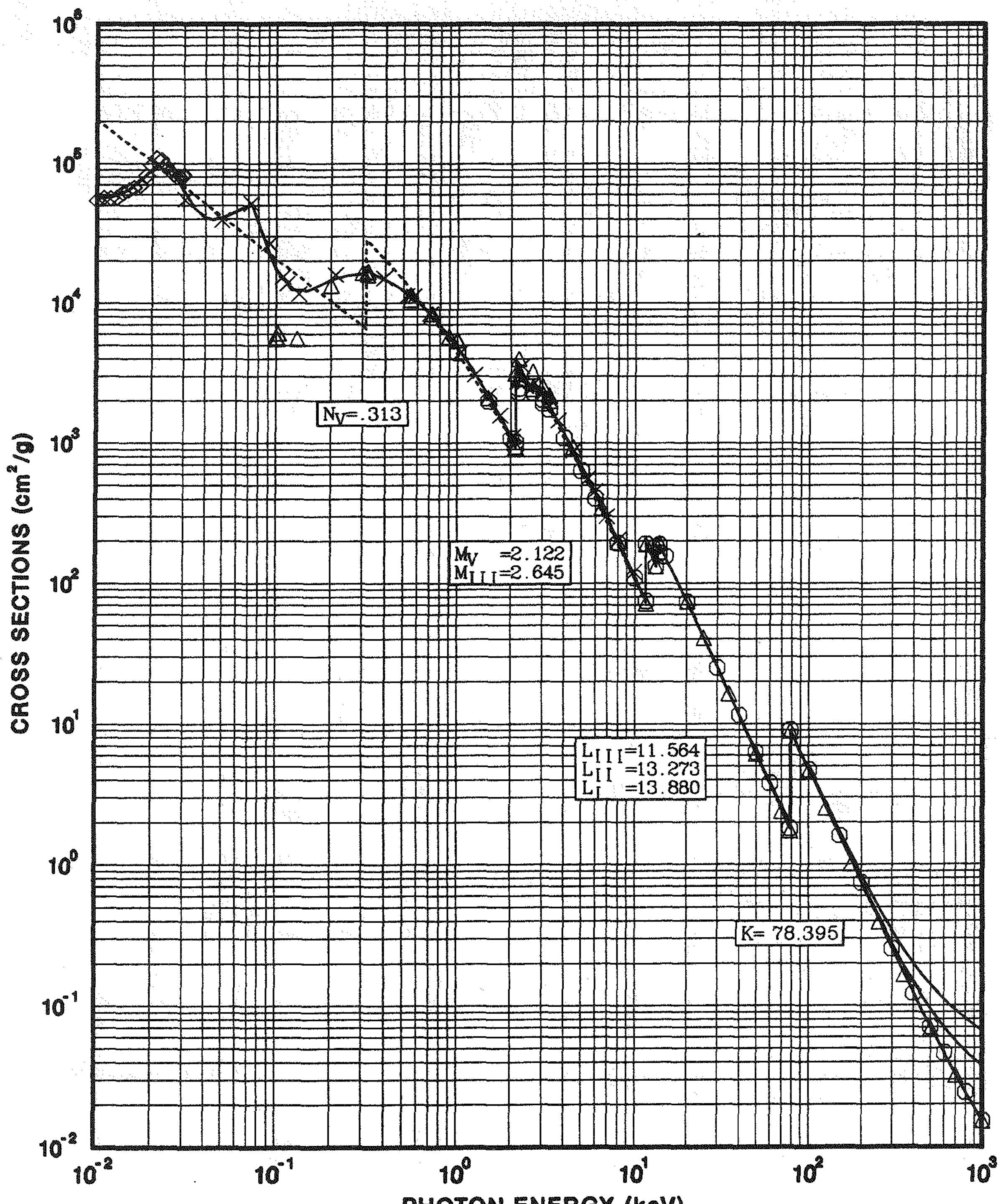
Barns/atom = 315.8 × cm^2/g

IRIDIUM 77



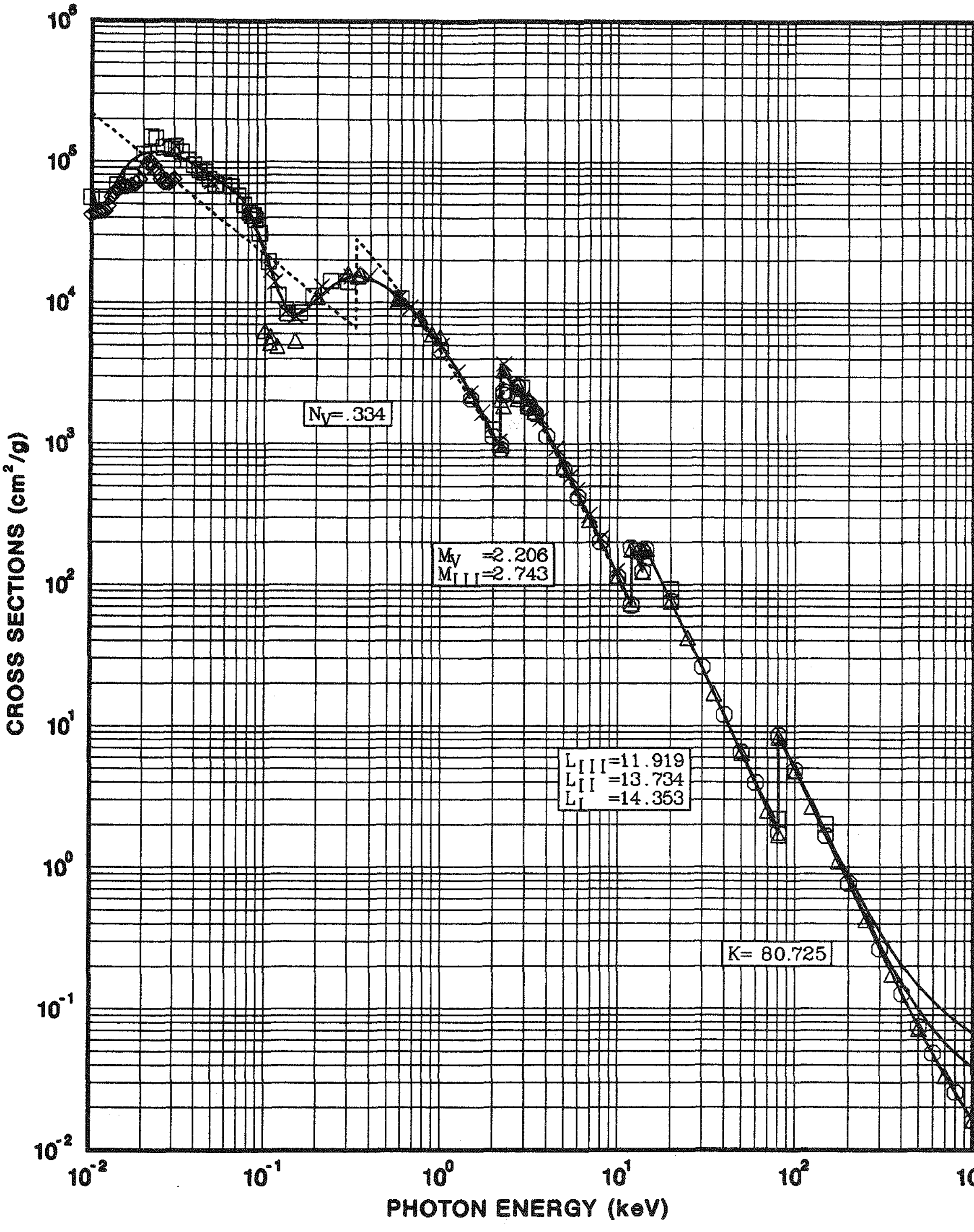
Barns/atom = 319.2 × cm²/g

PLATINUM 78



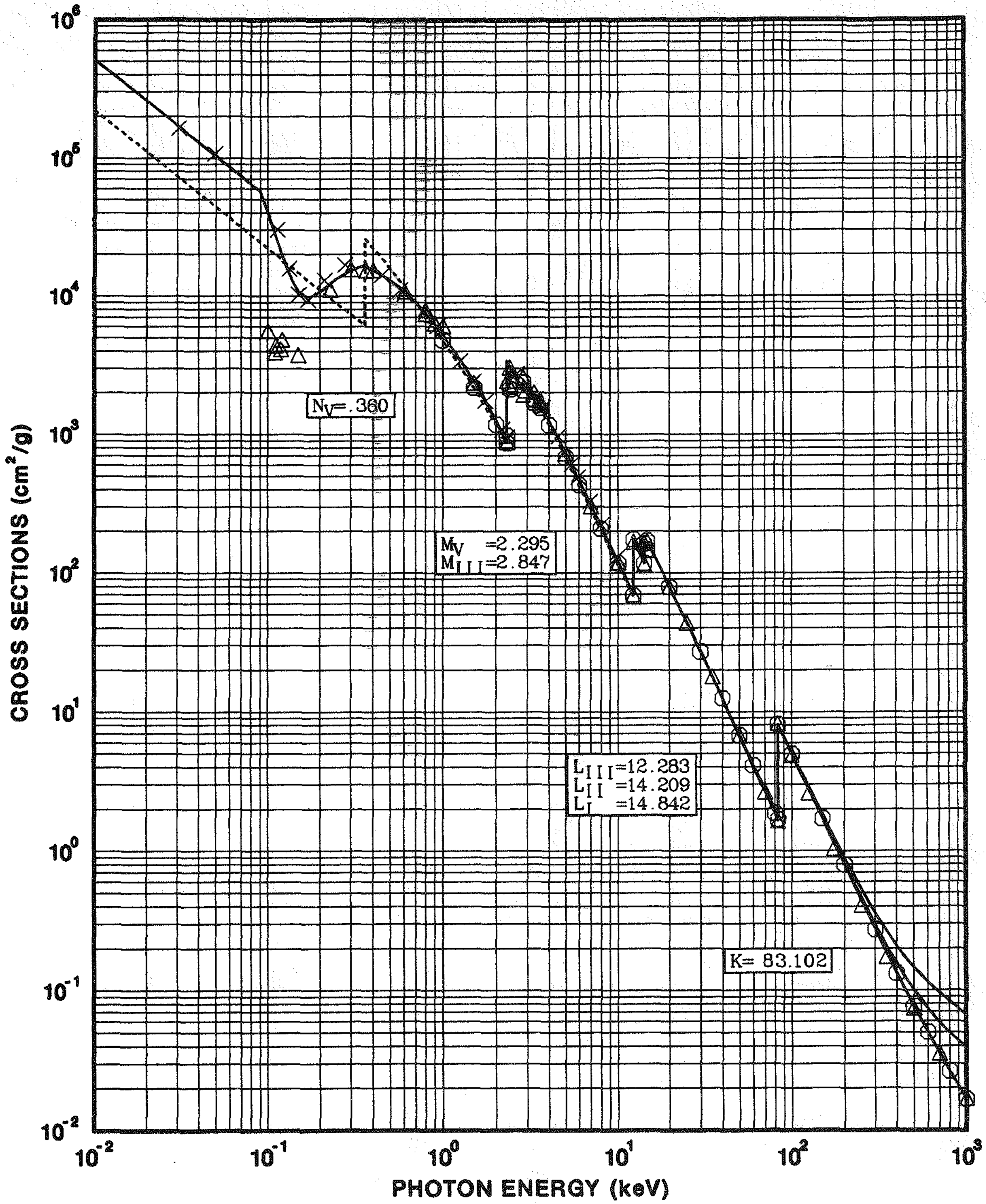
Barns/atom = 323.9 × cm^2/g

GOLD 79



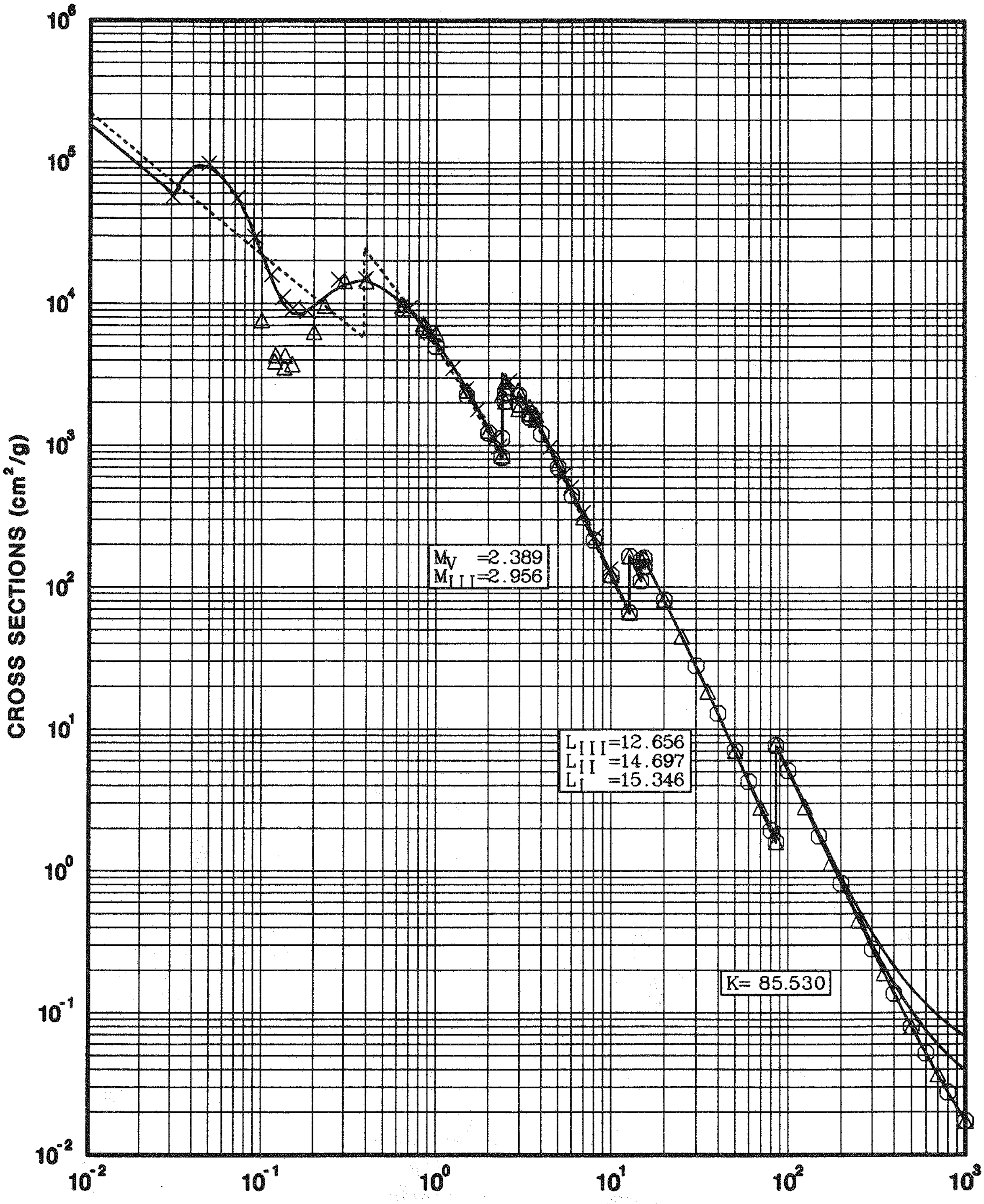
Barns/atom = 327.1 × cm^2/g

MERCURY 80



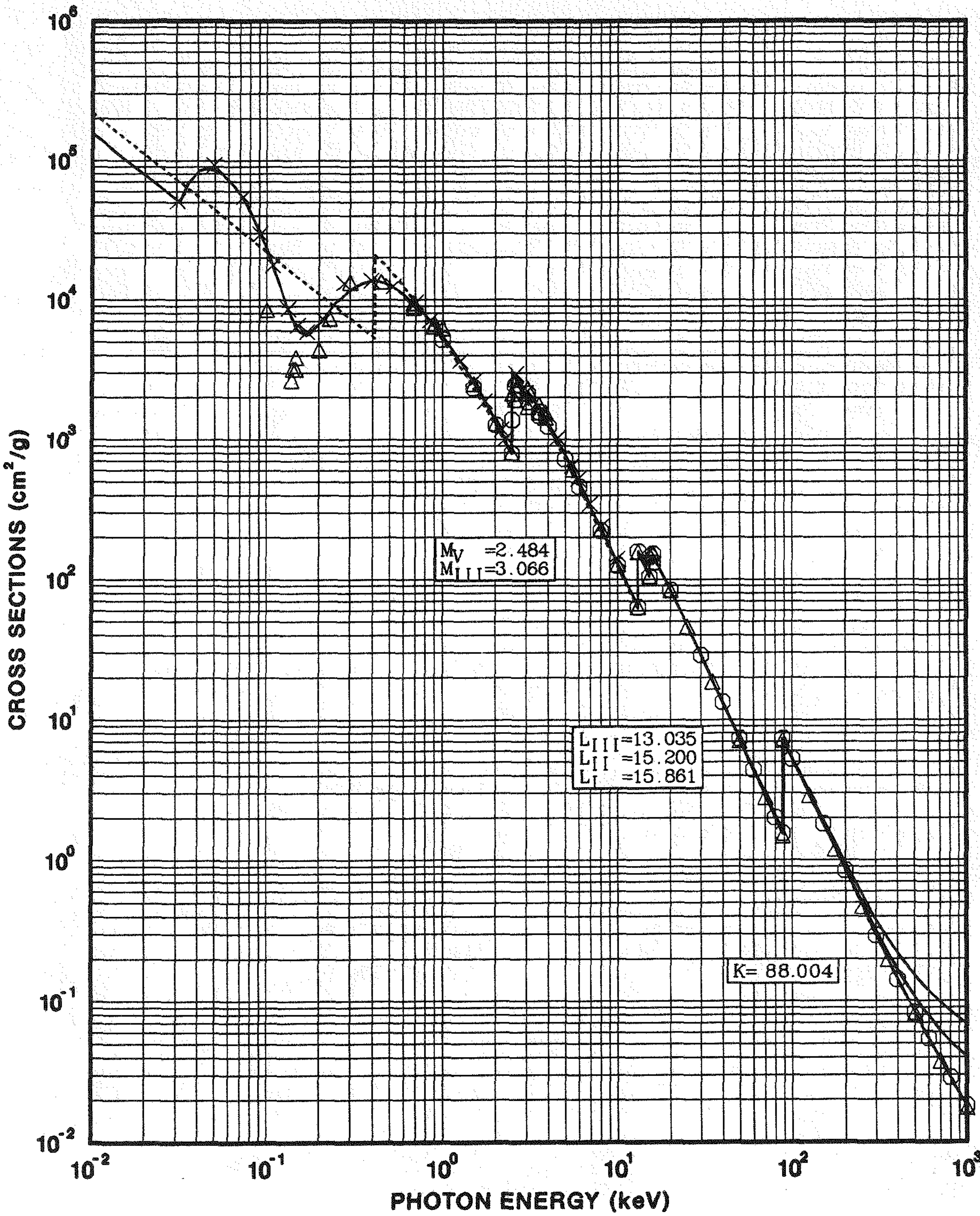
Barns/atom = 333.1 × cm^2/g

THALLIUM 81



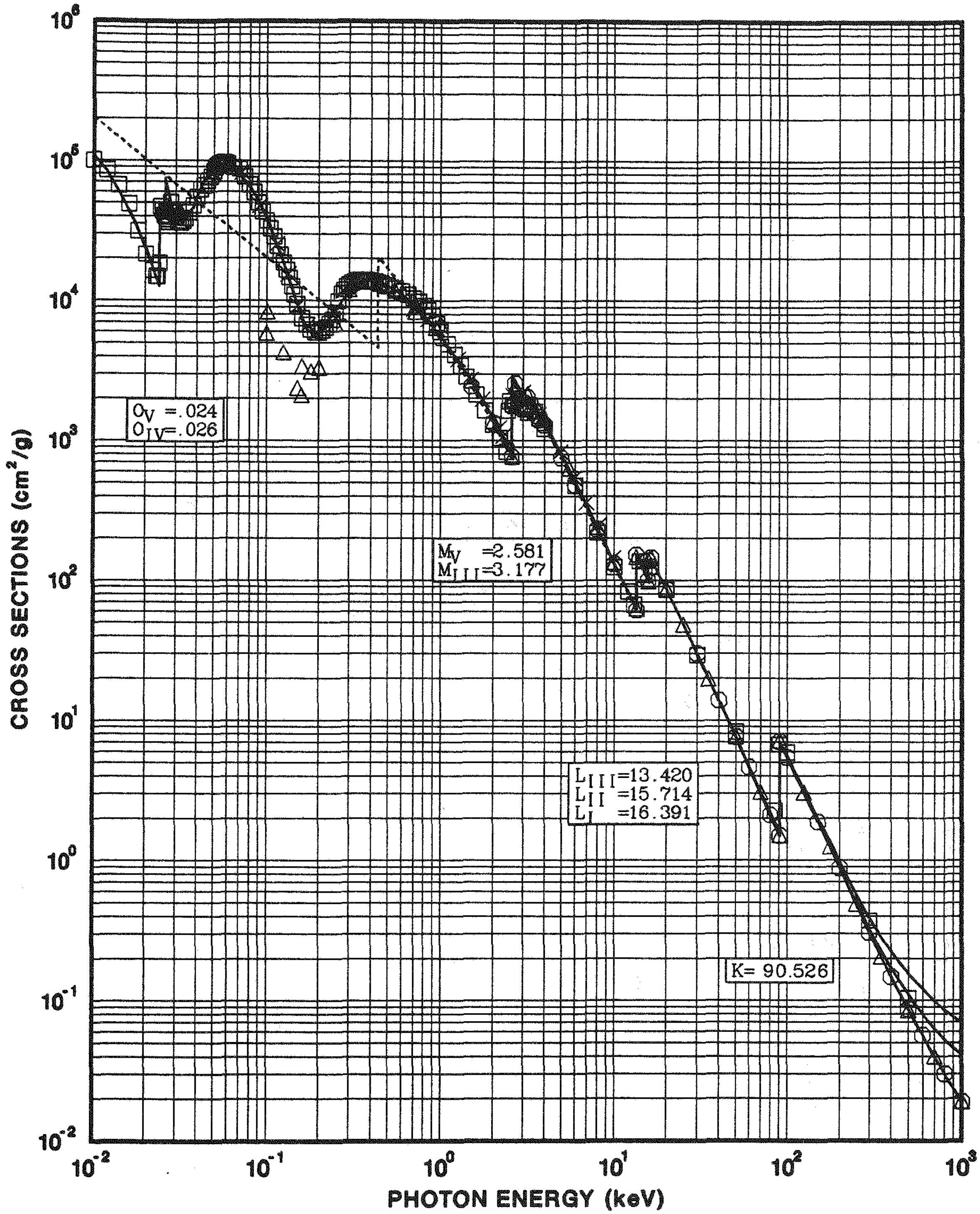
Barns/atom = 339.4 × cm^2/g

LEAD 82



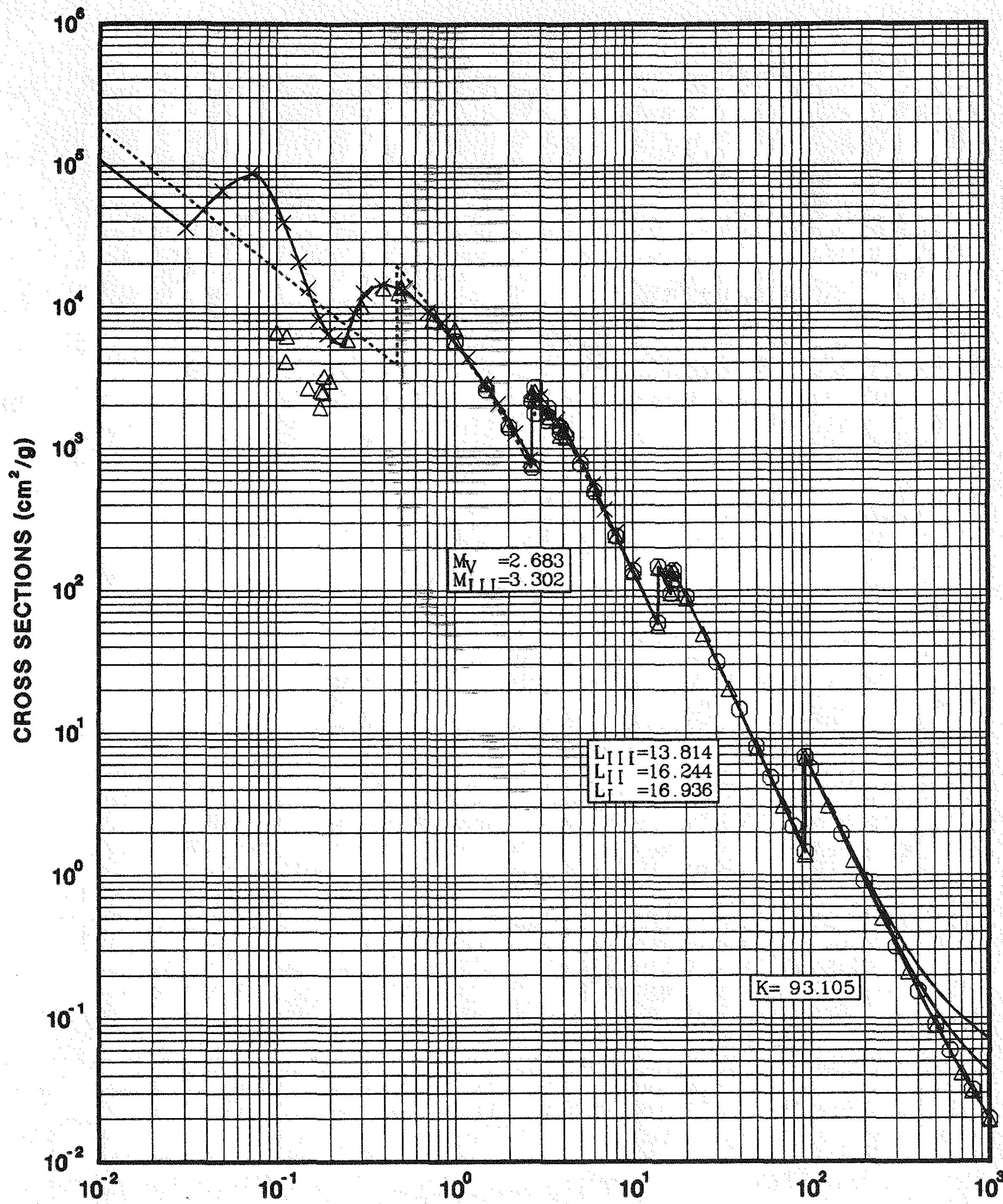
Barns/atom = $344.1 \times cm^2/g$

BISMUTH 83



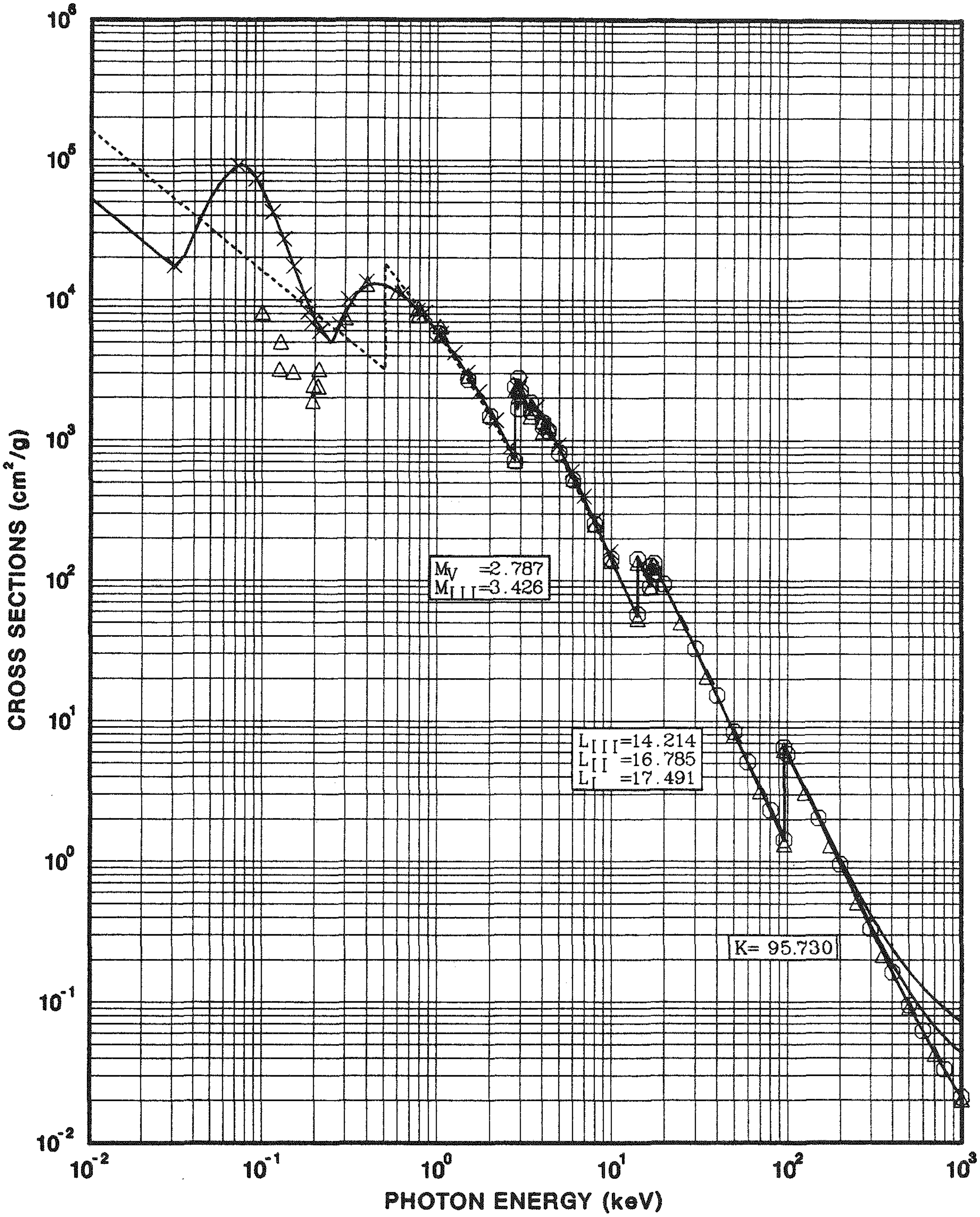
Barns/aton = 347.0 × cm^2/g

POLONIUM 84



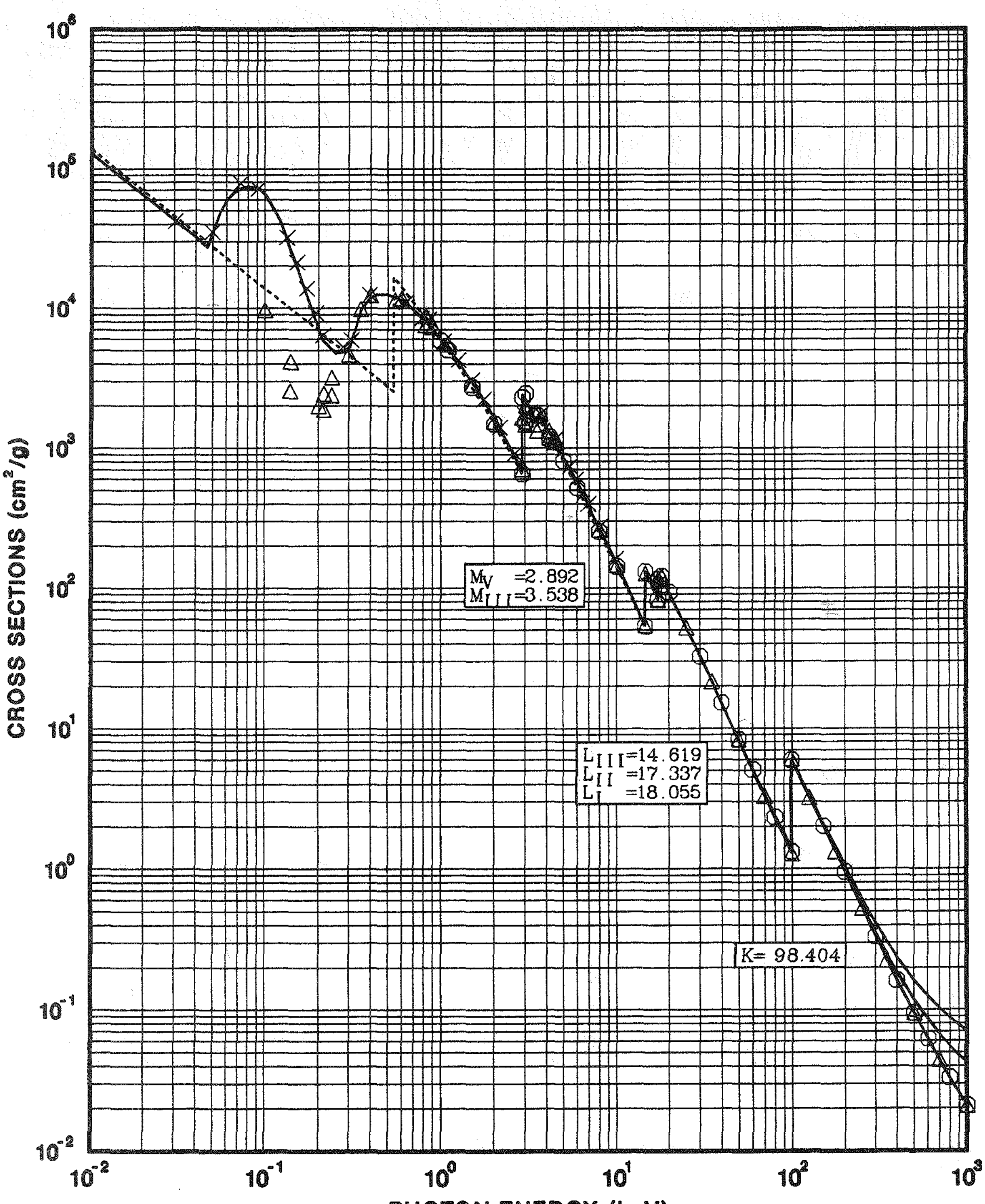
Barns/atom = 347.1 × cm^2/g

ASTATINE 85



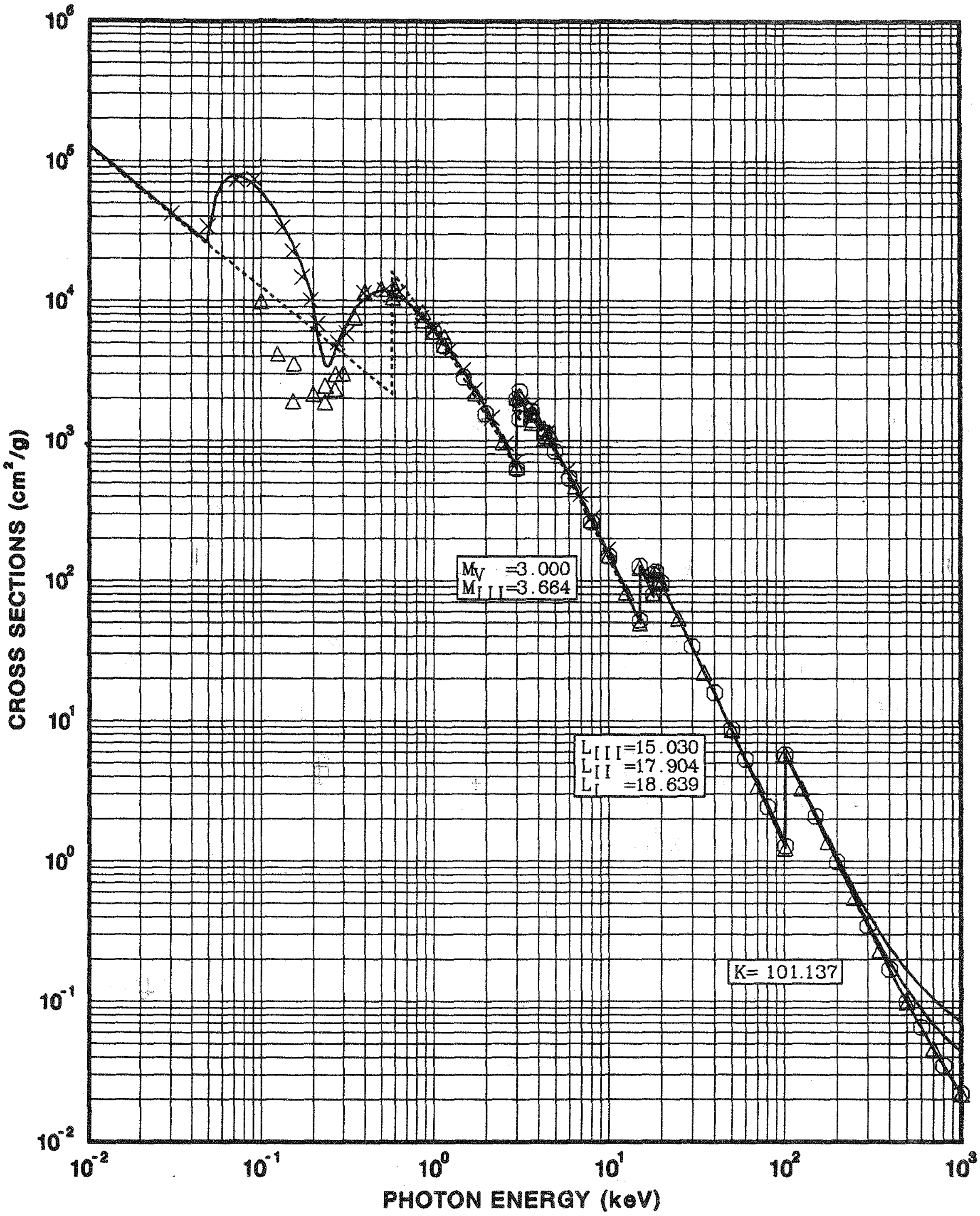
Barns/atom = 348.7 × cm²/g

RADON 86



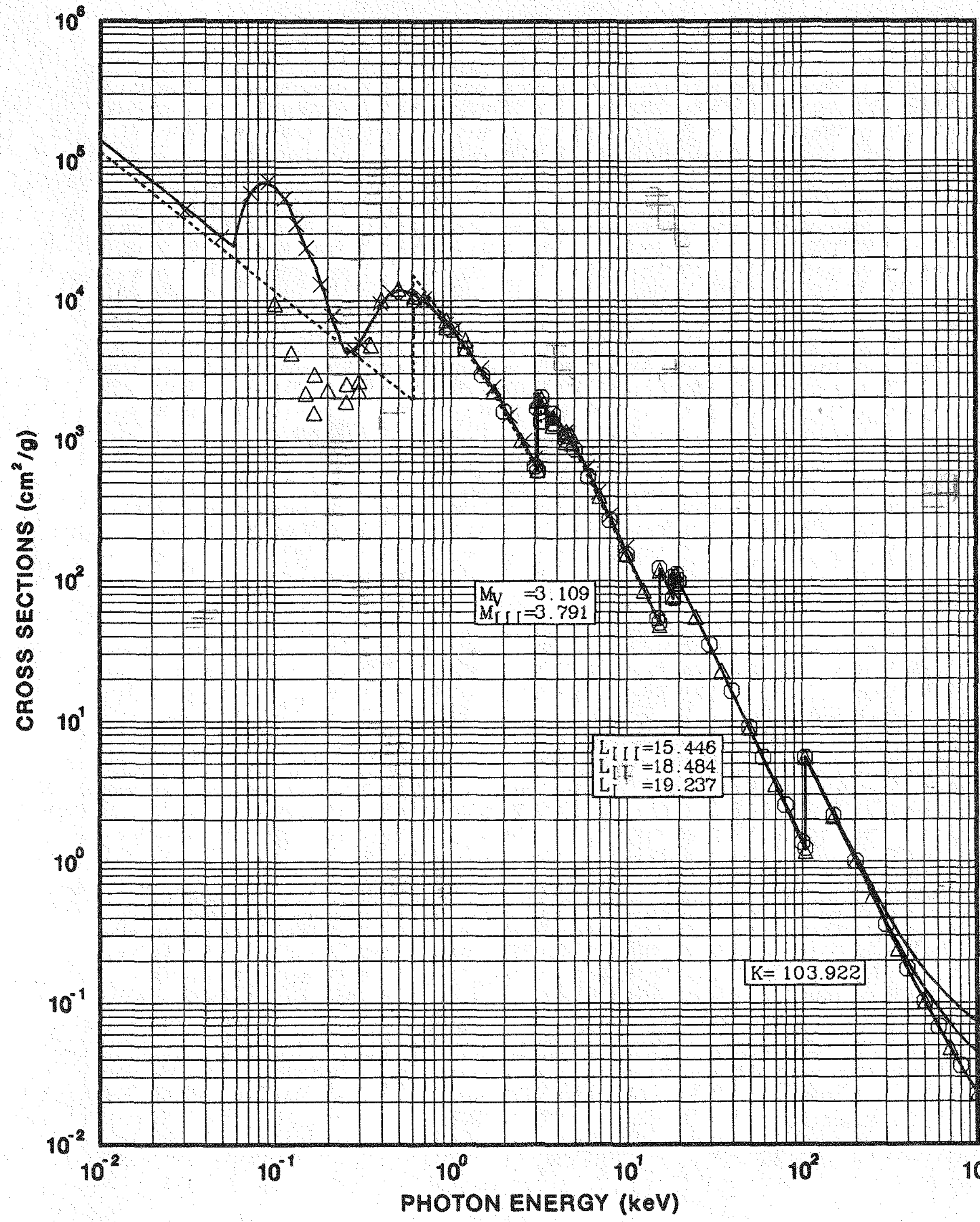
Barns/atom = 368.6 × cm^2/g

FRANCIUM 87



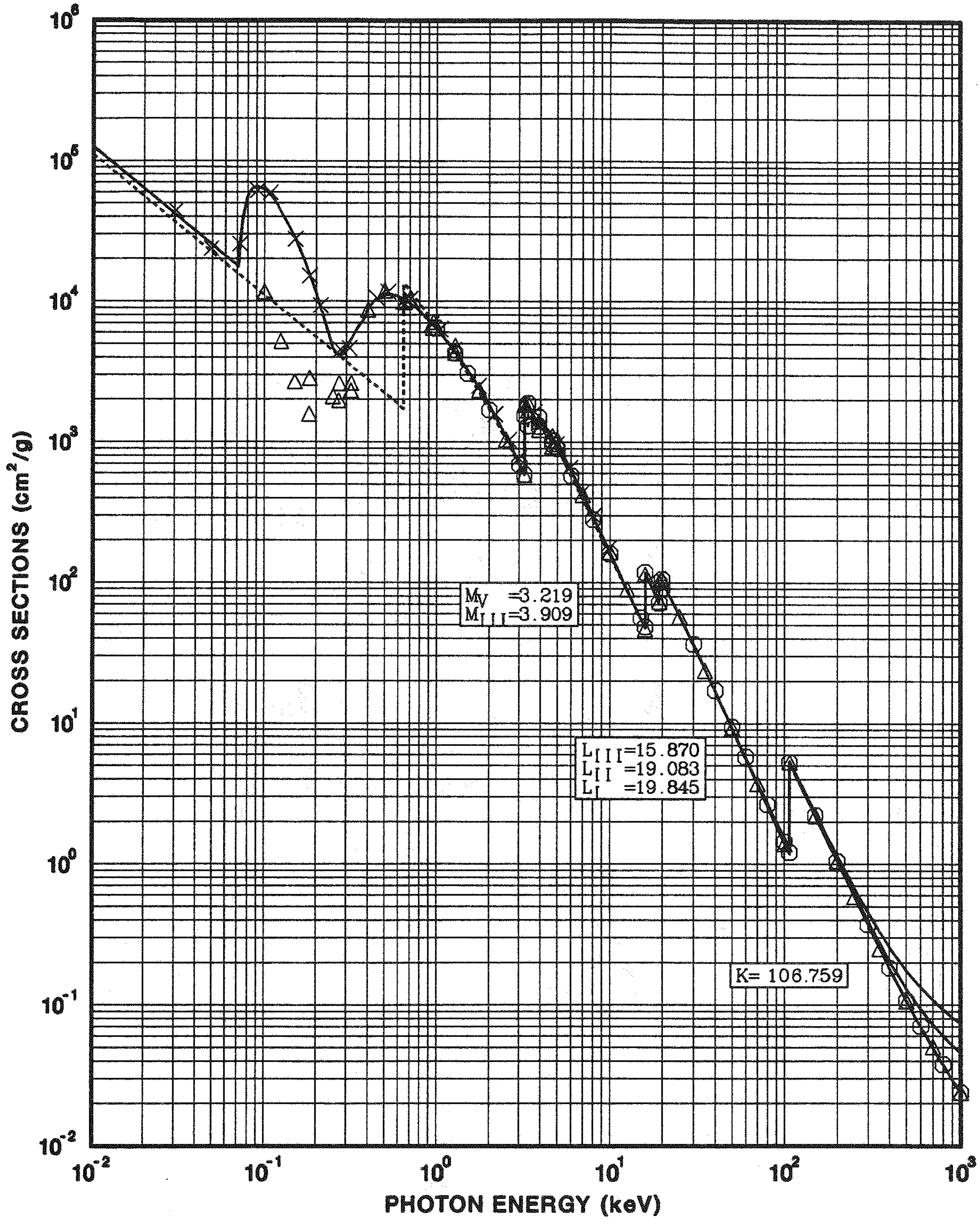
Barns/atom = 370.3 × cm^2/g

RADIUM 88



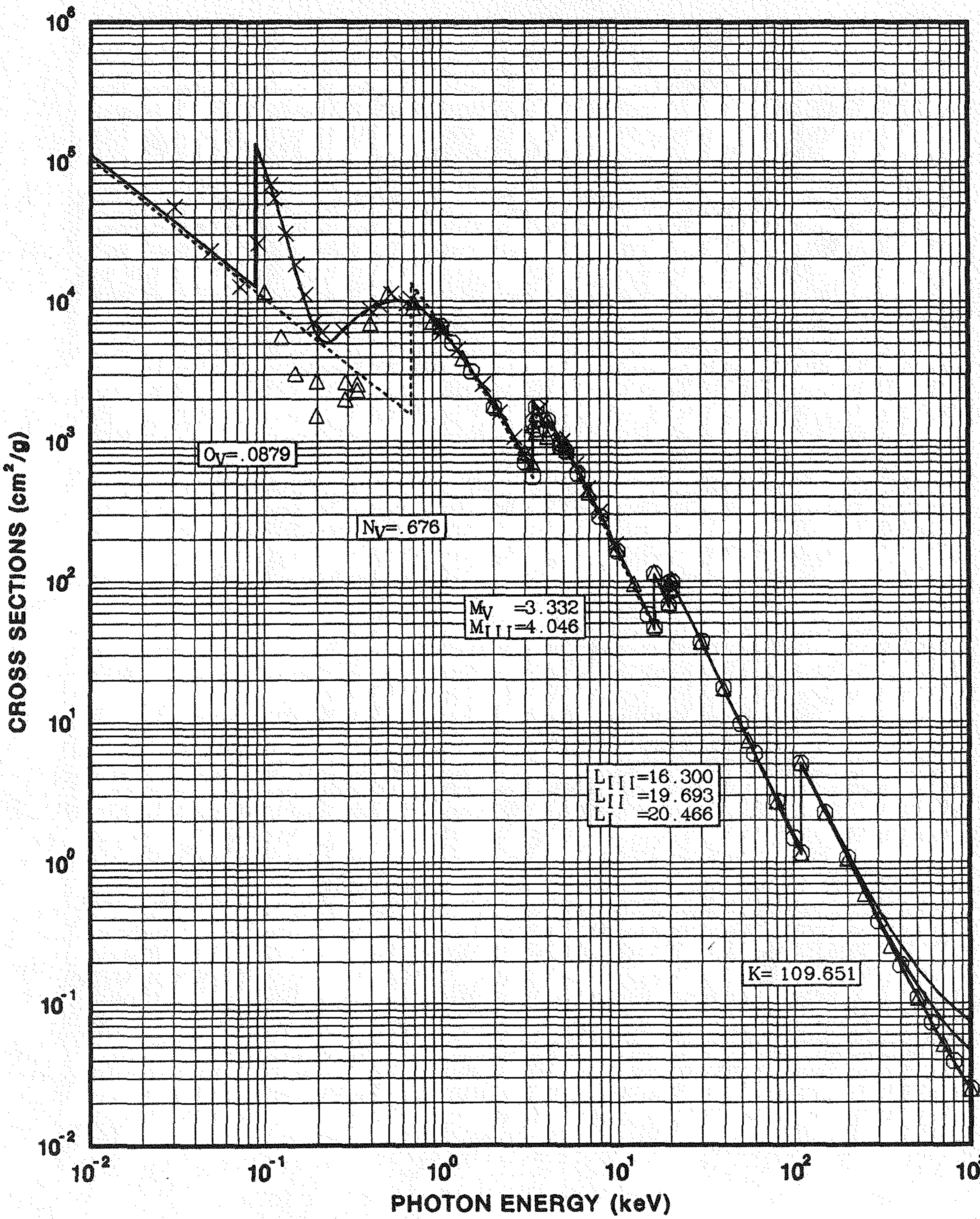
Barns/atom = 375.3 × cm^2/g

ACTINIUM 89



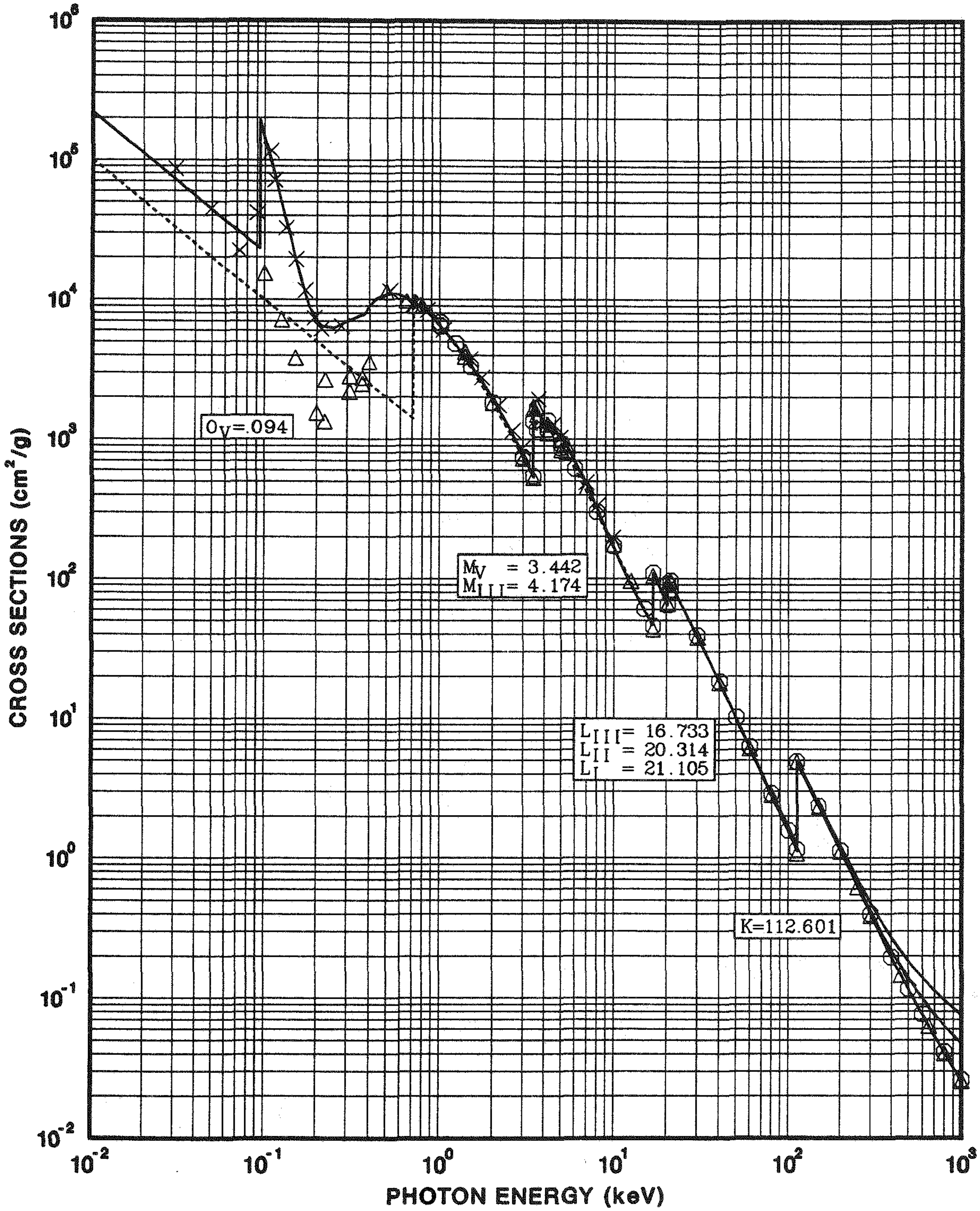
Barns/atom = 377.0 × cm^2/g

THORIUM 90



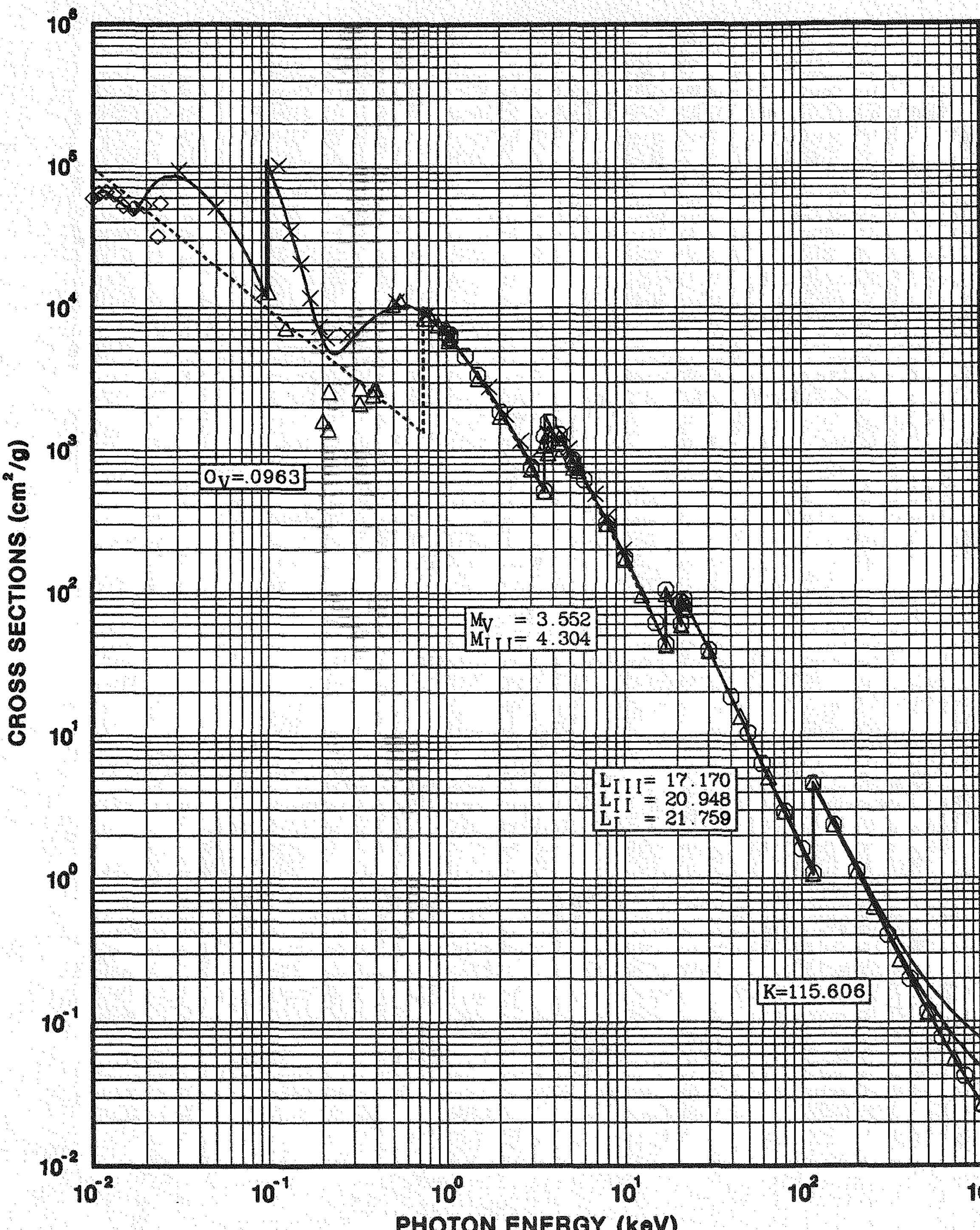
Barns/atom = 385.3 × cm²/g

PROTACTINIUM 91



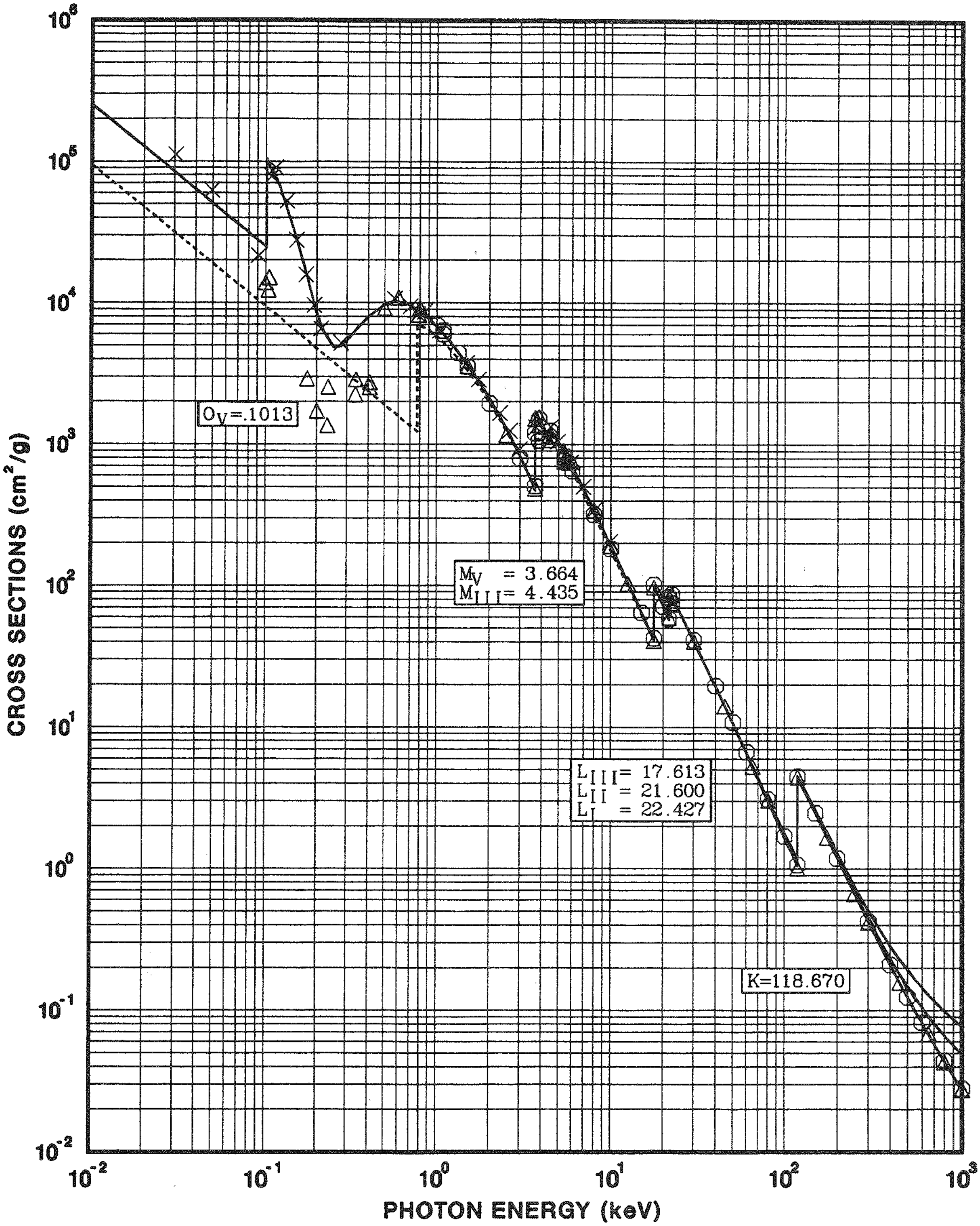
Barns/atom = 383.7 × cm^2/g

URANIUM 92



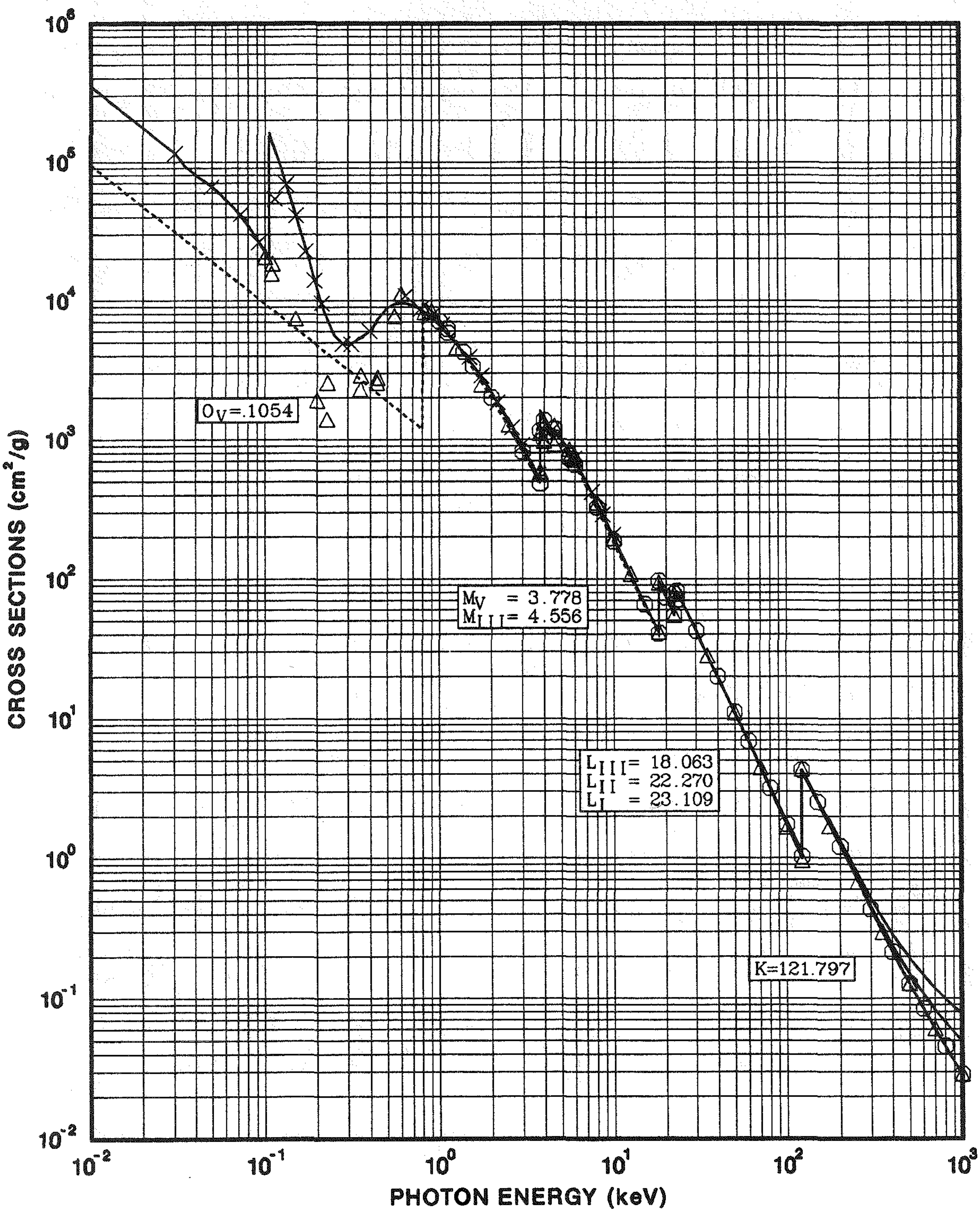
Barns/atom = 395.3 × cm^2/g

NEPTUNIUM 93



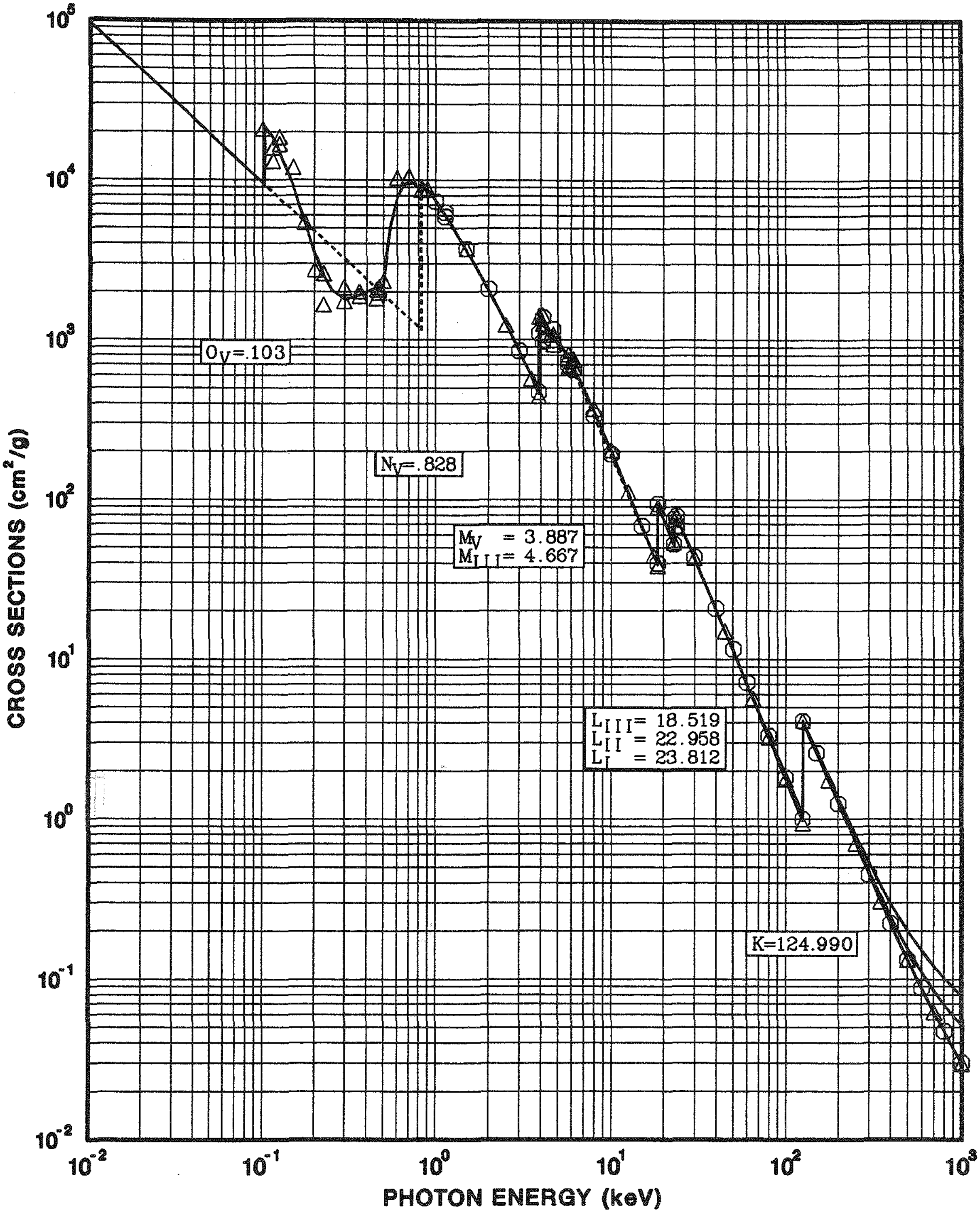
Barns/atom = 393.6 × cm^2/g

PLUTONIUM 94



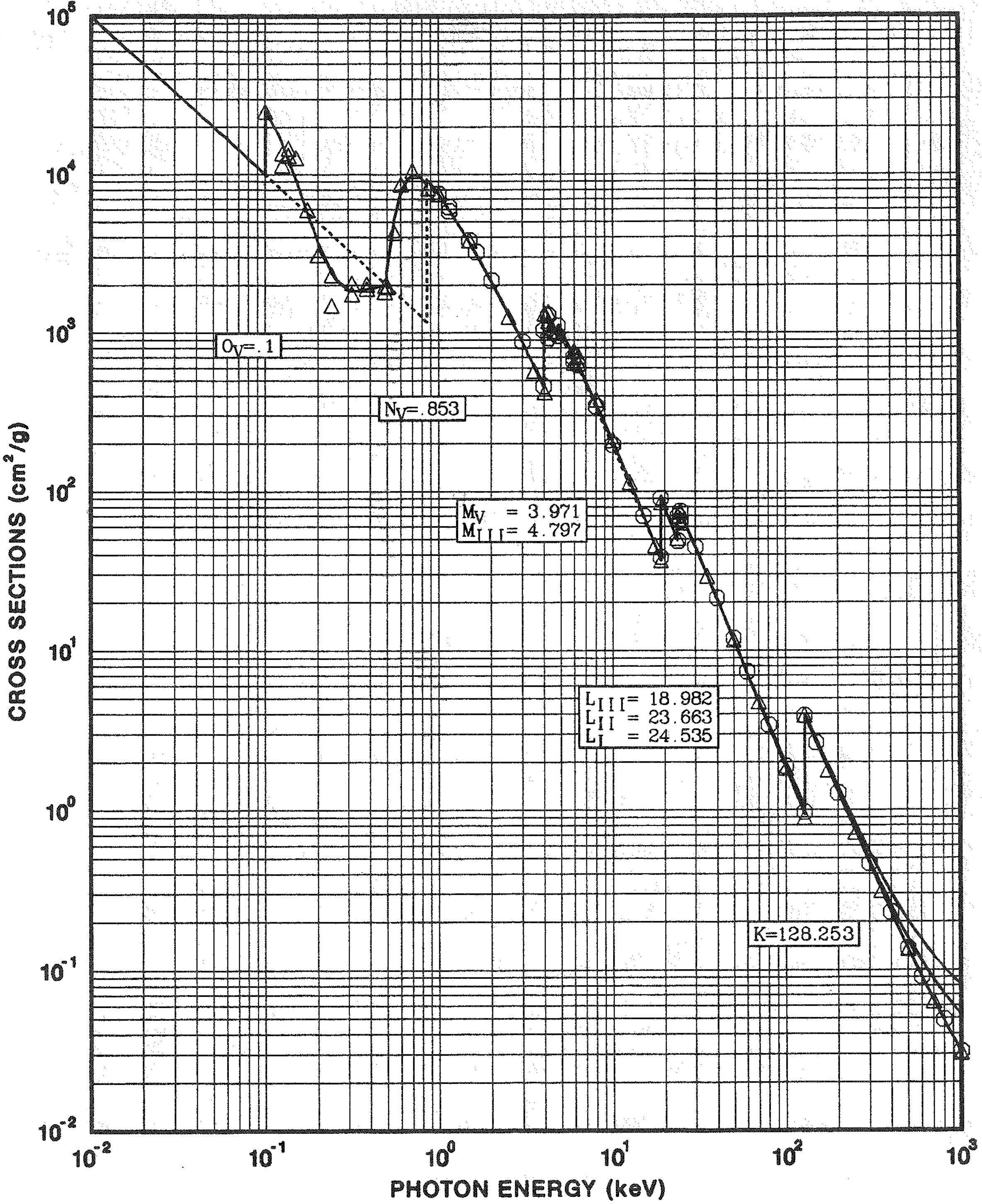
Barns/atom = 405.2 × cm^2/g

AMERICIUM 95



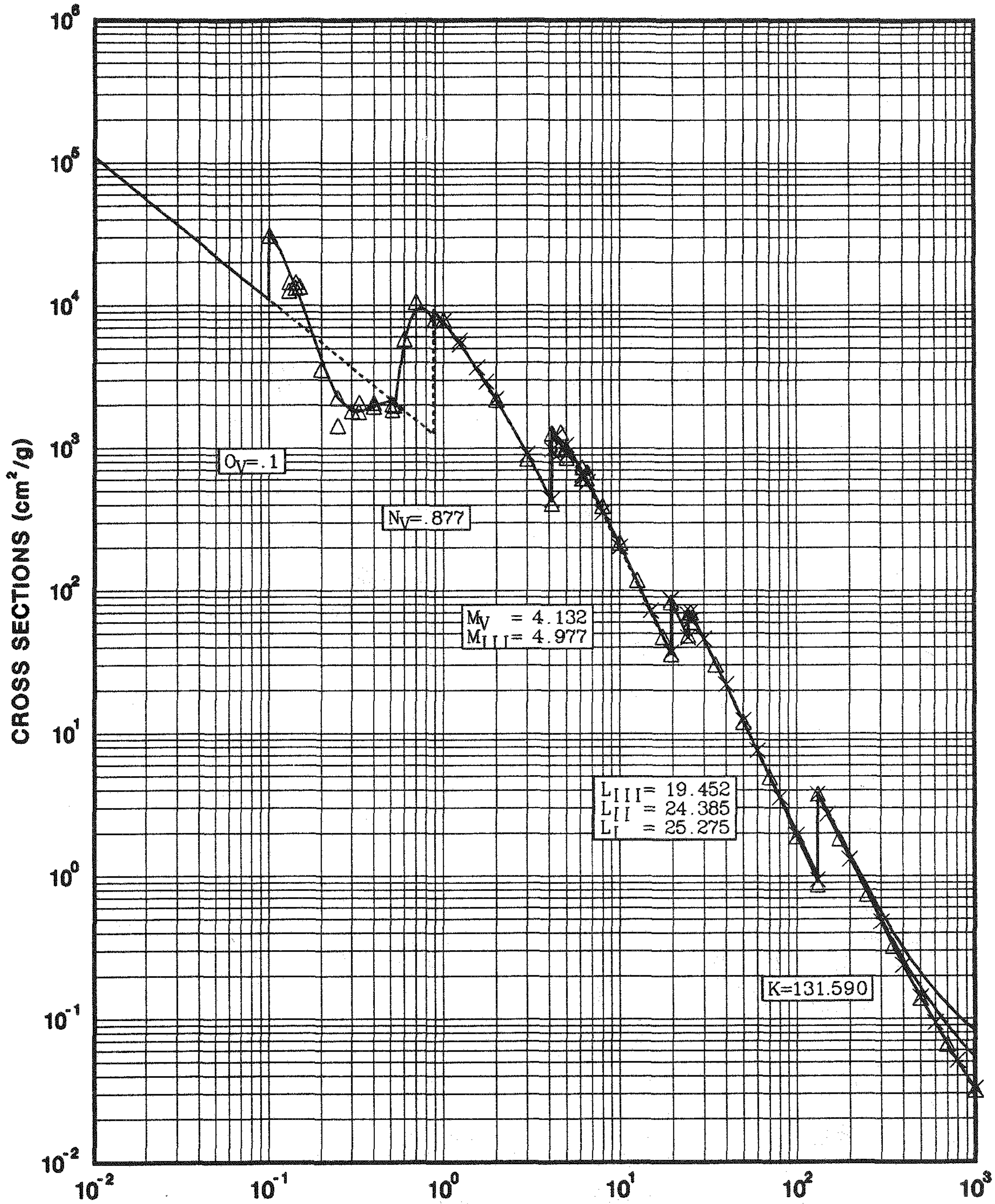
Barns/atom = 403.5 × cm^2/g

CURIUM 96



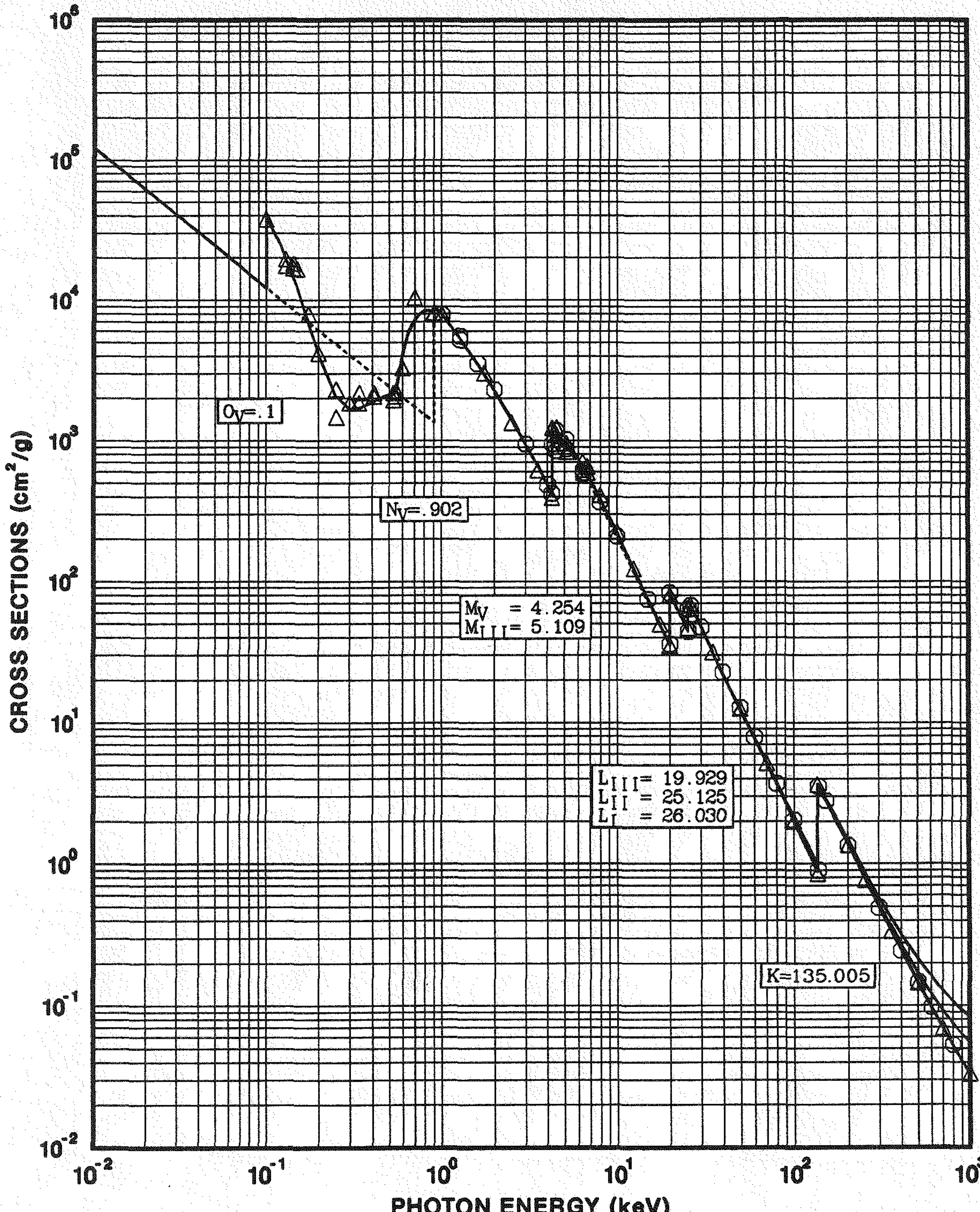
Barns/atom = 410.2 × cm^2/g

BERKELIUM 97



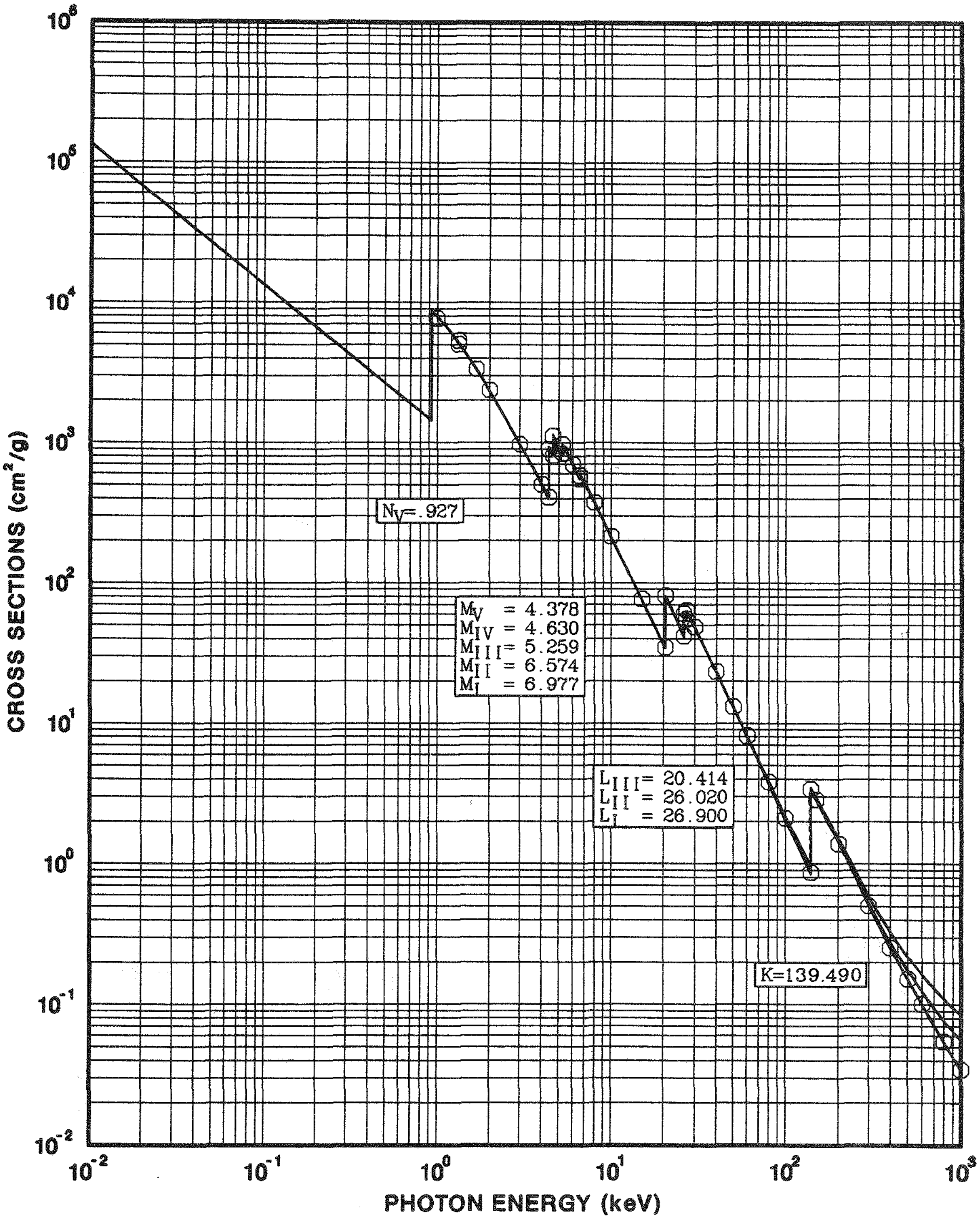
Barns/atom = 410.2 × cm^2/g

CALIFORNIUM 98



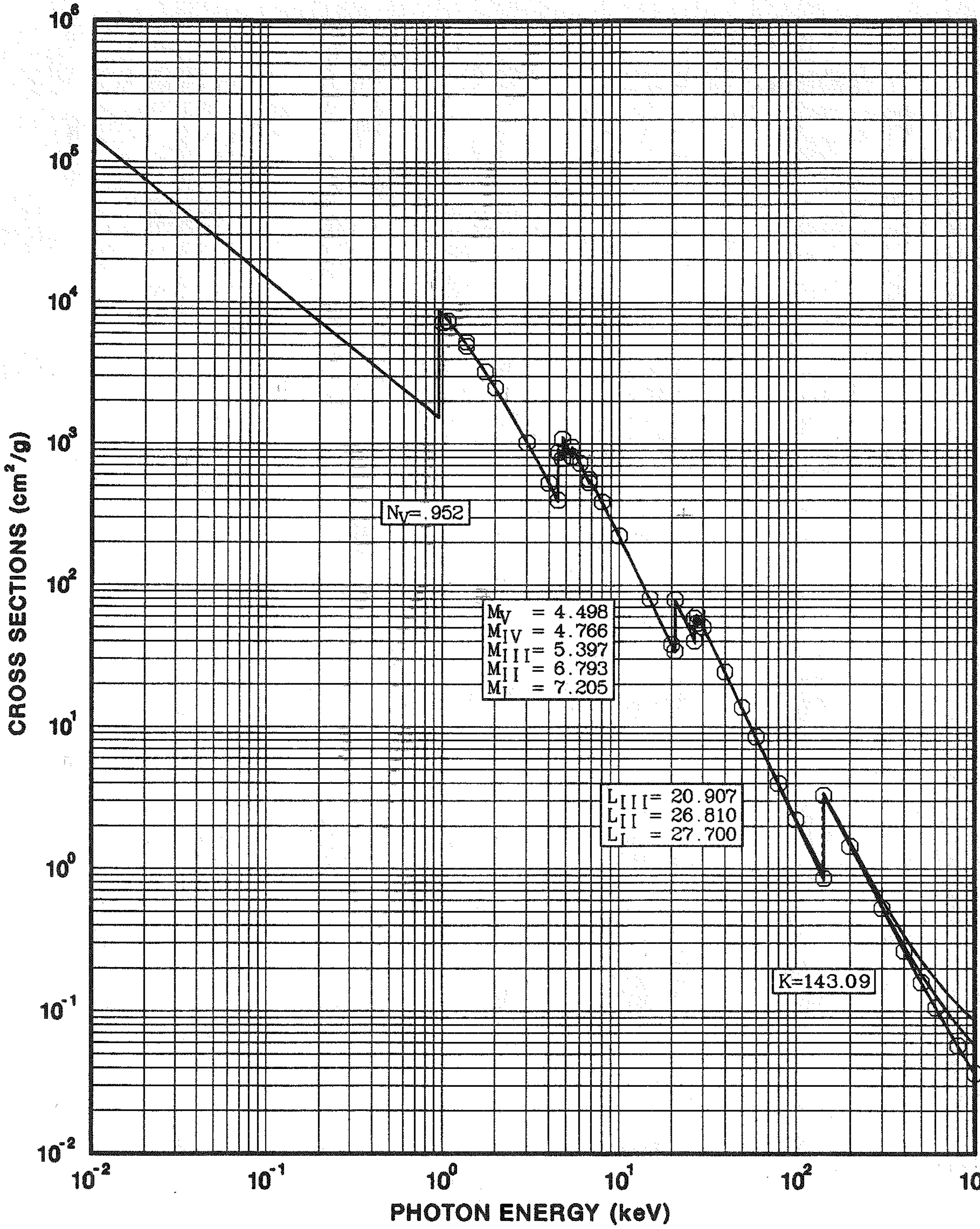
Barns/atom = 416.8 × cm^2/g

EINSTEINIUM 99



Barns/atom = 418.5 × cm^2/g

FERMIUM 100



Barns/atom = 426.8 × cm²/g

References

[1]F. Biggs and R. Lighthill, *Analytical Approximations for X-Ray Cross Sections II,* SC-RR-71 0507 (Albuquerque, NM: Sandia National Laboratories, December 1971).

[2]F. Biggs and R. Lighthill, *Analytical Approximations for X-Ray Cross Sections,* SC-RR-66-452 (Albuquerque, NM: Sandia National Laboratories, February 1967).

[3]R. C. Weast, Ed-in-Chief, *CRC Handbook of Chemistry and Physics,* 67th Ed (Boca Raton, FL: CRC Press, Inc., 1986-1987).

[4]D. Evans, *Handbuch der Physik,* Vol XXXIV (Berlin: Springer-Verlag, 1958) p 218.

[5]B. L. Henke, P. Lee, T. J. Tanaka, R. L. Shimabukuro, and B. K. Fujikawa, "Low-Energy X-Ray Interaction Coefficients: Photoabsorption, Scattering, and Reflection," *Atomic Data and Nuclear Data Tables,* Vol 27, Number 1 (New York, NY: Academic Press, January 1982).

[6]E. F. Plechaty, D. E. Cullen, and R. J. Howerton, *Tables and Graphs of Photon-Interaction Cross Sections From 0.1 keV to 100 MeV Derived from the LLL Evaluated-Nuclear-Data Library,* UCRL-50400, Vol 6, Rev 2 (Livermore, CA: Lawrence Livermore National Laboratory, December 7, 1978).

[7]R. W. Roussin, J. R. Knight, J. H. Hubbell, and R. J. Howerton, *Description of the DCL-99/HUGO Package of Photon Interaction Data in ENDF/B-V Format,* ORNL/RSIC-46 (ENDF-335) (Oak Ridge, TN: Oak Ridge National Laboratory, December 1983).

[8]H. J. Hagemann, W. Gudat, and C. Kunz, *Optical Constants from the Far Infrared to the X-Ray Region: Mg, Al, Cu, Ag, Au, Bi, C, and* Al_2O_3, DESY SR-74/7 (W. Germany, Deutsches Elektronen-Synchrotron DESY, May 1974).

[9]J. H. Weaver, C. Krafka, D. W. Lynch, and E. E. Koch, *Optical Properties of Metals,* Pt. I: *The Transition Metals* ($0.1 \leq h\nu \leq 500$ *eV),* Physik Daten, ISSN 0344-8401 NR.18-1 (Federal Republic of Germany: Faqchinformationszentrum, 1981).

[10]J. H. Weaver, C. Krafka, D. W. Lynch, and E. E. Koch, *Optical Properties of Metals,* Pt. II: *Noble Metals, Aluminum, Scandium, Yttrium, the Lanthanides and the Actinides* ($0.1 \leq h\nu \leq 500$ *eV),* Physik Daten, ISSN 0344-8401 NR. 18-2 (Federal Republic of Germany: Fachinformationszentrum, 1981).

[11]D. Y. Smith, E. Shiles, and M. Inokuti, *The Optical Properties and Complex Dielectric Function of Metallic Aluminum Form 0.04 to* 10^4 *eV,* ANL-83-24 (Chicago, IL: Argonne National Laboratory, March 1983).

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