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EXPERIMENTAL ELECTRON-IMPACT *K*-SHELL IONIZATION CROSS SECTIONS

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Experimental electron-impact K-shell ionization cross sections obtained from a search of the literature up to December 1999 are tabulated according to atomic number and incident electron energy. The data taken from the original papers have been reevaluated, where necessary, using the K-shell fluorescence yields compiled by Hubbell et al. and by Bambynek. Data are presented for elements H through U. © 2000 Academic Press

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INTRODUCTION

K-shell ionization cross sections by electron impact are needed in many branches of physics, including atomic physics, plasma physics, radiation physics, materials analysis by electron-probe microanalysis (EPMA), surface analysis by Auger-electron spectroscopy (AES), and thin-film analysis by electron energy-loss spectroscopy (EELS) [1]. In addition, the data are of basic importance for a better understanding of the electron–atom interaction. In recent years, there have been many new and improved measurements of K-shell ionization cross sections; hence, it is opportune to update the database compiled by Long et al. [2] about 10 years ago. In the present Table we have added many data which had not been included in the database of Long et al.

During the past decade, the study of ionization cross sections of atomic inner shells by electron impact has been of growing interest both experimentally [3–12] and theoretically [4, 13, 14]. Generally three techniques have been used to measure inner-shell ionization cross sections for both gas and solid targets. With one technique, measurements are made of the electron energy-loss spectra associated with the excitation of electrons from a particular shell. For the other two techniques, measurements are made of the decay products, either of characteristic x-rays or of Auger electrons. The latter two approaches are of particular value since data on the cross sections for the yields of x-rays or Auger electrons, relevant to EPMA and AES, respectively, are acquired directly [1]. For elements H and He, measurements are made of H^+ and He^+ ion or secondary electron numbers by crossed-beam techniques [15]. From the compilations of Long [2] and Joy [16, 17], it is seen that up until 10 years ago experimental K-shell ionization cross sections by electron impact were scarce in the low energy region (i.e., $U \leq 4$, where U is the reduced energy defined as the ratio between the incident electron energy and K-shell ionization energy) and discrepancies among such data from different experiments were apparent for some elements. In recent years, major progress with measurements in the low energy region has been made by Luo et al. [6–12]. Thin targets on a thick substrate were utilized in their experiments, and the effects of reflected electrons from the thick substrate were corrected based upon an electron transport calculation [7, 18]. Their method has the advantage of circumventing the difficulties of preparing self-supporting thin targets and has been applied to K-shell ionization cross section measurements for a number of elements.

Theoretically, many calculations of cross sections have been made using classical and quantum mechanical approaches. However, although each theoretical calculation has some region of validity, none has been fully successful in describing the phenomena over a wide range of atomic numbers Z and reduced energies U. A widely used and very successful classical model for atomic excitation and ionization was proposed by Gryzinski [19, 20], which can describe a wide range of experimental data except close to threshold ($U < 4$). Khare and Wadehra [13] and Luo and Joy [14] have presented the most recent quantum-mechanical calculations. Khare and Wadehra carried out calculations using the plane wave Born approximation (PWBA) with corrections for exchange, Coulomb, and relativistic effects. Good agreement with expermental data is obtained for $1 < U < 10^4$. Luo and Joy [14] performed an extensive series of calculations using first-order perturbation theory and Hartree–Slater wave functions for K, L (L_1 and L_2) and M (M_1, M_{23}, and M_{45}) shell ionization cross sections for incident electron energies ranging from near-threshold to 100 keV. Exchange and correlation energy effects were included in the calculation. More detailed reviews of theoretical calculations of inner-shell ionization cross sections can be found in Refs. [1, 13, 21]. In general, theories require a significant amount of computing time and do not give simple analytical formulae that are expedient for immediate use. Hence, numerous semiempirical and empirical expressions have been investigated [1, 21]. These analytical expressions can be useful in algorithms developed for microanalysis of materials. Most recently, Hombourger [21] proposed an empirical formula, based upon the analysis of expanded databases, to describe the K-shell ionization cross sections over a wide range of atomic numbers ($6 \leq Z \leq 79$) and reduced energies ($1 \leq U \leq 10^4$).

Powell [22] has made a comparison of several widely used empirical formulae (of Casnati et al. [23], Jakoby et al. [24], and Deutsch et al. [25]) and of some theoretical results (of Gryzinski [19, 20], Khare and Wadehra [13], and Luo and Joy [14]) with experimental data of K-shell ionization cross sections for C, N, O, Ne, Al, Ar, Fe, Ni, Cu, Mo, and Ag. He concluded that the empirical formula of Casnati et al. was superior to the equation of Gryzinski and to the empirical formulae of Jakoby et al. and Deutsch et al., that the theoretical results of Khare and Wadehra [13] were generally larger than the experimental values, and that the theoretical results of Luo and Joy [14] agree reasonably well with the measured data. Hombourger [21] also compared experimental data of K-shell ionization cross section with several empirical formulae and also found that the empirical formula of Casnati et al. was superior to others. In addition, we note that the most recently proposed empirical formula by Hombourger [21] is in part based upon the measured cross sections of Luo et al. [6–10] and its predictions for K-shell ionization cross section are similar to those of Casnati et al. In our own work, we have chosen the theoretical results of Luo and Joy [14] and the empirical formula of Casnati et al. [23] to compare with the experimental data measured by Luo et al. for Ti [10], Cr [7], Mn [8], Fe [8], Co [6], Ni [7], Cu [6], Zn [12], Nb [11], and Mo [9]. We observe that both the theoretical result of Luo and Joy [14] and the empirical formula of Casnati et al. [23] can reasonably describe most of the experimental data.

In the present Table of K-shell ionization cross sections, we have also indicated the experimental method employed, i.e., observation of x-ray or Auger electrons emitted in the subsequent deexcitation process, measurement of energy-loss spectra of electrons transmitted through thin target films or of ion or secondary electron numbers (only for H, He) by crossed-beam techniques, etc. The relation of the experimentally measured x-ray production cross section σ_X, Auger electron production cross-section σ_A, ionization cross section σ_I and the fluorescence yield f can be expressed in the form

$$\begin{aligned}\sigma_I &= \sigma_X/f \\ &= \sigma_A/(1-f).\end{aligned}$$

Taking the same approach as in Ref. [2], consistent fluorescence yields are used to normalize the tabulated values. Therefore, the K-shell ionization cross sections taken from original papers have all been reevaluated (with the exception of H, He, and elements measured with the energy-loss spectra method, because fluorescence yields are not involved in these measurements), using the K-shell fluorescence yields given by Bambynek [26] (for C, N, O, Ne, Ar, Ce, Nd, Sm, Gd, Ho, Er, Yb, W, Pt, Au, Pb, Bi, U) and Hubbell et al. [27] (for other elements). The fluorescence yields f used for the reevalution are given at the head of each tabulation. The values for incident electron energy and ionization cross section were restricted to three significant figures.

The K-shell ionization cross sections tabulated here were obtained from a search of the literature up to December 1999. Data in the present Table are extracted mostly from tabular listings in the original published papers. For papers in which only graphs of K-shell ionization cross sections are presented, the references are indicated at the end of each data block, but in general no effort has been made to extract the numerical values from the figures. Exceptions to the latter are made in cases where the numerical values can be read off with little uncertainty and in cases where the authors of the original papers kindly provided the numercial values upon our request.

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References

1. C. J. Powell, Rev. Mod. Phys. **48**, 33 (1976); C. J. Powell, in *Electron Impact Ionization*, edited by T. D. Märk and G. H. Dunn (Springer-Verlag, New York, 1985), Chap. 6

2. X. G. Long, M. T. Liu, F. Q. He, and X. F. Peng, Atomic Data and Nuclear Data Tables **45**, 353 (1990)

3. V. P. Shevelko, A. M. Solomon, and V. S. Vukstich, Phys. Scripta **43**, 158 (1991)

4. H. Schneider, I. Tobehn, E. F. Tobehn, and R. Hippler, Phys. Rev. Lett. **71**, 2707 (1993)

5. R. Shanker and R. Hippler, Z. Phys. D **42**, 161 (1997)

6. Z. An, T. H. Li, L. M. Wang, and Z. M. Luo, Phys. Rev. A **54**, 3067 (1996)

7. Z. M. Luo, Z. An, F. Q. He, T. H. Li, X. G. Long, and X. F. Peng, J. Phys. B **29**, 4001 (1996)

8. Z. M. Luo, Z. An, T. H. Li, L. M. Wang, Q. Zhu, and X. Y. Xia, J. Phys. B **30**, 2681 (1997)

9. F. Q. He, X. G. Long, X. F. Peng, Z. M. Luo, and Z. An, Nucl. Instrum. Methods B **114**, 213 (1996)

10. F. Q. He, X. F. Peng, X. G. Long, Z. M. Luo, and Z. An, Nucl. Instrum. Methods B **129**, 445 (1997)

11. X. F. Peng, F. Q. He, X. G. Long, Z. M. Luo, and Z. An, Phys. Rev. A **58**, 2034 (1998)

12. C. H. Tang, Z. An, T. H. Li, and Z. M. Luo, Nucl. Instrum. Methods B **155**, 1 (1999)

13. S. P. Khare and J. M. Wadehra, Can. J. Phys. **74**, 376 (1996)

14. S. Luo, Ph.D. thesis, The University of Tennessee, Knoxville, 1994; S. Luo and D. C. Joy, in *Microbeam Analysis-1991*, edited by D. G. Howitt (San Francisco Press, San Francisco, 1991), p. 67

15. R. G. Montague, M. F. A. Harrison, and A. C. H. Smith, J. Phys. B **17**, 3295 (1984)

16. D. C. Joy, Scanning **17**, 270 (1995)

17. http://web.utk.edu/~srcutk

18. Z. M. Luo, Phys. Rev. B **32**, 812; 824 (1985)

19. M. Gryzinski, Phys. Rev. A **138**, 322 (1965)

20. M. Gryzinski, Phys. Rev. A **138**, 336 (1965)

21. C. Hombourger, J. Phys. B **31**, 3693 (1998)

22. C. J. Powell, private communication and to be published

23. E. Casnati, A. Tartari, and C. Baraldi, J. Phys. B **15**, 155 (1982)

24. C. Jakoby, H. Genz, and A. Richter, J. Physique Coll. C **9**, 487 (1987)

25. H. Deutsch, D. Margreiter, and T. D. Märk, Z. Phys. D **29**, 31 (1994)

26. W. Bambynek, in *X-84: X-Ray and Inner-Shell Processes in Atoms, Molecules and Solids*, edited by A. Meisel (VEB Druckerei, Thomas Münzer, Langensalza, 1984) post-deadline Paper P-1

27. J. H. Hubbell, P. N. Trehan, Nirmal Singh, B. Chand, D. Mehta, M. L. Garg, R. R. Garg, Surinder Singh, and S. Puri, J. Phys. Chem. Ref. Data **23**, 339 (1994)

EXPLANATION OF TABLE

TABLE. Cross Sections for *K*-Shell Ionization by Electron Impact

The data are arranged first by increasing target atomic number and then by increasing incident electron energy.

Z	Target atomic number and element symbol
f	*K*-shell fluorescence yield used for the reevaluation
Energy	Incident electron energy in keV
Cross Section	*K*-shell ionization cross section and error in barn (1b $= 10^{-24}$ cm^2)
Type	Type of measurement
A	Auger-electron yield measurement
X	x-ray yield measurement
El	Transmission electron energy-loss measurement
I	H^+, He^+ ion number measurement
SE	Secondary electron number measurement
G	Gas target
Tn	Thin solid target
Ref	Reference key composed of the first two letters of the first author's surname and year of publication. Complete reference citations are given following the Table.

Note: 1.46 E-2 means 1.46×10^{-2}.

TABLE. Cross Sections for K-Shell Ionization by Electron Impact

See page 217 for Explanation of Tables

Energy (keV)	Cross Section (barn)	Type	Ref
Z=1 H			
1.46E-2	(5.44±0.25)E6	I,G	Sh87
1.48E-2	(6.61±0.41)E6	I,G	Sh87
1.50E-2	(7.62±0.38)E6	I,G	Sh87
1.51E-2	(8.20±0.29)E6	I,G	Sh87
1.52E-2	(8.70±0.45)E6	I,G	Sh87
1.54E-2	(9.90±0.46)E6	I,G	Sh87
1.56E-2	(1.08±0.03)E7	I,G	Sh87
1.59E-2	(1.25±0.05)E7	I,G	Sh87
1.61E-2	(1.37±0.06)E7	I,G	Sh87
1.64E-2	(1.45±0.05)E7	I,G	Sh87
1.66E-2	(1.63±0.03)E7	I,G	Sh87
1.69E-2	(1.68±0.06)E7	I,G	Sh87
1.71E-2	(1.73±0.05)E7	I,G	Sh87
1.74E-2	(1.96±0.06)E7	I,G	Sh87
1.76E-2	(2.07±0.05)E7	I,G	Sh87
1.79E-2	(2.15±0.05)E7	I,G	Sh87
1.81E-2	(2.22±0.06)E7	I,G	Sh87
1.84E-2	(2.35±0.03)E7	I,G	Sh87
1.87E-2	(2.50±0.06)E7	I,G	Sh87
1.90E-2	(2.61±0.04)E7	I,G	Sh87
1.93E-2	(2.75±0.05)E7	I,G	Sh87
1.96E-2	(2.81±0.04)E7	I,G	Sh87
2.00E-2	(2.93±0.09)E7	I,G	Sh87
2.04E-2	(3.11±0.10)E7	I,G	Sh87
2.09E-2	(3.34±0.02)E7	I,G	Sh87
2.14E-2	(3.39±0.04)E7	I,G	Sh87
2.20E-2	(3.61±0.05)E7	I,G	Sh87
2.26E-2	(3.76±0.09)E7	I,G	Sh87
2.33E-2	(4.01±0.06)E7	I,G	Sh87
2.40E-2	(4.15±0.06)E7	I,G	Sh87
2.48E-2	(4.30±0.10)E7	I,G	Sh87
2.50E-2	(4.20±0.84)E7	SE,G	Sh92
2.56E-2	(4.44±0.10)E7	I,G	Sh87
2.66E-2	(4.57±0.10)E7	I,G	Sh87
2.73E-2	(4.75±0.07)E7	I,G	Sh87
2.83E-2	(4.95±0.09)E7	I,G	Sh87
2.93E-2	(5.01±0.06)E7	I,G	Sh87
3.05E-2	(5.10±0.05)E7	I,G	Sh87
3.16E-2	(5.27±0.07)E7	I,G	Sh87
3.28E-2	(5.39±0.08)E7	I,G	Sh87
3.41E-2	(5.53±0.03)E7	I,G	Sh87
3.54E-2	(5.59±0.07)E7	I,G	Sh87
3.67E-2	(5.74±0.05)E7	I,G	Sh87
3.81E-2	(5.83±0.06)E7	I,G	Sh87
3.96E-2	(5.78±0.07)E7	I,G	Sh87
4.00E-2	(6.70±1.34)E7	SE,G	Sh92
4.12E-2	(5.89±0.04)E7	I,G	Sh87
4.29E-2	(6.02±0.07)E7	I,G	Sh87
4.47E-2	(6.07±0.05)E7	I,G	Sh87

Energy (keV)	Cross Section (barn)	Type	Ref
Z=1 H			
4.66E-2	(6.08±0.09)E7	I,G	Sh87
4.86E-2	(6.23±0.06)E7	I,G	Sh87
5.07E-2	(6.27±0.08)E7	I,G	Sh87
5.29E-2	(6.19±0.07)E7	I,G	Sh87
5.52E-2	(6.23±0.05)E7	I,G	Sh87
5.76E-2	(6.21±0.06)E7	I,G	Sh87
6.00E-2	(8.70±1.74)E7	SE,G	Sh92
6.01E-2	(6.13±0.10)E7	I,G	Sh87
6.30E-2	(6.14±0.07)E7	I,G	Sh87
6.60E-2	(6.11±0.04)E7	I,G	Sh87
6.90E-2	(6.11±0.06)E7	I,G	Sh87
7.21E-2	(6.01±0.05)E7	I,G	Sh87
7.55E-2	(5.96±0.08)E7	I,G	Sh87
7.95E-2	(5.91±0.09)E7	I,G	Sh87
8.40E-2	(5.84±0.07)E7	I,G	Sh87
8.90E-2	(5.78±0.09)E7	I,G	Sh87
9.40E-2	(5.59±0.08)E7	I,G	Sh87
1.00E-1	(7.10±1.42)E7	SE,G	Sh92
1.02E-1	(5.40±0.07)E7	I,G	Sh87
1.03E-1	(5.42±0.04)E7	I,G	Sh87
1.13E-1	(5.23±0.05)E7	I,G	Sh87
1.21E-1	(5.07±0.08)E7	I,G	Sh87
1.30E-1	(5.05±0.06)E7	I,G	Sh87
1.38E-1	(4.83±0.04)E7	I,G	Sh87
1.48E-1	(4.62±0.05)E7	I,G	Sh87
1.50E-1	(6.20±1.24)E7	SE,G	Sh92
1.58E-1	(4.55±0.05)E7	I,G	Sh87
1.68E-1	(4.43±0.08)E7	I,G	Sh87
1.78E-1	(4.28±0.04)E7	I,G	Sh87
1.88E-1	(4.10±0.07)E7	I,G	Sh87
1.98E-1	(3.98±0.07)E7	I,G	Sh87
2.13E-1	(3.79±0.07)E7	I,G	Sh87
2.28E-1	(3.61±0.04)E7	I,G	Sh87
2.48E-1	(3.43±0.03)E7	I,G	Sh87
2.50E-1	(4.70±0.94)E7	SE,G	Sh92
2.68E-1	(3.31±0.04)E7	I,G	Sh87
2.88E-1	(3.03±0.05)E7	I,G	Sh87
3.18E-1	(2.84±0.03)E7	I,G	Sh87
3.48E-1	(2.66±0.02)E7	I,G	Sh87
3.88E-1	(2.50±0.04)E7	I,G	Sh87
4.28E-1	(2.31±0.01)E7	I,G	Sh87
4.68E-1	(2.15±0.02)E7	I,G	Sh87
5.08E-1	(2.00±0.05)E7	I,G	Sh87
5.48E-1	(1.86±0.06)E7	I,G	Sh87
5.98E-1	(1.77±0.03)E7	I,G	Sh87
6.68E-1	(1.59±0.04)E7	I,G	Sh87
7.48E-1	(1.47±0.04)E7	I,G	Sh87
8.18E-1	(1.38±0.02)E7	I,G	Sh87
8.98E-1	(1.26±0.05)E7	I,G	Sh87

TABLE. Cross Sections for *K*-Shell Ionization by Electron Impact

See page 217 for Explanation of Tables

Energy (keV)	Cross Section (barn)	Type	Ref
Z=1 H			
9.98E-1	(1.13±0.01)E7	I,G	Sh87
1.10E0	(1.05±0.01)E7	I,G	Sh87
1.20E0	(9.82±0.19)E6	I,G	Sh87
1.30E0	(9.14±0.15)E6	I,G	Sh87
1.51E0	(8.07±0.17)E6	I,G	Sh87
1.66E0	(7.21±0.23)E6	I,G	Sh87
1.85E0	(6.73±0.22)E6	I,G	Sh87
2.00E0	(6.31±0.20)E6	I,G	Sh87
2.20E0	(5.77±0.10)E6	I,G	Sh87
2.45E0	(5.25±0.12)E6	I,G	Sh87
2.70E0	(4.72±0.11)E6	I,G	Sh87
3.00E0	(4.37±0.21)E6	I,G	Sh87
3.30E0	(4.03±0.12)E6	I,G	Sh87
3.65E0	(3.70±0.06)E6	I,G	Sh87
4.00E0	(3.39±0.17)E6	I,G	Sh87
Graphical data for 100-750 eV			Ro62
Graphical data from threshold to 750 eV			Fi58
Z=2 He			
2.00 E-2	(1.00±0.15)E5	I,G	We87a
2.10 E-2	(2.00±0.30)E5	I,G	We87a
2.20 E-2	(6.00±0.90)E5	I,G	We87a
2.30 E-2	(5.00±0.75)E5	I,G	We87a
2.40 E-2	(3.00±0.45)E5	I,G	We87a
2.50 E-2	(8.00±1.20)E5	I,G	We87a
2.50 E-2	(7.00±0.21)E5	I,G	St80
2.50 E-2	(5.19±0.23)E5	I,G	Ra65
2.55 E-2	(1.14±0.05)E6	I,G	Ra65
2.60 E-2	(1.90±0.40)E6	I,G	Mo84
2.60 E-2	(2.10±0.32)E6	I,G	We87a
2.60 E-2	(1.75±0.08)E6	I,G	Ra65
2.65 E-2	(2.40±0.40)E6	I,G	Mo84
2.65 E-2	(2.36±0.11)E6	I,G	Ra65
2.66 E-2	(2.42±0.08)E6	I,G	Sh88
2.70 E-2	(3.10±0.40)E6	I,G	Mo84
2.70 E-2	(2.80±0.42)E6	I,G	We87a
2.70 E-2	(3.03±0.14)E6	I,G	Ra65
2.75 E-2	(3.70±0.40)E6	I,G	Mo84
2.75 E-2	(3.63±0.16)E6	I,G	Ra65
2.76 E-2	(3.66±0.09)E6	I,G	Sh88
2.80 E-2	(4.30±0.40)E6	I,G	Mo84
2.80 E-2	(3.50±0.53)E6	I,G	We87a
2.80 E-2	(4.25±0.19)E6	I,G	Ra65
2.85 E-2	(4.90±0.40)E6	I,G	Mo84
2.85 E-2	(4.86±0.22)E6	I,G	Ra65
2.86 E-2	(4.80±0.13)E6	I,G	Sh88
2.90 E-2	(5.50±0.40)E6	I,G	Mo84

Energy (keV)	Cross Section (barn)	Type	Ref
Z=2 He			
2.90 E-2	(4.70±0.71)E6	I,G	We87a
2.90 E-2	(5.53±0.25)E6	I,G	Ra65
2.95 E-2	(6.10±0.40)E6	I,G	Mo84
2.95 E-2	(6.14±0.28)E6	I,G	Ra65
2.96 E-2	(6.04±0.12)E6	I,G	Sh88
3.00 E-2	(6.60±0.41)E6	I,G	Mo84
3.00 E-2	(6.00±0.90)E6	I,G	We87a
3.00 E-2	(6.90±0.21)E6	I,G	St80
3.00 E-2	(6.74±0.30)E6	I,G	Ra65
3.05 E-2	(7.20±0.45)E6	I,G	Mo84
3.05 E-2	(7.37±0.33)E6	I,G	Ra65
3.06 E-2	(7.15±0.16)E6	I,G	Sh88
3.10 E-2	(7.80±0.48)E6	I,G	Mo84
3.10 E-2	(7.20±1.08)E6	I,G	We87a
3.10 E-2	(8.02±0.36)E6	I,G	Ra65
3.15 E-2	(8.30±0.51)E6	I,G	Mo84
3.15 E-2	(8.64±0.39)E6	I,G	Ra65
3.20 E-2	(8.90±0.55)E6	I,G	Mo84
3.20 E-2	(8.20±1.23)E6	I,G	We87a
3.20 E-2	(9.24±0.42)E6	I,G	Ra65
3.21 E-2	(8.71±0.22)E6	I,G	Sh88
3.25 E-2	(9.40±0.58)E6	I,G	Mo84
3.25 E-2	(9.85±0.44)E6	I,G	Ra65
3.30 E-2	(9.90±0.61)E6	I,G	Mo84
3.30 E-2	(9.50±1.38)E6	I,G	We87a
3.30 E-2	(1.04±0.05)E7	I,G	Ra65
3.35 E-2	(1.04±0.06)E7	I,G	Mo84
3.35 E-2	(1.09±0.05)E7	I,G	Ra65
3.36 E-2	(1.05±0.03)E7	I,G	Sh88
3.40 E-2	(1.09±0.07)E7	I,G	Mo84
3.40 E-2	(1.08±0.16)E7	I,G	We87a
3.40 E-2	(1.14±0.05)E7	I,G	Ra65
3.45 E-2	(1.14±0.07)E7	I,G	Mo84
3.50 E-2	(1.19±0.07)E7	I,G	Mo84
3.50 E-2	(1.17±0.18)E7	I,G	We87a
3.50 E-2	(1.25±0.04)E7	I,G	St80
3.55 E-2	(1.25±0.08)E7	I,G	Mo84
3.60 E-2	(1.29±0.08)E7	I,G	Mo84
3.60 E-2	(1.25±0.19)E7	I,G	We87a
3.60 E-2	(1.35±0.06)E7	I,G	Ra65
3.70 E-2	(1.39±0.09)E7	I,G	Mo84
3.70 E-2	(1.32±0.20)E7	I,G	We87a
3.80 E-2	(1.48±0.09)E7	I,G	Mo84
3.80 E-2	(1.46±0.22)E7	I,G	We87a
3.80 E-2	(1.55±0.07)E7	I,G	Ra65
3.86 E-2	(1.52±0.03)E7	I,G	Sh88
3.90 E-2	(1.56±0.10)E7	I,G	Mo84
3.90 E-2	(1.56±0.23)E7	I,G	We87a
4.00 E-2	(1.64±0.09)E7	I,G	Mo84

TABLE. Cross Sections for K-Shell Ionization by Electron Impact

See page 217 for Explanation of Tables

Energy (keV)	Cross Section (barn)	Type	Ref
Z=2 He			
4.00 E-2	(1.65±0.25)E7	I,G	We87a
4.00 E-2	(1.75±0.05)E7	I,G	St80
4.00 E-2	(1.72±0.08)E7	I,G	Ra65
4.10 E-2	(1.72±0.10)E7	I,G	Mo84
4.20 E-2	(1.79±0.10)E7	I,G	Mo84
4.30 E-2	(1.87±0.10)E7	I,G	Mo84
4.36 E-2	(1.90±0.03)E7	I,G	Sh88
4.40 E-2	(1.94±0.11)E7	I,G	Mo84
4.50 E-2	(2.00±0.11)E7	I,G	Mo84
4.50 E-2	(2.01±0.30)E7	I,G	We87a
4.50 E-2	(2.10±0.06)E7	I,G	St80
4.50 E-2	(2.10±0.09)E7	I,G	Ra65
4.60 E-2	(2.07±0.12)E7	I,G	Mo84
4.70 E-2	(2.13±0.12)E7	I,G	Mo84
4.80 E-2	(2.20±0.12)E7	I,G	Mo84
4.86 E-2	(2.26±0.05)E7	I,G	Sh88
4.90 E-2	(2.25±0.13)E7	I,G	Mo84
5.00 E-2	(2.30±0.13)E7	I,G	Mo84
5.00 E-2	(2.35±0.35)E7	I,G	We87a
5.00 E-2	(2.37±0.07)E7	I,G	St80
5.00 E-2	(2.43±0.11)E7	I,G	Ra65
5.10 E-2	(2.36±0.13)E7	I,G	Mo84
5.20 E-2	(2.40±0.13)E7	I,G	Mo84
5.36 E-2	(2.50±0.04)E7	I,G	Sh88
5.40 E-2	(2.50±0.14)E7	I,G	Mo84
5.50 E-2	(2.61±0.39)E7	I,G	We87a
5.50 E-2	(2.65±0.08)E7	I,G	St80
5.50 E-2	(2.71±0.12)E7	I,G	Ra65
5.60 E-2	(2.59±0.15)E7	I,G	Mo84
5.80 E-2	(2.67±0.15)E7	I,G	Mo84
5.86 E-2	(2.73±0.06)E7	I,G	Sh88
6.00 E-2	(2.75±0.15)E7	I,G	Mo84
6.00 E-2	(2.84±0.43)E7	I,G	We87a
6.00 E-2	(2.86±0.09)E7	I,G	St80
6.00 E-2	(2.90±0.13)E7	I,G	Ra65
6.50 E-2	(2.93±0.16)E7	I,G	Mo84
6.50 E-2	(3.02±0.45)E7	I,G	We87a
6.50 E-2	(3.06±0.09)E7	I,G	St80
6.50 E-2	(3.08±0.14)E7	I,G	Ra65
6.86 E-2	(3.05±0.07)E7	I,G	Sh88
7.00 E-2	(3.08±0.17)E7	I,G	Mo84
7.00 E-2	(3.18±0.48)E7	I,G	We87a
7.00 E-2	(3.23±0.10)E7	I,G	St80
7.00 E-2	(3.21±0.14)E7	I,G	Ra65
7.50 E-2	(3.21±0.18)E7	I,G	Mo84
7.50 E-2	(3.29±0.49)E7	I,G	We87a
7.50 E-2	(3.33±0.10)E7	I,G	St80
7.50 E-2	(3.34±0.15)E7	I,G	Ra65
7.86 E-2	(3.29±0.06)E7	I,G	Sh88

Energy (keV)	Cross Section (barn)	Type	Ref
Z=2 He			
8.00 E-2	(3.31±0.19)E7	I,G	Mo84
8.00 E-2	(3.37±0.51)E7	I,G	We87a
8.00 E-2	(3.44±0.10)E7	I,G	St80
8.00 E-2	(3.44±0.15)E7	I,G	Ra65
8.50 E-2	(3.40±0.19)E7	I,G	Mo84
8.50 E-2	(3.48±0.52)E7	I,G	We87a
8.50 E-2	(3.54±0.11)E7	I,G	St80
8.50 E-2	(3.51±0.16)E7	I,G	Ra65
8.86 E-2	(3.45±0.06)E7	I,G	Sh88
9.00 E-2	(3.48±0.19)E7	I,G	Mo84
9.00 E-2	(3.53±0.53)E7	I,G	We87a
9.00 E-2	(3.60±0.11)E7	I,G	St80
9.00 E-2	(3.57±0.16)E7	I,G	Ra65
9.02 E-2	(3.53±0.05)E7	I,G	Sh88
9.50 E-2	(3.54±0.20)E7	I,G	Mo84
9.50 E-2	(3.60±0.54)E7	I,G	We87a
9.50 E-2	(3.65±0.11)E7	I,G	St80
9.50 E-2	(3.62±0.16)E7	I,G	Ra65
9.52 E-2	(3.60±0.05)E7	I,G	Sh88
1.00 E-1	(3.58±0.17)E7	I,G	Mo84
1.00 E-1	(3.67±0.08)E7	I,G	Sh88
1.00 E-1	(3.65±0.55)E7	I,G	We87a
1.00 E-1	(3.69±0.11)E7	I,G	St80
1.00 E-1	(3.66±0.16)E7	I,G	Ra65
1.05 E-1	(3.61±0.17)E7	I,G	Mo84
1.05 E-1	(3.74±0.09)E7	I,G	Sh88
1.05 E-1	(3.69±0.55)E7	I,G	We87a
1.05 E-1	(3.73±0.11)E7	I,G	St80
1.05 E-1	(3.69±0.17)E7	I,G	Ra65
1.10 E-1	(3.63±0.17)E7	I,G	Mo84
1.10 E-1	(3.70±0.05)E7	I,G	Sh88
1.10 E-1	(3.68±0.55)E7	I,G	We87a
1.10 E-1	(3.74±0.11)E7	I,G	St80
1.10 E-1	(3.70±0.17)E7	I,G	Ra65
1.15 E-1	(3.64±0.17)E7	I,G	Mo84
1.15 E-1	(3.67±0.05)E7	I,G	Sh88
1.15 E-1	(3.70±0.56)E7	I,G	We87a
1.15 E-1	(3.74±0.11)E7	I,G	St80
1.15 E-1	(3.72±0.17)E7	I,G	Ra65
1.18 E-1	(3.65±0.18)E7	I,G	Mo84
1.20 E-1	(3.65±0.18)E7	I,G	Mo84
1.20 E-1	(3.70±0.04)E7	I,G	Sh88
1.20 E-1	(3.72±0.56)E7	I,G	We87a
1.20 E-1	(3.74±0.11)E7	I,G	St80
1.20 E-1	(3.73±0.17)E7	I,G	Ra65
1.25 E-1	(3.65±0.18)E7	I,G	Mo84
1.25 E-1	(3.73±0.56)E7	I,G	We87a
1.25 E-1	(3.73±0.11)E7	I,G	St80
1.25 E-1	(3.74±0.17)E7	I,G	Ra65

TABLE. Cross Sections for K-Shell Ionization by Electron Impact

See page 217 for Explanation of Tables

Energy (keV)	Cross Section (barn)	Type	Ref	Energy (keV)	Cross Section (barn)	Type	Ref
Z=2 He				Z=2 He			
1.30 E-1	(3.66±0.18)E7	I,G	Mo84	2.20 E-1	(3.25±0.04)E7	I,G	Sh88
1.30 E-1	(3.69±0.05)E7	I,G	Sh88	2.25 E-1	(3.25±0.18)E7	I,G	Mo84
1.30 E-1	(3.75±0.56)E7	I,G	We87a	2.50 E-1	(3.12±0.17)E7	I,G	Mo84
1.30 E-1	(3.72±0.11)E7	I,G	St80	2.50 E-1	(3.13±0.04)E7	I,G	Sh88
1.30 E-1	(3.74±0.17)E7	I,G	Ra65	2.50 E-1	(3.21±0.14)E7	I,G	Ra65
1.35 E-1	(3.66±0.18)E7	I,G	Mo84	2.75 E-1	(3.00±0.17)E7	I,G	Mo84
1.35 E-1	(3.74±0.56)E7	I,G	We87a	2.80 E-1	(2.89±0.03)E7	I,G	Sh88
1.35 E-1	(3.72±0.11)E7	I,G	St80	3.00 E-1	(2.88±0.16)E7	I,G	Mo84
1.35 E-1	(3.73±0.17)E7	I,G	Ra65	3.00 E-1	(2.97±0.13)E7	I,G	Ra65
1.40 E-1	(3.65±0.18)E7	I,G	Mo84	3.25 E-1	(2.65±0.03)E7	I,G	Sh88
1.40 E-1	(3.67±0.04)E7	I,G	Sh88	3.50 E-1	(2.66±0.15)E7	I,G	Mo84
1.40 E-1	(3.77±0.57)E7	I,G	We87a	3.50 E-1	(2.75±0.12)E7	I,G	Ra65
1.40 E-1	(3.72±0.11)E7	I,G	St80	3.75 E-1	(2.53±0.03)E7	I,G	Sh88
1.40 E-1	(3.72±0.17)E7	I,G	Ra65	4.00 E-1	(2.45±0.16)E7	I,G	Mo84
1.45 E-1	(3.63±0.17)E7	I,G	Mo84	4.00 E-1	(2.57±0.12)E7	I,G	Ra65
1.45 E-1	(3.77±0.57)E7	I,G	We87a	4.30 E-1	(2.32±0.03)E7	I,G	Sh88
1.45 E-1	(3.71±0.11)E7	I,G	St80	4.50 E-1	(2.27±0.15)E7	I,G	Mo84
1.45 E-1	(3.70±0.17)E7	I,G	Ra65	4.50 E-1	(2.39±0.11)E7	I,G	Ra65
1.50 E-1	(3.62±0.20)E7	I,G	Mo84	5.00 E-1	(2.13±0.14)E7	I,G	Mo84
1.50 E-1	(3.60±0.04)E7	I,G	Sh88	5.00 E-1	(2.09±0.03)E7	I,G	Sh88
1.50 E-1	(3.75±0.56)E7	I,G	We87a	5.00 E-1	(1.65±0.17)E7	I,G	Na80
1.50 E-1	(3.69±0.11)E7	I,G	St80	5.00 E-1	(1.80±0.36)E7	I,G	Sc66
1.50 E-1	(3.69±0.17)E7	I,G	Ra65	5.00 E-1	(2.24±0.10)E7	I,G	Ra65
1.55 E-1	(3.74±0.56)E7	I,G	We87a	5.50 E-1	(2.00±0.13)E7	I,G	Mo84
1.55 E-1	(3.67±0.11)E7	I,G	St80	5.50 E-1	(2.11±0.10)E7	I,G	Ra65
1.60 E-1	(3.58±0.20)E7	I,G	Mo84	5.70 E-1	(1.87±0.02)E7	I,G	Sh88
1.60 E-1	(3.58±0.04)E7	I,G	Sh88	6.00 E-1	(1.89±0.12)E7	I,G	Mo84
1.60 E-1	(3.73±0.56)E7	I,G	We87a	6.00 E-1	(1.57±0.31)E7	I,G	Sc66
1.60 E-1	(3.64±0.11)E7	I,G	St80	6.00 E-1	(2.00±0.09)E7	I,G	Ra65
1.65 E-1	(3.75±0.56)E7	I,G	We87a	6.50 E-1	(1.79±0.12)E7	I,G	Mo84
1.65 E-1	(3.62±0.11)E7	I,G	St80	6.50 E-1	(1.77±0.02)E7	I,G	Sh88
1.70 E-1	(3.54±0.20)E7	I,G	Mo84	6.50 E-1	(1.90±0.09)E7	I,G	Ra65
1.70 E-1	(3.55±0.05)E7	I,G	Sh88	7.00 E-1	(1.70±0.11)E7	I,G	Mo84
1.70 E-1	(3.73±0.56)E7	I,G	We87a	7.00 E-1	(1.44±0.14)E7	I,G	Na80
1.70 E-1	(3.58±0.11)E7	I,G	St80	7.00 E-1	(1.43±0.29)E7	I,G	Sc66
1.75 E-1	(3.71±0.56)E7	I,G	We87a	7.00 E-1	(1.80±0.08)E7	I,G	Ra65
1.75 E-1	(3.53±0.11)E7	I,G	St80	7.50 E-1	(1.62±0.11)E7	I,G	Mo84
1.75 E-1	(3.59±0.16)E7	I,G	Ra65	7.50 E-1	(1.61±0.02)E7	I,G	Sh88
1.80 E-1	(3.49±0.20)E7	I,G	Mo84	7.50 E-1	(1.71±0.08)E7	I,G	Ra65
1.80 E-1	(3.71±0.56)E7	I,G	We87a	8.00 E-1	(1.31±0.26)E7	I,G	Sc66
1.80 E-1	(3.49±0.10)E7	I,G	St80	8.00 E-1	(1.65±0.07)E7	I,G	Ra65
1.85 E-1	(3.71±0.56)E7	I,G	We87a	8.50 E-1	(1.57±0.07)E7	I,G	Ra65
1.90 E-1	(3.44±0.19)E7	I,G	Mo84	8.70 E-1	(1.44±0.02)E7	I,G	Sh88
1.90 E-1	(3.66±0.55)E7	I,G	We87a	9.00 E-1	(1.20±0.24)E7	I,G	Sc66
1.95 E-1	(3.42±0.05)E7	I,G	Sh88	9.00 E-1	(1.50±0.07)E7	I,G	Ra65
1.95 E-1	(3.64±0.55)E7	I,G	We87a	9.50 E-1	(1.45±0.07)E7	I,G	Ra65
2.00 E-1	(3.39±0.19)E7	I,G	Mo84	1.00 E0	(1.28±0.02)E7	I,G	Sh88
2.00 E-1	(3.66±0.55)E7	I,G	We87a	1.00 E0	(1.20±0.12)E7	I,G	Na80
2.00 E-1	(3.47±0.16)E7	I,G	Ra65	1.00 E0	(1.10±0.22)E7	I,G	Sc66

TABLE. Cross Sections for K-Shell Ionization by Electron Impact

See page 217 for Explanation of Tables

Energy (keV)	Cross Section (barn)	Type	Ref
Z=2 He			
1.00 E0	(1.41±0.06)E7	I,G	Ra65
1.15 E0	(1.19±0.02)E7	I,G	Sh88
1.20 E0	(9.54±1.91)E6	I,G	Sc66
1.32 E0	(1.07±0.02)E7	I,G	Sh88
1.40 E0	(8.36±1.67)E6	I,G	Sc66
1.50 E0	(8.21±0.82)E6	I,G	Na80
1.52 E0	(9.55±0.12)E6	I,G	Sh88
1.60 E0	(7.59±1.52)E6	I,G	Sc66
1.75 E0	(8.72±0.10)E6	I,G	Sh88
1.80 E0	(6.88±1.38)E6	I,G	Sc66
2.00 E0	(6.93±0.69)E6	I,G	Na80
2.00 E0	(6.22±1.24)E6	I,G	Sc66
2.01 E0	(7.96±0.09)E6	I,G	Sh88
2.30 E0	(6.93±0.08)E6	I,G	Sh88
2.50 E0	(5.55±0.56)E6	I,G	Na80
2.65 E0	(6.15±0.09)E6	I,G	Sh88
3.00 E0	(5.51±0.07)E6	I,G	Sh88
3.00 E0	(4.90±0.49)E6	I,G	Na80
3.00 E0	(4.77±0.95)E6	I,G	Sc66
3.50 E0	(5.20±0.13)E6	I,G	Sh88
3.50 E0	(4.24±0.42)E6	I,G	Na80
4.00 E0	(4.48±0.06)E6	I,G	Sh88
4.00 E0	(3.85±0.39)E6	I,G	Na80
4.00 E0	(3.55±0.71)E6	I,G	Sc66
4.50 E0	(3.46±0.35)E6	I,G	Na80
4.60 E0	(3.98±0.05)E6	I,G	Sh88
5.00 E0	(3.12±0.31)E6	I,G	Na80
5.00 E0	(2.93±0.59)E6	I,G	Sc66
5.30 E0	(3.37±0.04)E6	I,G	Sh88
6.00 E0	(2.55±0.51)E6	I,G	Sc66
6.10 E0	(3.08±0.03)E6	I,G	Sh88
7.00 E0	(2.76±0.03)E6	I,G	Sh88
8.00 E0	(2.50±0.03)E6	I,G	Sh88
8.00 E0	(2.00±0.40)E6	I,G	Sc66
9.00 E0	(2.24±0.03)E6	I,G	Sh88
1.00 E1	(1.95±0.05)E6	I,G	Sh88
1.00 E1	(1.67±0.33)E6	I,G	Sc66
1.20 E1	(1.43±0.29)E6	I,G	Sc66
1.40 E1	(1.28±0.26)E6	I,G	Sc66
1.60 E1	(1.13±0.23)E6	I,G	Sc66
Graphical data from threshold to 30 eV above threshold			Ke82
Z=6 C f=2.58E-3			
2.90 E-1	(7.22±0.79)E4	X,G	Ta73
3.00 E-1	(9.86±1.09)E4	X,G	Ta73
3.50 E-1	(1.53±0.17)E5	X,G	Ta73
4.00 E-1	(2.03±0.22)E5	X,G	Ta73
Z=6 C f=2.58E-3			
5.00 E-1	(2.61±0.29)E5	X,G	Ta73
6.00 E-1	(3.06±0.33)E5	X,G	Ta73
7.00 E-1	(3.17±0.34)E5	X,G	Ta73
8.00 E-1	(3.42±0.38)E5	X,G	Ta73
9.00 E-1	(3.41±0.38)E5	X,G	Ta73
1.00 E0	(3.43±0.37)E5	X,G	Ta73
1.25 E0	(3.41±0.38)E5	X,G	Ta73
1.50 E0	(3.35±0.37)E5	X,G	Ta73
1.75 E0	(3.19±0.36)E5	X,G	Ta73
2.00 E0	(3.02±0.33)E5	X,G	Ta73
2.00 E0	(4.73±0.71)E5	X,Tn	Hi71
3.00 E0	(2.53±0.28)E5	X,G	Ta73
3.00 E0	(3.53±0.36)E5	X,Tn	Hi71
4.00 E0	(2.20±0.24)E5	X,G	Ta73
4.00 E0	(2.90±0.20)E5	X,Tn	Hi71
5.00 E0	(1.91±0.21)E5	X,G	Ta73
5.00 E0	(2.36±0.11)E5	X,Tn	Hi71
6.00 E0	(1.72±0.19)E5	X,G	Ta73
7.00 E0	(1.85±0.09)E5	X,Tn	Hi71
8.50 E0	(1.39±0.16)E5	X,G	Ta73
1.00 E1	(1.35±0.06)E5	X,Tn	Hi71
1.06 E1	(1.22±0.14)E5	X,G	Ta73
1.26 E1	(1.07±0.11)E5	X,G	Ta73
1.47 E1	(9.59±1.06)E4	X,G	Ta73
1.50 E1	(9.48±0.47)E4	X,Tn	Hi71
1.68 E1	(8.93±0.98)E4	X,G	Ta73
2.00 E1	(7.53±0.38)E4	X,Tn	Hi71
2.50 E1	(6.26±0.31)E4	X,Tn	Hi71
2.50 E1	(7.50±1.50)E4	El,Tn	Is72
3.00 E1	(5.47±0.27)E4	X,Tn	Hi71
7.50 E1	6.00E3	El,Tn	Co72
8.00 E1	(3.70±0.60)E4	El,Tn	Eg75
Graphical data for 80 keV			Ro79
Z=7 N f=4.35E-3			
4.50 E-1	(6.11±0.67)E4	X,G	Ta73
5.00 E-1	(8.23±0.90)E4	X,G	Ta73
6.00 E-1	(9.60±0.48)E4	A,G	Gl71
6.00 E-1	(1.19±0.13)E5	X,G	Ta73
6.50 E-1	(1.15±0.05)E5	A,G	Gl71
7.00 E-1	(1.48±0.16)E5	X,G	Ta73
8.00 E-1	(1.66±0.18)E5	X,G	Ta73
9.00 E-1	(1.54±0.08)E5	A,G	Gl71
9.00 E-1	(1.73±0.18)E5	X,G	Ta73
1.00 E0	(1.70±0.09)E5	A,G	Gl71
1.00 E0	(1.87±0.21)E5	X,G	Ta73
1.10 E0	(1.79±0.09)E5	A,G	Gl71
1.21 E0	(1.87±0.10)E5	A,G	Gl71

TABLE. Cross Sections for *K*-Shell Ionization by Electron Impact

See page 217 for Explanation of Tables

Energy (keV)	Cross Section (barn)	Type	Ref
Z=7 N	f=4.35E-3		
1.25 E0	(1.94±0.22)E5	X,G	Ta73
1.41 E0	(1.91±0.10)E5	A,G	Gl71
1.50 E0	(1.91±0.21)E5	X,G	Ta73
1.51 E0	(1.91±0.10)E5	A,G	Gl71
1.61 E0	(1.91±0.10)E5	A,G	Gl71
1.71 E0	(1.90±0.10)E5	A,G	Gl71
1.75 E0	(1.95±0.22)E5	X,G	Ta73
1.81 E0	(1.91±0.10)E5	A,G	Gl71
2.00 E0	(1.84±0.21)E5	X,G	Ta73
2.01 E0	(1.87±0.10)E5	A,G	Gl71
2.41 E0	(1.81±0.09)E5	A,G	Gl71
2.81 E0	(1.74±0.09)E5	A,G	Gl71
3.00 E0	(1.61±0.17)E5	X,G	Ta73
3.22 E0	(1.66±0.09)E5	A,G	Gl71
3.62 E0	(1.60±0.08)E5	A,G	Gl71
4.00 E0	(1.47±0.16)E5	X,G	Ta73
4.02 E0	(1.51±0.08)E5	A,G	Gl71
4.82 E0	(1.39±0.07)E5	A,G	Gl71
5.63 E0	(1.31±0.07)E5	A,G	Gl71
6.00 E0	(1.13±0.12)E5	X,G	Ta73
6.43 E0	(1.20±0.07)E5	A,G	Gl71
7.24 E0	(1.12±0.05)E5	A,G	Gl71
8.04 E0	(1.05±0.05)E5	A,G	Gl71
8.50 E0	(9.52±1.04)E4	X,G	Ta73
8.84 E0	(9.91±0.50)E4	A,G	Gl71
9.65 E0	(9.33±0.47)E4	A,G	Gl71
1.05 E1	(8.82±0.45)E4	A,G	Gl71
1.06 E1	(8.32±0.91)E4	X,G	Ta73
1.26 E1	(7.18±0.79)E4	X,G	Ta73
1.47 E1	(6.25±0.69)E4	X,G	Ta73
1.68 E1	(6.00±0.66)E4	X,G	Ta73
2.50 E1	(5.30±1.50)E4	El,Tn	Is72
Graphical data for 80 keV			Ro79
Z=8 O	f=6.91E-3		
1.00 E0	(6.00±0.30)E4	A,G	Gl71
1.00 E0	(7.08±0.92)E4	X,G	Ta73
1.20 E0	(7.14±0.35)E4	A,G	Gl71
1.24 E0	(8.31±0.83)E4	A,G	Pl85
1.40 E0	(7.96±0.39)E4	A,G	Gl71
1.60 E0	(8.45±0.42)E4	A,G	Gl71
1.80 E0	(8.70±0.43)E4	A,G	Gl71
2.00 E0	(8.79±0.44)E4	A,G	Gl71
2.00 E0	(8.78±1.14)E4	X,G	Ta73
2.08 E0	(8.78±0.88)E4	A,G	Pl85
2.20 E0	(8.89±0.44)E4	A,G	Gl71
2.40 E0	(8.89±0.44)E4	A,G	Gl71
2.60 E0	(8.78±0.44)E4	A,G	Gl71
Z=8 O	f=6.91E-3		
2.90 E0	(8.66±0.43)E4	A,G	Gl71
3.00 E0	(8.48±0.42)E4	A,G	Gl71
3.00 E0	(8.74±1.14)E4	X,G	Ta73
3.11 E0	(8.50±0.85)E4	A,G	Pl85
3.20 E0	(8.41±0.42)E4	A,G	Gl71
3.50 E0	(8.18±0.45)E4	A,G	Gl71
3.80 E0	(8.00±0.40)E4	A,G	Gl71
4.00 E0	(8.36±1.08)E4	X,G	Ta73
4.10 E0	(7.80±0.39)E4	A,G	Gl71
4.40 E0	(7.59±0.38)E4	A,G	Gl71
4.50 E0	(7.53±0.37)E4	A,G	Gl71
4.70 E0	(7.40±0.36)E4	A,G	Gl71
5.00 E0	(7.10±0.35)E4	A,G	Gl71
5.00 E0	(7.29±0.95)E4	X,G	Ta73
5.50 E0	(6.83±0.34)E4	A,G	Gl71
6.00 E0	(6.55±0.33)E4	A,G	Gl71
6.00 E0	(6.37±0.81)E4	X,G	Ta73
7.00 E0	(6.10±0.31)E4	A,G	Gl71
8.00 E0	(5.71±0.28)E4	A,G	Gl71
8.50 E0	(5.23±0.53)E4	X,G	Ta73
9.00 E0	(5.34±0.26)E4	A,G	Gl71
1.00 E1	(5.03±0.25)E4	A,G	Gl71
1.06 E1	(4.37±0.57)E4	X,G	Ta73
1.10 E1	(4.75±0.24)E4	A,G	Gl71
1.20 E1	(4.51±0.22)E4	A,G	Gl71
1.26 E1	(3.91±0.50)E4	X,G	Ta73
1.30 E1	(4.25±0.21)E4	A,G	Gl71
1.68 E1	(3.20±0.42)E4	X,G	Ta73
2.50 E1	(4.00±1.50)E4	E1,Tn	Is72
Z=10 Ne	f=1.52E-2		
9.50 E-1	(6.12±0.67)E3	X,G	Ta73
1.00 E0	(9.35±1.03)E3	X,G	Ta73
1.25 E0	(2.11±0.23)E4	X,G	Ta73
1.26 E0	(1.59±0.28)E4	A,G	Pl85
1.31 E0	(2.02±0.10)E4	A,G	Gl71
1.50 E0	(2.94±0.33)E4	X,G	Ta73
1.54 E0	(3.01±0.51)E4	A,G	Pl85
1.74 E0	(2.89±0.14)E4	A,G	Gl71
1.75 E0	(3.42±0.38)E4	X,G	Ta73
2.00 E0	(3.82±0.42)E4	X,G	Ta73
2.04 E0	(4.13±0.46)E4	A,G	Pl85
2.18 E0	(3.33±0.16)E4	A,G	Gl71
2.50 E0	(3.76±0.41)E4	X,G	Ta73
2.61 E0	(3.59±0.18)E4	A,G	Gl71
3.00 E0	(3.90±0.43)E4	X,G	Ta73
3.05 E0	(3.69±0.18)E4	A,G	Gl71
3.26 E0	(3.69±0.18)E4	A,G	Gl71

TABLE. Cross Sections for K-Shell Ionization by Electron Impact

See page 217 for Explanation of Tables

Z=10 Ne f=1.52E-2

Energy (keV)	Cross Section (barn)	Type	Ref
3.32 E0	(4.19±0.71)E4	A,G	Pl85
3.48 E0	(3.69±0.18)E4	A,G	Gl71
3.50 E0	(4.02±0.44)E4	X,G	Ta73
3.70 E0	(3.69±0.18)E4	A,G	Gl71
3.92 E0	(3.67±0.18)E4	A,G	Gl71
4.00 E0	(4.09±0.45)E4	X,G	Ta73
4.08 E0	(3.61±0.61)E4	A,G	Pl85
4.13 E0	(3.64±0.18)E4	A,G	Gl71
4.35 E0	(3.62±0.18)E4	A,G	Gl71
5.04 E0	(3.32±0.56)E4	A,G	Pl85
5.22 E0	(3.48±0.17)E4	A,G	Gl71
6.00 E0	(3.57±0.39)E4	X,G	Ta73
6.09 E0	(3.32±0.16)E4	A,G	Gl71
6.96 E0	(3.17±0.16)E4	A,G	Gl71
7.83 E0	(3.00±0.15)E4	A,G	Gl71
8.50 E0	(3.20±0.36)E4	X,G	Ta73
8.70 E0	(2.88±0.14)E4	A,G	Gl71
1.00 E1	(2.66±0.14)E4	A,G	Gl71
1.04 E1	(2.59±0.13)E4	A,G	Gl71
1.06 E1	(2.73±0.31)E4	X,G	Ta73
1.26 E1	(2.40±0.27)E4	X,G	Ta73
1.46 E1	(2.28±0.24)E4	X,G	Ta73
Graphical data for 0.871-5.37 keV			Hi81

Z=11 Na f=2.10E-2

Energy (keV)	Cross Section (barn)	Type	Ref
7.00 E4	(4.00±0.64)E3	X,Tn	Ka80
2.30 E5	(4.00±0.64)E3	X,Tn	Ka80

Z=12 Mg f=2.60E-2

Energy (keV)	Cross Section (barn)	Type	Ref
1.00 E4	(9.14±1.46)E2	X,Tn	Mc88
2.00 E4	(1.24±0.20)E3	X,Tn	Mc88
5.00 E4	(2.13±0.58)E3	X,Tn	Ho79
7.00 E4	(2.76±0.44)E3	X,Tn	Ka80
2.30 E5	(2.93±0.47)E3	X,Tn	Ka80

Z=13 Al f=3.87E-2

Energy (keV)	Cross Section (barn)	Type	Ref
2.58 E0	(1.09±0.12)E4	X,Tn	Hi69
3.68 E0	(1.35±0.15)E4	X,Tn	Hi69
5.06 E0	(1.41±0.16)E4	X,Tn	Hi69
6.54 E0	(1.35±0.15)E4	X,Tn	Hi69
8.79 E0	(1.24±0.14)E4	X,Tn	Hi69
1.10 E1	(1.18±0.13)E4	X,Tn	Hi69
1.38 E1	(1.05±0.12)E4	X,Tn	Hi69
1.72 E1	(9.22±1.01)E3	X,Tn	Hi69
2.18 E1	(8.19±0.90)E3	X,Tn	Hi69
2.58 E1	(7.38±0.81)E3	X,Tn	Hi69

Z=13 Al f=3.87E-2

Energy (keV)	Cross Section (barn)	Type	Ref
2.97 E1	(6.72±0.74)E3	X,Tn	Hi69
1.00 E2	(1.41±0.21)E3	X,Tn	We87b
1.00 E4	(8.16±1.31)E2	X,Tn	Mc88
2.00 E4	(1.16±0.18)E3	X,Tn	Mc88
5.00 E4	(2.01±0.28)E3	X,Tn	Ho79
7.00 E4	(2.20±0.35)E3	X,Tn	Ka80
1.50 E5	(2.62±1.05)E3	X,Tn	Is77
2.30 E5	(2.35±0.38)E3	X,Tn	Ka80
Graphical data for 80 keV			Ro79

Z=14 Si f=4.30E-2

Energy (keV)	Cross Section (barn)	Type	Ref
2.99 E0	(9.62±0.96)E3	A,G	Pl85
5.13 E0	(9.29±0.93)E3	A,G	Pl85
5.69 E0	(9.40±0.94)E3	A,G	Pl85
6.62 E0	(1.04±0.10)E4	A,G	Pl85
7.95 E0	(1.05±0.11)E4	A,G	Pl85
1.57 E4	(1.62±0.37)E3	X,Tn	Sh94
2.57 E4	(1.83±0.42)E3	X,Tn	Sh94
5.00 E4	(1.74±0.25)E3	X,Tn	Ho79
1.50 E5	(2.46±0.98)E3	X,Tn	Is77
Graphical data for 100 keV			Pa89

Z=17 Cl f=8.90E-2

Energy (keV)	Cross Section (barn)	Type	Ref
7.00 E4	(1.29±0.21)E3	X,Tn	Ka80
2.30 E5	(1.38±0.22)E3	X,Tn	Ka80
2.70 E5	(1.34±0.54)E3	X,Tn	Is77

Z=18 Ar f=1.20E-1

Energy (keV)	Cross Section (barn)	Type	Ref
3.37 E0	(3.15±0.38)E2	X,G	Hi82
3.59 E0	(7.48±0.91)E2	X,G	Hi82
3.64 E0	(7.86±1.57)E2	A,G	Pl85
3.85 E0	(1.05±0.12)E3	X,G	Hi82
3.99 E0	(1.29±0.26)E3	A,G	Pl85
4.00 E0	(1.31±0.17)E3	X,G	Ta73
4.03 E0	(1.22±0.15)E3	X,G	Hi82
4.19 E0	(1.38±0.14)E3	X,G	Qu82
4.32 E0	(1.43±0.17)E3	X,G	Hi82
4.54 E0	(1.59±0.31)E3	A,G	Pl85
4.56 E0	(1.60±0.19)E3	X,G	Hi82
5.00 E0	(1.82±0.24)E3	X,G	Ta73
5.05 E0	(2.17±0.43)E3	A,G	Pl85
5.11 E0	(1.72±0.17)E3	X,G	Qu82
5.46 E0	(2.08±0.25)E3	X,G	Hi82
5.97 E0	(2.65±0.53)E3	A,G	Pl85
6.00 E0	(2.28±0.30)E3	X,G	Ta73
6.10 E0	(2.18±0.22)E3	X,G	Qu82

TABLE. Cross Sections for *K*-Shell Ionization by Electron Impact

See page 217 for Explanation of Tables

Energy (keV)	Cross Section (barn)	Type	Ref
Z=18 Ar	f=1.20E-1		
6.42 E0	(2.57±0.32)E3	X,G	Hi82
6.99 E0	(2.65±0.53)E3	A,G	Pl85
7.27 E0	(2.60±0.32)E3	X,G	Hi82
7.68 E0	(2.56±0.26)E3	X,G	Qu82
8.00 E0	(3.23±0.64)E3	A,G	Pl85
8.11 E0	(2.80±0.35)E3	X,G	Hi82
8.20 E0	(2.99±0.31)E3	X,G	Qu82
8.50 E0	(2.79±0.36)E3	X,G	Ta73
8.90 E0	(3.32±0.66)E3	A,G	Pl85
9.18 E0	(2.86±0.35)E3	X,G	Hi82
9.74 E0	(2.84±0.57)E3	A,G	Pl85
1.00 E1	(2.75±0.34)E3	X,G	Hi82
1.03 E1	(2.95±0.30)E3	X,G	Qu82
1.06 E1	(2.79±0.36)E3	X,G	Ta73
1.10 E1	(2.78±0.34)E3	X,G	Hi82
1.20 E1	(2.75±0.34)E3	X,G	Hi82
1.26 E1	(2.83±0.36)E3	X,G	Ta73
1.47 E1	(2.77±0.36)E3	X,G	Ta73
1.68 E1	(2.67±0.35)E3	X,G	Ta73
1.89 E1	(2.62±0.34)E3	X,G	Ta73
2.00 E4	(7.76±0.93)E2	X,G	Ho79
3.00 E4	(8.01±0.96)E2	X,G	Ho79
4.00 E4	(8.33±1.00)E2	X,G	Ho79
5.00 E4	(8.31±1.00)E2	X,G	Ho79
6.00 E4	(8.82±1.06)E2	X,G	Ho79
Graphical data for 3.21-4.20 keV			Hi83
Z=19 K	f=1.32E-1		
3.75 E0	(2.12±0.32)E2	X,G	Sh91
4.00 E0	(5.41±0.82)E2	X,G	Sh91
4.50 E0	(7.42±1.11)E2	X,G	Sh91
5.00 E0	(1.17±0.18)E3	X,G	Sh91
6.00 E0	(1.56±0.23)E3	X,G	Sh91
7.00 E0	(1.77±0.27)E3	X,G	Sh91
8.00 E0	(1.85±0.28)E3	X,G	Sh91
9.00 E0	(1.98±0.30)E3	X,G	Sh91
1.00 E1	(2.15±0.32)E3	X,G	Sh91
1.10 E1	(2.25±0.34)E3	X,G	Sh91
1.20 E1	(2.28±0.34)E3	X,G	Sh91
1.30 E1	(2.30±0.35)E3	X,G	Sh91
1.50 E1	(2.25±0.34)E3	X,G	Sh91
1.75 E1	(2.17±0.33)E3	X,G	Sh91
2.00 E1	(2.10±0.32)E3	X,G	Sh91
2.50 E1	(1.93±0.29)E3	X,G	Sh91
3.00 E1	(1.78±0.27)E3	X,G	Sh91
3.50 E1	(1.67±0.25)E3	X,G	Sh91
4.00 E1	(1.51±0.22)E3	X,G	Sh91
4.50 E1	(1.40±0.21)E3	X,G	Sh91
Z=20 Ca	f=1.47E-1		
4.50 E0	(4.77±0.72)E2	X,G	Sh91
5.00 E0	(5.66±0.85)E2	X,G	Sh91
5.50 E0	(6.54±0.99)E2	X,G	Sh91
6.00 E0	(9.65±1.45)E2	X,G	Sh91
7.00 E0	(1.11±0.17)E3	X,G	Sh91
8.00 E0	(1.16±0.18)E3	X,G	Sh91
9.00 E0	(1.26±0.19)E3	X,G	Sh91
1.00 E1	(1.41±0.21)E3	X,G	Sh91
1.10 E1	(1.45±0.22)E3	X,G	Sh91
1.20 E1	(1.52±0.23)E3	X,G	Sh91
1.30 E1	(1.65±0.24)E3	X,G	Sh91
1.40 E1	(1.75±0.27)E3	X,G	Sh91
1.50 E1	(1.76±0.27)E3	X,G	Sh91
1.60 E1	(1.74±0.27)E3	X,G	Sh91
1.70 E1	(1.70±0.26)E3	X,G	Sh91
1.80 E1	(1.69±0.26)E3	X,G	Sh91
2.00 E1	(1.66±0.26)E3	X,G	Sh91
2.50 E1	(1.60±0.24)E3	X,G	Sh91
3.00 E1	(1.52±0.23)E3	X,G	Sh91
3.50 E1	(1.43±0.21)E3	X,G	Sh91
4.00 E1	(1.26±0.19)E3	X,G	Sh91
4.50 E1	(1.19±0.18)E3	X,G	Sh91
2.00 E4	(6.75±0.88)E2	X,G	Ho79
3.50 E4	(7.23±0.94)E2	X,G	Ho79
5.00 E4	(7.71±1.00)E2	X,G	Ho79
6.00 E4	(7.89±1.03)E2	X,G	Ho79
7.00 E4	(9.86±3.95)E2	X,Tn	Is77
1.50 E5	(1.01±0.40)E3	X,Tn	Is77
2.70 E5	(1.16±0.47)E3	X,Tn	Is77
Z=22 Ti	f=2.18E-1		
5.50 E0	(3.62±0.50)E1	X,Tn	He97
5.91 E0	5.01 E2	X,Tn	Je75
6.00 E0	(1.02±0.13)E2	X,Tn	He97
6.46 E0	6.61 E2	X,Tn	Je75
7.00 E0	(3.66±0.40)E2	X,Tn	He97
7.45 E0	9.13 E2	X,Tn	Je75
8.44 E0	1.07 E3	X,Tn	Je75
9.00 E0	(5.17±0.55)E2	X,Tn	He97
9.44 E0	1.21 E3	X,Tn	Je75
9.98 E0	1.27 E3	X,Tn	Je75
1.00 E1	(6.52±0.69)E2	X,Tn	He97
1.04 E1	1.31 E3	X,Tn	Je75
1.15 E1	1.36 E3	X,Tn	Je75
1.20 E1	(8.84±0.94)E2	X,Tn	He97
1.25 E1	1.39 E3	X,Tn	Je75
1.34 E1	1.41 E3	X,Tn	Je75
1.40 E1	(8.89±0.95)E2	X,Tn	He97

TABLE. Cross Sections for *K*-Shell Ionization by Electron Impact

See page 217 for Explanation of Tables

Energy (keV)	Cross Section (barn)	Type	Ref
Z=22 Ti	f=2.18E-1		
1.49 E1	1.43 E3	X,Tn	Je75
1.60 E1	(1.14±0.12)E3	X,Tn	He97
1.80 E1	1.43 E3	X,Tn	Je75
2.00 E1	(1.22±0.13)E3	X,Tn	He97
2.30 E1	1.37 E3	X,Tn	Je75
2.50 E1	(1.14±0.12)E3	X,Tn	He97
2.80 E1	1.30 E3	X,Tn	Je75
2.90 E1	(1.06±0.11)E3	X,Tn	He97
3.30 E1	1.23 E3	X,Tn	Je75
3.80 E1	1.16 E3	X,Tn	Je75
4.30 E1	1.10 E3	X,Tn	Je75
4.70 E1	1.05 E3	X,Tn	Je75
5.00 E1	1.03 E3	X,Tn	Je75
1.00 E2	(2.59±0.39)E2	X,Tn	We87b
Graphical data for 300 MeV			Wa87
Z=23 V	f=2.53E-1		
2.00 E3	(3.49±0.35)E2	X,Tn	Sc72
Z=24 Cr	f=2.86E-1		
6.00 E0	(3.16±0.39)E1	X,Tn	Lu96
6.25 E0	(8.97±1.08)E1	X,Tn	Lu96
6.50 E0	(1.66±0.18)E2	X,Tn	Lu96
7.00 E0	(1.96±0.22)E2	X,Tn	Lu96
8.00 E0	(4.19±0.48)E2	X,Tn	Lu96
1.00 E1	(6.57±0.79)E2	X,Tn	Lu96
1.20 E1	(8.42±1.06)E2	X,Tn	Lu96
1.40 E1	(9.55±1.23)E2	X,Tn	Lu96
1.60 E1	(9.80±1.30)E2	X,Tn	Lu96
2.00 E1	(1.01±0.14)E3	X,Tn	Lu96
2.30 E1	(9.51±1.31)E2	X,Tn	Lu96
2.50 E1	(8.94±1.23)E2	X,Tn	Lu96
2.00 E3	(2.67±0.27)E2	X,Tn	Sc72
2.00 E4	(4.44±0.44)E2	X,Tn	Ho79
3.50 E4	(4.94±0.49)E2	X,Tn	Ho79
5.00 E4	(4.95±0.49)E2	X,Tn	Ho79
6.00 E4	(5.21±0.52)E2	X,Tn	Ho79
Graphical data for 300 MeV			Wa87
Graphical data for 80-200 keV			Pa89
Z=25 Mn	f=3.19E-1		
6.71 E0	(2.56±0.59)E1	X,Tn	Sh80
6.90 E0	(6.69±1.28)E1	X,Tn	Sh80
6.91 E0	(4.20±0.60)E1	X,Tn	Ta99b
7.40 E0	(1.47±0.30)E2	X,Tn	Sh80
7.50 E0	(1.30±0.18)E2	X,Tn	Lu97

Energy (keV)	Cross Section (barn)	Type	Ref
Z=25 Mn	f=3.19E-1		
8.00 E0	(2.36±0.31)E2	X,Tn	Sh80
8.47 E0	(3.18±0.43)E2	X,Tn	Ta99b
9.00 E0	(3.46±0.38)E2	X,Tn	Sh80
9.49 E0	(4.63±0.65)E2	X,Tn	Lu97
9.97 E0	(4.68±0.65)E2	X,Tn	Ta99b
1.10 E1	(5.10±0.54)E2	X,Tn	Sh80
1.15 E1	(6.05±0.88)E2	X,Tn	Lu97
1.15 E1	(5.86±0.85)E2	X,Tn	Ta99b
1.35 E1	(6.60±0.98)E2	X,Tn	Lu97
1.35 E1	(6.32±0.94)E2	X,Tn	Ta99b
1.50 E1	(6.44±0.69)E2	X,Tn	Sh80
1.56 E1	(6.88±1.06)E2	X,Tn	Lu97
1.56 E1	(6.69±1.02)E2	X,Tn	Ta99b
1.77 E1	(6.83±1.07)E2	X,Tn	Ta99b
1.78 E1	(6.80±1.07)E2	X,Tn	Lu97
1.96 E1	(7.23±1.13)E2	X,Tn	Ta99b
1.99 E1	(7.35±1.17)E2	X,Tn	Lu97
2.00 E1	(6.66±0.70)E2	X,Tn	Sh80
2.17 E1	(7.36±1.21)E2	X,Tn	Lu97
2.18 E1	(7.16±1.15)E2	X,Tn	Ta99b
2.37 E1	(7.53±1.25)E2	X,Tn	Lu97
2.37 E1	(6.90±1.13)E2	X,Tn	Ta99b
2.56 E1	(6.94±1.14)E2	X,Tn	Ta99b
2.59 E1	(7.17±1.23)E2	X,Tn	Lu97
2.00 E3	(2.66±0.31)E2	X,Tn	Sc72
5.00 E4	(4.27±0.38)E2	X,Tn	Ho79
Graphical data for 50 keV			Fi67
Graphical data for 350 MeV			Wa87
Z=26 Fe	f=3.51E-1		
7.50 E0	(6.52±0.76)E1	X,Tn	He96a
7.93 E0	(1.05±0.12)E2	X,Tn	Lu97
8.00 E0	(9.83±0.97)E1	X,Tn	He96a
9.00 E0	(2.22±0.17)E2	X,Tn	He96a
1.00 E1	(3.57±0.24)E2	X,Tn	He96a
1.00 E1	(3.59±0.42)E2	X,Tn	Lu97
1.10 E1	(4.01±0.26)E2	X,Tn	He96a
1.20 E1	(5.70±0.38)E2	X,Tn	He96a
1.21 E1	(4.77±0.58)E2	X,Tn	Lu97
1.40 E1	(7.56±0.49)E2	X,Tn	He96a
1.42 E1	(6.06±0.77)E2	X,Tn	Lu97
1.60 E1	(8.04±0.51)E2	X,Tn	He96a
1.63 E1	(6.72±0.87)E2	X,Tn	Lu97
1.80 E1	(8.46±0.54)E2	X,Tn	He96a
1.84 E1	(6.82±0.90)E2	X,Tn	Lu97
2.00 E1	(8.77±0.54)E2	X,Tn	He96a
2.04 E1	(6.75±0.92)E2	X,Tn	Lu97
2.20 E1	(8.40±0.58)E2	X,Tn	He96a

TABLE. Cross Sections for *K*-Shell Ionization by Electron Impact

See page 217 for Explanation of Tables

Energy (keV)	Cross Section (barn)	Type	Ref
Z=26 Fe	f=3.51E-1		
2.23 E1	(6.99±0.99)E2	X,Tn	Lu97
2.48 E1	(6.90±0.97)E2	X,Tn	Lu97
2.50 E1	(8.67±0.56)E2	X,Tn	He96a
2.80 E1	(8.59±0.57)E2	X,Tn	He96a
2.00 E3	(2.52±0.25)E2	X,Tn	Sc72
Graphical data for 80-200 keV			Pa89
Graphical data for 7.5-28keV			He96c
Z=27 Co	f=3.82E-1		
8.50 E0	(8.58±1.10)E1	X,Tn	An96
1.06 E1	(3.13±0.40)E2	X,Tn	An96
1.27 E1	(4.53±0.57)E2	X,Tn	An96
1.48 E1	(5.01±0.68)E2	X,Tn	An96
1.67 E1	(5.25±0.69)E2	X,Tn	An96
1.87 E1	(5.73±0.77)E2	X,Tn	An96
2.09 E1	(5.67±0.76)E2	X,Tn	An96
2.28 E1	(5.46±0.74)E2	X,Tn	An96
2.49 E1	(5.24±0.76)E2	X,Tn	An96
2.00 E3	(2.40±0.30)E2	X,Tn	Sc72
Graphical data for 80-200 keV			Pa89
Z=28 Ni	f=4.12E-1		
8.91 E0	1.06 E2	X,Tn	Je75
9.00 E0	(8.04±0.80)E1	X,Tn	Lu96
9.83 E0	1.94 E2	X,Tn	Je75
1.00 E1	(1.06±0.12)E2	X,Tn	Lu96
1.20 E1	(3.52±0.45)E2	X,Tn	Lu96
1.23 E1	3.53 E2	X,Tn	Je75
1.47 E1	4.48 E2	X,Tn	Je75
1.48 E1	3.18 E2	X,Tn	Po47
1.60 E1	(4.82±0.54)E2	X,Tn	Lu96
1.97 E1	5.31 E2	X,Tn	Je75
2.00 E1	(5.14±0.60)E2	X,Tn	Lu96
2.47 E1	5.55 E2	X,Tn	Je75
2.48 E1	3.91 E2	X,Tn	Po47
2.50 E1	(5.50±0.75)E2	X,Tn	Lu96
2.98 E1	5.56 E2	X,Tn	Je75
3.00 E1	(5.40±0.72)E2	X,Tn	Lu96
3.40 E1	(5.20±0.73)E2	X,Tn	Lu96
3.48 E1	5.43 E2	X,Tn	Je75
3.57 E1	3.84 E2	X,Tn	Po47
3.97 E1	5.29 E2	X,Tn	Je75
4.47 E1	5.14 E2	X,Tn	Je75
4.62 E1	3.65 E2	X,Tn	Po47
4.97 E1	5.00 E2	X,Tn	Je75
5.56 E1	3.39 E2	X,Tn	Po47
7.00 E1	(3.16±0.20)E2	X,Tn	Sm45

Energy (keV)	Cross Section (barn)	Type	Ref
Z=28 Ni	f=4.12E-1		
7.53 E1	2.99 E2	X,Tn	Po47
9.51 E1	2.76 E2	X,Tn	Po47
1.25 E2	2.45 E2	X,Tn	Po47
1.53 E2	2.24 E2	X,Tn	Po47
1.83 E2	2.07 E2	X,Tn	Po47
4.90 E2	(3.39±0.84)E2	X,Tn	Se74
6.70 E2	(3.47±0.86)E2	X,Tn	Se74
2.00 E3	(2.35±0.27)E2	X,Tn	Sc72
2.00 E4	(2.79±0.22)E2	X,Tn	Ho79
5.00 E4	(3.32±0.26)E2	X,Tn	Ho79
6.00 E4	(3.69±0.29)E2	X,Tn	Ho79
9.00 E5	(4.94±0.39)E2	X,Tn	Ge82
1.50 E6	(5.99±0.48)E2	X,Tn	Ge82
2.00 E6	(6.23±0.50)E2	X,Tn	Ge82
Graphical data for 3.0-21 MeV			Da75
Graphical data for 300 MeV			Wa87
Graphical data for 100 keV			Pa89
Graphical data for 120 keV			Ba92
Z=29 Cu	f=4.41E-1		
9.00 E0	(1.01±0.10)E1	X,Tn	He97
9.12 E0	(1.60±0.36)E1	X,Tn	Sh81
9.27 E0	(1.09±0.20)E1	X,Tn	Sh80
9.40 E0	(2.02±0.20)E1	X,Tn	An96
9.50 E0	(3.29±0.61)E1	X,Tn	Sh80
9.50 E0	(2.02±0.20)E1	X,Tn	He97
1.00 E1	(8.68±1.72)E1	X,Tn	Sh81
1.00 E1	(6.78±1.11)E1	X,Tn	Sh80
1.05 E1	(5.05±0.50)E1	X,Tn	He97
1.10 E1	(1.21±0.18)E2	X,Tn	Sh80
1.16 E1	(1.56±0.18)E2	X,Tn	An96
1.20 E1	(1.88±0.21)E2	X,Tn	Sh80
1.20 E1	(1.52±0.11)E2	X,Tn	He97
1.36 E1	(2.59±0.29)E2	X,Tn	An96
1.50 E1	(2.97±0.36)E2	X,Tn	Sh81
1.50 E1	(2.97±0.31)E2	X,Tn	Sh80
1.50 E1	(2.94±0.21)E2	X,Tn	He97
1.54 E1	(3.06±0.34)E2	X,Tn	An96
1.75 E1	(3.42±0.25)E2	X,Tn	He97
1.77 E1	(3.78±0.41)E2	X,Tn	An96
1.97 E1	(3.84±0.42)E2	X,Tn	An96
2.00 E1	(3.83±0.41)E2	X,Tn	Sh81
2.00 E1	(4.06±0.40)E2	X,Tn	Sh80
2.00 E1	(3.76±0.27)E2	X,Tn	He97
2.17 E1	(4.16±0.44)E2	X,Tn	An96
2.25 E1	(3.99±0.28)E2	X,Tn	He97
2.39 E1	(4.02±0.48)E2	X,Tn	An96
2.50 E1	(4.01±0.45)E2	X,Tn	Sh81

TABLE. Cross Sections for K-Shell Ionization by Electron Impact

See page 217 for Explanation of Tables

Energy (keV)	Cross Section (barn)	Type	Ref
Z=29 Cu f=4.41E-1			
2.50 E1	(4.19±0.40)E2	X,Tn	Sh80
2.50 E1	(5.56±0.09)E2	X,Tn	Da72
2.50 E1	(4.14±0.30)E2	X,Tn	He97
2.59 E1	(4.01±0.43)E2	X,Tn	An96
2.80 E1	(4.10±0.28)E2	X,Tn	He97
3.00 E1	(5.89±0.07)E2	X,Tn	Da72
4.00 E1	(5.50±0.05)E2	X,Tn	Da72
6.00 E1	(5.29±0.16)E2	X,Tn	Da72
8.00 E1	(4.83±0.04)E2	X,Tn	Da72
8.10 E1	(2.71±0.27)E2	X,Tn	Hu72
1.00 E2	(1.87±0.28)E2	X,Tn	We87b
1.00 E2	(4.02±0.05)E2	X,Tn	Da72
1.14 E2	(2.51±0.25)E2	X,Tn	Hu72
1.35 E2	(3.69±0.02)E2	X,Tn	Da72
1.52 E2	(2.21±0.18)E2	X,Tn	Hu72
3.00 E2	(2.23±0.20)E2	X,Tn	Be78
4.00 E2	(2.05±0.18)E2	X,Tn	Be78
5.00 E2	(1.98±0.18)E2	X,Tn	Be78
6.00 E2	(1.93±0.17)E2	X,Tn	Be78
2.00 E3	(2.00±0.19)E2	X,Tn	Sc72
4.00 E4	(2.66±0.18)E2	X,Tn	Ho79
1.50 E5	(4.34±0.69)E2	X,Tn	Is77
1.50 E5	(3.97±0.05)E2	X,Tn	Mi70
3.00 E5	(4.48±0.05)E2	X,Tn	Mi70
5.00 E5	(4.76±0.06)E2	X,Tn	Mi70
7.00 E5	(4.76±0.06)E2	X,Tn	Mi70
9.00 E5	(4.78±0.07)E2	X,Tn	Mi70
9.00 E5	(4.65±0.30)E2	X,Tn	Ge82
1.50 E6	(5.98±0.41)E2	X,Tn	Ge82
2.00 E6	(6.35±0.41)E2	X,Tn	Ge82
Graphical data for 50 keV			Fi67
Graphical data for 350 MeV			Wa87
Graphical data for 80-200 keV			Pa89
Z=30 Zn f=4.69E-1			
1.03 E1	(2.62±0.32)E1	X,Tn	Ta99a
1.14 E1	(9.66±0.97)E1	X,Tn	Ta99a
1.26 E1	(1.53±0.15)E2	X,Tn	Ta99a
1.42 E1	(1.94±0.20)E2	X,Tn	Ta99a
1.57 E1	(2.40±0.27)E2	X,Tn	Ta99a
1.77 E1	(2.62±0.29)E2	X,Tn	Ta99a
1.99 E1	(2.91±0.34)E2	X,Tn	Ta99a
2.17 E1	(3.06±0.35)E2	X,Tn	Ta99a
2.39 E1	(3.23±0.39)E2	X,Tn	Ta99a
2.57 E1	(3.24±0.41)E2	X,Tn	Ta99a
2.00 E3	(1.87±0.21)E2	X,Tn	Sc72
1.50 E5	(4.04±0.60)E2	X,Tn	Is77
Graphical data for 350 MeV			Wa87
Z=32 Ge f=5.23E-1			
1.12 E1	(4.91±1.01)E0	X,Tn	Sh81
1.20 E1	(3.85±0.61)E1	X,Tn	Sh81
1.50 E1	(1.40±0.14)E2	X,Tn	Sh81
2.00 E1	(2.17±0.23)E2	X,Tn	Sh81
2.50 E1	(2.45±0.25)E2	X,Tn	Sh81
2.00 E4	(2.00±0.17)E2	X,Tn	Ho79
3.50 E4	(2.17±0.18)E2	X,Tn	Ho79
5.00 E4	(2.25±0.18)E2	X,Tn	Ho79
6.00 E4	(2.31±0.19)E2	X,Tn	Ho79
Graphical data for 350 MeV			Wa87
Graphical data for 100 keV			Pa89
Z=33 As f=5.49E-1			
2.00 E3	(1.38±0.15)E2	X,Tn	Sc72
Z=34 Se f=5.74E-1			
6.00 E1	(2.14±0.20)E2	X,Tn	Ki81
1.00 E2	(1.87±0.18)E2	X,Tn	Ki81
2.00 E2	(1.51±0.13)E2	X,Tn	Ki81
3.00 E2	(1.34±0.12)E2	X,Tn	Ki81
3.00 E2	(1.54±0.13)E2	X,Tn	Be78
4.00 E2	(1.29±0.11)E2	X,Tn	Ki81
4.00 E2	(1.43±0.12)E2	X,Tn	Be78
5.00 E2	(1.25±0.11)E2	X,Tn	Ki81
5.00 E2	(1.38±0.12)E2	X,Tn	Be78
6.00 E2	(1.21±0.11)E2	X,Tn	Ki81
6.00 E2	(1.35±0.12)E2	X,Tn	Be78
2.00 E3	(1.16±0.12)E2	X,Tn	Sc72
7.00 E4	(2.79±0.42)E2	X,Tn	Is77
1.50 E5	(2.85±0.43)E2	X,Tn	Is77
Graphical data for 50 keV			Fi67
Z=35 Br f=5.98E-1			
2.00 E3	(1.16±0.12)E2	X,Tn	Sc72
Z=36 Kr f=6.21E-1			
2.00 E4	(1.53±0.06)E2	X,G	Ho79
3.00 E4	(1.60±0.06)E2	X,G	Ho79
4.00 E4	(1.66±0.06)E2	X,G	Ho79
5.00 E4	(1.75±0.07)E2	X,G	Ho79
6.00 E4	(1.80±0.07)E2	X,G	Ho79
Z=37 Rb f=6.43E-1			
1.60 E1	(2.35±0.35)E1	X,G	Sh91

TABLE. Cross Sections for K-Shell Ionization by Electron Impact

See page 217 for Explanation of Tables

Energy (keV)	Cross Section (barn)	Type	Ref
Z=37 Rb f=6.43E-1			
1.70 E1	(4.49±0.67)E1	X,G	Sh91
1.80 E1	(5.67±0.85)E1	X,G	Sh91
1.90 E1	(7.41±1.11)E1	X,G	Sh91
2.00 E1	(8.00±1.20)E1	X,G	Sh91
2.25 E1	(8.45±1.27)E1	X,G	Sh91
2.50 E1	(9.09±1.36)E1	X,G	Sh91
3.00 E1	(1.00±0.15)E2	X,G	Sh91
3.50 E1	(1.05±0.16)E2	X,G	Sh91
4.00 E1	(1.14±0.18)E2	X,G	Sh91
4.50 E1	(1.28±0.19)E2	X,G	Sh91
2.00 E3	(1.06±0.10)E2	X,Tn	Sc72
Z=38 Sr f=6.65E-1			
1.70 E1	(1.66±0.25)E1	X,G	Sh91
1.80 E1	(2.09±0.31)E1	X,G	Sh91
1.90 E1	(3.11±0.47)E1	X,G	Sh91
2.00 E1	(4.77±0.72)E1	X,G	Sh91
2.50 E1	(7.33±1.10)E1	X,G	Sh91
3.00 E1	(8.27±1.24)E1	X,G	Sh91
3.50 E1	(8.95±1.34)E1	X,G	Sh91
4.00 E1	(9.26±1.39)E1	X,G	Sh91
4.50 E1	(1.03±0.15)E2	X,G	Sh91
2.00 E3	(9.31±0.95)E1	X,Tn	Sc72
1.50 E5	(2.15±0.04)E2	X,Tn	Mi70
3.00 E5	(2.23±0.03)E2	X,Tn	Mi70
5.00 E5	(2.44±0.04)E2	X,Tn	Mi70
7.00 E5	(2.62±0.04)E2	X,Tn	Mi70
9.00 E5	(2.65±0.04)E2	X,Tn	Mi70
Z=39 Y f=6.85E-1			
4.90 E2	(7.58±1.87)E1	X,Tn	Se74
6.70 E2	(7.89±1.97)E1	X,Tn	Se74
5.00 E4	(1.43±0.15)E2	X,Tn	Ho79
7.00 E4	(1.96±0.29)E2	X,Tn	Is77
1.50 E5	(1.94±0.29)E2	X,Tn	Is77
2.70 E5	(2.13±0.32)E2	X,Tn	Is77
Graphical data for 300-380 MeV			Wa87
Z=40 Zr f=7.05E-1			
1.00 E2	(8.21±1.23)E1	X,Tn	We87b
2.40 E2	(9.32±0.52)E1	X,Tn	Ha64
5.30 E2	(1.19±0.08)E2	X,Tn	Ha64
8.20 E2	(1.29±0.09)E2	X,Tn	Ha64
1.13 E3	(1.19±0.09)E2	X,Tn	Ha64
1.44 E3	(1.03±0.10)E2	X,Tn	Ha64
Z=41 Nb f=7.24E-1			
2.00 E1	(1.10±0.14)E1	X,Tn	Pe98
2.20 E1	(1.97±0.21)E1	X,Tn	Pe98
2.40 E1	(2.49±0.25)E1	X,Tn	Pe98
2.60 E1	(3.24±0.30)E1	X,Tn	Pe98
2.80 E1	(4.34±0.49)E1	X,Tn	Pe98
3.00 E1	(5.49±0.60)E1	X,Tn	Pe98
3.20 E1	(6.04±0.80)E1	X,Tn	Pe98
3.40 E1	(6.75±0.91)E1	X,Tn	Pe98
Z=42 Mo f=7.42E-1			
2.10 E1	(1.60±0.14)E1	X,Tn	He96b
2.20 E1	(2.86±0.28)E1	X,Tn	He96b
2.40 E1	(3.90±0.35)E1	X,Tn	He96b
2.60 E1	(5.13±0.42)E1	X,Tn	He96b
2.80 E1	(6.27±0.54)E1	X,Tn	He96b
3.00 E1	(7.28±0.68)E1	X,Tn	He96b
3.20 E1	(7.90±0.83)E1	X,Tn	He96b
3.40 E1	(8.96±0.89)E1	X,Tn	He96b
3.60 E1	(9.71±1.06)E1	X,Tn	He96b
3.80 E1	(1.10±0.12)E2	X,Tn	He96b
4.00 E1	(1.34±0.18)E2	X,Tn	He96b
9.00 E4	(1.52±0.23)E2	X,Tn	Is77
1.50 E5	(1.45±0.02)E2	X,Tn	Mi70
3.00 E5	(1.55±0.02)E2	X,Tn	Mi70
5.00 E5	(1.68±0.02)E2	X,Tn	Mi70
7.00 E5	(1.71±0.03)E2	X,Tn	Mi70
9.00 E5	(1.79±0.02)E2	X,Tn	Mi70
Graphical data for 80-200 keV			Pa89
Graphical data for 21-41 keV			He96c
Z=46 Pd f=8.07E-1			
3.00 E2	(6.83±0.61)E1	X,Tn	Ri77
4.00 E2	(6.55±0.61)E1	X,Tn	Ri77
5.00 E2	(6.55±0.61)E1	X,Tn	Ri77
6.00 E2	(6.53±0.61)E1	X,Tn	Ri77
2.50 E3	(7.21±0.72)E1	X,Tn	Be70
7.10 E3	(7.92±0.79)E1	X,Tn	Be70
9.00 E4	(1.18±0.17)E2	X,Tn	Is77
2.50 E5	(1.25±0.18)E2	X,Tn	Is77
Z=47 Ag f=8.22E-1			
2.60 E1	(1.92±0.30)E0	X,Tn	Sh81
2.70 E1	(6.27±0.91)E0	X,Tn	Sh81
2.80 E1	(9.20±1.11)E0	X,Tn	Sh81
2.90 E1	(1.26±0.16)E1	X,Tn	Sh81
3.00 E1	(1.66±0.19)E1	X,Tn	Sh81

TABLE. Cross Sections for K-Shell Ionization by Electron Impact

See page 217 for Explanation of Tables

Energy (keV)	Cross Section (barn)	Type	Ref
Z=47 Ag f=8.22E-1			
3.00 E1	(2.60±0.06)E1	X,Tn	Da72
3.05 E1	(1.48±0.13)E1	X,Tn	Cl35
3.85 E1	(2.89±0.26)E1	X,Tn	Cl35
4.00 E1	(5.04±0.09)E1	X,Tn	Da72
5.00 E1	(6.38±0.10)E1	X,Tn	Da72
5.10 E1	(3.77±0.34)E1	X,Tn	Cl35
6.00 E1	(6.87±0.11)E1	X,Tn	Da72
6.00 E1	(5.56±0.67)E1	X,Tn	Ki81
6.38 E1	(4.12±0.36)E1	X,Tn	Cl35
7.65 E1	(4.29±0.38)E1	X,Tn	Cl35
8.00 E1	(6.86±0.07)E1	X,Tn	Da72
8.93 E1	(4.38±0.39)E1	X,Tn	Cl35
1.00 E2	(4.92±0.74)E1	X,Tn	We87b
1.00 E2	(6.86±0.06)E1	X,Tn	Da72
1.00 E2	(5.97±0.72)E1	X,Tn	Ki81
1.00 E2	(5.75±0.59)E1	X,Tn	Re66
1.02 E2	(4.29±0.38)E1	X,Tn	Cl35
1.14 E2	(4.99±0.45)E1	X,Tn	Hu72
1.20 E2	(6.84±0.07)E1	X,Tn	Da72
1.28 E2	(4.20±0.37)E1	X,Tn	Cl35
1.40 E2	(6.60±0.10)E1	X,Tn	Da72
1.50 E2	(5.75±0.59)E1	X,Tn	Re66
1.53 E2	(4.12±0.36)E1	X,Tn	Cl35
1.79 E2	(3.94±0.36)E1	X,Tn	Cl35
2.00 E2	(5.66±0.68)E1	X,Tn	Ki81
2.00 E2	(5.15±0.48)E1	X,Tn	Re66
2.50 E2	(5.15±0.48)E1	X,Tn	Re66
3.00 E2	(5.46±0.66)E1	X,Tn	Ki81
3.00 E2	(4.77±0.48)E1	X,Tn	Re66
3.00 E2	(6.05±0.55)E1	X,Tn	Ri77
3.00 E2	(5.64±0.57)E1	X,Tn	Sc76
4.00 E2	(5.26±0.63)E1	X,Tn	Ki81
4.00 E2	(5.84±0.53)E1	X,Tn	Ri77
4.00 E2	(5.35±0.54)E1	X,Tn	Sc76
4.90 E2	(3.72±0.91)E1	X,Tn	Se74
5.00 E2	(5.26±0.63)E1	X,Tn	Ki81
5.00 E2	(5.66±0.51)E1	X,Tn	Ri77
5.00 E2	(5.07±0.50)E1	X,Tn	Sc76
6.00 E2	(5.26±0.63)E1	X,Tn	Ki81
6.00 E2	(5.51±0.50)E1	X,Tn	Ri77
6.00 E2	(5.26±0.53)E1	X,Tn	Sc76
6.70 E2	(4.01±1.01)E1	X,Tn	Se74
1.00 E3	(4.57±0.48)E1	X,Tn	Re66
2.00 E3	(5.72±0.51)E1	X,Tn	Sc72
2.00 E4	(7.77±0.50)E1	X,Tn	Ho79
3.50 E4	(8.68±0.50)E1	X,Tn	Ho79
5.00 E4	(8.78±0.50)E1	X,Tn	Ho79
6.00 E4	(9.59±0.61)E1	X,Tn	Ho79
9.00 E5	(1.48±0.11)E2	X,Tn	Ge82

Energy (keV)	Cross Section (barn)	Type	Ref
Z=47 Ag f=8.22E-1			
1.50 E6	(1.45±0.11)E2	X,Tn	Ge82
2.00 E6	(1.57±0.11)E2	X,Tn	Ge82
Graphical data for 50 keV			Fi67
Graphical data for 100-400 keV			Ha66
Graphical data for 3.0-30 MeV			Da75
Graphical data for 300-380 MeV			Wa87
Graphical data for 12.3-75 keV			Sc93
Graphical data for 80-200 keV			Pa89
Z=48 Cd f=8.36E-1			
2.00 E3	(4.59±0.41)E1	X,Tn	Sc72
Z=49 In f=8.48E-1			
3.00 E2	(5.73±0.52)E1	X,Tn	Ri77
4.00 E2	(5.58±0.50)E1	X,Tn	Ri77
5.00 E2	(5.64±0.51)E1	X,Tn	Ri77
6.00 E2	(5.67±0.51)E1	X,Tn	Ri77
2.00 E3	(4.34±0.39)E1	X,Tn	Sc72
1.50 E5	(1.28±0.19)E2	X,Tn	Is77
1.50 E5	(9.63±0.13)E1	X,Tn	Mi70
3.00 E5	(1.18±0.02)E2	X,Tn	Mi70
5.00 E5	(1.23±0.02)E2	X,Tn	Mi70
7.00 E5	(1.25±0.02)E2	X,Tn	Mi70
9.00 E5	(1.30±0.02)E2	X,Tn	Mi70
Z=50 Sn f=8.61E-1			
2.00 E2	(4.59±0.49)E1	X,Tn	Re66
2.40 E2	(5.79±0.30)E1	X,Tn	Ha64
3.00 E2	(5.09±0.46)E1	X,Tn	Ri77
4.00 E2	(4.88±0.44)E1	X,Tn	Ri77
5.00 E2	(4.87±0.44)E1	X,Tn	Ri77
5.30 E2	(6.09±0.30)E1	X,Tn	Ha64
6.00 E2	(3.90±0.39)E1	X,Tn	Re66
6.00 E2	(4.84±0.44)E1	X,Tn	Ri77
8.00 E2	(3.80±0.39)E1	X,Tn	Re66
8.20 E2	(6.78±0.40)E1	X,Tn	Ha64
1.00 E3	(3.80±0.39)E1	X,Tn	Re66
1.13 E3	(7.18±0.40)E1	X,Tn	Ha64
1.20 E3	(3.90±0.39)E1	X,Tn	Re66
1.40 E3	(4.10±0.39)E1	X,Tn	Re66
1.44 E3	(7.18±0.40)E1	X,Tn	Ha64
1.70 E3	(4.19±0.39)E1	X,Tn	Re66
2.00 E3	(4.29±0.39)E1	X,Tn	Re66
2.00 E3	(4.29±0.39)E1	X,Tn	Sc72
2.00 E4	(7.08±0.50)E1	X,Tn	Ho79
5.00 E4	(8.28±0.60)E1	X,Tn	Ho79

TABLE. Cross Sections for K-Shell Ionization by Electron Impact

See page 217 for Explanation of Tables

Energy (keV)	Cross Section (barn)	Type	Ref
Z=50 Sn f=8.61E-1			
1.50 E5	(1.11±0.17)E2	X,Tn	Is77
Graphical data for 50 keV			Fi67
Graphical data for 50-500 keV			Mo64
Graphical data for 100-400 keV			Ha66
Graphical data for 300-380 MeV			Wa87
Z=51 Sb f=8.72E-1			
6.00 E1	(3.38±0.41)E1	X,Tn	Ki81
1.00 E2	(3.84±0.56)E1	X,Tn	We87b
1.00 E2	(3.99±0.48)E1	X,Tn	Ki81
2.00 E2	(4.09±0.49)E1	X,Tn	Ki81
3.00 E2	(3.79±0.46)E1	X,Tn	Ki81
4.00 E2	(3.69±0.44)E1	X,Tn	Ki81
5.00 E2	(3.69±0.44)E1	X,Tn	Ki81
6.00 E2	(3.79±0.46)E1	X,Tn	Ki81
2.00 E3	(4.09±0.37)E1	X,Tn	Sc72
Z=52 Te f=8.83E-1			
2.00 E3	(3.76±0.34)E1	X,Tn	Sc72
Graphical data for 300-380 MeV			Wa87
Z=54 Xe f=9.03E-1			
2.00 E4	(4.92±0.49)E1	X,G	Ho79
3.00 E4	(5.41±0.49)E1	X,G	Ho79
4.00 E4	(5.61±0.49)E1	X,G	Ho79
5.00 E4	(5.71±0.49)E1	X,G	Ho79
6.00 E4	(5.91±0.49)E1	X,G	Ho79
Z=56 Ba f=9.20E-1			
1.00 E2	(2.51±0.37)E1	X,Tn	We87b
2.00 E3	(2.95±0.26)E1	X,Tn	Sc72
7.00 E4	(7.48±1.13)E1	X,Tn	Is77
9.00 E4	(6.72±1.01)E1	X,Tn	Is77
1.50 E5	(7.60±1.14)E1	X,Tn	Is77
2.70 E5	(8.77±1.31)E1	X,Tn	Is77
Z=57 La f=9.28E-1			
1.00 E2	(2.31±0.35)E1	X,Tn	We87b
2.00 E3	(1.85±0.17)E1	X,Tn	Sc72
Z=58 Ce f=9.10E-1			
2.00 E3	(2.34±0.21)E1	X,Tn	Sc72
Z=59 Pr f=9.41E-1			
1.00 E2	(1.97±0.29)E1	X,Tn	We87b
2.00 E3	(2.31±0.20)E1	X,Tn	Sc72
Z=60 Nd f=9.18E-1			
2.00 E3	(2.14±0.19)E1	X,Tn	Sc72
Z=62 Sm f=9.26E-1			
2.00 E3	(2.20±0.19)E1	X,Tn	Sc72
9.00 E4	(5.37±0.80)E1	X,Tn	Is77
Z=63 Eu f=9.62E-1			
2.00 E3	(2.04±0.18)E1	X,Tn	Sc72
Z=64 Gd f=9.32E-1			
2.00 E3	(2.09±0.19)E1	X,Tn	Sc72
Z=67 Ho f=9.40E-1			
2.00 E4	(3.41±0.30)E1	X,Tn	Ho79
5.00 E4	(4.21±0.40)E1	X,Tn	Ho79
9.00 E4	(3.80±0.57)E1	X,Tn	Is77
Z=68 Er f=9.43E-1			
2.00 E3	(1.70±0.15)E1	X,Tn	Sc72
Z=69 Tm f=9.79E-1			
3.00 E5	(4.59±0.09)E1	X,Tn	Mi70
5.00 E5	(4.48±0.06)E1	X,Tn	Mi70
7.00 E5	(4.59±0.06)E1	X,Tn	Mi70
9.00 E5	(4.78±0.06)E1	X,Tn	Mi70
Z=70 Yb f=9.47E-1			
4.90 E2	(1.32±0.33)E1	X,Tn	Se74
6.70 E2	(1.67±0.41)E1	X,Tn	Se74
2.00 E3	(1.55±0.14)E1	X,Tn	Sc72
Z=73 Ta f=9.83E-1			
4.90 E2	(1.10±0.27)E1	X,Tn	Se74
6.70 E2	(1.46±0.29)E1	X,Tn	Se74
3.00 E5	(3.72±0.05)E1	X,Tn	Mi70
5.00 E5	(4.24±0.16)E1	X,Tn	Mi70

TABLE. Cross Sections for *K*-Shell Ionization by Electron Impact

See page 217 for Explanation of Tables

Energy (keV)	Cross Section (barn)	Type	Ref
Z=74 W f=9.54E-1			
2.40 E2	(1.97±0.16)E1	X,Tn	Ha64
5.30 E2	(2.39±0.25)E1	X,Tn	Ha64
8.20 E2	(3.46±0.35)E1	X,Tn	Ha64
1.13 E3	(3.41±0.35)E1	X,Tn	Ha64
1.44 E3	(2.50±0.38)E1	X,Tn	Ha64
Graphical data for 200-550 keV			Ha66
Z=78 Pt f=9.59E-1			
2.00 E3	(1.21±0.11)E1	X,Tn	Sc72
Z=79 Au f=9.60E-1			
9.00 E1	(2.47±0.30)E0	X,Tn	Da72
1.00 E2	(4.45±0.10)E0	X,Tn	Da72
1.20 E2	(5.93±0.10)E0	X,Tn	Da72
1.40 E2	(6.52±0.10)E0	X,Tn	Da72
2.00 E2	(8.60±0.10)E0	X,Tn	Re66
4.90 E2	(1.06±0.26)E1	X,Tn	Se74
6.00 E2	(9.94±1.00)E0	X,Tn	Re66
6.70 E2	(1.48±0.36)E1	X,Tn	Se74
8.00 E2	(9.94±1.00)E0	X,Tn	Re66
1.00 E3	(9.94±1.00)E0	X,Tn	Re66
1.20 E3	(9.94±1.00)E0	X,Tn	Re66
1.40 E3	(9.94±1.00)E0	X,Tn	Re66
1.70 E3	(1.08±0.10)E1	X,Tn	Re66
2.00 E3	(1.08±0.10)E1	X,Tn	Re66
2.00 E3	(1.21±0.11)E1	X,Tn	Sc72
2.50 E3	(1.10±0.11)E1	X,Tn	Be70
7.10 E3	(1.41±0.14)E1	X,Tn	Be70
2.00 E4	(2.27±0.10)E1	X,Tn	Ho79
3.50 E4	(2.43±0.10)E1	X,Tn	Ho79
5.00 E4	(2.51±0.10)E1	X,Tn	Ho79
6.00 E4	(2.67±0.10)E1	X,Tn	Ho79
9.00 E4	(2.86±0.29)E1	X,Tn	Is77

Energy (keV)	Cross Section (barn)	Type	Ref
Z=79 Au f=9.60E-1			
3.00 E5	(3.04±0.04)E1	X,Tn	Mi70
5.00 E5	(3.17±0.05)E1	X,Tn	Mi70
7.00 E5	(3.36±0.05)E1	X,Tn	Mi70
9.00 E5	(3.44±0.05)E1	X,Tn	Mi70
Graphical data for 100-500 keV			Mo64
Graphical data for 240-550 keV			Ha66
Graphical data for 3.0-21 MeV			Da75
Z=82 Pb f=9.63E-1			
2.40 E2	(1.72±0.20)E1	X,Tn	Ha64
4.90 E2	(6.53±3.22)E0	X,Tn	Se74
5.30 E2	(1.88±0.28)E1	X,Tn	Ha64
6.70 E2	(9.75±4.82)E0	X,Tn	Se74
8.20 E2	(2.56±0.35)E1	X,Tn	Ha64
1.13 E3	(2.61±0.35)E1	X,Tn	Ha64
1.44 E3	(2.49±0.50)E1	X,Tn	Ha64
2.00 E3	(1.03±0.09)E1	X,Tn	Sc72
5.00 E4	(2.41±0.20)E1	X,Tn	Ho79
9.00 E4	(2.27±0.23)E1	X,Tn	Is77
Graphical data for 250-550 keV			Ha66
Z=83 Bi f=9.64E-1			
2.00 E3	(9.93±0.90)E0	X,Tn	Sc72
3.50 E4	(2.11±0.10)E1	X,Tn	Ho79
5.00 E4	(2.11±0.10)E1	X,Tn	Ho79
6.00 E4	(2.22±0.10)E1	X,Tn	Ho79
9.00 E4	(2.15±0.21)E1	X,Tn	Is77
3.00 E5	(3.00±0.05)E1	X,Tn	Mi70
5.00 E5	(3.24±0.05)E1	X,Tn	Mi70
Z=92 U f=9.70E-1			
9.00 E4	(1.81±0.18)E1	X,Tn	Is77

REFERENCES FOR TABLE

Cl35 J. C. Clark, Phys. Rev. **48**, 30 (1935)
Sm45 A. E. Smick and P. Kirkpatrick, Phys. Rev. **67**, 153 (1945)
Po47 L. T. Pockman, D. L. Webster, P. Kirkpatrick and K. Harworth, Phys. Rev. **71**, 330 (1947)
Fi58 W. L. Fite and R. T. Brackmann, Phys. Rev. **112**, 1141 (1958)
Ro62 E. W. Rothe, L. L. Marino, R. H. Neynaber and S. M. Trujillo, Phys. Rev. **125**, 582 (1962)
Ha64 H. Hansen, H. Weigmann and A. Flammersfeld, Nucl. Phys. **58**, 241 (1964)
Mo64 J. W. Motz and R. C. Placious, Phys. Rev. **136A**, 662 (1964)
Ra65 D. Rapp and P. Englander-Golden, J. Chem. Phys. **43**, 1464 (1965)
Ha66 H. Hansen and A. Flammersfeld, Nucl. Phys. **79**, 135 (1966)
Re66 D. H. Rester and W. E. Dance, Phys. Rev. **152**, 1 (1966)
Sc66 B. L. Schram, A. J. H. Boerboom and J. Kistemaker, Physica **32**, 185 (1966)
Fi67 B. Fischer and K. W. Hoffmann, Z. Phys. **204**, 122 (1967)
Hi69 W. Hink and A. Ziegler, Z. Phys. **266**, 222 (1969)
Be70 K. H. Berkner, S. N. Kaplan and R.V. Pyle, Bull. Am. Phys. Soc. **15**, 786 (1970)
Mi70 L. M. Middleman, R. L. Ford and R. Hofstadter, Phys. Rev. **A2**, 1429 (1970)
Gl71 G. Glupe and W. Mehlhorn, J. Physique, Suppl. **32**, C4-40 (1971); G. Glupe and W. Mehlhorn, Phys Lett. **25A**, 274 (1967)
Hi71 W. Hink and H. Paschke, Phys. Rev. **A4**, 507 (1971); W. Hink and H. Paschke, Z. Phys. **244**, 140 (1971)
Co72 P. C. Colliex and B. Jouffrey, Phil. Mag. **25**, 491 (1972)
Da72 D. V. Davis, V. D. Mistry and C. A. Quarles, Phys. Lett. **38A**, 169 (1972)
Hu72 H. Hubner, K. Ilgen and K.-W. Hoffmann, Z. Phys. **255**, 269 (1972)
Is72 M. Isaacson, J. Chem. Phys. **56**, 1813 (1972)
Sc72 W. Scholz, A. Li-Scholz, R. Collé and I. L. Preiss, Phys. Rev. Lett. **29**, 761 (1972); A. Li-Scholz, R. Collé, I. L. Preiss and W. Scholz, Phys. Rev. **A7**, 1957 (1973)
Ta73 H. Tawara, K. G. Harrison and F. J. De Heer, Physica **63**, 351 (1973)
Se74 S. A. H. Seif el Naser, D. Berenyi and G. Bibok, Z. Phys. **267**, 169 (1974)
Da75 G. R. Dangerfield and B. M. Spicer, J. Phys. **8**, 1744 (1975)
Eg75 R. F. Egerton, Phil. Mag. **31**, 199 (1975)
Je75 J. Jessenberger and W. Hink, Z. Phys. **A275**, 331 (1975)
Sc76 B. Schlenk, D. Berenyi, S. Ricz, A. Valek and G. Hock, Acta Phys. Hung. **41**, 159 (1976)
Is77 K. Ishii, M. Kamiya, K. Sera, S. Morita, H. Tawara, M. Oyamada and T. C. Chu, Phys. Rev. **A15**, 906 (1977)
Ri77 S. Ricz, B. Schlenk, D. Berenyi, G. Hock and A.Valek, Acta Phys. Hung. **42**, 269 (1977)
Be78 D. Berenyi, G. Hock, S. Ricz, B. Schlenk and A. Valek, J. Phys. **B11**, 709 (1978)
Ho79 D. H. H. Hoffmann, C. Brendel, H. Genz, W. Low, S. Muller and A. Richter, Z. Phys. **A293**, 187 (1979); D. H. H. Hoffmann, H. Genz, W. Low and A. Richter, Phys. Lett. **65A**, 304 (1978)
Ro79 C. J. Rossouw and M. J. Whelan, J. Phys. **D12**, 797 (1979)
Ka80 M. Kamiya, A. Kuwako, K. Ishii, S. Morita and M. Oyamada, Phys. Rev. **A22**, 413 (1980)
Na80 P. Nagy, A. Skutlartz and V. Schmidt, J. Phys. **B13**, 1249 (1980)
Sh80 K. Shima, Phys. Lett. 77A, 237 (1980)
St80 K. Stephan, H. Helm and T. D. Mark, J. Chem. Phys. **73**, 3763 (1980)
Hi81 W. Hink, L. Kees, H.-P. Schmitt and A.Wolf, in Proceedings of the International Conference on X-ray Processes and Inner-Shell Ionization (Plenum Press, New York, 1981), p. 327
Ki81 K. Kiss, G. Kalman, J. Palinkas and B. Schlenk, Acta Phys. Hung. **50**, 97 (1981)
Sh81 K. Shima, T. Nakagawa, K. Umetani and T. Mikumo, Phys. Rev. **A24**, 72 (1981)
Ge82 H. Genz, C. Brendel, P. Eschwey, U. Kuhn, W. Low, A. Richter and P. Seserko, Z. Phys. **305**, 9 (1982)

REFERENCES FOR TABLE continued

Hi82 R. Hippler, K. Saeed, I. McGregor and H. Kleinpoppen, Z. Phys. **A307**, 83 (1982)

Ke82 G. A. Keenan, I. C. Walker and D. F. Dance, J. Phys. **B15**, 2509 (1982)

Qu82 C. Quarles and M. Semaan, Phys. Rev. **A26**, 3147 (1982)

Hi83 R. Hippler, H. Klar, K. Saeed, I. McGregor, A. J. Duncan and H. Kleinpoppen, J. Phys. **B16**, L617 (1983)

Mo84 R. G. Montague, M. F. A. Harrison and A. C. H. Smith, J. Phys. **B17**, 3295 (1984)

Pl85 H. Platten, G. Schiwietz and G. Nolte, Phys. Lett. **107A**, 83 (1985)

Sh87 M. B. Shah, D. S. Elliott and H. B.Gilbody, J. Phys. **B20**, 3501 (1987)

Wa87 Y. Watanabe, T. Kubozoe, T. Tomimasu, T. Mikado and T. Yamazaki, Phys. Rev. **A35**, 1423 (1987)

We87a R. C. Wetzel, F. A. Baiocchi, T. R. Hayes and R. S. Freund, Phys. Rev. **A35**, 559 (1987)

We87b G. L. Westbrook and C. A. Quarles, Nucl. Instrum. Methods, **B24-25**, 196 (1987)

Mc88 S. C. McDonald and B. M. Spicer, Phys. Rev. **A37**, 985 (1988)

Sh88 M. B. Shah, D. S. Elliott, P. McCallion and H. B. Gilbody, J. Phys. **B21**, 2751 (1988)

Pa89 J. H. Paterson, J. N. Chapman, W. A. P. Nicholson and J. M. Titchmarsh, J. Microscopy, **154**, 1 (1989)

Sh91 V. P. Shevelko, A. M. Solomon and V. S. Vukstich, Phys. Scripta **43,** 158 (1991)

Ba92 R. Gauvin and G. L'Esperance, in Proceedings of the Electron Microscopy Society of America, edited by G. W. Bailey, J. Bentley and J. A. Small (San Francisco Press, San Francisco, 1992), p. 1266

Sh92 T. W. Shyn, Phys. Rev. **A45**, 2951 (1992)

Sc93 H. Schneider, I. Tobehn, F. Ebel and R. Hippler, Phys. Rev. Lett. **71**, 2707 (1993)

Sh94 A. V. Shchagin, V. I. Pristupa and N. A. Khizhnyak, Nucl. Instrum. Methods **B84**, 9 (1994)

An96 Z. An, T. H. Li, L. M. Wang, X. Y. Xia and Z. M. Luo, Phys. Rev. **A54**, 3067 (1996)

He96a F. Q. He, X. G. Long, X. F. Peng, Z. M. Luo and Z. An, Acta Physica Sinica **5**, 499 (1996)

He96b F. Q. He, X. G. Long, X. F. Peng, Z. M. Luo and Z. An, Nucl. Instrum. Methods **B 114**, 213 (1996)

He96c F. Q. He, X. G. Long, X. F. Peng, Z. M. Luo and Z. An, Chin. Phys. Lett. **13**, 175 (1996)

Lu96 Z. M. Luo, Z. An, F. Q. He, T. H. Li, X. G. Long and X. F. Peng, J. Phys. **B29**, 4001 (1996)

He97 F. Q. He, X. F. Peng, X. G. Long, Z. M. Luo and Z. An, Nucl. Instrum. Methods **B129**, 445 (1997)

Lu97 Z. M. Luo, Z. An, T. H. Li, L. M. Wang, Q. Zhu and X. Y. Xia, J. Phys. **B30**, 2681 (1997)

Pe98 X. F. Peng, F. Q. He, X. G. Long, Z. M. Luo and Z. An, Phys. Rev. **A58**, 1 (1998)

Ta99a C. H. Tang, Z. M. Luo, Z. An and T. H. Li, Chin. Phys. Lett. **16**, 505 (1999)

Ta99b C. H. Tang, Z. An, T. H. Li and Z. M. Luo, Nucl. Instrum. Methods **B155**, 1 (1999)