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INELASTIC-COLLISION CROSS SECTIONS FOR Ne

by

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ABSTRACT

Cross sections for inelastic collisions of slow electrons and the dipole oscillator-strength distribution for the neon atom are given in tabular form. The results are based on experimental data that have been checked and adjusted for internal consistency. These data have been used in the study of the electron degradation spectra by the first author as part of his thesis work.

1. Introduction

This report contains the details of electron-impact and optical cross sections used in the Ph.D. thesis[1] (hereafter referred to as TH), entitled Inner-Shell Contributions to Electron Degradation Spectra by S. C. Soong. In TH, a consistent set of e-Ne inelastic collision cross sections is used to compute the electron degradation spectra. The tabulated data in this report supplement those given in the thesis in graphical form for slow incident electrons and low-energy photons.

2. Discrete Energy-Loss Cross Sections

For incident energies $T > 40\ I$, where I is the lowest ionization potential, three groups of discrete energy-loss cross sections for the L shell are given by the Bethe formula, Eq. 45, and Table 3 of TH. For $T \le 40\ I$, these cross sections are tabulated in Table 1 of this report.

The discrete energy-loss cross sections for the K shell have not been measured experimentally. The lack of these cross sections is not a serious setback for the study of electron degradation in neon because of the following reasons. For electron slowing down in neon, discrete excitation of the K shell plays a negligible role compared to excitation and ionization of the L shell. For the Auger-electron production, knowledge of the excitation cross sections is not required. The production rate is proportional to the total K-shell section, which has been measured by Mehlhorn.[2]

3. Differential Energy-Loss Cross Sections

Equation 43 of TH expresses the differential energy-loss cross section for $T > 40\ I_s$ (for $s = K$ or L shell) in terms of the dipole oscillator strength and of an empirical function $\phi_s(E)$, where E is the energy loss. The oscillator strengths for single photoionization of the 2p, 2s, 1s orbitals and those for the multiple L-shell ionization (from either 2s or 2p) are given in Tables 2, 3, 4, and 5, respectively. The functions ϕ_L and ϕ_K, which were adopted on the basis of fragmentary empirical evidence, are given in Tables 6 and 7.

The experimental results of Grissom et al. (Ref. 46 in TH) suggest a more accurate representation of the L-shell cross section in which the quantity within the logarithm of Eq. 43 is reduced by a factor $1-(I^2/2E^2)(1-I/T)$. (This implies that the cutoff momentum transfer for distant collisions is less than unity for slow incident electrons.)

For ≤ 40I, we assume that the differential energy-loss cross section is given by RHS of Eq. 43 in TH, times a normalization coefficient. The normalization constants were adjusted to ensure consistency with the total ionization cross section after integration over E. The normalization coefficients for the L and K shells are given in Tables 8 and 9, respectively. The resulting differential energy-loss cross section is consistent with the experimental results of Grissom et al., and varies smoothly from the Born region to the region of lower energies. Figure 1 shows the differential energy-loss cross section for several incident energies.

4. Total Ionization Cross Sections

The total ionization cross section is obtained by integrating the differential energy-loss cross section. The total ionization cross section of the L shell obtained in this manner can be represented, for $T > 40\ I_s$, by

$$Q_L^i(T) = \frac{4\pi a_0^2 R^2}{TI}\left(2.739 \ln \frac{T}{I} + 1.984\right)$$

and that of the K shell by

$$Q_K^i(T) = \frac{4\pi a_0^2 \alpha^2 R}{\beta^2 I_K}\left\{1.372\left[\ln \frac{mc^2\beta^2}{2I_K(1-\beta^2)} - \beta^2\right] + 0.4406\right\}$$

where $\beta = v/c$, $a_0 = 0.529$ Å, $\alpha = 1/137$, and $R = 13.6$ eV. For $T \le 40\ I_s$, these cross sections are given in Tables 10 and 11.

5. Electron Shake-Off

Evaluation of the function [cf. Eq. 7 of TH]

$$H_K(T', T+I_K) = \int_{T+I_K}^{\frac{1}{2}(T'+I_K)} dE\, \frac{Q_K(T', E)}{S(T')}\left[a_K^i(E) + a_K^{ii}(E)\int_T^{E-E_K} d\epsilon\, N_K(\epsilon)\right]$$

requires a knowledge of the shake-off probability $a_K^{ii}(E)$ and the spectrum $N_K(\epsilon)$ of multiply-ionized electrons. The shake-off probability has been measured by Carlson et al. (see Ref. 25 of TH) and is reproduced here in Table 12. The spectrum $N_K(\epsilon)$ can be represented as the following superpositions of the shake-off spectrum $\mathcal{S}(\epsilon)$

$$N_K(\epsilon) = \frac{\mathcal{S}(\epsilon) + \mathcal{S}(E - E_K - \epsilon)}{A(E - E_K)} ,$$

where

$$A(E) = \int_0^E d\epsilon\, \mathcal{S}(\epsilon) \quad . \tag{A1}$$

The shake-off spectrum has been calculated by Levinger[3] and the result has been confirmed experimentally by Carlson et al. (cf. Ref. 27 of TH). The function A(E) is given in Table 13. The integrated spectrum of electrons produced by multiple ionization, which occurs in the above expression for $H_K(T', T + I_K)$, is

$$\int_T^{E-E_K} d\epsilon\, N_K(\epsilon) = \frac{A(E - E_K - T) + A(E - E_K) - A(T)}{A(E - E_K)} \quad . \tag{A2}$$

6. Ionization of the L Shell

Since $a_L^{ii}(E)$ is not available directly from experiment, we evaluate $H_L(T', T + I)$ by using the formula

$$H_L(T', T+I) = \int_{T+I}^{\frac{1}{2}(T'+1)} \frac{dE}{2B(T')} \left\{ \frac{f_L(E)}{E} \ln \frac{4IT}{E^2} + \frac{f_{LM}(E)}{E} \ln \frac{4I_{LM}T}{E^2} \int_T^{E-E_L} d\epsilon\, N_L(\epsilon) \right.$$

$$\left. + 8\phi_L(E) \left[\frac{1}{E^2} - \frac{1}{E(T - E + I)} + \frac{1}{(T - E + I)^2} \right] \right\}$$

where I_{LM} = 62.7 eV, $f_{LM}(E)$ is given in Table 5, and $\int_T^{E-E_L} d\epsilon\, N_L(\epsilon)$ is also given[4] by Eq. A1, provided that the unit of energy is taken to be I_{LM} = 62.7 eV instead of E_{so} = 910 eV. The first two terms within the braces represent the contribution from distant collisions, while the last term represents that from close collisions. The first term gives the electron spectrum produced in single ionization, while the second term gives that produced in multiple ionization. The third term gives the spectrum produced in both types of ionization since $\phi_L(E)$ is determined from secondary electron spectrum measurements.[5]

7. Symbols Used in the Tables

FORTRAN notations are used, i.e., 2.032D-01 = 2.032×10^{-1}.

A(E)	See Eq. A1 [Table 13]
E	Energy transfer
E_{so}	Threshold for electron shake-off in neon = 910 eV [Tables 12 and 13]
I	The lowest ionization potential = 12.6 eV
I(2s)	Binding energy of the 2s electron = 48.5 eV [Table 3]
I(1s)	Binding energy of the 1s electron = 870 eV [Table 4]
I(K)	= I(1s) [Tables 4, 7, 9, and 11]
I(LM)	Threshold for multiple ionization of the neon L shell = 62.7 eV [Table 5]
PHI	$\phi(E)$ [Tables 6 and 7]
Q1	$\frac{TI}{\pi e^4} Q_1(T)$ [Table 1]
Q2	$\frac{TI}{\pi e^4} Q_2(T)$ [Table 1]
Q3	$\frac{TI}{\pi e^4} Q_3(T)$ [Table 1]
QI	$\frac{TI}{\pi e^4} Q_i(T)$ [Tables 10 and 11]
T	Incident kinetic energy

E(df/dE) = E f (E)

TABLE 1. Discrete Energy-Loss Cross Sections (L Shell)

T/I	Q1	Q2	Q3
1.000D 00	2.032D-02	2.815D-03	3.717D-04
1.075D 00	2.671D-02	5.795D-03	1.892D-03
1.156D 00	3.343D-02	8.929D-03	3.493D-03
1.242D 00	4.049D-02	1.223D-02	5.179D-03
1.336D 00	4.791D-02	1.569D-02	6.953D-03
1.436D 00	5.571D-02	1.934D-02	8.821D-03
1.544D 00	6.392D-02	2.318D-02	1.079D-02
1.660D 00	7.254D-02	2.721D-02	1.285D-02
1.784D 00	8.160D-02	3.144D-02	1.502D-02
1.918D 00	9.113D-02	3.589D-02	1.731D-02
2.062D 00	1.011D-01	4.056D-02	1.971D-02
2.217D 00	1.116D-01	4.546D-02	2.222D-02
2.383D 00	1.227D-01	5.059D-02	2.486D-02
2.562D 00	1.342D-01	5.598D-02	2.763D-02
2.754D 00	1.464D-01	6.161D-02	3.052D-02
2.961D 00	1.591D-01	6.751D-02	3.355D-02
3.183D 00	1.725D-01	7.367D-02	3.672D-02
3.422D 00	1.865D-01	8.011D-02	4.004D-02
3.679D 00	2.011D-01	8.684D-02	4.349D-02
3.955D 00	2.164D-01	9.386D-02	4.710D-02
4.252D 00	2.325D-01	1.012D-01	5.086D-02
4.571D 00	2.493D-01	1.088D-01	5.477D-02
4.914D 00	2.668D-01	1.167D-01	5.884D-02
5.283D 00	2.851D-01	1.249D-01	6.303D-02
5.679D 00	3.036D-01	1.328D-01	6.709D-02
6.105D 00	3.219D-01	1.411D-01	7.135D-02
6.564D 00	3.414D-01	1.498D-01	7.577D-02
7.056D 00	3.612D-01	1.576D-01	7.979D-02
7.586D 00	3.798D-01	1.665D-01	8.434D-02
8.155D 00	4.006D-01	1.747D-01	8.854D-02
8.767D 00	4.202D-01	1.840D-01	9.327D-02
9.425D 00	4.422D-01	1.925D-01	9.759D-02
1.013D 01	4.624D-01	2.012D-01	1.020D-01
1.089D 01	4.832D-01	2.100D-01	1.065D-01
1.171D 01	5.043D-01	2.186D-01	1.108D-01
1.259D 01	5.251D-01	2.272D-01	1.152D-01
1.353D 01	5.460D-01	2.359D-01	1.195D-01
1.455D 01	5.668D-01	2.440D-01	1.237D-01
1.564D 01	5.865D-01	2.518D-01	1.276D-01
1.682D 01	6.057D-01	2.597D-01	1.316D-01
1.808D 01	6.251D-01	2.675D-01	1.355D-01
1.943D 01	6.447D-01	2.754D-01	1.395D-01
2.089D 01	6.637D-01	2.827D-01	1.431D-01
2.246D 01	6.818D-01	2.896D-01	1.466D-01
2.418D 01	6.984D-01	2.963D-01	1.499D-01
2.596D 01	7.155D-01	3.030D-01	1.533D-01
2.791D 01	7.322D-01	3.096D-01	1.566D-01
3.000D 01	7.486D-01	3.160D-01	1.598D-01
3.225D 01	7.647D-01	3.223D-01	1.629D-01
3.467D 01	7.809D-01	3.287D-01	1.662D-01
3.728D 01	7.982D-01	3.355D-01	1.695D-01
4.007D 01	8.153D-01	3.421D-01	1.728D-01

TABLE 2. Oscillator Strength Density (2p)

I/E	$f_{2p}(E)$	I/E	$f_{2p}(E)$
0	0	5.100D-01	3.386D 00
1.000D-02	6.187D-03	5.200D-01	3.347D 00
2.000D-02	3.412D-02	5.300D-01	3.311D 00
3.000D-02	9.455D-02	5.400D-01	3.269D 00
4.000D-02	1.794D-01	5.500D-01	3.233D 00
5.000D-02	2.895D-01	5.600D-01	3.194D 00
6.000D-02	4.233D-01	5.700D-01	3.154D 00
7.000D-02	5.840D-01	5.800D-01	3.115D 00
8.000D-02	7.558D-01	5.900D-01	3.074D 00
9.000D-02	9.541D-01	6.000D-01	3.028D 00
1.000D-01	1.141D 00	6.100D-01	2.988D 00
1.100D-01	1.336D 00	6.200D-01	2.948D 00
1.200D-01	1.540D 00	6.300D-01	2.910D 00
1.300D-01	1.722D 00	6.400D-01	2.869D 00
1.400D-01	1.921D 00	6.500D-01	2.825D 00
1.500D-01	2.087D 00	6.600D-01	2.784D 00
1.600D-01	2.255D 00	6.700D-01	2.743D 00
1.700D-01	2.397D 00	6.800D-01	2.697D 00
1.800D-01	2.542D 00	6.900D-01	2.654D 00
1.900D-01	2.666D 00	7.000D-01	2.613D 00
2.000D-01	2.778D 00	7.100D-01	2.566D 00
2.100D-01	2.879D 00	7.200D-01	2.525D 00
2.200D-01	2.990D 00	7.300D-01	2.484D 00
2.300D-01	3.082D 00	7.400D-01	2.437D 00
2.400D-01	3.166D 00	7.500D-01	2.396D 00
2.500D-01	3.240D 00	7.600D-01	2.354D 00
2.600D-01	3.306D 00	7.700D-01	2.308D 00
2.700D-01	3.367D 00	7.800D-01	2.266D 00
2.800D-01	3.419D 00	7.900D-01	2.219D 00
2.900D-01	3.466D 00	8.000D-01	2.178D 00
3.000D-01	3.509D 00	8.100D-01	2.130D 00
3.100D-01	3.545D 00	8.200D-01	2.082D 00
3.200D-01	3.574D 00	8.300D-01	2.039D 00
3.300D-01	3.598D 00	8.400D-01	1.997D 00
3.400D-01	3.619D 00	8.500D-01	1.949D 00
3.500D-01	3.637D 00	8.600D-01	1.904D 00
3.600D-01	3.651D 00	8.700D-01	1.859D 00
3.700D-01	3.661D 00	8.800D-01	1.815D 00
3.800D-01	3.670D 00	8.900D-01	1.769D 00
3.900D-01	3.675D 00	9.000D-01	1.723D 00
4.000D-01	3.675D 00	9.100D-01	1.679D 00
4.100D-01	3.670D 00	9.200D-01	1.632D 00
4.200D-01	3.662D 00	9.300D-01	1.588D 00
4.300D-01	3.644D 00	9.400D-01	1.543D 00
4.400D-01	3.622D 00	9.500D-01	1.494D 00
4.500D-01	3.592D 00	9.600D-01	1.448D 00
4.600D-01	3.564D 00	9.700D-01	1.405D 00
4.700D-01	3.531D 00	9.800D-01	1.356D 00
4.800D-01	3.498D 00	9.900D-01	1.308D 00
4.900D-01	3.461D 00	1.000D 00	1.259D 00
5.000D-01	3.422D 00		

TABLE 3. Oscillator Strength Density (2s)

I(2s)/E	$f_{2s}(E)$	I(2s)/E	$f_{2s}(E)$
0	0	5.1000D-01	4.102D-01
1.0000D-02	3.077D-03	5.2000D-01	4.087D-01
2.0000D-02	1.743D-02	5.3000D-01	4.071D-01
3.0000D-02	4.102D-02	5.4000D-01	4.051D-01
4.0000D-02	6.666D-02	5.5000D-01	4.025D-01
5.0000D-02	9.230D-02	5.6000D-01	4.005D-01
6.0000D-02	1.154D-01	5.7000D-01	3.979D-01
7.0000D-02	1.385D-01	5.8000D-01	3.954D-01
8.0000D-02	1.600D-01	5.9000D-01	3.928D-01
9.0000D-02	1.836D-01	6.0000D-01	3.897D-01
1.0000D-01	2.082D-01	6.1000D-01	3.866D-01
1.1000D-01	2.349D-01	6.2000D-01	3.836D-01
1.2000D-01	2.595D-01	6.3000D-01	3.800D-01
1.3000D-01	2.800D-01	6.4000D-01	3.766D-01
1.4000D-01	2.984D-01	6.5000D-01	3.733D-01
1.5000D-01	3.159D-01	6.6000D-01	3.692D-01
1.6000D-01	3.287D-01	6.7000D-01	3.653D-01
1.7000D-01	3.410D-01	6.8000D-01	3.610D-01
1.8000D-01	3.513D-01	6.9000D-01	3.564D-01
1.9000D-01	3.600D-01	7.0000D-01	3.513D-01
2.0000D-01	3.687D-01	7.1000D-01	3.461D-01
2.1000D-01	3.748D-01	7.2000D-01	3.410D-01
2.2000D-01	3.810D-01	7.3000D-01	3.357D-01
2.3000D-01	3.861D-01	7.4000D-01	3.297D-01
2.4000D-01	3.907D-01	7.5000D-01	3.236D-01
2.5000D-01	3.948D-01	7.6000D-01	3.174D-01
2.6000D-01	3.986D-01	7.7000D-01	3.097D-01
2.7000D-01	4.020D-01	7.8000D-01	3.025D-01
2.8000D-01	4.048D-01	7.9000D-01	2.943D-01
2.9000D-01	4.077D-01	8.0000D-01	2.856D-01
3.0000D-01	4.097D-01	8.1000D-01	2.769D-01
3.1000D-01	4.113D-01	8.2000D-01	2.684D-01
3.2000D-01	4.131D-01	8.3000D-01	2.595D-01
3.3000D-01	4.148D-01	8.4000D-01	2.497D-01
3.4000D-01	4.164D-01	8.5000D-01	2.405D-01
3.5000D-01	4.179D-01	8.6000D-01	2.308D-01
3.6000D-01	4.184D-01	8.7000D-01	2.205D-01
3.7000D-01	4.189D-01	8.8000D-01	2.102D-01
3.8000D-01	4.195D-01	8.9000D-01	2.000D-01
3.9000D-01	4.198D-01	9.0000D-01	1.897D-01
4.0000D-01	4.197D-01	9.1000D-01	1.795D-01
4.1000D-01	4.195D-01	9.2000D-01	1.692D-01
4.2000D-01	4.189D-01	9.3000D-01	1.584D-01
4.3000D-01	4.185D-01	9.4000D-01	1.477D-01
4.4000D-01	4.179D-01	9.5000D-01	1.359D-01
4.5000D-01	4.172D-01	9.6000D-01	1.241D-01
4.6000D-01	4.164D-01	9.7000D-01	1.128D-01
4.7000D-01	4.154D-01	9.8000D-01	1.005D-01
4.8000D-01	4.143D-01	9.9000D-01	8.820D-02
4.9000D-01	4.129D-01	1.0000D 00	7.692D-02
5.0000D-01	4.120D-01		

TABLE 4. Oscillator Strength Density (1s)

I(1s)/E	$f_{1s}(E)$	I(1s)/E	$f_{1s}(E)$
0	0	5.100D-01	9.719D-01
1.000D-02	4.074D-04	5.200D-01	1.004D 00
2.000D-02	2.008D-03	5.300D-01	1.036D 00
3.000D-02	4.695D-03	5.400D-01	1.069D 00
4.000D-02	8.361D-03	5.500D-01	1.103D 00
5.000D-02	1.290D-02	5.600D-01	1.137D 00
6.000D-02	1.834D-02	5.700D-01	1.171D 00
7.000D-02	2.452D-02	5.800D-01	1.205D 00
8.000D-02	3.155D-02	5.900D-01	1.239D 00
9.000D-02	3.942D-02	6.000D-01	1.273D 00
1.000D-01	4.811D-02	6.100D-01	1.308D 00
1.100D-01	5.761D-02	6.200D-01	1.342D 00
1.200D-01	6.790D-02	6.300D-01	1.377D 00
1.300D-01	7.900D-02	6.400D-01	1.412D 00
1.400D-01	9.087D-02	6.500D-01	1.447D 00
1.500D-01	1.035D-01	6.600D-01	1.482D 00
1.600D-01	1.170D-01	6.700D-01	1.518D 00
1.700D-01	1.311D-01	6.800D-01	1.554D 00
1.800D-01	1.461D-01	6.900D-01	1.590D 00
1.900D-01	1.618D-01	7.000D-01	1.628D 00
2.000D-01	1.783D-01	7.100D-01	1.665D 00
2.100D-01	1.998D-01	7.200D-01	1.703D 00
2.200D-01	2.182D-01	7.300D-01	1.741D 00
2.300D-01	2.376D-01	7.400D-01	1.779D 00
2.400D-01	2.580D-01	7.500D-01	1.818D 00
2.500D-01	2.784D-01	7.600D-01	1.[illegible]57D 00
2.600D-01	[illegible].988D-01	7.700D-01	1.8[illegible]5D 00
2.700D-01	[illegible].191D-01	7.800D-01	1.934D 00
2.800D-01	3.395D-01	7.900D-01	1.973D 00
2.900D-01	3.628D-01	8.000D-01	2.012D 00
3.000D-01	3.861D-01	8.100D-01	2.051D 00
3.100D-01	4.093D-01	8.200D-01	2.089D 00
3.200D-01	4.336D-01	8.300D-01	2.128D 00
3.300D-01	4.578D-01	8.400D-01	2.167D 00
3.400D-01	4.840D-01	8.500D-01	2.206D 00
3.500D-01	5.102D-01	8.600D-01	2.246D 00
3.600D-01	5.364D-01	8.700D-01	2.285D 00
3.700D-01	5.626D-01	8.800D-01	2.325D 00
3.800D-01	5.898D-01	8.900D-01	2.365D 00
3.900D-01	6.179D-01	9.000D-01	2.405D 00
4.000D-01	6.460D-01	9.100D-01	2.444D 00
4.100D-01	6.741D-01	9.200D-01	2.485D 00
4.200D-01	7.023D-01	9.300D-01	2.526D 00
4.300D-01	7.304D-01	9.400D-01	2.567D 00
4.400D-01	7.595D-01	9.500D-01	2.607D 00
4.500D-01	7.886D-01	9.600D-01	2.648D 00
4.600D-01	8.177D-01	9.700D-01	2.689D 00
4.700D-01	8.478D-01	9.800D-01	2.730D 00
4.800D-01	8.778D-01	9.900D-01	2.770D 00
4.900D-01	9.089D-01	1.000D 00	2.811D 00
5.000D-01	9.399D-01		

TABLE 5. Oscillator Strength Density (LM)

I(LM)/E	$f_{LM}(E)$	I(LM)/E	$f_{LM}(E)$
0	0	5.1000D-01	1.5310D-01
1.0000D-02	7.1790D-04	5.2000D-01	1.5260D-01
2.0000D-02	2.3590D-03	3.3000D-01	1.5170D-01
3.0000D-02	4.7180D-03	5.4000D-01	1.5110D-01
4.0000D-02	7.6920D-03	5.5000D-01	1.5020D-01
5.0000D-02	1.1790D-02	5.6000D-01	1.4910D-01
6.0000D-02	1.6200D-02	5.7000D-01	1.4770D-01
7.0000D-02	2.1130D-02	5.8000D-01	1.4670D-01
8.0000D-02	2.6250D-02	5.9000D-01	1.4520D-01
9.0000D-02	3.2000D-02	6.0000D-01	1.4410D-01
1.0000D-01	3.8460D-02	6.1000D-01	1.4230D-01
1.1000D-01	4.4410D-02	6.2000D-01	1.4100D-01
1.2000D-01	5.1280D-02	6.3000D-01	1.3920D-01
1.3000D-01	5.7230D-02	6.4000D-01	1.3740D-01
1.4000D-01	6.4000D-02	6.5000D-01	1.3590D-01
1.5000D-01	6.9530D-02	6.6000D-01	1.3370D-01
1.6000D-01	7.4460D-02	6.7000D-01	1.3180D-01
1.7000D-01	7.9790D-02	6.8000D-01	1.2940D-01
1.8000D-01	8.5630D-02	6.9000D-01	1.2720D-01
1.9000D-01	9.0760D-02	7.0000D-01	1.2510D-01
2.0000D-01	9.5890D-02	7.1000D-01	1.2260D-01
2.1000D-01	1.0060D-01	7.2000D-01	1.2010D-01
2.2000D-01	1.0510D-01	7.3000D-01	1.1730D-01
2.3000D-01	1.0940D-01	7.4000D-01	1.1440D-01
2.4000D-01	1.1330D-01	7.5000D-01	1.1150D-01
2.5000D-01	1.1690D-01	7.6000D-01	1.0880D-01
2.6000D-01	1.2080D-01	7.7000D-01	1.0560D-01
2.7000D-01	1.2470D-01	7.8000D-01	1.0260D-01
2.8000D-01	1.2820D-01	7.9000D-01	9.9480D-02
2.9000D-01	1.3130D-01	8.0000D-01	9.6400D-02
3.0000D-01	1.3430D-01	8.1000D-01	9.2710D-02
3.1000D-01	1.3700D-01	8.2000D-01	8.9430D-02
3.2000D-01	1.3930D-01	8.3000D-01	8.5840D-02
3.3000D-01	1.4130D-01	8.4000D-01	8.2050D-02
3.4000D-01	1.4360D-01	8.5000D-01	7.8250D-02
3.5000D-01	1.4490D-01	8.6000D-01	7.3840D-02
3.6000D-01	1.4670D-01	8.7000D-01	6.9330D-02
3.7000D-01	1.4800D-01	8.8000D-01	6.5120D-02
3.8000D-01	1.4920D-01	8.9000D-01	6.0710D-02
3.9000D-01	1.5020D-01	9.0000D-01	5.5890D-02
4.0000D-01	1.5130D-01	9.1000D-01	5.1280D-02
4.1000D-01	1.5200D-01	9.2000D-01	4.6150D-02
4.2000D-01	1.5260D-01	9.3000D-01	4.1020D-02
4.3000D-01	1.5310D-01	9.4000D-01	3.5890D-02
4.4000D-01	1.5370D-01	9.5000D-01	2.9740D-02
4.5000D-01	1.5400D-01	9.6000D-01	2.4000D-02
4.6000D-01	1.5410D-01	9.7000D-01	1.7950D-02
4.7000D-01	1.5410D-01	9.8000D-01	1.2310D-02
4.8000D-01	1.5400D-01	9.9000D-01	6.1530D-03
4.9000D-01	1.5380D-01	1.0000D 00	0
5.0000D-01	1.5370D-01		

TABLE 6. The Empirical Function Phi (L Shell)

I/E	PHI
0	1.0000D 00
1.0000D-02	1.0000D 00
2.0000D-02	1.0000D 00
3.0000D-02	1.0000D 00
4.0000D-02	1.0000D 00
5.0000D-02	1.0000D 00
6.0000D-02	1.0000D 00
7.0000D-02	1.0000D 00
8.0000D-02	1.0000D 00
9.0000D-02	1.0000D 00
1.0000D-01	1.0000D 00
1.1000D-01	1.0000D 00
1.2000D-01	1.0000D 00
1.3000D-01	1.0000D 00
1.4000D-01	1.0000D 00
1.5000D-01	1.0000D 00
1.6000D-01	1.0000D 00
1.7000D-01	1.0000D 00
1.8000D-01	9.9950D-01
1.9000D-01	9.9800D-01
2.0000D-01	9.9500D-01
2.1000D-01	9.8750D-01
2.2000D-01	9.7900D-01
2.3000D-01	9.6500D-01
2.4000D-01	9.4950D-01
2.5000D-01	9.3100D-01
2.6000D-01	9.0970D-01
2.7000D-01	8.8730D-01
2.8000D-01	8.6250D-01
2.9000D-01	8.3600D-01
3.0000D-01	8.0950D-01
3.1000D-01	7.8400D-01
3.2000D-01	7.5900D-01
3.3000D-01	7.3450D-01
3.4000D-01	7.0950D-01
3.5000D-01	6.8550D-01
3.6000D-01	6.6250D-01
3.7000D-01	6.4100D-01
3.8000D-01	6.2050D-01
3.9000D-01	6.0050D-01
4.0000D-01	5.8000D-01
4.1000D-01	5.6110D-01
4.2000D-01	5.4170D-01
4.3000D-01	5.2400D-01
4.4000D-01	5.0110D-01
4.5000D-01	4.8900D-01
4.6000D-01	4.7190D-01
4.7000D-01	4.5610D-01
4.8000D-01	4.4130D-01
4.9000D-01	4.2870D-01
5.0000D-01	4.1150D-01

I/E	PHI
5.1000D-01	3.9760D-01
5.2000D-01	3.8410D-01
5.3000D-01	3.7180D-01
5.4000D-01	3.5880D-01
5.5000D-01	3.4650D-01
5.6000D-01	3.3440D-01
5.7000D-01	3.2250D-01
5.8000D-01	3.1120D-01
5.9000D-01	3.0020D-01
6.0000D-01	2.9000D-01
6.1000D-01	2.8000D-01
6.2000D-01	2.7030D-01
6.3000D-01	2.6070D-01
6.4000D-01	2.5130D-01
6.5000D-01	2.4250D-01
6.6000D-01	2.3380D-01
6.7000D-01	2.2520D-01
6.8000D-01	2.1620D-01
6.9000D-01	2.0730D-01
7.0000D-01	1.9900D-01
7.1000D-01	1.9080D-01
7.2000D-01	1.8260D-01
7.3000D-01	1.7420D-01
7.4000D-01	1.6580D-01
7.5000D-01	1.5800D-01
7.6000D-01	1.5050D-01
7.7000D-01	1.4300D-01
7.8000D-01	1.3600D-01
7.9000D-01	1.2890D-01
8.0000D-01	1.2200D-01
8.1000D-01	1.1520D-01
8.2000D-01	1.0860D-01
8.3000D-01	1.0260D-01
8.4000D-01	9.6100D-02
8.5000D-01	9.0000D-02
8.6000D-01	8.3400D-02
8.7000D-01	7.7200D-02
8.8000D-01	7.0600D-02
8.9000D-01	6.4700D-02
9.0000D-01	5.7500D-02
9.1000D-01	5.1600D-02
9.2000D-01	4.5900D-02
9.3000D-01	4.0150D-02
9.4000D-01	3.4550D-02
9.5000D-01	2.9000D-02
9.6000D-01	2.3050D-02
9.7000D-01	1.7150D-02
9.8000D-01	1.1350D-02
9.9000D-01	5.6500D-03
1.0000D 00	0

TABLE 7. The Empirical Function Phi (K Shell)

I(K)/E	PHI	I(K)/E	PHI
0	1.0000 00	5.1000D-01	1.342D 00
1.0000D-02	1.001D 00	5.2000D-01	1.333D 00
2.0000D-02	1.008D 00	5.3000D-01	1.324D 00
3.0000D-02	1.025D 00	5.4000D-01	1.313D 00
4.0000D-02	1.048D 00	5.5000D-01	1.300D 00
5.0000D-02	1.068D 00	5.6000D-01	1.286D 00
6.0000D-02	1.087D 00	5.7000D-01	1.272D 00
7.0000D-02	1.107D 00	5.8000D-01	1.254D 00
8.0000D-02	1.125D 00	5.9000D-01	1.238D 00
9.0000D-02	1.142D 00	6.0000D-01	1.220D 00
1.0000D-01	1.159D 00	6.1000D-01	1.202D 00
1.1000D-01	1.175D 00	6.2000D-01	1.182D 00
1.2000D-01	1.191D 00	6.3000D-01	1.163D 00
1.3000D-01	1.205D 00	6.4000D-01	1.142D 00
1.4000D-01	1.220D 00	6.5000D-01	1.120D 00
1.5000D-01	1.233D 00	6.6000D-01	1.097D 00
1.6000D-01	1.246D 00	6.7000D-01	1.074D 00
1.7000D-01	1.258D 00	6.8000D-01	1.048D 00
1.8000D-01	1.268D 00	6.9000D-01	1.023D 00
1.9000D-01	1.279D 00	7.0000D-01	9.980D-01
2.0000D-01	1.290D 00	7.1000D-01	9.723D-01
2.1000D-01	1.301D 00	7.2000D-01	9.461D-01
2.2000D-01	1.311D 00	7.3000D-01	9.193D-01
2.3000D-01	1.322D 00	7.4000D-01	8.924D-01
2.4000D-01	1.331D 00	7.5000D-01	8.650D-01
2.5000D-01	1.340D 00	7.6000D-01	8.373D-01
2.6000D-01	1.348D 00	7.7000D-01	8.091D-01
2.7000D-01	1.355D 00	7.8000D-01	7.811D-01
2.8000D-01	1.362D 00	7.9000D-01	7.520D-01
2.9000D-01	1.368D 00	8.0000D-01	7.225D-01
3.0000D-01	1.374D 00	8.1000D-01	6.924D-01
3.1000D-01	1.379D 00	8.2000D-01	6.619D-01
3.2000D-01	1.384D 00	8.3000D-01	6.309D-01
3.3000D-01	1.388D 00	8.4000D-01	5.993D-01
3.4000D-01	1.391D 00	8.5000D-01	5.670D-01
3.5000D-01	1.394D 00	8.6000D-01	5.342D-01
3.6000D-01	1.396D 00	8.7000D-01	5.007D-01
3.7000D-01	1.398D 00	8.8000D-01	4.678D-01
3.8000D-01	1.400D 00	8.9000D-01	4.328D-01
3.9000D-01	1.400D 00	9.0000D-01	3.970D-01
4.0000D-01	1.400D 00	9.1000D-01	3.602D-01
4.1000D-01	1.399D 00	9.2000D-01	3.226D-01
4.2000D-01	1.397D 00	9.3000D-01	2.825D-01
4.3000D-01	1.394D 00	9.4000D-01	2.435D-01
4.4000D-01	1.391D 00	9.5000D-01	2.040D-01
4.5000D-01	1.386D 00	9.6000D-01	1.641D-01
4.6000D-01	1.381D 00	9.7000D-01	1.237D-01
4.7000D-01	1.375D 00	9.8000D-01	8.290D-02
4.8000D-01	1.367D 00	9.9000D-01	4.170D-02
4.9000D-01	1.359D 00	1.000D 00	0
5.0000D-01	1.351D 00		

TABLE 8. Normalization of the Differential Energy-Loss Cross Section (L Shell)

T/I	NORMALIZATION COEFFICIENT
1.000D 00	0
1.075D 00	2.909D-02
1.156D 00	5.818D-02
1.242D 00	8.727D-02
1.336D 00	1.164D-01
1.436D 00	1.455D-01
1.544D 00	1.745D-01
1.660D 00	2.036D-01
1.784D 00	2.327D-01
1.918D 00	2.618D-01
2.062D 00	2.909D-01
2.217D 00	3.200D-01
2.383D 00	3.491D-01
2.562D 00	3.782D-01
2.754D 00	4.073D-01
2.961D 00	4.364D-01
3.183D 00	4.655D-01
3.422D 00	4.946D-01
3.679D 00	5.236D-01
3.955D 00	5.527D-01
4.252D 00	5.818D-01
4.571D 00	6.109D-01
4.914D 00	6.400D-01
5.283D 00	6.660D-01
5.679D 00	6.920D-01
6.105D 00	7.190D-01
6.564D 00	7.400D-01
7.056D 00	7.650D-01
7.586D 00	7.850D-01
8.155D 00	8.090D-01
8.767D 00	8.284D-01
9.425D 00	8.472D-01
1.013D 01	8.654D-01
1.089D 01	8.821D-01
1.171D 01	8.978D-01
1.259D 01	9.128D-01
1.353D 01	9.255D-01
1.455D 01	9.359D-01
1.564D 01	9.458D-01
1.682D 01	9.551D-01
1.808D 01	9.643D-01
1.943D 01	9.713D-01
2.089D 01	9.768D-01
2.246D 01	9.807D-01
2.418D 01	9.845D-01
2.596D 01	9.876D-01
2.791D 01	9.902D-01
3.000D 01	9.922D-01
3.225D 01	9.933D-01
3.467D 01	9.956D-01
3.728D 01	9.981D-01
4.007D 01	1.000D 00

TABLE 9. Normalization of the Differential Energy-Loss Cross Section (K Shell)

T/I(K)	NORMALIZATION COEFFICIENT
1.000D 00	3.160D-01
1.077D 00	3.255D-01
1.159D 00	3.362D-01
1.248D 00	3.478D-01
1.343D 00	3.580D-01
1.446D 00	3.720D-01
1.557D 00	3.810D-01
1.676D 00	3.930D-01
1.804D 00	4.030D-01
1.943D 00	4.171D-01
2.091D 00	4.285D-01
2.251D 00	4.414D-01
2.424D 00	4.566D-01
2.609D 00	4.696D-01
2.809D 00	4.817D-01
3.024D 00	4.947D-01
3.256D 00	5.080D-01
3.505D 00	5.217D-01
3.773D 00	5.358D-01
4.062D 00	5.497D-01
4.373D 00	5.647D-01
4.708D 00	5.804D-01
5.069D 00	5.974D-01
5.457D 00	6.126D-01
5.875D 00	6.277D-01
6.325D 00	6.409D-01
6.809D 00	6.527D-01
7.330D 00	6.628D-01
7.891D 00	6.738D-01
8.496D 00	6.856D-01
9.146D 00	6.958D-01
9.846D 00	7.049D-01
1.060D 01	7.123D-01
1.141D 01	7.218D-01
1.229D 01	7.337D-01
1.323D 01	7.429D-01
1.424D 01	7.506D-01
1.533D 01	7.561D-01
1.650D 01	7.632D-01
1.777D 01	7.717D-01
1.913D 01	7.784D-01
2.059D 01	7.842D-01
2.217D 01	7.884D-01
2.387D 01	7.943D-01
2.569D 01	8.014D-01
2.766D 01	8.080D-01
2.978D 01	8.145D-01
3.206D 01	8.212D-01
3.451D 01	8.269D-01
3.716D 01	8.320D-01
4.000D 01	8.367D-01

TABLE 10. Total Ionization Cross Section (L Shell)

T/I	QI
1.000D 00	0.
1.075D 00	2.030D-03
1.156D 00	9.022D-03
1.242D 00	2.210D-02
1.336D 00	4.248D-02
1.436D 00	7.128D-02
1.544D 00	1.096D-01
1.660D 00	1.586D-01
1.784D 00	2.192D-01
1.918D 00	2.924D-01
2.062D 00	3.793D-01
2.217D 00	4.804D-01
2.383D 00	6.127D-01
2.562D 00	7.479D-01
2.754D 00	8.998D-01
2.961D 00	1.074D 00
3.183D 00	1.261D 00
3.422D 00	1.467D 00
3.679D 00	1.691D 00
3.955D 00	1.933D 00
4.252D 00	2.193D 00
4.571D 00	2.471D 00
4.914D 00	2.767D 00
5.283D 00	3.065D 00
5.679D 00	3.379D 00
6.105D 00	3.713D 00
6.564D 00	4.030D 00
7.056D 00	4.380D 00
7.586D 00	4.713D 00
8.155D 00	5.080D 00
8.767D 00	5.427D 00
9.425D 00	5.778D 00
1.013D 01	6.132D 00
1.089D 01	6.481D 00
1.171D 01	6.829D 00
1.259D 01	7.177D 00
1.353D 01	7.513D 00
1.455D 01	7.833D 00
1.564D 01	8.154D 00
1.682D 01	8.472D 00
1.808D 01	8.792D 00
1.943D 01	9.095D 00
2.089D 01	9.385D 00
2.246D 01	9.661D 00
2.415D 01	9.936D 00
2.596D 01	1.020D 01
2.791D 01	1.047D 01
3.000D 01	1.072D 01
3.225D 01	1.097D 01
3.467D 01	1.122D 01
3.728D 01	1.148D 01
4.007D 01	1.173D 01

TABLE 11. Total Ionization Cross Section (K Shell)

T/I(K)	QI
1.000D 00	0
1.077D 00	4.852D-02
1.159D 00	1.033D-01
1.248D 00	1.643D-01
1.343D 00	2.328D-01
1.446D 00	3.050D-01
1.557D 00	3.816D-01
1.676D 00	4.638D-01
1.804D 00	5.468D-01
1.943D 00	6.298D-01
2.091D 00	7.200D-01
2.251D 00	8.158D-01
2.424D 00	9.192D-01
2.609D 00	1.021D 00
2.809D 00	1.124D 00
3.024D 00	1.230D 00
3.256D 00	1.340D 00
3.505D 00	1.452D 00
3.773D 00	1.568D 00
4.062D 00	1.686D 00
4.373D 00	1.810D 00
4.708D 00	1.938D 00
5.069D 00	2.074D 00
5.457D 00	2.206D 00
5.875D 00	2.340D 00
6.325D 00	2.470D 00
6.809D 00	2.596D 00
7.330D 00	2.717D 00
7.891D 00	2.843D 00
8.496D 00	2.974D 00
9.146D 00	3.100D 00
9.846D 00	3.222D 00
1.060D 01	3.338D 00
1.141D 01	3.464D 00
1.229D 01	3.603D 00
1.323D 01	3.730D 00
1.424D 01	3.851D 00
1.533D 01	3.961D 00
1.650D 01	4.080D 00
1.777D 01	4.207D 00
1.913D 01	4.325D 00
2.059D 01	4.439D 00
2.217D 01	4.543D 00
2.387D 01	4.658D 00
2.569D 01	4.780D 00
2.766D 01	4.900D 00
2.978D 01	5.020D 00
3.206D 01	5.142D 00
3.451D 01	5.258D 00
3.716D 01	5.370D 00
4.000D 01	5.480D 00

TABLE 12. Electron Shake-Off Probability

E/E_{so}	Probability
0	0
5.0000D-02	1.4000D-01
1.0000D-01	1.7800D-01
1.5000D-01	1.9600D-01
2.0000D-01	2.0600D-01
2.5000D-01	2.1100D-01
3.0000D-01	2.1450D-01
3.5000D-01	2.1680D-01
4.0000D-01	2.1850D-01
4.5000D-01	2.2000D-01
5.0000D-01	2.2080D-01
5.5000D-01	2.2130D-01
6.0000D-01	2.2170D-01
6.5000D-01	2.2200D-01

TABLE 13. Spectrum of the Shake-Off Electron

E/E_{so}	A(E)
0	0
1.0000D-01	2.0000D-01
2.0000D-01	3.5000D-01
3.0000D-01	4.6000D-01
4.0000D-01	5.4000D-01
5.0000D-01	6.0000D-01
6.0000D-01	6.5500D-01
7.0000D-01	7.0000D-01
8.0000D-01	7.4000D-01
9.0000D-01	7.7400D-01
1.0000D 00	8.0000D-01
1.1000D 00	8.2700D-01
1.2000D 00	8.4800D-01
1.3000D 00	8.6600D-01
1.4000D 00	8.8000D-01
1.5000D 00	8.9500D-01
1.6000D 00	9.0700D-01
1.7000D 00	9.1800D-01
1.8000D 00	9.2500D-01
1.9000D 00	9.3200D-01
2.0000D 00	9.4000D-01
2.1000D 00	9.4500D-01
2.2000D 00	9.5000D-01
2.3000D 00	9.5600D-01
2.4000D 00	9.6000D-01
2.5000D 00	9.6500D-01
2.6000D 00	9.6900D-01
2.7000D 00	9.7100D-01
2.8000D 00	9.7600D-01
2.9000D 00	9.7900D-01
3.0000D 00	9.8100D-01
3.1000D 00	9.8400D-01
3.2000D 00	9.8700D-01
3.3000D 00	9.9000D-01
3.4000D 00	9.9200D-01
3.5000D 00	9.9400D-01
3.6000D 00	9.9500D-01
3.7000D 00	9.9600D-01
3.8000D 00	9.9700D-01
3.9000D 00	9.9800D-01
4.0000D 00	9.9900D-01
4.1000D 00	1.0000D 00

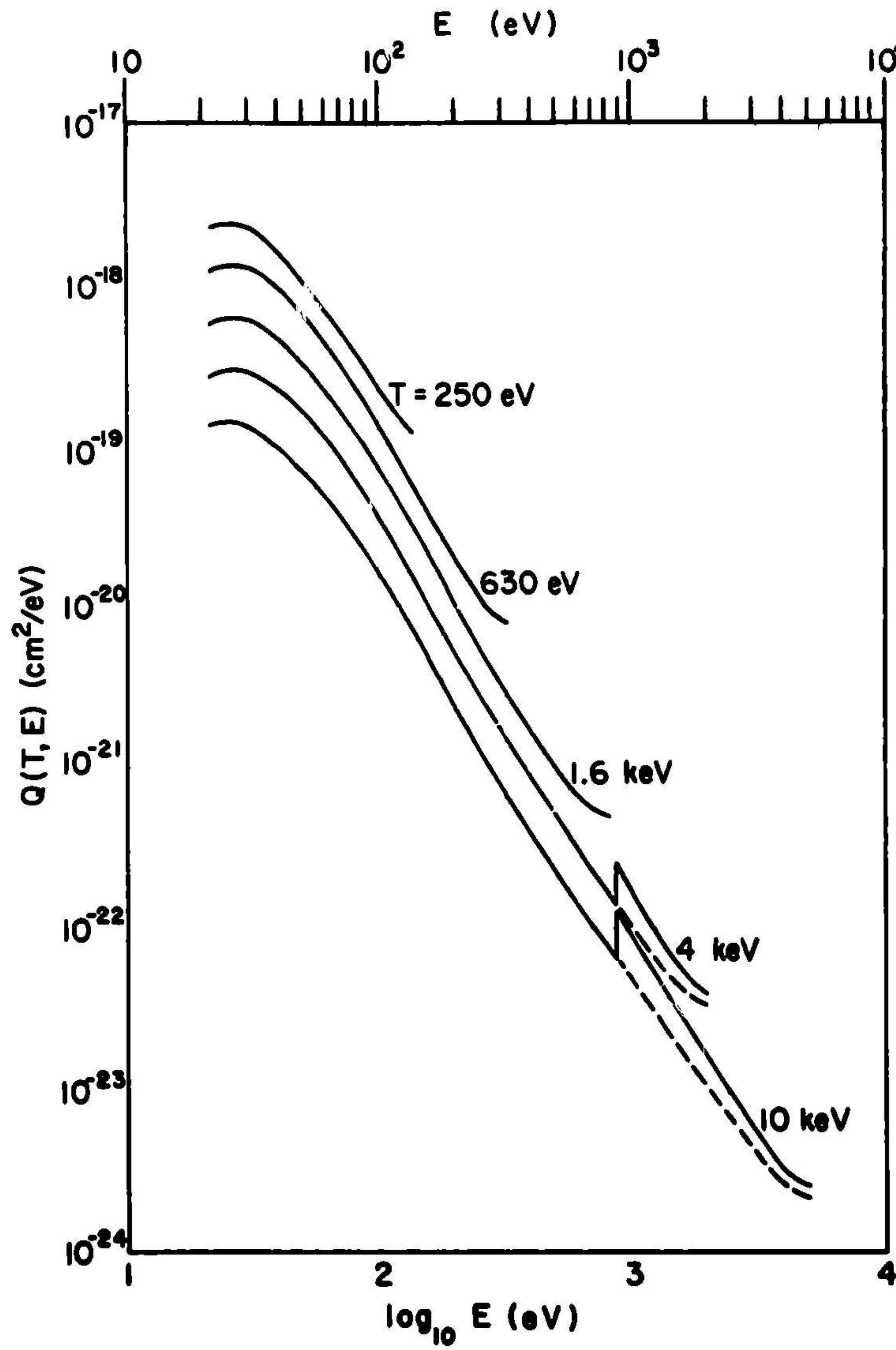

FIG. 1. The differential energy-loss cross section of neon. The broken curve (---) is the cross section for the L shell only, and the solid curve (—) is that for the sum of K and L shells.

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