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RADIATIVE OPACITY IN STELLAR ATMOSPHERES
I. METAL ABSORPTION COEFFICIENTS*

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ABSTRACT

The results of numerical computations of the atomic absorption coefficients due to the elements C, N, O, Na, Mg, Al, Si, Cr, Fe, and Ni are presented. The quantum defect method is used for the determination of the photo-ionization cross-sections except in the cases of Cr, Fe, and Ni For these metals, detailed hydrogenic approximations are used owing to the inapplicability of the quantum defect method when *LS* coupling is not valid These cross-sections are used to compute the atomic absorption coefficients for temperatures ranging from $\theta = 1\ 38$ to $\theta = 0\ 36$, with an interval of $\Delta\theta = 0\ 06$, and a range in wavelengths of $\lambda\lambda$1033–59958. The random errors involved in the empirical determination of the quantum defect are found to be comparable to the accuracy of the computed cross-sections estimated from comparisons with experimentally determined values. Finally, the relative importance of metal absorptions in radiative opacity is examined for the atmospheric conditions of the solar-type and other spectral classes.

I. INTRODUCTION

Recent advances in the theory of stellar atmospheres are largely due to the construction of detailed model atmospheres in which the condition of flux constancy is maintained with a high degree of accuracy. This, in turn, requires accurate knowledge of radiative opacity throughout the entire region of the spectrum. Because of the constancy requirement imposed upon the total flux, errors in the opacity in a certain wavelength region yield erroneous flux distribution with wavelength, not only in that region but also in the other spectral regions. For example, the principal cause for the still-existing disagreement between observations and the theoretically predicted variation of the solar continuum with wavelength appears to lie in the incomplete knowledge of opacity for the ultraviolet continuum (Matsushima 1967*b;* Matsushima and Terashita 1967).

In this respect, recent contributions are noted in the improved computations of absorption coefficients for H^- and other sources, such as $(H + H)$, H_2^+, H_2^-, He^-, and Rayleigh scattering. However, the opacity due to those sources other than H^- and Rayleigh scattering appears to play a relatively minor role in stellar atmospheres (Matsushima 1967*a*), and the major difficulty remains the treatment of absorption due to more complicated atoms. Absorption by metals is particularly important for the ultraviolet continuum of solar-type stars and for various groups of hydrogen-deficient stars.

Laboratory measurements of photo-ionization cross-sections are available only for several metals, and quantum-mechanical computations of accurate values for these complicated atoms are formidably laborious. Thus, the metal absorption coefficients computed by means of the hydrogenic approximation by Vitense (1951) have been widely used in the past years. However, comparisons with some of the recently determined experimental values indicate that the hydrogenic approximation may be in error by an order of magnitude or more in some cases.

In light of the above difficulty, a noteworthy contribution has recently been made by Burgess and Seaton (1960), who developed a general method of calculating photo-ionization cross-sections on the basis of the quantum defect theory. Application of this method for several metals by Peach (1962, 1967*b*) has revealed that it generally gives much better accuracy than the hydrogenic approximation in comparison with the values de-

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termined experimentally or by more accurate quantum-mechanical calculations. The method of Burgess and Seaton is generally applicable for the configurations in which LS coupling is valid, and it is sufficiently simple for application to a large number of metals of astrophysical interest.

The purpose of this paper is to present the result of the use of the general formula developed by Burgess and Seaton for the computation of atomic absorption coefficients for all the important metals and for a wide range of temperatures in order to facilitate model atmosphere calculations requiring these opacities. Only for those atoms for which LS coupling is not valid (i.e., Cr, Fe, and Ni) has the hydrogenic approximation been applied.

II. QUANTUM DEFECT METHOD

The quantum defect method is the same in principle as the Coulomb approximation of Bates and Damgaard (1949), which assumes that the major contribution to the transition integrals usually comes from the outer regions where the potential approximates a Coulomb potential (Bates 1946*a*, *b*). The quantum defect method was extended and adapted to bound-free cross-section calculations by Seaton (1958) and Burgess and Seaton (1960), and to free-free transition by Peach (1965).

Following Burgess and Seaton, if we consider an atom for which LS coupling is valid, the quantum numbers may be designated as $\alpha\, SL$ for the atom and $\alpha'' S'' L''$ for the ion. Thus, the final state is denoted by $\alpha'' S'' L'' kl' S' L'$, where $S'L'$ are the quantum numbers for the complete system consisting of the ion and the ionized electron with wave number k and angular momentum l'. The normal selection rules apply, namely: $S' = S$; $L' = L$, $L \pm 1$; and $l' = l \pm 1$. The photo-ionization cross-section for the ionization of the nl electron is given by

$$a_\nu = \frac{4\pi\alpha a_0^2}{3} \frac{h\nu}{E_{\mathrm{H}}} \sum_{l'=l\pm 1} C_{l'} \left| \int_0^\infty P_{nl}(r) G_{kl'}(r) r dr \right|^2 , \tag{1}$$

where α is the fine-structure constant; a_0, the Bohr radius; E_{H}, the ionization potential for hydrogen; $P_{nl}(r)$, the radial wave function for the bound n_l electron; $G_{kl'}(r)$, the radial wave function for the free kl' electron; and the numerical factors, $C_{l'}$, are due to integrations over spin and angular coordinates.

For an atom in a particular atomic energy level, designated by the quantum numbers $nlSL$, the effective quantum number, m, is defined by

$$m^2 = Z^2 E_{\mathrm{H}}/E_i = -1/\epsilon , \tag{2}$$

where Z is the residual charge on the ion and E_i is the ionization energy of the particular level. The quantum defect, μ, is then given by

$$\mu = n - m . \tag{3}$$

The procedure given by Burgess and Seaton (1960) assumes that for a given spectral series, the quantum defects can be approximated by a linear function of $\epsilon = -1/m^2$ as

$$\mu \simeq a + b\epsilon . \tag{4}$$

Thus, it is assumed that one may extrapolate for quantum defects, μ', at positive energies, or free states, by the relation

$$\mu' \simeq a + b\epsilon' , \tag{5}$$

where ϵ' is given by

$$\epsilon' = \frac{h\nu}{Z^2 E_{\mathrm{H}}} - \frac{1}{m^2} . \tag{6}$$

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The photo-ionization cross-section is then written in the form

$$a_\nu = \frac{4\pi\alpha a_0^2}{3}\frac{h\nu}{E_{\mathrm{H}}}\left(\frac{m}{Z}\right)^4 \sum_{l'=l\pm 1} C_{l'}\,|g(ml;\epsilon' l')|^2\,, \tag{7}$$

where g is the quantity which contains the transition integral and must be evaluated. It should be noted that in general $C_{l'}$ and g are functions of L', and the summation in the previous equation should be over L' as well as l' if the selection rules allow more than one value of L' for the transition from a particular level.

It is then assumed that the bound-state wave functions can be replaced by Coulomb wave functions of principal quantum number m, normalized such that

$$\int_0^\infty P_{nl}^2(r)\,dr = 1\,. \tag{8}$$

The radial wave functions for the free kl' electron are then approximated by linear combinations of two Coulomb wave functions with the correct asymptotic behavior. Thus, it is assumed that the radial transition integrals lead to a relation of the form

$$g(ml;\,\epsilon' l') = f(ml;\,\epsilon' l')\cos \pi\mu'(\epsilon) - h(ml;\,\epsilon' l')\sin \pi\mu'(\epsilon')\,. \tag{9}$$

The functions f and h are then expanded in power series in ϵ' and evaluated by Burgess and Seaton (1960). They find it convenient, however, to express the results in terms of more smoothly varying functions, G and χ, defined such that

$$f(ml;\,\epsilon' l') = \frac{G(ml;\,\epsilon' l')}{\zeta^{1/2}(ml)}\cos \pi[m + \chi(ml;\,\epsilon' l')] \tag{10}$$

$$h(ml;\,\epsilon' l') = \frac{G(ml;\,\epsilon' l')}{\zeta^{1/2}(ml)}\sin \pi[m + \chi(ml;\,\epsilon' l')]\,. \tag{11}$$

Their results are summarized by the following equations for the determination of g:

$$g(ml;\,\epsilon' l') = \frac{G(ml;\,\epsilon' l')}{\zeta^{1/2}(ml)}\cos \pi[m + \mu'(\epsilon') + \chi(ml;\,\epsilon' l')] \tag{12}$$

$$G(ml;\,\epsilon' l') = (-1)^{l+1}G_{ll'}(m)(1 + \epsilon' m^2)^{-\gamma_{ll'}(m)} \tag{13}$$

$$\chi(ml;\,\epsilon' l') = \chi_{ll'}(m) + \frac{\epsilon' m}{1 + \epsilon' m}\alpha_{ll'} + \frac{\epsilon' m^2}{1 + \epsilon' m^2}\beta_{ll'}\,, \tag{14}$$

$$\zeta(ml) = 1 + \frac{2}{m^3}\frac{\partial}{\partial\epsilon}\mu(\epsilon)\,. \tag{15}$$

The values of $G_{ll'}$, $\gamma_{ll'}$, $\chi_{ll'}$, $\alpha_{ll'}$, and $\beta_{ll'}$ are given in tabular form and may be interpolated for specific values of m.

Burgess and Seaton (1960) compared the results of their calculations of photo-ionization cross-sections using their general formula with determinations by other investigators and with some experimental results. They found excellent agreement in most cases, with larger discrepancies occurring only when the radial integral was sensitive to small changes in the wave functions. A qualitative estimate of this sensitivity is given by the term

$$\cos\phi = \cos \pi[m + \mu'(\epsilon') + \chi(ml;\,\epsilon' l')]\,. \tag{16}$$

This follows from the characteristics of the cosine function, the sensitivity being the greatest when $\cos\phi$ is near zero, since at this point the slope of the cosine is the largest.

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III. NUMERICAL PROCEDURE

In order to find the atomic absorption coefficient for a particular atom, it is necessary to sum over the photo-ionization cross-sections for all the levels of the atom, namely,

$$k_\nu = \sum_i a_\nu(i) \frac{g_i}{U_0} \exp\left[(E_i - E_1)/kT\right], \tag{17}$$

where g_i is the statistical weight of the ith level; E_i, the ionization energy from that level; E_1, the ionization potential of the atom; U_0, the partition function; and $a_\nu(i)$, the photo-ionization cross-section for the ith level, which is given by equation (7).

It has been pointed out by Peach (1962) that it is generally necessary to use the Burgess-Seaton method only for those levels for which $l < 2$ or 3, since for higher l values the departure from a hydrogenic state is small enough to make the hydrogenic approximation reasonably accurate. Therefore, for such levels we have used the hydrogenic approximation such that a_ν is given by

$$a_\nu = \frac{32\pi^2 e^6 R Z_{\text{eff}}^4}{(27)^{1/2} c h^3 \nu^3 n^5} = 2.815 \times 10^{29} \frac{Z_{\text{eff}}^4}{\nu^3 n^5} \ (\text{cm}^2), \tag{18}$$

where

$$Z_{\text{eff}}^2 = n^2 E_i / E_{\text{H}}. \tag{19}$$

In either case, the necessary data on the individual energy levels for each atom were taken from Moore (1949) with the exception of silicon, for which the more recent work by Radziemski and Andrew (1965) was used. While Moore's data have been revised also for some of the elements other than silicon, the errors due to the resulting differences in μ are found to be much smaller than the random errors involved in the empirical determination of a and b, except for silicon. Since a large range of temperatures is covered in the present computations, individual values of the partition functions for each temperature are taken from the tables by Drawin and Felenbok (1965). The lowest value of ΔE, the lowering of the ionization potential, is chosen since this value corresponds to an electron density which is as large as is found in the relatively cooler stellar atmosphere.

The contributions due to the highest energy levels near the series limit may be approximated by a procedure quite similar to that given by Unsöld (1955). If we use the approximation

$$g = 2U_1 n^2$$

for the statistical weight of a level, where U_1 is the partition function for the ionized atom, and let $A = 2.815 \times 10^{29}$, we have

$$k_\nu' = A \frac{Z_{\text{eff}}^4}{\nu^3} \frac{2U_1}{U_0} \exp(-E_1/kT) \sum_{n=N}^{\infty} \frac{1}{n^3} \exp(E_{\text{H}} Z_{\text{eff}}^2 / n^2 kT) \tag{20}$$

for the contribution to the atomic absorption coefficient due to the levels with $n \geq N$. If N is sufficiently large, the summation may be replaced by an integral over the variable, $x = -1/n^2$, such that

$$k_\nu' = A \frac{Z_{\text{eff}}^4}{\nu^3} \frac{U_1}{U_0} \exp(-E_1/kT) \int_{-1/N^2}^{0} \exp(-E_{\text{H}} Z_{\text{eff}}^2 x / kT) dx. \tag{21}$$

If the range of integration is extended to $+\infty$, then the free-free absorption is represented as well. Although Z_{eff} is actually a variable dependent upon n, if we choose N large enough, the value of Z_{eff} will be fairly constant and we may write

$$k_\nu' = A \frac{Z_{\text{eff}}^2}{\nu^3} \frac{U_1}{U_0} \frac{kT}{E_{\text{H}}} \exp\left[\left(E_{\text{H}} \frac{Z_{\text{eff}}^2}{N^2} - E_1\right) \Big/ kT\right]. \tag{22}$$

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For frequencies less than $\nu_N = E_H Z_{eff}^2/hN^2$, the limit of integration, $-1/N^2$, itself becomes a variable, $1/N^2 = h\nu/E_H Z_{eff}^2$, with the atomic absorption coefficient given by

$$k_\nu' = A \frac{Z_{eff}^2}{\nu^3} \frac{U_1}{U_0} \frac{kT}{E_H} \exp\left[(h\nu - E_1)/kT\right] . \tag{23}$$

In the present calculations, the above procedure was used for $\nu < 3 \times 10^{14}$ sec^{-1} (9993 Å) for all cases except iron and nickel. For these two metals, the large number of levels and the lack of experimental values for energy levels nearer the series limit necessitated lowering this criterion to $\nu < 50 \times 10^{14}$ sec^{-1} (5995 Å). In this way the atomic absorption coefficient is approximated for the very long wavelengths.

Thus, we note that the allowance for free-free absorption is based only on the hydrogenic approximation given above. However, examination of the results given by Peach (1967*b*) based on the more exact treatment (Peach 1965) indicates that in general the

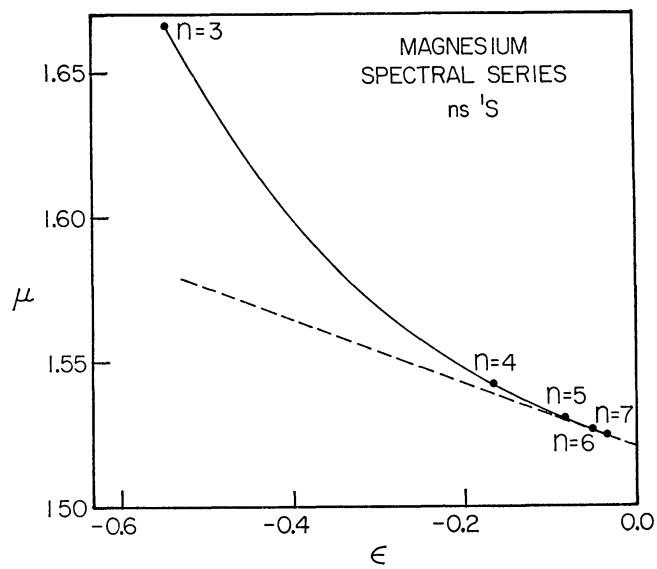

FIG 1.—Quantum defect for the Mg $ns\,^1S$ series as a function of energy ($\epsilon = -1/m^2$), with the value of n indicated for each of the empirical points. Dashed line indicates the linear approximation for the region near $\epsilon = 0$ (cf. Fig. 3).

free-free contribution is very small for the region of main interest, i.e., $\lambda < 6000$ Å. Furthermore, it should be pointed out that unfortunately it was necessary to use the hydrogenic approximation entirely in the cases of iron, chromium, and nickel. This is due to the fact that the quantum defect method can be applied only for atoms for which *LS* coupling is valid.

In the case of the photo-ionization cross-sections for which the Burgess and Seaton general formula is applicable, the first step is the determination of the constants in equation (4) for the approximation of the quantum defect for a particular spectral series. This is carried out by determining the quantum defect, μ, and the value of ϵ from equations (2) and (3). These empirical points are then plotted in order to determine a linear fit of the form given in equation (4). An example of this for the $ns\,^1S$ series of magnesium is shown in Figure 1, where the dashed line indicates the linear fit. Since we desire to use the linear approximation for extrapolation to positive values of ϵ, the region of the curve most important for the determination is that near $\epsilon = 0$.

For each level we then determine the values of the parameters $G_{ll'}$, $\gamma_{ll'}$, $\chi_{ll'}$, $\alpha_{ll'}$, and $\beta_{ll'}$ by interpolation in the tables given by Burgess and Seaton (1960). Using these quantities and the linear approximation for the quantum defects, we can determine the

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value of $g(ml;\epsilon'l')$ from equations (12)–(15). Substitution of this value into equation (7) leads to the determination of the photo-ionization cross-section.

IV. ACCURACY IN THE CALCULATIONS

Probably the most critical phase of the present method is the determination of the linear approximation for the quantum defect. For some spectral series, the determination is quite well defined, as is the case for the Mg $ns\ ^1S$ series shown in Figure 1. Unfortunately, this is not the case for many spectral series. Figure 2 shows the situation for the case of Ca $np\ ^1P$, in which the large scatter of the empirical points in the plot of μ as a function of ϵ makes the determination of a linear approximation very difficult.

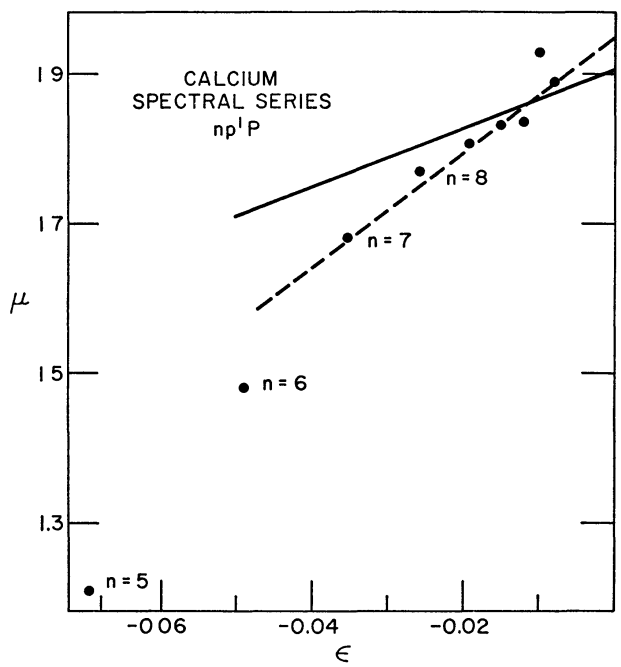

FIG. 2.—Same as Fig. 1 for the Ca $np\ ^1P$ series, except that the dashed line corresponds to the origina determination of the linear approximation while the solid line is a redetermination adjusted for better agreement with the experimentally determined cross-section for the Ca $4s\ ^1S$ level (cf. Fig. 3).

In the initial calculations (Travis and Matsushima 1967), the linear approximation was arbitrarily chosen to give the best apparent fit. However, it was subsequently decided to modify some of these linear approximations within reasonable apparent limits of the empirical points such that better agreement with several experimentally determined cross-sections could be obtained. Such is the case shown in Figure 2, in which the dashed line corresponds to the original determination and the solid line is the revised fit. The revised determination gives $a = 1.908$ and $b = 3.86$, which leads to a value of a_ν at the series limit for the Ca $4s\ ^1S$ level of 1.19×10^{18} cm^2, as compared with the experimental value of 1.2×10^{18} cm^2 given by Hudson and Carter (1967). On the other hand, the original determination ($a = 1.950$, $b = 7.72$) yields a value of 0.49×10^{18} cm^2.

The linear approximations for the quantum defects actually affect a cross-section in two ways. From the value of $\zeta(ml)$ (eq. [15]), there is a change in magnitude due to the b coefficient for the spectral series of the initial level itself, since

$$\frac{\partial}{\partial\epsilon}\mu(\epsilon) = b\,.$$

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However, this does not change the relative magnitude as a function of wavelength. There will be a change in the relative magnitude of the cross-section as a function of wavelength due to the factor, $\mu'(\epsilon')$, in equation (12). In this case, $\mu'(\epsilon')$ refers to the extrapolated value for the spectral series corresponding to the ejected electron with quantum numbers $\epsilon' l'$.

Although a cross-section may depend on several possible transitions ($l' = l \pm 1$; $L' = L, L \pm 1$), one particular transition generally dominates in the determination of the total cross-section. Thus, since the modifications are determined as much as possible by attempting to obtain agreement in both the magnitude at the series limit and the dependence on wavelength, this may involve the adjustment of the linear approximations for one or two spectral series affecting a particular cross-section.

It should be noted that in order to stay within the spirit of the method, the modifications are made only within reasonable limits set by the scatter in the plot of μ versus ϵ. Indeed, in some cases, such as the Mg $3p\ ^3P$ level at λ2515, there seems to be no justifiable modification, even though a discrepancy amounting to a factor of about 2 has been noted between the calculated and experimentally determined cross-sections.

TABLE 1

COMPARISON OF VARIOUS COMPUTED CROSS-SECTIONS WITH EXPERIMENTAL VALUES*

Determination	Na $3s\ ^2S$	Mg $3s\ ^1S$	Mg $3p\ ^3P$	Si $3p^2\ ^3P$	Si $3p^2\ ^1D$	Ca $4s\ ^1S$	Ca $4p\ ^3P$
Original	0 141	1 13	19 9	17 8	15 3	0 49	23.4
Revised	0 138	1 15	19.9	39 2	35 0	1 19	6 2
Experimental	0 116†	1 18‡	45§	37‖	33‖	1 2#	6.1**
	±0 012	±0 25		± 2	± 2	±0 14	± 0 3
Hydro. Approx.	6 38	4 70	7 3	4 4	4 9	4 41	6.38

* In units of 10^{-18} cm².
† Ditchburn, Justum, and Marr (1953)
‡ Ditchburn and Marr (1953)
§ Bötticher (1958)
‖ Rich (1967)
\# Hudson and Carter (1967)
** Kelm and Schlüter (1962).

The particular cases for which experimental data are available and to which this procedure has been applied are given in Table 1, which lists the series limit values of the cross-sections for the original and revised determinations as well as the experimental and hydrogenic approximation values. This provides an indication of the importance of the modifications and gives some insight as to the accuracy of the application of the general formula of Burgess and Seaton. The cross-sections calculated originally and the experimental values differ on the average by a factor of 2.2, whereas the revised values differ by a factor of about 1.2.

Comparison between the experimental values and those determined with the hydrogenic approximation shows quite clearly that, in general, the present computation is far superior, even without modification. This can be seen in Figure 3 as well, in which we show the comparison between the present calculations (solid lines), hydrogenic approximation values (dashed lines), and the experimental determinations (dotted lines). It should be noted that for the Na $3s\ ^2S$ cross-section, a change in scaling is necessary in order to show the hydrogenic approximation, which is in error by about a factor of 55.

After the major portion of the present calculations had already been carried out, a revised general formula was given by Peach (1967*a*) after recomputation of the radial integrals, and it was suggested that this should lead to more accurate results for the cross-sections from highly excited states of atoms and for those cross-sections which are sensitive to small changes in the wave functions. Using this revised formula, Peach carried out for some of the atoms considered here calculations similar to the present ones.

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At the same time, Peach tabulated the values of the coefficients in the linear fit for the determination of the quantum defect, i.e., the values of a and b defined by equation (4). These values are found to be considerably different in some cases from the corresponding values determined independently by the present authors, indicating the uncertainty involved in the empirical fit. Hence, these data provide an opportunity to examine the errors due to the empirical procedure by comparing the cross-sections resulting from different choices of a and b. A similar comparison of the cross-sections obtainable from the two general formulae with the use of identical a and b values would also yield some insight into the range of errors due to the empirical determination of the quantum defect as compared with the improvement due to the revised formula by Peach.

Thus, the comparison is made by calculating the values of a_ν at the series limit for carbon, silicon, and aluminum for the following three separate cases; (1) using the revised formula with the values of a and b given by Peach; (2) using the same revised formula but with the values of a and b determined independently by us from the same energy

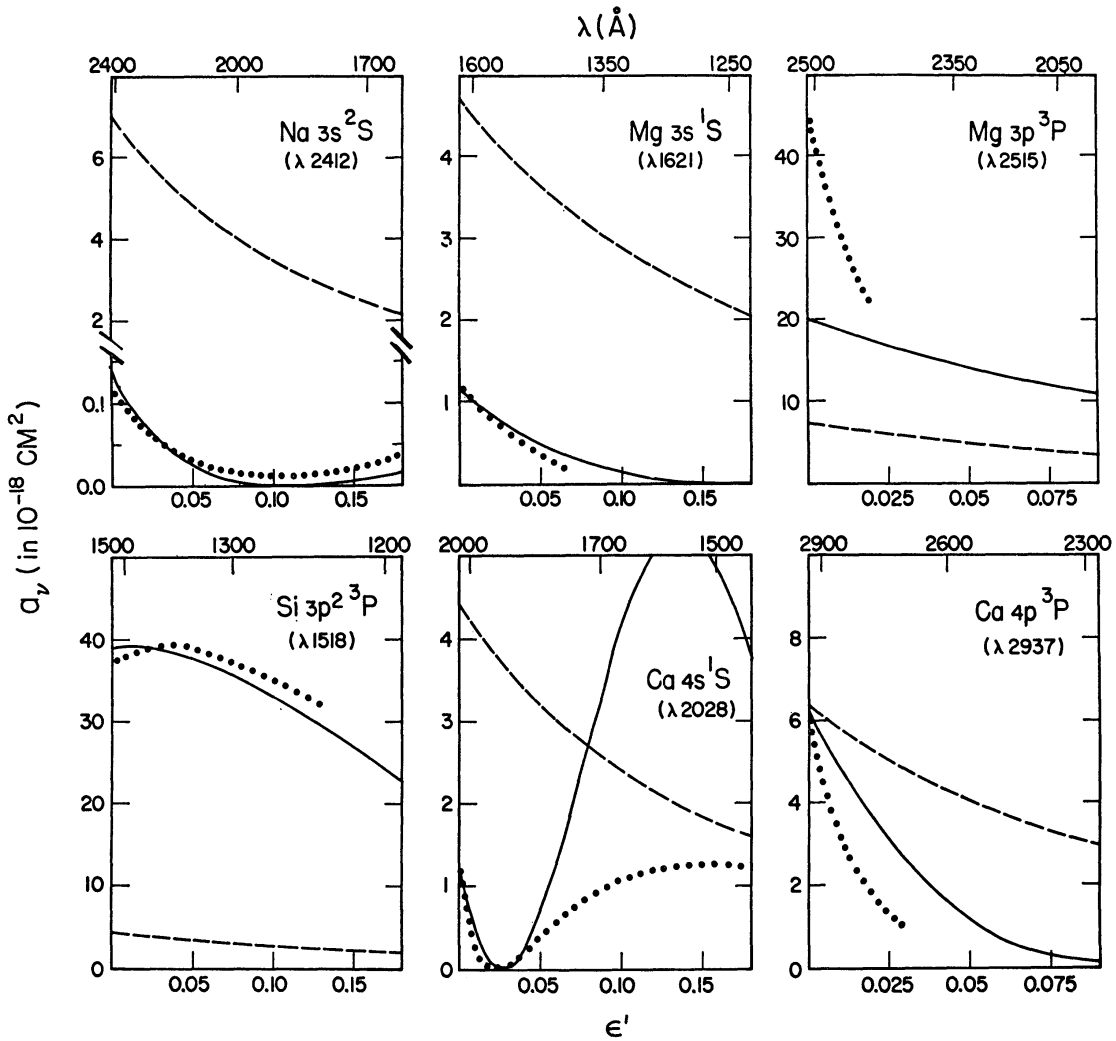

FIG 3 —Comparison of the photo-ionization cross-sections for the six indicated levels between the present calculations (*solid line*), the experimental determinations (*dotted line*), and the hydrogenic approximations (*dashed line*). Note the change in scaling used in the case of Na $3s\,^2S$ in order to show the hydrogenic approximation (cf. Figs. 1 and 2).

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level data adopted by Peach; and (3) using the same values of a and b as in (2) but employing the general formula of Burgess and Seaton. Denoting the resulting three different values of the cross-section by $a_\nu(1)$, $a_\nu(2)$, and $a_\nu(3)$, respectively, a comparison between $a_\nu(1)$ and $a_\nu(2)$ indicates the errors introduced due to the difficulty in the empirical determination of a and b. On the other hand, a comparison between $a_\nu(2)$ and $a_\nu(3)$ indicates the difference between the two general formulae. These calculations are performed for the forty-four states belonging to the three atoms mentioned. It should be pointed out that this includes all the levels of these three atoms for which the general formula is applied in the present computations.

The comparison of the result of the above calculations is shown in Figure 4, where the logarithm of the ratio of $a_\nu(2)$ to $a_\nu(3)$ is plotted against the corresponding ratio of $a_\nu(1)$ to $a_\nu(2)$. It is found that, on the average, the values of $a_\nu(1)$ and $a_\nu(2)$ differ by

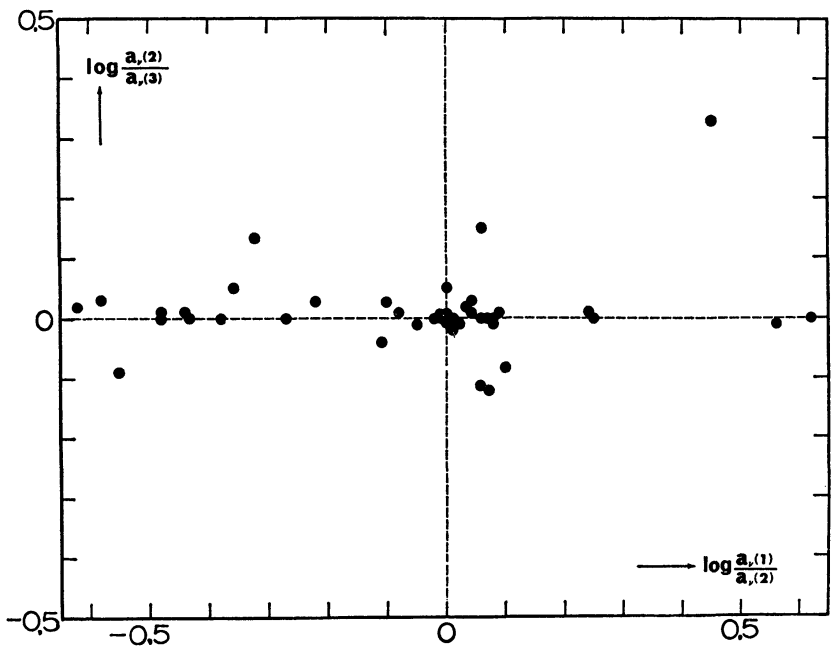

FIG. 4.—Comparison between the effect of different choices of the values of a and b and the differences between the general formula of Burgess and Seaton (1960) and that given by Peach (1967*a*).

about a factor of 1.81 whereas those of $a_\nu(2)$ and $a_\nu(3)$ differ by about 1.09. This is shown in Figure 4 by the much larger horizontal scatter than that in the vertical direction. In fact, the difference between the original formula by Burgess and Seaton and that by Peach is found to be generally less than 10 per cent, which appears to be much smaller than the random errors introduced in the empirical determination of the values of a and b. Thus, we conclude that the inherent difficulty in the empirical determination of the quantum defect is the limiting factor in the use of either general formula. For this reason, it is felt that the improvement in the general formula does not warrant a recomputation of the cross-sections presented in this paper.

It should be mentioned that new energy level data are available for some of the atoms considered here. However, the determination of the linear fit for the quantum defect is in no case affected by an amount more than the inherent uncertainty in the empirical determination, with the exception of silicon for which one level in the new data has a revised spectral term classification. This leads to large revisions, and the newer values are therefore used as previously indicated.

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Finally, it is noted that the apparent average effect of the use of different values of a and b in the above comparisons is about the same as the estimate of the accuracy based on comparisons with experimentally determined cross-sections. Thus, it seems reasonable to assume that the value of the cross-sections computed by means of the present method will be accurate, on the average, to within about a factor of 2 or 3, and that this is probably the limitation on the method due to the uncertainty in the empirical determination of the linear fit for the quantum defect.

V. RESULTS

By using the procedure outlined in the previous section, the photo-ionization cross-sections were determined and used to find the atomic absorption coefficient for the neutral metals: carbon, nitrogen, oxygen, sodium, magnesium, aluminum, silicon, calcium, chromium, iron, and nickel. The atomic absorption coefficients were calculated for eighteen temperatures ranging from $\theta = 1.38$ to $\theta = 0.36$, with an interval of $\Delta\theta = 0.06$. The results are given in Table 2, where the logarithm of the atomic absorption coefficient per neutral atom in units of 10^{-24} cm^2 is tabulated for each temperature and a range of wavelengths of λλ1033–59958. Discontinuities at the series limits are indicated by two successive values of the absorption coefficient for the same wavelength, or wave-

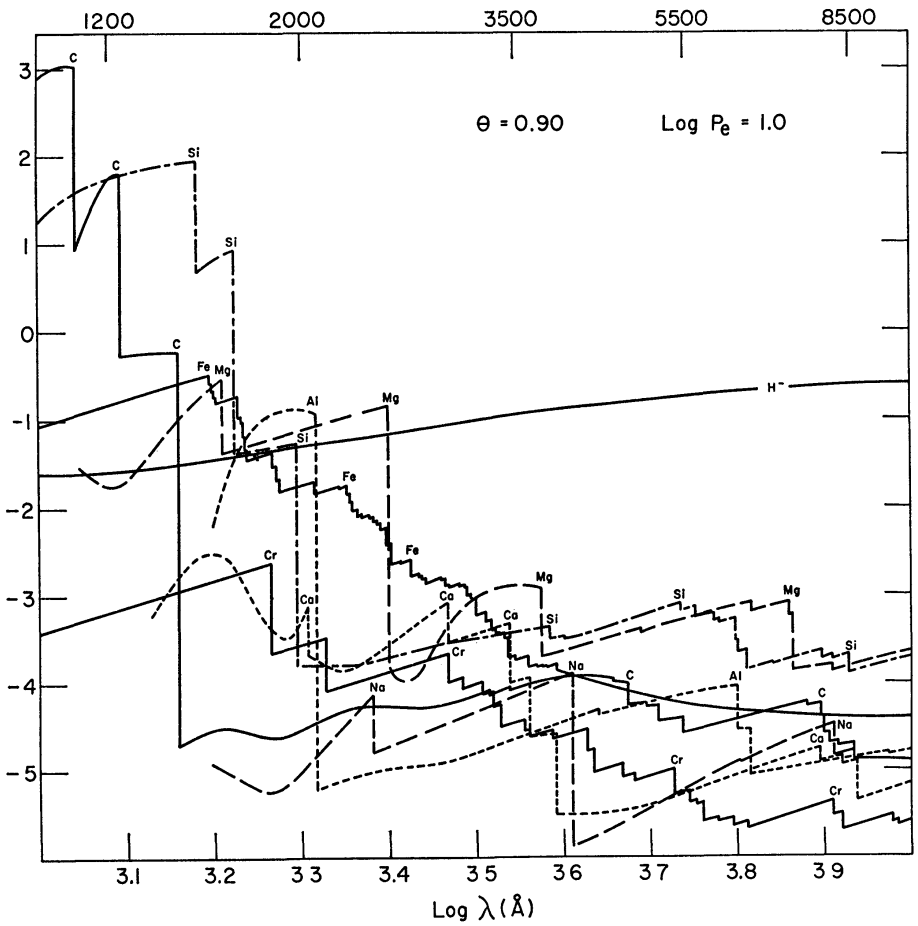

FIG. 5.—Logarithms of mass absorption coefficients for the individual metals for a solar abundance (Goldberg *et al.* 1960). The conditions, $\theta = 0.9$ and log $P_e = 1.0$, are chosen to correspond roughly to $\tau_{5000} \sim 0.5$ for a solar-type star. The individual absorption peaks are labeled to indicate the various metals, and the absorption due to H^- is included for comparison.

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lengths separated by only 1 Å. Considering the probable accuracy in the values, linear interpolation in both θ and λ should be sufficient.

An indication of the relative importance of the atomic absorption coefficients for the individual metals is given in Figure 5, where the logarithm of the mass absorption coefficient for each individual metal is shown for the case of the solar abundances by Goldberg, Müller, and Aller (1960). The conditions of $\theta = 0.90$ and log $P_e = 1.0$ correspond roughly to $\tau_{5000} \sim 0.5$ for a solar-type star. For comparison, the H^- absorption, which was computed by using an approximation polynomial given by Matsushima (1967*a*), is also shown. It is readily apparent that for the short-wavelength side of the Mg $3p^3P$ series limit at λ2515, the absorption will be due largely to silicon, carbon, magnesium, and aluminum. Just to the long-wavelength side of this limit, the metal absorption seems to be dominated by the many levels of iron, for which we were unfortunately forced to use only the hydrogenic approximation.

Finally, in Figure 6 we show the total mass absorption coefficient due to the neutral

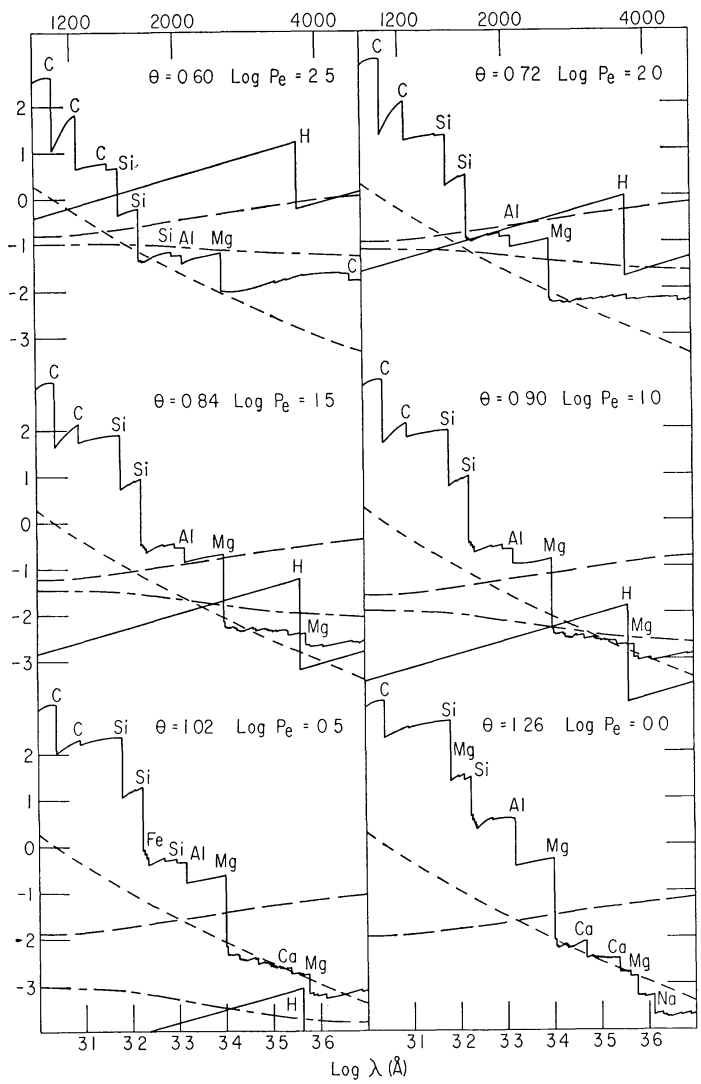

FIG. 6—Comparison of the total mass absorption coefficient (log values) due to the metal. *line*), the absorption due to H^- (*broken line*), Rayleigh scattering (*dashed line*), neutral H bour. (*solid line*), and H_2^+ (*dashed-broken line*) for six sets of θ and log P_e corresponding roughly to τ_{5000} for main-sequence models with T_e = 8400°, 7200°, 6300°, 5800°, 5040°, and 4200° K.

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TABLE 2

LOG ATOMIC ABSORPTION COEFFICIENT IN UNITS OF BARNS *** CARBON

λ \ θ	1.38	1.32	1.26	1.20	1.14	1.08	1.02	0.96	0.90	0.84	0.78	0.72	0.66	0.60	0.54	0.48	0.42	0.36
1033	6.710	6.709	6.709	6.708	6.707	6.707	6.706	6.705	6.704	6.703	6.701	6.699	6.696	6.693	6.689	6.684	6.674	6.648
1051	6.740	6.739	6.738	6.737	6.736	6.735	6.734	6.733	6.732	6.730	6.727	6.724	6.721	6.716	6.711	6.704	6.692	6.664
1070	6.754	6.753	6.752	6.751	6.750	6.749	6.747	6.746	6.744	6.742	6.738	6.735	6.731	6.725	6.719	6.711	6.697	6.668
1090	6.752	6.751	6.750	6.749	6.748	6.747	6.745	6.743	6.741	6.739	6.735	6.731	6.727	6.721	6.714	6.705	6.691	6.661
1100	6.745	6.744	6.743	6.742	6.741	6.739	6.738	6.736	6.734	6.731	6.728	6.724	6.719	6.714	6.707	6.698	6.684	6.654
1100	4.012	4.088	4.164	4.239	4.316	4.392	4.469	4.545	4.623	4.700	4.777	4.855	4.934	5.013	5.092	5.171	5.247	5.310
1110	4.074	4.149	4.225	4.300	4.376	4.452	4.529	4.605	4.682	4.759	4.835	4.913	4.990	5.068	5.146	5.223	5.298	5.359
1153	4.528	4.602	4.677	4.752	4.827	4.901	4.976	5.051	5.125	5.199	5.273	5.346	5.419	5.491	5.562	5.632	5.697	5.747
1175	4.706	4.781	4.856	4.930	5.005	5.079	5.154	5.228	5.302	5.375	5.448	5.520	5.592	5.663	5.733	5.801	5.864	5.912
1199	4.830	4.905	4.979	5.054	5.128	5.203	5.277	5.351	5.425	5.498	5.570	5.642	5.714	5.784	5.853	5.920	5.983	6.029
1223	4.903	4.977	5.052	5.127	5.201	5.275	5.349	5.423	5.497	5.570	5.642	5.714	5.785	5.856	5.925	5.991	6.053	6.099
1238	4.923	4.997	5.072	5.146	5.221	5.295	5.369	5.443	5.517	5.590	5.662	5.734	5.805	5.875	5.944	6.011	6.072	6.118
1238	2.157	2.317	2.476	2.636	2.795	2.954	3.113	3.272	3.430	3.587	3.744	3.900	4.055	4.209	4.362	4.513	4.661	4.796
1249	2.161	2.321	2.480	2.640	2.799	2.958	3.117	3.276	3.434	3.592	3.748	3.904	4.059	4.213	4.366	4.517	4.665	4.800
1303	2.180	2.339	2.499	2.658	2.818	2.977	3.136	3.294	3.453	3.610	3.767	3.923	4.078	4.232	4.384	4.535	4.682	4.816
1362	2.194	2.354	2.513	2.673	2.832	2.991	3.150	3.309	3.467	3.624	3.781	3.937	4.092	4.246	4.399	4.549	4.696	4.829
1394	2.199	2.359	2.518	2.678	2.837	2.996	3.155	3.314	3.472	3.630	3.786	3.942	4.097	4.251	4.404	4.554	4.701	4.834
1427	2.203	2.362	2.522	2.681	2.841	3.000	3.159	3.318	3.476	3.633	3.790	3.946	4.101	4.255	4.407	4.558	4.705	4.839
1443	2.204	2.363	2.523	2.682	2.842	3.001	3.160	3.319	3.477	3.634	3.791	3.947	4.102	4.256	4.409	4.559	4.707	4.841
1443	-4.723	-4.266	-3.808	-3.348	-2.886	-2.422	-1.956	-1.487	-1.016	-0.541	-0.064	0.417	0.902	1.390	1.883	2.378	2.873	3.357
1462	-4.708	-4.249	-3.789	-3.328	-2.864	-2.398	-1.929	-1.458	-0.984	-0.507	-0.027	0.456	0.943	1.433	1.927	2.423	2.919	3.403
1498	-4.678	-4.217	-3.754	-3.289	-2.822	-2.352	-1.879	-1.403	-0.925	-0.444	0.040	0.528	1.018	1.512	2.009	2.507	3.004	3.488
1577	-4.630	-4.165	-3.697	-3.228	-2.755	-2.280	-1.802	-1.321	-0.837	-0.350	0.140	0.632	1.128	1.625	2.125	2.626	3.125	3.611
1665	-4.613	-4.148	-3.681	-3.212	-2.740	-2.265	-1.787	-1.305	-0.821	-0.334	0.156	0.649	1.146	1.645	2.147	2.650	3.151	3.639
1763	-4.624	-4.163	-3.700	-3.235	-2.768	-2.298	-1.826	-1.350	-0.870	-0.388	0.098	0.588	1.083	1.581	2.082	2.587	3.091	3.584
1816	-4.629	-4.171	-3.710	-3.248	-2.784	-2.317	-1.847	-1.374	-0.898	-0.419	0.065	0.552	1.045	1.542	2.043	2.548	3.053	3.548
1873	-4.627	-4.169	-3.710	-3.249	-2.786	-2.321	-1.853	-1.381	-0.907	-0.429	0.052	0.539	1.030	1.526	2.027	2.532	3.038	3.534
1934	-4.612	-4.154	-3.694	-3.232	-2.768	-2.301	-1.832	-1.360	-0.884	-0.405	0.077	0.564	1.056	1.553	2.054	2.558	3.064	3.559
1998	-4.586	-4.124	-3.661	-3.196	-2.728	-2.258	-1.785	-1.309	-0.830	-0.347	0.139	0.629	1.123	1.621	2.123	2.627	3.132	3.626
2067	-4.551	-4.086	-3.618	-3.149	-2.677	-2.202	-1.724	-1.243	-0.758	-0.271	0.219	0.713	1.210	1.710	2.213	2.718	3.222	3.714
2141	-4.514	-4.045	-3.574	-3.100	-2.623	-2.144	-1.661	-1.175	-0.687	-0.195	0.299	0.796	1.296	1.798	2.303	2.809	3.313	3.803
2220	-4.483	-4.011	-3.536	-3.059	-2.578	-2.095	-1.609	-1.119	-0.627	-0.132	0.365	0.865	1.367	1.871	2.377	2.884	3.389	3.879
2306	-4.462	-3.987	-3.510	-3.030	-2.548	-2.062	-1.573	-1.081	-0.587	-0.090	0.410	0.912	1.416	1.922	2.430	2.938	3.444	3.935
2398	-4.452	-3.977	-3.499	-3.018	-2.534	-2.047	-1.556	-1.063	-0.567	-0.069	0.433	0.936	1.442	1.950	2.459	2.969	3.477	3.970
2498	-4.454	-3.979	-3.500	-3.019	-2.535	-2.048	-1.557	-1.063	-0.566	-0.067	0.436	0.941	1.448	1.958	2.469	2.982	3.492	3.988
2606	-4.463	-3.988	-3.510	-3.030	-2.546	-2.058	-1.568	-1.074	-0.576	-0.076	0.427	0.934	1.443	1.955	2.469	2.983	3.497	3.996
2725	-4.470	-3.996	-3.519	-3.038	-2.554	-2.067	-1.576	-1.082	-0.584	-0.082	0.422	0.930	1.441	1.955	2.471	2.989	3.505	4.008
2855	-4.466	-3.991	-3.513	-3.031	-2.546	-2.058	-1.566	-1.070	-0.570	-0.067	0.439	0.948	1.461	1.977	2.496	3.015	3.534	4.039
2997	-4.442	-3.964	-3.483	-2.998	-2.510	-2.019	-1.524	-1.025	-0.523	-0.018	0.490	1.002	1.516	2.033	2.552	3.073	3.591	4.097
3155	-4.396	-3.913	-3.428	-2.939	-2.447	-1.951	-1.452	-0.950	-0.445	0.062	0.572	1.085	1.601	2.118	2.637	3.157	3.675	4.179
3274	-4.355	-3.869	-3.380	-2.888	-2.393	-1.895	-1.394	-0.890	-0.383	0.126	0.638	1.151	1.667	2.184	2.703	3.223	3.740	4.243
3274	-4.564	-4.057	-3.547	-3.036	-2.523	-2.008	-1.492	-0.974	-0.455	0.064	0.585	1.107	1.630	2.153	2.678	3.201	3.722	4.228
3331	-4.531	-4.023	-3.513	-3.001	-2.488	-1.973	-1.457	-0.940	-0.421	0.099	0.619	1.141	1.663	2.186	2.710	3.233	3.753	4.259
3453	-4.466	-3.957	-3.447	-2.935	-2.422	-1.907	-1.391	-0.873	-0.355	0.164	0.685	1.205	1.727	2.250	2.772	3.295	3.814	4.318
3453	-4.576	-4.054	-3.532	-3.010	-2.487	-1.964	-1.440	-0.916	-0.392	0.133	0.657	1.182	1.707	2.233	2.758	3.282	3.803	4.309

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TABLE 2—*Continued*

LOG ATOMIC ABSORPTION COEFFICIENT IN UNITS OF BARNS *** CARBON (CONTINUED)

λ\θ	1.38	1.32	1.26	1.20	1.14	1.08	1.02	0.96	0.90	0.84	0.78	0.72	0.66	0.60	0.54	0.48	0.42	0.36
3526	-4.540	-4.018	-3.496	-2.973	-2.451	-1.928	-1.404	-0.880	-0.356	0.168	0.692	1.216	1.741	2.266	2.791	3.315	3.836	4.341
3747	-4.462	-3.940	-3.418	-2.896	-2.374	-1.851	-1.327	-0.804	-0.280	0.244	0.768	1.293	1.818	2.342	2.867	3.391	3.911	4.416
3997	-4.425	-3.903	-3.380	-2.857	-2.334	-1.811	-1.287	-0.762	-0.238	0.287	0.812	1.337	1.863	2.389	2.915	3.440	3.962	4.468
4282	-4.434	-3.911	-3.387	-2.863	-2.339	-1.814	-1.288	-0.762	-0.235	0.291	0.818	1.346	1.875	2.403	2.932	3.461	3.986	4.496
4541	-4.478	-3.954	-3.428	-2.903	-2.376	-1.849	-1.321	-0.793	-0.264	0.266	0.796	1.327	1.859	2.392	2.925	3.458	3.987	4.502
4541	-4.504	-3.978	-3.452	-2.926	-2.398	-1.871	-1.342	-0.813	-0.282	0.248	0.779	1.311	1.844	2.378	2.912	3.445	3.976	4.492
4612	-4.521	-3.995	-3.469	-2.941	-2.413	-1.885	-1.355	-0.825	-0.294	0.237	0.770	1.303	1.837	2.372	2.907	3.443	3.975	4.492
4720	-4.551	-4.024	-3.497	-2.968	-2.439	-1.909	-1.378	-0.847	-0.314	0.219	0.753	1.289	1.825	2.362	2.900	3.437	3.972	4.491
4720	-4.904	-4.364	-3.825	-3.284	-2.742	-2.199	-1.655	-1.110	-0.564	-0.017	0.531	1.080	1.630	2.181	2.733	3.284	3.832	4.364
4950	-4.905	-4.364	-3.822	-3.280	-2.736	-2.191	-1.645	-1.098	-0.550	-0.001	0.550	1.102	1.654	2.208	2.762	3.316	3.866	4.401
4950	-4.959	-4.416	-3.872	-3.328	-2.782	-2.235	-1.686	-1.137	-0.586	-0.035	0.518	1.072	1.627	2.183	2.739	3.295	3.847	4.384
4996	-4.959	-4.416	-3.872	-3.327	-2.780	-2.233	-1.684	-1.134	-0.583	-0.031	0.522	1.076	1.632	2.188	2.745	3.301	3.854	4.391
5112	-4.960	-4.417	-3.872	-3.326	-2.778	-2.230	-1.680	-1.129	-0.576	-0.023	0.531	1.087	1.644	2.201	2.759	3.316	3.870	4.409
5112	-5.246	-4.689	-4.131	-3.572	-3.011	-2.449	-1.886	-1.322	-0.756	-0.190	0.377	0.945	1.513	2.082	2.651	3.218	3.782	4.330
5450	-5.212	-4.653	-4.093	-3.531	-2.969	-2.405	-1.839	-1.273	-0.705	-0.137	0.432	1.001	1.572	2.142	2.713	3.282	3.847	4.397
5455	-5.212	-4.653	-4.092	-3.531	-2.968	-2.404	-1.839	-1.272	-0.705	-0.137	0.432	1.002	1.572	2.143	2.713	3.283	3.848	4.397
5455	-5.574	-4.990	-4.406	-3.822	-3.237	-2.652	-2.067	-1.482	-0.896	-0.312	0.273	0.857	1.441	2.024	2.607	3.187	3.762	4.320
5894	-5.485	-4.901	-4.317	-3.732	-3.148	-2.563	-1.977	-1.392	-0.807	-0.222	0.363	0.947	1.531	2.114	2.696	3.276	3.852	4.410
5894	-5.506	-4.920	-4.334	-3.748	-3.162	-2.576	-1.990	-1.403	-0.817	-0.231	0.354	0.939	1.524	2.108	2.690	3.271	3.847	4.406
5995	-5.486	-4.900	-4.314	-3.728	-3.142	-2.556	-1.970	-1.384	-0.797	-0.212	0.374	0.959	1.543	2.127	2.710	3.290	3.866	4.425
6662	-5.365	-4.780	-4.195	-3.609	-3.023	-2.438	-1.852	-1.266	-0.680	-0.095	0.490	1.075	1.659	2.243	2.825	3.405	3.981	4.539
7494	-5.232	-4.647	-4.062	-3.477	-2.892	-2.307	-1.721	-1.136	-0.551	0.034	0.619	1.203	1.786	2.369	2.951	3.531	4.106	4.665
7576	-5.219	-4.634	-4.050	-3.465	-2.880	-2.295	-1.709	-1.124	-0.539	0.046	0.631	1.215	1.798	2.381	2.963	3.543	4.118	4.676
7577	-5.267	-4.681	-4.096	-3.510	-2.924	-2.338	-1.751	-1.165	-0.579	0.007	0.592	1.178	1.762	2.346	2.929	3.510	4.086	4.646
7824	-5.230	-4.645	-4.059	-3.474	-2.888	-2.302	-1.716	-1.130	-0.543	0.042	0.627	1.213	1.797	2.381	2.964	3.545	4.121	4.680
7824	-5.232	-4.647	-4.061	-3.476	-2.890	-2.304	-1.718	-1.131	-0.545	0.040	0.626	1.211	1.795	2.379	2.962	3.543	4.119	4.679
7886	-5.223	-4.638	-4.052	-3.467	-2.881	-2.295	-1.709	-1.122	-0.536	0.049	0.635	1.220	1.804	2.388	2.971	3.552	4.128	4.687
7887	-5.425	-4.837	-4.248	-3.660	-3.071	-2.481	-1.892	-1.302	-0.713	-0.123	0.466	1.055	1.643	2.231	2.819	3.404	3.984	4.548
7916	-5.421	-4.833	-4.244	-3.656	-3.067	-2.478	-1.888	-1.298	-0.709	-0.120	0.470	1.058	1.647	2.235	2.822	3.407	3.988	4.552
7916	-5.648	-5.055	-4.462	-3.868	-3.274	-2.679	-2.085	-1.490	-0.895	-0.300	0.295	0.889	1.483	2.077	2.670	3.261	3.848	4.417
7933	-5.646	-5.053	-4.460	-3.866	-3.272	-2.678	-2.083	-1.488	-0.893	-0.298	0.297	0.891	1.485	2.079	2.672	3.263	3.850	4.419
7933	-5.652	-5.058	-4.465	-3.871	-3.277	-2.682	-2.088	-1.492	-0.897	-0.302	0.292	0.887	1.482	2.076	2.669	3.260	3.846	4.416
8057	-5.638	-5.045	-4.451	-3.857	-3.263	-2.669	-2.074	-1.479	-0.884	-0.289	0.306	0.901	1.495	2.089	2.682	3.274	3.860	4.430
8057	-5.787	-5.190	-4.592	-3.994	-3.396	-2.797	-2.198	-1.599	-0.999	-0.400	0.199	0.798	1.397	1.995	2.592	3.188	3.779	4.353
8230	-5.771	-5.174	-4.576	-3.978	-3.380	-2.781	-2.182	-1.583	-0.983	-0.384	0.215	0.815	1.413	2.012	2.609	3.205	3.796	4.370
8230	-5.848	-5.248	-4.648	-4.047	-3.446	-2.845	-2.244	-1.642	-1.040	-0.438	0.163	0.765	1.366	1.967	2.567	3.164	3.757	4.334
8565	-5.820	-5.220	-4.620	-4.019	-3.418	-2.817	-2.215	-1.613	-1.011	-0.409	0.193	0.795	1.397	1.998	2.598	3.196	3.790	4.367
8600	-5.817	-5.217	-4.617	-4.016	-3.415	-2.814	-2.212	-1.610	-1.007	-0.406	0.196	0.798	1.400	2.001	2.601	3.200	3.793	4.370
8600	-6.072	-5.463	-4.854	-4.245	-3.635	-3.025	-2.415	-1.804	-1.194	-0.584	0.027	0.636	1.246	1.854	2.462	3.068	3.669	4.252
9993	-6.162	-5.543	-4.925	-4.306	-3.687	-3.068	-2.449	-1.829	-1.210	-0.591	0.027	0.646	1.263	1.880	2.496	3.109	3.717	4.308
11991	-6.129	-5.503	-4.877	-4.251	-3.625	-2.998	-2.372	-1.746	-1.120	-0.495	0.130	0.754	1.377	2.000	2.621	3.239	3.853	4.449
14989	-5.718	-5.077	-4.436	-3.795	-3.153	-2.511	-1.869	-1.227	-0.584	0.058	0.699	1.341	1.982	2.622	3.261	3.899	4.532	5.152
19986	-5.661	-5.010	-4.359	-3.708	-3.056	-2.405	-1.753	-1.101	-0.450	0.201	0.851	1.502	2.151	2.800	3.447	4.093	4.733	5.361
29979	-5.489	-4.829	-4.168	-3.508	-2.848	-2.187	-1.527	-0.867	-0.207	0.452	1.111	1.769	2.426	3.082	3.738	4.390	5.038	5.673
59958	-5.053	-4.384	-3.716	-3.047	-2.379	-1.711	-1.043	-0.375	0.292	0.959	1.625	2.290	2.955	3.618	4.280	4.940	5.595	6.236

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TABLE 2—*Continued*

LOG ATOMIC ABSORPTION COEFFICIENT IN UNITS OF BARNS *** NITROGEN

λ \ θ	1.38	1.32	1.26	1.20	1.14	1.08	1.02	0.96	0.90	0.84	0.78	0.72	0.66	0.60	0.54	0.48	0.42	0.36
1033	2.505	2.719	2.932	3.145	3.359	3.572	3.784	3.997	4.210	4.422	4.633	4.845	5.050	5.253	5.451	5.642	5.825	5.995
1070	2.519	2.733	2.946	3.159	3.372	3.585	3.798	4.011	4.223	4.435	4.647	4.858	5.064	5.267	5.464	5.656	5.839	6.009
1110	2.529	2.743	2.956	3.169	3.383	3.596	3.808	4.021	4.234	4.446	4.657	4.869	5.074	5.277	5.475	5.666	5.849	6.019
1129	2.533	2.746	2.960	3.173	3.386	3.599	3.812	4.024	4.237	4.449	4.661	4.872	5.078	5.280	5.478	5.670	5.853	6.022
1129	-8.918	-8.273	-7.627	-6.978	-6.326	-5.672	-5.014	-4.353	-3.688	-3.020	-2.348	-1.673	-0.998	-0.323	0.352	1.026	1.694	2.354
1249	-8.863	-8.220	-7.574	-6.926	-6.276	-5.622	-4.965	-4.305	-3.641	-2.973	-2.301	-1.625	-0.950	-0.273	0.403	1.077	1.747	2.407
1362	-8.812	-8.170	-7.526	-6.879	-6.229	-5.577	-4.921	-4.261	-3.597	-2.930	-2.258	-1.582	-0.907	-0.230	0.446	1.121	1.792	2.453
1498	-8.756	-8.115	-7.472	-6.827	-6.178	-5.526	-4.871	-4.212	-3.549	-2.882	-2.211	-1.535	-0.860	-0.183	0.494	1.169	1.840	2.503
1665	-8.698	-8.058	-7.416	-6.771	-6.124	-5.473	-4.818	-4.160	-3.498	-2.831	-2.160	-1.485	-0.810	-0.133	0.544	1.220	1.892	2.556
1873	-8.638	-7.999	-7.357	-6.713	-6.066	-5.416	-4.762	-4.105	-3.443	-2.777	-2.106	-1.430	-0.755	-0.078	0.600	1.276	1.949	2.614
2141	-8.576	-7.937	-7.295	-6.651	-6.004	-5.354	-4.700	-4.043	-3.381	-2.715	-2.044	-1.368	-0.693	-0.016	0.663	1.341	2.015	2.681
2498	-8.496	-7.856	-7.214	-6.570	-5.923	-5.272	-4.619	-3.961	-3.299	-2.633	-1.962	-1.287	-0.611	0.067	0.746	1.425	2.100	2.768
2725	-8.434	-7.794	-7.152	-6.508	-5.861	-5.211	-4.558	-3.900	-3.239	-2.573	-1.903	-1.228	-0.552	0.125	0.804	1.483	2.159	2.827
2940	-8.363	-7.724	-7.082	-6.439	-5.792	-5.143	-4.490	-3.834	-3.173	-2.508	-1.839	-1.164	-0.490	0.187	0.865	1.543	2.218	2.887
2940	-8.629	-7.973	-7.315	-6.654	-5.990	-5.324	-4.654	-3.981	-3.305	-2.624	-1.940	-1.252	-0.564	0.124	0.813	1.500	2.184	2.859
3210	-8.542	-7.887	-7.229	-6.568	-5.905	-5.239	-4.570	-3.897	-3.221	-2.542	-1.858	-1.170	-0.484	0.204	0.892	1.579	2.262	2.937
3210	-9.239	-8.526	-7.813	-7.099	-6.385	-5.670	-4.955	-4.239	-3.522	-2.805	-2.087	-1.368	-0.653	0.060	0.771	1.478	2.178	2.868
3747	-9.037	-8.326	-7.615	-6.904	-6.192	-5.479	-4.766	-4.053	-3.338	-2.623	-1.907	-1.190	-0.478	0.234	0.942	1.647	2.346	3.035
4208	-8.857	-8.147	-7.438	-6.728	-6.017	-5.307	-4.595	-3.883	-3.171	-2.457	-1.743	-1.029	-0.318	0.391	1.098	1.801	2.498	3.185
4208	-8.933	-8.221	-7.509	-6.796	-6.083	-5.369	-4.655	-3.941	-3.226	-2.510	-1.793	-1.076	-0.363	0.349	1.059	1.764	2.464	3.154
4443	-8.844	-8.133	-7.421	-6.709	-5.997	-5.284	-4.571	-3.857	-3.143	-2.428	-1.712	-0.995	-0.283	0.428	1.137	1.841	2.540	3.229
4443	-9.248	-8.526	-7.804	-7.081	-6.358	-5.634	-4.909	-4.184	-3.457	-2.730	-2.002	-1.272	-0.546	0.179	0.902	1.622	2.337	3.041
4579	-9.497	-8.764	-8.032	-7.299	-6.565	-5.830	-5.095	-4.359	-3.622	-2.885	-2.146	-1.405	-0.668	0.068	0.802	1.533	2.258	2.974
4580	-9.497	-8.764	-8.032	-7.299	-6.565	-5.830	-5.095	-4.359	-3.622	-2.885	-2.146	-1.405	-0.668	0.068	0.802	1.533	2.258	2.974
4855	-9.443	-8.710	-7.978	-7.244	-6.511	-5.776	-5.041	-4.305	-3.567	-2.829	-2.090	-1.349	-0.612	0.125	0.860	1.591	2.318	3.034
4855	-9.489	-8.755	-8.021	-7.286	-6.551	-5.815	-5.078	-4.340	-3.601	-2.862	-2.121	-1.378	-0.639	0.099	0.836	1.569	2.298	3.016
4875	-9.486	-8.752	-8.017	-7.283	-6.547	-5.811	-5.074	-4.336	-3.598	-2.858	-2.117	-1.374	-0.635	0.104	0.840	1.573	2.302	3.020
4875	-9.652	-8.912	-8.171	-7.430	-6.688	-5.945	-5.202	-4.458	-3.712	-2.966	-2.219	-1.469	-0.724	0.021	0.764	1.504	2.239	2.964
5114	-9.611	-8.870	-8.129	-7.387	-6.645	-5.902	-5.159	-4.414	-3.668	-2.922	-2.174	-1.424	-0.677	0.068	0.812	1.553	2.288	3.014
5114	-9.695	-8.952	-8.207	-7.463	-6.718	-5.972	-5.225	-4.477	-3.729	-2.979	-2.227	-1.474	-0.725	0.024	0.771	1.516	2.254	2.984
5656	-9.596	-8.852	-8.108	-7.363	-6.618	-5.871	-5.124	-4.376	-3.626	-2.876	-2.124	-1.370	-0.619	0.131	0.880	1.625	2.365	3.096
5656	-10.852	-10.051	-9.249	-8.447	-7.644	-6.840	-6.034	-5.229	-4.421	-3.614	-2.805	-1.996	-1.192	-0.390	0.410	1.203	1.990	2.764
7325	-10.502	-9.701	-8.899	-8.097	-7.293	-6.489	-5.684	-4.878	-4.071	-3.264	-2.455	-1.647	-0.843	-0.041	0.758	1.551	2.337	3.110
7325	-10.520	-9.717	-8.914	-8.111	-7.306	-6.501	-5.695	-4.888	-4.080	-3.272	-2.463	-1.654	-0.849	-0.046	0.753	1.547	2.333	3.107
7606	-10.467	-9.664	-8.861	-8.058	-7.253	-6.448	-5.642	-4.835	-4.028	-3.220	-2.411	-1.602	-0.797	0.005	0.805	1.598	2.385	3.158
7606	-10.530	-9.723	-8.916	-8.109	-7.301	-6.492	-5.683	-4.873	-4.062	-3.252	-2.440	-1.628	-0.821	-0.017	0.784	1.580	2.368	3.143
7863	-10.482	-9.675	-8.869	-8.061	-7.253	-6.444	-5.636	-4.826	-4.016	-3.205	-2.394	-1.582	-0.775	0.029	0.830	1.626	2.414	3.188
7863	-10.482	-9.675	-8.869	-8.061	-7.253	-6.444	-5.636	-4.826	-4.016	-3.204	-2.394	-1.582	-0.775	0.030	0.830	1.626	2.414	3.188
8565	-10.358	-9.552	-8.746	-7.938	-7.131	-6.323	-5.514	-4.705	-3.894	-3.084	-2.274	-1.462	-0.656	0.148	0.949	1.744	2.531	3.306
9993	-10.562	-9.738	-8.913	-8.089	-7.264	-6.439	-5.614	-4.789	-3.964	-3.138	-2.313	-1.487	-0.667	0.150	0.963	1.769	2.568	3.353
11991	-10.352	-9.526	-8.700	-7.874	-7.048	-6.221	-5.395	-4.569	-3.743	-2.917	-2.090	-1.264	-0.443	0.375	1.189	1.997	2.797	3.582
14989	-9.728	-8.889	-8.050	-7.211	-6.371	-5.531	-4.690	-3.849	-3.008	-2.166	-1.324	-0.481	0.358	1.194	2.027	2.856	3.678	4.491
19986	-9.671	-8.822	-7.973	-7.124	-6.274	-5.424	-4.574	-3.724	-2.873	-2.022	-1.171	-0.320	0.527	1.371	2.213	3.050	3.880	4.700
29979	-9.499	-8.640	-7.782	-6.924	-6.066	-5.207	-4.348	-3.489	-2.630	-1.771	-0.912	-0.053	0.802	1.654	2.503	3.347	4.185	5.012
59958	-9.062	-8.196	-7.330	-6.463	-5.597	-4.731	-3.864	-2.998	-2.131	-1.265	-0.398	0.469	1.330	2.190	3.046	3.897	4.741	5.575

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TABLE 2—*Continued*

LOG ATOMIC ABSORPTION COEFFICIENT IN UNITS OF BARNS *** OXYGEN

λ\θ	1.38	1.32	1.26	1.20	1.14	1.08	1.02	0.96	0.90	0.84	0.78	0.72	0.66	0.60	0.54	0.48	0.42	0.36
1033	-8.222	-7.649	-7.074	-6.497	-5.919	-5.338	-4.755	-4.170	-3.581	-2.989	-2.393	-1.795	-1.192	-0.585	0.025	0.640	1.257	1.876
1070	-8.192	-7.619	-7.045	-6.469	-5.892	-5.312	-4.730	-4.145	-3.557	-2.966	-2.372	-1.773	-1.171	-0.565	0.045	0.658	1.276	1.894
1110	-8.160	-7.589	-7.015	-6.441	-5.864	-5.286	-4.704	-4.121	-3.534	-2.943	-2.350	-1.752	-1.151	-0.545	0.064	0.677	1.294	1.912
1199	-8.098	-7.528	-6.957	-6.384	-5.809	-5.233	-4.653	-4.071	-3.486	-2.898	-2.306	-1.710	-1.110	-0.506	0.103	0.716	1.332	1.950
1249	-8.067	-7.498	-6.928	-6.356	-5.783	-5.207	-4.629	-4.047	-3.463	-2.876	-2.284	-1.689	-1.090	-0.486	0.122	0.734	1.350	1.968
1303	-8.038	-7.471	-6.901	-6.330	-5.757	-5.182	-4.605	-4.025	-3.441	-2.854	-2.263	-1.669	-1.070	-0.467	0.141	0.753	1.369	1.987
1362	-8.012	-7.445	-6.876	-6.306	-5.734	-5.160	-4.583	-4.003	-3.420	-2.834	-2.244	-1.650	-1.052	-0.449	0.159	0.771	1.387	2.005
1498	-7.968	-7.402	-6.835	-6.266	-5.695	-5.122	-4.546	-3.968	-3.386	-2.800	-2.211	-1.617	-1.019	-0.416	0.192	0.804	1.421	2.041
1665	-7.946	-7.380	-6.814	-6.245	-5.675	-5.102	-4.526	-3.947	-3.365	-2.779	-2.189	-1.594	-0.994	-0.390	0.220	0.834	1.454	2.075
1873	-7.962	-7.396	-6.829	-6.259	-5.687	-5.112	-4.535	-3.953	-3.368	-2.778	-2.184	-1.585	-0.981	-0.372	0.242	0.862	1.486	2.113
2141	-8.053	-7.484	-6.911	-6.336	-5.758	-5.176	-4.591	-4.000	-3.406	-2.806	-2.201	-1.591	-0.976	-0.357	0.268	0.897	1.530	2.166
2498	-8.304	-7.715	-7.121	-6.522	-5.919	-5.312	-4.699	-4.083	-3.462	-2.837	-2.209	-1.577	-0.942	-0.304	0.337	0.980	1.625	2.270
2725	-8.496	-7.874	-7.249	-6.621	-5.991	-5.358	-4.722	-4.085	-3.446	-2.805	-2.163	-1.520	-0.875	-0.229	0.418	1.066	1.715	2.363
2772	-8.521	-7.892	-7.261	-6.627	-5.992	-5.354	-4.715	-4.075	-3.434	-2.791	-2.147	-1.502	-0.856	-0.209	0.438	1.087	1.736	2.385
2772	-8.542	-7.910	-7.275	-6.639	-6.001	-5.362	-4.722	-4.080	-3.437	-2.794	-2.149	-1.504	-0.858	-0.211	0.437	1.086	1.736	2.384
2855	-8.537	-7.899	-7.259	-6.618	-5.977	-5.334	-4.691	-4.048	-3.403	-2.758	-2.112	-1.466	-0.819	-0.171	0.477	1.126	1.776	2.424
3026	-8.482	-7.837	-7.192	-6.547	-5.902	-5.256	-4.611	-3.965	-3.319	-2.672	-2.026	-1.379	-0.731	-0.084	0.564	1.213	1.862	2.509
3026	-8.484	-7.839	-7.193	-6.548	-5.903	-5.257	-4.611	-3.965	-3.319	-2.673	-2.026	-1.379	-0.732	-0.084	0.564	1.213	1.862	2.509
3331	-8.315	-7.670	-7.025	-6.381	-5.736	-5.091	-4.445	-3.800	-3.154	-2.509	-1.863	-1.217	-0.570	0.076	0.723	1.370	2.018	2.663
3747	-8.104	-7.459	-6.815	-6.170	-5.525	-4.881	-4.236	-3.591	-2.946	-2.301	-1.655	-1.010	-0.364	0.281	0.927	1.573	2.218	2.862
3997	-7.988	-7.344	-6.699	-6.055	-5.410	-4.766	-4.121	-3.476	-2.831	-2.186	-1.541	-0.896	-0.251	0.394	1.040	1.685	2.330	2.972
4308	-7.856	-7.211	-6.567	-5.922	-5.278	-4.633	-3.989	-3.344	-2.699	-2.054	-1.409	-0.764	-0.119	0.526	1.170	1.815	2.459	3.101
4308	-8.975	-8.315	-7.654	-6.993	-6.331	-5.668	-5.005	-4.340	-3.673	-3.005	-2.335	-1.663	-0.988	-0.310	0.371	1.056	1.744	2.433
4715	-8.808	-8.148	-7.487	-6.826	-6.165	-5.503	-4.839	-4.175	-3.510	-2.843	-2.174	-1.503	-0.830	-0.154	0.525	1.208	1.893	2.580
4715	-10.456	-9.714	-8.971	-8.228	-7.484	-6.740	-5.995	-5.249	-4.502	-3.755	-3.007	-2.258	-1.509	-0.760	-0.011	0.738	1.486	2.230
5995	-10.105	-9.363	-8.621	-7.878	-7.135	-6.391	-5.646	-4.901	-4.155	-3.409	-2.662	-1.914	-1.166	-0.418	0.330	1.077	1.824	2.567
6963	-9.875	-9.134	-8.393	-7.651	-6.908	-6.165	-5.421	-4.677	-3.932	-3.186	-2.440	-1.694	-0.947	-0.200	0.547	1.294	2.040	2.782
6963	-9.882	-9.140	-8.398	-7.656	-6.913	-6.170	-5.425	-4.681	-3.935	-3.190	-2.443	-1.696	-0.949	-0.202	0.545	1.292	2.038	2.781
7346	-9.801	-9.060	-8.318	-7.576	-6.833	-6.090	-5.346	-4.602	-3.857	-3.111	-2.365	-1.618	-0.871	-0.124	0.623	1.369	2.115	2.857
7346	-9.804	-9.063	-8.321	-7.578	-6.836	-6.092	-5.348	-4.604	-3.858	-3.113	-2.366	-1.620	-0.873	-0.125	0.622	1.368	2.114	2.856
8053	-9.670	-8.929	-8.187	-7.444	-6.702	-5.959	-5.215	-4.470	-3.726	-2.980	-2.234	-1.488	-0.741	0.006	0.753	1.499	2.244	2.986
8053	-9.670	-8.929	-8.187	-7.444	-6.702	-5.959	-5.215	-4.470	-3.726	-2.980	-2.234	-1.487	-0.741	0.006	0.753	1.499	2.244	2.986
8098	-9.662	-8.921	-8.179	-7.437	-6.694	-5.951	-5.207	-4.463	-3.718	-2.972	-2.226	-1.480	-0.733	0.014	0.760	1.507	2.252	2.994
8098	-9.662	-8.921	-8.179	-7.437	-6.694	-5.951	-5.207	-4.463	-3.718	-2.972	-2.226	-1.480	-0.733	0.014	0.760	1.507	2.252	2.994
8565	-9.581	-8.840	-8.098	-7.356	-6.613	-5.870	-5.126	-4.382	-3.637	-2.892	-2.146	-1.400	-0.653	0.093	0.840	1.586	2.331	3.073
9308	-9.462	-8.721	-7.979	-7.237	-6.495	-5.752	-5.008	-4.264	-3.519	-2.774	-2.028	-1.282	-0.536	0.210	0.956	1.702	2.447	3.189
9308	-10.040	-9.284	-8.527	-7.769	-7.011	-6.251	-5.491	-4.729	-3.966	-3.203	-2.439	-1.675	-0.910	-0.145	0.620	1.384	2.148	2.907
9845	-9.957	-9.201	-8.445	-7.687	-6.929	-6.170	-5.409	-4.648	-3.886	-3.123	-2.359	-1.596	-0.831	-0.066	0.699	1.462	2.225	2.984
9846	-10.384	-9.604	-8.823	-8.042	-7.262	-6.481	-5.700	-4.919	-4.139	-3.358	-2.577	-1.797	-1.017	-0.239	0.540	1.316	2.091	2.861
9993	-10.365	-9.584	-8.804	-8.023	-7.242	-6.462	-5.681	-4.900	-4.119	-3.339	-2.558	-1.777	-0.997	-0.218	0.559	1.336	2.111	2.881
11991	-10.122	-9.341	-8.561	-7.781	-7.001	-6.220	-5.439	-4.658	-3.877	-3.097	-2.316	-1.536	-0.757	0.022	0.800	1.576	2.351	3.121
14989	-9.832	-9.052	-8.271	-7.491	-6.710	-5.929	-5.149	-4.368	-3.587	-2.807	-2.026	-1.245	-0.466	0.313	1.091	1.868	2.643	3.412
19986	-9.108	-8.314	-7.519	-6.724	-5.928	-5.132	-4.335	-3.538	-2.740	-1.941	-1.142	-0.342	0.459	1.261	2.064	2.869	3.675	4.482
29979	-8.936	-8.133	-7.329	-6.524	-5.720	-4.915	-4.109	-3.304	-2.497	-1.690	-0.883	-0.075	0.734	1.544	2.355	3.167	3.981	4.795
59958	-8.500	-7.688	-6.876	-6.064	-5.251	-4.439	-3.626	-2.812	-1.998	-1.184	-0.369	0.447	1.263	2.080	2.897	3.716	4.537	5.358

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TABLE 2—*Continued*

LOG ATOMIC ABSORPTION COEFFICIENT IN UNITS OF BARNS *** SODIUM

λ \ θ	1.38	1.32	1.26	1.20	1.14	1.08	1.02	0.96	0.90	0.84	0.78	0.72	0.66	0.60	0.54	0.48	0.42	0.36
1033	4.891	4.891	4.891	4.890	4.891	4.891	4.891	4.890	4.889	4.886	4.879	4.866	4.842	4.801	4.741	4.664	4.556	4.402
1070	4.883	4.883	4.883	4.882	4.883	4.883	4.883	4.883	4.883	4.881	4.876	4.867	4.847	4.812	4.759	4.692	4.593	4.448
1110	4.870	4.870	4.870	4.870	4.871	4.871	4.872	4.872	4.873	4.873	4.870	4.864	4.849	4.821	4.777	4.719	4.629	4.491
1153	4.853	4.853	4.853	4.853	4.854	4.855	4.856	4.857	4.859	4.860	4.861	4.859	4.850	4.829	4.793	4.744	4.663	4.533
1199	4.829	4.829	4.830	4.830	4.831	4.832	4.833	4.836	4.839	4.843	4.847	4.850	4.847	4.834	4.808	4.768	4.695	4.571
1249	4.797	4.797	4.798	4.798	4.800	4.801	4.804	4.807	4.812	4.819	4.827	4.836	4.841	4.837	4.820	4.790	4.725	4.607
1303	4.754	4.755	4.755	4.756	4.758	4.760	4.764	4.769	4.777	4.788	4.801	4.817	4.831	4.837	4.831	4.810	4.752	4.641
1362	4.697	4.697	4.698	4.700	4.702	4.706	4.711	4.719	4.730	4.746	4.766	4.791	4.816	4.834	4.839	4.827	4.777	4.671
1427	4.618	4.619	4.621	4.623	4.627	4.632	4.640	4.651	4.668	4.691	4.721	4.758	4.796	4.828	4.844	4.842	4.800	4.699
1498	4.509	4.511	4.514	4.517	4.524	4.532	4.544	4.562	4.587	4.621	4.665	4.717	4.772	4.819	4.848	4.856	4.820	4.724
1577	4.351	4.355	4.360	4.366	4.377	4.391	4.412	4.441	4.480	4.533	4.597	4.671	4.745	4.809	4.852	4.869	4.839	4.746
1665	4.106	4.114	4.125	4.139	4.161	4.189	4.228	4.280	4.347	4.429	4.523	4.624	4.722	4.803	4.857	4.882	4.857	4.767
1763	3.675	3.701	3.736	3.780	3.838	3.909	3.995	4.095	4.210	4.335	4.466	4.595	4.713	4.807	4.870	4.900	4.877	4.787
1873	3.023	3.158	3.295	3.434	3.577	3.722	3.870	4.021	4.173	4.326	4.474	4.615	4.739	4.835	4.899	4.927	4.902	4.810
1998	3.816	3.848	3.888	3.938	3.999	4.073	4.158	4.256	4.364	4.481	4.600	4.717	4.821	4.902	4.952	4.970	4.937	4.839
2141	4.472	4.481	4.494	4.510	4.531	4.559	4.595	4.639	4.694	4.757	4.828	4.901	4.968	5.018	5.042	5.040	4.990	4.879
2306	4.930	4.935	4.940	4.947	4.957	4.970	4.987	5.008	5.035	5.067	5.102	5.138	5.167	5.181	5.174	5.143	5.070	4.939
2412	5.150	5.153	5.157	5.161	5.169	5.177	5.189	5.203	5.221	5.242	5.264	5.285	5.297	5.293	5.267	5.219	5.130	4.986
2412	3.524	3.652	3.781	3.910	4.040	4.171	4.301	4.432	4.561	4.688	4.809	4.920	5.012	5.077	5.108	5.105	5.051	4.932
2498	3.593	3.721	3.849	3.977	4.106	4.235	4.364	4.493	4.621	4.745	4.863	4.971	5.060	5.120	5.147	5.139	5.080	4.957
2725	3.761	3.888	4.015	4.142	4.269	4.396	4.523	4.648	4.772	4.892	5.004	5.105	5.186	5.238	5.255	5.237	5.166	5.031
2997	3.939	4.065	4.191	4.317	4.443	4.569	4.694	4.817	4.938	5.055	5.163	5.259	5.335	5.380	5.389	5.361	5.281	5.134
3331	4.126	4.252	4.378	4.504	4.629	4.754	4.877	5.000	5.119	5.234	5.340	5.433	5.504	5.545	5.549	5.515	5.427	5.272
3747	4.326	4.452	4.577	4.702	4.828	4.952	5.075	5.197	5.315	5.429	5.534	5.626	5.695	5.734	5.735	5.697	5.605	5.445
3997	4.431	4.556	4.682	4.807	4.932	5.057	5.180	5.301	5.419	5.533	5.638	5.729	5.799	5.837	5.837	5.799	5.706	5.544
4084	4.465	4.591	4.717	4.842	4.967	5.091	5.214	5.335	5.454	5.567	5.672	5.764	5.833	5.871	5.871	5.833	5.739	5.578
4084	1.601	1.836	2.071	2.307	2.544	2.780	3.017	3.253	3.486	3.716	3.937	4.146	4.334	4.490	4.608	4.687	4.709	4.662
4282	1.692	1.925	2.159	2.393	2.629	2.864	3.100	3.334	3.567	3.796	4.016	4.224	4.410	4.565	4.682	4.760	4.782	4.733
4612	1.875	2.105	2.336	2.568	2.800	3.032	3.264	3.496	3.726	3.951	4.168	4.373	4.557	4.709	4.823	4.899	4.918	4.867
4996	2.090	2.317	2.545	2.773	3.002	3.231	3.460	3.688	3.914	4.137	4.350	4.552	4.731	4.880	4.991	5.063	5.079	5.025
5450	2.314	2.539	2.765	2.990	3.217	3.443	3.669	3.895	4.118	4.337	4.548	4.746	4.923	5.068	5.176	5.245	5.257	5.201
5995	2.540	2.763	2.987	3.210	3.435	3.660	3.884	4.107	4.328	4.544	4.753	4.949	5.123	5.266	5.371	5.437	5.447	5.387
6365	2.670	2.893	3.116	3.338	3.562	3.786	4.009	4.231	4.451	4.667	4.874	5.069	5.242	5.383	5.487	5.552	5.561	5.499
6365	2.639	2.863	3.088	3.313	3.539	3.765	3.989	4.213	4.434	4.652	4.860	5.056	5.230	5.373	5.478	5.544	5.553	5.493
6662	2.732	2.956	3.181	3.405	3.631	3.856	4.080	4.303	4.524	4.740	4.948	5.144	5.317	5.459	5.563	5.628	5.637	5.575
7494	2.956	3.179	3.403	3.626	3.851	4.075	4.298	4.520	4.739	4.955	5.161	5.355	5.527	5.668	5.770	5.834	5.841	5.778
8145	3.100	3.323	3.546	3.769	3.993	4.217	4.439	4.661	4.880	5.095	5.301	5.494	5.666	5.806	5.908	5.970	5.977	5.913
8145	2.611	2.848	3.085	3.322	3.561	3.799	4.036	4.273	4.508	4.738	4.959	5.168	5.356	5.511	5.629	5.708	5.729	5.680
8565	2.679	2.916	3.153	3.391	3.629	3.868	4.106	4.342	4.577	4.807	5.029	5.239	5.425	5.581	5.699	5.777	5.799	5.750
9993	2.412	2.673	2.934	3.195	3.456	3.715	3.975	4.232	4.486	4.736	4.975	5.202	5.406	5.578	5.710	5.804	5.839	5.803
11991	2.791	3.051	3.312	3.572	3.833	4.094	4.353	4.611	4.866	5.116	5.357	5.586	5.792	5.966	6.101	6.196	6.235	6.203
14989	2.625	2.898	3.172	3.445	3.719	3.991	4.263	4.534	4.802	5.064	5.318	5.559	5.777	5.963	6.110	6.217	6.267	6.247
19986	2.682	2.965	3.249	3.532	3.815	4.098	4.379	4.659	4.936	5.208	5.470	5.720	5.946	6.140	6.296	6.411	6.469	6.455
29979	2.854	3.147	3.439	3.731	4.024	4.315	4.605	4.894	5.179	5.459	5.730	5.987	6.221	6.423	6.586	6.709	6.774	6.768
59958	3.290	3.591	3.892	4.192	4.492	4.791	5.089	5.385	5.678	5.966	6.244	6.508	6.750	6.959	7.129	7.258	7.330	7.331

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TABLE 2—*Continued*

LOG ATOMIC ABSORPTION COEFFICIENT IN UNITS OF BARNS *** MAGNESIUM

λ \ θ	1.38	1.32	1.26	1.20	1.14	1.08	1.02	0.96	0.90	0.84	0.78	0.72	0.66	0.60	0.54	0.48	0.42	0.36
1033	5.280	5.282	5.285	5.289	5.295	5.304	5.317	5.334	5.357	5.389	5.426	5.477	5.532	5.585	5.620	5.615	5.544	5.401
1110	4.885	4.892	4.902	4.916	4.936	4.963	5.000	5.048	5.108	5.181	5.263	5.358	5.455	5.545	5.612	5.629	5.576	5.443
1153	4.532	4.550	4.575	4.610	4.655	4.713	4.786	4.872	4.972	5.083	5.199	5.324	5.444	5.553	5.634	5.662	5.617	5.491
1199	3.914	3.995	4.091	4.200	4.322	4.454	4.593	4.738	4.885	5.035	5.181	5.327	5.464	5.585	5.675	5.710	5.670	5.548
1249	3.854	3.957	4.073	4.200	4.336	4.479	4.627	4.778	4.930	5.083	5.231	5.379	5.517	5.639	5.729	5.764	5.725	5.603
1303	4.617	4.639	4.669	4.710	4.762	4.828	4.909	5.003	5.111	5.228	5.350	5.479	5.603	5.714	5.796	5.825	5.780	5.654
1362	5.098	5.106	5.117	5.134	5.157	5.188	5.229	5.282	5.348	5.427	5.516	5.616	5.718	5.811	5.880	5.899	5.847	5.715
1427	5.443	5.447	5.453	5.462	5.474	5.491	5.514	5.545	5.587	5.639	5.700	5.776	5.855	5.929	5.984	5.992	5.931	5.793
1498	5.719	5.721	5.725	5.730	5.737	5.748	5.762	5.782	5.809	5.844	5.887	5.942	6.002	6.060	6.099	6.096	6.027	5.883
1577	5.954	5.955	5.957	5.961	5.965	5.972	5.982	5.995	6.013	6.037	6.067	6.107	6.152	6.194	6.219	6.204	6.125	5.974
1621	6.063	6.064	6.066	6.068	6.072	6.078	6.086	6.096	6.111	6.132	6.156	6.190	6.228	6.263	6.281	6.259	6.174	6.018
1621	3.967	4.130	4.292	4.455	4.617	4.779	4.940	5.100	5.259	5.416	5.567	5.717	5.857	5.978	6.069	6.104	6.063	5.940
1665	4.001	4.164	4.327	4.489	4.651	4.813	4.974	5.134	5.293	5.450	5.601	5.751	5.890	6.011	6.101	6.135	6.094	5.970
1763	4.074	4.237	4.399	4.562	4.724	4.885	5.047	5.206	5.365	5.521	5.672	5.821	5.960	6.080	6.169	6.203	6.160	6.034
1873	4.150	4.313	4.476	4.638	4.800	4.962	5.123	5.283	5.441	5.598	5.748	5.898	6.036	6.157	6.245	6.279	6.236	6.110
1998	4.231	4.393	4.556	4.719	4.880	5.042	5.204	5.363	5.522	5.679	5.830	5.980	6.118	6.240	6.329	6.363	6.322	6.198
2141	4.315	4.478	4.640	4.803	4.965	5.127	5.288	5.448	5.607	5.764	5.915	6.065	6.204	6.326	6.416	6.451	6.410	6.286
2306	4.403	4.566	4.729	4.891	5.053	5.215	5.376	5.536	5.695	5.852	6.003	6.152	6.291	6.413	6.502	6.536	6.495	6.371
2515	4.504	4.667	4.829	4.992	5.153	5.315	5.477	5.636	5.795	5.951	6.102	6.251	6.389	6.510	6.599	6.632	6.590	6.464
2515	0.596	0.867	1.140	1.416	1.694	1.974	2.258	2.544	2.834	3.126	3.417	3.713	4.003	4.281	4.533	4.734	4.863	4.914
2725	0.369	0.653	0.940	1.231	1.525	1.824	2.128	2.435	2.745	3.059	3.372	3.689	3.998	4.295	4.563	4.779	4.922	4.984
2997	1.250	1.515	1.780	2.046	2.313	2.582	2.851	3.122	3.394	3.667	3.937	4.211	4.478	4.733	4.961	5.139	5.247	5.277
3331	1.592	1.855	2.118	2.382	2.646	2.911	3.177	3.442	3.708	3.975	4.238	4.502	4.759	5.003	5.219	5.385	5.480	5.497
3756	1.582	1.846	2.110	2.376	2.641	2.908	3.177	3.445	3.714	3.985	4.252	4.523	4.786	5.037	5.260	5.434	5.538	5.563
3756	0.157	0.500	0.844	1.189	1.534	1.881	2.229	2.576	2.923	3.269	3.610	3.952	4.283	4.598	4.881	5.111	5.264	5.335
4282	0.309	0.652	0.997	1.343	1.690	2.037	2.385	2.733	3.080	3.427	3.769	4.111	4.442	4.758	5.041	5.271	5.425	5.496
4884	0.468	0.813	1.159	1.505	1.853	2.201	2.550	2.898	3.246	3.593	3.936	4.278	4.610	4.926	5.210	5.440	5.594	5.665
4884	0.360	0.715	1.070	1.425	1.781	2.136	2.492	2.846	3.200	3.552	3.899	4.246	4.581	4.900	5.188	5.420	5.577	5.650
5504	0.505	0.860	1.215	1.571	1.926	2.282	2.638	2.992	3.346	3.699	4.046	4.393	4.729	5.048	5.335	5.568	5.725	5.798
5504	0.503	0.858	1.213	1.569	1.925	2.281	2.637	2.991	3.345	3.698	4.045	4.392	4.728	5.047	5.335	5.567	5.724	5.798
5995	0.599	0.955	1.310	1.666	2.022	2.378	2.734	3.089	3.443	3.796	4.143	4.490	4.826	5.145	5.433	5.666	5.823	5.896
6550	0.694	1.050	1.405	1.762	2.117	2.473	2.829	3.184	3.539	3.891	4.239	4.586	4.922	5.242	5.530	5.763	5.920	5.994
6550	0.562	0.921	1.280	1.640	2.000	2.359	2.719	3.078	3.436	3.792	4.144	4.494	4.834	5.158	5.449	5.686	5.847	5.925
7237	0.670	1.029	1.388	1.748	2.107	2.467	2.827	3.185	3.543	3.900	4.251	4.602	4.942	5.265	5.557	5.794	5.955	6.032
7237	0.490	0.851	1.213	1.575	1.936	2.298	2.661	3.022	3.383	3.743	4.097	4.452	4.795	5.123	5.419	5.660	5.826	5.909
7292	0.499	0.860	1.221	1.583	1.944	2.306	2.669	3.030	3.391	3.751	4.105	4.460	4.804	5.131	5.427	5.668	5.834	5.917
7292	-0.383	0.008	0.399	0.791	1.183	1.575	1.968	2.360	2.752	3.143	3.528	3.912	4.286	4.644	4.969	5.239	5.432	5.542
8115	-0.341	0.054	0.450	0.846	1.242	1.638	2.035	2.431	2.827	3.220	3.609	3.997	4.374	4.734	5.061	5.334	5.530	5.642
8115	-0.464	-0.061	0.343	0.747	1.151	1.554	1.958	2.359	2.761	3.160	3.553	3.945	4.327	4.690	5.022	5.298	5.497	5.612
9993	-0.238	0.167	0.571	0.976	1.380	1.784	2.188	2.591	2.992	3.392	3.786	4.178	4.560	4.925	5.257	5.533	5.734	5.849
11991	-0.116	0.290	0.698	1.105	1.512	1.918	2.325	2.730	3.134	3.535	3.932	4.328	4.712	5.078	5.413	5.692	5.894	6.012
14989	-0.231	0.192	0.617	1.042	1.466	1.890	2.315	2.738	3.161	3.581	3.997	4.411	4.815	5.202	5.559	5.862	6.093	6.251
19986	-0.175	0.260	0.694	1.129	1.562	1.997	2.431	2.863	3.295	3.725	4.149	4.572	4.984	5.380	5.745	6.056	6.295	6.460
29979	-0.002	0.441	0.884	1.328	1.771	2.214	2.657	3.098	3.538	3.976	4.408	4.839	5.259	5.663	6.035	6.354	6.600	6.773
59958	0.434	0.885	1.337	1.789	2.239	2.690	3.141	3.589	4.037	4.483	4.922	5.361	5.788	6.199	6.578	6.903	7.156	7.336

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TABLE 2—*Continued*

LOG ATOMIC ABSORPTION COEFFICIENT IN UNITS OF BARNS *** ALUMINUM

λ \ θ	1.38	1.32	1.26	1.20	1.14	1.08	1.02	0.96	0.90	0.84	0.78	0.72	0.66	0.60	0.54	0.48	0.42	0.36
1033	6.314	6.313	6.312	6.312	6.311	6.311	6.310	6.309	6.308	6.306	6.303	6.298	6.288	6.269	6.234	6.171	6.073	5.948
1153	6.344	6.344	6.343	6.343	6.342	6.341	6.341	6.339	6.338	6.337	6.334	6.328	6.318	6.300	6.264	6.200	6.102	5.975
1199	6.735	6.734	6.734	6.733	6.733	6.732	6.731	6.730	6.729	6.727	6.724	6.719	6.709	6.690	6.655	6.590	6.491	6.364
1249	6.929	6.928	6.928	6.927	6.927	6.926	6.925	6.924	6.923	6.921	6.919	6.913	6.903	6.884	6.849	6.784	6.685	6.558
1303	6.983	6.983	6.982	6.982	6.981	6.980	6.980	6.978	6.977	6.976	6.973	6.967	6.957	6.938	6.903	6.839	6.740	6.613
1362	6.900	6.899	6.898	6.898	6.897	6.897	6.896	6.895	6.894	6.892	6.889	6.884	6.874	6.855	6.819	6.756	6.657	6.530
1427	6.628	6.628	6.627	6.626	6.626	6.625	6.624	6.623	6.622	6.620	6.618	6.612	6.602	6.584	6.549	6.485	6.387	6.262
1498	6.002	6.002	6.001	6.001	6.000	5.999	5.999	5.998	5.997	5.995	5.992	5.987	5.978	5.960	5.926	5.866	5.773	5.657
1577	6.050	6.050	6.049	6.049	6.048	6.047	6.047	6.046	6.045	6.043	6.040	6.035	6.026	6.008	5.974	5.912	5.819	5.701
1665	6.788	6.788	6.787	6.787	6.786	6.785	6.785	6.783	6.782	6.781	6.778	6.772	6.762	6.744	6.708	6.645	6.546	6.420
1763	7.168	7.167	7.167	7.166	7.166	7.165	7.164	7.163	7.162	7.160	7.157	7.152	7.142	7.123	7.088	7.024	6.925	6.798
1873	7.354	7.353	7.353	7.352	7.352	7.351	7.350	7.349	7.348	7.346	7.343	7.338	7.328	7.309	7.274	7.210	7.111	6.983
1998	7.391	7.391	7.390	7.390	7.389	7.388	7.388	7.387	7.385	7.384	7.381	7.375	7.365	7.347	7.311	7.247	7.148	7.022
2074	7.346	7.345	7.344	7.344	7.343	7.343	7.342	7.341	7.340	7.338	7.335	7.330	7.320	7.301	7.266	7.202	7.103	6.977
2074	1.130	1.362	1.595	1.829	2.066	2.303	2.543	2.783	3.025	3.267	3.510	3.752	3.991	4.222	4.438	4.627	4.782	4.911
2141	1.190	1.422	1.656	1.891	2.128	2.366	2.606	2.847	3.089	3.331	3.574	3.816	4.055	4.286	4.502	4.690	4.845	4.973
2306	1.292	1.525	1.759	1.995	2.232	2.470	2.710	2.951	3.193	3.436	3.679	3.921	4.160	4.391	4.607	4.796	4.951	5.079
2498	1.360	1.592	1.825	2.060	2.297	2.535	2.774	3.015	3.257	3.499	3.743	3.985	4.224	4.456	4.672	4.862	5.018	5.147
2725	1.420	1.650	1.881	2.115	2.350	2.586	2.825	3.064	3.305	3.548	3.791	4.032	4.271	4.503	4.720	4.910	5.067	5.197
2997	1.510	1.739	1.968	2.200	2.434	2.669	2.906	3.144	3.384	3.625	3.867	4.107	4.345	4.576	4.792	4.982	5.138	5.267
3331	1.658	1.886	2.116	2.347	2.580	2.814	3.050	3.287	3.526	3.765	4.006	4.245	4.481	4.710	4.924	5.111	5.265	5.392
3747	1.849	2.078	2.308	2.539	2.772	3.006	3.242	3.479	3.717	3.956	4.195	4.433	4.667	4.895	5.107	5.291	5.443	5.567
3997	1.950	2.179	2.409	2.640	2.873	3.108	3.343	3.580	3.818	4.056	4.295	4.532	4.767	4.993	5.204	5.388	5.539	5.662
4282	2.050	2.278	2.508	2.739	2.972	3.206	3.442	3.678	3.916	4.154	4.393	4.630	4.864	5.090	5.300	5.484	5.634	5.756
4360	2.074	2.302	2.532	2.764	2.996	3.231	3.466	3.702	3.940	4.178	4.417	4.653	4.887	5.113	5.324	5.507	5.657	5.779
4360	1.932	2.175	2.419	2.662	2.906	3.151	3.395	3.640	3.885	4.129	4.374	4.616	4.854	5.085	5.299	5.486	5.638	5.763
4612	2.000	2.243	2.487	2.730	2.974	3.218	3.463	3.707	3.952	4.197	4.441	4.683	4.922	5.152	5.366	5.552	5.705	5.829
4996	2.082	2.326	2.569	2.813	3.057	3.301	3.545	3.790	4.034	4.279	4.524	4.766	5.004	5.234	5.448	5.635	5.787	5.912
5450	2.155	2.398	2.642	2.885	3.129	3.373	3.618	3.862	4.107	4.352	4.597	4.839	5.077	5.308	5.522	5.709	5.862	5.987
5995	2.219	2.462	2.705	2.949	3.193	3.437	3.681	3.926	4.171	4.416	4.661	4.903	5.142	5.373	5.588	5.776	5.929	6.055
6311	2.247	2.490	2.734	2.977	3.221	3.466	3.710	3.955	4.200	4.445	4.690	4.933	5.172	5.403	5.619	5.806	5.960	6.087
6312	1.683	1.934	2.185	2.438	2.691	2.945	3.200	3.456	3.713	3.971	4.229	4.486	4.740	4.986	5.218	5.422	5.594	5.738
6527	1.673	1.924	2.177	2.430	2.684	2.939	3.195	3.452	3.710	3.969	4.228	4.486	4.742	4.990	5.223	5.429	5.602	5.748
6527	0.827	1.121	1.415	1.710	2.004	2.298	2.593	2.888	3.183	3.478	3.771	4.063	4.350	4.629	4.891	5.125	5.324	5.495
6662	0.843	1.137	1.431	1.725	2.020	2.315	2.610	2.904	3.200	3.494	3.788	4.080	4.367	4.646	4.909	5.143	5.343	5.513
7494	0.925	1.220	1.515	1.810	2.106	2.402	2.698	2.994	3.290	3.585	3.881	4.173	4.462	4.742	5.005	5.241	5.442	5.614
8565	1.008	1.304	1.600	1.897	2.194	2.490	2.788	3.085	3.382	3.679	3.976	4.270	4.560	4.841	5.106	5.343	5.545	5.719
9442	1.064	1.360	1.657	1.955	2.252	2.550	2.848	3.147	3.445	3.743	4.041	4.336	4.627	4.910	5.176	5.415	5.618	5.793
9443	1.048	1.345	1.643	1.941	2.239	2.537	2.836	3.135	3.434	3.733	4.031	4.326	4.618	4.901	5.168	5.407	5.611	5.786
9993	1.077	1.375	1.673	1.972	2.271	2.570	2.869	3.169	3.468	3.768	4.067	4.363	4.656	4.940	5.207	5.447	5.652	5.828
11991	1.116	1.426	1.737	2.048	2.359	2.671	2.984	3.297	3.610	3.924	4.237	4.548	4.856	5.156	5.440	5.705	5.943	6.169
14989	1.007	1.330	1.654	1.978	2.303	2.629	2.955	3.280	3.607	3.933	4.259	4.583	4.903	5.215	5.510	5.788	6.039	6.279
19986	1.064	1.397	1.731	2.065	2.400	2.735	3.071	3.406	3.741	4.077	4.411	4.744	5.072	5.393	5.696	5.981	6.240	6.488
29979	1.236	1.579	1.922	2.265	2.608	2.952	3.296	3.640	3.984	4.328	4.670	5.011	5.347	5.676	5.986	6.279	6.545	6.800
59958	1.672	2.023	2.374	2.726	3.077	3.428	3.780	4.132	4.483	4.834	5.184	5.532	5.876	6.211	6.529	6.829	7.102	7.363

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TABLE 2—*Continued*

LOG ATOMIC ABSORPTION COEFFICIENT IN UNITS OF BARNS *** SILICON

λ \ θ	1.38	1.32	1.26	1.20	1.14	1.08	1.02	0.96	0.90	0.84	0.78	0.72	0.66	0.60	0.54	0.48	0.42	0.36
1033	7.061	7.059	7.057	7.056	7.054	7.053	7.051	7.049	7.047	7.045	7.043	7.040	7.036	7.029	7.013	6.978	6.894	6.718
1070	7.169	7.167	7.164	7.162	7.160	7.158	7.155	7.153	7.150	7.147	7.143	7.139	7.134	7.125	7.108	7.071	6.985	6.807
1110	7.264	7.261	7.258	7.256	7.253	7.250	7.246	7.243	7.239	7.235	7.231	7.225	7.219	7.209	7.190	7.151	7.064	6.883
1131	7.306	7.303	7.300	7.298	7.294	7.291	7.287	7.284	7.280	7.275	7.270	7.264	7.257	7.246	7.227	7.187	7.099	6.917
1153	7.346	7.343	7.340	7.337	7.333	7.330	7.326	7.322	7.317	7.312	7.307	7.300	7.292	7.281	7.261	7.220	7.131	6.949
1175	7.383	7.380	7.376	7.373	7.370	7.366	7.361	7.357	7.352	7.347	7.341	7.334	7.325	7.313	7.293	7.252	7.162	6.978
1199	7.417	7.414	7.410	7.407	7.403	7.399	7.395	7.390	7.385	7.379	7.373	7.365	7.356	7.344	7.323	7.281	7.190	7.006
1223	7.449	7.446	7.442	7.438	7.434	7.430	7.425	7.420	7.415	7.409	7.403	7.395	7.386	7.373	7.351	7.309	7.218	7.033
1249	7.478	7.475	7.471	7.467	7.463	7.459	7.454	7.449	7.443	7.437	7.430	7.423	7.413	7.400	7.378	7.336	7.244	7.059
1275	7.505	7.501	7.497	7.494	7.490	7.485	7.480	7.475	7.469	7.463	7.456	7.449	7.439	7.426	7.404	7.361	7.269	7.084
1303	7.529	7.525	7.521	7.518	7.513	7.509	7.504	7.499	7.494	7.487	7.481	7.473	7.463	7.450	7.428	7.385	7.294	7.109
1332	7.550	7.546	7.543	7.539	7.535	7.531	7.526	7.521	7.515	7.509	7.503	7.495	7.486	7.473	7.451	7.409	7.317	7.133
1362	7.568	7.565	7.561	7.558	7.554	7.549	7.545	7.540	7.535	7.529	7.523	7.515	7.506	7.494	7.472	7.430	7.339	7.155
1394	7.583	7.580	7.577	7.573	7.570	7.566	7.561	7.557	7.552	7.546	7.540	7.533	7.525	7.512	7.492	7.450	7.360	7.177
1427	7.595	7.592	7.589	7.586	7.582	7.579	7.575	7.570	7.566	7.561	7.555	7.549	7.541	7.529	7.509	7.468	7.379	7.196
1462	7.604	7.601	7.598	7.595	7.592	7.588	7.585	7.581	7.576	7.572	7.567	7.561	7.553	7.543	7.523	7.483	7.395	7.213
1498	7.608	7.605	7.602	7.600	7.597	7.594	7.591	7.587	7.584	7.579	7.575	7.570	7.563	7.553	7.534	7.495	7.408	7.227
1518	7.608	7.606	7.603	7.601	7.598	7.595	7.592	7.589	7.586	7.582	7.578	7.573	7.566	7.557	7.539	7.500	7.413	7.233
1518	5.989	6.031	6.073	6.115	6.157	6.198	6.239	6.279	6.319	6.359	6.398	6.436	6.473	6.506	6.530	6.534	6.489	6.352
1537	6.036	6.078	6.119	6.161	6.203	6.244	6.285	6.325	6.365	6.405	6.444	6.482	6.519	6.551	6.576	6.579	6.535	6.397
1577	6.119	6.161	6.202	6.244	6.286	6.327	6.367	6.408	6.448	6.488	6.526	6.564	6.601	6.633	6.658	6.661	6.616	6.478
1620	6.186	6.228	6.270	6.311	6.353	6.394	6.435	6.475	6.515	6.555	6.594	6.631	6.668	6.700	6.724	6.728	6.683	6.544
1665	6.239	6.281	6.323	6.365	6.406	6.447	6.488	6.528	6.568	6.608	6.647	6.685	6.721	6.753	6.777	6.781	6.735	6.597
1674	6.248	6.290	6.331	6.373	6.414	6.456	6.496	6.537	6.577	6.616	6.655	6.693	6.729	6.762	6.786	6.789	6.744	6.606
1674	3.390	3.500	3.609	3.718	3.827	3.936	4.044	4.153	4.260	4.368	4.475	4.582	4.688	4.793	4.893	4.977	5.022	4.988
1713	3.408	3.518	3.627	3.736	3.845	3.954	4.062	4.170	4.278	4.386	4.493	4.600	4.707	4.812	4.912	4.997	5.043	5.011
1763	3.429	3.539	3.648	3.758	3.867	3.975	4.084	4.192	4.300	4.407	4.515	4.622	4.728	4.834	4.935	5.021	5.069	5.040
1816	3.450	3.560	3.669	3.778	3.887	3.996	4.104	4.213	4.320	4.428	4.535	4.643	4.750	4.855	4.957	5.044	5.093	5.067
1873	3.470	3.580	3.689	3.799	3.908	4.016	4.125	4.233	4.341	4.448	4.556	4.663	4.770	4.876	4.978	5.066	5.116	5.092
1934	3.490	3.599	3.709	3.818	3.927	4.036	4.144	4.252	4.360	4.468	4.575	4.682	4.790	4.896	4.997	5.086	5.137	5.113
1974	3.502	3.611	3.721	3.830	3.939	4.048	4.156	4.264	4.372	4.480	4.587	4.694	4.801	4.907	5.009	5.097	5.149	5.125
1974	-0.666	-0.360	-0.052	0.258	0.570	0.883	1.199	1.516	1.836	2.158	2.483	2.810	3.138	3.466	3.789	4.094	4.353	4.523
1998	-0.666	-0.359	-0.051	0.259	0.571	0.884	1.200	1.518	1.838	2.160	2.485	2.812	3.141	3.469	3.792	4.098	4.358	4.528
2067	-0.666	-0.359	-0.051	0.259	0.571	0.884	1.200	1.518	1.839	2.162	2.488	2.815	3.145	3.474	3.799	4.106	4.368	4.540
2141	-0.666	-0.360	-0.052	0.258	0.570	0.884	1.200	1.519	1.840	2.164	2.490	2.819	3.149	3.480	3.806	4.114	4.378	4.552
2220	-0.664	-0.357	-0.049	0.262	0.574	0.889	1.205	1.525	1.847	2.171	2.499	2.829	3.160	3.492	3.820	4.130	4.395	4.571
2306	-0.657	-0.349	-0.039	0.272	0.586	0.902	1.220	1.541	1.864	2.191	2.520	2.851	3.185	3.518	3.847	4.159	4.425	4.602
2398	-0.642	-0.332	-0.021	0.293	0.608	0.926	1.246	1.570	1.895	2.224	2.555	2.888	3.224	3.559	3.889	4.202	4.470	4.648
2498	-0.620	-0.308	0.005	0.321	0.640	0.960	1.283	1.609	1.937	2.268	2.602	2.938	3.275	3.612	3.944	4.258	4.526	4.705
2606	-0.593	-0.278	0.038	0.356	0.677	1.001	1.327	1.655	1.986	2.320	2.655	2.993	3.333	3.671	4.004	4.319	4.588	4.767
2725	-0.563	-0.246	0.072	0.393	0.717	1.043	1.371	1.702	2.035	2.371	2.709	3.049	3.390	3.730	4.064	4.380	4.649	4.828
2855	-0.533	-0.214	0.106	0.429	0.755	1.083	1.413	1.746	2.081	2.419	2.758	3.099	3.442	3.783	4.118	4.435	4.705	4.885
2997	-0.504	-0.184	0.138	0.462	0.789	1.118	1.450	1.784	2.121	2.460	2.801	3.143	3.487	3.829	4.165	4.483	4.754	4.935
3155	-0.476	-0.156	0.167	0.492	0.820	1.150	1.482	1.817	2.155	2.495	2.836	3.180	3.525	3.868	4.206	4.525	4.797	4.979
3331	-0.446	-0.126	0.196	0.522	0.849	1.180	1.513	1.848	2.186	2.526	2.869	3.213	3.559	3.904	4.242	4.563	4.837	5.020

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TABLE 2—*Continued*

LOG ATOMIC ABSORPTION COEFFICIENT IN UNITS OF BARNS *** SILICON (CONTINUED)

λ \ θ	1.38	1.32	1.26	1.20	1.14	1.08	1.02	0.96	0.90	0.84	0.78	0.72	0.66	0.60	0.54	0.48	0.42	0.36
3526	-0.410	-0.091	0.231	0.556	0.883	1.213	1.546	1.882	2.220	2.560	2.903	3.249	3.595	3.940	4.280	4.602	4.877	5.062
3747	-0.363	-0.045	0.277	0.601	0.928	1.257	1.590	1.925	2.263	2.604	2.947	3.292	3.639	3.986	4.326	4.649	4.926	5.112
3839	-0.341	-0.023	0.298	0.622	0.949	1.278	1.610	1.945	2.283	2.624	2.967	3.313	3.660	4.006	4.347	4.670	4.947	5.134
3839	-0.715	-0.364	-0.011	0.344	0.699	1.056	1.414	1.772	2.132	2.492	2.853	3.215	3.576	3.935	4.287	4.619	4.905	5.098
3993	-0.681	-0.329	0.024	0.378	0.734	1.091	1.448	1.807	2.167	2.528	2.889	3.251	3.612	3.972	4.324	4.657	4.943	5.137
3993	-0.771	-0.408	-0.046	0.318	0.681	1.045	1.409	1.773	2.137	2.502	2.867	3.232	3.596	3.958	4.312	4.647	4.935	5.130
3997	-0.770	-0.407	-0.045	0.319	0.682	1.046	1.410	1.774	2.138	2.503	2.868	3.233	3.597	3.959	4.313	4.648	4.936	5.131
4282	-0.695	-0.333	0.030	0.394	0.757	1.121	1.485	1.849	2.214	2.579	2.944	3.309	3.673	4.035	4.390	4.725	5.012	5.208
4612	-0.595	-0.233	0.129	0.492	0.855	1.219	1.582	1.946	2.310	2.675	3.040	3.404	3.768	4.129	4.483	4.818	5.105	5.300
4996	-0.479	-0.117	0.245	0.607	0.970	1.333	1.696	2.059	2.423	2.786	3.150	3.514	3.877	4.237	4.590	4.924	5.210	5.404
5416	-0.362	-0.001	0.360	0.722	1.084	1.447	1.809	2.172	2.534	2.898	3.261	3.624	3.986	4.346	4.698	5.031	5.316	5.509
5416	-0.404	-0.041	0.322	0.685	1.048	1.411	1.775	2.139	2.503	2.867	3.232	3.596	3.960	4.321	4.674	5.008	5.294	5.489
5435	-0.398	-0.036	0.327	0.690	1.053	1.416	1.780	2.144	2.508	2.872	3.237	3.601	3.964	4.325	4.679	5.013	5.299	5.494
5436	-0.478	-0.113	0.252	0.618	0.983	1.349	1.715	2.082	2.448	2.815	3.182	3.549	3.915	4.279	4.635	4.971	5.260	5.457
5450	-0.474	-0.109	0.256	0.621	0.987	1.353	1.719	2.086	2.452	2.819	3.186	3.553	3.919	4.282	4.638	4.975	5.263	5.460
5643	-0.425	-0.061	0.304	0.670	1.035	1.401	1.767	2.133	2.499	2.866	3.232	3.599	3.964	4.328	4.683	5.019	5.308	5.504
5643	-0.594	-0.224	0.146	0.516	0.886	1.257	1.627	1.999	2.370	2.741	3.113	3.485	3.856	4.224	4.585	4.926	5.220	5.422
5925	-0.546	-0.176	0.194	0.564	0.935	1.306	1.677	2.048	2.420	2.791	3.163	3.535	3.906	4.275	4.636	4.978	5.272	5.474
5926	-0.650	-0.277	0.095	0.468	0.841	1.215	1.588	1.962	2.337	2.711	3.086	3.461	3.835	4.207	4.571	4.916	5.213	5.419
5995	-0.636	-0.263	0.109	0.482	0.855	1.228	1.602	1.976	2.350	2.725	3.100	3.475	3.849	4.221	4.585	4.930	5.227	5.433
6011	-0.633	-0.260	0.112	0.485	0.858	1.232	1.605	1.979	2.353	2.728	3.103	3.478	3.852	4.224	4.588	4.933	5.230	5.436
6011	-0.685	-0.312	0.062	0.436	0.811	1.185	1.560	1.936	2.311	2.688	3.064	3.440	3.816	4.189	4.555	4.902	5.201	5.408
6287	-0.629	-0.256	0.118	0.492	0.866	1.241	1.616	1.991	2.367	2.743	3.119	3.496	3.871	4.244	4.610	4.957	5.256	5.463
6287	-0.949	-0.569	-0.189	0.192	0.573	0.955	1.338	1.721	2.105	2.490	2.875	3.261	3.646	4.030	4.406	4.763	5.072	5.290
6310	-0.944	-0.565	-0.185	0.196	0.577	0.959	1.342	1.725	2.109	2.494	2.879	3.265	3.651	4.034	4.410	4.767	5.077	5.295
6311	-1.125	-0.740	-0.355	0.032	0.420	0.808	1.197	1.587	1.977	2.369	2.761	3.153	3.545	3.935	4.318	4.681	4.997	5.221
6450	-1.098	-0.713	-0.327	0.059	0.447	0.835	1.224	1.614	2.004	2.395	2.787	3.180	3.572	3.962	4.344	4.708	5.024	5.248
6451	-1.469	-1.066	-0.662	-0.257	0.148	0.553	0.959	1.365	1.772	2.179	2.586	2.993	3.399	3.802	4.198	4.574	4.901	5.136
6662	-1.431	-1.027	-0.624	-0.219	0.186	0.591	0.997	1.404	1.810	2.217	2.624	3.031	3.437	3.841	4.236	4.612	4.939	5.174
6933	-1.383	-0.979	-0.576	-0.171	0.234	0.639	1.045	1.452	1.858	2.265	2.672	3.079	3.486	3.889	4.284	4.660	4.988	5.223
6933	-1.420	-1.014	-0.608	-0.202	0.205	0.612	1.020	1.428	1.836	2.245	2.653	3.062	3.469	3.874	4.271	4.647	4.976	5.212
7494	-1.322	-0.916	-0.511	-0.104	0.303	0.710	1.117	1.525	1.933	2.342	2.750	3.159	3.566	3.971	4.368	4.744	5.073	5.309
7890	-1.257	-0.851	-0.445	-0.039	0.368	0.775	1.182	1.590	1.998	2.407	2.815	3.224	3.631	4.036	4.432	4.809	5.137	5.374
7891	-1.386	-0.976	-0.566	-0.155	0.256	0.668	1.080	1.493	1.905	2.318	2.731	3.144	3.555	3.964	4.365	4.745	5.078	5.318
8090	-1.355	-0.945	-0.534	-0.123	0.288	0.700	1.112	1.524	1.937	2.350	2.762	3.175	3.587	3.996	4.396	4.777	5.109	5.349
8090	-1.413	-1.001	-0.588	-0.175	0.238	0.652	1.066	1.481	1.896	2.311	2.725	3.140	3.554	3.964	4.367	4.749	5.084	5.325
8467	-1.355	-0.943	-0.531	-0.118	0.296	0.710	1.124	1.539	1.953	2.368	2.783	3.198	3.611	4.022	4.424	4.807	5.141	5.382
8468	-1.684	-1.257	-0.830	-0.402	0.025	0.453	0.880	1.308	1.735	2.162	2.588	3.015	3.439	3.860	4.273	4.664	5.008	5.258
8565	-1.670	-1.243	-0.816	-0.388	0.039	0.467	0.894	1.322	1.749	2.176	2.603	3.029	3.453	3.874	4.287	4.679	5.022	5.272
9993	-1.512	-1.083	-0.653	-0.224	0.205	0.635	1.064	1.493	1.922	2.350	2.778	3.205	3.631	4.053	4.467	4.860	5.204	5.455
11991	-1.576	-1.139	-0.703	-0.265	0.171	0.608	1.044	1.480	1.916	2.351	2.786	3.220	3.652	4.080	4.501	4.901	5.250	5.508
14989	-1.450	-0.997	-0.544	-0.091	0.362	0.815	1.269	1.722	2.176	2.629	3.083	3.536	3.988	4.437	4.877	5.298	5.672	5.957
19986	-1.393	-0.930	-0.467	-0.004	0.459	0.922	1.384	1.847	2.310	2.773	3.235	3.697	4.158	4.615	5.063	5.492	5.874	6.166
29979	-1.221	-0.748	-0.277	0.195	0.667	1.139	1.610	2.082	2.553	3.024	3.494	3.964	4.433	4.898	5.354	5.790	6.179	6.479
59958	-0.785	-0.304	0.176	0.656	1.136	1.615	2.094	2.573	3.052	3.530	4.008	4.485	4.961	5.433	5.896	6.339	6.735	7.042

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TABLE 2—*Continued*

LOG ATOMIC ABSORPTION COEFFICIENT IN UNITS OF BARNS *** CALCIUM

λ \ θ	1.38	1.32	1.26	1.20	1.14	1.08	1.02	0.96	0.90	0.84	0.78	0.72	0.66	0.60	0.54	0.48	0.42	0.36
1033	6.221	6.219	6.216	6.213	6.208	6.201	6.192	6.169	6.163	6.141	6.110	6.067	6.009	5.927	5.818	5.678	5.511	5.297
1153	6.221	6.218	6.215	6.212	6.207	6.201	6.192	6.169	6.164	6.143	6.113	6.071	6.014	5.935	5.828	5.691	5.527	5.317
1249	4.790	4.804	4.821	4.845	4.873	4.908	4.949	4.985	5.047	5.100	5.150	5.193	5.223	5.230	5.207	5.150	5.060	4.919
1362	6.150	6.147	6.143	6.138	6.132	6.123	6.112	6.087	6.079	6.054	6.020	5.975	5.915	5.834	5.726	5.592	5.434	5.234
1498	6.677	6.675	6.671	6.666	6.660	6.652	6.640	6.615	6.606	6.580	6.544	6.495	6.429	6.340	6.222	6.074	5.897	5.675
1665	6.602	6.600	6.598	6.596	6.593	6.588	6.581	6.562	6.560	6.542	6.518	6.482	6.432	6.360	6.260	6.132	5.975	5.771
1873	5.316	5.353	5.397	5.448	5.506	5.569	5.636	5.695	5.776	5.843	5.902	5.949	5.978	5.981	5.950	5.884	5.782	5.627
1998	5.840	5.845	5.852	5.861	5.872	5.886	5.903	5.912	5.945	5.967	5.988	6.003	6.005	5.989	5.944	5.869	5.763	5.608
2028	6.079	6.080	6.081	6.083	6.085	6.088	6.091	6.085	6.100	6.103	6.104	6.098	6.081	6.047	5.988	5.900	5.785	5.623
2028	4.607	4.729	4.850	4.971	5.091	5.208	5.322	5.422	5.537	5.633	5.718	5.788	5.836	5.857	5.843	5.792	5.705	5.565
2141	4.419	4.551	4.682	4.813	4.942	5.069	5.194	5.304	5.429	5.535	5.630	5.709	5.768	5.798	5.794	5.752	5.675	5.544
2306	4.325	4.468	4.610	4.752	4.891	5.029	5.163	5.282	5.415	5.530	5.633	5.720	5.785	5.822	5.824	5.789	5.717	5.592
2498	4.622	4.753	4.884	5.014	5.143	5.271	5.395	5.504	5.629	5.735	5.830	5.908	5.967	5.996	5.991	5.950	5.872	5.740
2725	4.986	5.108	5.229	5.350	5.469	5.587	5.701	5.800	5.915	6.012	6.096	6.165	6.213	6.234	6.219	6.167	6.080	5.939
2937	5.223	5.342	5.459	5.577	5.692	5.805	5.915	6.010	6.121	6.213	6.293	6.357	6.400	6.415	6.395	6.338	6.245	6.098
2937	4.550	4.700	4.849	4.996	5.141	5.283	5.422	5.545	5.682	5.800	5.906	5.994	6.062	6.100	6.103	6.069	5.997	5.871
2997	4.577	4.726	4.875	5.022	5.167	5.310	5.448	5.571	5.708	5.826	5.931	6.020	6.088	6.126	6.128	6.094	6.022	5.896
3331	4.713	4.862	5.011	5.158	5.303	5.445	5.583	5.706	5.843	5.961	6.066	6.154	6.221	6.258	6.260	6.224	6.151	6.024
3454	4.760	4.909	5.058	5.205	5.350	5.492	5.630	5.753	5.890	6.007	6.112	6.200	6.267	6.304	6.306	6.270	6.196	6.068
3454	3.979	4.140	4.300	4.459	4.616	4.770	4.921	5.056	5.206	5.337	5.456	5.559	5.641	5.696	5.716	5.700	5.649	5.546
3642	4.046	4.207	4.367	4.525	4.682	4.836	4.986	5.121	5.270	5.401	5.519	5.622	5.703	5.757	5.776	5.759	5.707	5.603
3642	3.241	3.416	3.589	3.763	3.934	4.104	4.270	4.422	4.591	4.741	4.882	5.008	5.116	5.198	5.249	5.266	5.252	5.188
3747	3.270	3.444	3.618	3.791	3.962	4.131	4.297	4.449	4.617	4.767	4.907	5.032	5.140	5.222	5.272	5.288	5.273	5.209
3898	3.311	3.485	3.658	3.831	4.001	4.170	4.336	4.487	4.654	4.803	4.942	5.067	5.174	5.255	5.304	5.321	5.305	5.241
3898	1.720	1.971	2.222	2.473	2.722	2.971	3.216	3.448	3.696	3.925	4.144	4.347	4.530	4.686	4.806	4.891	4.938	4.931
4282	1.666	1.924	2.183	2.442	2.699	2.955	3.208	3.448	3.703	3.940	4.166	4.377	4.567	4.729	4.856	4.946	5.000	4.999
4996	1.659	1.933	2.206	2.479	2.750	3.020	3.285	3.537	3.803	4.050	4.286	4.505	4.704	4.874	5.008	5.104	5.164	5.168
5628	1.800	2.076	2.353	2.629	2.903	3.174	3.442	3.695	3.963	4.212	4.449	4.669	4.869	5.039	5.174	5.271	5.330	5.335
5628	1.796	2.073	2.350	2.627	2.901	3.172	3.440	3.694	3.962	4.211	4.448	4.668	4.868	5.039	5.173	5.270	5.330	5.334
5995	1.894	2.171	2.448	2.724	2.997	3.269	3.537	3.790	4.058	4.306	4.543	4.763	4.962	5.132	5.266	5.364	5.423	5.426
6254	1.962	2.239	2.515	2.790	3.064	3.335	3.603	3.855	4.123	4.371	4.607	4.827	5.025	5.195	5.329	5.426	5.485	5.488
6254	1.959	2.237	2.513	2.789	3.062	3.333	3.601	3.853	4.121	4.370	4.606	4.826	5.024	5.194	5.328	5.425	5.484	5.487
7494	2.224	2.500	2.776	3.052	3.324	3.595	3.862	4.114	4.380	4.628	4.864	5.083	5.281	5.450	5.583	5.679	5.737	5.740
7849	2.288	2.564	2.840	3.115	3.388	3.658	3.925	4.177	4.444	4.691	4.927	5.146	5.344	5.513	5.646	5.742	5.800	5.802
7849	2.083	2.365	2.646	2.926	3.204	3.480	3.753	4.010	4.283	4.536	4.777	5.002	5.206	5.381	5.520	5.622	5.686	5.694
8328	2.160	2.442	2.723	3.003	3.281	3.557	3.830	4.087	4.360	4.613	4.854	5.079	5.283	5.458	5.597	5.699	5.763	5.772
8328	2.034	2.318	2.602	2.885	3.167	3.446	3.722	3.982	4.258	4.515	4.760	4.989	5.196	5.375	5.518	5.623	5.690	5.703
8657	2.084	2.368	2.652	2.936	3.217	3.496	3.772	4.033	4.309	4.565	4.810	5.039	5.246	5.425	5.568	5.673	5.741	5.753
8657	1.416	1.729	2.040	2.351	2.659	2.964	3.265	3.551	3.852	4.133	4.401	4.653	4.883	5.083	5.247	5.372	5.459	5.490
9993	1.603	1.916	2.227	2.538	2.846	3.151	3.452	3.738	4.039	4.320	4.588	4.840	5.070	5.270	5.434	5.559	5.646	5.677
1991	1.905	2.225	2.546	2.866	3.184	3.500	3.813	4.112	4.428	4.732	5.027	5.310	5.576	5.819	6.033	6.217	6.376	6.505
4989	1.894	2.226	2.557	2.888	3.216	3.543	3.866	4.175	4.501	4.814	5.119	5.411	5.686	5.938	6.160	6.353	6.520	6.656
9986	1.951	2.293	2.634	2.975	3.313	3.649	3.982	4.300	4.635	4.958	5.271	5.572	5.855	6.116	6.346	6.547	6.721	6.865
9979	2.123	2.474	2.825	3.174	3.521	3.867	4.208	4.534	4.878	5.209	5.530	5.839	6.130	6.398	6.637	6.845	7.027	7.178
9958	2.560	2.919	3.277	3.635	3.990	4.343	4.692	5.026	5.377	5.715	6.044	6.360	6.659	6.934	7.179	7.394	7.583	7.741

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TABLE 2—*Continued*

LOG ATOMIC ABSORPTION COEFFICIENT IN UNITS OF BARNS *** CHROMIUM

λ \ θ	1.38	1.32	1.26	1.20	1.14	1.08	1.02	0.96	0.90	0.84	0.78	0.72	0.66	0.60	0.54	0.48	0.42	0.36
1033	5.787	5.779	5.768	5.757	5.743	5.728	5.711	5.691	5.668	5.640	5.606	5.565	5.515	5.451	5.368	5.271	5.187	5.125
1498	6.271	6.263	6.252	6.241	6.228	6.213	6.195	6.175	6.152	6.124	6.090	6.050	5.999	5.935	5.852	5.755	5.671	5.610
1763	6.483	6.475	6.464	6.452	6.439	6.424	6.407	6.387	6.364	6.336	6.302	6.261	6.211	6.146	6.064	5.966	5.883	5.821
1832	6.533	6.525	6.514	6.503	6.489	6.474	6.457	6.437	6.414	6.386	6.352	6.311	6.261	6.197	6.114	6.017	5.933	5.871
1832	4.965	5.016	5.066	5.117	5.167	5.218	5.269	5.320	5.371	5.421	5.469	5.514	5.552	5.579	5.589	5.582	5.585	5.601
1998	5.078	5.129	5.179	5.230	5.280	5.331	5.382	5.433	5.484	5.534	5.582	5.627	5.665	5.692	5.702	5.695	5.697	5.714
2128	5.160	5.211	5.262	5.312	5.363	5.413	5.464	5.515	5.566	5.616	5.664	5.709	5.747	5.775	5.784	5.777	5.780	5.797
2128	3.792	3.943	4.092	4.241	4.388	4.534	4.677	4.817	4.954	5.086	5.210	5.326	5.428	5.513	5.573	5.609	5.648	5.695
2306	3.896	4.047	4.196	4.345	4.492	4.638	4.781	4.921	5.058	5.190	5.314	5.430	5.532	5.617	5.677	5.713	5.752	5.799
2498	4.000	4.151	4.301	4.449	4.597	4.742	4.885	5.026	5.162	5.294	5.419	5.534	5.637	5.721	5.781	5.817	5.856	5.903
2725	4.114	4.265	4.414	4.563	4.710	4.855	4.999	5.139	5.276	5.407	5.532	5.647	5.750	5.834	5.895	5.931	5.970	6.017
2937	4.211	4.362	4.512	4.660	4.807	4.953	5.096	5.237	5.373	5.505	5.630	5.745	5.848	5.932	5.992	6.028	6.067	6.114
2937	3.756	3.923	4.089	4.253	4.417	4.578	4.738	4.894	5.048	5.196	5.337	5.469	5.588	5.690	5.767	5.820	5.876	5.940
3056	3.808	3.975	4.140	4.305	4.468	4.630	4.789	4.946	5.099	5.247	5.389	5.521	5.640	5.741	5.818	5.871	5.927	5.991
3056	3.629	3.803	3.976	4.148	4.318	4.487	4.654	4.817	4.977	5.132	5.281	5.419	5.546	5.654	5.737	5.797	5.859	5.929
3210	3.693	3.867	4.040	4.212	4.382	4.551	4.718	4.881	5.042	5.197	5.345	5.483	5.610	5.718	5.801	5.861	5.923	5.993
3210	3.506	3.686	3.865	4.042	4.219	4.393	4.566	4.736	4.902	5.063	5.218	5.363	5.496	5.611	5.701	5.768	5.837	5.915
3302	3.543	3.723	3.901	4.079	4.255	4.430	4.603	4.773	4.939	5.100	5.255	5.400	5.533	5.648	5.738	5.805	5.874	5.952
3302	3.300	3.487	3.673	3.858	4.042	4.225	4.405	4.583	4.758	4.928	5.091	5.246	5.388	5.511	5.611	5.687	5.766	5.852
3375	3.329	3.516	3.701	3.886	4.070	4.253	4.434	4.612	4.787	4.956	5.120	5.274	5.416	5.540	5.640	5.716	5.794	5.881
3375	2.932	3.136	3.339	3.541	3.742	3.942	4.139	4.334	4.526	4.712	4.892	5.062	5.219	5.359	5.473	5.564	5.657	5.757
3600	3.016	3.220	3.423	3.625	3.826	4.026	4.224	4.418	4.610	4.796	4.976	5.146	5.304	5.443	5.558	5.648	5.741	5.841
3600	2.828	3.040	3.251	3.462	3.671	3.878	4.083	4.286	4.485	4.679	4.866	5.044	5.208	5.355	5.476	5.573	5.673	5.779
3654	2.847	3.060	3.270	3.481	3.690	3.897	4.103	4.305	4.504	4.698	4.885	5.063	5.228	5.374	5.495	5.593	5.692	5.798
3654	2.711	2.931	3.149	3.366	3.582	3.796	4.008	4.216	4.421	4.621	4.813	4.996	5.166	5.317	5.443	5.545	5.649	5.760
3860	2.783	3.002	3.220	3.438	3.653	3.867	4.079	4.288	4.493	4.692	4.885	5.068	5.237	5.389	5.515	5.617	5.720	5.831
3860	2.622	2.849	3.074	3.299	3.521	3.742	3.960	4.175	4.386	4.592	4.791	4.979	5.155	5.312	5.443	5.550	5.659	5.775
4246	2.746	2.973	3.199	3.423	3.645	3.866	4.084	4.299	4.510	4.716	4.915	5.103	5.279	5.436	5.568	5.675	5.783	5.899
4246	2.678	2.906	3.132	3.358	3.582	3.804	4.023	4.240	4.452	4.660	4.860	5.050	5.228	5.387	5.520	5.630	5.741	5.859
4252	2.680	2.908	3.134	3.360	3.584	3.806	4.025	4.242	4.454	4.662	4.862	5.052	5.230	5.389	5.522	5.631	5.743	5.861
4252	2.430	2.664	2.896	3.128	3.358	3.586	3.813	4.036	4.256	4.470	4.678	4.876	5.061	5.228	5.370	5.488	5.608	5.735
4314	2.449	2.683	2.915	3.146	3.377	3.605	3.831	4.055	4.274	4.489	4.697	4.895	5.080	5.247	5.389	5.507	5.626	5.753
4314	2.058	2.307	2.554	2.801	3.046	3.289	3.531	3.769	4.003	4.232	4.455	4.667	4.867	5.048	5.203	5.335	5.468	5.608
4658	2.158	2.407	2.654	2.901	3.146	3.390	3.631	3.869	4.103	4.333	4.555	4.767	4.967	5.148	5.304	5.435	5.568	5.708
4658	1.949	2.206	2.461	2.715	2.968	3.220	3.468	3.714	3.956	4.193	4.423	4.643	4.850	5.038	5.201	5.339	5.480	5.627
4807	1.989	2.246	2.502	2.756	3.009	3.260	3.509	3.755	3.997	4.234	4.464	4.684	4.891	5.079	5.242	5.380	5.520	5.667
4807	1.848	2.111	2.373	2.633	2.892	3.149	3.403	3.654	3.902	4.144	4.379	4.604	4.815	5.009	5.177	5.320	5.464	5.616
5995	1.083	1.390	1.698	2.007	2.314	2.622	2.929	3.235	3.540	3.841	4.138	4.429	4.710	5.030	5.277	5.561	5.866	6.200
7494	0.801	1.133	1.466	1.798	2.130	2.462	2.792	3.122	3.450	3.775	4.094	4.407	4.710	5.052	5.319	5.624	5.948	6.301
9993	0.599	0.955	1.311	1.667	2.022	2.377	2.730	3.082	3.432	3.779	4.120	4.454	4.777	5.139	5.426	5.749	6.091	6.462
11991	0.543	0.910	1.278	1.645	2.011	2.377	2.741	3.104	3.464	3.821	4.172	4.515	4.849	5.220	5.516	5.848	6.198	6.577
14989	0.533	0.911	1.289	1.666	2.043	2.419	2.794	3.167	3.537	3.903	4.264	4.616	4.959	5.339	5.643	5.983	6.342	6.729
19986	0.590	0.978	1.366	1.753	2.140	2.526	2.910	3.292	3.671	4.046	4.416	4.777	5.128	5.516	5.829	6.177	6.544	6.938
29979	0.762	1.159	1.557	1.953	2.348	2.743	3.136	3.526	3.914	4.297	4.675	5.044	5.403	5.799	6.119	6.475	6.849	7.250
59958	1.198	1.604	2.009	2.413	2.817	3.219	3.619	4.018	4.413	4.804	5.189	5.566	5.932	6.335	6.662	7.025	7.405	7.813

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TABLE 2—*Continued*

LOG ATOMIC ABSORPTION COEFFICIENT IN UNITS OF BARNS *** IRON

λ \ θ	1.38	1.32	1.26	1.20	1.14	1.08	1.02	0.96	0.90	0.84	0.78	0.72	0.66	0.60	0.54	0.48	0.42	0.36
1032	6.135	6.137	6.138	6.139	6.139	6.138	6.136	6.132	6.127	6.119	6.108	6.093	6.072	6.042	5.999	5.933	5.853	5.689
1568	6.680	6.682	6.683	6.684	6.684	6.683	6.681	6.677	6.672	6.664	6.653	6.638	6.617	6.587	6.544	6.478	6.398	6.234
1594	6.248	6.262	6.276	6.290	6.303	6.316	6.327	6.338	6.348	6.355	6.361	6.363	6.361	6.351	6.329	6.287	6.232	6.095
1688	6.323	6.338	6.352	6.366	6.379	6.391	6.403	6.414	6.423	6.431	6.436	6.439	6.436	6.427	6.405	6.363	6.308	6.170
1724	5.227	5.283	5.340	5.397	5.455	5.514	5.574	5.634	5.695	5.756	5.817	5.877	5.933	5.983	6.021	6.039	6.041	5.958
1847	5.316	5.372	5.429	5.486	5.544	5.603	5.662	5.723	5.784	5.845	5.906	5.965	6.022	6.072	6.110	6.127	6.130	6.047
1881	4.425	4.537	4.649	4.763	4.878	4.992	5.107	5.222	5.337	5.450	5.560	5.667	5.767	5.858	5.934	5.985	6.018	5.961
2059	4.542	4.654	4.767	4.881	4.995	5.110	5.225	5.340	5.454	5.567	5.677	5.784	5.885	5.976	6.052	6.103	6.135	6.079
2075	4.235	4.372	4.509	4.645	4.781	4.916	5.050	5.183	5.314	5.443	5.568	5.689	5.802	5.905	5.991	6.052	6.093	6.045
2205	4.315	4.452	4.588	4.725	4.861	4.996	5.130	5.263	5.394	5.523	5.648	5.769	5.882	5.985	6.071	6.132	6.173	6.125
2205	4.299	4.437	4.573	4.710	4.846	4.982	5.117	5.250	5.382	5.511	5.636	5.757	5.871	5.974	6.061	6.123	6.165	6.117
2251	4.326	4.463	4.600	4.737	4.873	5.009	5.143	5.277	5.408	5.538	5.663	5.784	5.898	6.001	6.088	6.149	6.191	6.143
2290	3.925	4.076	4.226	4.377	4.527	4.677	4.826	4.974	5.120	5.264	5.405	5.541	5.670	5.789	5.892	5.969	6.028	5.997
2309	3.936	4.087	4.238	4.388	4.539	4.689	4.838	4.985	5.132	5.276	5.416	5.552	5.682	5.800	5.903	5.981	6.039	6.008
2343	3.786	3.944	4.102	4.259	4.417	4.573	4.729	4.884	5.036	5.187	5.334	5.476	5.612	5.737	5.846	5.930	5.995	5.970
2393	3.813	3.971	4.129	4.287	4.444	4.600	4.756	4.911	5.064	5.214	5.361	5.503	5.639	5.764	5.873	5.957	6.022	5.997
2418	3.705	3.869	4.033	4.196	4.359	4.522	4.683	4.843	5.001	5.156	5.308	5.456	5.596	5.726	5.840	5.928	5.997	5.977
2435	3.715	3.879	4.042	4.206	4.369	4.531	4.692	4.852	5.010	5.166	5.318	5.465	5.605	5.735	5.849	5.937	6.006	5.986
2499	3.613	3.778	3.943	4.107	4.272	4.436	4.599	4.762	4.922	5.081	5.236	5.387	5.532	5.666	5.785	5.879	5.954	5.940
2513	3.337	3.511	3.685	3.860	4.034	4.209	4.382	4.555	4.726	4.896	5.062	5.224	5.380	5.525	5.656	5.761	5.848	5.846
2518	3.339	3.513	3.687	3.862	4.036	4.210	4.384	4.557	4.728	4.898	5.064	5.226	5.382	5.527	5.657	5.763	5.850	5.847
2550	3.007	3.197	3.387	3.577	3.767	3.957	4.146	4.334	4.520	4.704	4.885	5.061	5.231	5.390	5.534	5.653	5.753	5.764
2644	3.014	3.207	3.400	3.592	3.785	3.976	4.168	4.357	4.546	4.732	4.914	5.092	5.264	5.425	5.570	5.690	5.792	5.803
2714	2.692	2.902	3.112	3.321	3.530	3.738	3.944	4.149	4.352	4.553	4.749	4.941	5.126	5.301	5.459	5.593	5.707	5.732
2886	2.648	2.863	3.077	3.291	3.504	3.717	3.928	4.137	4.344	4.549	4.750	4.947	5.136	5.315	5.479	5.617	5.736	5.766
2948	2.529	2.746	2.963	3.179	3.394	3.609	3.822	4.034	4.245	4.453	4.658	4.858	5.052	5.236	5.405	5.549	5.674	5.711
3115	2.412	2.634	2.855	3.076	3.296	3.516	3.734	3.952	4.168	4.382	4.593	4.799	5.000	5.191	5.368	5.520	5.654	5.699
3196	2.098	2.327	2.557	2.786	3.016	3.245	3.474	3.702	3.929	4.155	4.378	4.598	4.813	5.020	5.212	5.380	5.531	5.593
3239	2.115	2.345	2.574	2.804	3.033	3.262	3.491	3.719	3.946	4.172	4.395	4.616	4.831	5.037	5.229	5.397	5.548	5.611
3496	1.217	1.486	1.756	2.028	2.300	2.574	2.849	3.125	3.400	3.675	3.947	4.216	4.479	4.733	4.971	5.183	5.375	5.475
3766	0.977	1.272	1.568	1.864	2.160	2.457	2.753	3.048	3.343	3.635	3.923	4.207	4.484	4.749	4.998	5.219	5.420	5.528
4174	0.950	1.259	1.567	1.876	2.184	2.491	2.797	3.101	3.404	3.704	3.999	4.289	4.572	4.843	5.096	5.322	5.527	5.638
4627	0.923	1.239	1.555	1.871	2.186	2.500	2.813	3.124	3.433	3.738	4.040	4.336	4.624	4.901	5.159	5.390	5.600	5.716
5055	0.872	1.192	1.511	1.831	2.149	2.467	2.784	3.099	3.412	3.722	4.027	4.328	4.620	4.901	5.164	5.400	5.614	5.735
5445	0.565	0.898	1.230	1.563	1.894	2.225	2.555	2.883	3.209	3.531	3.850	4.163	4.468	4.761	5.036	5.284	5.509	5.641
5995	-0.123	0.246	0.616	0.986	1.357	1.728	2.100	2.471	2.842	3.212	3.580	3.946	4.307	4.662	5.008	5.336	5.655	5.897
6662	-0.271	0.110	0.492	0.874	1.257	1.640	2.024	2.407	2.790	3.172	3.551	3.928	4.301	4.667	5.023	5.361	5.690	5.942
7494	-0.404	-0.011	0.383	0.778	1.173	1.568	1.963	2.358	2.752	3.145	3.536	3.924	4.308	4.684	5.051	5.399	5.737	5.998
8565	-0.518	-0.112	0.294	0.700	1.107	1.513	1.920	2.326	2.732	3.136	3.538	3.937	4.331	4.718	5.094	5.452	5.799	6.069
9993	-0.606	-0.189	0.229	0.647	1.065	1.483	1.901	2.318	2.734	3.149	3.562	3.971	4.375	4.771	5.157	5.524	5.880	6.159
11991	-0.662	-0.234	0.195	0.625	1.054	1.483	1.911	2.339	2.766	3.191	3.614	4.033	4.446	4.852	5.247	5.623	5.988	6.275
14989	-0.673	-0.233	0.207	0.646	1.086	1.525	1.964	2.402	2.839	3.274	3.706	4.134	4.556	4.971	5.375	5.759	6.131	6.427
19986	-0.616	-0.166	0.284	0.733	1.183	1.632	2.080	2.527	2.973	3.417	3.858	4.295	4.726	5.148	5.560	5.952	6.333	6.636
29979	-0.444	0.015	0.474	0.933	1.391	1.849	2.306	2.762	3.216	3.668	4.117	4.562	5.001	5.431	5.851	6.250	6.638	6.948
59958	-0.008	0.460	0.927	1.393	1.860	2.325	2.790	3.253	3.715	4.175	4.631	5.083	5.529	5.967	6.393	6.800	7.195	7.511

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TABLE 2—*Continued*

LOG ATOMIC ABSORPTION COEFFICIENT IN UNITS OF BARNS *** NICKEL

λ \ θ	1.38	1.32	1.26	1.20	1.14	1.08	1.02	0.96	0.90	0.84	0.78	0.72	0.66	0.60	0.54	0.48	0.42	0.36
1032	6.137	6.132	6.127	6.123	6.118	6.113	6.107	6.102	6.096	6.090	6.082	6.074	6.064	6.050	6.028	5.991	5.928	5.816
1419	6.550	6.545	6.540	6.536	6.531	6.526	6.520	6.515	6.509	6.503	6.495	6.487	6.477	6.463	6.441	6.404	6.341	6.229
1419	6.094	6.092	6.090	6.088	6.086	6.084	6.083	6.081	6.080	6.078	6.077	6.075	6.073	6.069	6.061	6.042	6.001	5.919
1642	6.285	6.283	6.281	6.279	6.277	6.275	6.273	6.272	6.270	6.269	6.267	6.266	6.264	6.260	6.252	6.233	6.192	6.110
1642	5.279	5.298	5.317	5.337	5.358	5.380	5.403	5.428	5.456	5.487	5.521	5.560	5.603	5.652	5.703	5.749	5.779	5.771
1718	5.338	5.357	5.376	5.396	5.416	5.438	5.462	5.487	5.515	5.545	5.580	5.618	5.662	5.710	5.761	5.808	5.838	5.830
1741	3.508	3.625	3.743	3.863	3.986	4.111	4.239	4.369	4.503	4.641	4.782	4.926	5.072	5.218	5.360	5.490	5.594	5.648
1810	3.558	3.675	3.793	3.914	4.036	4.161	4.289	4.420	4.554	4.691	4.832	4.976	5.122	5.268	5.411	5.541	5.644	5.699
1810	2.659	2.839	3.020	3.203	3.386	3.570	3.756	3.942	4.130	4.318	4.506	4.694	4.880	5.063	5.238	5.397	5.526	5.603
2046	2.820	3.000	3.181	3.363	3.546	3.731	3.916	4.103	4.290	4.478	4.666	4.854	5.041	5.224	5.399	5.558	5.687	5.763
2046	2.573	2.772	2.970	3.169	3.368	3.567	3.766	3.966	4.166	4.365	4.564	4.762	4.958	5.149	5.332	5.499	5.635	5.717
2212	2.674	2.873	3.071	3.270	3.469	3.668	3.868	4.067	4.267	4.467	4.665	4.863	5.059	5.250	5.434	5.600	5.736	5.819
2258	2.584	2.786	2.989	3.192	3.395	3.598	3.802	4.005	4.209	4.412	4.615	4.816	5.016	5.211	5.398	5.568	5.708	5.795
2300	2.607	2.810	3.013	3.216	3.419	3.622	3.825	4.029	4.232	4.436	4.638	4.840	5.040	5.235	5.422	5.592	5.732	5.818
2388	2.241	2.451	2.661	2.871	3.082	3.294	3.505	3.718	3.930	4.144	4.356	4.568	4.779	4.986	5.186	5.369	5.523	5.625
2445	2.273	2.482	2.692	2.903	3.113	3.325	3.537	3.749	3.962	4.175	4.388	4.600	4.810	5.017	5.217	5.400	5.554	5.656
2513	2.167	2.373	2.580	2.787	2.995	3.204	3.413	3.624	3.835	4.047	4.259	4.471	4.683	4.891	5.093	5.281	5.439	5.547
2648	2.234	2.440	2.647	2.854	3.062	3.271	3.481	3.691	3.902	4.114	4.326	4.539	4.750	4.959	5.161	5.348	5.507	5.615
2725	2.216	2.418	2.619	2.821	3.024	3.227	3.430	3.634	3.839	4.044	4.250	4.456	4.661	4.865	5.062	5.246	5.403	5.511
2833	2.266	2.468	2.669	2.871	3.074	3.277	3.480	3.684	3.889	4.094	4.300	4.506	4.711	4.915	5.112	5.296	5.453	5.561
2833	2.098	2.307	2.515	2.724	2.933	3.143	3.353	3.564	3.775	3.987	4.199	4.412	4.624	4.834	5.039	5.230	5.395	5.510
2911	2.134	2.343	2.551	2.760	2.969	3.179	3.389	3.600	3.811	4.023	4.235	4.448	4.660	4.870	5.075	5.266	5.431	5.546
2911	2.027	2.240	2.452	2.665	2.879	3.092	3.306	3.521	3.736	3.952	4.168	4.385	4.602	4.817	5.026	5.222	5.391	5.511
3122	2.045	2.260	2.474	2.689	2.904	3.119	3.335	3.552	3.769	3.988	4.206	4.426	4.645	4.863	5.075	5.275	5.448	5.572
3122	1.494	1.719	1.944	2.171	2.398	2.627	2.858	3.090	3.325	3.563	3.803	4.045	4.290	4.535	4.776	5.006	5.210	5.365
3234	1.540	1.765	1.990	2.217	2.444	2.673	2.904	3.137	3.371	3.609	3.849	4.091	4.336	4.581	4.823	5.052	5.256	5.411
3234	1.283	1.513	1.744	1.977	2.212	2.449	2.688	2.931	3.176	3.426	3.679	3.936	4.195	4.455	4.712	4.956	5.174	5.342
3272	1.298	1.528	1.759	1.992	2.227	2.464	2.703	2.946	3.192	3.441	3.694	3.951	4.210	4.470	4.727	4.971	5.189	5.357
3317	0.504	0.774	1.048	1.325	1.606	1.892	2.181	2.473	2.768	3.067	3.367	3.669	3.970	4.269	4.560	4.835	5.080	5.272
3496	0.572	0.842	1.116	1.393	1.675	1.960	2.249	2.541	2.837	3.135	3.435	3.737	4.038	4.337	4.628	4.904	5.149	5.340
3541	-0.019	0.304	0.626	0.948	1.271	1.595	1.918	2.242	2.566	2.890	3.213	3.535	3.855	4.170	4.476	4.765	5.022	5.224
3664	-0.221	0.108	0.437	0.766	1.097	1.427	1.758	2.089	2.420	2.752	3.082	3.412	3.739	4.061	4.375	4.671	4.936	5.146
3764	-0.400	-0.066	0.269	0.604	0.940	1.277	1.614	1.951	2.289	2.626	2.963	3.299	3.633	3.962	4.282	4.585	4.856	5.072
4632	-0.334	0.001	0.337	0.674	1.012	1.351	1.691	2.032	2.373	2.715	3.056	3.396	3.735	4.069	4.394	4.702	4.978	5.199
5292	-0.242	0.087	0.418	0.749	1.081	1.414	1.748	2.082	2.417	2.753	3.088	3.423	3.756	4.084	4.405	4.707	4.979	5.196
5995	-0.351	0.004	0.361	0.727	1.080	1.442	1.806	2.172	2.540	2.911	3.284	3.660	4.037	4.414	4.788	5.154	5.497	5.797
6662	-0.500	-0.132	0.237	0.615	0.980	1.354	1.730	2.108	2.488	2.871	3.255	3.642	4.030	4.418	4.803	5.179	5.532	5.842
7494	-0.633	-0.253	0.128	0.518	0.895	1.281	1.669	2.059	2.450	2.845	3.240	3.638	4.037	4.435	4.831	5.217	5.579	5.898
8565	-0.746	-0.355	0.039	0.441	0.829	1.227	1.626	2.027	2.430	2.836	3.242	3.651	4.060	4.469	4.874	5.270	5.641	5.969
9993	-0.835	-0.431	-0.026	0.387	0.787	1.196	1.607	2.019	2.433	2.849	3.266	3.685	4.104	4.522	4.937	5.342	5.723	6.059
11991	-0.891	-0.476	-0.060	0.365	0.776	1.196	1.617	2.040	2.465	2.891	3.318	3.746	4.175	4.603	5.027	5.441	5.830	6.174
14989	-0.901	-0.476	-0.049	0.387	0.808	1.239	1.670	2.103	2.537	2.973	3.410	3.847	4.285	4.722	5.154	5.577	5.974	6.326
19986	-0.844	-0.409	0.029	0.474	0.905	1.345	1.786	2.228	2.672	3.116	3.562	4.008	4.455	4.900	5.340	5.770	6.175	6.535
29979	-0.672	-0.227	0.219	0.673	1.114	1.562	2.012	2.463	2.914	3.368	3.821	4.276	4.730	5.182	5.630	6.068	6.480	6.847
59958	-0.236	0.217	0.672	1.134	1.582	2.038	2.496	2.954	3.414	3.874	4.335	4.797	5.258	5.718	6.173	6.618	7.037	7.411

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metals for six cases using the solar abundances again. Each combination of θ and log P_e is chosen so as roughly to represent the values of T and P_e at $\tau_{5000} \sim 0.5$ for a main-sequence star with the effective temperature of 8400°, 7200°, 6300°, 5800°, 5040°, and 4200° K, respectively. The value of the H^- absorption has again been indicated as well as the absorptions due to H_2^+, Rayleigh scattering, and neutral hydrogen. The Rayleigh scattering coefficient is computed by using the polynomials given by Dalgarno and Williams (1962) for scattering from molecular hydrogen and by Dalgarno (Gingerich 1964) for scattering from atomic hydrogen. For the absorption due to the H_2^+ ions, we used the polynomial approximation given by Matsushima (1967*a*).

The larger peaks in the metal absorption curve are labeled to indicate which metal is responsible for the discontinuity. The expected decrease in importance of the metals with the lower ionization potentials as the temperature increases is quite apparent, with the curve almost completely dominated by carbon, silicon, and magnesium at the highest temperature.

VI. SUMMARY

In this paper we have attempted to give a fairly accurate and comprehensive account of the continuous absorption coefficients due to neutral metals. The results are tabulated in the accompanying tables. While there is certainly much left to be desired with regard to the accuracy of computed photo-ionization cross-sections, it remains doubtful that experimental determinations for such a large number of levels and atoms will ever be possible for a complete account of the total absorption. In any case, the present values should certainly be superior to those obtainable from the hydrogenic approximation.

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REFERENCES

Bates, D. R. 1946*a*, *M.N.*, **106**, 421.
———. 1946*b*, *ibid.*, p 432.
Bates, D. R., and Damgaard, A. 1949, *Phil. Trans. Roy. Soc. London, A*, **242**, 101.
Bötticher, W. 1958, *Zs f. Phys*, **150**, 336.
Burgess, A, and Seaton, M. J. 1960, *M.N.R.A.S.*, **120**, 121.
Dalgarno, A, and Williams, D A. 1962, *Ap. J.*, **136**, 690
Ditchburn, R. W., Justum, P. J, and Marr, G. V. 1953, *Proc. Roy Soc. London, A*, **219**, 89.
Ditchburn, R W, and Marr, G V. 1953, *Proc. Phys Soc. London, A*, **66**, 655.
Drawin, H., and Felenbok, P. 1965, *Data for Plasmas in Local Thermodynamic Equilibrium* (Paris: Gauthier-Villars), p. 267
Gingerich, O 1964, *Proc 1st Harvard-Smithsonian Conference on Stellar Atmospheres*, p. 17.
Goldberg, L., Müller, E A., and Aller, L. H 1960, *Ap J. Suppl.*, **5**, 1.
Hudson, R. D., and Carter, V L. 1967, *Ap. J.*, **149**, 229.
Kelm, S, and Schlüter, D. 1962, *Zs. f. Ap*, **56**, 78.
Matsushima, S. 1967*a*, *Ann. d'ap.*, **30**, 23.
———. 1967*b*, *A J*, **72**, 815.
Matsushima, S, and Terashita, Y. 1967, *Ann. d'ap*, **30**, 189.
Moore, C. E 1949, *Atomic Energy Levels*, Vols. **I** and **II**. N.B S. Circ 467
Peach, G. 1962, *M.N R A S*, **124**, 371.
———. 1965, *ibid*, **130**, 361.
———. 1967*a*, *Mem. R.A.S.*, **71**, 13.
———. 1967*b*, *ibid.*, p. 29.

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Radziemski, L. J., and Andrew, K. L. 1965, *J. Opt Soc. Am.*, **55**, 474.
Rich, J. C. 1967, *Ap. J.*, **148**, 275.
Seaton, M. J. 1958, *M.N.R.A.S.*, **118**, 504.
Travis, L. D., and Matsushima, S. 1967, *A J.*, **72**, 833.
Unsöld, A. 1955, *Physik der Sternatmosphären* (Berlin: Springer-Verlag), p. 168.
Vitense, E. 1951, *Zs. f. Ap.*, **28**, 81.

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