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Title: NEUTRON CROSS SECTIONS  
OF NATURAL CHLORINE

Prepared by

M. H. Kalos

J. H. Ray

Date: 30 September 1963

Contract No.: DA-18-108-CML-7156  
(UNC Project 2185)

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| <p>AD _____ Accession No. _____<br/> United Nuclear Corporation, Development<br/> Division, White Plains, N. Y.<br/> NEUTRON CROSS SECTIONS OF NATURAL<br/> CHLORINE<br/> Report No. UNC-5067, 30 September 1963,<br/> pp., 4 tables<br/> Contract DA-18-108-CML-7156<br/> Complete sets of cross sections for natural<br/> chlorine are presented for the range of inci-<br/> dent neutron energies from 0.02 to 18 Mev.</p> | <p>AD _____ Accession No. _____<br/> United Nuclear Corporation, Development<br/> Division, White Plains, N. Y.<br/> NEUTRON CROSS SECTIONS OF NATURAL<br/> CHLORINE<br/> Report No. UNC-5067, 30 September 1963,<br/> pp., 4 tables<br/> Contract DA-18-108-CML-7156<br/> Complete sets of cross sections for natural<br/> chlorine are presented for the range of inci-<br/> dent neutron energies from 0.02 to 18 Mev.</p> | <p>UNCLASSIFIED</p> | <p>UNCLASSIFIED</p> |
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**Contractor: United Nuclear Corporation  
Development Division – NDA  
Contract No.: DA-18-108-CML-7156 (UNC Project 2185)**

**UNC-5067  
TOPICAL REPORT**

**Title: NEUTRON CROSS SECTIONS OF NATURAL CHLORINE**

**Prepared by  
M. H. Kalos  
J. H. Ray**

**Date: 30 September 1963**

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**Previous Reports Published on this Contract**

**UNC-5038      M. H. Kalos et al., Revised Cross Sections for Neutron Interactions  
with Oxygen and Deuterium (Aug. 31, 1962).**

## **ABSTRACT**

Complete sets of cross sections for natural chlorine are presented for the range of incident neutron energies from 0.02 ev to 18 Mev.

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## 1. INTRODUCTION

The naturally occurring isotopic mixture of chlorine consists of 75.4%  $\text{Cl}^{35}$  and 24.6%  $\text{Cl}^{37}$ . The following cross sections for this mixture have been compiled for incident neutron energies from 0.02 ev to 18 Mev:  $\sigma_T$ ,  $\sigma_{n,\gamma}$ ,  $\sigma_{n,p}$ ,  $\sigma_{n,\alpha}$ ,  $\sigma_{n,d}$ ,  $\sigma_{n,2n}$ ,  $\sigma_{n,n'}$ ,  $\sigma_{n,x}$ , and  $\sigma_{n,n}$ . The data are presented in Table 1. Cross sections for production of neutrons by inelastic scattering, for production of gamma rays by inelastic scattering, and for production of gamma rays by neutron capture are given. Legendre polynomial coefficients to describe the angular distribution of elastically scattered neutrons are also given.

It should be stated here that very little information is available on neutron interactions with chlorine in the energy range above about 0.25 Mev.

### 1.1 NEUTRON CROSS SECTIONS FOR CHLORINE

#### 1.1.1 The Total Cross Section, $\sigma_T$

In the energy ranges below 1100 ev and above 0.2 Mev, the total cross section was taken from BNL 325.<sup>1,2</sup> From 0.2 to 0.75 Mev the data were averaged in such a way as to preserve as well as possible the shape of the data. In this averaging process the data were integrated by trapezoidal rule from the midpoint of the interval below the mesh point in question to the midpoint of the interval above it, and the integral divided by the energy range of the integration.

Table 1 — Chlorine — Cross Sections as a Function of Energy

| E, Mev | $\sigma_T$<br>barns | $\sigma_{n,\gamma}$<br>mb | $\sigma_{n,p}$<br>mb | $\sigma_{n,\alpha}$<br>mb | $\sigma_{n,d}$<br>barns | $\sigma_{n,2n}$<br>mb | $\sigma_{n,n'}$<br>barns | $\sigma_{n,x}$<br>barns | $\sigma_n$<br>barns |
|--------|---------------------|---------------------------|----------------------|---------------------------|-------------------------|-----------------------|--------------------------|-------------------------|---------------------|
| 18.0   | 2.00                | .0                        | 33.0                 | 90.0                      | .151                    | 22.                   | .704                     | 1.000                   | 1.000               |
| 17.1   | 2.01                |                           | 30.0                 | 91.0                      | .154                    | 18.5                  | .707                     | 1.000                   | 1.010               |
| 16.3   | 2.01                |                           | 29.0                 | 95.0                      | .151                    | 15.5                  | .710                     | 1.000                   | 1.010               |
| 15.5   | 2.01                |                           | 29.0                 | 97.0                      | .146                    | 12.0                  | .716                     | 1.000                   | 1.010               |
| 14.75  | 2.00                |                           | 31.3                 | 104.0                     | .136                    | 8.4                   | .720                     | 1.000                   | 1.000               |
| 14.0   | 1.98                |                           | 34.5                 | 107.0                     | .130                    | 5.0                   | .724                     | 1.000                   | .980                |
| 13.3   | 1.96                |                           | 39.0                 | 114.0                     | .109                    | 3.0                   | .735                     | 1.000                   | .960                |
| 12.7   | 1.97                |                           | 45.7                 | 122.5                     | .088                    | 1.4                   | .742                     | 1.000                   | .970                |
| 12.1   | 1.94                |                           | 53.0                 | 130.0                     | .062                    | .0                    | .755                     | 1.000                   | .940                |
| 11.5   | 1.95                |                           | 58.0                 | 139.2                     | .030                    |                       | .773                     | 1.000                   | .950                |
| 10.9   | 2.00                |                           | 66.0                 | 146.0                     | .000                    |                       | .788                     | 1.000                   | 1.000               |
| 10.4   | 2.05                |                           | 73.0                 | 153.0                     |                         |                       | .804                     | 1.030                   | 1.020               |
| 9.89   | 2.10                |                           | 81.0                 | 160.0                     |                         |                       | .829                     | 1.070                   | 1.030               |
| 9.41   | 2.20                |                           | 89.0                 | 165.0                     |                         |                       | .856                     | 1.110                   | 1.090               |
| 8.95   | 2.26                |                           | 97.0                 | 169.0                     |                         |                       | .894                     | 1.160                   | 1.100               |
| 8.51   | 2.32                |                           | 101.0                | 171.0                     |                         |                       | .923                     | 1.195                   | 1.125               |
| 8.10   | 2.38                |                           | 104.0                | 172.0                     |                         |                       | .944                     | 1.220                   | 1.160               |
| 7.70   | 2.42                |                           | 105.0                | 171.0                     |                         |                       | .974                     | 1.250                   | 1.170               |
| 7.33   | 2.49                |                           | 105.0                | 170.0                     |                         |                       | .995                     | 1.270                   | 1.220               |
| 6.97   | 2.55                |                           | 105.0                | 167.0                     |                         |                       | 1.008                    | 1.280                   | 1.270               |
| 6.63   | 2.60                |                           | 105.0                | 163.0                     |                         |                       | 1.002                    | 1.270                   | 1.330               |
| 6.30   | 2.64                |                           | 105.0                | 157.0                     |                         |                       | .998                     | 1.260                   | 1.380               |
| 6.00   | 2.68                |                           | 105.0                | 150.0                     |                         |                       | .975                     | 1.230                   | 1.450               |
| 5.70   | 2.70                |                           | 105.0                | 142.0                     |                         |                       | .948                     | 1.195                   | 1.505               |
| 5.43   | 2.72                |                           | 105.0                | 131.0                     |                         |                       | .924                     | 1.160                   | 1.560               |
| 5.16   | 2.74                |                           | 105.0                | 112.0                     |                         |                       | .893                     | 1.110                   | 1.630               |
| 4.91   | 2.75                |                           | 105.0                | 100.0                     |                         |                       | .858                     | 1.063                   | 1.687               |
| 4.67   | 2.80                |                           | 105.0                | 89.0                      |                         |                       | .836                     | 1.030                   | 1.770               |
| 4.44   | 2.85                |                           | 104.0                | 76.0                      |                         |                       | .820                     | 1.000                   | 1.850               |
| 4.23   | 2.90                |                           | 103.0                | 64.0                      |                         |                       | .803                     | .970                    | 1.930               |
| 4.02   | 2.95                |                           | 101.0                | 47.0                      |                         |                       | .784                     | .932                    | 2.018               |
| 3.82   | 3.01                |                           | 99.0                 | 37.0                      |                         |                       | .767                     | .903                    | 2.107               |
| 3.64   | 3.07                |                           | 96.2                 | 28.0                      |                         |                       | .749                     | .873                    | 2.197               |
| 3.46   | 3.09                |                           | 93.5                 | 21.0                      |                         |                       | .728                     | .843                    | 2.247               |
| 3.29   | 3.10                |                           | 91.0                 | 16.0                      |                         |                       | .699                     | .806                    | 2.294               |

Table 1 — (Continued)

| E, Mev | $\sigma_T$<br>barns | $\sigma_{n,\gamma}$<br>mb | $\sigma_{n,p}$<br>mb | $\sigma_{n,\alpha}$<br>mb | $\sigma_{n,d}$<br>barns | $\sigma_{n,2n}$<br>mb | $\sigma_{n,n'}$<br>barns | $\sigma_{n,x}$<br>barns | $\sigma_n$<br>barns |
|--------|---------------------|---------------------------|----------------------|---------------------------|-------------------------|-----------------------|--------------------------|-------------------------|---------------------|
| 3.13   | 3.10                | .0                        | 88.0                 | 13.0                      | .000                    | .0                    | .674                     | .775                    | 2.325               |
| 2.97   | 3.10                | →                         | 85.0                 | 8.6                       | →                       | →                     | .649                     | .743                    | 2.357               |
| 2.83   | 3.10                | →                         | 81.5                 | 6.2                       | →                       | →                     | .625                     | .713                    | 2.387               |
| 2.69   | 3.10                | →                         | 78.5                 | 4.2                       | →                       | →                     | .597                     | .680                    | 2.420               |
| 2.56   | 3.09                | →                         | 76.0                 | 2.8                       | →                       | →                     | .578                     | .657                    | 2.433               |
| 2.44   | 3.05                | →                         | 72.0                 | 1.9                       | →                       | →                     | .561                     | .635                    | 2.415               |
| 2.32   | 3.01                | →                         | 68.5                 | 1.1                       | →                       | →                     | .540                     | .610                    | 2.400               |
| 2.21   | 2.98                | →                         | 65.2                 | .66                       | →                       | →                     | .518                     | .584                    | 2.397               |
| 2.10   | 2.96                | →                         | 61.8                 | .33                       | →                       | →                     | .492                     | .554                    | 2.406               |
| 2.00   | 2.93                | →                         | 58.3                 | .1                        | →                       | →                     | .464                     | .522                    | 2.408               |
| 1.90   | 2.90                | →                         | 55.0                 | .0                        | →                       | →                     | .430                     | .485                    | 2.415               |
| 1.81   | 2.86                | .016                      | 52.0                 | →                         | →                       | →                     | .393                     | .445                    | 2.415               |
| 1.72   | 2.81                | .017                      | 48.5                 | →                         | →                       | →                     | .354                     | .403                    | 2.407               |
| 1.63   | 2.76                | .018                      | 45.0                 | →                         | →                       | →                     | .335                     | .380                    | 2.380               |
| 1.55   | 2.72                | .019                      | 41.5                 | →                         | →                       | →                     | .314                     | .356                    | 2.364               |
| 1.48   | 2.68                | .020                      | 38.5                 | →                         | →                       | →                     | .294                     | .333                    | 2.347               |
| 1.41   | 2.63                | .021                      | 36.0                 | →                         | →                       | →                     | .270                     | .306                    | 2.324               |
| 1.34   | 2.58                | .022                      | 33.0                 | →                         | →                       | →                     | .243                     | .276                    | 2.304               |
| 1.27   | 2.52                | .023                      | 30.0                 | →                         | →                       | →                     | .210                     | .240                    | 2.280               |
| 1.21   | 2.46                | .024                      | 27.1                 | →                         | →                       | →                     | .176                     | .203                    | 2.257               |
| 1.15   | 2.41                | .026                      | 24.7                 | →                         | →                       | →                     | .139                     | .164                    | 2.246               |
| 1.096  | 2.36                | .027                      | 22.2                 | →                         | →                       | →                     | .097                     | .119                    | 2.241               |
| 1.042  | 2.31                | .029                      | 20.1                 | →                         | →                       | →                     | .047                     | .067                    | 2.243               |
| .991   | 2.23                | .030                      | 18.0                 | →                         | →                       | →                     | .000                     | .018                    | 2.212               |
| .943   | 2.22                | .031                      | 16.2                 | →                         | →                       | →                     | →                        | .016                    | 2.204               |
| .897   | 2.31                | .033                      | 14.5                 | →                         | →                       | →                     | →                        | .015                    | 2.295               |
| .853   | 2.35                | .035                      | 12.8                 | →                         | →                       | →                     | →                        | .013                    | 2.337               |
| .812   | 2.30                | .036                      | 11.2                 | →                         | →                       | →                     | →                        | .011                    | 2.289               |
| .772   | 2.150               | .038                      | 9.5                  | →                         | →                       | →                     | →                        | .010                    | 2.140               |
| .734   | 2.203               | .040                      | 8.0                  | →                         | →                       | →                     | →                        | .008                    | 2.195               |
| .699   | 2.232               | .043                      | 6.8                  | →                         | →                       | →                     | →                        | .007                    | 2.225               |
| .666   | 2.073               | .045                      | 5.6                  | →                         | →                       | →                     | →                        | .006                    | 2.067               |
| .632   | 2.396               | .047                      | 4.3                  | →                         | →                       | →                     | →                        | .004                    | 2.392               |
| .601   | 2.079               | .049                      | 3.25                 | →                         | →                       | →                     | →                        | .003                    | 2.076               |

Table 1 — (Continued)

| E, Mev | $\sigma_T$<br>barns | $\sigma_{n,\gamma}$<br>mb | $\sigma_{n,p}$<br>mb | $\sigma_{n,\alpha}$<br>mb | $\sigma_{n,d}$<br>barns | $\sigma_{n,2n}$<br>mb | $\sigma_{n,n'}$<br>barns | $\sigma_{n,x}$<br>barns | $\sigma_n$<br>barns |
|--------|---------------------|---------------------------|----------------------|---------------------------|-------------------------|-----------------------|--------------------------|-------------------------|---------------------|
| .572   | 2.116               | .052                      | 2.40                 | .0                        | .000                    | .0                    | .000                     | .002                    | 2.114               |
| .544   | 2.357               | .054                      | 1.75                 |                           |                         |                       |                          | .002                    | 2.355               |
| .518   | 2.246               | .057                      | 1.25                 |                           |                         |                       |                          | .001                    | 2.245               |
| .492   | 2.242               | .060                      | .66                  |                           |                         |                       |                          | .001                    | 2.241               |
| .468   | 2.420               | .064                      | .25                  |                           |                         |                       |                          | .000                    | 2.420               |
| .445   | 1.880               | .067                      | .02                  |                           |                         |                       |                          | .000                    | 1.880               |
| .424   | 2.395               | .070                      | .015                 |                           |                         |                       |                          | .000                    | 2.395               |
| .403   | 2.060               | .074                      | .013                 |                           |                         |                       |                          | .000                    | 2.060               |
| .383   | 2.136               | .077                      | .012                 |                           |                         |                       |                          | .000                    | 2.136               |
| .365   | 1.869               | .081                      | .011                 |                           |                         |                       |                          | .000                    | 1.869               |
| .347   | 3.167               | .086                      | .011                 |                           |                         |                       |                          | .000                    | 3.167               |
| .330   | 1.567               | .090                      | .010                 |                           |                         |                       |                          | .000                    | 1.567               |
| .314   | 2.082               | .094                      | .010                 |                           |                         |                       |                          | .000                    | 2.082               |
| .299   | 1.693               | .100                      | .010                 |                           |                         |                       |                          | .000                    | 1.693               |
| .284   | 2.246               | .105                      | .010                 |                           |                         |                       |                          | .000                    | 2.246               |
| .270   | 1.712               | .110                      | .010                 |                           |                         |                       |                          | .000                    | 1.712               |
| .257   | 1.884               | .115                      | .010                 |                           |                         |                       |                          | .000                    | 1.884               |
| .244   | 1.792               | .122                      | .011                 |                           |                         |                       |                          | .000                    | 1.792               |
| .233   | 1.980               | .128                      | .011                 |                           |                         |                       |                          | .000                    | 1.980               |
| .221   | 2.055               | .134                      | .012                 |                           |                         |                       |                          | .000                    | 2.055               |
| .210   | 1.493               | .140                      | .012                 |                           |                         |                       |                          | .000                    | 1.493               |
| .200   | 3.054*              | .332*                     | .013                 |                           |                         |                       |                          | .000                    | 3.054               |
| .190   | 2.159*              | .513*                     | .014                 |                           |                         |                       |                          | .001                    | 2.158               |
| .181   | 1.334*              | .170*                     | .014                 |                           |                         |                       |                          | .000                    | 1.334               |
| .172   | 1.000               | .025                      | .015                 |                           |                         |                       |                          | .000                    | 1.000               |
| .163   | 1.700               | .025                      | .016                 |                           |                         |                       |                          | .000                    | 1.700               |
| .155   | 1.488*              | .163*                     | .017                 |                           |                         |                       |                          | .000                    | 1.488               |
| .148   | 2.165*              | .215*                     | .018                 |                           |                         |                       |                          | .000                    | 2.165               |
| .141   | 2.279*              | 1.042*                    | .019                 |                           |                         |                       |                          | .001                    | 2.278               |
| .134   | 2.025*              | .941*                     | .020                 |                           |                         |                       |                          | .001                    | 2.024               |
| .127   | 1.367*              | .812*                     | .021                 |                           |                         |                       |                          | .001                    | 1.366               |
| .121   | 1.100               | .040                      | .022                 |                           |                         |                       |                          | .000                    | 1.100               |

\*Averaged over fine structure of resonance.

Table 1 — (Continued)

| E, Mev | $\sigma_T$<br>barns | $\sigma_{n,\gamma}$<br>mb | $\sigma_{n,p}$<br>mb | $\sigma_{n,\alpha}$<br>mb | $\sigma_{n,d}$<br>barns | $\sigma_{n,n}$<br>mb | $\sigma_{n,n'}$<br>barns | $\sigma_{n,x}$<br>barns | $\sigma_n$<br>barns |
|--------|---------------------|---------------------------|----------------------|---------------------------|-------------------------|----------------------|--------------------------|-------------------------|---------------------|
| .115   | 2.321*              | .919*                     | .023                 | .0                        | .000                    | .0                   | .000                     | .001                    | 2.320               |
| .1096  | .800                | .050                      | .024                 |                           |                         |                      |                          | .000                    | .800                |
| .1042  | 1.906*              | 1.243*                    | .025                 |                           |                         |                      |                          | .001                    | 1.905               |
| .0991  | .800                | .014                      | .026                 |                           |                         |                      |                          | .000                    | .800                |
| .0943  | 1.000               | .008                      | .027                 |                           |                         |                      |                          | .000                    | 1.000               |
| .0897  | 1.111               | .007                      | .028                 |                           |                         |                      |                          | .000                    | 1.111               |
| .0853  | 1.159               | .006                      | .030                 |                           |                         |                      |                          | .000                    | 1.159               |
| .0812  | 1.190               | .007                      | .032                 |                           |                         |                      |                          | .000                    | 1.190               |
| .0772  | 1.240               | .010                      | .034                 |                           |                         |                      |                          | .000                    | 1.240               |
| .0734  | 1.410               | .040                      | .036                 |                           |                         |                      |                          | .000                    | 1.410               |
| .0699  | 2.573*              | 4.625*                    | .037                 |                           |                         |                      |                          | .005                    | 2.568               |
| .0666  | .996*               | .802*                     | .039                 |                           |                         |                      |                          | .001                    | .995                |
| .0632  | 2.203*              | 7.095*                    | .041                 |                           |                         |                      |                          | .007                    | 2.196               |
| .0601  | 2.892*              | 7.463*                    | .043                 |                           |                         |                      |                          | .008                    | 2.884               |
| .0572  | 1.100               | .126                      | .046                 |                           |                         |                      |                          | .000                    | 1.100               |
| .0544  | 1.556*              | 5.262*                    | .048                 |                           |                         |                      |                          | .005                    | 1.551               |
| .0518  | 1.300               | .120                      | .050                 |                           |                         |                      |                          | .000                    | 1.300               |
| .0492  | 2.000               | .320                      | .053                 |                           |                         |                      |                          | .000                    | 2.000               |
| .0468  | 6.634*              | 8.071*                    | .056                 |                           |                         |                      |                          | .008                    | 6.626               |
| .0445  | .760                | .090                      | .058                 |                           |                         |                      |                          | .000                    | .760                |
| .0424  | .920                | .060                      | .061                 |                           |                         |                      |                          | .000                    | .920                |
| .0403  | 1.030               | .047                      | .064                 |                           |                         |                      |                          | .000                    | 1.030               |
| .0383  | 1.110               | .038                      | .067                 |                           |                         |                      |                          | .000                    | 1.110               |
| .0365  | 1.190               | .036                      | .071                 |                           |                         |                      |                          | .000                    | 1.190               |
| .0347  | 1.260               | .043                      | .075                 |                           |                         |                      |                          | .000                    | 1.260               |
| .0330  | 1.370               | .057                      | .079                 |                           |                         |                      |                          | .000                    | 1.370               |
| .0314  | 1.480               | .080                      | .083                 |                           |                         |                      |                          | .000                    | 1.480               |
| .0299  | 1.670               | .170                      | .087                 |                           |                         |                      |                          | .000                    | 1.670               |
| .0284  | 2.100               | .550                      | .092                 |                           |                         |                      |                          | .001                    | 2.099               |
| .0270  | 9.483*              | 20.646*                   | .096                 |                           |                         |                      |                          | .021                    | 9.462               |
| .0257  | 14.001*             | 26.056*                   | .101                 |                           |                         |                      |                          | .026                    | 13.975              |
| .0244  | .300                | 1.744                     | .106                 |                           |                         |                      |                          | .002                    | .298                |

\*Averaged over fine structure of resonance.

Table 1 — (Continued)

| E, Mev | $\sigma_T$<br>barns | $\sigma_{n,\gamma}$<br>mb | $\sigma_{n,p}$<br>mb | $\sigma_{n,\alpha}$<br>mb | $\sigma_{n,d}$<br>barns | $\sigma_{n,n}$<br>mb | $\sigma_{n,n'}$<br>barns | $\sigma_{n,x}$<br>barns | $\sigma_n$<br>barns |
|--------|---------------------|---------------------------|----------------------|---------------------------|-------------------------|----------------------|--------------------------|-------------------------|---------------------|
| .0233  | .560                | .450                      | .111                 | .0                        | .000                    | .0                   | .000                     | .001                    | .559                |
| .0221  | .670                | .200                      | .117                 |                           |                         |                      |                          | .000                    | .670                |
| .0210  | .740                | .140                      | .124                 |                           |                         |                      |                          | .000                    | .740                |
| .0200  | .830                | .128                      | .131                 |                           |                         |                      |                          | .000                    | .830                |
| .0190  | .980                | .150                      | .138                 |                           |                         |                      |                          | .000                    | .980                |
| E, kev |                     |                           |                      |                           |                         |                      |                          |                         |                     |
| 18.1   | 1.300               | .330                      | .146                 |                           |                         |                      |                          | .000                    | 1.300               |
| 17.2   | 57.759**            | 798.700**                 | 159.730**            |                           |                         |                      |                          | .958                    | 56.801              |
| 16.3   | .640                | 1.5                       | .300                 |                           |                         |                      |                          | .002                    | .638                |
| 15.5   | 1.70                | 1.5                       | .300                 |                           |                         |                      |                          | .002                    | 1.698               |
| 14.8   | 65.037**            | 1048.2**                  | 201.64**             |                           |                         |                      |                          | 1.250                   | 63.787              |
| 14.1   | .760                | .9                        | .200                 |                           |                         |                      |                          | .001                    | .759                |
| 13.4   | .861                | .16                       | .030                 |                           |                         |                      |                          | .000                    | .861                |
| 12.7   | .920                | .11                       | .013                 |                           |                         |                      |                          | .000                    | .920                |
| 12.1   | .950                | .09                       | .008                 |                           |                         |                      |                          | .000                    | .950                |
| 11.5   | .990                | .09                       | .006                 |                           |                         |                      |                          | .000                    | .990                |
| 10.96  | 1.02                | .10                       | .005                 |                           |                         |                      |                          | .000                    | 1.020               |
| 10.42  | 1.06                | .13                       | .005                 |                           |                         |                      |                          | .000                    | 1.060               |
| 9.91   | 1.11                | .20                       | .004                 |                           |                         |                      |                          | .000                    | 1.110               |
| 9.43   | 1.20                | .45                       | .004                 |                           |                         |                      |                          | .000                    | 1.200               |
| 8.97   | 1.50                | 2.5                       | .004                 |                           |                         |                      |                          | .003                    | 1.497               |
| 8.53   | 9.762*              | 92.421*                   | .004                 |                           |                         |                      |                          | .092                    | 9.670               |
| 8.12   | .930                | .90                       | .003                 |                           |                         |                      |                          | .001                    | .929                |
| 7.72   | .975                | .30                       | .003                 |                           |                         |                      |                          | .000                    | .975                |
| 7.34   | 1.01                | .20                       | .003                 |                           |                         |                      |                          | .000                    | 1.010               |
| 6.99   | 1.03                | .17                       | .003                 |                           |                         |                      |                          | .000                    | 1.030               |
| 6.66   | 1.05                | .153                      | .003                 |                           |                         |                      |                          | .000                    | 1.050               |
| 6.32   | 1.08                | .146                      | .003                 |                           |                         |                      |                          | .000                    | 1.080               |
| 6.01   | 1.09                | .144                      | .003                 |                           |                         |                      |                          | .000                    | 1.090               |

\*Averaged over fine structure of resonance.

\*\*Value at peak of resonance near tabulated energy.

Table 1 — (Continued)

| E, kev | $\sigma_T$<br>barns | $\sigma_{n,\gamma}$<br>mb | $\sigma_{n,p}$<br>mb | $\sigma_{n,\alpha}$<br>mb | $\sigma_{n,d}$<br>barns | $\sigma_{n,2n}$<br>mb | $\sigma_{n,n'}$<br>barns | $\sigma_{n,x}$<br>barns | $\sigma_n$<br>barns |
|--------|---------------------|---------------------------|----------------------|---------------------------|-------------------------|-----------------------|--------------------------|-------------------------|---------------------|
| 5.72   | 1.10                | .148                      | .003                 | .0                        | .000                    | .0                    | .000                     | .000                    | 1.100               |
| 5.44   | 1.11                | .159                      | .003                 |                           |                         |                       |                          | .000                    | 1.110               |
| 5.18   | 1.12                | .171                      | .004                 |                           |                         |                       |                          | .000                    | 1.120               |
| 4.92   | 1.16                | .200                      | .005                 |                           |                         |                       |                          | .000                    | 1.160               |
| 4.68   | 1.21                | .280                      | .010                 |                           |                         |                       |                          | .000                    | 1.210               |
| 4.45   | 1.50                | 1.0                       | .050                 |                           |                         |                       |                          | .001                    | 1.499               |
| 4.24   | 23.684*             | 11828.*                   | 828.*                |                           |                         |                       |                          | 12.656                  | 11.028              |
| 4.03   | 1.20                | 1.0                       | .040                 |                           |                         |                       |                          | .001                    | 1.199               |
| 3.83   | 1.24                | .318                      | .007                 |                           |                         |                       |                          | .000                    | 1.240               |
| 3.65   | 1.26                | .310                      | .005                 |                           |                         |                       |                          | .000                    | 1.260               |
| 3.47   | 1.28                | .325                      | .005                 |                           |                         |                       |                          | .000                    | 1.280               |
| 3.30   | 1.30                | .350                      | .004                 |                           |                         |                       |                          | .000                    | 1.300               |
| 3.14   | 1.32                | .385                      | .004                 |                           |                         |                       |                          | .000                    | 1.320               |
| 2.99   | 1.34                | .430                      | .005                 |                           |                         |                       |                          | .000                    | 1.340               |
| 2.84   | 1.37                | .475                      | .005                 |                           |                         |                       |                          | .000                    | 1.370               |
| 2.70   | 1.40                | .525                      | .005                 |                           |                         |                       |                          | .001                    | 1.399               |
| 2.57   | 1.43                | .580                      | .005                 |                           |                         |                       |                          | .001                    | 1.429               |
| 2.44   | 1.46                | .655                      | .006                 |                           |                         |                       |                          | .001                    | 1.459               |
| 2.33   | 1.49                | .710                      | .006                 |                           |                         |                       |                          | .001                    | 1.489               |
| 2.21   | 1.51                | .800                      | .007                 |                           |                         |                       |                          | .001                    | 1.509               |
| 2.10   | 1.56                | .890                      | .007                 |                           |                         |                       |                          | .001                    | 1.559               |
| 2.00   | 1.60                | 1.00                      | .008                 |                           |                         |                       |                          | .001                    | 1.599               |
| 1.90   | 1.63                | 1.10                      | .009                 |                           |                         |                       |                          | .001                    | 1.629               |
| 1.81   | 1.66                | 1.22                      | .010                 |                           |                         |                       |                          | .001                    | 1.659               |
| 1.72   | 1.69                | 1.39                      | .011                 |                           |                         |                       |                          | .001                    | 1.689               |
| 1.63   | 1.73                | 1.57                      | .012                 |                           |                         |                       |                          | .002                    | 1.728               |
| 1.55   | 1.77                | 1.75                      | .014                 |                           |                         |                       |                          | .002                    | 1.768               |
| 1.48   | 1.81                | 2.00                      | .015                 |                           |                         |                       |                          | .002                    | 1.808               |
| 1.41   | 1.85                | 2.17                      | .017                 |                           |                         |                       |                          | .002                    | 1.848               |
| 1.34   | 1.89                | 2.40                      | .019                 |                           |                         |                       |                          | .002                    | 1.888               |
| 1.27   | 1.93                | 2.80                      | .021                 |                           |                         |                       |                          | .003                    | 1.927               |
| 1.21   | 1.97                | 3.10                      | .027                 |                           |                         |                       |                          | .003                    | 1.967               |

\*Averaged over fine structure of resonance.

Table 1 — (Continued)

| E, kev | $\sigma_T$<br>barns | $\sigma_{n,\gamma}$<br>mb | $\sigma_{n,p}$<br>mb | $\sigma_{n,\alpha}$<br>mb | $\sigma_{n,d}$<br>barns | $\sigma_{n,m}$<br>mb | $\sigma_{n,n'}$<br>barns | $\sigma_{n,x}$<br>barns | $\sigma_n$<br>barns |
|--------|---------------------|---------------------------|----------------------|---------------------------|-------------------------|----------------------|--------------------------|-------------------------|---------------------|
| 1.15   | 2.01                | 3.60                      | .060                 | .0                        | .000                    | .0                   | .000                     | .004                    | 2.006               |
| 1.096  | 13.419**            | 10122.**                  | 1012.0**             |                           |                         |                      |                          | 11.134                  | 2.285               |
| 1.042  | 2.10                | 5.0                       | .045                 |                           |                         |                      |                          | .005                    | 2.095               |
| .991   | 2.15                | 4.8                       | .035                 |                           |                         |                      |                          | .005                    | 2.145               |
| .943   | 2.20                | 5.25                      | .036                 |                           |                         |                      |                          | .005                    | 2.195               |
| .897   | 2.25                | 5.90                      | .038                 |                           |                         |                      |                          | .006                    | 2.244               |
| .853   | 2.30                | 6.55                      | .041                 |                           |                         |                      |                          | .007                    | 2.293               |
| .812   | 2.36                | 7.33                      | .046                 |                           |                         |                      |                          | .007                    | 2.353               |
| .772   | 2.42                | 8.10                      | .051                 |                           |                         |                      |                          | .008                    | 2.412               |
| .734   | 2.48                | 9.00                      | .058                 |                           |                         |                      |                          | .009                    | 2.471               |
| .699   | 2.54                | 9.90                      | .068                 |                           |                         |                      |                          | .010                    | 2.530               |
| .666   | 2.60                | 10.80                     | .078                 |                           |                         |                      |                          | .011                    | 2.589               |
| .633   | 2.67                | 12.00                     | .092                 |                           |                         |                      |                          | .012                    | 2.658               |
| .601   | 2.74                | 13.50                     | .110                 |                           |                         |                      |                          | .014                    | 2.726               |
| .572   | 2.82                | 15.00                     | .14                  |                           |                         |                      |                          | .015                    | 2.805               |
| .544   | 2.89                | 16.50                     | .17                  |                           |                         |                      |                          | .017                    | 2.873               |
| .518   | 2.97                | 18.70                     | .24                  |                           |                         |                      |                          | .019                    | 2.951               |
| .492   | 3.05                | 21.00                     | .35                  |                           |                         |                      |                          | .021                    | 3.029               |
| .468   | 3.13                | 25.00                     | .60                  |                           |                         |                      |                          | .026                    | 3.104               |
| .445   | 3.21                | 32.00                     | 1.30                 |                           |                         |                      |                          | .033                    | 3.177               |
| .424   | 3.30                | 150.                      | 3.00                 |                           |                         |                      |                          | .153                    | 3.147               |
| .403   | 193.76**            | 155750.**                 | 21801.**             |                           |                         |                      |                          | 177.551                 | 16.209              |
| .383   | 3.52                | 180.                      | 6.00                 |                           |                         |                      |                          | .186                    | 3.334               |
| .365   | 3.52                | 43.                       | 1.70                 |                           |                         |                      |                          | .045                    | 3.475               |
| .347   | 3.60                | 40.2                      | .80                  |                           |                         |                      |                          | .041                    | 3.559               |
| .330   | 3.69                | 42.3                      | .60                  |                           |                         |                      |                          | .043                    | 3.647               |
| .314   | 3.80                | 45.                       | .50                  |                           |                         |                      |                          | .046                    | 3.754               |
| .299   | 3.91                | 49.                       | .45                  |                           |                         |                      |                          | .049                    | 3.861               |
| .284   | 4.07                | 52.5                      | .42                  |                           |                         |                      |                          | .053                    | 4.017               |
| .270   | 4.21                | 57.                       | .41                  |                           |                         |                      |                          | .057                    | 4.153               |
| .257   | 4.36                | 61.                       | .41                  |                           |                         |                      |                          | .061                    | 4.299               |
| .244   | 4.52                | 66.5                      | .42                  |                           |                         |                      |                          | .067                    | 4.453               |

\*\*Value at peak of resonance near tabulated energy.

Table 1 — (Continued)

| E, kev | $\sigma_T$<br>barns | $\sigma_{n,\gamma}$<br>mb    | $\sigma_{n,p}$<br>mb | $\sigma_{n,\alpha}$<br>mb | $\sigma_{n,d}$<br>barns | $\sigma_{n,2n}$<br>mb | $\sigma_{n,n'}$<br>barns | $\sigma_{n,x}$<br>barns | $\sigma_n$<br>barns |
|--------|---------------------|------------------------------|----------------------|---------------------------|-------------------------|-----------------------|--------------------------|-------------------------|---------------------|
| •233   | 4.68                | 72.                          | .43                  | .0                        | .000                    | .0                    | .000                     | .072                    | 4.608               |
| •221   | 4.84                | 77.5                         | .45                  |                           |                         |                       |                          | .078                    | 4.762               |
| •210   | 4.95                | 83.5                         | .475                 |                           |                         |                       |                          | .084                    | 4.866               |
| •200   | 5.08                | 90.                          | .50                  |                           |                         |                       |                          | .091                    | 4.989               |
| •190   | 5.25                | 97.                          | .53                  |                           |                         |                       |                          | .098                    | 5.152               |
| E, ev  |                     | $\sigma_{n,\gamma}$<br>barns |                      |                           |                         |                       |                          |                         |                     |
| 181.   | 5.40                | .103                         | .56                  |                           |                         |                       |                          | .104                    | 5.296               |
| 172.   | 5.59                | .110                         | .59                  |                           |                         |                       |                          | .111                    | 5.479               |
| 163.   | 5.76                | .118                         | .63                  |                           |                         |                       |                          | .119                    | 5.641               |
| 155.   | 5.90                | .127                         | .67                  |                           |                         |                       |                          | .128                    | 5.772               |
| 148.   | 6.08                | .136                         | .71                  |                           |                         |                       |                          | .137                    | 5.943               |
| 141.   | 6.22                | .146                         | .75                  |                           |                         |                       |                          | .147                    | 6.073               |
| 134.   | 6.38                | .155                         | .79                  |                           |                         |                       |                          | .156                    | 6.224               |
| 127.   | 6.55                | .167                         | .84                  |                           |                         |                       |                          | .168                    | 6.382               |
| 121.   | 6.72                | .176                         | .89                  |                           |                         |                       |                          | .177                    | 6.543               |
| 115.   | 6.95                | .187                         | .95                  |                           |                         |                       |                          | .188                    | 6.762               |
| 109.6  | 7.17                | .200                         | .99                  |                           |                         |                       |                          | .201                    | 6.969               |
| 104.2  | 7.40                | .211                         | 1.04                 |                           |                         |                       |                          | .212                    | 7.188               |
| 99.1   | 7.60                | .225                         | 1.10                 |                           |                         |                       |                          | .226                    | 7.374               |
| 94.3   | 7.80                | .237                         | 1.17                 |                           |                         |                       |                          | .238                    | 7.562               |
| 89.7   | 8.00                | .250                         | 1.24                 |                           |                         |                       |                          | .251                    | 7.749               |
| 85.3   | 8.20                | .263                         | 1.31                 |                           |                         |                       |                          | .264                    | 7.936               |
| 81.2   | 8.40                | .277                         | 1.38                 |                           |                         |                       |                          | .278                    | 8.122               |
| 77.2   | 8.60                | .292                         | 1.44                 |                           |                         |                       |                          | .293                    | 8.307               |
| 73.4   | 8.80                | .308                         | 1.52                 |                           |                         |                       |                          | .310                    | 8.490               |
| 69.9   | 9.00                | .322                         | 1.60                 |                           |                         |                       |                          | .324                    | 8.676               |
| 66.6   | 9.20                | .339                         | 1.68                 |                           |                         |                       |                          | .341                    | 8.859               |
| 63.3   | 9.40                | .356                         | 1.76                 |                           |                         |                       |                          | .358                    | 9.042               |
| 60.1   | 9.60                | .374                         | 1.84                 |                           |                         |                       |                          | .376                    | 9.224               |
| 57.2   | 9.80                | .392                         | 1.92                 |                           |                         |                       |                          | .394                    | 9.406               |
| 54.4   | 10.00               | .410                         | 2.00                 |                           |                         |                       |                          | .412                    | 9.588               |

Table 1 — (Continued)

| E, ev | $\sigma_T$<br>barns | $\sigma_{n,\gamma}$<br>barns | $\sigma_{n,p}$<br>mb | $\sigma_{n,\alpha}$<br>mb | $\sigma_{n,d}$<br>barns | $\sigma_{n,n}$<br>mb | $\sigma_{n,n'}$<br>barns | $\sigma_{n,x}$<br>barns | $\sigma_n$<br>barns |
|-------|---------------------|------------------------------|----------------------|---------------------------|-------------------------|----------------------|--------------------------|-------------------------|---------------------|
| 51.8  | 10.25               | .429                         | 2.10                 | .0                        | .000                    | .0                   | .000                     | .431                    | 9.819               |
| 49.2  | 10.50               | .450                         | 2.20                 |                           |                         |                      |                          | .452                    | 10.048              |
| 46.8  | 10.75               | .471                         | 2.30                 |                           |                         |                      |                          | .473                    | 10.277              |
| 44.5  | 11.00               | .490                         | 2.40                 |                           |                         |                      |                          | .492                    | 10.508              |
| 42.4  | 11.20               | .510                         | 2.50                 |                           |                         |                      |                          | .513                    | 10.687              |
| 40.3  | 11.40               | .535                         | 2.57                 |                           |                         |                      |                          | .538                    | 10.862              |
| 38.3  | 11.60               | .560                         | 2.68                 |                           |                         |                      |                          | .563                    | 11.037              |
| 36.5  | 11.80               | .582                         | 2.77                 |                           |                         |                      |                          | .585                    | 11.215              |
| 34.7  | 12.00               | .608                         | 2.87                 |                           |                         |                      |                          | .611                    | 11.389              |
| 33.0  | 12.25               | .635                         | 2.97                 |                           |                         |                      |                          | .638                    | 11.612              |
| 31.4  | 12.50               | .660                         | 3.11                 |                           |                         |                      |                          | .663                    | 11.837              |
| 29.9  | 12.75               | .688                         | 3.21                 |                           |                         |                      |                          | .691                    | 12.059              |
| 28.4  | 13.00               | .718                         | 3.35                 |                           |                         |                      |                          | .721                    | 12.279              |
| 27.0  | 13.20               | .750                         | 3.49                 |                           |                         |                      |                          | .753                    | 12.447              |
| 25.7  | 13.40               | .780                         | 3.62                 |                           |                         |                      |                          | .784                    | 12.616              |
| 24.4  | 13.60               | .810                         | 3.75                 |                           |                         |                      |                          | .814                    | 12.786              |
| 23.3  | 13.75               | .840                         | 3.88                 |                           |                         |                      |                          | .844                    | 12.906              |
| 22.1  | 13.90               | .880                         | 4.00                 |                           |                         |                      |                          | .884                    | 13.016              |
| 21.0  | 14.05               | .918                         | 4.15                 |                           |                         |                      |                          | .922                    | 13.128              |
| 20.0  | 14.20               | .950                         | 4.30                 |                           |                         |                      |                          | .954                    | 13.246              |
| 19.0  | 14.40               | .985                         | 4.43                 |                           |                         |                      |                          | .989                    | 13.411              |
| 18.1  | 14.60               | 1.025                        | 4.57                 |                           |                         |                      |                          | 1.030                   | 13.570              |
| 17.2  | 14.80               | 1.055                        | 4.73                 |                           |                         |                      |                          | 1.060                   | 13.740              |
| 16.3  | 15.00               | 1.100                        | 4.90                 |                           |                         |                      |                          | 1.105                   | 13.895              |
| 15.5  | 15.10               | 1.145                        | 5.05                 |                           |                         |                      |                          | 1.150                   | 13.950              |
| 14.8  | 15.25               | 1.180                        | 5.20                 |                           |                         |                      |                          | 1.185                   | 14.065              |
| 14.1  | 15.40               | 1.220                        | 5.35                 |                           |                         |                      |                          | 1.225                   | 14.175              |
| 13.4  | 15.55               | 1.260                        | 5.55                 |                           |                         |                      |                          | 1.266                   | 14.284              |
| 12.7  | 15.70               | 1.310                        | 5.75                 |                           |                         |                      |                          | 1.316                   | 14.384              |
| 12.1  | 15.85               | 1.355                        | 5.95                 |                           |                         |                      |                          | 1.361                   | 14.489              |
| 11.5  | 16.00               | 1.395                        | 6.10                 |                           |                         |                      |                          | 1.401                   | 14.599              |
| 10.96 | 16.10               | 1.435                        | 6.25                 |                           |                         |                      |                          | 1.441                   | 14.659              |
| 10.42 | 16.20               | 1.480                        | 6.45                 |                           |                         |                      |                          | 1.486                   | 14.714              |
| 9.91  | 16.30               | 1.525                        | 6.65                 |                           |                         |                      |                          | 1.532                   | 14.768              |

Table 1 — (Continued)

| E, ev | $\sigma_T$<br>barns | $\sigma_{n,\gamma}$<br>barns | $\sigma_{n,p}$<br>mb | $\sigma_{n,\alpha}$<br>mb | $\sigma_{n,d}$<br>barns | $\sigma_{n,2n}$<br>mb | $\sigma_{n,n'}$<br>barns | $\sigma_{n,x}$<br>barns | $\sigma_n$<br>barns |
|-------|---------------------|------------------------------|----------------------|---------------------------|-------------------------|-----------------------|--------------------------|-------------------------|---------------------|
| 9.43  | 16.40               | 1.580                        | 6.90                 | .0                        | .000                    | .0                    | .000                     | 1.587                   | 14.813              |
| 8.97  | 16.55               | 1.630                        | 7.10                 |                           |                         |                       |                          | 1.637                   | 14.913              |
| 8.53  | 16.65               | 1.685                        | 7.30                 |                           |                         |                       |                          | 1.692                   | 14.958              |
| 8.12  | 16.80               | 1.735                        | 7.50                 |                           |                         |                       |                          | 1.743                   | 15.057              |
| 7.72  | 16.95               | 1.790                        | 7.75                 |                           |                         |                       |                          | 1.798                   | 15.152              |
| 7.34  | 17.05               | 1.840                        | 7.95                 |                           |                         |                       |                          | 1.848                   | 15.202              |
| 6.99  | 17.15               | 1.900                        | 8.15                 |                           |                         |                       |                          | 1.908                   | 15.242              |
| 6.66  | 17.25               | 1.96                         | 8.4                  |                           |                         |                       |                          | 1.968                   | 15.282              |
| 6.33  | 17.35               | 2.02                         | 8.65                 |                           |                         |                       |                          | 2.029                   | 15.321              |
| 6.01  | 17.45               | 2.09                         | 8.9                  |                           |                         |                       |                          | 2.099                   | 15.351              |
| 5.72  | 17.55               | 2.15                         | 9.2                  |                           |                         |                       |                          | 2.159                   | 15.391              |
| 5.44  | 17.65               | 2.20                         | 9.4                  |                           |                         |                       |                          | 2.209                   | 15.441              |
| 5.18  | 17.75               | 2.25                         | 9.6                  |                           |                         |                       |                          | 2.260                   | 15.490              |
| 4.92  | 17.85               | 2.31                         | 9.9                  |                           |                         |                       |                          | 2.320                   | 15.530              |
| 4.68  | 17.95               | 2.40                         | 10.2                 |                           |                         |                       |                          | 2.410                   | 15.540              |
| 4.45  | 18.05               | 2.49                         | 10.5                 |                           |                         |                       |                          | 2.501                   | 15.549              |
| 4.24  | 18.15               | 2.56                         | 10.8                 |                           |                         |                       |                          | 2.571                   | 15.579              |
| 4.03  | 18.25               | 2.62                         | 11.1                 |                           |                         |                       |                          | 2.631                   | 15.619              |
| 3.83  | 18.40               | 2.69                         | 11.4                 |                           |                         |                       |                          | 2.701                   | 15.699              |
| 3.65  | 18.50               | 2.76                         | 11.7                 |                           |                         |                       |                          | 2.772                   | 15.728              |
| 3.47  | 18.60               | 2.83                         | 12.0                 |                           |                         |                       |                          | 2.842                   | 15.758              |
| 3.30  | 18.75               | 2.90                         | 12.3                 |                           |                         |                       |                          | 2.912                   | 15.838              |
| 3.14  | 18.90               | 3.00                         | 12.7                 |                           |                         |                       |                          | 3.013                   | 15.887              |
| 2.99  | 19.00               | 3.10                         | 13.0                 |                           |                         |                       |                          | 3.113                   | 15.887              |
| 2.84  | 19.10               | 3.18                         | 13.3                 |                           |                         |                       |                          | 3.193                   | 15.907              |
| 2.70  | 19.20               | 3.26                         | 13.7                 |                           |                         |                       |                          | 3.274                   | 15.926              |
| 2.57  | 19.30               | 3.33                         | 14.0                 |                           |                         |                       |                          | 3.344                   | 15.956              |
| 2.44  | 19.40               | 3.40                         | 14.3                 |                           |                         |                       |                          | 3.414                   | 15.986              |
| 2.33  | 19.50               | 3.50                         | 14.7                 |                           |                         |                       |                          | 3.515                   | 15.985              |
| 2.21  | 19.60               | 3.60                         | 15.1                 |                           |                         |                       |                          | 3.615                   | 15.985              |
| 2.10  | 19.70               | 3.69                         | 15.5                 |                           |                         |                       |                          | 3.706                   | 15.994              |
| 2.00  | 19.80               | 3.76                         | 15.9                 |                           |                         |                       |                          | 3.776                   | 16.024              |
| 1.90  | 19.90               | 3.88                         | 16.3                 |                           |                         |                       |                          | 3.896                   | 16.004              |
| 1.81  | 20.00               | 3.98                         | 16.8                 |                           |                         |                       |                          | 3.997                   | 16.003              |

Table 1 — (Continued)

| E, ev | $\sigma_T$<br>barns | $\sigma_{n,\gamma}$<br>barns | $\sigma_{n,p}$<br>mb | $\sigma_{n,\alpha}$<br>mb | $\sigma_{n,d}$<br>barns | $\sigma_{n,n}$<br>mb | $\sigma_{n,n'}$<br>barns | $\sigma_{n,x}$<br>barns | $\sigma_n$<br>barns |
|-------|---------------------|------------------------------|----------------------|---------------------------|-------------------------|----------------------|--------------------------|-------------------------|---------------------|
| 1.72  | 20.08               | 4.09                         | 17.3                 | .0                        | .000                    | .0                   | .000                     | 4.107                   | 15.975              |
| 1.63  | 20.16               | 4.20                         | 17.8                 |                           |                         |                      |                          | 4.218                   | 15.942              |
| 1.55  | 20.25               | 4.30                         | 18.2                 |                           |                         |                      |                          | 4.318                   | 15.932              |
| 1.48  | 20.33               | 4.40                         | 18.6                 |                           |                         |                      |                          | 4.419                   | 15.911              |
| 1.41  | 20.42               | 4.50                         | 19.0                 |                           |                         |                      |                          | 4.519                   | 15.901              |
| 1.34  | 20.50               | 4.61                         | 19.5                 |                           |                         |                      |                          | 4.630                   | 15.870              |
| 1.27  | 20.58               | 4.72                         | 20.0                 |                           |                         |                      |                          | 4.740                   | 15.840              |
| 1.21  | 20.67               | 4.85                         | 20.6                 |                           |                         |                      |                          | 4.871                   | 15.799              |
| 1.15  | 20.75               | 5.00                         | 21.1                 |                           |                         |                      |                          | 5.021                   | 15.729              |
| 1.096 | 20.83               | 5.12                         | 21.6                 |                           |                         |                      |                          | 5.142                   | 15.688              |
| 1.042 | 20.92               | 5.24                         | 22.1                 |                           |                         |                      |                          | 5.262                   | 15.658              |
| .991  | 21.00               | 5.36                         | 22.7                 |                           |                         |                      |                          | 5.383                   | 15.617              |
| .943  | 21.20               | 5.48                         | 23.3                 |                           |                         |                      |                          | 5.503                   | 15.697              |
| .897  | 21.40               | 5.61                         | 23.9                 |                           |                         |                      |                          | 5.634                   | 15.766              |
| .853  | 21.60               | 5.75                         | 24.5                 |                           |                         |                      |                          | 5.775                   | 15.825              |
| .812  | 21.80               | 5.97                         | 25.1                 |                           |                         |                      |                          | 5.995                   | 15.805              |
| .772  | 22.00               | 6.10                         | 25.8                 |                           |                         |                      |                          | 6.126                   | 15.874              |
| .734  | 22.20               | 6.25                         | 26.5                 |                           |                         |                      |                          | 6.277                   | 15.923              |
| .699  | 22.40               | 6.38                         | 27.2                 |                           |                         |                      |                          | 6.407                   | 15.993              |
| .666  | 22.60               | 6.50                         | 27.9                 |                           |                         |                      |                          | 6.528                   | 16.072              |
| .633  | 22.80               | 6.65                         | 28.8                 |                           |                         |                      |                          | 6.679                   | 16.121              |
| .601  | 23.00               | 6.80                         | 29.5                 |                           |                         |                      |                          | 6.830                   | 16.170              |
| .572  | 23.20               | 7.00                         | 30.1                 |                           |                         |                      |                          | 7.030                   | 16.170              |
| .544  | 23.40               | 7.20                         | 30.9                 |                           |                         |                      |                          | 7.231                   | 16.169              |
| .518  | 23.60               | 7.40                         | 31.7                 |                           |                         |                      |                          | 7.432                   | 16.168              |
| .492  | 23.80               | 7.60                         | 32.5                 |                           |                         |                      |                          | 7.633                   | 16.167              |
| .468  | 24.00               | 7.80                         | 33.4                 |                           |                         |                      |                          | 7.833                   | 16.167              |
| .445  | 24.20               | 7.97                         | 34.3                 |                           |                         |                      |                          | 8.004                   | 16.196              |
| .424  | 24.40               | 8.15                         | 35.2                 |                           |                         |                      |                          | 8.185                   | 16.215              |
| .403  | 24.60               | 8.38                         | 36.1                 |                           |                         |                      |                          | 8.416                   | 16.184              |
| .383  | 24.80               | 8.56                         | 37.0                 |                           |                         |                      |                          | 8.597                   | 16.203              |
| .365  | 25.00               | 8.78                         | 38.0                 |                           |                         |                      |                          | 8.818                   | 16.182              |
| .347  | 25.25               | 9.00                         | 39.0                 |                           |                         |                      |                          | 9.039                   | 16.211              |
| .330  | 25.50               | 9.25                         | 40.0                 |                           |                         |                      |                          | 9.290                   | 16.210              |
| .314  | 25.75               | 9.45                         | 41.0                 |                           |                         |                      |                          | 9.491                   | 16.259              |

Table 1 — (Continued)

| E, ev | $\sigma_T$<br>barns | $\sigma_{n,\gamma}$<br>barns | $\sigma_{n,p}$<br>mb | $\sigma_{n,\alpha}$<br>mb | $\sigma_{n,d}$<br>barns | $\sigma_{n,zn}$<br>mb | $\sigma_{n,n'}$<br>barns | $\sigma_{n,x}$<br>barns | $\sigma_n$<br>barns |
|-------|---------------------|------------------------------|----------------------|---------------------------|-------------------------|-----------------------|--------------------------|-------------------------|---------------------|
| .299  | 26.00               | 9.65                         | 42.0                 | .0                        | .000                    | .0                    | .000                     | 9.692                   | 16.308              |
| .284  | 26.30               | 10.0                         | 43.1                 |                           |                         |                       |                          | 10.043                  | 16.257              |
| .270  | 26.60               | 10.2                         | 44.2                 |                           |                         |                       |                          | 10.244                  | 16.356              |
| .257  | 26.90               | 10.4                         | 45.4                 |                           |                         |                       |                          | 10.445                  | 16.455              |
| .244  | 27.20               | 10.7                         | 46.5                 |                           |                         |                       |                          | 10.746                  | 16.454              |
| .233  | 27.50               | 11.0                         | 47.7                 |                           |                         |                       |                          | 11.048                  | 16.452              |
| .221  | 27.80               | 11.3                         | 49.0                 |                           |                         |                       |                          | 11.349                  | 16.451              |
| .210  | 28.10               | 11.6                         | 50.0                 |                           |                         |                       |                          | 11.650                  | 16.450              |
| .200  | 28.40               | 11.9                         | 51.5                 |                           |                         |                       |                          | 11.952                  | 16.448              |
| .190  | 28.70               | 12.2                         | 52.5                 |                           |                         |                       |                          | 12.253                  | 16.447              |
| .181  | 29.10               | 12.5                         | 54.0                 |                           |                         |                       |                          | 12.554                  | 16.546              |
| .172  | 29.40               | 12.8                         | 56.0                 |                           |                         |                       |                          | 12.856                  | 16.544              |
| .163  | 29.80               | 13.1                         | 57.5                 |                           |                         |                       |                          | 13.158                  | 16.642              |
| .155  | 30.00               | 13.5                         | 59.0                 |                           |                         |                       |                          | 13.559                  | 16.441              |
| .148  | 30.30               | 13.8                         | 60.0                 |                           |                         |                       |                          | 13.860                  | 16.440              |
| .141  | 30.60               | 14.2                         | 61.0                 |                           |                         |                       |                          | 14.261                  | 16.339              |
| .134  | 31.00               | 14.6                         | 62.5                 |                           |                         |                       |                          | 14.663                  | 16.337              |
| .127  | 31.40               | 15.0                         | 64.0                 |                           |                         |                       |                          | 15.064                  | 16.336              |
| .121  | 31.80               | 15.4                         | 66.0                 |                           |                         |                       |                          | 15.466                  | 16.334              |
| .115  | 32.20               | 15.8                         | 68.0                 |                           |                         |                       |                          | 15.868                  | 16.332              |
| .1096 | 32.60               | 16.1                         | 69.5                 |                           |                         |                       |                          | 16.170                  | 16.430              |
| .1042 | 33.00               | 16.5                         | 71.0                 |                           |                         |                       |                          | 16.571                  | 16.429              |
| .0991 | 33.30               | 16.9                         | 72.5                 |                           |                         |                       |                          | 16.973                  | 16.327              |
| .0943 | 33.70               | 17.3                         | 74.5                 |                           |                         |                       |                          | 17.375                  | 16.325              |
| .0897 | 34.20               | 17.8                         | 76.5                 |                           |                         |                       |                          | 17.877                  | 16.323              |
| .0853 | 34.60               | 18.2                         | 78.5                 |                           |                         |                       |                          | 18.279                  | 16.321              |
| .0812 | 35.00               | 18.7                         | 80.5                 |                           |                         |                       |                          | 18.781                  | 16.219              |
| .0772 | 35.40               | 19.2                         | 82.5                 |                           |                         |                       |                          | 19.283                  | 16.117              |
| .0734 | 35.80               | 19.7                         | 84.5                 |                           |                         |                       |                          | 19.785                  | 16.015              |
| .0699 | 36.20               | 20.2                         | 86.5                 |                           |                         |                       |                          | 20.287                  | 15.913              |
| .0666 | 36.60               | 20.7                         | 89.0                 |                           |                         |                       |                          | 20.789                  | 15.811              |
| .0633 | 37.10               | 21.2                         | 91.0                 |                           |                         |                       |                          | 21.291                  | 15.809              |
| .0601 | 37.60               | 21.7                         | 93.5                 |                           |                         |                       |                          | 21.794                  | 15.806              |
| .0572 | 38.20               | 22.2                         | 96.0                 |                           |                         |                       |                          | 22.296                  | 15.904              |
| .0544 | 38.80               | 22.8                         | 98.0                 |                           |                         |                       |                          | 22.898                  | 15.902              |

Table 1 — (Continued)

| E, ev | $\sigma_T$<br>barns | $\sigma_{n,\gamma}$<br>barns | $\sigma_{n,p}$<br>mb | $\sigma_{n,\alpha}$<br>mb | $\sigma_{n,d}$<br>barns | $\sigma_{n,2n}$<br>mb | $\sigma_{n,n'}$<br>barns | $\sigma_{n,x}$<br>barns | $\sigma_n$<br>barns |
|-------|---------------------|------------------------------|----------------------|---------------------------|-------------------------|-----------------------|--------------------------|-------------------------|---------------------|
| •0518 | 34.30               | 23.3                         | 100.                 | •0                        | •000                    | •0                    | •000                     | 23.400                  | 15.900              |
| •0492 | 40.00               | 24.0                         | 103.                 |                           |                         |                       |                          | 24.103                  | 15.897              |
| •0468 | 40.50               | 24.7                         | 105.                 |                           |                         |                       |                          | 24.805                  | 15.695              |
| •0445 | 41.10               | 25.3                         | 108.                 |                           |                         |                       |                          | 25.408                  | 15.692              |
| •0424 | 41.60               | 25.9                         | 111.                 |                           |                         |                       |                          | 26.011                  | 15.589              |
| •0403 | 42.20               | 26.6                         | 114.                 |                           |                         |                       |                          | 26.714                  | 15.486              |
| •0383 | 42.90               | 27.2                         | 117.                 |                           |                         |                       |                          | 27.317                  | 15.583              |
| •0365 | 43.40               | 27.9                         | 120.                 |                           |                         |                       |                          | 28.020                  | 15.380              |
| •0347 | 43.90               | 28.7                         | 123.                 |                           |                         |                       |                          | 28.823                  | 15.077              |
| •0333 | 44.40               | 29.3                         | 126.                 |                           |                         |                       |                          | 29.426                  | 14.974              |
| •0314 | 45.00               | 30.1                         | 129.                 |                           |                         |                       |                          | 30.229                  | 14.771              |
| •0299 | 45.60               | 31.0                         | 133.                 |                           |                         |                       |                          | 31.133                  | 14.467              |
| •0284 | 46.20               | 31.9                         | 136.                 |                           |                         |                       |                          | 32.036                  | 14.164              |
| •0270 | 46.80               | 32.8                         | 139.                 |                           |                         |                       |                          | 32.939                  | 13.861              |
| •0257 | 47.40               | 33.6                         | 143.                 |                           |                         |                       |                          | 33.743                  | 13.657              |
| •0244 | 48.00               | 34.4                         | 146.                 |                           |                         |                       |                          | 34.546                  | 13.454              |
| •0233 | 48.70               | 35.2                         | 149.                 |                           |                         |                       |                          | 35.349                  | 13.351              |
| •0221 | 49.50               | 36.0                         | 153.                 |                           |                         |                       |                          | 36.153                  | 13.347              |
| •0210 | 50.20               | 36.9                         | 158.                 |                           |                         |                       |                          | 37.058                  | 13.142              |
| •0200 | 51.00               | 37.9                         | 162.                 |                           |                         |                       |                          | 38.062                  | 12.938              |
| •0190 | 51.80               | 38.8                         | 166.                 |                           |                         |                       |                          | 38.966                  | 12.834              |

In the range from 1100 ev to 0.2 Mev the total cross section was computed from the resonance parameters given below, as was the value at the peak of the 405 ev resonance, shown in the tables at 403 ev.

| Isotope | $E_0$              | $\Gamma_n^0$ | $\Gamma_\gamma$ | $\Gamma_p$ | $g$ | $\ell$ | Reference |
|---------|--------------------|--------------|-----------------|------------|-----|--------|-----------|
| 35      | - 210              | 1.38         | 0.5             | 0.0024     | 5/8 | 0      | 3         |
| 35      | 405                | 0.001888     | 0.5             | 0.070      | 5/8 | 1      | 3         |
| 35      | 1100               | 0.000169     | 0.5             | 0.050      | 5/8 | 1      | 3         |
| 35      | 4300               | 0.003965     | 0.5             | 0.035      | 5/8 | 1      | 3         |
| 37      | 8700               | 0.536        | 0.5             | 0          | 1/2 | 0      | 2         |
| 35      | 15 $\times 10^3$   | 0.245        | 0.5             | 0.10       | 1/2 | 0      | 3         |
| 35      | 17 $\times 10^3$   | 0.268        | 0.5             | 0.10       | 1/2 | 0      | 3         |
| -       | 25.5 $\times 10^3$ | 1.566        | 0.5             | 0          | 1/2 | 0      | 2         |
| 35      | 27 $\times 10^3$   | 1.065        | 0.5             | 0          | 1/2 | 0      | 2         |
| -       | 47 $\times 10^3$   | 1.617        | 0.5             | 0          | 1/2 | 0      | 2         |
| -       | 55 $\times 10^3$   | 0.235        | 0.5             | 0          | 1/2 | 0      | 2         |
| -       | 59 $\times 10^3$   | 0.371        | 0.5             | 0          | 1/2 | 0      | 2         |
| -       | 63 $\times 10^3$   | 0.339        | 0.5             | 0          | 1/2 | 0      | 2         |
| -       | 68.5 $\times 10^3$ | 0.478        | 0.5             | 0          | 1/2 | 0      | 2         |
| 35      | 102 $\times 10^3$  | 0.751        | 0.5             | 0          | 1/2 | 0      | 2         |
| 35      | 113 $\times 10^3$  | 1.487        | 0.5             | 0          | 1/2 | 0      | 2         |
| 37      | 125 $\times 10^3$  | 0.424        | 0.5             | 0          | 1/2 | 0      | 2         |
| 37      | 128 $\times 10^3$  | 0.839        | 0.5             | 0          | 1/2 | 0      | 2         |
| 35      | 135 $\times 10^3$  | 1.633        | 0.5             | 0          | 1/2 | 0      | 2         |
| 37      | 139 $\times 10^3$  | 2.146        | 0.5             | 0          | 1/2 | 0      | 2         |
| 35      | 143 $\times 10^3$  | 1.058        | 0.5             | 0          | 1/2 | 0      | 2         |
| 37      | 145 $\times 10^3$  | 3.808        | 0.5             | 0          | 1/2 | 0      | 2         |
| 37      | 159 $\times 10^3$  | 1.755        | 0.5             | 0          | 1/2 | 0      | 2         |
| 37      | 180 $\times 10^3$  | 2.593        | 0.5             | 0          | 1/2 | 0      | 2         |
| 35      | 190 $\times 10^3$  | 2.753        | 0.5             | 0          | 1/2 | 0      | 2         |
| 37      | 193 $\times 10^3$  | 1.480        | 0.5             | 0          | 1/2 | 0      | 2         |
| 35      | 202 $\times 10^3$  | 6.230        | 0.5             | 0          | 1/2 | 0      | 2         |

$\sigma_{\text{pot}} = 1.2$  b. Energies and widths are given in ev. Where isotopic assignments were made, the factor  $g$  was weighted by the isotopic abundance  $a$  in the calculations. Where there is no assignment,  $g$  was used without weighting.  $a(35) = 0.754$ ,  $a(37) = 0.246$ .

### 1.1.2 The (n, $\gamma$ ) Cross Section

The radiative capture cross section was measured by Meadows and Whalen<sup>4</sup> at 0.0253 ev. Their value is 34.2 barns. Popov and Shapiro,<sup>3,5</sup> whose parameters we have used for the lowest few resonances, use the value from BNL 325, 33.6 b. For consistency with the resonance calculations, we also have used 33.6 b at 0.025 ev. A  $1/v$  line was carried through this point to 2 ev and then faired into the cross-section curve calculated from the resonance parameters, finally coinciding with that curve at about 40 ev. The calculated curve was followed up to 0.21 Mev above which a  $1/E$  line was followed passing through 0.1 mb at about 0.3 Mev. The cross section was considered to go to zero at about 2 Mev because of competition with other reactions.

### 1.1.3 The (n,p) Cross Section

For neutron energies below about 18 kev, the (n,p) cross section was calculated from resonance parameters. Above this energy, we found only one measurement of  $\sigma_{n,p}$  in  $\text{Cl}^{35}$ , that of Scalan and Fink<sup>6</sup> at 14.8 Mev. To give an indication of the rising part of the cross section at high energies we have, therefore, adapted the curve of  $\sigma_{n,p}$  in phosphorus given in BNL 325.<sup>1</sup> Phosphorus is an odd-odd nucleus, as is  $\text{Cl}^{35}$ . In addition, the Q value for the reaction in phosphorus is not vastly different from the corresponding Q in chlorine so that the competition due to neutron emission does not lead to very different level densities. Ashby and Catron<sup>7</sup> give -0.7025 Mev as the Q for the (n,p) reaction in phosphorus and +0.6139 Mev in  $\text{Cl}^{35}$ . Thus, the steep rise in the  $\sigma_{n,p}$  curve in  $\text{Cl}^{35}$  should appear at an energy about 1.3 Mev below that at which it appears in P. Accordingly, we have used a smoothed version of the  $\sigma_{n,p}$  curve for P shifted in energy so that it rises most steeply at about 0.5 Mev and becomes flat at about 4.5 Mev, remaining so until about 8 Mev. The curve was then brought down through Scalan and Fink's point at 14.8 Mev. For inclusion in this compilation the values had, of course, to be weighted by 0.754, the abundance of  $\text{Cl}^{35}$  in natural Cl. In the range between 18 kev and about 0.5 Mev, a  $1/E$  curve was used which passed through 0.13 mb at 20 kev.

BNL 325<sup>1</sup> shows a curve of  $\sigma_{n,p}$  in  $\text{Cl}^{37}$  rising sharply at about 12 Mev, and Scalan and Fink<sup>6</sup> have measured this cross section at 14.8 Mev. These values are in good agreement and were included in the tabulations weighted by the abundance of  $\text{Cl}^{37}$ .

#### 1.1.4 The (n, $\alpha$ ) Cross Section

In the range from 3 to 4 Mev, data for the (n, $\alpha$ ) cross section in  $\text{Cl}^{35}$  came from BNL 325.<sup>1</sup> The gap between this steeply rising part of the curve and the point at 14.8 Mev measured by Scalan and Fink<sup>6</sup> was bridged by a curve which rises to a peak at about 8 Mev and descends again at higher energies.

The only measurement found of  $\sigma_{n,\alpha}$  in  $\text{Cl}^{37}$  is that of Scalan and Fink<sup>6</sup> at 14.8 Mev. From examination of the Q values of Ashby and Catron<sup>7</sup> for (n,p) and (n, $\alpha$ ) reactions in nearby odd-odd nuclides, we concluded that the (n, $\alpha$ ) reaction could be expected to appear about 1 Mev below the (n,p) reaction. Accordingly, we have drawn the curve for  $\sigma_{n,\alpha}$  starting at about 11 Mev and passing through Scalan and Fink's point at 14.8 Mev.

#### 1.1.5 The (n,2n) Cross Section

Scalan and Fink<sup>6</sup> have measured cross sections for the (n,2n) reaction leading to the ground state of  $\text{Cl}^{34}$  and to the 32.4 minute isomer. The sum of these has been taken to be the (n,2n) cross section in  $\text{Cl}^{35}$ . Ashby and Catron<sup>7</sup> give the Q value for the (n,2n) reaction in  $\text{Cl}^{35}$  as -12.5 Mev. We have taken 12.5 Mev as the threshold for the reaction and have drawn a curve through Scalan and Fink's point. The Q value for (n,2n) in  $\text{Cl}^{37}$  is -10.3 Mev,<sup>7</sup> and no measurement of  $\sigma_{n,2n}$  in this isotope was found in the literature. Because of this and because  $\text{Cl}^{37}$  is also three times less abundant than  $\text{Cl}^{35}$ , we have taken  $\sigma_{n,2n}$  in  $\text{Cl}^{35}$  to be  $\sigma_{n,2n}$  in natural chlorine.

#### 1.1.6 The (n,n') and (n,x) Cross Sections

No measurements of inelastic scattering of neutrons by chlorine were found. In the range from 4 to 11 Mev, values of the elastic scattering cross section were

taken from the work of Longley<sup>8</sup> and subtracted from values of the total cross section from BNL 325.<sup>1</sup> The resulting nonelastic cross section was extended to lower energies by assuming it to be equal to the (n,p) cross section at 1 Mev. It was assumed to be constant at 1 b above 11 Mev.

The Landolt-Börnstein tables<sup>9</sup> show the first excited level in Cl<sup>35</sup> at 1.22 Mev and that in Cl<sup>37</sup> at 0.838 Mev. The spin and parity assignments, however, are insufficient to permit Hauser-Feshbach calculations of cross sections for the excitation of individual levels. We therefore have taken the total inelastic scattering cross section to be the difference between the nonelastic cross section described above and the sum of the cross sections for all of the other nonelastic reactions. In the region around 12 Mev, however, this technique led to a rise in  $\sigma_{n,n'}$  which we considered to be very unlikely behavior. Therefore, we led the  $\sigma_{n,n'}$  curve smoothly downward and ascribed that part of  $\sigma_{n,x}$  to the appearance of a charged particle reaction for which no measurements were available. It should be mentioned here that the use of Longley's<sup>8</sup> values of  $\sigma_n$  and the BNL 325<sup>1</sup> values of  $\sigma_T$  gives a rising curve of  $\sigma_{n,x}$  in this range, making the situation worse rather than better.

Table 2 displays the cross section for inelastic scattering of neutrons from energy E to energy E'. It was calculated using a complete statistical assumption<sup>10</sup> and the following parameters:

$E_1 = 1.0$  Mev, energy of first level

$E_0 = 4.0$  Mev, energy of transition to exponential density of levels

$B = 1.0/\text{Mev}$ , level density for  $E_1 \geq E \geq E_0$

$a = 3.6/\text{Mev}$ , level density parameter for exponential distribution

density =  $\exp(\sqrt{2aE})$  for  $E > E_1$ .

The spectrum of gamma rays following inelastic neutron scattering was computed using Troubetzkoy's statistical theory<sup>11</sup> as embodied in the GRAINS computer program. The same level density parameters were used as for the neutron spectrum. This spectrum is shown in Table 3.

Table 2 — Chlorine — Cross Sections for the Production of Inelastic Neutrons

| E, Mev | $\sigma_{n,n'}$<br>barns | $\sigma_{n,n'}(E,E')$ , barns/Mev, for $E'$ given in Mev |       |       |       |       |       |       |       |        |
|--------|--------------------------|----------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|--------|
|        |                          | 0.5                                                      | 1.0   | 1.5   | 2.0   | 3.0   | 4.0   | 6.0   | 8.0   | 10.0   |
| 18.0   | .704                     | .0683                                                    | .1063 | .1295 | .1360 | .1257 | .1021 | .0533 | .0228 | .00803 |
| 17.1   | .707                     | .0728                                                    | .1110 | .1341 | .1404 | .1301 | .1025 | .0516 | .0209 | .00672 |
| 16.3   | .710                     | .0774                                                    | .1186 | .1399 | .1444 | .1310 | .1019 | .0497 | .0192 | .00604 |
| 15.5   | .716                     | .0809                                                    | .1242 | .1453 | .1504 | .1337 | .1020 | .0474 | .0174 | .00487 |
| 14.75  | .720                     | .0864                                                    | .1310 | .1511 | .1553 | .1359 | .1033 | .0451 | .0153 | .00396 |
| 14.0   | .724                     | .0883                                                    | .1372 | .1583 | .1596 | .1376 | .1022 | .0431 | .0135 | .00398 |
| 13.3   | .735                     | .0948                                                    | .1444 | .1659 | .1658 | .1402 | .1014 | .0406 | .0118 | .00478 |
| 12.7   | .742                     | .1005                                                    | .1517 | .1704 | .1707 | .1419 | .1011 | .0384 | .0102 | .00742 |
| 12.1   | .755                     | .1031                                                    | .1582 | .1784 | .1765 | .1438 | .1004 | .0362 | .0089 | .01004 |
| 11.5   | .773                     | .1098                                                    | .1687 | .1863 | .1837 | .1465 | .1001 | .0335 | .0118 | .01507 |
| 10.9   | .788                     | .1170                                                    | .1761 | .1942 | .1886 | .1475 | .0982 | .0307 | .0182 | .0     |
| 10.4   | .804                     | .1246                                                    | .1837 | .2006 | .1942 | .1479 | .0961 | .0280 | .0257 |        |
| 9.89   | .829                     | .1409                                                    | .1990 | .2096 | .1983 | .1492 | .0942 | .0279 | .0372 |        |
| 9.41   | .856                     | .1370                                                    | .2026 | .2156 | .2050 | .1481 | .0912 | .0394 | .0529 |        |
| 8.95   | .894                     | .1395                                                    | .2110 | .2235 | .2092 | .1489 | .0872 | .0561 | .0745 |        |
| 8.51   | .923                     | .1495                                                    | .2178 | .2294 | .2123 | .1463 | .0840 | .0785 | .0    |        |
| 8.10   | .944                     | .1510                                                    | .2209 | .2275 | .2084 | .1397 | .0774 | .1051 |       |        |
| 7.70   | .974                     | .1544                                                    | .2179 | .2242 | .2023 | .1321 | .0934 | .1400 |       |        |
| 7.33   | .995                     | .1522                                                    | .2169 | .2219 | .1985 | .1261 | .1224 | .1846 |       |        |
| 6.97   | 1.008                    | .1502                                                    | .2082 | .2097 | .1852 | .1220 | .1542 | .2319 |       |        |
| 6.63   | 1.002                    | .1463                                                    | .1987 | .1974 | .1713 | .1445 | .1924 | .0    |       |        |
| 6.30   | .998                     | .1337                                                    | .1823 | .1788 | .1524 | .1634 | .2211 |       |       |        |
| 6.00   | .975                     | .1214                                                    | .1626 | .1576 | .1380 | .1989 | .2652 |       |       |        |
| 5.70   | .948                     | .1119                                                    | .1474 | .1416 | .1564 | .2335 | .3113 |       |       |        |
| 5.43   | .924                     | .1044                                                    | .1337 | .1349 | .1800 | .2700 | .3600 |       |       |        |
| 5.16   | .893                     | .0996                                                    | .1143 | .1482 | .1982 | .2869 | .3964 |       |       |        |
| 4.91   | .850                     | .0886                                                    | .1016 | .1655 | .2203 | .3315 | .0    |       |       |        |
| 4.67   | .836                     | .0711                                                    | .1212 | .1822 | .2430 | .3647 |       |       |       |        |
| 4.44   | .820                     | .0686                                                    | .1378 | .2075 | .2604 | .3905 |       |       |       |        |
| 4.23   | .803                     | .0779                                                    | .1555 | .2345 | .3120 | .4590 |       |       |       |        |
| 4.02   | .784                     | .0847                                                    | .1693 | .2532 | .3371 | .5057 |       |       |       |        |
| 3.82   | .767                     | .0964                                                    | .1929 | .2893 | .3858 | .0    |       |       |       |        |
| 3.64   | .749                     | .1075                                                    | .2149 | .3224 | .4299 |       |       |       |       |        |
| 3.46   | .728                     | .1203                                                    | .2406 | .3609 | .4812 |       |       |       |       |        |
| 3.29   | .699                     | .1333                                                    | .2666 | .3999 | .5332 |       |       |       |       |        |
| 3.13   | .674                     | .1486                                                    | .2971 | .4457 | .5942 |       |       |       |       |        |
| 2.97   | .649                     | .1672                                                    | .3345 | .5017 | .0    |       |       |       |       |        |
| 2.83   | .625                     | .1866                                                    | .3733 | .5599 |       |       |       |       |       |        |
| 2.69   | .597                     | .2090                                                    | .4181 | .6271 |       |       |       |       |       |        |
| 2.56   | .578                     | .2375                                                    | .4750 | .7125 |       |       |       |       |       |        |
| 2.44   | .561                     | .2705                                                    | .5411 | .0    |       |       |       |       |       |        |
| 2.32   | .540                     | .3099                                                    | .6198 |       |       |       |       |       |       |        |
| 2.21   | .518                     | .3538                                                    | .7076 |       |       |       |       |       |       |        |
| 2.10   | .492                     | .4066                                                    | .8132 |       |       |       |       |       |       |        |
| 2.00   | .464                     | .4640                                                    | .0    |       |       |       |       |       |       |        |
| 1.90   | .430                     | .5309                                                    |       |       |       |       |       |       |       |        |
| 1.81   | .393                     | .5990                                                    |       |       |       |       |       |       |       |        |
| 1.72   | .354                     | .6829                                                    |       |       |       |       |       |       |       |        |
| 1.63   | .335                     | .8440                                                    |       |       |       |       |       |       |       |        |
| 1.55   | .314                     | 1.0380                                                   |       |       |       |       |       |       |       |        |
| 1.48   | .294                     | .0                                                       |       |       |       |       |       |       |       |        |

**Table 3 — Chlorine — Cross Sections for Gamma Ray Production Following Neutron Inelastic Scattering**

| $\sigma_{n,n'}(E, E_\gamma)$ , barns, for $E_\gamma$ between Group Boundaries, given in Mev |                          |      |       |        |        |       |       |       |       |        |        |
|---------------------------------------------------------------------------------------------|--------------------------|------|-------|--------|--------|-------|-------|-------|-------|--------|--------|
| $E$ , Mev                                                                                   | $\sigma_{n,n'}$<br>barns | 0-.5 | .5-1. | 1.-1.5 | 1.5-2. | 2.-3. | 3.-4. | 4.-6. | 6.-8. | 8.-10. | 10.-18 |
| 18.0                                                                                        | .704                     | .001 | .014  | .134   | .115   | .210  | .206  | .425  | .346  | .208   | .172   |
| 17.1                                                                                        | .707                     | .001 | .014  | .134   | .115   | .206  | .198  | .404  | .326  | .195   | .163   |
| 16.3                                                                                        | .710                     | .001 | .014  | .134   | .114   | .202  | .191  | .384  | .307  | .185   | .156   |
| 15.5                                                                                        | .716                     | .001 | .014  | .134   | .114   | .198  | .184  | .364  | .289  | .177   | .149   |
| 14.75                                                                                       | .720                     | .001 | .013  | .135   | .113   | .194  | .176  | .343  | .272  | .173   | .139   |
| 14.0                                                                                        | .724                     | .001 | .013  | .135   | .112   | .189  | .167  | .321  | .258  | .172   | .127   |
| 13.3                                                                                        | .735                     | .001 | .013  | .136   | .112   | .186  | .160  | .304  | .250  | .176   | .109   |
| 12.7                                                                                        | .742                     | .001 | .013  | .137   | .112   | .182  | .153  | .289  | .246  | .179   | .090   |
| 12.1                                                                                        | .755                     | .001 | .013  | .140   | .113   | .181  | .147  | .277  | .248  | .180   | .069   |
| 11.5                                                                                        | .773                     | .001 | .014  | .143   | .114   | .179  | .142  | .270  | .256  | .177   | .046   |
| 10.9                                                                                        | .788                     | .001 | .014  | .146   | .116   | .178  | .138  | .267  | .265  | .165   | .023   |
| 10.4                                                                                        | .804                     | .001 | .014  | .150   | .118   | .178  | .135  | .271  | .272  | .149   | .006   |
| 9.89                                                                                        | .829                     | .001 | .014  | .156   | .122   | .180  | .136  | .282  | .276  | .118   | .000   |
| 9.41                                                                                        | .856                     | .001 | .015  | .162   | .126   | .185  | .139  | .296  | .274  | .082   |        |
| 8.94                                                                                        | .894                     | .001 | .015  | .172   | .133   | .194  | .146  | .315  | .266  | .049   |        |
| 8.51                                                                                        | .923                     | .001 | .016  | .181   | .140   | .204  | .154  | .328  | .247  | .018   |        |
| 8.10                                                                                        | .944                     | .001 | .017  | .190   | .147   | .215  | .163  | .334  | .212  | .001   |        |
| 7.70                                                                                        | .974                     | .001 | .018  | .202   | .156   | .230  | .174  | .335  | .162  | .000   |        |
| 7.33                                                                                        | .995                     | .001 | .019  | .214   | .166   | .245  | .184  | .325  | .115  |        |        |
| 6.97                                                                                        | 1.008                    | .001 | .020  | .225   | .176   | .261  | .190  | .306  | .071  |        |        |
| 6.63                                                                                        | 1.002                    | .001 | .020  | .234   | .183   | .272  | .191  | .277  | .034  |        |        |
| 6.30                                                                                        | .998                     | .001 | .021  | .243   | .192   | .283  | .190  | .240  | .001  |        |        |
| 6.00                                                                                        | .975                     | .001 | .021  | .248   | .196   | .287  | .183  | .193  | .000  |        |        |
| 5.70                                                                                        | .948                     | .001 | .021  | .252   | .200   | .289  | .172  | .143  |       |        |        |
| 5.43                                                                                        | .924                     | .001 | .022  | .256   | .203   | .289  | .162  | .104  |       |        |        |
| 5.16                                                                                        | .893                     | .001 | .022  | .258   | .204   | .285  | .148  | .070  |       |        |        |
| 4.91                                                                                        | .850                     | .001 | .021  | .256   | .201   | .274  | .133  | .044  |       |        |        |
| 4.67                                                                                        | .836                     | .001 | .022  | .262   | .205   | .272  | .121  | .025  |       |        |        |
| 4.44                                                                                        | .820                     | .001 | .022  | .267   | .207   | .267  | .108  | .011  |       |        |        |
| 4.23                                                                                        | .803                     | .001 | .022  | .272   | .209   | .260  | .093  | .003  |       |        |        |
| 4.02                                                                                        | .784                     | .001 | .023  | .277   | .210   | .251  | .074  | .000  |       |        |        |
| 3.82                                                                                        | .767                     | .001 | .023  | .282   | .212   | .242  | .054  |       |       |        |        |
| 3.64                                                                                        | .749                     | .001 | .023  | .288   | .212   | .231  | .037  |       |       |        |        |
| 3.46                                                                                        | .728                     | .001 | .023  | .293   | .212   | .217  | .022  |       |       |        |        |
| 3.29                                                                                        | .699                     | .001 | .023  | .295   | .209   | .197  | .010  |       |       |        |        |
| 3.13                                                                                        | .674                     | .001 | .023  | .298   | .206   | .176  | .002  |       |       |        |        |
| 2.97                                                                                        | .649                     | .001 | .023  | .303   | .204   | .148  | .000  |       |       |        |        |
| 2.83                                                                                        | .625                     | .001 | .023  | .307   | .200   | .122  |       |       |       |        |        |
| 2.69                                                                                        | .597                     | .001 | .023  | .311   | .194   | .095  |       |       |       |        |        |
| 2.56                                                                                        | .578                     | .001 | .023  | .318   | .190   | .071  |       |       |       |        |        |
| 2.44                                                                                        | .561                     | .001 | .023  | .327   | .184   | .050  |       |       |       |        |        |
| 2.32                                                                                        | .540                     | .001 | .024  | .335   | .174   | .030  |       |       |       |        |        |
| 2.21                                                                                        | .518                     | .001 | .024  | .342   | .161   | .015  |       |       |       |        |        |
| 2.10                                                                                        | .492                     | .001 | .024  | .348   | .141   | .007  |       |       |       |        |        |
| 2.00                                                                                        | .464                     | .001 | .024  | .349   | .115   | .000  |       |       |       |        |        |
| 1.90                                                                                        | .430                     | .001 | .025  | .346   | .084   |       |       |       |       |        |        |
| 1.81                                                                                        | .393                     | .000 | .025  | .336   | .057   |       |       |       |       |        |        |
| 1.72                                                                                        | .354                     | .000 | .025  | .321   | .033   |       |       |       |       |        |        |
| 1.63                                                                                        | .335                     | .000 | .027  | .320   | .014   |       |       |       |       |        |        |
| 1.55                                                                                        | .314                     | .000 | .029  | .311   | .009   |       |       |       |       |        |        |
| 1.48                                                                                        | .294                     | .000 | .031  | .293   | .000   |       |       |       |       |        |        |
| 1.41                                                                                        | .270                     | .000 | .033  | .269   |        |       |       |       |       |        |        |
| 1.34                                                                                        | .243                     | .000 | .036  | .242   |        |       |       |       |       |        |        |
| 1.27                                                                                        | .210                     | .000 | .039  | .208   |        |       |       |       |       |        |        |
| 1.21                                                                                        | .176                     | .000 | .042  | .174   |        |       |       |       |       |        |        |
| 1.15                                                                                        | .139                     | .000 | .046  | .139   |        |       |       |       |       |        |        |
| 1.096                                                                                       | .097                     | .000 | .050  | .095   |        |       |       |       |       |        |        |
| 1.042                                                                                       | .047                     | .000 | .047  | .039   |        |       |       |       |       |        |        |

### 1.1.7 The (n,d) Cross Section

Ashby and Catron<sup>7</sup> give the Q value for the (n,d) reaction in Cl<sup>35</sup> as -4.14 Mev and, in Cl<sup>37</sup>, as -6.17 Mev. No measurements of cross sections for this reaction were found in the literature. We have ascribed the extra part of  $\sigma_{n,x}$  to this reaction. That the cross section rises steeply at about 11 Mev, rather than about 4 Mev as given by the Q value for (n,d) in Cl<sup>35</sup>, is not implausible. Coulomb barrier effects and competition of the (n,p) and (n, $\alpha$ ) reactions both may be expected to inhibit the (n,d) reaction for some distance above its threshold.

### 1.1.8 The Elastic Scattering Cross Section, $\sigma_n$

In the range of incident neutron energies from 4 to 11 Mev values of  $\sigma_n$  were taken from the work of Longley.<sup>8</sup> Elsewhere the relation  $\sigma_n = \sigma_T - \sigma_{n,x}$  was used.

## 1.2 ANGULAR DISTRIBUTION OF ELASTICALLY SCATTERED NEUTRONS

Guseinov and Nikolaev<sup>12</sup> show the angular distribution of fast neutrons elastically scattered from chlorine to be similar to that from potassium. We, therefore, have used the Legendre coefficients for potassium from UNC-5002.<sup>13</sup> (See Table 4.)

## 1.3 GAMMA RAYS FROM NEUTRON CAPTURE

Groshev<sup>14</sup> lists 31 gamma rays emitted in the capture of thermal neutrons by chlorine. These are listed below. We have assumed that the spectrum of gammas is independent of the energy of the captured neutron.

| $E_\gamma$ , Mev | Intensity,<br>% | $E_\gamma$ , Mev | Intensity,<br>% | $E_\gamma$ , Mev | Intensity,<br>% |
|------------------|-----------------|------------------|-----------------|------------------|-----------------|
| 8.58             | 2.8             | 4.79             | 1.9             | 2.88             | 9.5             |
| 7.79             | 7.8             | 4.64             | 2.3             | 2.83             | 2.              |
| 7.42             | 14.             | 4.50             | 2.2             | 2.71             | 2.              |
| 6.99             | 1.9             | 4.15             | 2.3             | 2.51             | 1.              |
| 6.64             | 14.4            | 4.05             | 2.1             | 1.95             | 29.             |
| 6.11             | 21.4            | 3.90             | 1.8             | 1.72             | 1.              |
| 5.72             | 5.6             | 3.63             | 2.9             | 1.67             | 1.              |
| 5.50             | 2.              | 3.40             | 3.6             | 1.60             | 2.4             |
| 5.28             | 1.6             | 3.08             | 4.5             | 1.165            | 36.             |
| 4.98             | 6.              | 3.02             | 3.5             | 0.79             | 23.             |
|                  |                 |                  |                 | 0.51             | <26.            |

Table 4 --- Chlorine -- Legendre Expansion Coefficients for the Angular Distribution of  
Elastically Scattered Neutrons

| E, Mev | f <sub>1</sub> | f <sub>2</sub> | f <sub>3</sub> | f <sub>4</sub> | f <sub>5</sub> | f <sub>6</sub> | f <sub>7</sub> | f <sub>8</sub> |
|--------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| 18.00  | .721           | .571           | .437           | .384           | .314           | .261           | .222           | .135           |
| 17.10  | .718           | .568           | .442           | .385           | .312           | .259           | .216           | .128           |
| 16.30  | .716           | .566           | .448           | .386           | .308           | .256           | .209           | .120           |
| 15.50  | .715           | .565           | .456           | .385           | .303           | .253           | .202           | .110           |
| 14.75  | .715           | .564           | .463           | .384           | .296           | .248           | .193           | .098           |
| 14.00  | .715           | .564           | .467           | .380           | .288           | .233           | .182           | .082           |
| 13.30  | .715           | .563           | .467           | .370           | .272           | .214           | .167           | .066           |
| 12.70  | .716           | .564           | .461           | .356           | .248           | .195           | .151           | .050           |
| 12.10  | .720           | .565           | .451           | .342           | .226           | .176           | .134           | .040           |
| 11.50  | .732           | .567           | .443           | .328           | .204           | .160           | .112           | .033           |
| 10.90  | .744           | .571           | .437           | .316           | .184           | .144           | .092           | .026           |
| 10.40  | .754           | .577           | .431           | .304           | .172           | .130           | .077           | .022           |
| 9.89   | .762           | .581           | .427           | .288           | .161           | .118           | .064           | .018           |
| 9.41   | .770           | .586           | .423           | .270           | .152           | .107           | .054           | .015           |
| 8.95   | .776           | .589           | .420           | .258           | .141           | .096           | .046           | .012           |
| 8.51   | .779           | .592           | .416           | .239           | .131           | .086           | .039           | .010           |
| 8.10   | .780           | .593           | .412           | .221           | .120           | .076           | .032           | .009           |
| 7.70   | .781           | .593           | .407           | .193           | .110           | .068           | .025           | .008           |
| 7.33   | .780           | .591           | .400           | .169           | .100           | .060           | .019           | .006           |
| 6.97   | .778           | .587           | .392           | .140           | .090           | .053           | .014           | .005           |
| 6.63   | .725           | .554           | .378           | .119           | .081           | .046           | .010           | .003           |
| 6.30   | .668           | .514           | .340           | .103           | .071           | .039           | .007           | .002           |
| 6.00   | .640           | .480           | .297           | .092           | .062           | .033           | .004           | .002           |
| 5.70   | .599           | .450           | .272           | .085           | .053           | .027           | .002           | .001           |
| 5.43   | .560           | .430           | .252           | .080           | .045           | .022           | .000           | .001           |
| 5.16   | .520           | .413           | .233           | .076           | .039           | .017           | .000           | .000           |
| 4.91   | .491           | .399           | .218           | .072           | .033           | .013           | —              | —              |
| 4.67   | .455           | .386           | .202           | .068           | .028           | .010           | —              | —              |
| 4.44   | .423           | .374           | .185           | .065           | .023           | .007           | —              | —              |
| 4.23   | .397           | .364           | .170           | .061           | .019           | .005           | —              | —              |
| 4.02   | .370           | .352           | .156           | .058           | .016           | .004           | —              | —              |
| 3.82   | .342           | .341           | .142           | .055           | .013           | .003           | —              | —              |
| 3.64   | .323           | .332           | .130           | .052           | .010           | .002           | —              | —              |
| 3.46   | .310           | .321           | .116           | .049           | .007           | .002           | —              | —              |
| 3.29   | .295           | .312           | .104           | .046           | .004           | .001           | .000           | .000           |

Table A — (Continued)

| E, Mev | f <sub>1</sub> | f <sub>2</sub> | f <sub>3</sub> | f <sub>4</sub> | f <sub>5</sub> | f <sub>6</sub> | f <sub>7</sub> | f <sub>8</sub> |
|--------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| 3.13   | .283           | .303           | .094           | .044           | .002           | .001           |                |                |
| 2.97   | .267           | .294           | .084           | .041           | .001           | .001           |                |                |
| 2.83   | .260           | .286           | .074           | .039           | -.001          | .001           |                |                |
| 2.69   | .248           | .277           | .066           | .036           | -.002          | .000           |                |                |
| 2.56   | .240           | .269           | .058           | .034           | -.002          |                |                |                |
| 2.44   | .230           | .261           | .052           | .032           | -.002          |                |                |                |
| 2.32   | .222           | .253           | .045           | .030           | -.003          |                |                |                |
| 2.21   | .216           | .246           | .038           | .028           | -.003          |                |                |                |
| 2.10   | .207           | .238           | .029           | .026           | -.003          |                |                |                |
| 2.00   | .201           | .230           | .022           | .024           | -.003          |                |                |                |
| 1.90   | .195           | .225           | .014           | .023           | -.002          |                |                |                |
| 1.81   | .190           | .219           | .005           | .022           | -.002          |                |                |                |
| 1.72   | .182           | .210           | -.001          | .022           | -.002          |                |                |                |
| 1.63   | .180           | .207           | -.004          | .022           | -.002          |                |                |                |
| 1.55   | .178           | .201           | -.007          | .022           | -.002          |                |                |                |
| 1.48   | .177           | .199           | -.010          | .022           | -.001          |                |                |                |
| 1.41   | .177           | .197           | -.010          | .021           | -.001          |                |                |                |
| 1.34   | .180           | .194           | -.009          | .021           | -.001          |                |                |                |
| 1.27   | .210           | .191           | -.008          | .020           | -.001          |                |                |                |
| 1.21   | .228           | .189           | -.008          | .020           | -.001          |                |                |                |
| 1.15   | .240           | .188           | -.007          | .019           | -.001          |                |                |                |
| 1.096  | .238           | .185           | -.006          | .018           | -.001          |                |                |                |
| 1.042  | .232           | .183           | -.004          | .018           | -.000          |                |                |                |
| E, kev |                |                |                |                |                |                |                |                |
| 991.00 | .210           | .180           | .000           | .016           |                |                |                |                |
| 943.00 | .190           | .175           | .001           | .015           |                |                |                |                |
| 897.00 | .180           | .167           | .002           | .013           |                |                |                |                |
| 853.00 | .163           | .159           | .001           | .011           |                |                |                |                |
| 812.00 | .150           | .140           | .000           | .010           |                |                |                |                |
| 772.00 | .130           | .113           | -.001          | .009           |                |                |                |                |
| 734.00 | .115           | .095           | -.002          | .008           |                |                |                |                |
| 699.00 | .085           | .092           | -.005          | .007           |                |                |                |                |
| 666.00 | .050           | .100           | -.006          | .006           |                |                |                |                |
| 632.00 | .040           | .108           | -.006          | .006           |                |                |                |                |
| 601.00 | .058           | .107           | -.005          | .005           |                |                |                |                |
| 572.00 | .085           | .102           | -.005          | .004           |                |                |                |                |

Table 4 — (Continued)

| E, kev | f <sub>1</sub> | f <sub>2</sub> | f <sub>3</sub> | f <sub>4</sub> | f <sub>5</sub> | f <sub>6</sub> | f <sub>7</sub> | f <sub>8</sub> |
|--------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| 544.00 | .115           | .100           | -.005          | .004           | .000           | .000           | .000           | .000           |
| 518.00 | .128           | .091           | -.005          | .003           |                |                |                |                |
| 492.00 | .135           | .085           | -.005          | .003           |                |                |                |                |
| 468.00 | .137           | .080           | -.005          | .002           |                |                |                |                |
| 445.00 | .134           | .073           | -.004          | .002           |                |                |                |                |
| 424.00 | .130           | .067           | -.004          | .002           |                |                |                |                |
| 403.00 | .124           | .062           | -.004          | .001           |                |                |                |                |
| 383.00 | .122           | .060           | -.003          | .001           |                |                |                |                |
| 365.00 | .120           | .055           | -.003          | .001           |                |                |                |                |
| 347.00 | .117           | .050           | -.002          | .001           |                |                |                |                |
| 330.00 | .115           | .046           | -.002          | .000           |                |                |                |                |
| 314.00 | .113           | .042           | -.002          |                |                |                |                |                |
| 299.00 | .112           | .040           | -.001          |                |                |                |                |                |
| 284.00 | .110           | .038           | -.001          |                |                |                |                |                |
| 270.00 | .109           | .035           | -.001          |                |                |                |                |                |
| 257.00 | .107           | .032           | .000           |                |                |                |                |                |
| 244.00 | .105           | .029           |                |                |                |                |                |                |
| 233.00 | .098           | .026           |                |                |                |                |                |                |
| 221.00 | .091           | .024           |                |                |                |                |                |                |
| 210.00 | .085           | .021           |                |                |                |                |                |                |
| 200.00 | .080           | .020           |                |                |                |                |                |                |
| 190.00 | .071           | .019           |                |                |                |                |                |                |
| 181.00 | .064           | .017           |                |                |                |                |                |                |
| 172.00 | .057           | .016           |                |                |                |                |                |                |
| 163.00 | .048           | .014           |                |                |                |                |                |                |
| 155.00 | .042           | .012           |                |                |                |                |                |                |
| 148.00 | .038           | .011           |                |                |                |                |                |                |
| 141.00 | .032           | .010           |                |                |                |                |                |                |
| 134.00 | .028           | .009           |                |                |                |                |                |                |
| 127.00 | .022           | .008           |                |                |                |                |                |                |
| 121.00 | .018           | .007           |                |                |                |                |                |                |
| 115.00 | .016           | .006           |                |                |                |                |                |                |
| 109.60 | .013           | .006           |                |                |                |                |                |                |
| 104.20 | .011           | .005           |                |                |                |                |                |                |
| 99.10  | .009           | .004           |                |                |                |                |                |                |
| 94.30  | .008           | .004           |                |                |                |                |                |                |

Table 4 — (Continued)

| E, kev | $f_1$ | $f_2$ | $f_3$ | $f_4$ | $f_5$ | $f_6$ | $f_7$ | $f_8$ |
|--------|-------|-------|-------|-------|-------|-------|-------|-------|
| 89.70  | .007  | .003  | .000  | .000  | .000  | .000  | .000  | .000  |
| 85.30  | .006  | .003  |       |       |       |       |       |       |
| 81.20  | .005  | .003  |       |       |       |       |       |       |
| 77.20  | .005  | .002  |       |       |       |       |       |       |
| 73.40  | .004  | .002  |       |       |       |       |       |       |
| 69.90  | .004  | .002  |       |       |       |       |       |       |
| 66.60  | .003  | .001  |       |       |       |       |       |       |
| 63.20  | .003  | .001  |       |       |       |       |       |       |
| 60.10  | .003  | .001  |       |       |       |       |       |       |
| 57.20  | .002  | .001  |       |       |       |       |       |       |
| 54.40  | .002  | .001  |       |       |       |       |       |       |
| 51.80  | .002  | .001  |       |       |       |       |       |       |
| 49.20  | .002  | .001  |       |       |       |       |       |       |
| 46.80  | .002  | .000  |       |       |       |       |       |       |
| 44.50  | .001  |       |       |       |       |       |       |       |
| 42.40  | .001  |       |       |       |       |       |       |       |
| 40.30  | .001  |       |       |       |       |       |       |       |
| 38.30  | .001  |       |       |       |       |       |       |       |
| 36.50  | .001  |       |       |       |       |       |       |       |
| 34.70  | .001  |       |       |       |       |       |       |       |
| 33.00  | .001  |       |       |       |       |       |       |       |
| 31.40  | .001  |       |       |       |       |       |       |       |
| 29.90  | .001  |       |       |       |       |       |       |       |
| 28.40  | .001  |       |       |       |       |       |       |       |
| 27.00  | .001  |       |       |       |       |       |       |       |
| 25.70  | .001  |       |       |       |       |       |       |       |
| 24.40  | .001  |       |       |       |       |       |       |       |
| 23.30  | .001  |       |       |       |       |       |       |       |
| 22.10  | .001  |       |       |       |       |       |       |       |
| 21.00  | .001  |       |       |       |       |       |       |       |
| 20.00  | .001  |       |       |       |       |       |       |       |
| 19.00  | .001  |       |       |       |       |       |       |       |
| 18.10  | .001  |       |       |       |       |       |       |       |
| 17.20  | .001  |       |       |       |       |       |       |       |
| 16.30  | .000  |       |       |       |       |       |       |       |

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