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LIBMOD -- A FORTRAN-IV PROGRAM FOR MODIFICATION OR
CREATION OF INCITE CROSS SECTION LIBRARIES

IDAHO NUCLEAR CORPORATION
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LIBMOD -- A FORTRAN-IV Program For Modification
Or Creation Of INCITE Cross Section Libraries

By

R. L. Curtis and R. A. Grimesey

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ABSTRACT

The LIBMOD code has been written to satisfy the need for a general means of updating the cross section library used by the INCITE code. The required procedures as well as the equations involved in creating and modifying the cross section data are described in detail. The program contains logic to process absorption, fission, and elastic and inelastic scattering cross section data. In addition, logic has been provided for the calculation of total scattering cross sections from differential scattering data, slowing down sources into the thermal energy range assuming a $1/E$ flux above the upper cutoff energy, and gas model differential scattering data utilizing either the Wigner-Wilkins or Brown and St. John prescriptions. The present version of the code is set up to handle the zeroth and first Legendre moments of the scattering cross sections and sources.

The LIBMOD code is written in the FORTRAN-IV language and versions have been written for both the IBM-360/75 and the IBM-7040 digital computers.

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I. INTRODUCTION

Due to the continuous improvement of cross section measurement techniques and the ensuing changes in cross section data, it is mandatory to have some method available for the user of the INCITE^[1] code to modify the cross section library tape. The LIBMOD code provides the user with a flexible means of creating, modifying, making additions to, deleting, mixing, editing, merging or listing cross section data on existing INCITE library tapes or creating and listing cross sections on a completely new INCITE library tape.

Several options are available for the creation and placement of cross section data on a library tape for use specifically by INCITE. The LIBMOD code has been provided with logic to calculate $1/V$ absorption or fission cross sections from an input cross section and its corresponding energy, total scattering cross sections from differential scattering data, slowing down sources into the thermal energy range assuming a $1/E$ flux above the upper cutoff energy, and free gas model differential scattering data utilizing either the Wigner-Wilkins or Brown and St. John prescriptions.

II. OPERATION OF CODE

The LIBMOD code has been set up to manipulate the data on the INCITE^[1] library tape in as general a manner as possible. However, from a practical standpoint, it is necessary to impose certain limitations on the generality of the code for ease in programming. The sections following describe the general procedures that must be followed in performing a particular task using the LIBMOD code.

1. CREATION OF A COMPLETELY NEW LIBRARY TAPE

The creation of a completely new library tape means that no references will be made to cross section data on an existing library tape. That is, the new tape will be completely created by either reading in or calculating cross section data. The types of calculations that can be performed are (a) the calculation of $1/V$ absorption or fission cross sections, (b) the calculation of the zeroth and first Legendre moments of the $1/E$ slowing down sources from above the upper cutoff energy, and, (c) the calculation of the zeroth and first Legendre moments of the free gas model differential scattering cross sections utilizing either the Wigner-Wilkins or Brown and St. John prescriptions.

When a completely new tape is created the new tape will always be created on FORTRAN logical unit NTC, where NTC is an integer input by the user to specify the tape unit used.

2. MODIFYING, MAKING ADDITIONS TO, OR DELETING CROSS SECTION DATA PRESENTLY ON AN EXISTING LIBRARY TAPE

All or any part of the cross section data presently on existing library tapes can be modified, added to, or deleted using the LIBMOD code. This task may be performed either by reading in data or by using any of the routines available in the LIBMOD code for the calculation of cross section data. The only restriction is that the materials must be processed in ascending order of the material identification number.

In all cases the code is set up to read the existing cross section data from either or both of the tapes located on FORTRAN logical units NTA or NTB and write the updated cross section data on FORTRAN logical unit NTC. As before, NTA, NTB and NTC are integers input by the user to specify the tape units used.

3. MIXING OF CROSS SECTION DATA

The LIBMOD code permits the mixing of the cross section data of two or more materials on an existing library tape, to form a new material, on a new library tape. This task can be performed at the same time that cross section data on an existing tape are being created, modified, added to, or deleted to form updated materials. As previously described concerning the modification of cross section data, the existing data can be read from either or both of the tapes located on FORTRAN logical units NTA or NTB and the mixed materials will be written on FORTRAN logical NTC.

4. EDITING AND MERGING OF CROSS SECTION DATA

Editing refers to the process of transferring the data for selected materials, located on an existing library tape, to another tape to create a shorter working library containing only those materials required for a particular study. The purpose of this procedure is to reduce the machine time normally required by the INCITE code to locate the desired materials used in a particular problem. The editing operation can be performed separately or in conjunction with a problem where material data are being created, modified, added, deleted or mixed. Normally, when data on an existing library tape are being operated on, only those materials which are actually being manipulated will appear on the new tape. However, the edit options allow the user to transfer all or part of the remaining materials located on the original tape to the new tape. Again, as previously stated for other cross section operations, material cross section data to be transferred may be located on either of the FORTRAN logical units NTA or NTB and the resultant tape will be created on unit NTC.

Merging refers to the process of transferring the cross section data sets of individual materials located on different library tapes to one common library tape. In this context, merging is really a special case of the editing operation, and, in actual practice, the merging operation is accomplished by using the edit options to place all or part of the materials from the two separate tapes located on FORTRAN logical units NTA and NTB onto the tape located on unit NTC. The only restriction in the use of this option is that materials possessing the same identification numbers on the two tapes cannot be merged onto the same tape. Merging can be performed concurrently with the operations of creating, modifying, adding, mixing or editing of cross section data.

5. LISTING OF CROSS SECTION DATA

An option is available in the LIBMOD code to provide the user with a listing of the cross section data of all or part of the materials on a library tape.

A tape that is to be listed must be located on FORTRAN logical unit NTC. Thus, a library tape that has been newly created during a problem run can be listed at the end of the same problem. An existing library tape can be listed simply by locating it on FORTRAN logical unit NTC and setting the list option.

III. DISCUSSION OF EQUATIONS

1. FREE GAS KERNELS

An option is provided in LIBMOD whereby gas scattering kernels may be calculated for a moderator atom of mass A at a temperature T. Two prescriptions for the total scattering cross section, $\sigma_s(v_r)$, have been provided which have been extensively used in the past. They are the so-called Wigner-Wilkins^[2] and Brown & St. John^[3] gas kernels. If v_r is the relative velocity between the neutron and the target atom in lab coordinates $\sigma_s(v_r)$ is expressed as

$$\sigma_s(v_r) = \sigma_0 + \sigma_1 e^{-\alpha v_r^2}, \quad (1)$$

where σ_0 = free atom potential scattering cross section.

σ_1 and α are the Brown & St. John parameters permitting a monatomic fit to bound atom data.

$v_r = |\vec{v} - \vec{v}_2|$ = relative speed of the neutron in the lab system.

v = speed of the incident neutron in the lab system.

v_2 = speed of the Maxwellian target in the lab system.

The Doppler broadened differential scattering cross section is obtained by integrating the undoppler broadened differential cross section over all speeds v_2 and directions μ of the target atom before collision in the lab system. The target atoms are considered to be a gas in a Maxwellian distribution of velocities at temperature T.

$$\sigma_{s0}(v \rightarrow v', \alpha) = \frac{1}{2v} \iint v_r \sigma_s(v_r) M(v_2) P(v \rightarrow v', v_2, \mu) dv_2 d\mu, \quad (2)$$

where v' = the final neutron velocity in lab system.

$M(v_2)$ = Maxwellian speed distribution for a molecule of mass ratio A, temperature T.

$\sigma_s(v_r) P(v \rightarrow v', v_2, \mu)$ = differential cross section for fixed target velocity v_2, μ .

$\sigma_s(v_r)$ is given by equation (1) for v_r .

After the appropriate domains of integration have been found^{[2][3]}, two terms in the resultant scattering kernel, equation (2), are obtained which correspond to the two terms in equation (1). The first term is the Wigner-Wilkins kernel and the second is the contribution from the Brown & St. John fitting parameters.

$$\sigma_{s0}(v \rightarrow v', \alpha) = \sigma_{s0}^1(v \rightarrow v') + \sigma_{s0}^2(v \rightarrow v', \alpha). \quad (3)$$

If the kernels are transformed to the energy variable by

$$\sigma_s(E \rightarrow E') = \frac{\sigma_s(v \rightarrow v')}{v'} , \quad (4)$$

the following equations result for the two terms in equation (3) for the downscatter elements, i.e., $E' < E$.

$$\begin{aligned} \sigma_{s0}^1(E \rightarrow E') = \frac{\sigma_0 \theta^2}{2E} & \left\{ \operatorname{erf}(\theta x' - \xi x) + \operatorname{erf}(\theta x' + \xi x) \right. \\ & \left. + e^{(x^2 - x'^2)} \left[\operatorname{erf}(\theta x - \xi x') - \operatorname{erf}(\theta x + \xi x') \right] \right\} , \quad (5) \end{aligned}$$

where

$$\theta = \frac{A+1}{2\sqrt{A}} , \quad \xi = \frac{A-1}{2\sqrt{A}} , \quad \beta^2 = \frac{1}{2kT} ,$$

$$x = \beta v = \sqrt{\frac{E}{kT}} , \quad \text{and} \quad \operatorname{erf}(x) = \frac{2}{\sqrt{\pi}} \int_0^x e^{-t^2} dt ,$$

and

$$\begin{aligned} \sigma_{s0}^2(E \rightarrow E', \alpha) = \frac{\sigma_1 \theta^2}{2E} \frac{\tau^3}{\lambda} & \left\{ e^{-\frac{\alpha \tau^2}{\beta^2} x^2} \left[\operatorname{erf}(\theta x' - \xi x) \right. \right. \\ & \left. \left. + \operatorname{erf}(\theta x' + \xi x) \right] + e^{(x^2 - \lambda x'^2)} \left[\operatorname{erf}(\theta x - \xi x') - \operatorname{erf}(\theta x + \xi x') \right] \right\} , \quad (6) \end{aligned}$$

where

$$\theta = \frac{A+1}{2\tau\sqrt{A}}, \quad \xi = \tau\sqrt{A} - \theta,$$

$$\tau^2 = \frac{A\beta^2}{A\beta^2 + \alpha}, \quad \lambda = 1+A(1-\tau^2).$$

The detailed balance condition is used to obtain the upscatter portion of the matrix after the downscatter elements have been computed by equations (5) and (6). The detailed balance condition is,

$$\begin{matrix} v' M(E') \sigma(E' \rightarrow E) \\ (E' < E) \end{matrix} = \begin{matrix} v M(E) \sigma(E \rightarrow E') \\ (E' < E) \end{matrix}.$$

$$\begin{matrix} \sigma(E' \rightarrow E) \\ (E' < E) \end{matrix} = \frac{v}{v'} \frac{M(E)}{M(E')} \sigma(E \rightarrow E') \begin{matrix} \\ (E' < E) \end{matrix} = \frac{E}{E'} e^{-(x^2 - x'^2)} \sigma(E \rightarrow E') \begin{matrix} \\ (E' < E) \end{matrix} \quad (7)$$

Equations (5), (6), and (7) are used when the Brown & St. John kernel is requested. If the Wigner-Wilkins kernel is requested only equations (5) and (7) are used.

Equations (5), (6), and (7) yield the isotropic scattering matrix $\sigma_{s0}(E \rightarrow E')$. Equation (17) in INCITE^[1] requires a linearly anisotropic F_1 scattering matrix based on equation (1) corresponding to the two terms in equation (3). $\sigma_{s1}(v \rightarrow v', \alpha)$ is given as,

$$\sigma_{s1}(v \rightarrow v', \alpha) = \frac{1}{2v} \iint v_r \sigma(v_r) M(v_2) P(v \rightarrow v', v_2, \mu) \cos(\vec{v} \cdot \vec{v}', v_2, \mu) dv_2 d\mu \quad (8)$$

Evaluation of this integral yields two terms as in equation (3).

$$\sigma_{s1}(v \rightarrow v', \alpha) = \sigma_{s1}^1(v \rightarrow v') + \sigma_{s1}^2(v \rightarrow v', \alpha) \quad (9)$$

The downscatter form, i.e., $E' < E$, of the two terms on the r.h.s. of equation (9) after transforming using equation (4) is^[4]

$$\begin{aligned} \sigma_{sl}^1(E \rightarrow E') = & \frac{\sigma_0}{2} \frac{\theta^2}{x^2} \sqrt{\frac{A}{E E'}} \left\{ (\theta x'^2 - \xi x^2 - \sqrt{A}) \left[\text{erf}(\theta x' - \xi x) \right. \right. \\ & + \left. \text{erf}(\theta x' + \xi x) \right] + e^{(x^2 - x'^2)} (\theta x^2 - \xi x'^2 - \sqrt{A}) \left[\text{erf}(\theta x - \xi x') \right. \\ & \left. \left. - \text{erf}(\theta x + \xi x') \right] + \frac{2}{\sqrt{\pi}} \left[(x+x') e^{-(\theta x' - \xi x)^2} - |x-x'| e^{-(\theta x' + \xi x)^2} \right] \right\}, \quad (10) \end{aligned}$$

where the parameters θ and ξ are defined as in equation (5), and

$$\begin{aligned} \sigma_{sl}^2(E \rightarrow E', \alpha) = & \frac{\sigma_1}{2} \frac{(A+1)^2}{4A} \frac{\tau^3}{\lambda} \frac{1}{x^2} \frac{v}{\sqrt{E \rightarrow E'}} \left\{ \begin{array}{l} - \frac{\alpha \tau^2}{\beta^2} x^2 \\ c \text{ times} \end{array} \right. \\ & \left[(\theta x'^2 - \xi x^2 - v) \left(\text{erf}(\theta x' - \xi x) + \text{erf}(\theta x' + \xi x) \right) \right] \\ & + e^{x^2 - \lambda x'^2} \left[(\theta x^2 - \xi x'^2 - v) \left(\text{erf}(\theta x - \xi x') - \text{erf}(\theta x + \xi x') \right) \right] \\ & \left. + \frac{2}{\sqrt{\pi}} e^{-\frac{\alpha \tau^2}{\beta^2} x^2} \left[(x+x') e^{-(\theta x' - \xi x)^2} - |x-x'| e^{-(\theta x' + \xi x)^2} \right] \right\}, \quad (11) \end{aligned}$$

where $v = \frac{\tau \sqrt{A}}{\lambda}$ and $\theta, \xi, \lambda, \tau$ are defined as in equation (6). (See Appendix A.)

It is observed that equation (11) reduces to equation (10) when $\alpha = 0$ provided σ_1 is replaced by σ_0 , the free atom cross section. Equation (11) is in a different form than the corresponding equation in reference 4. A derivation of this transformation is given in Appendix A. The detailed balance condition, equation (7), is applied to equation (10) and (11) in a manner identical to its use in equations (5) and (6) for computing the upscatter elements of the matrix. Two sets of Brown and St. John parameters for H in H_2O and D in D_2O are given in Appendix B.

2. ERROR FUNCTION ROUTINE

A special routine was written to generate the error functions used in the calculations of the gas model cross sections. This routine was necessary to rapidly generate error functions while satisfying pre-determined accuracy requirements. The degree of accuracy required depends on the magnitude of the argument, the magnitude of the other error function arguments (when the sum of two error functions is required), and where the error function occurs in the gas model equations.

In general, the function

$$\text{erf}(x) = \frac{2}{\sqrt{\pi}} \int_0^x e^{-y^2} dy$$

will be calculated by using an appropriate method for various ranges of the argument x . In all cases the argument x is real and $\text{erf}(-x) = -\text{erf}(x)$. The different techniques utilized in calculating $\text{erf}(x)$ are outlined below.

For $x = 0.0$, $\text{erf}(x) = 0.0$

For $0 < |x| \leq .12$, a power series expansion is utilized, i.e.,

$$\text{erf}(x) = \frac{2}{\sqrt{\pi}} \left[x - \frac{x^3}{113} + \frac{x^5}{215} - \frac{x^7}{317} + \frac{x^9}{419} - \dots \right]$$

The number of terms required was reduced to three by a technique for the economization of the series using Chebyshev polynomials. The final equation is

$$\text{erf}(x) = a_1 x + a_3 x^3 + a_5 x^5,$$

where

$$a_1 = 1.12837916, \quad a_3 = -.376124046, \quad a_5 = .112368934.$$

For $.12 < |x| \leq 3.0$, the computation of $\text{erf}(x)$ is accomplished by the algorithm: [5]

$$\text{erf}(x) = \frac{x}{|x|} \left\{ 1 - \frac{e^{-x^2}}{\sqrt{\pi}} \frac{1}{|x| + \frac{1}{\sqrt{\pi + |x| \left(2 - \frac{b_0 + b_1|x| + b_2x^2 + b_3|x|^3}{c_0 + c_1|x| + c_2x^2 + c_3|x|^3} \right)}}} \right\},$$

where

$$\begin{aligned} b_0 &= .85840766, & c_0 &= 1.0, \\ b_1 &= .30781819, & c_1 &= .65097427, \\ b_2 &= .063832389, & c_2 &= .22948482, \\ b_3 &= -1.8240508 \times 10^{-4}, & c_3 &= .034030182. \end{aligned}$$

For $3.0 < x$, the calculation is performed using a Chebyshev series, the algorithm is:

$$\begin{aligned} \text{erf}(x) = 1 - \frac{e^{-x^2}}{x} & \left[\frac{1}{2} c_0 + c_1 T_2\left(\frac{4}{x}\right) + c_2 T_4\left(\frac{4}{x}\right) + c_3 T_6\left(\frac{4}{x}\right) \right. \\ & \left. + c_4 T_8\left(\frac{4}{x}\right) + c_5 T_{10}\left(\frac{4}{x}\right) \right], \end{aligned}$$

where

$$\begin{aligned} c_0 &= 1.11185139, & c_3 &= -5.53 \times 10^{-6}, \\ c_1 &= -0.00809033, & c_4 &= 2.4 \times 10^{-7}, \\ c_2 &= 0.00016777, & c_5 &= -1.0 \times 10^{-8}, \end{aligned}$$

and $T_n\left(\frac{4}{x}\right)$ is the n^{th} Chebyshev polynomial as a function of $\frac{4}{x}$ [6]. If two error functions are to be subtracted and in both cases $|x| > 9.1$ then the complementary error function, i.e., $1 - \text{erf}(x)$, is calculated for both arguments and the difference is taken.

In all cases the routine examines the arguments of the error functions to be summed and determines the accuracy required.

3. SLOWING DOWN SOURCES

In using the INCITE code to calculate energy dependent spectra and associated average cross sections, it is necessary to account for those neutrons which are scattered into the thermal energy range under consideration, from above that range. This is accomplished by properly utilizing the source terms which are an integral part of the energy-dependent flux and current equations solved by the INCITE code. In calculating these source terms in the epithermal region, a reasonable assumption is that the energy-dependent neutron flux and current have a $1/E'$ dependence and that the target atoms for all elements in the homogeneous mixture are at rest in the laboratory system of coordinates. With these two assumptions, the source terms $S_0^k(E)$ and $S_1^k(E)$ for isotope k become

$$S_0^k(E) = \int_{E_c}^{\frac{E}{\alpha_k}} \frac{N_k \sigma_{s0}^k dE'}{(E')^2 (1 - \alpha_k)} \quad (12)$$

and

$$S_1^k(E) = \int_{E_c}^{\frac{E}{\alpha_k}} \frac{N_k \mu_k \sigma_{s0}^k J(E') dE'}{(E') (1 - \alpha_k)}, \quad (13)$$

where

$$\alpha_k = \left[\frac{A_k - 1}{A_k + 1} \right]^2$$

In integrating Equation (12), it is assumed that the scattering cross section of material k in the epithermal region is equal to the potential scattering cross section and therefore constant. The result is

$$S_0^k(E) = \frac{N_k \sigma_{s0}^k}{1 - \alpha_k} \left[\frac{1}{E_c} - \frac{\alpha_k}{E} \right] \quad (14)$$

In equation (13), the assumption of isotropic scattering for targets at rest in the center of mass system yields for μ_k ,

$$\mu_k = \frac{A_k + 1}{2} \sqrt{\frac{E}{E'}} - \frac{A_k - 1}{2} \sqrt{\frac{E'}{E}} \quad (15)$$

The current $J(E')$ may be defined by

$$J(E') = D(E') B F_0(E') = \frac{D(E') B}{E'} \quad (16)$$

where $F_0(E')$ is assumed $1/E'$ as in equation (12). (See Reference 1.)

If $D(E')$ and σ_{s0}^k are assumed constant in the epithermal region and equations (15) and (16) are used in equation (13), the result of the integration is

$$S_1^k(E) = - \frac{D B N_k \sigma_{s0}^k}{3 \sqrt{E} (1 - \alpha_k)} \left\{ (A_k + 1) E \left[\left(\frac{\alpha_k}{E} \right)^{\frac{3}{2}} - \left(\frac{1}{E_c} \right)^{\frac{3}{2}} \right] \right. \\ \left. - 3(A_k - 1) \left[\left(\frac{\alpha_k}{E} \right)^{\frac{1}{2}} - \left(\frac{1}{E_c} \right)^{\frac{1}{2}} \right] \right\}, \quad (17)$$

where

$$D = \frac{1}{3 \Sigma_{tr}} = \frac{1}{3 \sum_{k=1}^{NOI} N_k \left(\sigma_a^k + \sigma_{s0}^k - \sigma_{s1}^k \right)} \quad (18)$$

Since the values of N_k , D , and B are determined from the properties of the material for which a spectrum is to be calculated, the actual isotropic, $S_0^k(E)$, and linearly anisotropic, $S_1^k(E)$, source terms calculated by LIBMOD and placed on the library tape have been divided through by N_k and $D B N_k$, respectively.

4. ENERGY GROUP WIDTHS

Whenever a new library tape is being created without reference to an existing library tape, the energy point structure must be read in and the associated mesh widths about each energy point must either be read in or calculated. These energy widths will be placed on the library tape along with the energy point structure and will be used by both the LIBMOD code and the INCITE code to perform the required trapezoidal integrations.

If the group widths are calculated by the code the following formulation will be employed.

$$\Delta_1 = \frac{EN(2)}{2}$$

$$\Delta_I = \frac{EN(I+1) - EN(I-1)}{2} \quad ; \quad I = 2, 3, \dots, NOG-1$$

$$\Delta_{NOG} = \frac{EN(NOG) - EN(NOG-1)}{2} \quad .$$

IV. INTEGRATION OF TOTAL SCATTERING CROSS SECTIONS

The zeroth and first Legendre moments of the total scattering cross sections are calculated according to the equations

$$\sigma_{s0}(E) = \int_0^{\infty} \sigma_{s0}(E \rightarrow E') dE' \quad (19)$$

and

$$v_{s1}(E) = \int_0^{\infty} v_{s1}(E \rightarrow E') dE' . \quad (20)$$

These cross sections are required for averaging over the flux and current spectra to obtain average multigroup cross section data. For most scattering kernels, analytic formulas for the integrated kernel are not available and recourse is then made to approximate numerical integration of the Legendre moments of the differential scattering kernels. A trapezoidal scheme was chosen for use in the INCITE code because of its inherent simplicity and speed when used in conjunction with a Gauss Seidel iteration scheme. However, the differential scattering functions are sharply peaked around $E=E'$ and consequently, the utilization of a trapezoidal integration scheme may yield an excessive amount of error. This is especially the case when calculations are performed using free gas moderators of high mass number such as oxygen and for some inelastic scattering kernels. The problem may also be accentuated by the use of an energy mesh structure incorporating rapidly varying mesh intervals.

This problem is not of major importance when calculating energy dependent spectra since the within group scattering terms do not appear in the solution equations, thus, eliminating the overriding source of the error. This is not the case when calculating the average total scattering cross sections, but, since most of the error occurs about $E=E'$, certain corrections can be made to improve the results. That is, the value of the differential scattering cross section can be modified at the point $E=E'$ to force the trapezoidal integrals to agree with experimental or theoretical values of the total cross sections.

An option has been provided in the LIBMOD code to allow the user to input correct total scattering cross sections and modify the within group differential scattering cross sections so that use of a trapezoidal integration scheme will yield correct totals. The formulation used to perform this modification is shown below. The trapezoidal integral is

$$\sigma_s(E) = \sum_j \sigma_{s_{ij}} \Delta_j = \sum_{j \neq i} \sigma_{s_{ij}} \Delta_j + \sigma_{s_{ii}} \Delta_i, \quad (21)$$

where $\sigma_{s_{ii}}$ is the within group scattering term.

A modified within group scattering term is then calculated according to

$$\sigma_{s_{ii}}^O = \frac{\sigma_s^*(E) - \sum_{j \neq i} \sigma_{s_{ij}} \Delta_j}{\Delta_i}, \quad (22)$$

where $\sigma_{s_{ii}}^O$ is the modified differential scattering cross section and $\sigma_s^*(E)$ is the correct total scattering cross section read in. Then it follows that

$$\sigma_s(E) = \sum_{j \neq i} \sigma_{s_{ij}} \Delta_j + \sigma_{s_{ii}}^O \Delta_i = \sigma_s^*(E). \quad (23)$$

The resultant modified, within group, differential scattering cross sections are placed on the library tape in place of the usual within group scattering terms and used as such.

V. DISCUSSION OF MIXING OF CROSS SECTION DATA

Mixing refers to the process of combining properly weighted materials on an existing library tape to form new materials. The purpose of mixing is to reduce the computer time normally required by the INCITE code to (a) locate materials on a library tape and (b) form the proper compositions for spectral or averaging purposes. A secondary benefit is that of providing a certain amount of convenience to the user, that is, if in a particular study, a composition such as stainless steel is frequently encountered it may be expedient to form a new material composed of the properly weighted elements in the stainless steel alloy.

Mixing of cross section data to form a new material can be performed to create either a molecular material or a pure mixture or alloy. If a new molecular material is to be formed by mixing the elemental materials presently contained on the library tape, one would normally specify the number of atoms of each element contained in the molecule, i.e., for H_2O the input weighting factors would be 2.0 for hydrogen and 1.0 for oxygen. When this material is used in calculating a spectrum one would then input the molecular density of H_2O in the medium being considered. However, if a mixture or an alloy is to be formed, i.e., such as stainless steel, one would normally input the atom density of each of the materials to form a mixture of the macroscopic cross sections. Then, when this material is used in a spectrum calculation, instead of the atom density, the user would input the volume fraction of the mixture or alloy appearing in the medium for which a spectrum or average cross sections are desired. (See the input for performing the mixing calculation, Section VI.)

VI. LIBMOD INPUT PREPARATION

The input format utilized by the LIBMOD code reflects an attempt to make use of a general input scheme, similar to that employed by the INCITE code, which facilitates the input of large, as well as, small amounts of unrelated input data but which is not overly burdensome to the occasional user. This scheme obviates the usual requirements that (a) the input data deck be ordered in a particular unalterable fashion and (b) complete groups of data, such as scattering matrices, be input where possibly only one or two numbers from the data group may actually be necessary.

1.0 THE PROBLEM DATA DECK

In running a LIBMOD problem, certain types of data cards must be present in a fixed order, however, other data cards are required only if specific types of data are being input.

The following three types are always required in the order shown.

- Type 1: One problem title card (only one is permitted).
- Type 2: One or more integer data cards.
- Type 3: One or more floating point data cards.

If cross section data are to be read in or revised, the following material data cards are required for each material to be revised in addition to those described above. These cards must be arranged in the order shown below.

- Type 4: One material identification card.
- Type 5: One or more material integer data cards.
- Type 6: One or more material floating point data cards.

Library material data cards, i.e., cards of types 4 through 6 are repeated until all library materials which are to be added or revised have been described. All data read in on card types 4 through 6 will be set to zero before reading more cards of the same type. Thus no data of this type will be retained for future use. The materials being revised, added or edited must be processed in ascending order of their material identification numbers.

The data cards of each particular type, with the exception of the problem and material title cards, may be in any order within the data deck for their respective type of card, however, the last card of each type must always have a 1 in column 1.

2.0 DISCUSSION OF TYPES OF DATA CARDS

2.1 Problem Title Card

The information on the problem title card is read in using a 12A6 format and must be punched as follows:

Columns 1-6	TAPIDA	Identification number of existing library tape located on unit NTA, if one is used.
Columns 7-12	TAPIDB	Identification number of existing library tape located on unit NTB, if one is used.
Columns 13-18	TAPIDC	Identification number to be placed on the library tape being created on unit NTC, if necessary.
Columns 19-72	TITLE(I) (I=1,9)	Any identifying numeric or alphabetic characters which identify or describe the problem.

2.2 Integer Data Cards

The information on this type of card is read in using a (I1,1X,2I3,2X,I2,15I4) format where columns 1 through 12 contain information identifying the data on the card and columns 13 through 72 contain up to 15 words of integer data in 4-column fields. All integer data words must be positioned as far right as possible in their proper fields.

The following paragraph describes the information that must be specified in columns 1 through 12 of every card containing integer data:

Column 1		If this column is left blank or set to 0, then more cards containing integer data are to follow. If a 1 is placed in this column, it signifies that this is the last card containing integer data and at least one card containing floating point data will follow.
Columns 3-5	Index 1	These indices identify the type of integer data to be found on this card.
Columns 6-8	Index 2	
Columns 11-12		These columns specify the number of words of data on the card. If left blank, the program assumes 15 words of data.
Columns 13-16		These 4 column fields contain the integer data in consecutive order. Consecutive words of integer data on the card will be identified by successive integer values of the Index 2. Up to 15 words of data are permitted per card.
17-20		
21-24		
25-28		
:		
69-72		

2.3 Floating Point Data Cards

The information on these cards is read in using a (2I1,2I3,2X,I2,5E12.8) format where columns 1 through 12 contain information identifying the data on the card and columns 13 through 72 contain up to five words of floating point data in 12-column fields.

Much the same type of information must be specified in columns 1 through 12 of the floating point data cards as is necessary for the cards containing integer data.

Column 1			If this column is left blank or set to 0, then more cards containing floating point data are to follow.
			If a 1 is placed in this column, it signifies that this is the last card containing floating point data.
Column 2	Index 1	}	These indices identify the type of floating point data to be found on this card.
Columns 3-5	Index 2		
Columns 6-8	Index 3		
Columns 11-12			These columns specify the number of words of data on the card. If left blank, the program assumes five words of data.
Columns 13-24			These 12 column fields contain the floating point data. Consecutive words of data on the card will be identified by successive integer values of the Index 3. Up to five words of data are permitted per card.
25-36			
37-48			
49-60			
61-72			

A few examples of acceptable ways of writing the floating point number +3.1415927 under FORTRAN E12.8 format are as follows:

CARD COLUMNS

1	2	3	4	5	6	7	8	9	10	11	12
3	.	1	4	1	5	9	2	7			
	3	.	1	4	1	5	9	2	7		
+	3	.	1	4	1	5	9	2	7		
3	.	1	4	1	5	9	2	7		+	0
.	3	1	4	1	5	9	2	7		+	1
	.	3	1	4	1	5	9	2	7	+	1
3	.	1	4	1	5	9	2	7	E	+	0
	3	.	1	4	1	5	9	2	7	E	0
	3	1	4	1	5	9	2	7	E	+	1
3	1	4	1	5	9	2	7	E	+	0	1

2.4 Material Identification Card

The information on this card is read in using an E12.8, 10A6 format and must be punched as follows:

Columns 1-12	AAID	Identification number of material to be added or revised.
Columns 13-72	WWORD(I) (I=1,10)	Any identifying numeric or alphabetic characters may be punched to identify or describe the material.

3.0 INPUT DATA

3.1 Problem Title Card

Columns	Mnemonic Name of Data	Description
1-6	TAPIDA	Identification number of existing library tape located on unit NTA. If left blank, identification will not be checked.
7-12	TAPIDB	Identification number of existing library tape located on unit NTB. If left blank, identification will not be checked.
13-18	TAPIDC	Identification number to be placed on the library tape being created.
19-72	TITLE(I) (I=1,9)	Any numeric or alphabetic characters which identify or describe the problem being run.

3.2 Integer Data Cards

Index 1 Cols. 3-5	Index 2 Cols. 6-8	Mnemonic Name of Data	Description or Function of Data
0	1	INEW	Type of problem 0--An existing library tape is being revised, edited or listed. 1--A completely new library tape is being created without reference to an existing library tape.
0	2	IADD	Total number of materials which are to be revised or added 0--No materials are to be revised or added. N--N materials are to be revised or added. (One set of material data cards must be included for each material to be revised or added.)
0	3	NTA	Tape unit assignment number of first tape. -1--NTA will be set to 8. 0--Tape unit will not be used. N--Number of the FORTRAN logical unit on which an existing library tape is to be located and from which data will be taken for processing.
0	4	NTB	Tape unit assignment number of second tape -1--NTB will be set to 10. 0--Tape unit will not be used. N--Number of the FORTRAN logical unit on which an existing library tape is to be located and from which data will be taken for processing.
0	5	IEDITA	Editing option for data tape located on unit NTA.

Index 1 Cols. 3-5	Index 2 Cols. 6-8	Mnemonic Name of Data	Description or Function of Data
			-1--All materials on the tape located on unit NTA will be transferred to the tape located on unit NTC.
			0--No editing of library tape is desired, i.e., none of the materials on the tape located on unit NTA, except those being revised, are to be transferred to the tape located on unit NTC.
			NA--NA materials on the tape located on unit NTA, in addition to those being revised, are to be transferred to the tape located on unit NTC.
			(NA $\leq$ 100)
			The identification numbers of the materials to be transferred are specified by the vector EAIDA(J), (see flt 0,2,J)*.
0	6	IEDITB	Editing option for data tape located on unit NTB.
			-1--All materials on the tape located on tape unit NTB will be transferred to the tape located on unit NTC.
			0--No editing of library tape is desired, i.e., none of the materials on the tape located on unit NTB, except those being revised, are to be transferred to tape located on unit NTC.
			NB--NB materials on the tape located on unit NTB, in addition to those being revised, are to be transferred to the tape located on unit NTC.
			(NB $\leq$ 100)
			The identification numbers of the materials to be transferred are specified by the vector EAIDB(J), (see flt 0,3,J).

*References to associated input quantities found in the sections describing the integer and floating point data cards are denoted by the words "int" or "flt" followed by the identifying values of the indices separated by commas.

Index 1 Cols. 3-5	Index 2 Cols. 6-8	Mnemonic Name of Data	Description or Function of Data
0	7	NTC	Tape unit assignment number of tape being created -1--NTC will be set to 9. 0--Tape unit will not be used. N--Number of FORTRAN logical unit on which new library tape is to be created.
0	8	ILIST	Listing option -1--List complete library tape located on unit NTC. 0--Do not list library tape. NL--List NL materials on library tape located on unit NTC. ($NL \leq 100$) The identification numbers of the materials to be listed are specified by the vector AIDL(J), (see flt 0,4,J).
0	9	NOG	Number of energy points used to represent the energy dependent cross section data on the library tape being generated or revised
0	10	NNUCL	Number of materials on library tape being created
0	11	IDEL	Option specifying procedure for obtaining energy group widths when a completely new library is being formed, (see section III.4) 0--Energy group widths will be input along with the energy points. 1--Energy points will be read in and the energy group widths about each energy point will be calculated. The energy points and group widths are read in by the vectors EN(J), (see flt 0,0,J) and DEL(J), (see flt 0,1,J), respectively.

A 1 punch in column 1 will signify the last card of this type.

3.3 Floating Point Data Cards

In all cases below, as previously stated, the values of the three indices determine what type of data has been placed on the card. The value J of Index 3 indicates that the first data field on the card contains the Jth value of the appropriate data and that successive words of data across the card will be identified by successive integer values of Index 3.

The material identification numbers input when Index 2 is equal to 2, 3 or 4, must always be ordered so that ascending values of I correspond to ascending values of the material identification number.

Index 1 Col. 2	Index 2 Cols. 3-5	Index 3 Cols. 6-8	Mnemonic Name of Data	Description or Function of Data
0	0	J	EN(J)	Point values of the energy (eV) ($1 \leq J \leq 101$; J increases with energy) These data are required only if a completely new library is being created without reference to an existing library, i.e., if INEW=1, (see int 0,1 and int 0,11).
0	1	J	DEL(J)	Energy mesh widths about each energy point (eV) ($1 \leq J \leq 101$; J increases with energy) These data are required only if IDEL=0 and a completely new library is being created, (see int 0,11).
0	2	J	EAIDA(J)	Identification numbers of those materials which are to be transferred unchanged from the tape located on unit NTA to the tape located on unit NTC ($1 \leq J \leq 100$; EAIDA(J) must increase with increasing values of J) The first NA numbers in the EAIDA(J) vector are used, (see int 0,5).

Index 1 Col. 2	Index 2 Cols. 3-5	Index 3 Cols. 6-8	Mnemonic Name of Data	Description or Function of Data
0	3	J	EAIDB(J)	Identification numbers of those materials which are to be transferred unchanged from the tape located on unit NTB to the tape located on unit NTC ($1 \leq J \leq 100$; EAIDB(J) must increase with increasing values of J) The first NB numbers in the EAIDB(J) vector are used (see int 0,6).
0	4	J	AIDL(J)	Identification numbers of materials which are to be listed from the tape located on unit NTC ($1 \leq J \leq 100$; AIDL(J) must increase with increasing values of J) The first NL numbers in the AIDL(J) vector are used (see int 0,8).

A 1 punch in column 1 will signify the last card of this type.

3.4 Material Identification Card

Columns	Mnemonic Name of Data	Description
1-12	AAID	Identification number of material to be added or revised.
13-72	WORD(I) (I=1,10)	Any numeric or alphabetic characters which describe the material.

3.5 Material Integer Data Cards

The following cards specify in what way material AAID is to be processed, i.e., whether it is to be revised or added, and the various options for performing these tasks.

Index 1 Cols. 3-5	Index 2 Cols. 6-8	Mnemonic Name of Data	Description or Function of Data
0	1	NREV	Revision option 1--A new material is to be placed on the library tape and all of the data will be read in from cards. 2--The cross section data of material number AAID which is presently on an existing tape located on unit NTA or NTB will be revised. Only those cross section data which are actually being revised need be read in. The tape unit is specified by NTAPE (see matint 0,7).** 3--A new material is to be formed by mixing materials presently on existing tapes located on units NTA and NTB. The only additional fixed point data required when NREV=3 are IMIX (see matint 0,8) and MTAPE (see matint 1,J).
0	2	NNABS	Absorption cross section options -1--Delete this reaction from a material already on tape. 0--This reaction is not to be revised, or, if a new material is being read in, this reaction is not present. 1--Read from cards the new or revised absorption cross sections (see matflt 0,1,J). 2--Calculate 1/V absorption cross sections from σ_{E_0} and E_0 data read in on cards (see matflt 0,0,1 and matflt 0,0,2).

**References to associated input quantities found in the sections describing the material integer and floating point data cards are denoted by the words "matint" and "matflt" followed by the identifying values of the indices separated by commas.

Index 1 Cols. 3-5	Index 2 Cols. 6-8	Mnemonic Name of Data	Description or Function of Data
0	3	NNFIS	<p>Fission cross section options</p> <p>-1--Delete this reaction from a material already on tape.</p> <p>0--This reaction is not to be revised, or, if a new material is being read in, this reaction is not present.</p> <p>1--Read from cards the new or revised fission cross sections (see matflt 0,2,J).</p> <p>2--Calculate 1/V fission cross sections from σ_{E_0} and E_0 data read in on cards (see matflt 0,0,3 and matflt 0,0,4).</p>
0	4	NNSCT	<p>Scattering cross section options</p> <p>-1--Delete this reaction from a material already on tape.</p> <p>0--This reaction is not to be revised, or, if a new material is being read in, this reaction is not present.</p> <p>1--Read from cards the new or revised energy dependent values of both the total isotropic and linearly anisotropic scattering cross sections (see matflt 0,3,J and matflt 0,4,J).</p> <p>2--Read in one constant value of both the total isotropic and linearly anisotropic scattering cross sections (see matflt 0,0,6 and matflt 0,0,7).</p> <p>3--Calculate the energy dependent total isotropic and linearly anisotropic scattering cross sections by trapezoidally integrating the differential scattering cross sections that are being calculated or read in for this material.</p> <p>4--Read from cards NOG energy dependent values of both the total isotropic and linearly anisotropic scattering cross sections and correct the within group differential scattering terms such that the integral will equal the total isotropic and anisotropic terms as input (see matflt 0,3,J and matflt 0,4,J).</p>

Index 1 Cols. 3-5	Index 2 Cols. 6-8	Mnemonic Name of Data	Description or Function of Data
0	5	NNKER	Differential scattering cross section option -1--Delete the differential scattering cross sections. 0--This reaction is not to be revised, or, if a new material is being read in, this reaction is not present. 1--Read from cards the new or revised isotropic and linearly anisotropic differential scattering matrices for this material (see matflt 1,I,J and matflt 2,I,J). 2--Calculate free gas model isotropic and linearly anisotropic differential scattering matrices for this material (see matflt 0,0,8 through matflt 0,0,13).
0	6	NNSOR	Source option -1--Delete this reaction. 0--This reaction is not to be revised, or, if a new material is being read in, this reaction is not present. 1--Read from cards new or revised isotropic and linearly anisotropic source terms for this material (see matflt 0,5,J and matflt 0,6,J). 2--Calculate isotropic and linearly anisotropic 1/E slowing down source terms for this material (see matflt 0,0,8 and matflt 0,0,10).
0	7	NTAPE	Tape specification 0--Material AAID is not being revised. N--Material AAID is being revised and is contained as part of the data on the tape located on FORTRAN logical unit N. N must equal either NTA or NTB. A non-zero value of NTAPE must be input when a material is being revised, i.e., if NREV=2 (see matint 0,0,1).

Index 1 Cols. 3-5	Index 2 Cols. 6-8	Mnemonic Name of Data	Description or Function of Data
0	8	IMIX	<p>Mixture option</p> <p>0--This material is not to be formed by mixing.</p> <p>N--This material will be formed by mixing N materials taken from either or both of the tapes located on units NTA and NTB.</p> <p>($N \leq 25$)</p> <p>A non-zero value of IMIX must be input when a material is being formed by mixing, i.e., if NREV=3 (see matint 0,0,1).</p>
0	9	IOUTOP	<p>Output option</p> <p>0--List only the option flags controlling the modification or creation of a material.</p> <p>1--In addition to the standard output, list the input cards containing the cross section data to be used in modifying or creating this material.</p>
1	J	MTAPE(J)	<p>FORTTRAN logical tape unit from which the J^{th} material for forming the mixed material is to be read. MTAPE(J) must equal either NTA or NTB.</p> <p>($1 \leq J \leq 25$)</p> <p>These data are required when a material is being formed by mixing, i.e., if NREV=3 (see matint 0,0,1). The identification numbers for the materials required to form the mixture and their corresponding fractions or densities are specified by the PAID(J) (see matflt 0,7,J) and FRACT(J) (see matflt 0,8,J) vectors, respectively.</p>

A 1 punch in column 1 will signify the last card of this type for a particular material.

3.6 Material Floating Point Data Cards

Again, as was the case for the problem floating point cards, the values of the three indices determine what type of data has been placed on the cards. The value J of Index 3 indicates that the first data field on the card contains the Jth value of the appropriate data and that successive words of data across the card will be identified by successive integer values of Index 3.

Index 1 Col. 2	Index 2 Cols. 3-5	Index 3 Cols. 6-8	Mnemonic Name of Data	Description or Function of Data
0	0	1	SIGA	The point value of the 1/V absorption cross section at energy EOA (barns).
0	0	2	EOA	Energy of input 1/V absorption cross section (eV). The input quantities SIGA and EOA are required if NOG point values of the absorption cross section are to be calculated, i.e., if NNABS=2 (see matint 0,2).
0	0	3	SIGF	The point value of the 1/V fission cross section at energy EOF (b).
0	0	4	EOF	Energy of input 1/V fission cross section (eV). The input quantities SIGF and EOF are required if NOG point values of the fission cross section are to be calculated, i.e., if NNFIS=2 (see matint 0,3).
0	0	5	ANU	Number of neutrons produced per fission (energy independent).
0	0	6	SIGSO	The point value of the energy independent total isotropic scattering cross section (b).
0	0	7	SIGS1	The point value of the energy independent total anisotropic scattering cross section (b).

Index 1 Col. 2	Index 2 Cols. 3-5	Index 3 Cols. 6-8	Mnemonic Name of Data	Description or Function of Data
				The input quantities SIGSC and SIGS1 are required if NOG energy independent point values of the isotropic and linearly anisotropic cross sections are to be generated, i.e., if NNSCT=2 (see matint 0,4).
0	0	8	AMAS	Mass of the material in atomic mass units. This quantity is required if either Wigner-Wilkins or Brown and St. John scattering matrices or 1/E slowing down sources are to be calculated, i.e., if NNKER=2 or NNSOR=2 (see matint 0,5 or matint 0,6).
0	0	9	TEMP	Temperature of material in °K. This quantity is required if either Wigner-Wilkins or Brown and St. John scattering matrices are to be calculated, i.e., if NNKER=2 (see matint 0,5).
0	0	10	FAS	Free atom scattering cross section (b). This quantity is required if either Wigner-Wilkins or Brown and St. John scattering matrices or 1/E slowing down sources are to be calculated, i.e., if NNKER=2 or NNSOR=2 (see matint 0,5 or matint 0,6).
0	0	11	SIG1	Brown and St. John scattering coefficient.
0	0	12	ALFA	Brown and St. John exponential coefficient. The input quantities SIG1 and ALFA are non-zero if a Brown and St. John gas scattering matrix is to be calculated.
0	0	13	CUTOFF	Smallest value of isotropic differential scattering cross section desired in scattering matrix (if set to 0.0 code uses 10^{-8}).

Index 1 Col. 2	Index 2 Cols. 3-5	Index 3 Cols. 6-8	Mnemonic Name of Data	Description or Function of Data
				This quantity is required if a scattering matrix is either read in or calculated, i.e., if NNKER=1 or 2 (see matint 0,5).
0	1	J	BMIC(J)	Point values of the energy dependent absorption cross sections. ($1 \leq J \leq 101$; J increases with energy) These data are required when the absorption cross sections are to be read in from cards, i.e., if NNABS=1 (see matint 0,2). Only those data which are new or are actually being revised need be input.
0	2	J	BMIC(J+NOG)	Point values of the energy dependent fission cross sections. ($1 \leq J \leq 101$; J increases with energy) These data are required when the fission cross sections are to be read in from cards, i.e., if NNFIS=1 (see matint 0,3). Only those data which are new or are actually being revised need be input.
0	3	J	BMIC(J+2*NOG)	Point values of the energy dependent isotropic scattering cross sections. ($1 \leq J \leq 101$; J increases with energy)
0	4	J	BMIC(J+3*NOG)	Point values of the energy dependent linearly anisotropic scattering cross sections. ($1 \leq J \leq 101$; J increases with energy) The input vectors BMIC(J+2*NOG) and BMIC(J+3*NOG) are utilized if energy dependent point values of the total isotropic and linearly anisotropic scattering cross

Index 1 Col. 2	Index 2 Cols. 3-5	Index 3 Cols. 6-8	Mnemonic Name of Data	Description or Function of Data
				sections are to be read in, i.e., if NNSCT=1 or 4 (see matint 0,4). Only those data which are new or are actually being revised need be input.
0	5	J	BMIC(J+4*NOG)	Point values of the energy dependent isotropic sources. ($1 \leq J \leq 101$; J increases with energy)
0	6	J	BMIC(J+5*NOG)	Point values of the energy dependent linearly anisotropic sources. ($1 \leq J \leq 101$; J increases with energy) The input vectors BMIC(J+4*NOG) and BMIC(J+5*NOG) are utilized if energy dependent point values of the isotropic and linearly anisotropic sources are to be read in, i.e., if NNSOR=1 (see matint 0,6). Only those data which are new or are actually being revised need be input.
0	7	J	PAID(J)	Identification number of J^{th} material to be used in forming a mixture. ($1 \leq J \leq 25$; PAID(J) increases with increasing values of J)
0	8	J	FRACT(J)	Number of atoms or fraction of J^{th} material in mixture. ($1 \leq J \leq 25$) The input vectors PAID(J) and FRACT(J) are utilized only if a material is to be formed by mixing, i.e., if NREV=3 (see matint 0,1, matint 0,8 and matint 1,J).
1	I	J	SIGSO(I,J)	Point values of the isotropic differential cross section for scattering from the I^{th} energy point to the J^{th} energy point. ($1 \leq J \leq 101$; $1 \leq I \leq 101$; J and I increase with energy)

Index 1 Cols. 2	Index 2 Cols. 3-5	Index 3 Cols. 6-8	Mnemonic Name of Data	Description or Function of Data
2	I	J	SIGSl(I,J)	Point values of the linearly anisotropic differential cross section for scattering from the I th energy point to the J th energy point. (1 ≤ J ≤ 101; 1 ≤ I ≤ 101; J and I increase with energy) The input vectors SIGSO(I,J) and SIGSl(I,J) are utilized if energy dependent point values of the isotropic and linearly anisotropic differential scattering cross sections are to be read in, i.e., if NKER=1 (see matint 0,5). Only those data which are new or are actually being revised need be input.

Anytime differential scattering cross sections are revised, read in, or calculated, a detailed balance calculation will be performed to generate the upscatter terms in the matrix using the new downscatter terms. Therefore, in revising or reading in cross sections, only the downscatter terms need be input.

A 1 punch in column 1 will signify the last card of this type for a particular material.

4. CONDENSED DESCRIPTION OF LIBMOD INPUT

This section contains a complete listing of the input in a condensed form and should facilitate the use of the code by those familiar with the input. Individuals inexperienced in the use of the code will find a detailed description of the input in Sections VI-1, 2, and 3.

Problem Title Card

Mnemonic Name		Description
Columns	of Data	
1-6	TAPIDA	Identification number of tape on unit NTA
7-12	TAPIDB	Identification number of tape on unit NTB If TAPIDA (TAPIDB) is left blank the identification numbers of the tapes on unit NTA (NTB) will not be checked.
13-18	TAPIDC	Identification number to be placed on tape created on unit NTC.
19-72	TITLE(I) (I=1,9)	Any numeric or alphabetic characters to identify or describe the problem being run.

Index 1 Cols. 3-5	Index 2 Cols. 6-8	Mnemonic Name of Data	Description or Function of Data
0	1	INEW	Type of problem: 0-Revise, edit or list an existing tape, 1-Create a new library tape
0	2	IADD	Number of materials to be revised or added: 0-None, N-Revise or add N materials
0	3	NTA	Tape unit assignment for first data tape: -1-NTA set to 8, 0-Tape not used, N-First data tape assigned to unit N
0	4	NTB	Tape unit assignment for second data tape: -1-NTB set to 10, 0-Tape not used, N-Second data tape assigned to unit N
0	5	IEDITA	Editing option for data tape on unit NTA: -1-All materials transferred, 0-No editing, NA-NA materials transferred
0	6	IEDITB	Editing option for data tape on unit NTB: -1-All materials transferred, 0-No editing, NB-NB materials transferred
0	7	NTC	Tape unit assignment for tape being created: -1-NTC set to 9, 0-Tape not used, N-Tape being created assigned to unit N
0	8	ILIST	Listing option: -1-Complete listing, 0-No listing, NL-list NL materials
0	9	NOG	Number of energy points
0	10	NNUCL	Number of materials on new library tape
0	11	IDEL	Energy group width option: 0-Read in widths, 1-Calculate widths

General Floating Point Data

Index 1 Col. 2	Index 2 Cols. 3-5	Index 3 Cols. 6-8	Mnemonic Name of Data	Description or Function of Data
0	0	J	EN(J)	Point values of the energy
0	1	J	DEL(J)	Energy mesh widths
0	2	J	EAIDA(J)	Materials to be transferred from tape on unit NTA to tape created on NTC
0	3	J	EAIDB(J)	Materials to be transferred from tape on unit NTB to tape created on NTC
0	4	J	AIDL(J)	Materials to be listed from tape located on unit NTC

Material Identification Card

Columns	Mnemonic Name of Data	Description
1-12	AAID	Identification number of material to be added or revised
13-72	TITLE(I) (I=1,10)	Any numeric or alphabetic characters to describe the material

Material Integer Data

Index 1 Cols. 3-5	Index 2 Cols. 6-8	Mnemonic Name of Data	Description or Function of Data
0	1	NREV	Revision option: 1-Add a material, 2-Revise a material, 3-Form a material by mixing

Index 1 Cols. 3-5	Index 2 Cols. 6-8	Mnemonic Name of Data	Description or Function of Data
0	2	NNABS	Absorption cross section option: -1-Delete this reaction, 0-Cross sections will not be added or revised, 1-Read in cross sections, 2-Calculate 1/V cross sections
0	3	NNFIS	Fission cross section option: -1-Delete this reaction, 0-Cross sections will not be added or revised, 1-Read in cross sections, 2-Calculate 1/V cross sections
0	4	NNSCT	Scattering cross section options: -1-Delete this reaction, 0-Cross sections will not be added or revised, 1-Read in cross sections, 2-Read in energy independent value of cross sections, 3-Calculate total cross sections by integrating differentials, 4-Read in cross sections and adjust within group differential scattering terms
0	5	MNKER	Differential scattering cross section options: -1-Delete this reaction, 0-Cross sections will not be added or revised, 1-Read in cross sections, 2-Calculate gas model cross sections
0	6	NNSOR	Source options: -1-Delete this reaction, 0-Sources will not be added or revised, 1-Read in sources, 2-Calculate sources
0	7	NTAPE	Tape specification: 0-Cross sections are not being revised, N-Material AAID is being revised and is located on the data tape on unit N
0	8	IMIX	Mixture option: 0-No mixing is desired, N-Material AAID will be formed by mixing N materials
0	9	IOUTOP	Output options: 0-Standard output, 1-Additional output
1	J	MTAPE(J)	Specifies tape unit from which J th mixture material will be read

Material Floating Point Data

Index 1 Col. 2	Index 2 Cols. 3-5	Index 3 Cols. 6-8	Mnemonic Name of Data	Description or Function of Data
0	0	1	SIGA	Absorption cross section at energy EOA
0	0	2	EOA	Energy of cross section SIGA
0	0	3	SIGF	Fission cross section at energy EOF
0	0	4	EOF	Energy of cross section SIGF
0	0	5	ANU	Neutrons produced per fission
0	0	6	SIGS0	Total isotropic scattering cross section
0	0	7	SIGS1	Total anisotropic scattering cross section
0	0	8	AMAS	Mass of material
0	0	9	TEMP	Temperature of material
0	0	10	FAS	Free atom scattering cross section
0	0	11	SIG1	Brown and St. John scattering coefficient
0	0	12	ALFA	Brown and St. John exponential coefficient
0	0	13	CUTOFF	Cutoff value of scattering matrix
0	1	J	BMIC(J)	Absorption cross sections
0	2	J	BMIC(J+NOG)	Fission cross sections

Index 1 Col. 2	Index 2 Cols. 3-5	Index 3 Cols. 6-8	Mnemonic Name of Data	Description or Function of Data
0	3	J	BMIC(J+2*NOG)	Isotropic scattering cross sections
0	4	J	BMIC(J+3*NOG)	Linearly anisotropic scattering cross sections
0	5	J	BMIC(J+4*NOG)	Isotropic sources
0	6	J	BMIC(J+5*NOG)	Linearly anisotropic sources
0	7	J	PAID(J)	J th material used in forming mixture
0	8	J	FRACT(J)	Number of atoms or fraction of J th material in mixture
1	I	J	SIGS0(I,J)	Isotropic differential scattering cross sections
2	I	J	SIGS1(I,J)	Linearly anisotropic differential scattering cross sections

VII. SAMPLE PROBLEM

The sample problem which follows utilizes two previously created tapes located on FORTRAN logical units 8 and 10. A new tape is then created on unit 10 by (a) calculating the cross sections for a new material numbered 1.00300, (b) revising the cross section data for a material numbered 5.01 which was located on the tape on unit 8, (c) transferring materials numbered 13.0 and 24.0 from unit 8 and materials numbered 26.0 and 28.0 from unit 10, and (d) mixing a new material numbered 417.75 using materials numbered 17.0 and 20.0 located on tapes on units 8 and 10. A listing is then made of the data on the new tape.

1. INPUT

Return To.

[illegible]

BF-0001

43

LIBMOD SAMPLE PROBLEM

2. OUTPUT

GENERAL INPUT DATA

```

PROBLEM TYPE ***** 0
MATERIALS ADDED OR REVISED ** 3
TAPE UNIT A ***** 8
TAPE UNIT B ***** 10
EDITING OPTION FOR UNIT A *** 2
EDITING OPTION FOR UNIT B *** 2
TAPE UNIT C ***** 9
LISTING OPTION ***** -1
NUMBER OF GROUPS ***** 101
MATERIALS ON NEW LIBRARY TAPE 7
DELTA OPTION ***** 0

```

THE FOLLOWING MATERIALS WERE PROCESSED

```

*****

```

MATERIAL INPUT DATA

HYDROGEN IN H₂O (FREE GAS) A=1.88, SIGO=20.4, TEMP=300.0 K

MATERIAL IDENTIFICATION NO. = 1.00300

```

UPDATING OPTION ***** 1
ABSORPTION OPTION ***** 2
FISSION OPTION ***** 0
SCATTERING OPTION ***** 3
FREE GAS MODEL OPTION *** 2
SOURCE OPTION ***** 2
OUTPUT OPTION ***** 0

```

```

*****

```

MATERIAL INPUT DATA

BORON-10 REVISED 1/20/69 1/V ABS=3837.0 B, CONST SCT=4.0 B

MATERIAL IDENTIFICATION NO. = 5.01000

```

UPDATING OPTION ***** 2
ABSORPTION OPTION ***** 2
FISSION OPTION ***** 0
SCATTERING OPTION ***** 2

```

FREE GAS MODEL OPTION *** 0
 SOURCE OPTION ***** 0
 TAPE UNIT WITH MATERIAL * 8
 OUTPUT OPTION ***** 0

MATERIAL NO. 13.00000 WAS TRANSFERRED FROM TAPE ON UNIT 8

MATERIAL NO. 24.00000 WAS TRANSFERRED FROM TAPE ON UNIT 8

MATERIAL NO. 26.00000 WAS TRANSFERRED FROM TAPE ON UNIT 10

MATERIAL NO. 28.00000 WAS TRANSFERRED FROM TAPE ON UNIT 10

MATERIAL INPUT DATA

CALCIUM CHLORIDE MOLECULE (CACL2)

MATERIAL IDENTIFICATION NO. = 417.75000

UPDATING OPTION ***** 3
 ABSORPTION OPTION ***** 0
 FISSION OPTION ***** 0
 SCATTERING OPTION ***** 0
 FREE GAS MODEL OPTION *** 0
 SOURCE OPTION ***** 0
 MIXTURE OPTION ***** 2
 OUTPUT OPTION ***** 0

THIS MATERIAL WILL BE FORMED BY MIXING

MATERIALS IN
MIXTURE

FRACTION

TAPE NUMBER

17.00000
200.00000

2.00000E 00
1.00000E 00

8
10

LIBRARY LISTING

TAPE
IDENTIFICATION

021069

NUMBER OF
NUCLIDES

7

NUMBER OF
GROUPS

40

GROUP	ENERGY	DELTA
1	0.00100000	0.00125000
2	0.00250000	0.00150000
3	0.00400000	0.00150000
4	0.00550000	0.00150000
5	0.00700000	0.00150000
6	0.00850000	0.00150000
7	0.01000000	0.00175000
8	0.01200000	0.00225000
9	0.01450000	0.00275000
10	0.01750000	0.00325000
11	0.02100000	0.00375000
12	0.02500000	0.00425000
13	0.02950000	0.00450000
14	0.03400000	0.00475000
15	0.03900000	0.00500000
16	0.04400000	0.00525000
17	0.04950000	0.00565000
18	0.05530000	0.00590000
19	0.06130000	0.00610000
20	0.06750000	0.00635000
21	0.07400000	0.00665000
22	0.08080000	0.00690000
23	0.08780000	0.00710000
24	0.09500000	0.00735000
25	0.10250000	0.00750000
26	0.11000000	0.00775000
27	0.11800000	0.00800000
28	0.12600000	0.00825000
29	0.13450000	0.00850000
30	0.14300000	0.00875000
31	0.15200000	0.00900000
32	0.16100000	0.00925000
33	0.17050000	0.00950000
34	0.18000000	0.00975000
35	0.19000000	0.01000000
36	0.20000000	0.01050000
37	0.21100000	0.01150000
38	0.22300000	0.01250000
39	0.23600000	0.01350000
40	0.25000000	0.01450000

HYDROGEN IN H2O (FREE GAS) A=1.88, SIG0=20.4, TEMP=300.0 K

ISOTOPE I.D. NO. = 1.00300

	NABS	NFIS	NSCT	NKER	NDA	NU		
	1	0	1	1	1800	0.		
GROUP	ENERGY	ABSORPTION	FISSION	TOTAL P0 SCATTER	TOTAL P1 SCATTER	P0 SOURCE	P1 SOURCE	
1	0.001000	1.66993E 00	0.	8.69937E 01	6.14020E 00	0.	0.	
2	0.002500	1.05616E 00	0.	5.70337E 01	5.74456E 00	0.	0.	
3	0.004000	8.34965E-01	0.	4.66132E 01	5.62110E 00	0.	0.	
4	0.005500	7.12061E-01	0.	4.10144E 01	5.58287E 00	0.	0.	
5	0.007000	6.31174E-01	0.	3.74477E 01	5.58425E 00	0.	0.	
6	0.008500	5.72781E-01	0.	3.49531E 01	5.60680E 00	0.	0.	
7	0.010000	5.28078E-01	0.	3.31013E 01	5.64143E 00	0.	0.	
8	0.012000	4.82067E-01	0.	3.12585E 01	5.69659E 00	0.	0.	
9	0.014500	4.38545E-01	0.	2.95872E 01	5.77191E 00	0.	0.	
10	0.017500	3.99190E-01	0.	2.81483E 01	5.86398E 00	0.	0.	
11	0.021000	3.64409E-01	0.	2.69443E 01	5.96773E 00	0.	0.	
12	0.025000	3.33986E-01	0.	2.59514E 01	6.07772E 00	5.97243E 00	-5.77866E 00	
13	0.029500	3.07459E-01	0.	2.51372E 01	6.18894E 00	1.87907E 01	-1.66848E 01	
14	0.034000	2.86391E-01	0.	2.45299E 01	6.28915E 00	2.82158E 01	-2.30817E 01	
15	0.039000	2.67403E-01	0.	2.40130E 01	6.38658E 00	3.61373E 01	-2.70699E 01	
16	0.044000	2.51751E-01	0.	2.36114E 01	6.47288E 00	4.22584E 01	-2.90444E 01	
17	0.049500	2.37354E-01	0.	2.32607E 01	6.55495E 00	4.75633E 01	-2.97705E 01	
18	0.055300	2.24562E-01	0.	2.29651E 01	6.62972E 00	5.20145E 01	-2.95014E 01	
19	0.061300	2.13289E-01	0.	2.27175E 01	6.69671E 00	5.57328E 01	-2.85179E 01	
20	0.067500	2.03257E-01	0.	2.25075E 01	6.75672E 00	5.88806E 01	-2.70259E 01	
21	0.074000	1.94125E-01	0.	2.23246E 01	6.81091E 00	6.16143E 01	-2.51370E 01	
22	0.080800	1.85777E-01	0.	2.21640E 01	6.85959E 00	6.40035E 01	-2.29442E 01	
23	0.087800	1.78218E-01	0.	2.20242E 01	6.90285E 00	6.60763E 01	-2.05534E 01	
24	0.095000	1.71331E-01	0.	2.19014E 01	6.94131E 00	6.78897E 01	-1.80216E 01	
25	0.102500	1.64944E-01	0.	2.17907E 01	6.97556E 00	6.95078E 01	-1.53545E 01	
26	0.110000	1.59222E-01	0.	2.16948E 01	7.00571E 00	7.09052E 01	-1.26895E 01	
27	0.118000	1.53730E-01	0.	2.16038E 01	7.03246E 00	7.22000E 01	-9.87252E 00	
28	0.126000	1.48769E-01	0.	2.15231E 01	7.05574E 00	7.33303E 01	-7.09732E 00	
29	0.134500	1.43992E-01	0.	2.14445E 01	7.07549E 00	7.43840E 01	-4.20477E 00	
30	0.143000	1.39647E-01	0.	2.13724E 01	7.09182E 00	7.53124E 01	-1.37597E 00	
31	0.152000	1.35449E-01	0.	2.12990E 01	7.10370E 00	7.61822E 01	1.54670E 00	
32	0.161000	1.31609E-01	0.	2.12274E 01	7.11109E 00	7.69548E 01	4.39403E 00	
33	0.170500	1.27890E-01	0.	2.11491E 01	7.11137E 00	7.76819E 01	7.31881E 00	
34	0.180000	1.24469E-01	0.	2.10654E 01	7.10355E 00	7.83321E 01	1.01628E 01	
35	0.190000	1.21149E-01	0.	2.09643E 01	7.08173E 00	7.89464E 01	1.30725E 01	
36	0.200000	1.18082E-01	0.	2.08435E 01	7.04209E 00	7.94992E 01	1.58997E 01	
37	0.211000	1.14963E-01	0.	2.06713E 01	6.96446E 00	8.00468E 01	1.89192E 01	
38	0.223000	1.11827E-01	0.	2.04117E 01	6.81832E 00	8.05826E 01	2.21110E 01	
39	0.236000	1.08703E-01	0.	1.99986E 01	6.54513E 00	8.11015E 01	2.54561E 01	
40	0.250000	1.05616E-01	0.	1.93072E 01	6.02930E 00	8.16000E 01	2.89362E 01	

TEMPERATURE	FREE ATOM SIGMA	SCATTERING MASS
0.30000E 03	0.20400E 02	0.18800E 31

GROUP	LGUP	IHGDN
1	1	40
2	1	40
3	1	40
4	1	40
5	1	40
6	1	40
7	1	40
8	1	40
9	1	40
10	1	40
11	1	40
12	1	40
13	1	40
14	1	40
15	1	40
16	1	40
17	1	40
18	1	40
19	1	40
20	1	40
21	1	40
22	1	40
23	1	40
24	1	40
25	1	40
26	1	40
27	1	40
28	1	40
29	1	40
30	1	40
31	1	40
32	1	40
33	1	40
34	1	40
35	1	40
36	1	40
37	1	40
38	1	40
39	1	40
40	1	40

THE ZEROth AND THE FIRST MOMENTS OF THE DIFFERENTIAL

SCATTERING CROSS SECTIONS

THE VALUES OF THE CROSS SECTIONS FOR SCATTERING TO A PARTICULAR ENERGY POINT

ARE LISTED IN THE FOLLOWING ORDER.

GROUP	GROUP	GROUP	GROUP	GROUP	GROUP	GROUP	GROUP	GROUP	GROUP
1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40

P0 SCATTERING FROM GROUP 1 ENERGY= 0.00100

3.61719E 03	3.39350E 03	3.18365E 03	2.98677E 03	2.80207E 03	2.62879E 03	2.46622E 03	2.26500E 03	2.03640E 03	1.79232E 03
1.54429E 03	1.30257E 03	1.07555E 03	8.88095E 02	7.17874E 02	5.80280E 02	4.59182E 02	3.58747E 02	2.77904E 02	2.13454E 02
1.61871E 02	1.21196E 02	8.99732E 01	6.62277E 01	4.81307E 01	3.49787E 01	2.48855E 01	1.77046E 01	1.23307E 01	8.58790E 00
5.85522E 00	3.99206E 00	2.66448E 00	1.77837E 00	1.16206E 00	7.59226E-01	4.75364E-01	2.85288E-01	1.64062E-01	9.04172E-02

P0 SCATTERING FROM GROUP 2 ENERGY= 0.00250

1.43850E 03	2.26452E 03	2.12499E 03	1.99406E 03	1.87120E 03	1.75591E 03	1.64772E 03	1.51377E 03	1.36153E 03	1.19892E 03
1.03359E 03	8.72361E 02	7.20841E 02	5.95638E 02	4.81858E 02	3.89812E 02	3.08734E 02	2.41429E 02	1.87202E 02	1.43930E 02
1.09261E 02	8.16945E 01	6.08641E 01	4.48523E 01	3.26350E 01	2.37455E 01	1.69150E 01	1.20493E 01	8.40321E 00	5.86036E 00
4.00127E 00	2.75195E 00	1.82615E 00	1.22067E 00	7.98825E-01	5.22748E-01	3.27881E-01	1.97116E-01	1.13598E-01	6.27419E-02

P0 SCATTERING FROM GROUP 3 ENERGY= 0.00400

8.93854E 02	1.40747E 03	1.77226E 03	1.66345E 03	1.56131E 03	1.46545E 03	1.37547E 03	1.26404E 03	1.13735E 03	1.00198E 03
8.64263E 02	7.23896E 02	6.03535E 02	4.99049E 02	4.04026E 02	3.27096E 02	2.59279E 02	2.02934E 02	1.57496E 02	1.21204E 02
9.20993E 01	6.91021E 01	5.14108E 01	3.79259E 01	2.76270E 01	2.01242E 01	1.43525E 01	1.02361E 01	7.14769E 00	4.99107E 00
3.41230E 00	2.33289E 00	1.56159E 00	1.04528E 00	6.85063E-01	4.48966E-01	2.82056E-01	1.69860E-01	9.80736E-02	5.42773E-02

P0 SCATTERING FROM GROUP 4 ENERGY= 0.00550

6.46311E 02	1.01793E 03	1.28205E 03	1.49631E 03	1.40475E 03	1.31879E 03	1.23809E 03	1.13812E 03	1.02443E 03	9.02887E 02
7.79190E 02	6.58432E 02	5.44799E 02	4.50776E 02	3.65209E 02	2.95884E 02	2.34724E 02	1.83869E 02	1.42823E 02	1.10010E 02
8.36709E 01	6.28392E 01	4.67980E 01	3.45593E 01	2.52007E 01	1.83763E 01	1.31207E 01	9.36811E 00	6.54937E 00	4.57871E 00
3.13430E 00	2.14552E 00	1.43807E 00	9.63654E-01	6.32565E-01	4.15123E-01	2.61193E-01	1.57553E-01	9.11284E-02	5.05289E-02

PO SCATTERING FROM GROUP 5 ENERGY= 0.00700

5.04875E 02	7.95362E 02	1.00197E 03	1.16967E 03	1.31322E 03	1.23312E 03	1.15791E 03	1.06471E 03	9.58683E 02	8.45295E 02
7.29844E 02	6.17076E 02	5.10899E 02	4.22989E 02	3.42934E 02	2.78028E 02	2.20726E 02	1.73041E 02	1.34523E 02	1.03704E 02
7.89446E 01	5.93443E 01	4.42371E 01	3.26998E 01	2.38688E 01	1.74226E 01	1.24530E 01	8.90088E 00	6.22974E 00	4.36016E 00
2.98823E 00	2.04794E 00	1.37437E 00	9.22298E-01	6.06070E-01	3.98261E-01	2.50932E-01	1.51604E-01	8.78290E-02	4.87860E-02

PO SCATTERING FROM GROUP 6 ENERGY= 0.00850

4.13371E 02	6.51368E 02	8.20757E 02	9.58344E 02	1.07618E 03	1.18004E 03	1.10828E 03	1.01935E 03	9.18149E 02	8.09879E 02
6.99590E 02	5.91810E 02	4.90272E 02	4.06153E 02	3.29501E 02	2.67313E 02	2.12372E 02	1.66618E 02	1.29631E 02	1.00013E 02
7.61991E 01	5.73307E 01	4.27746E 01	3.16479E 01	2.31231E 01	1.68944E 01	1.20877E 01	8.64848E 00	6.05956E 00	4.24557E 00
2.91295E 00	1.99858E 00	1.34281E 00	9.02191E-01	5.93578E-01	3.90526E-01	2.46391E-01	1.49080E-01	8.64897E-02	4.81270E-02

PO SCATTERING FROM GROUP 7 ENERGY= 0.01000

3.49331E 02	5.50589E 02	6.93930E 02	8.10434E 02	9.10276E 02	9.98323E 02	1.07736E 03	9.91160E 02	8.93042E 02	7.88033E 02
6.81021E 02	5.76395E 02	4.77773E 02	3.96023E 02	3.21485E 02	2.60974E 02	2.07478E 02	1.62896E 02	1.26829E 02	9.79268E 01
7.46694E 01	5.62268E 01	4.19869E 01	3.10923E 01	2.27379E 01	1.66280E 01	1.19086E 01	8.52849E 00	5.98155E 00	4.19515E 00
2.88142E 00	1.97905E 00	1.33116E 00	8.95358E-01	5.89763E-01	3.88468E-01	2.45399E-01	1.48681E-01	8.63912E-02	4.81456E-02

PO SCATTERING FROM GROUP 8 ENERGY= 0.01200

2.88863E 02	4.55431E 02	5.74174E 02	6.70768E 02	7.53614E 02	8.26729E 02	8.92408E 02	9.70876E 02	8.75119E 02	7.72591E 02
6.68052E 02	5.65781E 02	4.69313E 02	3.89290E 02	3.16270E 02	2.56944E 02	2.04452E 02	1.60667E 02	1.25212E 02	9.67714E 01
7.38631E 01	5.56782E 01	4.16222E 01	3.08564E 01	2.25912E 01	1.65396E 01	1.18597E 01	8.50372E 00	5.97179E 00	4.19362E 00
2.88423E 00	1.98362E 00	1.33610E 00	8.99926E-01	5.93641E-01	3.91581E-01	2.47764E-01	1.50370E-01	8.75348E-02	4.88784E-02

PO SCATTERING FROM GROUP 9 ENERGY= 0.01450

2.36756E 02	3.73427E 02	4.70970E 02	5.50403E 02	6.18598E 02	6.78840E 02	7.33003E 02	7.97777E 02	8.69261E 02	7.67854E 02
6.64394E 02	5.63106E 02	4.67487E 02	3.88101E 02	3.15598E 02	2.56636E 02	2.04414E 02	1.60808E 02	1.25460E 02	9.70729E 01
7.41808E 01	5.59865E 01	4.19054E 01	3.11064E 01	2.28048E 01	1.67182E 01	1.20047E 01	8.61978E 00	6.06229E 00	4.26346E 00
2.93682E 00	2.02291E 00	1.36478E 00	9.20728E-01	6.08389E-01	4.01988E-01	2.54815E-01	1.54955E-01	9.03968E-02	5.05922E-02

PO SCATTERING FROM GROUP 10 ENERGY= 0.01750

1.93904E 02	3.05985E 02	3.86088E 02	4.51403E 02	5.07544E 02	5.57193E 02	6.01880E 02	6.55384E 02	7.14513E 02	7.76494E 02
6.72361E 02	5.70333E 02	4.73930E 02	3.93817E 02	3.20576E 02	2.60951E 02	2.08085E 02	1.63890E 02	1.28020E 02	9.91780E 01
7.58885E 01	5.73534E 01	4.29884E 01	3.19559E 01	2.34622E 01	1.72254E 01	1.23882E 01	8.90898E 00	6.27596E 00	4.42092E 00
3.05053E 00	2.10481E 00	1.42258E 00	9.61425E-01	6.36466E-01	4.21317E-01	2.67609E-01	1.63093E-01	9.53680E-02	5.35079E-02

PO SCATTERING FROM GROUP 11 ENERGY= 0.02100

1.59411E 02	2.51696E 02	3.17757E 02	3.71702E 02	4.18134E 02	4.59250E 02	4.96303E 02	5.40725E 02	5.89899E 02	6.41539E 02
6.93712E 02	5.88967E 02	4.89902E 02	4.07492E 02	3.32073E 02	2.70606E 02	2.16043E 02	1.70372E 02	1.33255E 02	1.03371E 02
7.92073E 01	5.99482E 01	4.49999E 01	3.35020E 01	2.46360E 01	1.81155E 01	1.30499E 01	9.40035E 00	6.63365E 00	4.68098E 00
3.23585E 00	2.23673E 00	1.51461E 00	1.02556E 00	6.80263E-01	4.51192E-01	2.87198E-01	1.75437E-01	1.02844E-01	5.78551E-02

PO SCATTERING FROM GROUP 12 ENERGY= 0.02500

1.31847E 02	2.08309E 02	2.63143E 02	3.07995E 02	3.46662E 02	3.80952E 02	4.11896E 02	4.49052E 02	4.90256E 02	5.33618E 02
5.77527E 02	6.20634E 02	5.16773E 02	4.30283E 02	3.51043E 02	2.86387E 02	2.28925E 02	1.80765E 02	1.41573E 02	1.09975E 02
8.43882E 01	6.39648E 01	4.80884E 01	3.58573E 01	2.64108E 01	1.94519E 01	1.40366E 01	1.01283E 01	7.16016E 00	5.06153E 00
3.50550E 00	2.42765E 00	1.64711E 00	1.11745E 00	7.42724E-01	4.93620E-01	3.14897E-01	1.92819E-01	1.13324E-01	6.39236E-02

PO SCATTERING FROM GROUP 13 ENERGY= 0.02950

1.09805E 02	1.73608E 02	2.19459E 02	2.57033E 02	2.89482E 02	3.18306E 02	3.44357E 02	3.75691E 02	4.10510E 02	4.47236E 02
4.84519E 02	5.21219E 02	5.56391E 02	4.63747E 02	3.78774E 02	3.09362E 02	2.47597E 02	1.95764E 02	1.53526E 02	1.19425E 02
9.17715E 01	6.96656E 01	5.24548E 01	3.91747E 01	2.89013E 01	2.13207E 01	1.54116E 01	1.11395E 01	7.88928E 00	5.58698E 00
3.87674E 00	2.68980E 00	1.82858E 00	1.24300E 00	8.27868E-01	5.51328E-01	3.52498E-01	2.16364E-01	1.27492E-01	7.21164E-02

PO SCATTERING FROM GROUP 14 ENERGY= 0.03400

9.36261E 01	1.48135E 02	1.87387E 02	2.19613E 02	2.47492E 02	2.72297E 02	2.94750E 02	3.21800E 02	3.51920E 02	3.83761E 02
4.15166E 02	4.48147E 02	4.78880E 02	5.05041E 02	4.12919E 02	3.37589E 02	2.70487E 02	2.14110E 02	1.68114E 02	1.30934E 02
1.00745E 02	7.65796E 01	5.77397E 01	4.31821E 01	3.19040E 01	2.35699E 01	1.70636E 01	1.23524E 01	8.76247E 00	6.21533E 00
4.32004E 00	3.00242E 00	2.04472E 00	1.39236E 00	9.29056E-01	6.19847E-01	3.97098E-01	2.44270E-01	1.44272E-01	8.18116E-02

PO SCATTERING FROM GROUP 15 ENERGY= 0.03900

8.00576E 01	1.26769E 02	1.60481E 02	1.88216E 02	2.12256E 02	2.33682E 02	2.53110E 02	2.76559E 02	3.02726E 02	3.30457E 02
3.58754E 02	3.86761E 02	4.13754E 02	4.36799E 02	4.58556E 02	3.75271E 02	3.01006E 02	2.38540E 02	1.87517E 02	1.46222E 02
1.12650E 02	8.57424E 01	6.47357E 01	4.84813E 01	3.58708E 01	2.65384E 01	1.92419E 01	1.39504E 01	9.91185E 00	7.04181E 00
4.90272E 00	3.41308E 00	2.32847E 00	1.58836E 00	1.06178E 00	7.09686E-01	4.55559E-01	2.80836E-01	1.66256E-01	9.45135E-02

PO SCATTERING FROM GROUP 16 ENERGY= 0.04400

6.95995E 01	1.10297E 02	1.39734E 02	1.64003E 02	1.85077E 02	2.03894E 02	2.20984E 02	2.41648E 02	2.64757E 02	2.89307E 02
3.14424E 02	3.39352E 02	3.63449E 02	3.84078E 02	4.03608E 02	4.20142E 02	3.37319E 02	2.67586E 02	2.10568E 02	1.64373E 02
1.26775E 02	9.66061E 01	7.30251E 01	5.47565E 01	4.05653E 01	3.00497E 01	2.18172E 01	1.58387E 01	1.12696E 01	8.01777E 00
5.59057E 00	3.89774E 00	2.66329E 00	1.81959E 00	1.21834E 00	8.15659E-01	5.24521E-01	3.23975E-01	1.92196E-01	1.09505E-01

PO SCATTERING FROM GROUP 17 ENERGY= 0.04950

6.05625E 01	9.60599E 01	1.21799E 02	1.43066E 02	1.61573E 02	1.78128E 02	1.93191E 02	2.11440E 02	2.31895E 02	2.53683E 02
2.76038E 02	2.98292E 02	3.19869E 02	3.38398E 02	3.55992E 02	3.70930E 02	3.84785E 02	3.05535E 02	2.40673E 02	1.88067E 02
1.45207E 02	1.10776E 02	8.38335E 01	6.29358E 01	4.66825E 01	3.46238E 01	2.51713E 01	1.82977E 01	1.30372E 01	9.28823E 00
6.48591E 00	4.52857E 00	3.09908E 00	2.12057E 00	1.42215E 00	9.53633E-01	6.14324E-01	3.80169E-01	2.25996E-01	1.29047E-01

PO SCATTERING FROM GROUP 18 ENERGY= 0.05530

5.30066E 01	8.41531E 01	1.06796E 02	1.25548E 02	1.41901E 02	1.56559E 02	1.69921E 02	1.86142E 02	2.04368E 02	2.23834E 02
2.43865E 02	2.63867E 02	2.83323E 02	3.00082E 02	3.16044E 02	3.29637E 02	3.42282E 02	3.53418E 02	2.78646E 02	2.17946E 02
1.68444E 02	1.28637E 02	9.74544E 01	7.32417E 01	5.43890E 01	4.03857E 01	2.93959E 01	2.13946E 01	1.52635E 01	1.08883E 01
7.61360E 00	5.32317E 00	3.64808E 00	2.49980E 00	1.67900E 00	1.12756E 00	7.27561E-01	4.51053E-01	2.68654E-01	1.53725E-01

PO SCATTERING FROM GROUP 19 ENERGY= 0.06130

4.67201E 01	7.42437E 01	9.43058E 01	1.10960E 02	1.25516E 02	1.38590E 02	1.50531E 02	1.65055E 02	1.81416E 02	1.98938E 02
2.17022E 02	2.35136E 02	2.52813E 02	2.68088E 02	2.82680E 02	2.95144E 02	3.06773E 02	3.17044E 02	3.25870E 02	2.55099E 02
1.97334E 02	1.50841E 02	1.14385E 02	8.60512E 01	6.39672E 01	4.75468E 01	3.46463E 01	2.52437E 01	1.80306E 01	1.28773E 01
9.01554E 00	6.31117E 00	4.33083E 00	2.97153E 00	1.99858E 00	1.34402E 00	8.68548E-01	5.39346E-01	3.21815E-01	1.84498E-01

PO SCATTERING FROM GROUP 20 ENERGY= 0.06750

4.14222E 01	6.58898E 01	8.37729E 01	9.86552E 01	1.11691E 02	1.23424E 02	1.34161E 02	1.47249E 02	1.62027E 02	1.77899E 02
1.94330E 02	2.10839E 02	2.27003E 02	2.41014E 02	2.54441E 02	2.65944E 02	2.76708E 02	2.86244E 02	2.94462E 02	3.01485E 02
2.33401E 02	1.78559E 02	1.35521E 02	1.02041E 02	7.59237E 01	5.64863E 01	4.12011E 01	3.00493E 01	2.14858E 01	1.53612E 01
1.07666E 01	7.54541E 00	5.18394E 00	3.56110E 00	2.39812E 00	1.61473E 00	1.04493E 00	6.49853E-01	3.88387E-01	2.23058E-01

PO SCATTERING FROM GROUP 21 ENERGY= 0.07400

3.68446E 01	5.86689E 01	7.46654E 01	8.80115E 01	9.97291E 01	1.10298E 02	1.19989E 02	1.31828E 02	1.45230E 02	1.59665E 02
1.74654E 02	1.89764E 02	2.04607E 02	2.17515E 02	2.29923E 02	2.40586E 02	2.50595E 02	2.59488E 02	2.67176E 02	2.73765E 02
2.79445E 02	2.13943E 02	1.62502E 02	1.22455E 02	9.11884E 01	6.78999E 01	4.95706E 01	3.61861E 01	2.58985E 01	1.85339E 01
1.30036E 01	9.12254E 00	6.27429E 00	4.31483E 00	2.90904E 00	1.96101E 00	1.27054E 00	7.91326E-01	4.73657E-01	2.72474E-01

PO SCATTERING FROM GROUP 22 ENERGY= 0.08080

3.28668E 01	5.23916E 01	6.67448E 01	7.87516E 01	8.93187E 01	9.88714E 01	1.07648E 02	1.18394E 02	1.30591E 02	1.43766E 02
1.57490E 02	1.71371E 02	1.85052E 02	1.96990E 02	2.08502E 02	2.18426E 02	2.27769E 02	2.36098E 02	2.43319E 02	2.49528E 02
2.54896E 02	2.59476E 02	1.97223E 02	1.48725E 02	1.10833E 02	8.25898E 01	6.03435E 01	4.40859E 01	3.15797E 01	2.26192E 01
1.58847E 01	1.11541E 01	7.67914E 00	5.28619E 00	3.56767E 00	2.40755E 00	1.56179E 00	9.73895E-01	5.83747E-01	3.36312E-01

PO SCATTERING FROM GROUP 23 ENERGY= 0.08780

2.94375E 01	4.69774E 01	5.99103E 01	7.07581E 01	8.03286E 01	8.89999E 01	9.69834E 01	1.06780E 02	1.17929E 02	1.30008E 02
1.42630E 02	1.55438E 02	1.68105E 02	1.79195E 02	1.89923E 02	1.99201E 02	2.07964E 02	2.15798E 02	2.22613E 02	2.28489E 02
2.33584E 02	2.37945E 02	2.41584E 02	1.82290E 02	1.35936E 02	1.01362E 02	7.41116E 01	5.41831E 01	3.88422E 01	2.78424E 01
1.95687E 01	1.37524E 01	9.47625E 00	6.52906E 00	4.41062E 00	2.97920E 00	1.93464E 00	1.20778E 00	7.24847E-01	4.18171E-01

PO SCATTERING FROM GROUP 24 ENERGY= 0.09500

2.64584E 01	4.22714E 01	5.39671E 01	6.38040E 01	7.25042E 01	8.04049E 01	8.76944E 01	9.66593E 01	1.06889E 02	1.18006E 02
1.29659E 02	1.41524E 02	1.53298E 02	1.63640E 02	1.73677E 02	1.82385E 02	1.90635E 02	1.98034E 02	2.04489E 02	2.10073E 02
2.14929E 02	2.19098E 02	2.22586E 02	2.25479E 02	1.68237E 02	1.25519E 02	9.18308E 01	6.71793E 01	4.81909E 01	3.45668E 01
2.43124E 01	1.70985E 01	1.17911E 01	8.13031E 00	5.49689E 00	3.71604E 00	2.41538E 00	1.50945E 00	9.06908E-01	5.23842E-01

PO SCATTERING FROM GROUP 25 ENERGY= 0.10250

2.38204E 01	3.81021E 01	4.86989E 01	5.76367E 01	6.55620E 01	7.27759E 01	7.94460E 01	8.76682E 01	9.70764E 01	1.07331E 02
1.18115E 02	1.29132E 02	1.40104E 02	1.49773E 02	1.59189E 02	1.67384E 02	1.75171E 02	1.82178E 02	1.88310E 02	1.93631E 02
1.98272E 02	2.02269E 02	2.05623E 02	2.08413E 02	2.10741E 02	1.57309E 02	1.15150E 02	8.42846E 01	6.04967E 01	4.34194E 01
3.05582E 01	2.15049E 01	1.48399E 01	1.02396E 01	6.92813E 00	4.68710E 00	3.04910E 00	1.90723E 00	1.14706E 00	6.63285E-01

PO SCATTERING FROM GROUP 26 ENERGY= 0.11000

2.15608E 01	3.45289E 01	4.41813E 01	5.23455E 01	5.96031E 01	6.62244E 01	7.23596E 01	7.99397E 01	8.86363E 01	9.81434E 01
1.08174E 02	1.18454E 02	1.28727E 02	1.37810E 02	1.46684E 02	1.54430E 02	1.61815E 02	1.68480E 02	1.74330E 02	1.79422E 02
1.83877E 02	1.87724E 02	1.90962E 02	1.93664E 02	1.95924E 02	1.97727E 02	1.44801E 02	1.06036E 02	7.61464E 01	5.46786E 01
3.85029E 01	2.71105E 01	1.87191E 01	1.29239E 01	8.74980E 00	5.92329E 00	3.85602E 00	2.41386E 00	1.45302E 00	8.41001E-01

PO SCATTERING FROM GROUP 27 ENERGY= 0.11800

1.94860E 01	3.12455E 01	4.00278E 01	4.74780E 01	5.41185E 01	6.01915E 01	6.58312E 01	7.28156E 01	8.08513E 01	8.96630E 01
9.89904E 01	1.08584E 02	1.18204E 02	1.26739E 02	1.35105E 02	1.42432E 02	1.49438E 02	1.55783E 02	1.61370E 02	1.66248E 02
1.70528E 02	1.74236E 02	1.77367E 02	1.79987E 02	1.82186E 02	1.83945E 02	1.85432E 02	1.35843E 02	9.75940E 01	7.01105E 01
4.93930E 01	3.47953E 01	2.40376E 01	1.66047E 01	1.12481E 01	7.61895E 00	4.96306E 00	3.10909E 00	1.87298E 00	1.08501E 00

PO SCATTERING FROM GROUP 28 ENERGY= 0.12600

1.76921E 01	2.84049E 01	3.64322E 01	4.32617E 01	4.93650E 01	5.49600E 01	6.01671E 01	6.66310E 01	7.40882E 01	8.22904E 01
9.10007E 01	9.99895E 01	1.09034E 02	1.17086E 02	1.25004E 02	1.31960E 02	1.38633E 02	1.44695E 02	1.50050E 02	1.54738E 02
1.58865E 02	1.62451E 02	1.65488E 02	1.68037E 02	1.70182E 02	1.71903E 02	1.73362E 02	1.74510E 02	1.25418E 02	9.01316E 01
6.35229E 01	4.47671E 01	3.09398E 01	2.13820E 01	1.44912E 01	9.82034E 00	6.40053E 00	4.01199E 00	2.41851E 00	1.40206E 00

PO SCATTERING FROM GROUP 29 ENERGY= 0.13450

1.60373E 01	2.57827E 01	3.31107E 01	3.93644E 01	4.49685E 01	5.01187E 01	5.49229E 01	6.09010E 01	6.78175E 01	7.54491E 01
8.35806E 01	9.20015E 01	1.00505E 02	1.08102E 02	1.15596E 02	1.22203E 02	1.28562E 02	1.34356E 02	1.39491E 02	1.44001E 02
1.47984E 02	1.51455E 02	1.54404E 02	1.56887E 02	1.58982E 02	1.60669E 02	1.62103E 02	1.63235E 02	1.64174E 02	1.18021E 02
8.32072E 01	5.86599E 01	4.05569E 01	2.80390E 01	1.90107E 01	1.28886E 01	8.40430E 00	5.27081E 00	3.17923E 00	1.84427E 00

PO SCATTERING FROM GROUP 30 ENERGY= 0.14300

1.45956E 01	2.34962E 01	3.02125E 01	3.59615E 01	4.11275E 01	4.58865E 01	5.03358E 01	5.58854E 01	6.23243E 01	6.94508E 01
7.70691E 01	8.49855E 01	9.30078E 01	1.00198E 02	1.07316E 02	1.13611E 02	1.19687E 02	1.25243E 02	1.30182E 02	1.34533E 02
1.38387E 02	1.41757E 02	1.44628E 02	1.47052E 02	1.49105E 02	1.50761E 02	1.52174E 02	1.53292E 02	1.54223E 02	1.54945E 02
1.09270E 02	7.70557E 01	5.32919E 01	3.68550E 01	2.49965E 01	1.69527E 01	1.10587E 01	6.93862E 00	4.18727E 00	2.43036E 00

PO SCATTERING FROM GROUP 31 ENERGY= 0.15200

1.32609E 01	2.13780E 01	2.75256E 01	3.28044E 01	3.75613E 01	4.19545E 01	4.60715E 01	5.12197E 01	5.72098E 01	6.38610E 01
7.09953E 01	7.84348E 01	8.60014E 01	9.28072E 01	9.95667E 01	1.05565E 02	1.11374E 02	1.16702E 02	1.21454E 02	1.25655E 02
1.29387E 02	1.32660E 02	1.35458E 02	1.37828E 02	1.39840E 02	1.41470E 02	1.42863E 02	1.43969E 02	1.44893E 02	1.45612E 02
1.46198E 02	1.03122E 02	7.13383E 01	4.93486E 01	3.34800E 01	2.27130E 01	1.48214E 01	9.30301E 00	5.61652E 00	3.26146E 00

PO SCATTERING FROM GROUP 32 ENERGY= 0.16100

1.20907E 01	1.95194E 01	2.51655E 01	3.00294E 01	3.44244E 01	3.84938E 01	4.23161E 01	4.71072E 01	5.26977E 01	5.89247E 01
6.55262E 01	7.26386E 01	7.97960E 01	8.62557E 01	9.26928E 01	9.84232E 01	1.03991E 02	1.09114E 02	1.13698E 02	1.17763E 02
1.21385E 02	1.24572E 02	1.27304E 02	1.29625E 02	1.31602E 02	1.33208E 02	1.34585E 02	1.35682E 02	1.36600E 02	1.37317E 02
1.37903E 02	1.38352E 02	9.57295E 01	6.62358E 01	4.49474E 01	3.05000E 01	1.99083E 01	1.24998E 01	7.54912E 00	4.38541E 00

PO SCATTERING FROM GROUP 33 ENERGY= 0.17050

1.10046E 01	1.77924E 01	2.29712E 01	2.74472E 01	3.15034E 01	3.52686E 01	3.88138E 01	4.32687E 01	4.84825E 01	5.43084E 01
6.55998E 01	6.72065E 01	7.39745E 01	8.01044E 01	8.62336E 01	9.17084E 01	9.70450E 01	1.01972E 02	1.06395E 02	1.10329E 02
1.13847E 02	1.16951E 02	1.19621E 02	1.21896E 02	1.23841E 02	1.25424E 02	1.26787E 02	1.27875E 02	1.28789E 02	1.29505E 02
1.30092E 02	1.30542E 02	1.30904E 02	9.05893E 01	6.14858E 01	4.17310E 01	2.72454E 01	1.71110E 01	1.03371E 01	6.00697E 00

PO SCATTERING FROM GROUP 34 ENERGY= 0.18000

1.00470E 01	1.62687E 01	2.10334E 01	2.51645E 01	2.89190E 01	3.24138E 01	3.57115E 01	3.98656E 01	4.47413E 01	5.02067E 01
5.61288E 01	6.23696E 01	6.87851E 01	7.46159E 01	8.04657E 01	8.57079E 01	9.08343E 01	9.55828E 01	9.98589E 01	1.03674E 02
1.07096E 02	1.10126E 02	1.12740E 02	1.14974E 02	1.16889E 02	1.18454E 02	1.19804E 02	1.20885E 02	1.21797E 02	1.22512E 02
1.23101E 02	1.23554E 02	1.23918E 02	1.24192E 02	8.43063E 01	5.72286E 01	3.73705E 01	2.34748E 01	1.41849E 01	8.24515E 00

PO SCATTERING FROM GROUP 35 ENERGY= 0.19000

9.15730E 00	1.48502E 01	1.92278E 01	2.30359E 01	2.65069E 01	2.97463E 01	3.28105E 01	3.66809E 01	4.12366E 01	4.63602E 01
5.19310E 01	5.78223E 01	6.39012E 01	6.94456E 01	7.50272E 01	8.00460E 01	8.49700E 01	8.95465E 01	9.36812E 01	9.73826E 01
1.00713E 02	1.03671E 02	1.06231E 02	1.08426E 02	1.10314E 02	1.11861E 02	1.13200E 02	1.14275E 02	1.15184E 02	1.15900E 02
1.16491E 02	1.16948E 02	1.17315E 02	1.17594E 02	1.17813E 02	7.99841E 01	5.22378E 01	3.28195E 01	1.98354E 01	1.15321E 01

PO SCATTERING FROM GROUP 36 ENERGY= 0.20000

8.36835E 00	1.35925E 01	1.76255E 01	2.11449E 01	2.43631E 01	2.73737E 01	3.02287E 01	3.38428E 01	3.81104E 01	4.29247E 01
4.81770E 01	5.37513E 01	5.95233E 01	6.48061E 01	7.01424E 01	7.49563E 01	7.96950E 01	8.41133E 01	8.81182E 01	9.17148E 01
9.49609E 01	9.78532E 01	1.00364E 02	1.02524E 02	1.04387E 02	1.05918E 02	1.07248E 02	1.08319E 02	1.09227E 02	1.09944E 02
1.10538E 02	1.10998E 02	1.11370E 02	1.11652E 02	1.11875E 02	1.12040E 02	7.31824E 01	4.59846E 01	2.77964E 01	1.61633E 01

PO SCATTERING FROM GROUP 37 ENERGY= 0.21100

7.60060E 00	1.23674E 01	1.60626E 01	1.92994E 01	2.22676E 01	2.50531E 01	2.77006E 01	3.10624E 01	3.50436E 01	3.95504E 01
4.44848E 01	4.97414E 01	5.52059E 01	6.02257E 01	6.53149E 01	6.99223E 01	7.44732E 01	7.87316E 01	8.26050E 01	8.60953E 01
8.92563E 01	9.20823E 01	9.45440E 01	9.66684E 01	9.85069E 01	1.00023E 02	1.01343E 02	1.02411E 02	1.03319E 02	1.04038E 02
1.04636E 02	1.05100E 02	1.05476E 02	1.05763E 02	1.05990E 02	1.06160E 02	1.06296E 02	8.67994E 01	4.03835E 01	2.34861E 01

PO SCATTERING FROM GROUP 38 ENERGY= 0.22300

6.86575E 00	1.11909E 01	1.45598E 01	1.75223E 01	2.02493E 01	2.28160E 01	2.52613E 01	2.83755E 01	3.20753E 01	3.62802E 01
4.09012E 01	4.58440E 01	5.10033E 01	5.57620E 01	6.06043E 01	6.50052E 01	6.93685E 01	7.34668E 01	7.72082E 01	8.05918E 01
8.36673E 01	8.64269E 01	8.88395E 01	9.09288E 01	9.27432E 01	9.42446E 01	9.55570E 01	9.66216E 01	9.75301E 01	9.82525E 01
9.88547E 01	9.93239E 01	9.97060E 01	9.99977E 01	1.00230E 02	1.00403E 02	1.00544E 02	1.00653E 02	6.08561E 01	3.53966E 01

PO SCATTERING FROM GROUP 39 ENERGY= 0.23600

6.16897E 00	1.00766E 01	1.31345E 01	1.58350E 01	1.83289E 01	2.06816E 01	2.29335E 01	2.58084E 01	2.92360E 01	3.31464E 01
3.74622E 01	4.20973E 01	4.69566E 01	5.14575E 01	5.60566E 01	6.02531E 01	6.44296E 01	6.83685E 01	7.19782E 01	7.52557E 01
7.82463E 01	8.09396E 01	8.33034E 01	8.53580E 01	8.71491E 01	8.86367E 01	8.99417E 01	9.10042E 01	9.19143E 01	9.26406E 01
9.32482E 01	9.37233E 01	9.41116E 01	9.44092E 01	9.46469E 01	9.48253E 01	9.49701E 01	9.50831E 01	9.51677E 01	5.53590E 01

PC SCATTERING FROM GROUP 40 ENERGY= 0.25000

5.51613E 00	9.02984E 00	1.17940E 01	1.42457E 01	1.65186E 01	1.86718E 01	2.07365E 01	2.33817E 01	2.65478E 01	3.01739E 01
3.41928E 01	3.85276E 01	4.30948E 01	4.73436E 01	5.17038E 01	5.56991E 01	5.96914E 01	6.34726E 01	6.69524E 01	7.01248E 01
7.30305E 01	7.56585E 01	7.79739E 01	7.99947E 01	8.17630E 01	8.32374E 01	8.45359E 01	8.55971E 01	8.65097E 01	8.72406E 01
8.78546E 01	8.83365E 01	8.87319E 01	8.90360E 01	8.92798E 01	8.94635E 01	8.96133E 01	8.97305E 01	8.98188E 01	8.98826E 01

P1 SCATTERING FROM GROUP 1 ENERGY= 0.00100

1.21895E 03 6.95662E 02 4.95493E 02 3.80058E 02 3.02442E 02 2.45906E 02 2.02675E 02 1.58724E 02 1.18376E 02 8.38358E 01
5.58482E 01 3.42616E 01 1.84234E 01 8.31257E 00 1.36312E 00 -2.69757E 00 -5.07650E 00 -6.13913E 00 -6.33263E 00 -6.00801E 00
-5.39382E 00 -4.64510E 00 -3.87977E 00 -3.16183E 00 -2.51542E 00 -1.97723E 00 -1.51298E 00 -1.14854E 00 -8.50748E-01 -6.26006E-01
-4.50469E-01 -3.22780E-01 -2.25805E-01 -1.57794E-01 -1.06152E-01 -7.29985E-02 -4.82485E-02 -2.95540E-02 -1.76886E-02 -1.01437E-02

P1 SCATTERING FROM GROUP 2 ENERGY= 0.00250

2.94889E 02 7.75448E 02 5.54122E 02 4.26521E 02 3.40708E 02 2.78160E 02 2.30292E 02 1.81557E 02 1.36719E 02 9.82075E 01
6.68474E 01 4.24876E 01 2.44342E 01 1.27431E 01 4.54174E 00 -4.08829E-01 -3.47893E 00 -5.04706E 00 -5.59878E 00 -5.52516E 00
-5.08598E 00 -4.45771E 00 -3.77142E 00 -3.10343E 00 -2.48841E 00 -1.96834E 00 -1.51550E 00 -1.15565E 00 -8.59605E-01 -6.35358E-01
-4.58409E-01 -3.28858E-01 -2.30712E-01 -1.61215E-01 -1.10095E-01 -7.51070E-02 -4.91497E-02 -3.08465E-02 -1.83665E-02 -1.05581E-02

P1 SCATTERING FROM GROUP 3 ENERGY= 0.00400

1.39117E 02 3.67017E 02 6.16479E 02 4.75959E 02 3.81439E 02 3.12509E 02 2.59715E 02 2.05901E 02 1.56293E 02 1.13559E 02
7.86120E 01 5.13010E 01 3.08864E 01 1.75101E 01 7.97040E 00 2.06782E 00 -1.74330E 00 -3.85447E 00 -4.79242E 00 -4.99043E 00
-4.74231E 00 -4.24513E 00 -3.64565E 00 -3.03375E 00 -2.45412E 00 -1.95480E 00 -1.51399E 00 -1.16047E 00 -8.67116E-01 -6.43197E-01
-4.65586E-01 -3.35318E-01 -2.35862E-01 -1.65223E-01 -1.13053E-01 -7.71856E-02 -5.05738E-02 -3.18166E-02 -1.90543E-02 -1.09801E-02

P1 SCATTERING FROM GROUP 4 ENERGY= 0.00550

8.22412E 01 2.17731E 02 3.66832E 02 5.28547E 02 4.24784E 02 3.49080E 02 2.91055E 02 2.31847E 02 1.77171E 02 1.29950E 02
9.11888E 01 6.07377E 01 3.78077E 01 2.26342E 01 1.16654E 01 4.74450E 00 1.38995E-01 -2.55544E 00 -3.90936E 00 -4.40086E 00
-4.35995E 00 -4.00579E 00 -3.50143E 00 -2.95146E 00 -2.41152E 00 -1.93579E 00 -1.50915E 00 -1.16301E 00 -8.73223E-01 -6.50332E-01
-4.72568E-01 -3.41358E-01 -2.40802E-01 -1.69210E-01 -1.16107E-01 -7.94958E-02 -5.21610E-02 -3.28728E-02 -1.97523E-02 -1.14102E-02

P1 SCATTERING FROM GROUP 5 ENERGY= 0.00700

5.44939E 01 1.44819E 02 2.44787E 02 3.53699E 02 4.70898E 02 3.88002E 02 3.24426E 02 2.59490E 02 1.99432E 02 1.47443E 02
1.04627E 02 7.08354E 01 4.52272E 01 2.81376E 01 1.56432E 01 7.63369E 00 2.17745E 00 -1.14303E 00 -2.94447E 00 -3.75279E 00
-3.93629E 00 -3.73773E 00 -3.33751E 00 -2.85585E 00 -2.35996E 00 -1.91074E 00 -1.50035E 00 -1.16303E 00 -8.77677E-01 -6.56411E-01
-4.78869E-01 -3.47127E-01 -2.45644E-01 -1.73098E-01 -1.19144E-01 -8.16814E-02 -5.37640E-02 -3.39057E-02 -2.04599E-02 -1.18479E-02

P1 SCATTERING FROM GROUP 6 ENERGY= 0.00850

3.86682E 01 1.03186E 02 1.75028E 02 2.53670E 02 3.38621E 02 4.29414E 02 3.59945E 02 2.88929E 02 2.23158E 02 1.66104E 02
1.18979E 02 8.16340E 01 5.31748E 01 3.40434E 01 1.99215E 01 1.07487E 01 4.38201E 00 3.90117E-01 -1.89240E 00 -3.04225E 00
-3.46849E 00 -3.43895E 00 -3.15237E 00 -2.74572E 00 -2.29868E 00 -1.87918E 00 -1.48744E 00 -1.16036E 00 -8.80501E-01 -6.61549E-01
-4.84671E-01 -3.52561E-01 -2.50379E-01 -1.76833E-01 -1.22084E-01 -8.39141E-02 -5.53412E-02 -3.49596E-02 -2.12302E-02 -1.22930E-02

P1 SCATTERING FROM GROUP 7 ENERGY= 0.01000

2.87080E 01 7.69526E 01 1.31027E 02 1.90520E 02 2.55044E 02 3.24232E 02 3.97738E 02 3.20270E 02 2.48433E 02 1.86002E 02
1.34298E 02 9.31757E 01 6.16827E 01 4.03766E 01 2.45189E 01 1.41038E 01 6.76323E 00 2.05177E 00 -7.47482E-01 -2.26510E 00
-2.95359E 00 -3.10729E 00 -2.94457E 00 -2.62009E 00 -2.22701E 00 -1.84072E 00 -1.46998E 00 -1.15475E 00 -8.81461E-01 -6.65552E-01
-4.89737E-01 -3.57556E-01 -2.54796E-01 -1.80508E-01 -1.24985E-01 -8.61054E-02 -5.69463E-02 -3.60809E-02 -2.19249E-02 -1.27452E-02

P1 SCATTERING FROM GROUP 8 ENERGY= 0.01200

2.02426E 01	5.46232E 01	9.35280E 01	1.36643E 02	1.83670E 02	2.34331E 02	2.88361E 02	3.65212E 02	2.84705E 02	2.14583E 02
1.56329E 02	1.09798E 02	7.39572E 01	4.95306E 01	3.11792E 01	1.89767E 01	1.02323E 01	4.48158E 00	9.34075E-01	-1.11761E 00
-2.18819E 00	-2.61003E 00	-2.62940E 00	-2.42652E 00	-2.11389E 00	-1.77761E 00	-1.43901E 00	-1.14228E 00	-8.79646E-01	-6.68962E-01
-4.95313E-01	-3.63572E-01	-2.60352E-01	-1.85238E-01	-1.28727E-01	-8.90382E-02	-5.90551E-02	-3.75497E-02	-2.28917E-02	-1.33584E-02

P1 SCATTERING FROM GROUP 9 ENERGY= 0.01450

1.37626E 01	3.74979E 01	6.47196E 01	9.51903E 01	1.28685E 02	1.64993E 02	2.03912E 02	2.59543E 02	3.34504E 02	2.53871E 02
1.86655E 02	1.32719E 02	9.09179E 01	6.22081E 01	4.04283E 01	2.57638E 01	1.50818E 01	7.89286E 00	3.30695E 00	5.11530E-01
-1.09325E 00	-1.89176E 00	-2.16840E 00	-2.13859E 00	-1.94146E 00	-1.67783E 00	-1.38660E 00	-1.11775E 00	-8.71719E-01	-6.69669E-01
-5.00209E-01	-3.69863E-01	-2.66583E-01	-1.90758E-01	-1.33260E-01	-9.25758E-02	-6.16830E-02	-3.94122E-02	-2.41295E-02	-1.41399E-02

P1 SCATTERING FROM GROUP 10 ENERGY= 0.01750

9.06984E 00	2.50642E 01	4.37572E 01	6.49691E 01	8.85300E 01	1.14279E 02	1.42064E 02	1.82030E 02	2.36235E 02	3.06762E 02
2.27549E 02	1.63687E 02	1.13887E 02	7.94199E 01	5.30234E 01	3.50368E 01	2.17341E 01	1.25944E 01	6.59537E 00	2.78409E 00
4.46397E-01	-8.71565E-01	-1.50528E 00	-1.71745E 00	-1.68335E 00	-1.52347E 00	-1.30097E 00	-1.07342E 00	-8.52753E-01	-6.64558E-01
-5.02418E-01	-3.75207E-01	-2.72816E-01	-1.96694E-01	-1.38331E-01	-9.66736E-02	-6.47842E-02	-4.16145E-02	-2.56185E-02	-1.50966E-02

P1 SCATTERING FROM GROUP 11 ENERGY= 0.02100

5.76501E 00	1.62785E 01	2.89027E 01	4.35003E 01	5.99419E 01	7.81044E 01	9.78714E 01	1.26534E 02	1.65727E 02	2.17118E 02
2.82225E 02	2.05180E 02	1.44740E 02	1.02601E 02	7.00413E 01	4.76098E 01	3.07915E 01	1.90272E 01	1.11204E 01	5.93214E 00
2.59644E 00	5.67257E-01	-5.58495E-01	-1.10665E 00	-1.30107E 00	-1.28830E 00	-1.16468E 00	-9.97750E-01	-8.15326E-01	-6.48854E-01
-4.99352E-01	-3.77826E-01	-2.77989E-01	-2.02397E-01	-1.43605E-01	-1.01129E-01	-6.82720E-02	-4.41656E-02	-2.73644E-02	-1.62345E-02

P1 SCATTERING FROM GROUP 12 ENERGY= 0.02500

3.46800E 00	1.01455E 01	1.84951E 01	2.84113E 01	3.97940E 01	5.25482E 01	6.65841E 01	8.71451E 01	1.15549E 02	1.53150E 02
2.01194E 02	2.60695E 02	1.86126E 02	1.33783E 02	9.30082E 01	6.46383E 01	4.31108E 01	2.78199E 01	1.73404E 01	1.02878E 01
5.59456E 00	2.59266E 00	7.89682E-01	-2.24443E-01	-7.38630E-01	-9.33961E-01	-9.52139E-01	-8.73662E-01	-7.48358E-01	-6.15413E-01
-4.85596E-01	-3.74905E-01	-2.80403E-01	-2.06878E-01	-1.48513E-01	-1.05614E-01	-7.19722E-02	-4.69679E-02	-2.93436E-02	-1.75539E-02

P1 SCATTERING FROM GROUP 13 ENERGY= 0.02950

1.88088E 00	5.88477E 00	1.12310E 01	1.78375E 01	2.56263E 01	3.45233E 01	4.44581E 01	5.92036E 01	7.98368E 01	1.07472E 02
1.43149E 02	1.87727E 02	2.41806E 02	1.75850E 02	1.24094E 02	8.77677E 01	5.99139E 01	3.98704E 01	2.59117E 01	1.63277E 01
9.78279E 00	5.44704E 00	2.70966E 00	1.04800E 00	8.56632E-02	-4.04262E-01	-6.25651E-01	-6.75878E-01	-6.35335E-01	-5.53476E-01
-4.55219E-01	-3.62150E-01	-2.77424E-01	-2.08560E-01	-1.52117E-01	-1.09614E-01	-7.56030E-02	-4.98917E-02	-3.14937E-02	-1.90172E-02

P1 SCATTERING FROM GROUP 14 ENERGY= 0.03400

8.76340E-01	3.16923E 00	6.57484E 00	1.10272E 01	1.64634E 01	2.28237E 01	3.00512E 01	4.09437E 01	5.64086E 01	7.73921E 01
1.04785E 02	1.39337E 02	1.81588E 02	2.26668E 02	1.51761E 02	1.15884E 02	8.04183E 01	5.46396E 01	3.64685E 01	2.38084E 01
1.50039E 01	9.03259E 00	5.14311E 00	2.67798E 00	1.15544E 00	2.94047E-01	-1.86237E-01	-4.02532E-01	-4.73088E-01	-4.59540E-01
-4.04655E-01	-3.36708E-01	-2.66732E-01	-2.05594E-01	-1.53035E-01	-1.12078E-01	-7.84371E-02	-5.24373E-02	-3.34930E-02	-2.04404E-02

P1 SCATTERING FROM GROUP 15 ENERGY= 0.03900

1.52016E-01	1.19486E 00	3.16587E 00	6.01191E 00	9.68224E 00	1.41283E 01	1.93041E 01	2.72644E 01	3.87794E 01	5.46578E 01
7.56690E 01	1.02472E 02	1.35554E 02	1.71116E 02	2.12866E 02	1.54146E 02	1.08419E 02	7.48882E 01	5.10063E 01	3.41617E 01
2.22717E 01	1.40572E 01	8.57972E 00	5.00080E 00	2.69657E 00	1.31292E 00	4.65421E-01	1.10514E-02	-2.20837E-01	-3.08104E-01
-3.18530E-01	-2.89470E-01	-2.43195E-01	-1.95173E-01	-1.49852E-01	-1.12371E-01	-8.02601E-02	-5.46185E-02	-3.54270E-02	-2.19168E-02

P1 SCATTERING FROM GROUP 16 ENERGY= 0.04400

-3.23550E-01	-1.15678E-01	8.83363E-01	2.62978E 00	5.08158E 00	8.19862E 00	1.19427E 01	1.78470E 01	2.65791E 01	3.88440E 01
5.53190E 01	7.65926E 01	1.03112E 02	1.31843E 02	1.65785E 02	2.01327E 02	1.43057E 02	1.00027E 02	6.91278E 01	4.71249E 01
3.14180E 01	2.04178E 01	1.29593E 01	7.98385E 00	4.69387E 00	2.64726E 00	1.33005E 00	5.68414E-01	1.26067E-01	-9.44263E-02
-1.92548E-01	-2.16780E-01	-2.03863E-01	-1.75010E-01	-1.40847E-01	-1.09216E-01	-8.01712E-02	-5.58135E-02	-3.69001E-02	-2.32032E-02

P1 SCATTERING FROM GROUP 17 ENERGY= 0.04950

-6.69550E-01	-1.08244E 00	-8.18933E-01	8.47186E-02	1.59390E 00	3.67543E 00	6.29750E 00	1.05821E 01	1.71093E 01	2.64966E 01
3.93423E 01	5.61737E 01	7.74024E 01	1.00609E 02	1.28224E 02	1.57311E 02	1.90538E 02	1.34600E 02	9.41396E 01	6.50892E 01
4.41507E 01	2.93184E 01	1.91237E 01	1.22107E 01	7.54599E 00	4.56947E 00	2.58903E 00	1.39017E 00	6.45655E-01	2.31814E-01
4.77041E-03	-9.90566E-02	-1.36981E-01	-1.38110E-01	-1.22046E-01	-1.00400E-01	-7.70537E-02	-5.55294E-02	-3.77439E-02	-2.42782E-02

P1 SCATTERING FROM GROUP 18 ENERGY= 0.05530

-9.07086E-01	-1.75922E 00	-2.02845E 00	-1.74489E 00	-9.37336E-01	3.66566E-01	2.14026E 00	5.19217E 00	1.00308E 01	1.72008E 01
2.72350E 01	4.06092E 01	5.77033E 01	7.65793E 01	9.92203E 01	1.23223E 02	1.50788E 02	1.80771E 02	1.27654E 02	8.92492E 01
6.13461E 01	4.13950E 01	2.75319E 01	1.80103E 01	1.14861E 01	7.24515E 00	4.35756E 00	2.55660E 00	1.39270E 00	7.08032E-01
2.98445E-01	8.04351E-02	-3.15866E-02	-7.73006E-02	-8.88477E-02	-8.29827E-02	-6.91079E-02	-5.27172E-02	-3.73644E-02	-2.48188E-02

P1 SCATTERING FROM GROUP 19 ENERGY= 0.06130

-1.06462E 00	-2.22045E 00	-2.86961E 00	-3.03721E 00	-2.74733E 00	-2.02320E 00	-8.87167E-01	1.23131E 00	4.78187E 00	1.02489E 01
1.81109E 01	2.88002E 01	4.26691E 01	5.81553E 01	7.68917E 01	9.68932E 01	1.19995E 02	1.45245E 02	1.71987E 02	1.21314E 02
8.42518E 01	5.75489E 01	3.88306E 01	2.58439E 01	1.68392E 01	1.09039E 01	6.79437E 00	4.17763E 00	2.44170E 00	1.38478E 00
7.22029E-01	3.43982E-01	1.26794E-01	1.68228E-02	-3.52851E-02	-5.31731E-02	-5.40366E-02	-4.60497E-02	-3.50378E-02	-2.44489E-02

P1 SCATTERING FROM GROUP 20 ENERGY= 0.06750

-1.16590E 00	-2.52937E 00	-3.44926E 00	-3.94663E 00	-4.04183E 00	-3.75439E 00	-3.10321E 00	-1.70057E 00	8.53811E-01	4.99393E 00
1.11519E 01	1.97233E 01	3.10358E 01	4.38250E 01	5.94449E 01	7.62450E 01	9.57677E 01	1.17217E 02	1.40033E 02	1.64003E 02
1.14847E 02	7.92044E 01	5.40364E 01	3.64346E 01	2.41130E 01	1.59027E 01	1.01451E 01	6.42256E 00	3.90678E 00	2.33905E 00
1.32632E 00	7.25110E-01	3.59776E-01	1.58198E-01	4.74203E-02	-5.45285E-03	-2.85288E-02	-3.36393E-02	-2.97331E-02	-2.26364E-02

P1 SCATTERING FROM GROUP 21 ENERGY= 0.07400

-1.22772E 00	-2.73098E 00	-3.84461E 00	-4.58513E 00	-4.97263E 00	-5.02065E 00	-4.74625E 00	-3.90539E 00	-2.14036E 00	9.39194E-01
5.72523E 00	1.25805E 01	2.18110E 01	3.23944E 01	4.54572E 01	5.96231E 01	7.61945E 01	9.5039E 01	1.14071E 02	1.34708E 02
1.56573E 02	1.08834E 02	7.49207E 01	5.10341E 01	3.41841E 01	2.28568E 01	1.48323E 01	9.58189E 00	5.98328E 00	3.70230E 00
2.19778E 00	1.28070E 00	7.03929E-01	3.70312E-01	1.73993E-01	6.94006E-02	1.29120E-02	-1.23629E-02	-1.97701E-02	-1.85310E-02

P1 SCATTERING FROM GROUP 22 ENERGY= 0.08080

-1.25969E 00	-2.85180E 00	-4.10032E 00	-5.02015E 00	-5.62562E 00	-5.93074E 00	-5.94903E 00	-5.54996E 00	-4.41260E 00	-2.18473E 00
1.49024E 00	6.94611E 00	1.44689E 01	2.32350E 01	3.41833E 01	4.61645E 01	6.02822E 01	7.59757E 01	9.28317E 01	1.10685E 02
1.29667E 02	1.49626E 02	1.03761E 02	7.12676E 01	4.81959E 01	3.25724E 01	2.14123E 01	1.40401E 01	8.93125E 00	5.65063E 00
3.45305E 00	2.08807E 00	1.20935E 00	6.85643E-01	3.65010E-01	1.84417E-01	7.81631E-02	2.23183E-02	-2.66202E-03	-1.08226E-02

P1 SCATTERING FROM GROUP 23 ENERGY= 0.08780

-1.26939E 00	-2.91094E 00	-4.24837E 00	-5.29413E 00	-6.06047E 00	-6.55906E 00	-6.80151E 00	-6.74561E 00	-6.10224E 00	-4.55235E 00
-1.77018E 00	2.55252E 00	8.68382E 00	1.59616E 01	2.51714E 01	3.53509E 01	4.74396E 01	6.09653E 01	7.55707E 01	9.11091E 01
8.95735E 01	1.04990E 02	1.20905E 02	1.37198E 02	9.40893E 01	6.45692E 01	4.32185E 01	2.89147E 01	1.30595E 01	8.39439E 00
5.23243E 00	3.24088E 00	1.93724E 00	1.14419E 00	6.46045E-01	3.55954E-01	1.77229E-01	7.62548E-02	2.48672E-02	2.22835E-03

P1 SCATTERING FROM GROUP 24 ENERGY= 0.09500

-1.26317E 00	-2.92486E 00	-4.31679E 00	-5.44904E 00	-6.33218E 00	-6.97581E 00	-7.38984E 00	-7.60120E 00	-7.34872E 00	-6.34214E 00
-4.28294E 00	-8.85843E-01	4.10102E 00	1.01483E 01	1.79146E 01	2.65930E 01	3.69866E 01	4.86971E 01	6.14145E 01	7.50080E 01
8.95735E 01	1.04990E 02	1.20905E 02	1.37198E 02	9.40893E 01	6.45692E 01	4.32185E 01	2.89147E 01	1.88435E 01	1.22571E 01
7.75130E 00	4.88265E 00	2.98117E 00	1.80701E 00	1.05608E 00	6.08889E-01	3.25287E-01	1.58295E-01	6.77424E-02	2.32446E-02

P1 SCATTERING FROM GROUP 25 ENERGY= 0.10250

-1.24491E 00	-2.90528E 00	-4.32594E 00	-5.51540E 00	-6.48227E 00	-7.23471E 00	-7.78117E 00	-8.20322E 00	-8.26450E 00	-7.70071E 00
-6.23785E 00	-3.61145E 00	4.15268E-01	5.42422E 00	1.19670E 01	1.93682E 01	2.83155E 01	3.84731E 01	4.95723E 01	6.14962E 01
7.43269E 01	8.79566E 01	1.02071E 02	1.16558E 02	1.31519E 02	9.07736E 01	6.11613E 01	4.12155E 01	2.70873E 01	1.77853E 01
1.13733E 01	7.25558E 00	4.49897E 00	2.77700E 00	1.66069E 00	9.85048E-01	5.47835E-01	2.83289E-01	1.34224E-01	5.66058E-02

P1 SCATTERING FROM GROUP 26 ENERGY= 0.11000

-1.21876E 00	-2.86221E 00	-4.29163E 00	-5.51417E 00	-6.53668E 00	-7.36621E 00	-8.01021E 00	-8.59160E 00	-8.89552E 00	-8.68013E 00
-7.69283E 00	-5.68746E 00	-2.44080E 00	1.71925E 00	7.25679E 00	1.36047E 01	2.13554E 01	3.02251E 01	3.99791E 01	5.05129E 01
6.18974E 01	7.40359E 01	8.66455E 01	9.96239E 01	1.13056E 02	1.26325E 02	8.55719E 01	5.79995E 01	3.83732E 01	2.53803E 01
1.63696E 01	1.05430E 01	6.61217E 00	4.13420E 00	2.51235E 00	1.51856E 00	8.66170E-01	4.63983E-01	2.31623E-01	1.06338E-01

P1 SCATTERING FROM GROUP 27 ENERGY= 0.11800

-1.18470E 00	-2.79945E 00	-4.22238E 00	-5.46095E 00	-6.52037E 00	-7.40682E 00	-8.12611E 00	-8.83517E 00	-9.33876E 00	-9.41618E 00
-8.83472E 00	-7.36554E 00	-4.79861E 00	-1.38326E 00	3.26789E 00	8.68313E 00	1.53707E 01	2.30928E 01	3.16458E 01	4.09359E 01
5.10248E 01	6.18259E 01	7.30851E 01	8.47077E 01	9.67668E 01	1.08704E 02	1.21242E 02	8.25891E 01	5.49563E 01	3.65751E 01
2.37598E 01	1.54240E 01	9.76315E 00	6.16879E 00	3.79488E 00	2.32667E 00	1.35174E 00	7.41986E-01	3.83085E-01	1.84724E-01

P1 SCATTERING FROM GROUP 28 ENERGY= 0.12600

-1.14772E 00	-2.72431E 00	-4.13033E 00	-5.37076E 00	-6.45026E 00	-7.37393E 00	-8.14657E 00	-8.95034E 00	-9.60721E 00	-9.91496E 00
-9.65878E 00	-8.62508E 00	-6.61558E 00	-3.81553E 00	9.90271E-02	4.73574E 00	1.05327E 01	1.72907E 01	2.48320E 01	3.30727E 01
4.20667E 01	5.17361E 01	6.18515E 01	7.23249E 01	8.32195E 01	9.40273E 01	1.05399E 02	1.16564E 02	7.79287E 01	5.21256E 01
3.43571E 01	2.22474E 01	1.41844E 01	9.03407E 00	5.60974E 00	3.47578E 00	2.04629E 00	1.14247E 00	6.03177E-01	2.99855E-01

P1 SCATTERING FROM GROUP 29 ENERGY= 0.13450

```

-1.10648E 00 -2.63744E 00 -4.01680E 00 -5.24843E 00 -6.33540E 00 -7.28264E 00 -8.09361E 00 -8.97073E 00 -9.75173E 00 -1.02517E 01
-1.02727E 01 -9.61571E 00 -8.09384E 00 -5.83644E 00 -2.57550E 00 1.36702E 00 6.36586E 00 1.22591E 01 1.88898E 01 2.61839E 01
 3.41884E 01 4.28339E 01 5.19136E 01 6.13454E 01 7.11841E 01 8.09674E 01 9.12820E 01 1.01426E 02 1.11981E 02 7.52328E 01
 4.94000E 01 3.24435E 01 2.08124E 01 1.33444E 01 8.35051E 00 5.21843E 00 3.10487E 00 1.75652E 00 9.43076E-01 4.79227E-01

```

P1 SCATTERING FROM GROUP 30 ENERGY= 0.14300

```

-1.06393E 00 -2.54737E 00 -3.89347E 00 -5.10775E 00 -6.19164E 00 -7.15009E 00 -7.98568E 00 -8.91480E 00 -9.78940E 00 -1.04399E 01
-1.06829E 01 -1.03331E 01 -9.21385E 00 -7.40832E 00 -4.69546E 00 -1.33801E 00 2.98713E 00 8.14415E 00 1.39993E 01 2.04854E 01
 2.76441E 01 3.54130E 01 4.36049E 01 5.21433E 01 6.10757E 01 6.99793E 01 7.93859E 01 8.86532E 01 9.83099E 01 1.07746E 02
 7.10402E 01 4.68611E 01 3.02111E 01 1.94749E 01 1.22619E 01 7.71438E 00 4.62753E 00 2.64425E 00 1.43745E 00 7.42019E-01

```

P1 SCATTERING FROM GROUP 31 ENERGY= 0.15200

```

-1.02023E 00 -2.44919E 00 -3.75569E 00 -4.94602E 00 -6.01926E 00 -6.98061E 00 -7.83050E 00 -8.79603E 00 -9.74414E 00 -1.05178E 01
-1.09493E 01 -1.08651E 01 -1.00986E 01 -8.69317E 00 -6.46886E 00 -3.63581E 00 8.19159E-02 4.37460E 00 9.72694E 00 1.54792E 01
 2.18681E 01 2.88381E 01 3.62198E 01 4.39423E 01 5.20465E 01 6.01460E 01 6.87223E 01 7.71876E 01 8.60230E 01 9.46676E 01
 1.03594E 02 6.85984E 01 4.44171E 01 2.87657E 01 1.82072E 01 1.15202E 01 6.95786E 00 4.00880E 00 2.20129E 00 1.15055E 00

```

P1 SCATTERING FROM GROUP 32 ENERGY= 0.16100

```

-9.77596E-01 -2.34964E 00 -3.61717E 00 -4.77775E 00 -5.83494E 00 -6.79051E 00 -7.64527E 00 -8.63414E 00 -9.63509E 00 -1.05040E 01
-1.10855E 01 -1.12177E 01 -1.07436E 01 -9.67318E 00 -7.86145E 00 -5.47399E 00 -2.27457E 00 1.64876E 00 6.19698E 00 1.13169E 01
 1.70411E 01 2.33201E 01 3.00004E 01 3.70157E 01 4.44016E 01 5.18034E 01 5.96589E 01 6.74282E 01 7.55506E 01 8.35086E 01
 9.17353E 01 9.97445E 01 6.48173E 01 4.21388E 01 2.67869E 01 1.70275E 01 1.03409E 01 5.99727E 00 3.31931E 00 1.75162E 00

```

P1 SCATTERING FROM GROUP 33 ENERGY= 0.17050

```

-9.32596E-01 -2.24786E 00 -3.46958E 00 -4.59599E 00 -5.63067E 00 -6.57617E 00 -7.42930E 00 -8.43135E 00 -9.47006E 00 -1.04150E 01
-1.11224E 01 -1.14412E 01 -1.12231E 01 -1.04496E 01 -9.00658E 00 -7.01987E 00 -4.28944E 00 -8.82920E-01 3.11494E 00 7.65707E 00
 1.27727E 01 1.84181E 01 2.44542E 01 3.08194E 01 3.75445E 01 4.43039E 01 5.14960E 01 5.86244E 01 6.60902E 01 7.34161E 01
 8.09989E 01 8.83888E 01 9.59725E 01 6.26045E 01 3.99474E 01 2.54956E 01 1.55575E 01 9.07354E 00 5.05559E 00 2.68928E 00

```

P1 SCATTERING FROM GROUP 34 ENERGY= 0.18000

```

-8.91469E-01 -2.14863E 00 -3.32465E 00 -4.41776E 00 -5.42753E 00 -6.35322E 00 -7.19959E 00 -8.20580E 00 -9.26957E 00 -1.02716E 01
-1.10772E 01 -1.15467E 01 -1.15413E 01 -1.10177E 01 -9.88738E 00 -8.24345E 00 -5.91593E 00 -2.95568E 00 5.65334E-01 4.60562E 00
 9.19135E 00 1.42839E 01 1.97572E 01 2.55538E 01 3.17005E 01 3.78974E 01 4.45082E 01 5.10750E 01 5.79655E 01 6.47377E 01
 7.17564E 01 7.86040E 01 8.56372E 01 9.24668E 01 5.91894E 01 3.79036E 01 2.32201E 01 1.36053E 01 7.62190E 00 4.08057E 00

```

P1 SCATTERING FROM GROUP 35 ENERGY= 0.19000

```

-8.36504E-01 -2.04667E 00 -3.17307E 00 -4.22822E 00 -5.21084E 00 -6.11806E 00 -6.95333E 00 -7.95397E 00 -9.03236E 00 -1.00761E 01
-1.09627E 01 -1.15620E 01 -1.17416E 01 -1.14391E 01 -1.05888E 01 -9.25378E 00 -7.29200E 00 -4.73854E 00 -1.65395E 00 1.92564E 00
 6.02376E 00 1.06066E 01 1.55602E 01 2.08311E 01 2.64425E 01 3.21187E 01 3.81911E 01 4.42376E 01 5.05952E 01 5.68544E 01
 6.33507E 01 6.96963E 01 7.62200E 01 8.25596E 01 8.90336E 01 5.71850E 01 3.51538E 01 2.06810E 01 1.16406E 01 6.26668E 00

```

P1 SCATTERING FROM GROUP 36 ENERGY= 0.20000

-8.04604E-01	-1.95294E 00	-3.03014E 00	-4.04923E 00	-4.99674E 00	-5.88191E 00	-6.70030E 00	-7.69522E 00	-8.77662E 00	-9.84932E 00
-1.07982E 01	-1.15005E 01	-1.18343E 01	-1.17179E 01	-1.11063E 01	-1.00366E 01	-8.39039E 00	-6.19034E 00	-3.48619E 00	-3.09715E-01
3.36068E 00	7.49553E 00	1.19915E 01	1.67990E 01	2.19381E 01	2.71544E 01	3.27512E 01	3.83380E 01	4.42247E 01	5.00306E 01
5.60656E 01	6.19677E 01	6.80417E 01	7.39490E 01	7.99854E 01	8.58369E 01	5.29219E 01	3.12397E 01	1.76532E 01	9.54712E 00

P1 SCATTERING FROM GROUP 37 ENERGY= 0.21100

-7.71445E-01	-1.85388E 00	-2.88037E 00	-3.85415E 00	-4.77099E 00	-5.62711E 00	-6.42810E 00	-7.40380E 00	-8.48297E 00	-9.57460E 00
-1.05748E 01	-1.13688E 01	-1.18405E 01	-1.18961E 01	-1.15071E 01	-1.06874E 01	-9.34106E 00	-7.47838E 00	-5.13926E 00	-2.35059E 00
9.07007E-01	4.60846E 00	8.66098E 00	1.30186E 01	1.76988E 01	2.24680E 01	2.76020E 01	3.27414E 01	3.81699E 01	4.35348E 01
4.91209E 01	5.45918E 01	6.02285E 01	6.57155E 01	7.13270E 01	7.67694E 01	8.25653E 01	4.88918E 01	2.77287E 01	1.50592E 01

P1 SCATTERING FROM GROUP 38 ENERGY= 0.22300

-7.11249E-01	-1.75126E 00	-2.72720E 00	-3.65597E 00	-4.52870E 00	-5.35040E 00	-6.13025E 00	-7.08578E 00	-8.15825E 00	-9.25719E 00
-1.02967E 01	-1.11669E 01	-1.17609E 01	-1.19704E 01	-1.17867E 01	-1.11989E 01	-1.01323E 01	-8.58650E 00	-6.59208E 00	-4.17180E 00
-1.30713E 00	1.98061E 00	5.60898E 00	9.53563E 00	1.37755E 01	1.81153E 01	2.28047E 01	2.75143E 01	3.25022E 01	3.74432E 01
4.25979E 01	4.76546E 01	5.28716E 01	5.79557E 01	6.31590E 01	6.82093E 01	7.35901E 01	7.92582E 01	4.51000E 01	2.45868E 01

P1 SCATTERING FROM GROUP 39 ENERGY= 0.23600

-6.65116E-01	-1.62919E 00	-2.55186E 00	-3.43228E 00	-4.26975E 00	-5.07661E 00	-5.82020E 00	-6.74929E 00	-7.80393E 00	-8.90407E 00
-9.96780E 00	-1.09005E 01	-1.15994E 01	-1.19459E 01	-1.19450E 01	-1.15681E 01	-1.07605E 01	-9.50870E 00	-7.83668E 00	-5.76124E 00
-3.26595E 00	-3.69103E-01	2.85787E 00	6.37550E 00	1.01978E 01	1.41294E 01	1.83960E 01	2.26964E 01	2.72651E 01	3.18026E 01
3.65470E 01	4.12096E 01	4.60275E 01	5.07285E 01	5.55445E 01	6.02225E 01	6.52097E 01	7.04653E 01	7.59502E 01	4.15473E 01

P1 SCATTERING FROM GROUP 40 ENERGY= 0.25000

-6.18844E-01	-1.51952E 00	-2.38588E 00	-3.21689E 00	-4.01162E 00	-4.76932E 00	-5.48940E 00	-6.39017E 00	-7.41978E 00	-8.51317E 00
-9.59471E 00	-1.05800E 01	-1.13642E 01	-1.18236E 01	-1.19896E 01	-1.18022E 01	-1.12300E 01	-1.02476E 01	-8.87223E 00	-7.11641E 00
-4.96682E 00	-2.43471E 00	4.15507E-01	3.54952E 00	6.97779E 00	1.05248E 01	1.43923E 01	1.83064E 01	2.24792E 01	2.66357E 01
3.09925E 01	3.52834E 01	3.97247E 01	4.40645E 01	4.85156E 01	5.28430E 01	5.74597E 01	6.23276E 01	6.74097E 01	7.26712E 01

BORON-10 REVISED 1/20/69 1/V ABS=3837.0 B, CONST SCT=4.0 B

ISOTOPE I.D. NO. = 5.01000

	NABS	NFIS	NSCT	NKER	NDATA	NU
	1	0	1	0	120	0.
GROUP	ENERGY	ABSORPTION	FISSION	TOTAL PO SCATTER	TOTAL P1 SCATTER	
1	0.001000	1.92998E 04	0.	4.00000E 00	2.66670E-01	
2	0.002500	1.22062E 04	0.	4.00000E 00	2.66670E-01	
3	0.004000	9.64988E 03	0.	4.00000E 00	2.66670E-01	
4	0.005500	8.22945E 03	0.	4.00000E 00	2.66670E-01	
5	0.007000	7.29463E 03	0.	4.00000E 00	2.66670E-01	
6	0.008500	6.61977E 03	0.	4.00000E 00	2.66670E-01	
7	0.010000	6.10312E 03	0.	4.00000E 00	2.66670E-01	
8	0.012000	5.57136E 03	0.	4.00000E 00	2.66670E-01	
9	0.014500	5.06837E 03	0.	4.00000E 00	2.66670E-01	
10	0.017500	4.61353E 03	0.	4.00000E 00	2.66679E-01	
11	0.021000	4.21155E 03	0.	4.00000E 00	2.66670E-01	
12	0.025000	3.85995E 03	0.	4.00000E 00	2.66670E-01	
13	0.029500	3.55338E 03	0.	4.00000E 00	2.66670E-01	
14	0.034000	3.30988E 03	0.	4.00000E 00	2.66670E-01	
15	0.039000	3.09044E 03	0.	4.00000E 00	2.66670E-01	
16	0.044000	2.90955E 03	0.	4.00000E 00	2.66670E-01	
17	0.049500	2.74315E 03	0.	4.00000E 00	2.66670E-01	
18	0.055300	2.59531E 03	0.	4.00000E 00	2.66670E-01	
19	0.061300	2.46503E 03	0.	4.00000E 00	2.66670E-01	
20	0.067500	2.34909E 03	0.	4.00000E 00	2.66670E-01	
21	0.074000	2.24355E 03	0.	4.00000E 00	2.66670E-01	
22	0.080800	2.14707E 03	0.	4.00000E 00	2.66670E-01	
23	0.087800	2.05970E 03	0.	4.00000E 00	2.66670E-01	
24	0.095000	1.98011E 03	0.	4.00000E 00	2.66670E-01	
25	0.102500	1.90630E 03	0.	4.00000E 00	2.66670E-01	
26	0.110000	1.84016E 03	0.	4.00000E 00	2.66670E-01	
27	0.118000	1.77669E 03	0.	4.00000E 00	2.66670E-01	
28	0.126000	1.71936E 03	0.	4.00000E 00	2.66670E-01	
29	0.134500	1.66414E 03	0.	4.00000E 00	2.66670E-01	
30	0.143000	1.61393E 03	0.	4.00000E 00	2.66670E-01	
31	0.152000	1.56542E 03	0.	4.00000E 00	2.66670E-01	
32	0.161000	1.52103E 03	0.	4.00000E 00	2.66670E-01	
33	0.170500	1.47805E 03	0.	4.00000E 00	2.66670E-01	
34	0.180000	1.43852E 03	0.	4.00000E 00	2.66670E-01	
35	0.190000	1.40015E 03	0.	4.00000E 00	2.66670E-01	
36	0.200000	1.36470E 03	0.	4.00000E 00	2.66670E-01	
37	0.211000	1.32865E 03	0.	4.00000E 00	2.66670E-01	
38	0.223000	1.29241E 03	0.	4.00000E 00	2.66670E-01	
39	0.236000	1.25631E 03	0.	4.00000E 00	2.66670E-01	
40	0.250000	1.22062E 03	0.	4.00000E 00	2.66670E-01	

ALUMINUM 1/V ABS=.235 B, CONST SCAT=1.41 B

ISOTOPE I.D. NO. = 13.00000

	NABS	NFIS	NSCT	NKER	NDATA	NU
	1	0	1	0	120	0.
GROUP	ENERGY	ABSORPTION	FISSION	TOTAL P0 SCATTER	TOTAL P1 SCATTER	
1	0.001000	1.18203E-00	0.	1.41000E-00	3.48400E-01	
2	0.002500	7.47581E-01	0.	1.41000E-00	3.48400E-01	
3	0.004000	5.91014E-01	0.	1.41000E-00	3.48400E-01	
4	0.005500	5.04019E-01	0.	1.41000E-00	3.48400E-01	
5	0.007000	4.46765E-01	0.	1.41000E-00	3.48400E-01	
6	0.008500	4.05433E-01	0.	1.41000E-00	3.48400E-01	
7	0.010000	3.73790E-01	0.	1.41000E-00	3.48400E-01	
8	0.012000	3.41222E-01	0.	1.41000E-00	3.48400E-01	
9	0.014500	3.10416E-01	0.	1.41000E-00	3.48400E-01	
10	0.017500	2.82559E-01	0.	1.41000E-00	3.48400E-01	
11	0.021000	2.57940E-01	0.	1.41000E-00	3.48400E-01	
12	0.025000	2.36406E-01	0.	1.41000E-00	3.48400E-01	
13	0.029500	2.17629E-01	0.	1.41000E-00	3.48400E-01	
14	0.034000	2.02716E-01	0.	1.41000E-00	3.48400E-01	
15	0.039000	1.89276E-01	0.	1.41000E-00	3.48400E-01	
16	0.044000	1.78198E-01	0.	1.41000E-00	3.48400E-01	
17	0.049500	1.68006E-01	0.	1.41000E-00	3.48400E-01	
18	0.055300	1.58952E-01	0.	1.41000E-00	3.48400E-01	
19	0.061300	1.50973E-01	0.	1.41000E-00	3.48400E-01	
20	0.067500	1.43872E-01	0.	1.41000E-00	3.48400E-01	
21	0.074000	1.37408E-01	0.	1.41000E-00	3.48400E-01	
22	0.080800	1.31499E-01	0.	1.41000E-00	3.48400E-01	
23	0.087800	1.26148E-01	0.	1.41000E-00	3.48400E-01	
24	0.095000	1.21274E-01	0.	1.41000E-00	3.48400E-01	
25	0.102500	1.16752E-01	0.	1.41000E-00	3.48400E-01	
26	0.110000	1.12702E-01	0.	1.41000E-00	3.48400E-01	
27	0.118000	1.08815E-01	0.	1.41000E-00	3.48400E-01	
28	0.126000	1.05304E-01	0.	1.41000E-00	3.48400E-01	
29	0.134500	1.01922E-01	0.	1.41000E-00	3.48400E-01	
30	0.143000	9.88462E-02	0.	1.41000E-00	3.48400E-01	
31	0.152000	9.58752E-02	0.	1.41000E-00	3.48400E-01	
32	0.161000	9.31569E-02	0.	1.41000E-00	3.48400E-01	
33	0.170500	9.05245E-02	0.	1.41000E-00	3.48400E-01	
34	0.180000	8.81032E-02	0.	1.41000E-00	3.48400E-01	
35	0.190000	8.57534E-02	0.	1.41000E-00	3.48400E-01	
36	0.200000	8.35821E-02	0.	1.41000E-00	3.48400E-01	
37	0.211000	8.13742E-02	0.	1.41000E-00	3.48400E-01	
38	0.223000	7.91545E-02	0.	1.41000E-00	3.48400E-01	
39	0.236000	7.69435E-02	0.	1.41000E-00	3.48400E-01	
40	0.250000	7.47581E-02	0.	1.41000E-00	3.48400E-01	

CHROMIUM (NATURAL) 1/V ABS=3.1 B, CONST SCAT=3.0 B

ISOTOPE I.D. NO. = 24.00000

	NABS	NFIS	NSCT	NKER	NDATA	NU
	1	0	1	C	120	0.
GROUP	ENERGY	ABSORPTION	FISSION	TOTAL P0 SCATTER	TOTAL P1 SCATTER	
1	0.001000	1.55927E 01	0.	3.00000E 00	3.84500E-02	
2	0.002500	9.86170E 00	0.	3.00000E 00	3.84500E-02	
3	0.004000	7.79636E 00	0.	3.00000E 00	3.84500E-02	
4	0.005500	6.64876E 00	0.	3.00000E 00	3.84500E-02	
5	0.007000	5.89350E 00	0.	3.00000E 00	3.84500E-02	
6	0.008500	5.34826E 00	0.	3.00000E 00	3.84500E-02	
7	0.010000	4.93085E 00	0.	3.00000E 00	3.84500E-02	
8	0.012000	4.50123E 00	0.	3.00000E 00	3.84500E-02	
9	0.014500	4.09485E 00	0.	3.00000E 00	3.84500E-02	
10	0.017500	3.72737E 00	0.	3.00000E 00	3.84500E-02	
11	0.021000	3.40261E 00	0.	3.00000E 00	3.84500E-02	
12	0.025000	3.11854E 00	0.	3.00000E 00	3.84500E-02	
13	0.029500	2.87085E 00	0.	3.00000E 00	3.84500E-02	
14	0.034000	2.67413E 00	0.	3.00000E 00	3.84500E-02	
15	0.039000	2.49683E 00	0.	3.00000E 00	3.84500E-02	
16	0.044000	2.35069E 00	0.	3.00000E 00	3.84500E-02	
17	0.049500	2.21625E 00	0.	3.00000E 00	3.84500E-02	
18	0.055300	2.09681E 00	0.	3.00000E 00	3.84500E-02	
19	0.061300	1.99155E 00	0.	3.00000E 00	3.84500E-02	
20	0.067500	1.89789E 00	0.	3.00000E 00	3.84500E-02	
21	0.074000	1.81262E 00	0.	3.00000E 00	3.84500E-02	
22	0.080800	1.73467E 00	0.	3.00000E 00	3.84500E-02	
23	0.087800	1.66408E 00	0.	3.00000E 00	3.84500E-02	
24	0.095000	1.59978E 00	0.	3.00000E 00	3.84500E-02	
25	0.102500	1.54014E 00	0.	3.00000E 00	3.84500E-02	
26	0.110000	1.48671E 00	0.	3.00000E 00	3.84500E-02	
27	0.118000	1.43543E 00	0.	3.00000E 00	3.84500E-02	
28	0.126000	1.38911E 00	0.	3.00000E 00	3.84500E-02	
29	0.134500	1.34450E 00	0.	3.00000E 00	3.84500E-02	
30	0.143000	1.30393E 00	0.	3.00000E 00	3.84500E-02	
31	0.152000	1.26474E 00	0.	3.00000E 00	3.84500E-02	
32	0.161000	1.22888E 00	0.	3.00000E 00	3.84500E-02	
33	0.170500	1.19415E 00	0.	3.00000E 00	3.84500E-02	
34	0.180000	1.16221E 00	0.	3.00000E 00	3.84500E-02	
35	0.190000	1.13121E 00	0.	3.00000E 00	3.84500E-02	
36	0.200000	1.10257E 00	0.	3.00000E 00	3.84500E-02	
37	0.211000	1.07345E 00	0.	3.00000E 00	3.84500E-02	
38	0.223000	1.04417E 00	0.	3.00000E 00	3.84500E-02	
39	0.236000	1.01500E 00	0.	3.00000E 00	3.84500E-02	
40	0.250000	9.86170E-01	0.	3.00000E 00	3.84500E-02	

IRON (NATURAL) 1/V ABS=2.62 B, CONST SCAT=11.0 B

ISOTOPE I.D. NO. = 26.00000

	NABS	NFIS	NSCT	NKER	NDATA	NU
	1	0	1	0	120	0.
GROUP	ENERGY	ABSORPTION	FISSION		TOTAL PO SCATTER	TOTAL P1 SCATTER
1	0.001000	1.31784E 01	0.		1.10000E 01	1.31300E-01
2	0.002500	8.33473E 00	0.		1.10000E 01	1.31300E-01
3	0.004000	6.58918E 00	0.		1.10000E 01	1.31300E-01
4	0.005500	5.61927E 00	0.		1.10000E 01	1.31300E-01
5	0.007000	4.98095E 00	0.		1.10000E 01	1.31300E-01
6	0.008500	4.52014E 00	0.		1.10000E 01	1.31300E-01
7	0.010000	4.16737E 00	0.		1.10000E 01	1.31300E-01
8	0.012000	3.80427E 00	0.		1.10000E 01	1.31300E-01
9	0.014500	3.46081E 00	0.		1.10000E 01	1.31300E-01
10	0.017500	3.15023E 00	0.		1.10000E 01	1.31300E-01
11	0.021000	2.87576E 00	0.		1.10000E 01	1.31300E-01
12	0.025000	2.63567E 00	0.		1.10000E 01	1.31300E-01
13	0.029500	2.42633E 00	0.		1.10000E 01	1.31300E-01
14	0.034000	2.26007E 00	0.		1.10000E 01	1.31300E-01
15	0.039000	2.11023E 00	0.		1.10000E 01	1.31300E-01
16	0.044000	1.98671E 00	0.		1.10000E 01	1.31300E-01
17	0.049500	1.87309E 00	0.		1.10000E 01	1.31300E-01
18	0.055300	1.77214E 00	0.		1.10000E 01	1.31300E-01
19	0.061300	1.68318E 00	0.		1.10000E 01	1.31300E-01
20	0.067500	1.60402E 00	0.		1.10000E 01	1.31300E-01
21	0.074000	1.53195E 00	0.		1.10000E 01	1.31300E-01
22	0.080800	1.46607E 00	0.		1.10000E 01	1.31300E-01
23	0.087800	1.40642E 00	0.		1.10000E 01	1.31300E-01
24	0.095000	1.35207E 00	0.		1.10000E 01	1.31300E-01
25	0.102500	1.30167E 00	0.		1.10000E 01	1.31300E-01
26	0.110000	1.25651E 00	0.		1.10000E 01	1.31300E-01
27	0.118000	1.21317E 00	0.		1.10000E 01	1.31300E-01
28	0.126000	1.17402E 00	0.		1.10000E 01	1.31300E-01
29	0.134500	1.13632E 00	0.		1.10000E 01	1.31300E-01
30	0.143000	1.10203E 00	0.		1.10000E 01	1.31300E-01
31	0.152000	1.06891E 00	0.		1.10000E 01	1.31300E-01
32	0.161000	1.03860E 00	0.		1.10000E 01	1.31300E-01
33	0.170500	1.00925E 00	0.		1.10000E 01	1.31300E-01
34	0.180000	9.82257E-01	0.		1.10000E 01	1.31300E-01
35	0.190000	9.56059E-01	0.		1.10000E 01	1.31300E-01
36	0.200000	9.31851E-01	0.		1.10000E 01	1.31300E-01
37	0.211000	9.07236E-01	0.		1.10000E 01	1.31300E-01
38	0.223000	8.82489E-01	0.		1.10000E 01	1.31300E-01
39	0.236000	8.57839E-01	0.		1.10000E 01	1.31300E-01
40	0.250000	8.33473E-01	0.		1.10000E 01	1.31300E-01

NICKEL (NATURAL) 1/V ABS=4.6 B, CONST SCAT=17.5 B

ISOTOPE I.D. NO. = 28.00000

	NABS	NFIS	NSCT	NKER	NDATA	NU
	1	0	1	0	120	0.
GROUP	ENERGY	ABSORPTION	FISSION	TOTAL P0 SCATTER	TOTAL P1 SCATTER	
1	0.001000	2.31376E 01	0.	1.75000E 01	1.98700E-01	
2	0.002500	1.46335E 01	0.	1.75000E 01	1.98700E-01	
3	0.004000	1.15688E 01	0.	1.75000E 01	1.98700E-01	
4	0.005500	9.86590E 00	0.	1.75000E 01	1.98700E-01	
5	0.007000	8.74519E 00	0.	1.75000E 01	1.98700E-01	
6	0.008500	7.93613E 00	0.	1.75000E 01	1.98700E-01	
7	0.010000	7.31675E 00	0.	1.75000E 01	1.98700E-01	
8	0.012000	6.67925E 00	0.	1.75000E 01	1.98700E-01	
9	0.014500	6.07623E 00	0.	1.75000E 01	1.98700E-01	
10	0.017500	5.53094E 00	0.	1.75000E 01	1.98700E-01	
11	0.021000	5.04904E 00	0.	1.75000E 01	1.98700E-01	
12	0.025000	4.62752E 00	0.	1.75000E 01	1.98700E-01	
13	0.029500	4.25998E 00	0.	1.75000E 01	1.98700E-01	
14	0.034000	3.96806E 00	0.	1.75000E 01	1.98700E-01	
15	0.039000	3.70498E 00	0.	1.75000E 01	1.98700E-01	
16	0.044000	3.48812E 00	0.	1.75000E 01	1.98700E-01	
17	0.049500	3.28863E 00	0.	1.75000E 01	1.98700E-01	
18	0.055300	3.11140E 00	0.	1.75000E 01	1.98700E-01	
19	0.061300	2.95521E 00	0.	1.75000E 01	1.98700E-01	
20	0.067500	2.81622E 00	0.	1.75000E 01	1.98700E-01	
21	0.074000	2.68969E 00	0.	1.75000E 01	1.98700E-01	
22	0.080800	2.57402E 00	0.	1.75000E 01	1.98700E-01	
23	0.087800	2.46928E 00	0.	1.75000E 01	1.98700E-01	
24	0.095000	2.37357E 00	0.	1.75000E 01	1.98700E-01	
25	0.102500	2.28537E 00	0.	1.75000E 01	1.98700E-01	
26	0.110000	2.20608E 00	0.	1.75000E 01	1.98700E-01	
27	0.118000	2.12999E 00	0.	1.75000E 01	1.98700E-01	
28	0.126000	2.06126E 00	0.	1.75000E 01	1.98700E-01	
29	0.134500	1.99506E 00	0.	1.75000E 01	1.98700E-01	
30	0.143000	1.93486E 00	0.	1.75000E 01	1.98700E-01	
31	0.152000	1.87671E 00	0.	1.75000E 01	1.98700E-01	
32	0.161000	1.82350E 00	0.	1.75000E 01	1.98700E-01	
33	0.170500	1.77197E 00	0.	1.75000E 01	1.98700E-01	
34	0.180000	1.72457E 00	0.	1.75000E 01	1.98700E-01	
35	0.190000	1.67858E 00	0.	1.75000E 01	1.98700E-01	
36	0.200000	1.63607E 00	0.	1.75000E 01	1.98700E-01	
37	0.211000	1.59286E 00	0.	1.75000E 01	1.98700E-01	
38	0.223000	1.54941E 00	0.	1.75000E 01	1.98700E-01	
39	0.236000	1.50613E 00	0.	1.75000E 01	1.98700E-01	
40	0.250000	1.46335E 00	0.	1.75000E 01	1.98700E-01	

CALCIUM CHLORIDE MOLECULE (CaCl₂)

ISOTOPE I.D. NO. = 417.75000

	NABS	NFIS	NSCT	NKER	NDATA	NU
	1	0	1	0	120	0.
GROUP	ENERGY	ABSORPTION	FISSION	TOTAL P0 SCATTER	TOTAL P1 SCATTER	
1	0.001000	3.40223E 02	0.	3.52000E 01	6.55200E-01	
2	0.002500	2.15176E 02	0.	3.52000E 01	6.55200E-01	
3	0.004000	1.70112E 02	0.	3.52000E 01	6.55200E-01	
4	0.005500	1.45072E 02	0.	3.52000E 01	6.55200E-01	
5	0.007000	1.28592E 02	0.	3.52000E 01	6.55200E-01	
6	0.008500	1.16696E 02	0.	3.52000E 01	6.55200E-01	
7	0.010000	1.07588E 02	0.	3.52000E 01	6.55200E-01	
8	0.012000	9.82140E 01	0.	3.52000E 01	6.55200E-01	
9	0.014500	8.93470E 01	0.	3.52000E 01	6.55200E-01	
10	0.017500	8.13289E 01	0.	3.52000E 01	6.55200E-01	
11	0.021000	7.42428E 01	0.	3.52000E 01	6.55200E-01	
12	0.025000	6.80446E 01	0.	3.52000E 01	6.55200E-01	
13	0.029500	6.26402E 01	0.	3.52000E 01	6.55200E-01	
14	0.034000	5.83478E 01	0.	3.52000E 01	6.55200E-01	
15	0.039000	5.44793E 01	0.	3.52000E 01	6.55200E-01	
16	0.044000	5.12906E 01	0.	3.52000E 01	6.55200E-01	
17	0.049500	4.83572E 01	0.	3.52000E 01	6.55200E-01	
18	0.055300	4.57511E 01	0.	3.52000E 01	6.55200E-01	
19	0.061300	4.34544E 01	0.	3.52000E 01	6.55200E-01	
20	0.067500	4.14106E 01	0.	3.52000E 01	6.55200E-01	
21	0.074000	3.95501E 01	0.	3.52000E 01	6.55200E-01	
22	0.080800	3.78493E 01	0.	3.52000E 01	6.55200E-01	
23	0.087800	3.63092E 01	0.	3.52000E 01	6.55200E-01	
24	0.095000	3.49062E 01	0.	3.52000E 01	6.55200E-01	
25	0.102500	3.36048E 01	0.	3.52000E 01	6.55200E-01	
26	0.110000	3.24390E 01	0.	3.52000E 01	6.55200E-01	
27	0.118000	3.13201E 01	0.	3.52000E 01	6.55200E-01	
28	0.126000	3.03095E 01	0.	3.52000E 01	6.55200E-01	
29	0.134500	2.93361E 01	0.	3.52000E 01	6.55200E-01	
30	0.143000	2.84509E 01	0.	3.52000E 01	6.55200E-01	
31	0.152000	2.75957E 01	0.	3.52000E 01	6.55200E-01	
32	0.161000	2.68133E 01	0.	3.52000E 01	6.55200E-01	
33	0.170500	2.60556E 01	0.	3.52000E 01	6.55200E-01	
34	0.180000	2.53587E 01	0.	3.52000E 01	6.55200E-01	
35	0.190000	2.46824E 01	0.	3.52000E 01	6.55200E-01	
36	0.200000	2.40574E 01	0.	3.52000E 01	6.55200E-01	
37	0.211000	2.34219E 01	0.	3.52000E 01	6.55200E-01	
38	0.223000	2.27830E 01	0.	3.52000E 01	6.55200E-01	
39	0.236000	2.21466E 01	0.	3.52000E 01	6.55200E-01	
40	0.250000	2.15176E 01	0.	3.52000E 01	6.55200E-01	

END-OF-DATA ENCOUNTERED ON SYSTEM INPUT FILE.

VIII. DESCRIPTION OF THE ARRANGEMENT OF DATA ON THE LIBRARY TAPE

The INCITE library tape contains alphanumeric, integer, and floating point records. The alphanumeric records are used for identification purposes, the integer records control the reading of the cross section data, and the floating point records comprise the actual cross section data.

The initial data records on the tape are used to indicate the number of materials on the tape and describe the point values of the energy for which cross section data are actually provided. Subsequent records describe the cross section data, with similar types of data records being repeated for each material until all materials have been described. The identification numbers for the materials on the library tape are always arranged in ascending order. Presently, the largest identification number allowed for a material is 999.99999 with those digits beyond the 5th digit to the right of the decimal point being ignored by the current code package.

In an attempt to reduce the length of the cross section library, and thus, the time required for its processing, the cross section data on the tape are condensed as much as feasible. Therefore, the length and number of data records for a particular material depend on the amount of data required to describe the pertinent cross sections. In addition, each scattering matrix which is either read in or calculated, is examined and those scattering terms located on the tails of the peaked scattering function but below a certain value (determined by the user), are deleted from the matrix. The minimum number of records for any material on the tape is two and the maximum is seven.

A detailed description of the arrangement of the data on the library tape follows.

Location on Tape	Mnemonic Name of Data	Description or Function of Data
First Record	TAPID	Alphanumeric tape label (for identification purposes)
	NUCL	Number of materials on the tape
	NOG	Number of energy points used to represent the energy dependent cross section data on the tape
Second Record	EN(J) (J=1,NOG)	Point values of the energy structure
	DEL(J) (J=1,NOG)	Energy mesh widths associated with each energy point

The cross section data records for each material are arranged as shown below and are repeated for each material.

First data record for I^{th} material:

Mnemonic Name of Data	Description or Function of Data
AID	Material identification number
WORD(J) (J=1,12)	Description of material
NABS	Absorption reaction flag (If NABS=1, absorption cross sections are present)
NFIS	Fission reaction flag (If NFIS=1, fission cross sections are present)
NSCT	Scattering reaction flag (If NSCT=1, scattering cross sections are present)
NKER	Scattering matrix flag (If NKER=1, a scattering matrix is present)
NDATA	Integer to indicate the amount of cross section data on the tape for this material
ANU	Number of neutrons produced per fission

Second data record for I^{th} material:

Only that cross section data appropriate to the I^{th} material is included in this record. In all cases, if differential scattering cross sections are provided for a material, then the total isotropic and linearly anisotropic scattering cross sections and sources will also be present.

Mnemonic Name of Data	Description or Function of Data
SIGA(J) (J=1,NOG)	Absorption cross sections
SIGF(J) (J=1,NOG)	Fission cross sections
SIGTO(J) (J=1,NOG)	Total scattering cross sections

Mnemonic

Name of Data	Description or Function of Data
SIGTL(J) (J=1,NOG)	Linearly anisotropic component of the total scattering cross sections
S(J) (J=1,NOG)	Sources to account for the scattering from above the thermal energies
SAN(J) (J=1,NOG)	Linearly anisotropic component of the sources

Third data record for Ith material:

The following records are required only if differential scattering cross sections have been provided for this material, i.e., if NKER=1.

Mnemonic

Name of Data	Description or Function of Data
T	Temperature in °K at which the scattering matrix was calculated
FAS	Free atom scattering cross section (b)
AMAS	Mass of scattering material (amu)
LGUP(J) (J=1,NOG)	Lowest energy point in matrix permitting upscattering to the J th energy point
IHGDN(J) (J=1,NOG)	Highest energy point in matrix permitting downscattering to the J th energy point

Fourth data record for Ith material:

SIGSO(J,I) Isotropic differential scattering cross section
 (J=LGUP(I),IHGDN(I)) for scattering from the Jth energy point to the
 I=1,NOG Ith energy point

If this matrix contains greater than 5151 non-zero cross section values, the remaining portion of the matrix is written on the tape as the fifth record in the same form as above.

Fifth or sixth data record for Ith material:

SIGS1(J,I) Linearly anisotropic differential scattering cross
 (J=LGUP(I),IHGDN(I)) sections from the Jth energy point to the Ith
 I=1,NOG energy point

Again, if this matrix exceeds 5151 non-zero values, a seventh record is written.

IX. OPERATING INSTRUCTIONS

The LIBMOD code is written in FORTRAN-IV and consists of one controlling link and two computation links. It was originally written for the IBM 7040 and requires a 32k memory and utilizes the standard FORTRAN-IV monitor system with a chain feature.

The code requires seven tapes, four of which are assigned as follows:

<u>Description of Tape</u>	<u>FORTRAN Logical Tape Number</u>
Input Tape	5
Output Tape	6
Scratch Tape	3
Scratch Tape	4

The assigned locations of the three cross section data tapes are variable and are determined by the user as part of the input.

X. LIBMOD-SIMPLIFIED BLOCK DIAGRAM

XI. REFERENCES

- [1] R. L. Curtis and R. A. Grimesey, INCITE -- A FORTRAN-IV Program To Generate Thermal Neutron Spectra and Multigroup Constants Using Arbitrary Scattering Kernels, IN-1062 (November 1967).
- [2] E. P. Wigner and J. E. Wilkins, Effect of the Temperature of the Moderator on the Velocity Distribution of Neutrons With Numerical Calculations for H as Moderator, AECD-2275 (1944).
- [3] H. D. Brown and D. S. St. John, Neutron Energy Spectrum in D₂O, DP-33 (1954).
- [4] V. V. Smelov, "On the Question of Neutron Thermalization" (Letter to the Editor), Atomnaya Energiya (Atomic Energy), 3, Number 10 (1957).
- [5] J. Patry and J. Keller, "Zur Berechnung des Fehlerintegrals", Numerische Mathematik 6, H.2 (1964) pp. 89-97.
- [6] C. W. Clenshaw, G. F. Miller and M. Woodger, "Algorithms for Special Function I", Numerische Mathematik 4, H.9 (1963) pp. 403-419.

APPENDIX A

DERIVATION OF EQUATIONS (10) and (11)

Reference [4] gives the P-1 component of the Brown and St. John scattering probability in velocity space as

$$G_1(v, v') = \frac{(A+1)^2}{4A} \frac{\tau^3}{\lambda} \frac{x'}{x} \left\{ e^{-\frac{\alpha\tau^2}{\beta^2} x^2} \left[v \left(\frac{x'}{x} \theta - \frac{x}{x'} \eta - \frac{v}{xx'} \right) \right. \right.$$

times

$$\begin{aligned} & \left(\operatorname{erf}(x'\theta - x\eta) + \epsilon \operatorname{erf}(x'\theta + x\eta) \right) + \frac{2}{\sqrt{\pi}} \left(\frac{v}{x'} + \theta(x - x') \right) e^{-(x'\theta - x\eta)^2} \\ & - \epsilon \frac{2}{\sqrt{\pi}} \left(\frac{v}{x'} - \theta(x + x') \right) e^{-(x'\theta + x\eta)^2} \Bigg] \\ & + e^{x^2 - \lambda x'^2} \left[v \left(\frac{x}{x'} \theta - \frac{x'}{x} \eta - \frac{v}{xx'} \right) \left(\operatorname{erf}(x\theta - x'\eta) - \epsilon \operatorname{erf}(x'\eta + x\theta) \right) \right. \\ & + \frac{2}{\sqrt{\pi}} \left(\frac{v}{x} + \theta(x' - x) \right) e^{-(x\theta - x'\eta)^2} \\ & \left. + \epsilon \frac{2}{\sqrt{\pi}} \left(\frac{v}{x} - \theta(x + x') \right) e^{-(x\theta + x'\eta)^2} \right] \Bigg\}, \quad (A-1) \end{aligned}$$

where

$$v = \frac{\tau \sqrt{A}}{\lambda}, \quad \eta = \tau \sqrt{A} - \theta,$$

and

$$\epsilon = \begin{cases} +1 & \text{for } x > x' \\ -1 & \text{for } x < x' \end{cases}. \quad (A-2)$$

The other parameters in Equation (1) are defined for Equation (6) in the text.

A considerable simplification of Equation (A-1) can be made which will eliminate many of the redundant terms in this equation. First transform the kernel given by Equation (A-1) from a probability function in velocity space to the differential cross section in energy coordinates. The transformation from $G_1(v, v')$ in velocity space to $\sigma_{s1}(E \rightarrow E', \alpha)$ in energy coordinates is given by

$$\sigma_{s1}^2(E \rightarrow E', \alpha) = \frac{\sigma_{s1}^2(v \rightarrow v', \alpha)}{v'} = \frac{\sigma_1 G(v, v')}{v v'} \quad (A-3)$$

After applying Equation (A-3) to Equation (A-1), Equation (11) of the text was obtained by the following procedure.

1. Factor out $\frac{v}{xx'}$ from the r.h.s. of Equation (A-1).
2. Isolate the $\frac{1}{4}$ terms involving factor $2/\sqrt{\pi}$ in Equation (A-1). These terms are:

$$\begin{aligned} \frac{2}{\sqrt{\pi}} xx' & \left\{ e^{-\frac{\alpha \tau^2}{\beta^2} x^2} \left[\left(\frac{1}{x'} + \frac{\theta}{v} (x - x') \right) e^{-(x'\theta - x\eta)^2} \right. \right. \\ & \quad \left. \left. - \epsilon \left(\frac{1}{x'} - \frac{\theta}{v} (x + x') \right) e^{-(x'\theta + x\eta)^2} \right] \right. \\ & \quad + e^{x^2 - \lambda x'^2} \left[\left(\frac{1}{x} + \frac{\theta}{v} (x' - x) \right) e^{-(x\theta - x'\eta)^2} \right. \\ & \quad \left. \left. + \epsilon \left(\frac{1}{x} - \frac{\theta}{v} (x + x') \right) e^{-(x\theta + x'\eta)^2} \right] \right\} \quad (A-4) \end{aligned}$$

3. Use following transformations on Equation (A-4):

$$e^{(x^2 - \lambda x'^2)} \cdot e^{-(x\theta - x'\eta)^2} = e^{-\frac{\alpha\tau^2}{\beta^2} x^2} \cdot e^{-(x'\theta - x\eta)^2}$$

and

$$e^{(x^2 - \lambda x'^2)} \cdot e^{-(x\theta + x'\eta)^2} = e^{-\frac{\alpha\tau^2}{\beta^2} x^2} \cdot e^{-(x'\theta + x\eta)^2}. \quad (A-5)$$

These identities are easily verified by expanding the left hand side of the equation.

4. Applying Equations (A-5) to the second term in (A-4) yields:

$$\begin{aligned} & \frac{2}{\sqrt{\pi}} x x' \left\{ e^{-\frac{\alpha\tau^2}{\beta^2} x^2} \left[\left(\frac{1}{x} + \frac{1}{x'} \right) e^{-(\theta x' - \eta x)^2} + \epsilon \left(\frac{1}{x} - \frac{1}{x'} \right) e^{-(\theta x' + \eta x)^2} \right] \right\} \\ &= \frac{2}{\sqrt{\pi}} \left\{ e^{-\frac{\alpha\tau^2}{\beta^2} x^2} \left[(x+x') e^{-(\theta x' - \eta x)^2} - \epsilon (x-x') e^{-(\theta x' + \eta x)^2} \right] \right\}. \quad (A-6) \end{aligned}$$

5. The factor ϵ is a coefficient of the second term in Equation (A-6). From Equation (A-2), ϵ satisfies the following criteria:

$$\epsilon = \begin{cases} +1, & x > x' \\ -1, & x < x' \end{cases}. \quad (A-7)$$

The sign of the coefficient of ϵ is the same as the sign of ϵ in both cases and therefore the following substitution is made,

$$\epsilon(x-x') = |x-x'|. \quad (A-8)$$

Substitution of the r.h.s. of equation (A-8) into Equation (A-6) along with the application of Equation (A-3) and condition 1 above yields Equation (11) of the text where $\xi = \eta$. Equation (11) will then reduce to Equation (10) of the text when $\alpha = 0$ and σ_1 is replaced by σ_0 , the free atom scattering cross section.

APPENDIX B

PARAMETERS FOR THE BROWN AND ST. JOHN GAS KERNELS FOR H IN H_2O AND D IN D_2O

The parameters listed here are specified for the energy transfer kernels given in Equations (5) and (6) of the text of this report. They are based on a room temperature fit of the calculated scattering cross section to the experimental scattering cross section. The parameters for D in D_2O are taken from reference [3]. The parameters for H in H_2O are based on an approximate fit to the experimental data and may be modified by the user. In both cases, the ratio of the recommended mass of the atom to that of the neutron is the average bound mass of the atom over the thermal energy range and not the free atom mass. These same parameters are used in Equations 10 and 11 for the P-1 differential scattering cross section, however; no fit to experimental data is involved in this case.

<u>H in H_2O</u>	<u>D in D_2O</u>
$\sigma_0 = 20.4$ barns	$\sigma_0 = 3.3$ barns
$\sigma_1 = 20.0$ barns	$\sigma_1 = 1.6$ barns
$\alpha = 2.0$ eV/amu	$\alpha = 2.88$ eV/amu
$A = 1.88$ amu	$A = 3.6$ amu
$kT = 0.0253$ eV	$kT = 0.0253$ eV