

NUCLEAR DATA AND MEASUREMENTS SERIES

ANL/NDM-143

**A Compilation of Information on the $^{32}\text{S}(p,g)^{33}\text{Cl}$ Reaction and
Properties of Excited Levels in ^{33}Cl**

by

Roy E. Miller and Donald L. Smith

July 1997

**ARGONNE NATIONAL LABORATORY,
ARGONNE, ILLINOIS 60439, U.S.A.**

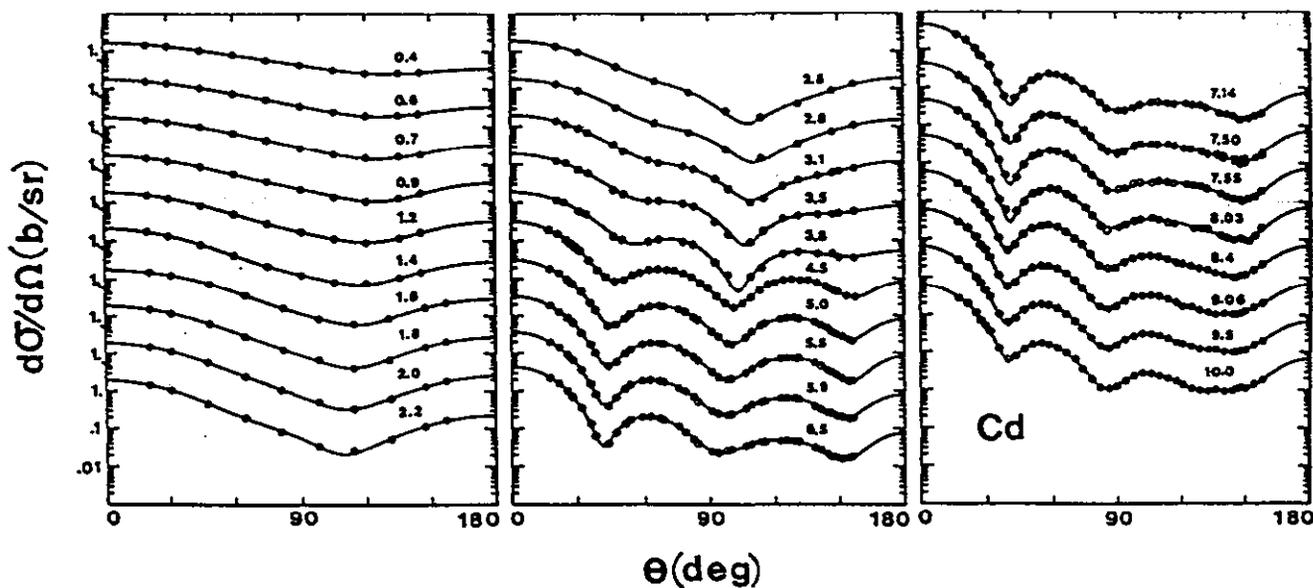
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ARGONNE NATIONAL LABORATORY, ARGONNE, ILLINOIS
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**A Compilation of Information on the $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$
Reaction and Properties of Excited Levels in ^{33}Cl ^a**

by

Roy E. Miller and Donald L. Smith

Technology Development Division

TD-207

Argonne National Laboratory

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U.S.A.

July 1997

DATA COMPILATION. Nuclear reaction $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$. Nuclear properties ^{33}Cl . Astrophysics. Resonance properties ($p + ^{32}\text{S}$). Reaction rates. Cross sections. Level structures. Level spins. Gamma-ray transitions. Gamma-ray angular distributions. Gamma-ray multipole mixing ratios. Lifetimes of ^{33}Cl excited states. Compound nucleus ($p + ^{32}\text{S}$).

^a This work was supported by the U.S. Department of Energy, Energy Research Programs, under Contract W-31-109-Eng-38.

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A.B. Smith, *Neutron Scattering and Models:- Molybdenum*, November 1997.

A Compilation of Information on the $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ Reaction and Properties of Excited Levels in ^{33}Cl ^a

by

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Abstract

This report documents a survey of the literature, and provides a compilation of data contained therein, for the $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ reaction. Considerable attention is paid to properties of the levels in ^{33}Cl which are located in the vicinity of excitation of the compound-nuclear system $^{32}\text{S} + p$ near the proton separation energy for ^{33}Cl . It is this particular energy region which is especially important for applications in nuclear astrophysics. Summaries of all the located references are provided and numerical data contained in them are compiled in EXFOR format where applicable.

^a This work was supported by the U.S. Department of Energy, Energy Research Programs, under Contract W-31-109-Eng-38.

^b Participant in the Argonne National Laboratory Summer 1997 Student Research Participation Program administered by the Division of Educational Programs.

1. Introduction

The (p,γ) and (p,α) hydrogen-burning reactions for nuclei in the mass range $A = 30-50$ are important for understanding energy generation and nucleosynthesis in hot and explosive stellar environments such as those found in novae and supernovae [A96, C83, RR88]. Reactions of the type (p,γ) contribute to the production of progressively heavier nuclei while (p,α) reactions are responsible in part for their destruction. Detailed knowledge of the competition between these reaction processes is of considerable importance in gaining an understanding of the relative abundances of various nuclear species that are generated in hot stellar environments and ultimately ejected into the interstellar medium as a consequence of violent nova and supernova processes.

Due to Coulomb barrier effects, the cross sections for these reactions tend to be quite small and difficult if not impossible to measure directly for energies of astrophysical interest. Furthermore, they tend to vary rapidly with interaction energy. The corresponding reaction rates for a Maxwellian distribution of reactant energies are also very sensitive to the temperature of stellar environment in question. Consequently, it is usually necessary to calculate the reaction cross sections using nuclear models and then derive reaction rates from these results. In the mass range $A = 30-50$, the cross sections can be influenced by prominent discrete resonances in the compound-nuclear systems as well as by continuum-compound and direct interaction processes. The relative importance of these mechanisms depends on structural details for the target nuclei involved. Extensive information on nuclear potentials, nuclear level densities, spins and parities of specific nuclear levels, and properties of discrete resonances and their decay modes (usually involving electromagnetic transitions) must be considered in performing these calculations.

A long-term program of compiling some of the important information needed for determining (p,γ) and (p,α) reaction rates involving targets in the mass range $A = 30-50$ has been undertaken at Argonne National Laboratory. The scope of this program is as follows: i) collect pertinent references from the literature; ii) prepare summaries of these references; iii) extract numerical values from these works and compile them in computerized data files for convenient access. Nuclear Science References (NSR) is used as the principal reference source for this activity [NSR97]. The emphasis, with a few exceptions, is on work reported during the last 30 years.

The present report focuses on the $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ reaction. A total of 27 reference citations pertaining to the $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ reaction were extracted from NSR. It was possible to locate 17 of these contributions through the available resources of the Argonne National Laboratory Technical Information Services. Summaries of these works appear in Section 2 while data files in EXFOR format [CINDA97], corresponding to references containing numerical as well as descriptive information, appear in Appendix A. The references to works included here are identified by codes for convenience in accessing the compiled information, *e.g.*, the contribution of Aleonard *et al.* (1974) is identified by the code A+74. In some cases two or more references are collected under the same code because of similarity or duplication. Absolute values of resonance strengths $S = (2J+1)\Gamma_p\Gamma_\gamma/\Gamma$ (where J = resonance spin, Γ_p = proton partial width, Γ_γ = gamma partial width and Γ = total width) for $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ which were reported in some of these references are collected into a single table

(Table 2) in Section 3 of the present report to facilitate their comparison. These resonance strengths can be used directly in calculating reaction rates according to the formalism given in Rolfs and Rodney [RR88] and elsewhere.

Appendix B lists those references appearing in NSR which we were unable to locate in the present compilation effort. These references are given in the exact form in which they appear in the NSR citation. The list is included in this report for the convenience of those readers who might wish to try and locate some of these references and examine their content.

Table 1: References, Summaries and EXFOR Data Files Included in this Compilation

Ref. Code	Author(s)	Summary	EXFOR File	Comment(s)
A+74	Aleonard <i>et al.</i>	X	X	
A+76	Aleonard <i>et al.</i>	X	X	
EE66	Engelbertink and P.M. Endt	X	X	
EIR72	Eswaran <i>et al.</i>	X	X	
ERI73	Eswaran <i>et al.</i>	X		
E+72	Eswaran <i>et al.</i>			Related to EIR72
E+74	Eswaran <i>et al.</i>			Related to E+75
E+75	Eswaran <i>et al.</i>	X (A) ^a		
H+72	Hubert <i>et al.</i>	X (A)		Related to A+74
I+92	Iliadis <i>et al.</i>	X	X	
KRA75	Keinonen <i>et al.</i>	X	X	
K+85	Kiss <i>et al.</i>	X	X	
PGA70	Prosser <i>et al.</i>	X (A)		
RWK87	Raisanen <i>et al.</i>	X	X	
S83	Sargood	X	X	

^a (A). Summary consists of the given abstract only

2. Summaries of Work Reported in the Literature

Written summaries were generated for those collected references where the content merited such an effort. Some of these references contain rather extensive information that is potentially useful for nuclear astrophysics applications while others are either abstracts or short communications that are basically extended abstracts. Repetition is avoided when identical material appears in more than one location. The lengths of the summaries presented here tend to reflect the relative content of pertinent information in the corresponding references. Those summaries with considerable information are organized according to a more or less standard format for the convenience of the reader. All the numerical information that was compiled in EXFOR format is printed in Appendix A but is not duplicated in the summaries.

A+74

TITLE

Strengths of (p, γ) Resonances in ^{33}Cl , ^{35}Cl and ^{28}Si

REFERENCE

M.M. Aleonard, C. Boursiquot, P. Hubert and P. Menrath, Physics Letters **49B**, No. 1, 40 (1974).

ABSTRACT

Absolute strength measurements have been performed for the $E_p = 580$ and 588 keV $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$, $E_p = 1214$ keV $^{34}\text{S}(p,\gamma)^{35}\text{Cl}$ and $E_p = 633$ and 744 keV $^{27}\text{Al}(p,\gamma)^{28}\text{Si}$ resonances with a Ge(Li) detector. Results are discussed with regard to the decay of isobaric analog resonances in ^{35}Cl and ^{37}Cl .

REACTION

$^{32}\text{S}(p,\gamma)^{33}\text{Cl}$

FACILITY

4-MV Van de Graaff accelerator, Centre d'Etudes Nucleaires de Bordeaux-Gradignan, France.

EXPERIMENT

Previously, absolute strength measurements had been hard to perform and often the discrepancies in the results were very large. The aim of this experiment was to benefit from the new, more reliable Ge(Li) detectors that had become available to measure absolute (p, γ) resonance strengths.

Measurements are described for the following resonances: $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ ($E_p = 580$ and 588 keV), $^{34}\text{S}(p,\gamma)^{35}\text{Cl}$ ($E_p = 1214$ keV) and $^{27}\text{Al}(p,\gamma)^{28}\text{Si}$ ($E_p = 633$ and 774 keV). The latter reaction was studied primarily as a check on the fidelity of the experimental procedures. Because of the importance of target stoichiometry, the elemental sulphur measurements were performed using more than one type of target, namely, the sulphur compounds Ag_2S , CdS and ZnS .

MEASUREMENT PROCEDURES

Most of the details of the apparatus and set-up for this experiment are described in a paper (in French) which documents an earlier investigation by Hubert *et al.* [H+72]. The abstract appears later in the present report. A brief description of these experimental issues and of the present experiment is included here: The 4-MV Van de Graaff accelerator at Centre d'Etudes Nucleaires de Bordeaux-Gradignan, France, was used. The proton beam from this accelerator was deflected through 90° by a magnet, passed through slits to stabilize and define it and then focused onto the target by a quadrupole lens doublet. A wall of 1-meter-thick concrete was placed between the target and exit slits (separated by 5 meters) in order to reduce the gammas and X-rays produced by the accelerator. In the present experiment the beam intensity was on the order of 10 microamperes so there were no problems with deadtime and target deterioration. The latter was checked before and after each measurement using a NaI detector. An 80-cm³ Ge(Li) detector was placed at an angle of 55° relative to the incident beam to measure gamma-ray yields. This detector's efficiency was determined using calibrated sources and gamma-rays from (p,γ) resonances whose decay schemes were well known. Proton charge was also recorded and a suppressor ring was set at a negative potential to minimize the effects of secondary electron emission. Proton-beam charge losses due to the cooling water jet were negligible and the accumulated charge was frequently checked for consistency using a current generator. The measurements were carried out using thick targets of Ag_2S , CdS and ZnS . The Ag_2S targets were prepared according to a method described by Watson *et al.* (Rev. Sci. Instr. **37**, 1605, 1966) while the CdS and ZnS targets were prepared by evaporation in vacuo. Resonance strengths for the sulphur (p,γ) reactions were determined with all three of these targets in order to minimize systematic errors traceable to target stoichiometry. Fresh aluminum targets were always used for the measurements on $^{27}\text{Al}(p,\gamma)^{28}\text{Si}$ in order to minimize any effects of surface oxidation.

DATA ACQUIRED

Absolute resonance strengths were measured for each of the reactions and levels indicated above, using the three sulphur target types mentioned above and the observed yields of the strongest and/or most specific gamma-ray transitions (see Table 1 in the article [A+74]). Although of little direct interest here, relative strength measurements were also performed for the $E_p = 588$ (^{33}Cl) and 1214 keV (^{35}Cl) resonances in chlorine using a NaI detector and thin Ag_2S targets (see Table 2 in the article [A+74]). This study provided still another check on the reliability of the present results.

DATA ANALYSIS

The approach used in analyzing the data from this experiment is described briefly in the paper. The

resonance strength is defined as $S = (2J+1)\Gamma_p\Gamma_\gamma/\Gamma$, where J is the spin of the resonance level and Γ_p , Γ_γ and Γ are the proton partial, gamma-ray partial and total widths, respectively. Good knowledge of isotopic constitution, proton stopping power, collected charge and Ge(Li) detector absolute efficiencies is required to convert the measured gamma-ray yields to resonance strengths. Data on the sulphur (p, γ) reactions obtained with three different targets were averaged to get final resonance strengths. Comparable, individually measured values agreed within the estimated errors. The relative (p, γ) resonance strengths for ^{33}Cl ($E_p = 588$ keV) and the ^{35}Cl ($E_p = 1214$ keV) were derived from thin target, NaI detector data without regard to either target constitution or proton stopping power.

RESULTS AND DISCUSSION

The present absolute resonance-strength results were compared with previously reported values (see Table 1 in the article [A+74]). The discrepancies in the results of these various strength measurements are quite large, particularly for the sulphur (p, γ) reactions, however no explanation of the differences is offered in this paper. In the case of the ^{33}Cl ($E_p = 588$ keV) and the ^{35}Cl ($E_p = 1214$ keV) results, the experimental values are systematically much lower than comparable M1 strengths calculated from theory (see Table 2 in the article [A+74]). This suggests that it would be necessary to introduce more configuration mixing to describe the properties of the negative parity levels in these nuclei, however this is not a relevant issue in the present context.

A+76

TITLE

Etude des Etats Excites du ^{33}Cl a l'Aide de la Reaction $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$

REFERENCE

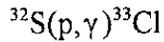
M.M. Aleonard, Ph. Hubert, L. Sarger and P. Mennrath, Nuclear Physics **A257**, 490 (1976). [In French].

ABSTRACT

Energies and strengths of resonances of the $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ reaction were determined in the range $E_p = 0.4$ - 2.6 MeV. Three new resonances were observed respectively at $E_p = 1588, 1748, 1880$ keV and the doublet of resonances at $E_p \approx 1900$ keV was clearly shown. The (p, γ) strengths of resonances at $E_p = 422, 580, 588, 721$ and 2577 keV were measured with a 80 cm^3 Ge(Li) detector. The Q-value of this reaction and the energies, γ -ray branchings and mean lifetimes of levels were determined. The spins and parities of the $E_x = 2.35, 3.82, 3.97, 3.98, 4.78$ MeV levels have been measured. A comparison of γ -ray transition strengths with mirror transitions and with model predictions is made

in the present work [A+76].

REACTION



FACILITY

4-MV Van de Graaff accelerator, Centre d'Etudes Nucleaires de Bordeaux-Gradignan, France.

EXPERIMENT

The present work [A+76] was undertaken to extend and improve an investigation that was reported earlier [A+74]. It concerns the properties of levels in ^{33}Cl excited by the $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ reaction. In particular, measurements were made of gamma-ray branching, mean lifetimes, radiative widths of unbound states, and angular distributions and multipolarities of electromagnetic transitions which de-excite the levels of ^{33}Cl . This work also aimed at identifying new resonances in the $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ reaction and at producing accurate values for resonance energies and strengths associated with this process. Extensive analysis of these data in the context of nuclear models is carried out and comparisons with earlier work are presented.

MEASUREMENT PROCEDURES

The basic experimental approach has been described in the earlier communication [A+74]. The target was designed to be of relatively low mass. A negative bias was applied to the target assembly to minimize secondary-electron emission. The beam passed through a liquid nitrogen cold trap that was intended to trap vapors of carbon and fluorine that might contaminate the targets. Beam energy resolution on the order of 1 keV at $E_p = 1750$ keV was obtained. Targets of sulphur enriched to 99.86% ^{32}S were utilized for nearly all aspects of this experiment. They consisted of 15-120 $\mu\text{g}/\text{cm}^2$ of Ag_2S on a gold support prepared by the method of Watson *et al.* (Rev. Sci. Instr. **37**, 1605, 1966). However, targets of natural sulphur in the form of Ag_2S , CdS and ZnS were also employed in much the same fashion as described earlier [A+74] for the absolute resonance strength measurements. Finally, the $E_p = 422$ and 721 keV resonances were investigated using thick targets (> 1 mg/cm^2). These CdS and ZnS targets were prepared by vacuum evaporation onto a gold support 0.1 mm thick. The evaporation of a very thin layer of gold (a few $\mu\text{g}/\text{cm}^2$) onto the surface of these targets insured a better tolerance to the proton beam. The excitation function was measured using a NaI (12.7×12.7 cm) placed at 55° relative to the proton beam. Dual discriminators allowed the selection of gamma-ray events with energies above 0.6 and 1.8 MeV, respectively. Resonance strengths and gamma-ray de-excitation spectra were measured with an 80-cm^3 $\text{Ge}(\text{Li})$ detector placed 3.5 cm from the target at 55° . When measuring the lifetimes of states in ^{33}Cl , this detector was moved back to 8 cm distance and was placed both at 0° and at the furthest accessible back angle, namely, 132° . Finally, a 60-cm^3 $\text{Ge}(\text{Li})$ detector placed 3.5 cm from the target was used as a monitor during the angular distribution measurements with the 80-cm^3 detector. Gamma-ray spectra were recorded with a 4096-

channel Intertechnique analyzer. These spectra were then transferred to a PDP-15 computer. Further analysis of the gamma peaks in these spectra was accomplished with an IRIS 80 computer. The gamma spectra were calibrated using reference gamma-ray lines from ^{22}Na , ^{40}K and ^{208}Tl . The gamma-ray energy resolution was determined to be 2.4 keV for the 80-cm³ Ge(Li) detector and 2.7 keV for the 60-cm³ Ge(Li) detector, both for the 1.3-MeV ^{60}Co line. The $^{32}\text{S}(p,\gamma)^{33}\text{C}$ excitation function was measured in the range $E_p = 560\text{-}2600$ keV in steps of 0.5-1 keV over the whole energy range. The Ag_2S targets used during this work were of the order of 15 $\mu\text{g}/\text{cm}^2$ thick. The accelerator energy calibration was achieved using the following well-known resonances: $^{34}\text{S}(p,\gamma)^{35}\text{Cl}$ ($E_p = 1213.7 \pm 1.0$ keV), $^{27}\text{Al}(p,\gamma)^{28}\text{Si}$ ($E_p = 632.6 \pm 0.2$ and 773.70 ± 0.03 keV) and $^{13}\text{C}(p,\gamma)^{14}\text{N}$ ($E_p = 1747.6 \pm 0.9$ keV). The state of the targets was examined periodically by looking at the 588-, 1757- and 2547-keV resonances in $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$. Absolute measurements of resonance strength for the 580- and 588-keV resonances were performed using thick targets of various chemical compositions of sulphur and the 80-cm³ Ge(Li) detector, as described earlier [A+74]. Relative strengths for other resonances were measured using Ag_2S targets and the NaI detector. The lifetimes of states in ^{33}Cl were measured using the well-known Doppler-shift attenuation method using the 80-cm³ Ge(Li) detector. The gamma-ray branching of many of the excited states in ^{33}Cl were known quite well, so this investigation focused on studies of new resonances and of certain negative parity states for which the branching had not been determined very precisely. Angular distribution measurements were performed at 0, 30, 45, 55 and 90°.

DATA ACQUIRED

The present investigation [A+76] for $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ provided data which yielded an excitation function from 560-2600 keV that served to locate three new resonances, enabled resonance strengths to be determined for 14 resonances, provided precise energy determinations for eight excited states in ^{33}Cl , yielded lifetimes for five excited states in ^{33}Cl , generated angular distribution coefficients for four gamma-ray transitions in ^{33}Cl , allowed spin/parity estimations to be made for 11 excited states in ^{33}Cl , and, finally, permitted M1/E2 multipole mixing ratios to be determined for gamma-ray transitions de-exciting 10 excited levels in ^{33}Cl .

DATA ANALYSIS

The data analysis procedures are outlined sketchily in the present paper [A+76], but reference is made to an earlier paper that describes a similar experiment [A+74]. The present paper [A+76] discusses the interpretation of these data in great detail and also makes extensive comparisons to other work. The details are too voluminous to include here.

RESULTS AND DISCUSSION

For present purposes, most of the information of interest on the $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ reaction is contained in figures and tables in the present paper [A+76]. The content of these figures and tables is as follows: Figs. 1 and 2 (excitation function of the reaction), Table 1 (resonance energies and strengths), Table 2 (precise values of level energies for ^{33}Cl), Fig. 4 (gamma-ray transitions which de-excite levels in

³³Cl), Table 3 (lifetimes of levels in ³³Cl), Table 4 (angular distribution coefficients), Table 5 (spins and parities of ³³Cl levels), and Table 6 (gamma-ray transition multipole mixing ratios). This extensive and apparently carefully performed investigation provides the most detailed collection of information on the ³²S(p,γ)³³Cl reaction of any of the references considered in our compilation.

EE66

TITLE

Measurements of (p,γ) Resonance Strengths in the s-d Shell

REFERENCE

G. A. P. Engelbertink and P. M. Endt, Nuclear Physics **88**, 12 (1966).

ABSTRACT

Resonance strengths of selected resonances in the $E_p = 0.3-2.1$ MeV region in the (p,γ) reactions on ²³Na, ²⁴⁻²⁶Mg, ²⁷Al, ²⁸⁻³⁰Si, ³¹P, ^{32,34}S, ^{35,37}Cl, ^{39,41}K and ⁴⁰Ca are compared through relative yield measurements, using targets of many different chemical compounds, each containing at least two of the investigated isotopes. If in a (N,Z) diagram lines are drawn between isotopes connected in this way, one obtains several closed cycles, providing internal checks on the measured strength ratios. The final best values of the relative strengths are obtained by least squares analysis. The $E_p = 621$ keV ³⁰Si(p,γ)³¹P resonance of which the strength is known from a γ-ray resonant absorption experiment, was used to convert the relative into absolute strengths.

REACTION

³²S(p,γ)³³Cl

FACILITY

3-MV Van de Graaff and Utrecht 850-keV Cockcroft-Walton generators at the Fysisch Laboratory, Rijksuniversiteit, Utrecht, the Netherlands.

EXPERIMENT

Relative (p,γ) strength measurements are made on those elements listed in the abstract. In many respects such relative measurements of resonance strengths are much easier to perform than absolute measurements, particular in experimental setups that rely on NaI detectors (in 1966 Ge(Li) detectors

were not commonly available). For example, the necessity for knowledge of the proton stopping power drops out if one uses thin targets and measures the ratio of the areas under the two resonance peaks. Detector solid angle is also irrelevant and other quantities like secondary electron emission and the detector efficiency per unit solid angle enter only in second order because of differences in proton energy and in the γ -ray spectrum at the two resonances in question. Several different targets were used for this experiment leading to an experimental over determination of several of the resonance strengths through a system of inter-related ratios. An example is given of using a NaCl target to obtain the Na and Cl resonances. After this, a target with one of these elements can be used and the ratio of say Na/S can be obtained with NaCl, KCl and K_2SO_4 targets. This procedure involving several different targets generates cyclical relationships which can be used to check consistency of the results. The system of equations defining these relationships between the various relative resonance strengths was linearized by a conversion to natural logarithms, and a least-squares analysis was then performed to extract best values for individual resonance strengths and to test for consistency of the experimental data. The well-known absolute strength of the resonance $^{30}\text{Si}(p,\gamma)^{31}\text{P}$ ($E_p = 621$ keV) was used for normalization purposes, thereby allowing the experimental relative (p,γ) strengths to be converted into absolute resonance strengths.

MEASUREMENT PROCEDURES

The Utrecht 850-keV Cockroft-Walton and the 3-MeV Van de Graaff generator were used to supply proton beams with energies in the range $E_p = 0.3$ -2.1 MeV. Strong resonances with known γ -decays within this energy region were selected for observation. A cylindrical 10 cm x 10 cm NaI scintillation crystal detector was placed at a front-face-to-target distance of 40 mm to detect the emitted γ -radiation. A list of the target compounds is given in the article [EE66] and most of the targets were prepared by vacuum evaporation onto 0.3 mm tantalum backings. The exception was Na_2SiO_3 for which the evaporation procedure proved unsuitable. A relatively thick target of this material was prepared by painting a thin layer of the powdered material mixed with water on the target backing. With such a thick target, only steps in the yield curve marked the presence of resonances. All of the targets were prepared with elemental materials having natural isotopic abundances. This had the advantage of insuring well-determined target stoichiometry but had the disadvantage that no data could be acquired for isotopes with low abundance. The beam power was always kept below 3 W to avoid deterioration of these targets. A useful check on target stability was afforded by repeating measurements on the first resonance at the end of a round of measurements on several other resonances. A calibrated current integrator was used to measure the proton charge and a negatively biased suppressor ring largely eliminated secondary electron emission effects. The various ratio measurements were repeated several times and the values reported in the tables of this article are averages.

DATA ACQUIRED

The present measurements of resonance gamma-ray yield curves obtained using various compounds of the elements in question enabled sixteen strength ratios for (p,γ) resonances to be determined (see Table 1 in the article [EE66]). In addition, a ratio of the strengths of the resonances at $E_p = 454$ and

1966 keV for $^{26}\text{Mg}(p,\gamma)^{27}\text{Al}$ was determined. This latter measurement was performed to provide a direct determination of the 1966-keV resonance strength for comparison with the indirect result which could be derived from data acquired earlier in this laboratory from a $^{26}\text{Mg}(p,\gamma)^{27}\text{Al}$ γ -ray resonance absorption experiment and from measurements of ^{26}Mg proton elastic scattering (see Section 4 in the article [EE66]). Also, thick-target yield curves of the $E_p = 414$ keV $^{29}\text{Si}(p,\gamma)^{30}\text{P}$ and 621 keV $^{30}\text{Si}(p,\gamma)^{31}\text{P}$ resonances were measured (see Fig. 2 in the article [EE66]).

DATA ANALYSIS

The data analysis procedure is described only briefly in this article [EE66] and it is based mainly on the formulas given on pp. 14-15. The background had to be subtracted and corrections were also made for gamma-ray coincident- and random-summing effects. Assigned errors were based on consideration of the insufficient knowledge of the ratios of the partial detector efficiencies and of the stopping powers at the different proton energies (where applicable for thick-target data), of background effects and of counting statistics. These contributions were added quadratically to obtain the total error in the relative strengths. The relative (p,γ) strengths obtained with targets of different thickness and prepared under different evaporation conditions did not show any differences beyond the combined experimental errors. The least-squares analysis performed in this work involved ten equations with six unknowns. It led to a normalized chi-square parameter of 1.07, indicating that the errors were neither under- or over-estimated. Through use of the known absolute strength of the $^{30}\text{Si}(p,\gamma)^{31}\text{P}$ ($E_p = 621$ keV) resonance, the various experimental relative strengths were converted into absolute values for individual (p,γ) reactions. The error in the normalized absolute strengths were found by adding quadratically to the relative error the error (8.4%) in the strength of the standard resonance and an estimated error (7%) for insufficient knowledge of the γ -ray spectrum. The experimental errors in the final results were typically of the order of 15%.

RESULTS AND DISCUSSION

The experimental (p,γ) strength ratios are given in Table 1 of the article [EE66]. The absolute strengths derived from this work are listed in Table 2. The present absolute strengths agree in many cases with other results reported in the literature to within the combined experimental errors. However, there are comparisons which differ by a factor of 2 to 3 and, in some instances, serious disagreements up to a factor of 50 are observed. The present results for the reaction $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ are in experimental agreement with one of the previously listed works but are not in agreement with the other. This investigation provided a set of resonances with known strengths which could then be used subsequently to obtain the strengths of other (p,γ) resonances on the same element through relative measurements.

EIR72

TITLE

Studies on Analog States in ^{33}Cl by Isospin-Forbidden Resonances in the Reaction $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$

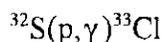
REFERENCES

M.A. Eswaran, M. Ismail and N.L. Ragoowansi, *Physical Review* **C5**, 1270 (1972). See also: Report BARC-598, Bhabha Atomic Research Centre, Bombay, India, 1972 (this is a pre-publication document which is essentially identical to the *Physical Review* paper). CONF Bombay, Volume **14B**, 5, 1972 (this is identical to the abstract of the *Physical Review* paper).

ABSTRACT

The residual activity between bursts of a mechanically chopped beam has been used to measure the yield of the reaction $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ systematically in the bombarding energy range $E_p = 3.36$ to 5.41 MeV. Two $T = 3/2$ states in ^{33}Cl at $E_p = 3.371 \pm 0.005$ MeV, $E_x = 5.550 \pm 0.007$ MeV and at $E_p = 5.282 \pm 0.006$ MeV, $E_x = 7.402 \pm 0.008$ MeV have been located with the resonance strengths $(2J+1)\Gamma_{p0}\Gamma_\gamma/\Gamma = 0.76 \pm 0.18$ and 1.50 ± 0.37 eV, respectively. Each of these resonances was narrower than the estimated 2-keV spread of the proton beam. These two states are interpreted as the analogs of the ground and the second excited state of ^{33}P with J^π values $1/2^+$ and $5/2^-$, respectively. γ -decay of the lower resonance, investigated with a Ge(Li) detector, shows $>88\%$ and $<12\%$ branchings to the first excited state and ground state of ^{33}Cl , respectively. The M1 strengths of these transitions are compared with those obtained from β analog transitions and with the theoretical predictions based on the many-particle shell-model calculations.

REACTION



FACILITY

5.5-MV Van de Graaff accelerator, Bhabha Atomic Research Centre, Trombay, Bombay, India.

EXPERIMENT

The present work searched for and studied the $T = 3/2$ isobaric analog states in ^{33}Cl in the range of excitation from 5.5 to 7.5 MeV. The yield curve for production of ^{33}Cl by the reaction $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ was measured as a function of proton energy. A cyclic activation technique was used in which the residual positron activity between bursts of mechanically chopped beams was measured with a plastic scintillator. Gamma-ray spectra from $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ were then measured with a Ge(Li) detector at various proton energies on and off selected resonances in order to establish the resonance decay

modes. These γ -ray data were also used in resonance strength determinations.

MEASUREMENT PROCEDURES

A proton beam produced by the 5.5-MeV Van de Graaff accelerator was chopped mechanically and then collimated by a 5-mm-diameter Ta aperture. The strong resonance in $^{27}\text{Al}(p,\gamma)^{28}\text{Si}$ at $E_p = 991.91$ keV was used for calibration of the beam energy analyzing system. Periodically during the measurements the beam energy calibration was checked using the prominent resonance in the $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ reaction at $E_p = 3.377$ MeV. A water-cooled $300 \mu\text{g}/\text{cm}^2$ target of natural Sb_2S_3 (^{32}S isotopic abundance 95%) was prepared by evaporation onto a thick gold backing. This target was mounted at the center of a 5-cm-diameter, thin-walled (0.8-mm), stainless-steel chamber. The target was oriented at 45° to the incoming proton beam and a β -detector consisting of a 10-cm-diameter 2.5-cm-thick plastic scintillator mounted on an XP1040 photomultiplier tube was placed at 90° with the front face being 5-cm from the target. This detector was used to measure positrons (β^+) emitted from the decay of 2.52-sec ^{33}Cl . Pulses corresponding to positron energy >500 keV were recorded with a Nuclear Data 4096-channel analyzer set up to operate in multi-channel scaling mode with a dwell time of 40 msec per channel. A proton beam of $2 \mu\text{A}$ was used. The proton energy loss due to finite target thickness was about 14 keV. This was presumably the major factor affecting the proton energy resolution. The ^{33}Cl yield excitation curve was measured in proton-energy increments of 10 keV except near individual resonances where steps of 2.5-keV or even smaller were taken. The operating cycle (bombard target for 4.0 sec, wait 0.5 sec and count for 10 sec) was repeated at each proton energy until a fixed amount of charge was accumulated, as monitored by a current integrator. A 30-cm^3 Ge(Li) detector was placed 4.5 cm from the target to record γ -ray spectra from the decay of resonance states identified at certain incident proton energies. Gamma yields were also measured at selected off-resonance proton energies to identify the background lines. A Nuclear Data 4096-channel analyzer was used to record all these spectra.

DATA ACQUIRED

The yield curve for $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ was measured over the range $E_p = 3.360$ - 5.410 MeV. Decay time curves for positron activity were recorded at each proton energy to enable background to be subtracted and thereby insure that the measured yield curve corresponded to just the ^{33}Cl activity. Fig. 1 of the article [EIR72] shows a typical decay curve. Fig. 2 in the article [EIR72] exhibits the yield curve resulting from this work. The incident proton energies and corresponding excitation energies in ^{33}Cl where prominent resonances were observed in the yield curve are listed in Table I of the article [EIR72] along with the corresponding levels observed in ^{33}Ar decay from an earlier study. In the case of the resonances which appeared well isolated, estimates or limits of the widths (Γ) were obtained and they are also reported in Table I. Gamma-ray spectra taken on and off the $E_p = 3.371$ -MeV resonance with the Ge(Li) detector allowed for a more precise determination of the resonance width of that state. An attempt was made to determine the width of the $E_p = 5.282$ -MeV resonance but this was hampered considerably by excessive contributions from proton inelastic scattering gammas. Table II of the article [EIR72] contains both energies and resonance strengths for the $T - 3/2$ states in ^{33}Cl . Table III of the article [EIR72] contains γ -ray widths for the M1 decays of the $1/2^+$, $3/2^+$ level of ^{33}Cl .

and their comparison with the β analog transitions while Table IV contains the M1 and E2 decay strengths of the $1/2^+$, $3/2^+$ level of ^{33}Cl and their comparison with the theoretical predictions. In order to check the reliability of the present resonance strength determinations, a measurement was made using an HH^+ beam to examine the $E_p = 0.588\text{-MeV}$ resonance which had been studied earlier by Engelbertink and Endt [EE66].

DATA ANALYSIS

Decay curves generated by multi-channel scaling were fitted by non-linear least squares analysis with an exponential function plus a constant background at lower proton energies while a second exponential term was included at higher energies because of possible contamination from the $^{32}\text{S}(p,\alpha)^{29}\text{P}$ reaction ($Q = -4.20\text{ MeV}$). This analysis showed that there was no significant contribution to the measured yield from the decay of ^{29}P with a 4.23-sec half life. Determination of the absolute strength of the $E_p = 3.371\text{-MeV}$ resonance was obtained by determining the thick-target yield of the 810-keV γ -ray and utilizing published proton stopping power data and the known absolute efficiency of the Ge(Li) detector. A correction was made for the fact that this resonance state decays with a branch of $>88\%$ to the 810 keV first-excited state in ^{33}Cl .

RESULTS AND DISCUSSION

Four of the resonances observed in this work were found to have energies in quite close agreement with results from earlier work on ^{33}Ar decay. A comparison of the $E_p = 0.588\text{-MeV}$ resonance strength measured in the present work with an earlier result from Engelbertink and Endt [EE66] showed excellent agreement. With regard to the lowest $T = 3/2$ state in ^{33}Cl , the value of M1 strength for the 5.550 to 0.810 MeV transition from the present work is in fairly good agreement with an earlier theoretical result. Since the multipole mixing of the M1 and E2 ratio is unknown, the best that could be done in the present experiment was to deduce a limit of $<1.8\text{ W.u.}$ for the E2 strength. This upper limit is consistent with the theoretical value of 0.2 W.u. The data provided and extensive discussions on their interpretation are well organized and presented in the present article [EIR72].

ERI73

TITLE

A Proposed Method for Assaying Sulphur by Proton Activation Analysis Using a Low-Energy Accelerator

REFERENCE

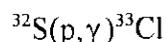
M.A. Eswaran, N.L. Ragoowansi and M. Ismail, Report IAEA-SM-170/6, International Atomic

Energy Agency (IAEA), Vienna, Austria, 489 (1973).

ABSTRACT

A new method of proton activation analysis is proposed for assaying sulphur using the capture reaction $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$. The method involves short irradiations of a few seconds by a mechanically chopped beam from a low-energy Van-de-Graaff accelerator, coupled with the measurement of the residual positron activity of $T_{1/2} = 2.52$ s, resulting from the decay of ^{33}Cl . A plastic scintillation detector was used for positron counting in conjunction with a multi-channel analyzer operated in the multi-scaling mode with a dwell time of 40 ms per channel. The time for irradiation was 4 s and for counting was 10 s. The repeated irradiation-counting sequence was automatically controlled by a timer-relay unit which effects mechanical chopping of the beam. This activation reaction features a high-abundance target isotope (95%), and the method is highly selective since only the counts showing the correct half-life are included for the analysis. The proposal is based on our detailed study [EIR72] of the excitation function for this reaction in the bombarding-energy range 3.3 to 5.4 MeV, applying this technique and using the model C-N Van-de-Graaff Accelerator at Trombay. A sensitivity of a few $\mu\text{g}/\text{cm}^2$ can be achieved by this method which is rapid and uses only a low-energy accelerator. This method can be fruitfully used in assaying sulphur in different materials, *e.g.*, in petroleum products.

REACTION



FACILITY

5.5-MeV Van de Graaff accelerator, Bhabha Atomic Research Center, Trombay, Bombay, India.

EXPERIMENT

The determination of sulphur content is of great importance in metallurgy, petroleum products, *etc.* Unfortunately, it is very difficult to do this by activation analysis, either with thermal or fast neutrons, because several elements interfere. It is proposed here that the assay of materials for sulphur can be done by using the capture reaction $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ ($Q = 2.29$ MeV) and a relatively low-energy accelerator through proton activation analysis. The main goal of this experiment is to explore the physics aspects and to demonstrate how this new approach can be carried out.

MEASUREMENT PROCEDURES

The procedure is similar to that described in Ref. EIR72. Sulphur targets were prepared by evaporating natural antimony sulphide (Sb_2S_3) to a thickness of $300 \mu\text{g}/\text{cm}^2$ onto a thick gold backing. This target was mounted at the center of a 5 cm diameter, thin-walled, stainless steel chamber coupled to the beam tube. The beam of protons was collimated to a size of 5 mm by tantalum apertures. This

beam was incident at 45 degrees to the sulfur targets. A current integrator was used to monitor the current of proton beams stopped in the target backing. A β -detector consisting of a 10-cm diameter x 2.5-cm thick plastic scintillator mounted on a XP1040 photomultiplier tube was placed at a 90° angle to the beam and 5 cm distant from the target. The pulses from this detector were analyzed by a Nuclear-Data 4096 channel analyzer operating in multi-scaling mode. A timer-relay unit controlled the beam chopping as well as the irradiation-counting sequence. Figure 1 of the article [ERI73] shows a schematic diagram of the set-up.

DATA ACQUIRED

Time spectra for decay of ^{33}Cl by the emission of energetic positrons (β^+) with endpoint energy of 4.51 MeV were recorded by cyclic activation. A sample time spectrum which required 25 minutes to accumulate at $E_p = 5.283$ MeV is given in Fig. 2 of the article [ERI73]. Also shown, in Fig. 3 is the excitation function which was determined earlier [EIR72] between the energies of 3.3 and 5.4 MeV for the reaction $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$. Presumably, the amount of sulphur present can be deduced from the yield of emitted positrons. However, this also depends on target thickness, detector efficiency and other experimental factors. At the relatively low proton bombarding energies used in these measurements ($E_p < 5.5$ MeV) there is no interference from other induced radioactivities unless silicon is present. Then, the $^{28}\text{Si}(p,\gamma)^{29}\text{P}$ reaction produces ^{29}P which decays by positron emission with a 4.23-sec half life. The end point energy of these interfering positrons is 3.945 MeV so they can be discriminated against by raising the detector bias, but at considerable expense to the detector efficiency. Another approach would be to separate the two positron radioactivities by fitting the observed decay curve with a sum of exponential functions plus a constant background component.

DATA ANALYSIS

The data analysis required is relatively unsophisticated for this approach to sulphur assay. It is indicated that in this particular demonstration experiment the counts in the decay curve for the first 5-second period (Region I in Fig. 2 of the article [ERI73]) were added and from this sum the counts in the later 5-second period (Region II of Fig. 2) are subtracted (thereby roughly eliminating the background). The most important requirement here is to discriminate against those events which do not correspond to the decay of 2.52-sec ^{33}Cl . Although no mention is made in the present article [ERI73], various types of standard samples would be required in order to calibrate the apparatus for quantitative measurements of other unknown materials under reproducible conditions (beam current, proton energy, target thickness, geometry, etc.).

RESULTS AND DISCUSSION

The technique investigated in the article, using the $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ reaction, is offered as a potentially fruitful one for assaying sulphur. The authors claim that their method is both rapid and non-destructive, and is applicable to both solid and liquid materials. Few data are provided to substantiate the claimed sensitivity of this method and the authors also fail to discuss how one might deal with such technical issues as target preparation, the outgassing and decomposition of materials in the

target vacuum chamber, etc. This article does not provide any information of particular utility for astrophysics so the reader is referred to the more relevant information in Ref. EIR72 for this purpose.

E+75

TITLE

T = 3/2 Analog Resonance in ^{33}Cl through Capture and Inelastic Scattering of Protons

REFERENCES

M.A. Eswaran, N.L. Ragoowansi, D.R. Chakrabarty and H.H. Oza, Report BARC-799, Bhabha Atomic Research Center, Bombay, India, 24 (1975). See also: Report BARC-768, 39 (1974).

ABSTRACT

Though the T = 3/2 state in ^{33}Cl at 7.4 MeV, corresponding to the analog of the second excited state in ^{33}P , has been identified in our previous work as a sharp resonance in the reaction $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$, this state has not been located successfully in the elastic scattering of protons. Owing to the fact that such an analog resonance is isospin forbidden, the proton width and the total width expected are much smaller than for the low T background states. In the present work we obtained the excitation function near this resonance for both the capture and inelastic scattering of protons from ^{32}S under same experimental conditions. Using a target which is only 4 keV thick for 5 MeV protons, excitation functions in the range $E_p = 5.270$ to 5.310 MeV in 1.3 keV steps were obtained for both the reactions $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ and $^{32}\text{S}(p,p')^{32}\text{S}$ by detecting the positrons in the decay of ^{33}Cl for the former reaction and the gamma ray of 2.237 MeV from ^{32}S in the latter reaction. This has revealed that just 15 keV above the analog state, there is a broad resonance in the inelastic scattering channel which is a low T (= 1/2) state. The presence of such a broad resonance close to the analog resonance in elastic scattering is likely to hamper the identification of the analog resonance. A limit on the resonance strength for inelastic scattering for this analog at $E_p = 5.282$ MeV is also obtained to be $\Gamma_p \Gamma_p / \Gamma < 10$ eV from the present data.

COMMENT

The same abstract appears in both of the references indicated above. Refs. E+74 and E+75 differ only in the fact that E+74 includes a figure. No textual information beyond the abstract is provided in either of these communications so a detailed summary has not been prepared.

H+72

TITLE

Etude des Etats Excites du Noyau ^{35}Cl : (I) Courbe d'Excitation de la Reaction $^{34}\text{S}(p,\gamma)^{35}\text{Cl}$, Energie et Rapports d'Embranchement des Niveaux du ^{35}Cl

REFERENCE

P. Hubert, M.M. Aleonard, D. Castera, F. Leccia and P. Mennrath, Nuclear Physics **A195**, 485 (1972). [In French].

ABSTRACT

Energies and resonance strengths have been determined for fifty-nine $^{34}\text{S}(p,\gamma)^{35}\text{Cl}$ resonances in the range $E_p = 700\text{-}2100$ keV. The measurement of the excitation function near $E_p = 1510$ keV, with a very thin target, shows that a strong resonance, already identified as an isobaric analog resonance, is split into two components. Decay schemes of forty-eight resonances were studied by means of a 60-cm^3 Ge(Li) detector. Energies and γ -branchings of all bound states are given, and six previously unreported levels at excitations $E_x = 4173.0 \pm 0.6$, 4838 ± 3 , 4853 ± 2 , 5587 ± 3 , 5802 ± 5 and 6489 ± 5 keV have been found. The reaction Q-value is 6367.4 ± 1.6 keV.

COMMENT

This work is included here because it provides a description of the experimental setup and measurement procedure which is relevant to Ref. A+74. No detailed summary has been prepared because most of the material in this communication is irrelevant for present purposes.

I+92

TITLE

Direct Proton Capture on ^{32}S

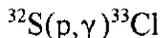
REFERENCE

C. Iliadis, U. Giesen, J. Gorres, M. Wiescher, S.M. Graff, R.E. Azuma and C.A. Barnes, Nuclear Physics **A539**, 97 (1992).

ABSTRACT

The $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ reaction has been measured in the proton-energy range $E_p = 0.4\text{-}2.0$ MeV. Non-resonant γ -transitions were observed to the final states in ^{33}Cl at $E_x = 0, 811$ and 2846 keV. The corresponding spectroscopic factors have been extracted from fits to the excitation functions and are compared to values from stripping data as well as theoretical model calculations. The astrophysical aspects of the $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ reaction are also discussed.

REACTION



FACILITY

3-MV Pelletron tandem accelerator, Kellogg Radiation Laboratory, California Institute of Technology, Pasadena, California, U.S.A.

EXPERIMENT

Radiative proton capture of ^{32}S was investigated, including consideration of both resonance capture and off-resonance direct capture interactions. The influence of possible interference between resonance and direct capture is discussed. This investigation involved the measurement of γ -ray yields at 55° and angular distributions for various proton energies in the range $E_p = 0.4 - 2.0$ MeV using a Ge detector. Both narrow and broad resonances were examined. On-resonance energies, strengths and gamma-ray branching were determined. Comparisons are made with the results from calculations made using theoretical models. Excitation functions of primary transitions to low-lying states in ^{33}Cl were determined off resonance and in the region of a broad resonance at 1898 keV. These data were also used to determine single-particle spectroscopic factors for the final states in ^{33}Cl and to calculate stellar reaction rates for temperatures in the range $T_9 = 0.05\text{-}2.0$. The relative importance of resonances and direct capture on these stellar reaction rates is examined in various temperature ranges. Comparison is made with the results of earlier work reported in the literature.

MEASUREMENT PROCEDURES

The measurements were carried out with the 3-MV Pelletron tandem accelerator at Kellogg Radiation Laboratory, California Institute of Technology. An RF source installed at the terminal provided proton beams in the energy range $0.4 - 2.0$ MeV with currents up to $65 \mu\text{A}$. The beam energy resolution was 2 keV, as measured using the well-known narrow $^{27}\text{Al}(p,\gamma)^{28}\text{Si}$ resonance at $E_R = 991.88 \pm 0.04$ keV. The proton energy was calibrated using this resonance as well as the $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ resonance at $E_R = 1757.2 \pm 0.9$ keV. Sulphur targets were prepared by implanting $80\text{-keV } ^{32}\text{S}$ ions into a 0.5-mm Ta backing using the SNICS source at the University of Notre Dame. The incident dose was $120 \mu\text{A}\cdot\text{h}$. This process yielded well-defined targets with thickness ~ 5 keV at $E_p = 1760\text{-keV}$ bombarding energy. The ratio of sulphur to tantalum in these targets was determined via thick-target

yield measurements on the well-known $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ ($E_R = 1757$ keV) resonance, using knowledge of S and Ta stopping powers. This ratio was found to be 1.0 ± 0.2 . These targets were water cooled and they proved to be very stable under proton bombardment. The proton beam passed through a set of horizontal and vertical slits before impinging on the target which was mounted at a 45° angle with respect to the incident beam. The emitted γ -radiation was observed with a 35% Ge detector that had an energy resolution of 2.0 keV at $E_\gamma = 1.3$ MeV. Gamma-ray yield measurements were performed on the known resonances and also in the energy range of $E_p = 1.38$ -1.93 MeV which spans a region where there are relatively few resonances and direct capture is expected to be significant. For absolute yield measurements this detector was placed at a 55° angle with respect to the incoming beam with a front-face-to-target distance of 1.8 cm. In order to reduce the amount of background the detector was shielded with 5 cm of lead. This detector was also used to examine the angular distribution at 0° , 55° and 90° for selected gamma-ray transitions and proton energies. In this case the setup involved placing the detector at a distance of 4.3 cm from the target.

DATA ACQUIRED

Narrow resonances were identified at five incident proton energies. The gamma-ray measurements performed at these resonances yielded γ -branching factors, angular-distribution coefficients, resonance strengths and additional spectroscopic information associated with electromagnetic transitions to final states in ^{33}Cl (see the article for details [I+92]). Gamma-ray yield measurements performed off resonance (and hence attributable mainly to direct capture) enabled an accurate determination of the relative importance of resonance and direct proton capture for ^{32}S to be accomplished. For completeness, the strength of a narrow resonance at 77 keV was estimated by means of calculations since the gamma-ray yield associated with this resonance was too difficult to measure.

DATA ANALYSIS

The data analysis procedure is outlined in Section 3 of the article [I+92]. Resonance strengths were calculated in the usual manner using the known detector efficiencies, measured gamma-ray yields and stopping power information. Measured angular distributions of resonance decay γ -transitions were analyzed in terms of Legendre polynomial expansions for the gamma rays associated with resonances at $E_R = 1588$ and 1748 keV. These experimental angular distributions indicated small $P_4(\cos \theta)$ components except for the ground-state transition of the 1588-keV resonance where $a_4 = 0.49 \pm 0.05$. Excitation functions of the primary transitions to ^{33}Cl states at $E_x = 0$, 811 and 2846 MeV were fitted by least-squares using a simple theoretical formalism with adjustable parameters. Breit-Wigner formalism was used in this analysis. The cross sections for direct capture were based on a method described earlier by Rolfs (see this article for a reference [I+92]). Spectroscopic factors were determined by comparing the observed and predicted cross sections to the final states of ^{33}Cl .

RESULTS AND DISCUSSION

The present results obtained for resonance energies and strengths are in good agreement with

previous values (see Table 1 of the article [I+92]). The γ -branching ratios listed in Table 2 of the article [I+92] are also in good overall agreement with previous results. Spectroscopic factors derived from the present work agree well with earlier results from ($^3\text{He},d$) and (d,n) stripping experiments for the first and second excited states of ^{33}Cl (see Table 3 of the article [I+92]). From this information it is concluded that for non-resonant proton capture on ^{32}S the simple direct-capture model is capable of reproducing the experimental cross sections with appropriate energy dependencies and angular distributions. There is some disagreement between certain reaction rates determined in the present work and those that were reported previously. It is noted that statistical (Hauser-Feshbach) theory is not applicable here because of the low level density of ^{33}Cl for $E_x < 4$ MeV.

COMMENTS

The previously recommended resonance strengths remain largely unchanged by the present results. However, this article [I+92] provides useful information for astrophysics because the derived stellar reaction rates of $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ are now based on more precise input data which include non-resonant proton capture contributions.

KRA75

TITLE

Strengths of Analogue Resonances in (p,γ) Reactions on Sulphur Isotopes

REFERENCE

J. Keinonen, M. Riihonen and A. Anttila, *Physica Scripta* **12**, 280 (1975).

ABSTRACT

Absolute strengths of the $E_p = 588$ keV resonance in the $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ reaction and of the $E_p = 1214$ keV resonance in the $^{34}\text{S}(p,\gamma)^{35}\text{Cl}$ reaction have been determined as 0.20 ± 0.04 eV and 9.8 ± 1.0 eV, respectively. The strength of the $E_p = 1542$ keV resonance in the $^{33}\text{S}(p,\gamma)^{34}\text{Cl}$ reaction and the $E_p = 1887$ keV resonance in the $^{36}\text{S}(p,\gamma)^{37}\text{Cl}$ reaction have been obtained as 1.4 ± 0.2 eV and 22 ± 3 eV, respectively, by comparison with the $E_p = 1214$ keV resonance in the $^{34}\text{S}(p,\gamma)^{35}\text{Cl}$ reaction. The total, proton and γ -ray widths of the $J^\pi = 7/2^-$ analogue states in ^{35}Cl and ^{37}Cl at $E_x = 7.55$ and 10.22 MeV, respectively, are given. The γ -ray decay of these isobaric analogue resonances in $^{34,35,36}\text{Cl}$ is discussed.

REACTION

$^{32}\text{S}(p,\gamma)^{33}\text{Cl}$

FACILITY

2.5-MV Van de Graaff accelerator, Department of Physics, University of Helsinki, Helsinki, Finland.

EXPERIMENT

The objective of this experiment was to investigate whether earlier reported resonance strength results for $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ and $^{34}\text{S}(p,\gamma)^{35}\text{Cl}$ were correct. An attempt was also made to redetermine the strengths of the resonances at $E_p = 1887$ and 1542 keV in the reactions $^{36}\text{S}(p,\gamma)^{37}\text{Cl}$ and $^{33}\text{S}(p,\gamma)^{34}\text{Cl}$, respectively. Due to low natural isotopic abundances of ^{33}S (0.74%) and ^{36}S (0.014%), (p,γ) strength measurements for production of ^{34}Cl and ^{37}Cl had been possible only by using enriched targets. Earlier strength measurements for ^{33}S gave results differing by factors of up to 10.

MEASUREMENT PROCEDURES

The Helsinki University 2.5-MV Van de Graaff accelerator supplied the proton beam and a 120-cm³ Ge(Li) detector (FWHM = 2.9 MeV at 2.6 MeV), coupled with a 4096 channel analyzer, detected the γ -ray radiation. The proton beam was kept below 5 μA to avoid target deterioration and the collected charge was measured with a calibrated current integrator. The Ge(Li) detector was placed at an angle of 55° relative to the incident beam. Its absolute efficiency was determined using calibrated gamma-ray sources. To measure the absolute strengths, ZnS targets were prepared and used. ZnS was chosen because it is the only sulphur compound known to not dissociate on evaporation. With other sulphur compounds, target stoichiometry is a serious problem. These targets were prepared on tantalum backings. However, the S-Zn ratio was checked by preparing targets on carbon backings under identical conditions and then assaying these latter targets by means of α -particle backscattering. A silicon surface barrier detector with an active area of 50 mm² was used to record the α -particle spectra. This detector was situated at an angle of 178° and a distance of 8 cm from the targets. The thickness of these targets was about 150 $\mu\text{g}/\text{cm}^2$ of ZnS. The reactions involving ^{33}S , ^{34}S and ^{36}S could not be observed successfully using targets made with elemental sulphur. Therefore, isotopically enriched targets were made from natural sulphur by using an electromagnetic separator and imbedding the sulphur ions into thin self-supporting carbon foils at an energy of 8 keV. The amounts of ^{33}S , ^{34}S and ^{36}S present in these targets were 0.5, 0.5 and 0.1 $\mu\text{g}/\text{cm}^2$, respectively.

DATA ACQUIRED

Absolute thick-target yields of selected gamma-ray transitions in the resonances observed at $E_p = 588$, 1214, 1542 and 1887 in the various isotopes of sulphur were measured (see Table I of the article [KRA75]). Measurements of α -particle backscattering were performed as indicated above for the purpose of establishing the target stoichiometry. These measurements were performed at the beginning and end of the (p,γ) experiment.

DATA ANALYSIS

The measured thick-target gamma-ray yields at the resonance proton energies were combined with proton stopping powers from the literature and other parameters of the experiment to yield (p, γ) resonance strengths for $^{32}\text{S}(p, \gamma)^{33}\text{Cl}$, $^{33}\text{S}(p, \gamma)^{34}\text{Cl}$, $^{34}\text{S}(p, \gamma)^{35}\text{Cl}$ and $^{36}\text{S}(p, \gamma)^{37}\text{Cl}$. The procedures and formulas used in this analysis are described in Section 3 of the article [KRA75]. The total uncertainties of the present results include a 2% uncertainty contribution for the stopping power of Zn and a 15% uncertainty contribution for that of S, leading to an effective uncertainty of 5% in the stopping power of the compound ZnS.

RESULTS AND DISCUSSION

The results of this experiment appear mainly in Tables I and II of this article [KRA75]. These include absolute (p, γ) resonance strengths for the four sulphur reactions considered and experimental M1 transition strengths in $^{34,35,36}\text{Cl}$. The experimental single-nucleon strengths of analogue states in ^{35}Cl and ^{37}Cl as well as the M1 transition strengths are lower than the theoretical values, suggesting that it would be useful in theoretical calculations to pay more attention to configuration mixing of the analogue states. Of specific interest in the present context is the fact that the present results agree quite well with previous results for the resonance strength of $^{32}\text{S}(p, \gamma)^{33}\text{Cl}$.

K+85

TITLE

Measurements of Relative Thick Target Yields for PIGE Analysis on Light Elements in the Proton Energy Interval 2.4-4.2 MeV

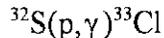
REFERENCE

A.Z. Kiss, E. Koltay, B. Nyako, E. Somorjal, A. Anttila and J. Raisanen, Journal of Radioanalytical and Nuclear Chemistry **89**, No. 1, 123 (1985).

ABSTRACT

In order to extend the energy range of the systematic investigation on relative thick target yields performed by Anttila *et al.* (J. Radioanal. Chem. **62**, 441, 1981) for $1 \leq E_p \leq 2.4$ MeV bombarding energies, gamma spectra and yield data are presented for elements $Z = 3-9, 11-17, 19$ and 21 in the energy range $2.4 \leq E_p \leq 4.2$ MeV, and the results are discussed from the point of view of the PIGE analysis.

REACTION



FACILITY

5-MV Van de Graaff accelerator, Institute of Nuclear Research, Hungarian Academy of Sciences, Debrecen, Hungary.

EXPERIMENT

Relative thick target yields are compiled to enable an optimal selection of experimental parameters on a given sample matrix to be made as the basis for practical applications of the PIGE (proton-induced gamma emission) method for determination of the constituents of samples. A consistent set of yield data is presented in the article [K+85] for nearly all $3 \leq Z \leq 21$ elements in the proton energy interval $1 \leq E_p \leq 4.2$ MeV. The yield data for $1 \leq E_p \leq 2.4$ MeV are taken from earlier research. Similar data were generated from measurements performed in the present experiment over the energy range $2.4 \leq E_p \leq 4.2$ MeV. These newer data were normalized to results from the earlier, lower-energy work. The intent of this work was clearly applied rather than basic. Furthermore, the results provided, while of general interest, are of little practical use for astrophysical purposes.

MEASUREMENT PROCEDURES

The proton beam was supplied by the 5-MV Van de Graaff accelerator of the Institute of Nuclear Research, Debrecen. This beam was well collimated and, furthermore, passed through a 50-cm-long liquid nitrogen cold trap before hitting the target (presumably in order to reduce buildup of contaminants on the targets). The angle between the beam and the targets was 45° . Elemental targets (Be, Mg, C, Al and Si) were prepared in the form of thick plates. All the other targets were made by pressing appropriate chemical compounds into pellets. A 25-cm³ Ge(Li) detector with 2.6-keV resolution for $E_\gamma = 1.33$ MeV gammas was used to detect the gamma radiation in the present experiment. This detector was situated at 55° relative to the beam direction at a detector-to-target distance of 10 cm. Since a larger Ge(Li) detector (100 cm³) had been used earlier for the work at energies $E_p \leq 2.4$ MeV, it was necessary to generate a relative efficiency calibration for these two detectors in the range $0.11 \leq E_\gamma \leq 3.56$ MeV so that the present results could be properly normalized to values from the earlier investigation. Beam currents in the range 1 nA to 1 μ A were used. The beam intensity was adjusted to keep the dead time for the detection system nearly constant for measurements with various samples. Gamma-ray spectral data were acquired with a 4K-channel analyzer and PDP-8 computer.

DATA ACQUIRED

Gamma-ray spectra from proton bombardment of thick samples at energies $E_p = 3.1, 3.8$ and 4.2 MeV were recorded for all elements in the range $3 \leq Z \leq 21$ except neon and argon. Typical spectra

from this work are shown as figures in the article [K+85], including one for sulfur at $E_p = 3.8$ MeV.

DATA ANALYSIS

Individual full-energy-peak lines in these gamma spectra were identified as belonging either to the element under consideration or to other components of the sample compound or to background sources. Reference was made to known level and decay schemes in this identification process. Yields of peaks attributed to the elements in question were determined and corrected for dead time losses. In many cases several lines corresponding to the same element were available, which offered some redundancy and hence a check against possible elemental assay errors. The present gamma-ray yields were generally normalized to earlier work at lower proton energies using the relative sensitivities of the 25 cm³ and the 100 cm³ detectors. Due to the strong decrease in the sensitivity of the smaller detector, no normalization was made for the gamma-ray peaks seen in the fluorine target spectra with $E_\gamma > 3.56$ MeV. The yields of these higher-energy gamma lines are presented only on the intensity scale of the 25-cm³ Ge(Li) detector.

RESULTS AND DISCUSSION

The results of this work appear in Figs. 1-17 and in Table I of the article [K+85]. This body of information represents a consistent set of thick target gamma-ray yields for $3 \leq Z \leq 21$ elements (except for neon and argon) in the bombarding proton energy interval $1 \leq E_p \leq 4.2$ MeV. When increasing the proton energy from 2.5 to 4.2 MeV, the number of isotopes with open (p,n) neutron channels increased from 7 to 15 in the present Z range. These reactions contribute gammas, along with the (p,p') gammas, that complicate gamma-ray spectra at higher proton energies. Under these conditions the higher-energy gamma peaks from (p, γ) reaction will lose their importance because of the rapid increase in the weight of the lower-energy gamma transitions connected to particle emission. A conclusion of this work is that applications for PIGE analysis broaden at higher proton bombarding energies because the opening reaction channels provide more signature reactions.

PGA70

TITLE

Properties of States in ³³Cl Excited Via the ³²S(p, γ)³³Cl Reaction

REFERENCE

F.W. Prosser, Jr., J.W. Gordan and L.A. Alexander, Bulletin of the American Physical Society **15**, No. 4, 566, Paper GE 11 (1970).

ABSTRACT

More accurate excitation energies of some of the compound states of ^{33}Cl have been obtained using Ge(Li) detectors. The Q-value for the $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ reaction has been determined in this way to be $Q = 2277.6 \pm 3.4$ keV. Angular distribution measurements at $E_x = 4465, 4746$ and 4834 keV uniquely determine the spins to be $J = 3/2, 5/2,$ and $3/2,$ respectively. The spin of the 4439 -keV state is either $1/2$ or $3/2$. An ambiguity also remains of $J = 5/2$ or $7/2$ for the spin of the 1985 -keV second excited state. The properties of the low-lying states of ^{33}Cl will be compared with the corresponding states of ^{33}S .

COMMENTS

This reference is only an abstract, as it appears above. It comes from the Bulletin of the American Physical Society. No further information was available on this work.

RWK87

TITLE

Absolute Thick-target γ -ray Yields for Elemental Analysis by 7- and 9-MeV Protons

REFERENCE

J. Raisanen, T. Witting and J. Keinonen, Nuclear Instruments and Methods in Physics Research **B28**, 199 (1987).

ABSTRACT

A systematic study of absolute thick-target γ -ray yields, produced in the bombardment of elements with $Z = 3-9, 11-17, 19, 20, 22-30, 32, 39-42, 44, 46-51, 53, 62, 64, 70, 72-74, 78, 79,$ and 82 by 7 and 9 MeV protons, has been carried out. The most suitable γ -ray energies and absolute yields for elemental analysis are listed. Relative neutron yields are also given.

FACILITY

5-MV tandem accelerator (EGP-10-11), Accelerator Laboratory, University of Helsinki, Helsinki, Finland.

EXPERIMENT

The aim of the present work was to use higher proton bombarding energies than had been used previously to examine γ -ray yields from particle emitting channels, to extend the elemental γ -ray yield data for PIGE analysis of elemental constituents with $Z > 20$, and to determine the most suitable γ -ray energies to use for elemental analysis purposes. Because their presence can be a complication in PIGE analysis at higher proton energies, the relative neutron yields under these conditions were also measured.

MEASUREMENT PROCEDURE

An incident beam of protons was supplied by the Helsinki University tandem accelerator. A shielded 80-cm³ Ge(Li) detector having an energy resolution of 1.9 keV at $E_\gamma = 1.33$ MeV and an efficiency of 18% was used to detect the γ -ray radiation. To increase the accuracy of the results by minimizing angular-distribution perturbations, this detector was positioned at 55° relative to the proton beam. Also, it was located at a target-to-detector distance of 27 cm to minimize uncertainties due to small changes in solid angle for the various targets. This detector was calibrated using ⁶⁰Co, ⁵⁶Co and ¹⁵²Eu standard gamma-ray sources. A BF₃ detector located 30 cm from the target detected the emitted neutrons. The collected proton charge was accurately determined using a calibrated current integrator and a suppressor against secondary electrons. Most of the targets that were used in this experiment were 1-mm thick by 1-cm² metallic plates. Powdered chemical compounds were used along with metallic-plate targets. The chemical-compound targets were 1-mm-thick by 6-mm in diameter pellets. The measurements were performed under varying beam conditions (0.1 to 20 nA) which were chosen to maintain relatively constant gamma-detector count rates and small dead times (< 1%).

DATA ACQUIRED

Gamma-ray spectra were recorded, full-energy peaks were identified and their yields were determined for those elements and proton energies given in the abstract. An approach similar to the one described in an earlier communication from this laboratory [K+85] was used.

DATA ANALYSIS

The gamma-ray peak yields were corrected for background (and/or interfering lines), for dead time and for detector efficiency. Furthermore, in cases where the targets were chemical compounds, corrections were also applied for proton stopping power so that equivalent elemental yields could be deduced from the measured data.

RESULTS AND DISCUSSION

The resulting thick-target absolute γ -ray yields per $\mu\text{C}\cdot\text{sr}$ for the various reactions and gamma rays considered are given in Table 1 of the article [RWK87]. Relative neutron yields for the various targets and proton energies are given in Table 2 of this article. An additional result from this work which is

of interest for the reaction $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ is that there is evidence that the (p,p') and (p,n) reactions dominate over the (p, γ) reaction at the higher proton energies (7 and 9 MeV). This is found by comparing the present gamma-ray yield values with corresponding previous yield values obtained at 4.2 MeV for the lighter elements. It is also noted that the (p, α) reaction is usable in elemental analysis for only a few light elements. This is due to the fact that there is a high Coulomb barrier for α particles which reduces the cross sections and leads to the dominant population of ground states in the product nuclei, and thus there are relatively few emitted signature gamma rays associated with this process that can be used for elemental assay purposes.

S83

TITLE

Effect of Excited States on Thermonuclear Reaction Rates

REFERENCE

D.G. Sargood, Australian Journal of Physics **36**, 583 (1983).

ABSTRACT

Values of the ratio of the thermonuclear reaction rate of a reaction, with target nuclei in a thermal distribution of energy states, to the reaction rate with all target nuclei in their ground states are tabulated for neutron, proton and α -particle induced reactions on the naturally occurring nuclei from ^{20}Ne to ^{70}Zn , at temperatures of 1, 2, 3.5, and 5 ($\times 10^9$) $^\circ\text{K}$. The ratios are determined from reaction rates based on statistical model cross sections.

REACTION

$^{32}\text{S}(p,\gamma)^{33}\text{Cl}$

FACILITY

None. This work is an analytical study.

EXPERIMENT

None. This paper deals only with theoretical calculations of the thermonuclear reaction rates $\langle\sigma v\rangle^*$ corresponding to target nuclei in a thermal distribution of energy states and corresponding reaction rates $\langle\sigma v\rangle^0$ obtained with all target nuclei in their ground states. Ratios of these two rates are derived

and compiled in this work.

MEASUREMENT PROCEDURE

None. In this study the cross sections are generated using statistical model calculations.

DATA ACQUIRED

None. No experimental data were produced in this investigation, but ratios of calculated reaction rates were generated for $T_9 = 1, 2, 3.5$ and 5 (*i.e.*, stellar temperatures in units of 10^9 °K) for a large number of target isotopes and nine different reaction types, namely, (n,γ) , (n,p) , (n,α) , (p,γ) , (p,n) , (p,α) , (α,γ) , (α,n) and (α,p) .

RESULTS AND DISCUSSION

The calculated values that are obtained for these ratios are listed in Tables 1-4 in the article [S83]. The author states that his work demonstrates that the excited states in target nuclei play a very important role in determining thermonuclear reaction rates under stellar conditions. The most dramatic effects occur very largely for reactions such as (n,p) and (n,α) on neutron-rich isotopes and (p,n) reactions on α -particle nucleus targets for which the stellar reaction rates are very small, *i.e.*, at least two, and sometimes as many as eight, orders of magnitude smaller than other strongly competing or even dominant open reaction channels. The statistical model appears to be the only means available to calculate the ratios $\langle\sigma v\rangle^*/\langle\sigma v\rangle^0$ in a systematic way for a large number of target nuclei and reactions. However, the statistical model is not reliable when the level density in the compound system (target + projectile) is relatively low. Under these conditions, the reaction rates calculated using experimental data and Maxwellian temperature distributions will lead to values which differ considerably from those obtained using the statistical model. Then, application of a correction factor obtained from the present compilation may lead to misleading results and should be viewed with some skepticism. However, if the level densities are relatively high and the statistical model can be expected to yield reasonably reliable values of $\langle\sigma v\rangle^0$, then the present correction factors, which are relatively insensitive to fine details of the model, can be used with reasonable confidence when applied to reaction rates based largely on experimental information.

3. Resonance Properties and Concluding Remarks

Most of the relevant numerical information provided in the references assembled for the present compilation can be categorized as follows: i) resonance energies and strengths for the $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ reaction, ii) properties of levels in ^{33}Cl , iii) features of gamma-ray transitions associated with the decay of excited levels in ^{33}Cl , *e.g.*, branching, angular distributions and transition strengths and multiplicities, and iv) data of an engineering nature which can be used in applications of the $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ reaction for the assay of sulphur in materials, *e.g.*, excitation functions for relative thick-target production of specific gamma rays. In astrophysics, the main concern is a determination of reaction rates for typical stellar environments. One of the articles reviewed here [I+92] examines the relative importance of resonance and direct capture reactions for $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ for stellar temperatures. This was prompted by the observation that the level density of ^{33}Cl is relatively low. However, the general conclusion is that while direct proton capture plays an important role in the relatively narrow stellar temperature window $T_9 = 0.12$ to 0.16 , resonance capture is still the dominant mechanism for the $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ reaction over most of the energy range of interest to astrophysics. Since resonance energies and strengths are so important for astrophysical considerations, values from the present review of the literature are compiled here in Table 2.

Table 2: Resonance Energies and Strengths Compiled from the Literature^a

Nominal E_p (keV) ^b	Ref. Code	E_p (keV) ^c	Resonance Strength (eV) ^d
77	I+92	77.3 ± 0.8 ^{e,f}	7.0×10^{-17} ^f
423	A+76	421.8 ± 0.6	$(9 \pm 4) \times 10^{-5}$
	I+92	424 ± 2 ^f	$(7.4 \pm 1.6) \times 10^{-5}$ ^f
580	A+76	579.8 ± 0.6	0.08 ± 0.01 (taken from Ref. A+74)
	A+74	580	0.08 ± 0.01
588	A+76	587.9 ± 0.5	0.21 ± 0.03 (taken from Ref. A+74)
	A+74	588	0.21 ± 0.03
	EE66	588	0.14 ± 0.02
	KRA75	588	0.20 ± 0.04
	I+92	589 ± 1 ^f	0.26 ± 0.06 ^f
721	A+76	720.7 ± 0.6	$(1.4 \pm 0.6) \times 10^{-4}$
1588	A+76	1587.8 ± 1.1	0.053 ± 0.007
	I+92	1589 ± 1 ^f	0.054 ± 0.012 ^f
1749	A+76	1748.4 ± 1.0	0.09 ± 0.02
	I+92	1749 ± 1 ^f	0.09 ± 0.018 ^f
1757	A+76	1757.2 ± 0.9	0.38 ± 0.04
1880	A+76	1879.7 ± 1.1	0.019 ± 0.008
1894	A+76	1893.8 ± 1.1	0.07 ± 0.02

Table 2 (cont'd): Resonance Energies and Strengths Compiled from the Literature^a

Nominal E_p (keV) ^b	Ref. Code	E_p (keV) ^c	Resonance Strength (eV) ^d
1899	A+76	1898±2	0.19±0.07
	I+92	1899±2 ^f	0.178±0.080 ^f
2229	A+76	2229.4±1.3	0.30±0.04
2255	A+76	2255.4±1.3	0.14±0.02
2547	A+76	2547.2±1.5	1.4±0.2
2577	A+76	2577±3	0.093±0.019
3371	EIR72	3371±5	0.76±0.18
4856	EIR72	4856±9	< 0.29
5282	EIR72	5282±6	1.50±0.37

^a Values given here are extracted from tables provided in the indicated references.

^b Nominal energy of the incident proton beam corresponding to the indicated $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ resonance. It is based on an unweighted average of measured values given here, rounded to the nearest 1 keV.

^c Measured proton energy corresponding to the indicated $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ resonance.

^d Resonance strength for the $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ reaction is defined as $S = (2J+1)\Gamma_p\Gamma_\gamma/\Gamma$, where J = resonance spin, Γ_p = proton partial width, Γ_γ = gamma partial width and Γ = total width.

^e This $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ resonance is too weak to be measured using available techniques. Resonance strength is obtained indirectly from calculations which utilize information available from the literature. ^f The resonance strengths originally provided by Iliadis *et al.* [I+92] are given as $\omega\gamma = (2J+1)\Gamma_p\Gamma_\gamma/[(2J_p+1)(2J_t+1)\Gamma]$. However, $J_p = 1/2$ for a proton projectile and $J_t = 0$ for the ^{32}S target in the case of the $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ resonances. Thus, $\omega\gamma = S/2$. The values in the present table are expressed in terms of S and are thus directly comparable to the other values from the literature. Furthermore, Iliadis *et al.* indicate that the energies which they give to identify the resonances are "resonance energies" E_R . However, these energies appear to differ little from incident proton energies E_p so no distinction is made for present purposes.

Acknowledgements

The authors are indebted to Prof. Michael C. Wiescher, Department of Physics, University of Notre Dame, for suggesting this research project and for his thoughtful guidance and encouragement during the course of our work. Valuable comments on this work and the present report were graciously provided by Prof. Laura Van Wormer, Physics Department, Hiram College. One of the authors (REM) received financial support for his stay at Argonne National Laboratory during the Summer of 1997 through the Student Research Participation Program administered by the Division of Educational Programs, Argonne National Laboratory.

References

A96

D. Arnett, *Supernovae and Nucleosynthesis*, Princeton University Press, Princeton, New Jersey (1996).

A+74

M.M. Aleonard, C. Boursiquot, P. Hubert and P. Mennrath, *Strengths of (p, γ) Resonances in ^{33}Cl , ^{35}Cl and ^{28}Si* , Physics Letters **49B**, No. 1, 40 (1974).

A+76

M.M. Aleonard, Ph. Hubert, L. Sarger and P. Mennrath, *Etudes des Etats Excites du ^{33}Cl a l'Aide de la Reaction $^{32}\text{S}(p, \gamma)^{33}\text{Cl}$* , Nuclear Physics **A257**, 490 (1976). [In French].

C83

D.D. Clayton, *Principles of Stellar Evolution and Nucleosynthesis*, University of Chicago Press, Chicago, Illinois (1983).

CINDA97

CINDA (1935-1997), *The Index to Literature and Computer Files on Microscopic Neutron Data*, International Atomic Energy Agency (IAEA), Vienna, Austria. CINDA includes an index to all available EXFOR files containing neutron reaction data available from the IAEA Nuclear Data Center.

EE66

G.A.P. Engelbertink and P.M. Endt, *Measurements of (p, γ) Resonance Strengths in the s - d Shell*, Nuclear Physics **88**, 12 (1966).

EIR72

M.A. Eswaran, M. Ismail and N.L. Ragoowansi, *Studies on Analog States in ^{33}Cl by Isospin-Forbidden Resonances in the Reaction $^{32}\text{S}(p, \gamma)^{33}\text{Cl}$* , Physical Review **C5**, 1270 (1972). See also: Report BARC-598, Bhabha Atomic Research Centre, Bombay, India, 1972 (this is a pre-publication document which is essentially identical to the Physical Review paper). CONF Bombay, Volume **14B**, 5, 1972 (this is identical to the abstract of the Physical Review paper indicated above).

ERI73

M.A. Eswaran, N.L. Ragoowansi and M. Ismail, *A Proposed Method for Assaying Sulphur by Proton Activation Analysis Using a Low-Energy Accelerator*, Report IAEA-SM-170/6, International Atomic Energy Agency (IAEA), Vienna, Austria, 489 (1973).

E+72

M.A. Eswaran, M. Ismail, N.L. Ragoowansi and H.H. Oza, Report BARC-608, Bhabha Atomic Research Centre, Bombay, India, 9, 1972 (this is identical to the abstract of the Physical Review paper identified by EIR72). See also: Report BARC-633, 4, 1972 (this is also identical to the abstract of the Physical Review paper identified by EIR72).

E+74

M.A. Eswaran, N.L. Ragoowansi, D.R. Chakrabarty and H.H. Oza, *T_{3/2} Analog Resonance in ³³Cl through Capture and Inelastic Scattering of Protons*, Report BARC-768, Bhabha Atomic Research Center, Bombay, India, 39 (1974).

E+75

M.A. Eswaran, N.L. Ragoowansi, D.R. Chakrabarty and H.H. Oza, Report BARC-799, Bhabha Atomic Research Center, Bombay, India, 24 (1975). This contribution is identical to Ref. E+74 except that the figure found in the earlier document is excluded here.

H+72

P. Hubert, M.M. Aleonard, D. Castera, F. Leccia and P. Mennrath, *Etude des Etats Excites du Noyau ³⁵Cl: (I) Courbe d'Excitation de la Reaction ³⁴S(p, γ)³⁵Cl, Energie et Rapports d'Embranchement des Niveaux du ³⁵Cl*, Nuclear Physics **A195**, 485 (1972). [In French].

I+92

C. Iliadis, U. Giesen, J. Gorres, M. Wiescher, S.M. Graff, R.E. Azuma and C.A. Barnes, *Direct Proton Capture on ³²S*, Nuclear Physics **A539**, 97 (1992).

KRA75

J. Keinonen, M. Riihonen and A. Anttila, *Strengths of Analogue Resonances in (p, γ) Reactions on Sulphur Isotopes*, Physica Scripta **12**, 280 (1975).

K+85

A.Z. Kiss, E. Koltay, B. Nyako, E. Somorjai, A. Anttila and J. Raisanen, *Measurements of Relative Thick Target Yields for PIGE Analysis on Light Elements in the Proton Energy Interval 2.4-4.2 MeV*, Journal of Radioanalytical and Nuclear Chemistry **89**, No. 1, 123 (1985).

NSR97

Nuclear Science References (NSR), National Nuclear Data Center (NNDC), Brookhaven National Laboratory, Upton, New York. Available from NNDC on-line services.

PGA70

F.W. Prosser, Jr., J.W. Gordan and L.A. Alexander, *Properties of States in ^{33}Cl Excited via the $^{32}\text{S}(p, \gamma)^{33}\text{Cl}$ Reaction*, Bulletin of the American Physical Society **15**, No.4, 566, Paper GE 11 (1970).

RWK87

J. Raisanen, T. Witting and J. Keinonen, *Absolute Thick-target γ -ray Yields for Elemental Analysis by 7 and 9 MeV Protons*, Nuclear Instruments and Methods in Physics Research **B28**, 199 (1987).

RR88

C.E. Rolfs and W.S. Rodney, *Cauldrons in the Cosmos*, University of Chicago Press, Chicago, Illinois (1988).

S83

D.G. Sargood, *Effect of Excited States on Thermonuclear Reaction Rates*, Australian Journal of Physics **36**, 583 (1983).

Appendix A: Compiled Information in EXFOR Format

The EXFOR format, which is widely used for compiling neutron cross section data, was adapted for the present purpose [CINDA97]. This format provides for an easily deciphered, platform-independent ASCII representation of both textual and numerical data. Furthermore, it is a format which is generally familiar to investigators in the nuclear data community. Since the EXFOR format has been used in the past almost exclusively for compiling data on neutron reactions, some creativity had to be exercised in producing the present files of data relevant to charged-particle reactions and properties of reaction-product nuclei while still preserving most of the historical characteristics of the file structure. These files have been sent to the National Nuclear Data Center, Brookhaven National Laboratory, Upton, New York, U.S.A., for inclusion in the library of data on charged-particle reactions which is being collected there.

A+74

ENTRY	A+74	0		A+74 0	1
SUBENT	A+74 1	0		A+74 1	1
BIB	13	51		A+74 1	2
INSTITUTE	{FRGRA}			A+74 1	3
REFERENCE	{J,PL/B,49B,1,40,1974}			A+74 1	4
AUTHORS	{M.M.ALEONARD,C.BOURSIQUOT,P.HUBERT,P.MENNRATH}			A+74 1	5
TITLE	STRENGTHS OF (P,GAMMA) RESONANCES IN 33CL, 35CL AND 28SI.			A+74 1	6
FACILITY	{VDG} 4-MV VAN DE GRAAFF ACCELERATOR, C.E.A. CENTRE D'ETUDES NUCLEAIRES DE BORDEAUX-GRADIGNAN, FRANCE.			A+74 1	7
INC-PART	{P} PROTONS.			A+74 1	8
TARGETS	AG2S, CDS AND ZNS TARGETS (APPROX. 300 MICROGRAM/CM**3 THICK) AS DESCRIBED IN THE ARTICLE. CDS AND ZNS TARGETS MADE BY VACUUM EVAPORATION. TARGETS WERE WATER COOLED.			A+74 1	9
METHOD	DETAILS DESCRIBED IN THE ARTICLE AND IN AN EARLIER REFERENCE. PROTON BEAM WAS DEFLECTED BY 90 DEG. TARGET WAS SHIELDED FROM BEAM-DEFINING SLITS TO REDUCE THE X-RAY BACKGROUND. PROTON BEAMS OF THE ORDER OF 10 MICROAMPERES WERE USED. NO PROBLEMS WITH TARGET DETERIORATION WERE NOTED. ABSOLUTE RESONANCE STRENGTH MEASUREMENTS WERE PERFORMED USING ALL THREE TARGETS TO MINIMIZE ERRORS TRACEABLE TO TARGET STOICHIOMETRY. RESONANCE STRENGTHS WERE DETERMINED FROM GAMMA-RAY YIELDS MEASURED AT 55 DEG. RELATIVE TO THE PROTON BEAM. A YIELD CURVE WAS GENERATED USING FULL-ENERGY PEAKS FOR GAMMA-RAYS DE-EXCITING THE RESONANCES. PERIODIC MEASUREMENTS OF WELL-KNOWN RESONANCE ENERGIES AND STRENGTHS FOR 27AL(P,GAMMA)28SI RESONANCES AT 633 AND 774 KEV PROVIDED A CHECK ON THE MEASUREMENT AND DATA ANALYSIS PROCEDURES. THE DETAILS GIVEN ON DATA ANALYSIS PROCEDURES ARE MINIMAL IN THIS PAPER BUT THERE IS A REFERENCE TO EARLIER WORK.			A+74 1	10
DETECTORS	{GELI} 80 CM**3 GE(LI) DETECTOR USED FOR THE ABSOLUTE RESONANCE STRENGTH MEASUREMENTS. DETECTOR WAS CALIBRATED USING STANDARD SOURCES AND WELL-KNOWN TRANSITIONS IN (P,GAMMA) DECAY SCHEMES. {NAICR} A NAI SCINTILLATION DETECTOR WAS USED TO CHECK THE CONDITION OF THE TARGETS BEFORE AND AFTER THE ABSOLUTE RESONANCE STRENGTH MEASUREMENTS.			A+74 1	11
MONITOR	{CI} CURRENT INTEGRATOR. CONSISTENCY CHECKED USING			A+74 1	12

COMMENT	A CURRENT GENERATOR.	A+74 1	40
	SINCE THE ORIGINAL STRENGTH MEASUREMENTS HAD LARGE	A+74 1	41
	DISCREPANCIES, THERE WERE RELATIVE (P,GAMMA) STRENGTH	A+74 1	42
	MEASUREMENTS PERFORMED ON 33CL (EP = 588 KEV) AND 35CL	A+74 1	43
	(1214 KEV) RESONANCES TO CHECK THE RESULTS.	A+74 1	44
ERR-ANALYS	THE RESONANCE STRENGTH DATA ACQUIRED WITH THE THREE	A+74 1	45
	DIFFERENT TARGET TYPES ARE COMPARED TO CHECK DATA	A+74 1	46
	CONSISTENCY AND POSSIBLE SOURCES OF SYSTEMATIC ERROR.	A+74 1	47
	AN AVERAGE OF THE RESONANCE STRENGTH VALUES FROM THESE	A+74 1	48
	THREE TARGETS WAS CALCULATED AT EACH RESONANCE. THE	A+74 1	49
	VALUES FOR THE INDIVIDUAL TARGETS THAT WERE USED IN	A+74 1	50
	THIS AVERAGING PROCESS WERE THEMSELVES AVERAGES OF	A+74 1	51
	SEVERAL REPEATED MEASUREMENTS.	A+74 1	52
STATUS	RESULTS PUBLISHED IN THE PHYSICS LETTERS B.	A+74 1	53
ENDBIB	51	A+74 1	54
ENDSUBENT	1	A+74	199999
SUBENT	A+74 2 0	A+74 2	1
BIB	2 11	A+74 2	2
REACTION	32S(P,GAMMA)33CL	A+74 2	3
COMMENT	TABLE 1 OF THE REFERENCE GIVES THE ABSOLUTE STRENGTHS	A+74 2	4
	FOR THE 580- AND 588-KEV RESONANCES. DATA FOR EACH OF	A+74 2	5
	THE THREE TARGETS USED ARE PROVIDED. EP = INCIDENT	A+74 2	6
	PROTON ENERGY FOR THE RESONANCE. EI = LEVEL OF 33CL	A+74 2	7
	FROM WHICH GAMMA-RAY TRANSITION INITIATES. EF =	A+74 2	8
	LEVEL OF 33CL AT WHICH GAMMA-RAY TRANSITION TERMINATES.	A+74 2	9
	BRANCHING RATIOS ARE GIVEN IN THE TABLE BUT ARE NOT	A+74 2	10
	PRESENTED HERE. TARGET = TARGET USED IN THE MEASUREMENT.	A+74 2	11
	STRENG = RESONANCE STRENGTH, AS DEFINED IN THE ARTICLE.	A+74 2	12
	ERR-STRENG = ERROR IN THE RESONANCE STRENGTH.	A+74 2	13
ENDBIB	11	A+74 2	14
DATA	6 6	A+74 2	15
EP	EI EF STRENG ERR-STRENG	A+74 2	16
KEV	KEV KEV TARGET EV EV	A+74 2	17
580.	2839. 0. AG2S 0.07 0.01	A+74 2	18
580.	2839. 0. CDS 0.09 0.02	A+74 2	19
580.	2839. 0. ZNS 0.07 0.02	A+74 2	20
588.	2846. 810. AG2S 0.18 0.04	A+74 2	21
588.	2846. 810. CDS 0.24 0.05	A+74 2	22
588.	2846. 810. ZNS 0.22 0.05	A+74 2	23
ENDDATA	8	A+74 2	24
ENDSUBENT	2	A+74	299999
ENDENTRY	2	A+74	999999

A+76

ENTRY	A+76	0	A+76 0	1
SUBENTRY	A+76 1	0	A+76 1	1
BIB	13	58	A+76 1	2
INSTITUTE	(FRGRA)		A+76 1	3
REFERENCE	(J,NP/A,257,490,1976)		A+76 1	4
AUTHORS	(M.M.ALEONARD,PH.HUBERT,L.SARGER,P.MENNRATH)		A+76 1	5
TITLE	ETUDE DES ETATS DU 33CL A L'AIDE DE LA REACTION		A+76 1	6
	32S(P,GAMMA)33CL		A+76 1	7
FACILITY	(VDG) 4-MV VAN DE GRAAFF ACCELERATOR, C.E.A. CENTRE		A+76 1	8
	D'ETUDES NUCLEAIRES DE BORDEAUX-GRADIGNAN, FRANCE.		A+76 1	9
INC-PART	(P) PROTONS.		A+76 1	10
TARGETS	AG2S ENRICHED TO 99.86 PERC IN 32S (15-120 MICROG/CM**2)		A+76 1	11
	ON A GOLD SUPPORT. PREPARED BY METHOD OF WATSON ET AL.		A+76 1	12
	(REFERENCE GIVEN IN THE PAPER). AG2S, CDS AND ZNS		A+76 1	13
	PREPARED BY VACUUM EVAPORATION USING COMPOUNDS OF		A+76 1	14
	NATURAL SULPHUR (> 1 MG/CM**2) ON A 0.1 MM THICK GOLD		A+76 1	15

	BACKING.			A+76 1	16	
METHOD	PROTON ENERGIES WERE IN THE 0.4 TO 2.6 MEV RANGE. THE			A+76 1	17	
	PROTON ENERGY RESOLUTION WAS 1 KEV AT EP = 1750 KEV.			A+76 1	18	
	THE PROTON ENERGY WAS CALIBRATED USING WELL-KNOWN			A+76 1	19	
	(P,GAMMA) RESONANCES IN ³⁴ S, ²⁷ Al AND ¹³ C. THE PRESENT			A+76 1	20	
	EXPERIMENT INVOLVED PROTON BOMBARDMENT OF VARIOUS			A+76 1	21	
	TARGETS INCLUDING THOSE CONTAINING SULPHUR COMPOUNDS			A+76 1	22	
	WITH BOTH NATURAL SULPHUR AND ³² S ENRICHED MATERIAL.			A+76 1	23	
	A RESONANCE EXCITATION FUNCTION WAS MEASURED IN STEPS			A+76 1	24	
	OF 0.5 TO 1 KEV FROM 560 TO 2600 KEV. THE DETECTOR WAS			A+76 1	25	
	PLACED AT 55 DEG. RELATIVE TO THE PROTON BEAM. THREE			A+76 1	26	
	NEW RESONANCES WERE IDENTIFIED. RESONANCE STRENGTHS			A+76 1	27	
	WERE DETERMINED FOR 14 RESONANCES BY LOOKING AT THE			A+76 1	28	
	PROMINENT RESONANCE DECAY GAMMA RAYS WITH A HIGH-			A+76 1	29	
	RESOLUTION GE(LI) DETECTOR. ANGULAR DISTRIBUTIONS WERE			A+76 1	30	
	MEASURED FOR GAMMA RAYS FROM SEVERAL OF THESE			A+76 1	31	
	RESONANCES. DATA TAKEN AT 0, 30, 45, 55 AND 90 DEG.			A+76 1	32	
	LIFETIMES FOR SEVERAL RESONANCES WERE MEASURED BY			A+76 1	33	
	DOPPLER-SHIFT ATTENUATION METHOD WITH THE GE(LI)			A+76 1	34	
	DETECTOR PLACED AT 0 AND 132 DEG. MULTIPOLE MIXING			A+76 1	35	
	RATIOS WERE ALSO DETERMINED FOR SEVERAL GAMMA-RAY			A+76 1	36	
	TRANSITIONS. RAW SPECTRAL DATA WERE RECORDED WITH A			A+76 1	37	
	4096-CHANNEL ANALYZER AND WERE LATER TRANSFER TO			A+76 1	38	
	COMPUTERS FOR FURTHER ANALYSIS.			A+76 1	39	
DETECTORS	(NAICR) NAI SCINTILLATION DETECTOR USED TO MEASURE			A+76 1	40	
	RESONANCE EXCITATION FUNCTION.			A+76 1	41	
	(GELI) 80-CM**3 GE(LI) DETECTOR USED TO MEASURE GAMMA-			A+76 1	42	
	RAY SPECTRA FOR THE DETERMINATION OF RESONANCE STRENGTHS			A+76 1	43	
	AND RESONANCE DECAY BRANCHING AND ANGULAR DISTRIBUTIONS.			A+76 1	44	
MONITORS	(GELI) 60-CM**3 GE(LI) DETECTOR USED DURING ANGULAR			A+76 1	45	
	DISTRIBUTION MEASUREMENTS WITH THE 80-CM**3 GE(LI)			A+76 1	46	
	DETECTOR.			A+76 1	47	
	(CI) A CURRENT INTEGRATOR WAS USED FOR NORMALIZATION OF			A+76 1	48	
	THE RESONANCE EXCITATION FUNCTION DATA.			A+76 1	49	
ERR-ANALYS	THE ESTIMATED ERRORS WERE BASED ON A CONSIDERATION OF			A+76 1	50	
	STATISTICS AND REPRODUCIBILITY. SYSTEMATIC ERRORS IN			A+76 1	51	
	THE ABSOLUTE RESONANCE STRENGTH MEASUREMENTS WERE			A+76 1	52	
	ESTIMATED BY COMPARING RESULTS FROM THE AG ² S, CDS AND			A+76 1	53	
	ZNS TARGETS.			A+76 1	54	
COMMENT	THIS EXPERIMENT WAS UNDERTAKEN TO IMPROVE AN EARLIER			A+76 1	55	
	INVESTIGATION FROM THIS GROUP. REFERENCES TO PAPERS ON			A+76 1	56	
	THIS EARLIER WORK SHOULD BE EXAMINED FOR A BETTER			A+76 1	57	
	UNDERSTANDING OF DETAILS OF THE MEASUREMENT AND			A+76 1	58	
	DATA ANALYSIS PROCEDURES.			A+76 1	59	
STATUS	RESULTS PUBLISHED IN NUCLEAR PHYSICS A (IN FRENCH).			A+76 1	60	
ENDBIB	58			A+76 1	61	
ENDSUBENT	1			A+76 199999		
SUBENTRY	A+76 2	0		A+76 2	1	
BIB	2	10		A+76 2	2	
REACTION	³² S(P,GAMMA) ³³ Cl			A+76 2	3	
COMMENT	ABSOLUTE RESONANCE STRENGTH VALUES OBTAINED FROM TABLE			A+76 2	4	
	1 OF THE PAPER. EP = RESONANCE ENERGY. ERR-EP = ERROR IN			A+76 2	5	
	RESONANCE ENERGY. EX = EXCITATION ENERGY IN ³³ Cl.			A+76 2	6	
	ERR-EX = ERROR IN EXCITATION ENERGY IN ³³ Cl.			A+76 2	7	
	STRENG = ABSOLUTE RESONANCE STRENGTH. ERR-STRENG =			A+76 2	8	
	ERROR IN ABSOLUTE RESONANCE STRENGTH. RESONANCE			A+76 2	9	
	STRENGTH IS DEFINED IN THE HEADING OF THIS TABLE.			A+76 2	10	
	VALUES GIVEN ARE DERIVED FROM MEASUREMENTS WITH TARGETS			A+76 2	11	
	MADE USING THREE SULPHUR COMPOUNDS (AG ² S, CDS AND ZNS).			A+76 2	12	
ENDBIB	10			A+76 2	13	
DATA	6	14		A+76 2	14	
EP	ERR-EP	EX	ERR-EX	STRENG	ERR-STRENG	A+76 2
KEV	KEV	KEV	KEV	EV	EV	A+76 2
421.8	0.6	2865.5	0.4	9.0000E-05	4.0000E-05	A+76 2
579.8	0.6	2838.7	0.8	0.08	0.01	A+76 2
587.9	0.5	2846.6	0.7	0.21	0.03	A+76 2
720.7	0.6	2975.4	0.3	1.4000E-04	0.6000E-04	A+76 2
1587.8	1.1	3816.2	1.2	0.053	0.007	A+76 2

1748.4	1.0	3971.5	1.1	0.09	0.02	A+76 2	22
1757.2	0.9	3980.4	1.0	0.38	0.04	A+76 2	23
1879.7	1.1	4099.2	1.2	0.019	0.008	A+76 2	24
1893.8	1.1	4112.9	1.2	0.07	0.02	A+76 2	25
1898.0	2.0	4117.0	2.0	0.19	0.07	A+76 2	26
2229.4	1.3	4438.3	1.4	0.30	0.04	A+76 2	27
2255.4	1.3	4463.6	1.8	0.14	0.02	A+76 2	28
2547.2	1.5	4746.5	1.5	1.4	0.2	A+76 2	29
2577.0	3.0	4775.0	3.0	0.093	0.019	A+76 2	30
ENDDATA		16				A+76 2	31
ENDSUBENT		2				A+76 299999	
SUBENTRY	A+76	3	0			A+76 3	1
BIB		2	9			A+76 3	2
REACTION	32S(P,GAMMA)33CL					A+76 3	3
COMMENT	THE ENERGIES OF LOW-LYING (< 4 MEV) EXCITED LEVELS IN 33CL WERE DEDUCED IN THE PRESENT WORK AS A CONSEQUENCE OF MEASURING THE RESONANCE EXCITATION FUNCTION AND OF DETERMINING RESONANCE LIFETIMES BY THE DOPPLER-SHIFT ATTENUATION METHOD AS APPLIED TO GAMMA RAYS WHICH DE-EXCITE THE RESONANCE STATES. EX = EXCITATION ENERGY IN 33CL. ERR-EX = ERROR IN EXCITATION ENERGY IN 33CL. VALUES OBTAINED FROM TABLE 2 OF PAPER.					A+76 3	4
						A+76 3	5
						A+76 3	6
						A+76 3	7
						A+76 3	8
						A+76 3	9
						A+76 3	10
						A+76 3	11
ENDBIB		9				A+76 3	12
DATA		2	8			A+76 3	13
EX	ERR-EX					A+76 3	14
KEV	KEV					A+76 3	15
810.7	0.3					A+76 3	16
1986.5	0.4					A+76 3	17
2351.8	0.3					A+76 3	18
2685.5	0.4					A+76 3	19
2839.0	0.3					A+76 3	20
2846.3	0.3					A+76 3	21
2975.4	0.3					A+76 3	22
3816.1	0.3					A+76 3	23
ENDDATA		10				A+76 3	24
ENDSUBENT		3				A+76 399999	
SUBENTRY	A+76	4	0			A+76 4	1
BIB		2	11			A+76 4	2
REACTION	32S(P,GAMMA)33CL					A+76 4	3
COMMENT	MEAN LIFETIMES OF 33CL STATES DETERMINED BY DOPPLER-SHIFT ATTENUATION METHOD. EX = 33CL LEVEL EXCITATION ENERGY. EI = INITIAL 33CL LEVEL FOR GAMMA-RAY TRANSITION. EF = FINAL 33CL LEVEL FOR GAMMA-RAY TRANSITION. EP = ENERGY OF RESONANCE WHERE LIFETIME MEASUREMENT WAS PERFORMED. TAU = MEAN LIFETIME OF 33CL LEVEL. ERR-TAU = ERROR IN MEAN LIFETIME OF 33CL LEVEL. MEASUREMENTS INDICATE THAT MEAN LIFETIME OF THE 2846-KEV LEVEL IN 33CL IS < 1 FS. VALUE IS NOT INCLUDED IN THE DATA BLOCK BELOW. VALUES FROM TABLE 3 OF THE PAPER.					A+76 4	4
						A+76 4	5
						A+76 4	6
						A+76 4	7
						A+76 4	8
						A+76 4	9
						A+76 4	10
						A+76 4	11
						A+76 4	12
						A+76 4	13
ENDBIB		11				A+76 4	14
DATA		6	7			A+76 4	15
EX	EI	EF	EP	TAU	ERR-TAU	A+76 4	16
KEV	KEV	KEV	KEV	FS	FS	A+76 4	17
1986.	1986.	0.	1588.	62.	6.	A+76 4	18
1986.	1986.	0.	2547.	58.	8.	A+76 4	19
2352.	2352.	811.	1588.	110.	10.	A+76 4	20
2352.	2352.	811.	2547.	77.	13.	A+76 4	21
2839.	2839.	0.	580.	4.4	1.5	A+76 4	22
2975.	2975.	0.	1588.	98.	13.	A+76 4	23
2975.	2975.	0.	2547.	82.	8.	A+76 4	24
ENDDATA		9				A+76 4	25
ENDSUBENT		4				A+76 499999	
SUBENTRY	A+76	5	0			A+76 5	1
BIB		2	11			A+76 5	2
REACTION	32S(P,GAMMA)33CL					A+76 5	3
COMMENT	ANGULAR DISTRIBUTION COEFFICIENTS FOR THE GAMMA-RAY TRANSITIONS THAT DE-EXCITE THE SELECTED RESONANCE STATE OF 33CL. THESE ARE COEFFICIENTS A2 AND A4 OF A LEGENDRE					A+76 5	4
						A+76 5	5
						A+76 5	6

						POLYNOMIAL EXPANSION. VALUES FROM TABLE 4 OF THE PAPER.	A+76 5	7	
						COMMON RESONANCE PROTON ENERGY EP IS INDICATED. EI =	A+76 5	8	
						INITIAL 33CL LEVEL FOR GAMMA-RAY TRANSITION. EF =	A+76 5	9	
						FINAL 33CL LEVEL FOR GAMMA-RAY TRANSITION. A2 =	A+76 5	10	
						COEFFICIENT OF P2 TERM IN LEGENDRE EXPANSION. ERR-A2 =	A+76 5	11	
						ERROR IN A2. A4 = COEFFICIENT OF P4 TERM IN LEGENDRE	A+76 5	12	
						EXPANSION. ERR-A4 = ERROR IN A4.	A+76 5	13	
ENDBIB						11	A+76 5	14	
COMMON						1 3	A+76 5	15	
EP							A+76 5	16	
KEY							A+76 5	17	
1588.							A+76 5	18	
ENDCOMMON						1 3	A+76 5	19	
DATA						6 8	A+76 5	20	
EI	EF	A2	ERR-A2	A4	ERR-A4		A+76 5	21	
KEY	KEY	NO-DIM	NO-DIM	NO-DIM	NO-DIM		A+76 5	22	
3816.	0.	-0.58	0.05	0.49	0.05		A+76 5	23	
3816.	1986.	0.18	0.02	0.03	0.04		A+76 5	24	
3816.	2352.	0.01	0.11	-0.03	0.08		A+76 5	25	
3816.	2839.	0.70	0.05	0.02	0.04		A+76 5	26	
1986.	0.	0.35	0.04	-0.06	0.03		A+76 5	27	
2352.	811.	0.19	0.05	0.05	0.04		A+76 5	28	
2352.	0.	-0.43	0.03	-0.02	0.03		A+76 5	29	
2975.	0.	0.23	0.10	-0.11	0.10		A+76 5	30	
ENDDATA						10	A+76 5	31	
ENDSUBENT						5	A+76	599999	
SUBENTRY	A+76	6	0				A+76 6	1	
BIB		2	11				A+76 6	2	
REACTION	32S(P,GAMMA)33CL							A+76 6	3
COMMENT	ANGULAR DISTRIBUTION COEFFICIENTS FOR THE GAMMA-RAY							A+76 6	4
	TRANSITIONS THAT DE-EXCITE THE SELECTED RESONANCE STATE							A+76 6	5
	OF 33CL. THESE ARE COEFFICIENTS A2 AND A4 OF A LEGENDRE							A+76 6	6
	POLYNOMIAL EXPANSION. VALUES FROM TABLE 4 OF THE PAPER.							A+76 6	7
	COMMON RESONANCE PROTON ENERGY EP IS INDICATED. EI =							A+76 6	8
	INITIAL 33CL LEVEL FOR GAMMA-RAY TRANSITION. EF =							A+76 6	9
	FINAL 33CL LEVEL FOR GAMMA-RAY TRANSITION. A2 =							A+76 6	10
	COEFFICIENT OF P2 TERM IN LEGENDRE EXPANSION. ERR-A2 =							A+76 6	11
	ERROR IN A2. A4 = COEFFICIENT OF P4 TERM IN LEGENDRE							A+76 6	12
	EXPANSION. ERR-A4 = ERROR IN A4.							A+76 6	13
ENDBIB						11	A+76 6	14	
COMMON						1 3	A+76 6	15	
EP							A+76 6	16	
KEY							A+76 6	17	
1748.							A+76 6	18	
ENDCOMMON						1 3	A+76 6	19	
DATA						6 2	A+76 6	20	
EI	EF	A2	ERR-A2	A4	ERR-A4		A+76 6	21	
KEY	KEY	NO-DIM	NO-DIM	NO-DIM	NO-DIM		A+76 6	22	
3972.	0.	0.84	0.08	0.05	0.05		A+76 6	23	
3972.	811.	-0.49	0.03	0.09	0.03		A+76 6	24	
ENDDATA						4	A+76 6	25	
ENDSUBENT						6	A+76	699999	
SUBENTRY	A+76	7	0				A+76 7	1	
BIB		2	11				A+76 7	2	
REACTION	32S(P,GAMMA)33CL							A+76 7	3
COMMENT	ANGULAR DISTRIBUTION COEFFICIENTS FOR THE GAMMA-RAY							A+76 7	4
	TRANSITIONS THAT DE-EXCITE THE SELECTED RESONANCE STATE							A+76 7	5
	OF 33CL. THESE ARE COEFFICIENTS A2 AND A4 OF A LEGENDRE							A+76 7	6
	POLYNOMIAL EXPANSION. VALUES FROM TABLE 4 OF THE PAPER.							A+76 7	7
	COMMON RESONANCE PROTON ENERGY EP IS INDICATED. EI =							A+76 7	8
	INITIAL 33CL LEVEL FOR GAMMA-RAY TRANSITION. EF =							A+76 7	9
	FINAL 33CL LEVEL FOR GAMMA-RAY TRANSITION. A2 =							A+76 7	10
	COEFFICIENT OF P2 TERM IN LEGENDRE EXPANSION. ERR-A2 =							A+76 7	11
	ERROR IN A2. A4 = COEFFICIENT OF P4 TERM IN LEGENDRE							A+76 7	12
	EXPANSION. ERR-A4 = ERROR IN A4.							A+76 7	13
ENDBIB						11	A+76 7	14	
COMMON						1 3	A+76 7	15	
EP							A+76 7	16	

KEV						A+76 7	17
1757.						A+76 7	18
ENDCOMMON		1	3			A+76 7	19
DATA		6	4			A+76 7	20
EI	EF	A2	ERR-A2	A4	ERR-A4	A+76 7	21
KEV	KEV	NO-DIM	NO-DIM	NO-DIM	NO-DIM	A+76 7	22
3980.	0.	-0.42	0.02	0.03	0.02	A+76 7	23
3980.	2685.	-0.49	0.06	0.04	0.06	A+76 7	24
3980.	2839.	0.40	0.15	-0.04	0.13	A+76 7	25
3980.	2846.	-0.75	0.08	0.04	0.09	A+76 7	26
ENDDATA		6				A+76 7	27
ENDSUBENT		7				A+76	799999
SUBENTRY	A+76	8	0			A+76 8	1
BIB		2	11			A+76 8	2
REACTION	32S(P,GAMMA)33CL					A+76 8	3
COMMENT	ANGULAR DISTRIBUTION COEFFICIENTS FOR THE GAMMA-RAY TRANSITIONS THAT DE-EXCITE THE SELECTED RESONANCE STATE OF 33CL. THESE ARE COEFFICIENTS A2 AND A4 OF A LEGENDRE POLYNOMIAL EXPANSION. VALUES FROM TABLE 4 OF THE PAPER. COMMON RESONANCE PROTON ENERGY EP IS INDICATED. EI = INITIAL 33CL LEVEL FOR GAMMA-RAY TRANSITION. EF = FINAL 33CL LEVEL FOR GAMMA-RAY TRANSITION. A2 = COEFFICIENT OF P2 TERM IN LEGENDRE EXPANSION. ERR-A2 = ERROR IN A2. A4 = COEFFICIENT OF P4 TERM IN LEGENDRE EXPANSION. ERR-A4 = ERROR IN A4.					A+76 8	4
						A+76 8	5
						A+76 8	6
						A+76 8	7
						A+76 8	8
						A+76 8	9
						A+76 8	10
						A+76 8	11
						A+76 8	12
						A+76 8	13
ENDBIB		11				A+76 8	14
COMMON		1	3			A+76 8	15
EP						A+76 8	16
KEV						A+76 8	17
2577.						A+76 8	18
ENDCOMMON		1	3			A+76 8	19
DATA		6	5			A+76 8	20
EI	EF	A2	ERR-A2	A4	ERR-A4	A+76 8	21
KEV	KEV	NO-DIM	NO-DIM	NO-DIM	NO-DIM	A+76 8	22
4775.	2685.	0.09	0.03	0.06	0.05	A+76 8	23
4775.	2839.	-0.39	0.03	0.06	0.05	A+76 8	24
4775.	2846	0.14	0.10	-0.11	0.11	A+76 8	25
2839.	0.	-0.51	0.04	0.02	0.04	A+76 8	26
1986.	0.	0.49	0.16	0.29	0.17	A+76 8	27
ENDDATA		7				A+76 8	28
ENDSUBENT		8				A+76	899999
SUBENTRY	A+76	9	0			A+76 9	1
BIB		2	19			A+76 9	2
REACTION	32S(P,GAMMA)33CL					A+76 9	3
COMMENT	MULTIPOLE MIXING RATIOS DEDUCED FOR OBSERVED GAMMA-RAY TRANSITIONS. EI = INITIAL 33CL LEVEL FOR GAMMA-RAY TRANSITION. EF = FINAL 33CL LEVEL FOR GAMMA-RAY TRANSITION. JIPI = ASSUMED SPIN/PARITY OF INITIAL 33CL LEVEL. JFPI = ASSUMED SPIN/PARITY OF FINAL 33CL LEVEL. POSITIVE VALUE INDICATES POSITIVE PARITY AND NEGATIVE VALUE INDICATES NEGATIVE PARITY. DELTA = MULTIPOLE MIXING RATIO. ERR-DELTA = ERROR IN MULTIPOLE MIXING RATIO. IDENT = IDENTIFICATION OF DATA ENTRY AS DEFINED IN COMMON BLOCK. MULT1 = FIRST MULTIPOLARITY. MULT2 = SECOND MULTIPOLARITY. SOMETIMES ONLY ONE MULTIPOLARITY (MULT1) APPEARS. WHEN MORE THAN ONE ENTRY APPEARS FOR THE SAME TRANSITION, THIS REFLECTS UNCERTAINTY IN THE SPIN/PARITY ASSIGNMENTS. IN SOME CASES MORE THAN ONE VALUE OF MIXING RATIO IS GIVEN FOR THE SAME TRANSITION AND ASSUMED SPIN/PARITY ASSIGNMENTS. INFORMATION FROM TABLE 6 OF THE PAPER.					A+76 9	4
						A+76 9	5
						A+76 9	6
						A+76 9	7
						A+76 9	8
						A+76 9	9
						A+76 9	10
						A+76 9	11
						A+76 9	12
						A+76 9	13
						A+76 9	14
						A+76 9	15
						A+76 9	16
						A+76 9	17
						A+76 9	18
						A+76 9	19
						A+76 9	20
						A+76 9	21
ENDBIB		19				A+76 9	22
COMMON		6	31			A+76 9	23
IDENT	EI	EF	JIPI	JFPI		A+76 9	24
NO-DIM	KEV	KEV	NO-DIM	NO-DIM	MULT1,MULT2	A+76 9	25
	1 1986.	0.	2.5	1.5	M1,E2	A+76 9	26
	2 1986.	0.	2.5	1.5	M1,E2	A+76 9	27

3	2352.	0.	1.5	1.5	M1,E2	A+76 9	28
4	2352.	811.	1.5	0.5	M1,E2	A+76 9	29
5	2685.	1986.	-2.5	2.5	E1	A+76 9	30
6	2685.	1986.	-3.5	2.5	E1	A+76 9	31
7	2839.	0.	2.5	1.5	M1,E2	A+76 9	32
8	2975.	0.	3.5	1.5	E2	A+76 9	33
9	3816.	0.	2.5	1.5	M1,E2	A+76 9	34
10	3816.	1986.	2.5	2.5	M1,E2	A+76 9	35
11	3816.	2352.	2.5	1.5	M1,E2	A+76 9	36
12	3816.	2839.	2.5	2.5	M1,E2	A+76 9	37
13	3972.	0.	1.5	1.5	M1,E2	A+76 9	38
14	3972.	811.	1.5	0.5	M1	A+76 9	39
15	3972.	811.	1.5	0.5	M1,E2	A+76 9	40
16	3980.	0.	-2.5	1.5	E1	A+76 9	41
17	3980.	2685.	-2.5	-2.5	M1,E2	A+76 9	42
18	3980.	2685.	-2.5	-3.5	M1,E2	A+76 9	43
19	3980.	2685.	-2.5	-3.5	M1,E2	A+76 9	44
20	3980.	2839.	-2.5	2.5	E1	A+76 9	45
21	3980.	2846.	-2.5	-1.5	M1,E2	A+76 9	46
22	3980.	2846.	-2.5	-1.5	M1,E2	A+76 9	47
23	4117.	0.	-1.5	1.5	E1	A+76 9	48
24	4117.	811.	-1.5	0.5	E1	A+76 9	49
25	4117.	2846.	-1.5	-1.5	M1	A+76 9	50
26	4775.	2685.	-3.5	-2.5	M1,E2	A+76 9	51
27	4775.	2685.	-3.5	-3.5	M1,E2	A+76 9	52
28	4775.	2839.	-3.5	2.5	E1,M2	A+76 9	53
29	4775.	2846.	-3.5	-1.5	E2	A+76 9	54
ENDCOMMON		6		31		A+76 9	55
DATA		3		29		A+76 9	56
IDENT	DELTA		ERR-DELTA			A+76 9	57
NO-DIM	NO-DIM		NO-DIM			A+76 9	58
	1 -4.		1.			A+76 9	59
	2 -0.53		0.06			A+76 9	60
	3 1.3		0.4			A+76 9	61
	4 -0.44		0.04			A+76 9	62
	5 0.0		0.5			A+76 9	63
	6 0.0		0.6			A+76 9	64
	7 0.10		0.02			A+76 9	65
	8 0.09		0.09			A+76 9	66
	9 2.5		0.3			A+76 9	67
	10 0.22		0.03			A+76 9	68
	11 -0.17		0.04			A+76 9	69
	12 -0.47		0.16			A+76 9	70
	13 -0.8		0.5			A+76 9	71
	14 0.00		0.02			A+76 9	72
	15 1.73		0.07			A+76 9	73
	16 0.01		0.02			A+76 9	74
	17 0.9		0.3			A+76 9	75
	18 -7.		2.			A+76 9	76
	19 -0.25		0.06			A+76 9	77
	20 0.03		0.15			A+76 9	78
	21 0.23		0.08			A+76 9	79
	22 1.3		0.4			A+76 9	80
	23 0.					A+76 9	81
	24 0.					A+76 9	82
	25 0.					A+76 9	83
	26 -0.21		0.04			A+76 9	84
	27 0.32		0.04			A+76 9	85
	28 0.02		0.02			A+76 9	86
	29 0.					A+76 9	87
ENDDATA		31				A+76 9	88
ENDSUBENT		9				A+76 999999	
SUBENTRY	A+76 10		0			A+7610	1
BIB	2		19			A+7610	2
REACTION	32S(P,GAMMA)33CL					A+7610	3
COMMENT	REDUCED MATRIX ELEMENTS DEDUCED FOR OBSERVED GAMMA-					A+7610	4
	RAY TRANSITIONS. EI = INITIAL 33CL LEVEL FOR GAMMA-					A+7610	5
	RAY TRANSITION. EF = FINAL 33CL LEVEL FOR GAMMA-RAY					A+7610	6

TRANSITION. JIPI = ASSUMED SPIN/PARITY OF INITIAL 33CL LEVEL. JFPI = ASSUMED SPIN/PARITY OF FINAL 33CL LEVEL. POSITIVE VALUE INDICATES POSITIVE PARITY AND NEGATIVE VALUE INDICATES NEGATIVE PARITY. MULT1 = FIRST MULTIPOLARITY. MULT2 = SECOND MULTIPOLARITY. ME1 = REDUCED MATRIX ELEMENT FOR MULT1. ERR-ME1 = ERROR IN ME1. ME2 = REDUCED MATRIX ELEMENT FOR MULT2. ERR-ME2 = ERROR IN ME2. IDENT = DATA ENTRY IDENTIFICATION FOR DATA ENTRY AS DEFINED IN COMMON BLOCK. SOMETIMES ONLY ONE MULTIPOLARITY (MULT1) APPEARS. WHEN MORE THAN ONE ENTRY APPEARS FOR THE SAME TRANSITION THIS REFLECTS UNCERTAINTY IN THE ASSUMED SPIN/PARITY ASSIGNMENTS. INFORMATION FROM TABLE 6 OF THE PAPER. NOTE INEQUALITY SIGNS FOR MATRIX ELEMENTS WITH IDENT = 9-13, 16-22 AND 28.

ENDBIB	COMMON	IDENT	NO-DIM	E1	EF	JIPI	JFPI	MULT1,MULT2	
									A+7610 7
									A+7610 8
									A+7610 9
									A+7610 10
									A+7610 11
									A+7610 12
									A+7610 13
									A+7610 14
									A+7610 15
									A+7610 16
									A+7610 17
									A+7610 18
									A+7610 19
									A+7610 20
									A+7610 21
									A+7610 22
									A+7610 23
									A+7610 24
									A+7610 25
									A+7610 26
									A+7610 27
									A+7610 28
									A+7610 29
									A+7610 30
									A+7610 31
									A+7610 32
									A+7610 33
									A+7610 34
									A+7610 35
									A+7610 36
									A+7610 37
									A+7610 38
									A+7610 39
									A+7610 40
									A+7610 41
									A+7610 42
									A+7610 43
									A+7610 44
									A+7610 45
									A+7610 46
									A+7610 47
									A+7610 48
									A+7610 49
									A+7610 50
									A+7610 51
									A+7610 52
									A+7610 53
									A+7610 54
									A+7610 55
									A+7610 56
									A+7610 57
									A+7610 58
									A+7610 59
									A+7610 60
									A+7610 61
									A+7610 62
									A+7610 63
									A+7610 64
									A+7610 65
									A+7610 66
									A+7610 67
									A+7610 68
									A+7610 69
									A+7610 70
									A+7610 71
									A+7610 72
									A+7610 73
									A+7610 74

ENDBIB	COMMON	IDENT	NO-DIM	ME1	ERR-ME1	ME2	ERR-ME2	
								A+7610 57
								A+7610 58
								A+7610 59
								A+7610 60
								A+7610 61
								A+7610 62
								A+7610 63
								A+7610 64
								A+7610 65
								A+7610 66
								A+7610 67
								A+7610 68
								A+7610 69
								A+7610 70
								A+7610 71
								A+7610 72
								A+7610 73
								A+7610 74

17	1.7000E-02		36.		A+7610	75
18	6.0000E-04		72.		A+7610	76
19	3.0000E-02		4.		A+7610	77
20	7.2000E-03				A+7610	78
21	4.7000E-02		6.		A+7610	79
22	1.8000E-02		90.		A+7610	80
23	2.9000E-04	1.1000E-04			A+7610	81
24	8.0000E-04	3.0000E-04			A+7610	82
25	0.11	0.07			A+7610	83
26	2.5000E-02	0.6000E-02	1.0	0.4	A+7610	84
27	2.4000E-02	0.6000E-02	2.1	0.7	A+7610	85
28	1.2000E-03	0.3000E-03	2.3		A+7610	86
29	8.	2.			A+7610	87
ENDDATA		31			A+7610	88
ENDSUBENT		10			A+761099999	
ENDENTRY		10			A+769999999	

EE66

ENTRY	EE66	0			EE66 0	1
SUBENT	EE66 1	0			EE66 1	1
BIB	13	39			EE66 1	2
INSTITUTE	(NEDUTR)				EE66 1	3
REFERENCE	(J,NP,88,12,1966)				EE66 1	4
AUTHORS	(G.A.P.ENGELBERTINK,P.M.ENDT)				EE66 1	5
TITLE	MEASUREMENTS OF (P,GAMMA) RESONANCE STRENGTHS IN THE S-D SHELL.				EE66 1	6
FACILITIES	(VDG) 3-MV VAN DE GRAAFF ACCELERATOR.				EE66 1	7
	(C-W) 850-KV COCKCROFT-WALTON GENERATOR.				EE66 1	8
	FYSISCH LAB., UTRECHT, RIIKSUNIVERSITEIT, NETHERLANDS.				EE66 1	9
INC-PART	(P) PROTONS.				EE66 1	10
TARGETS	THE FOLLOWING SULPHUR-BEARING COMPOUNDS WERE USED: NA2S2O7, MGSO4, P4S6, ZNS, K2SO4 AND CASO4. MATERIALS CONTAINED ELEMENTS WITH NATURAL ISOTOPIC ABUNDANCES. THESE TARGETS WERE PREPARED BY VACUUM EVAPORATION ONTO 0.3-MM TANTALUM BACKINGS. MATERIALS WERE SELECTED THAT WOULD NOT DECOMPOSE DURING THE EVAPORATION PROCESS.				EE66 1	11
					EE66 1	12
					EE66 1	13
					EE66 1	14
					EE66 1	15
					EE66 1	16
					EE66 1	17
METHOD	RELATIVE STRENGTH DETERMINATIONSS MADE BY COMPARISON OF THICK-TARGET YIELD MEASUREMENTS USING TARGETS OF VARIOUS CHEMICAL COMPOUNDS. USE OF A VARIETY OF TARGET MATERIALS AVOIDED SYSTEMATIC ERRORS DUE TO TARGET STOICHIOMETRY UNCERTAINTY. TARGETS WERE WATER COOLED TO MINIMIZE DETERIORATION. PROTON CHARGE MEASURED WITH A CURRENT INTEGRATOR. NEGATIVELY BIASED SUPPRESSOR RING PREVENTED LOSSES DUE TO SECONDARY ELECTRON EMISSION. RESONANCE STRENGTH RATIOS WERE MEASURED USING A NAI SCINTILLATION DETECTOR. RATIO DATA WERE NORMALIZED BY USING ABSOLUTE STRENGTH OF A 30SI(P,GAMMA)31P RESONANCE WHICH HAD BEEN DETERMINED IN AN EARLIER EXPERIMENT. RESONANCE STRENGTHS FOR 32P(P,GAMMA)33CL WERE OVER-DETERMINED. FINAL BEST VALUES DETERMINED BY A LEAST SQUARES ANALYSIS.				EE66 1	18
					EE66 1	19
					EE66 1	20
					EE66 1	21
					EE66 1	22
					EE66 1	23
					EE66 1	24
					EE66 1	25
					EE66 1	26
					EE66 1	27
					EE66 1	28
					EE66 1	29
					EE66 1	30
					EE66 1	31
					EE66 1	32
DETECTOR	(NAICR) NAI SCINTILLATION CRYSTAL DETECTOR.				EE66 1	33
MONITOR	(CI) CURRENT INTEGRATOR USED TO MEASURE PROTON CHARGE.				EE66 1	34
CORRECTION	BACKGROUND COUNTS WERE SUBTRACTED. CORRECTIONS WERE MADE FOR COINCIDENCE AND RANDOM SUMMING EFFECTS.				EE66 1	35
					EE66 1	36
ERR-ANALYS	DATA UNCERTAINTIES ARE INCLUDED FOR STRENGTH OF STANDARD RESONANCE (8.4 PERC) AND ESTIMATED ERROR FOR UNKNOWN GAMMA RAY SPECTRUM (7 PERC). TOTAL ERROR OF 15 PERC IS ASSIGNED TO THE FINAL RESULTS.				EE66 1	37
					EE66 1	38
					EE66 1	39
					EE66 1	40
STATUS	PUBLISHED IN NUCLEAR PHYSICS.				EE66 1	41

ENDBIB	39			EE66 1	42
ENDSUBENT	1			EE66 199999	
SUBENT	EE66 2	0		EE66 2	1
BIB	2	14		EE66 2	2
REACTION	32S(P,GAMMA)33CL			EE66 2	3
COMMENT	THE FOLLOWING DATA ARE RELATIVE STRENGTHS OF THE 588-KEV RESONANCE IN THE 32S(P,GAMMA)33CL REACTION TO THE STRENGTHS FOR SEVERAL OTHER RESONANCE REACTIONS. VALUES ARE EXPRESSED IN FORM INDICATED, WHERE THE SULPHUR VALUE IS IN THE DENOMINATOR. THESE MEASURED DATA ARE OBTAINED FROM TABLE 1 OF THE PAPER. RATIO = DEFINITION OF STRENGTH RATIOS. STRENGR = MEASURED STRENGTH RATIO FOR 588-KEV RESONANCE IN THE 32S(P,GAMMA)33CL REACTION. ERR-STRENGR = ERROR IN STRENGR. TARGET = TARGET MATERIAL USED IN THE RATIO MEASUREMENT. THE VALUES GIVEN ARE AVERAGE VALUES BASED ON SEVERAL MEASUREMENTS WITH DIFFERENT TARGET THICKNESSES. SEE PAPER FOR FURTHER DISCUSSION.			EE66 2	4
				EE66 2	5
				EE66 2	6
				EE66 2	7
				EE66 2	8
				EE66 2	9
				EE66 2	10
				EE66 2	11
				EE66 2	12
				EE66 2	13
				EE66 2	14
				EE66 2	15
				EE66 2	16
				EE66 2	17
ENDBIB	14			EE66 2	18
DATA	4	6		EE66 2	19
		STRENGR	STRENGR-ERR	EE66 2	20
TARGET	RATIO	NO-DIM	NO-DIM	EE66 2	21
NA2S2O7	23NA/32S	6.6	0.7	EE66 2	22
MGSO4	26MG/32S	6.6	0.7	EE66 2	23
P4S6	31P/32S	3.80	0.38	EE66 2	24
ZNS	34S/32S	150.	15.	EE66 2	25
K2SO4	39K/32S	230.	50.	EE66 2	26
CASO4	40CA/32S	2.02	0.20	EE66 2	27
ENDDATA	8			EE66 299999	
ENDSUBENT	2			EE66 3	1
SUBENT	EE66 3	0		EE66 3	2
BIB	2	4		EE66 3	3
REACTION	32S(P,GAMMA)33CL			EE66 3	4
COMMENT	STRENG = ABSOLUTE RESONANCE STRENGTH CALCULATED FROM MEASURED RELATIVE STRENGTHS. ERR-STRENG = ERROR IN STRENG. VALUE IS TAKEN FROM TABLE 2 OF PAPER.			EE66 3	5
				EE66 3	6
				EE66 3	7
				EE66 3	8
				EE66 3	9
ENDBIB	4			EE66 3	10
DATA	3	1		EE66 3	11
EP	STRENG	ERR-STRENG		EE66 3	12
KEV	KEV			EE66 399999	
588.	0.14	0.02		EE66999999	
ENDDATA	3				
ENDSUBENT	3				
ENDENTRY	3				

EIR72

ENTRY	EIR72	0		EIR72 0	1
SUBENT	EIR72 1	0		EIR72 1	1
BIB	13	53		EIR72 1	2
INSTITUTE	(INDTRM)			EIR72 1	3
REFERENCE	(J,PR/C,C5,4,1270,1972)			EIR72 1	4
AUTHORS	(M.A.ESWARAN,M.ISMAIL,N.L.RAGOOWANSI)			EIR72 1	5
TITLE	STUDIES ON ANALOG STATES IN 33CL BY ISOSPIN-FORBIDDEN RESONANCES IN THE REACTION 32S(P,GAMMA)33CL			EIR72 1	6
FACILITY	(VDG) 5-MV VAN DE GRAEFF ACCELERATOR, NUCLEAR PHYSICS DIVISION, BHABHA ATOMIC RESEARCH CENTRE, TROMBAY, BOMBAY, INDIA.			EIR72 1	7
	(P) PROTONS			EIR72 1	8
INC-PART				EIR72 1	9
TARGET	300-MICROGRAM SB2S3 ON THICK GOLD BACKING. NATURAL ISOTOPIIC ABUNDANCE. PREPARED BY VACUUM EVAPORATION.			EIR72 1	10
				EIR72 1	11
				EIR72 1	12
				EIR72 1	13

METHOD	TARGET WAS WATER COOLED.	EIR72 1	14
	(ACTIV) MEASURED RESONANCE EXCITATION FUNCTION IN	EIR72 1	15
	RANGE EP = 3.360-5.410 MEV BY DETECTING POSITRONS WITH	EIR72 1	16
	A PLASTIC SCINTILLATOR. TARGET WAS PLACED AT 45 DEG.	EIR72 1	17
	TO INCIDENT BEAM. BETA DETECTOR WAS AT 90 DEG. VAN DE	EIR72 1	18
	GRAAFF ACCELERATOR BEAM WAS MECHANICALLY CHOPPED.	EIR72 1	19
	MEASUREMENT WAS MADE IN STEPS OF 10 KEV AND THE PROTON	EIR72 1	20
	ENERGY LOSS IN TARGET WAS ABOUT 14 KEV. THIS WAS THE	EIR72 1	21
	MAJOR CONTRIBUTOR TO THE EXPERIMENTAL RESOLUTION.	EIR72 1	22
	CALIBRATED BEAM ENERGY USING $^{27}\text{Al}(p,\gamma)^{28}\text{Si}$	EIR72 1	23
	RESONANCE AT EP = 991.91 KEV. ^{33}Cl RADIOACTIVE DECAY	EIR72 1	24
	BETA EVENTS WITH ENERGY EXCEEDING 500 KEV WERE	EIR72 1	25
	RECORDED WITH A 4096-CHANNEL ANALYZER OPERATING IN	EIR72 1	26
	MULTI-SCALING MODE WITH A 40 MILLISEC. DWELL TIME.	EIR72 1	27
	BEAM CURRENT WAS TYPICALLY AROUND 2 MICROAMP. DECAY	EIR72 1	28
	CURVES WERE MEASURED AT EACH PROTON ENERGY. LOOKED	EIR72 1	29
	FOR 2.52-SEC ^{33}Cl ACTIVITY TO DISCRIMINATE AGAINST	EIR72 1	30
	BACKGROUND EVENTS. ABSOLUTE STRENGTH OF RESONANCES	EIR72 1	31
	WAS DETERMINED BY NORMALIZING TO THE $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$	EIR72 1	32
	RESONANCE AT EP = 3.371 MEV. THIS WAS MEASURED USING	EIR72 1	33
	A Ge(Li) DETECTOR WHICH VIEWED THE DECAY GAMMA RAYS	EIR72 1	34
	FROM THIS RESONANT STATE. USE WAS MADE OF STOPPING	EIR72 1	35
	POWER DATA AND THE MEASURED Ge(Li) DETECTOR EFFICIENCY	EIR72 1	36
	IN THIS ANALYSIS. GAMMA-RAY SPECTRA WERE ALSO RECORDED	EIR72 1	37
DETECTORS	AT VARIOUS OTHER PROTON ENERGIES ON AND OFF RESONANCES.	EIR72 1	38
	(SCINT) 10-CM DIA. BY 2.5-CM THICK PLASTIC SCINTILLATOR	EIR72 1	39
	MOUNTED ON XP1040 PHOTOMULTIPLIER. USED TO MEASURE	EIR72 1	40
	RESONANCE EXCITATION FUNCTION.	EIR72 1	41
	(GeLi) 30-CM**3 Ge(Li) DETECTOR. USED TO MEASURE GAMMA-	EIR72 1	42
	RAY SPECTRA AND ABSOLUTE STRENGTH OF 3.371-MEV	EIR72 1	43
	RESONANCE IN $^{32}\text{S}(p,\gamma)^{33}\text{Cl}$.	EIR72 1	44
MONITOR	(CI) CURRENT INTEGRATOR. USED TO MEASURE ACCUMULATED	EIR72 1	45
	BEAM CHARGE DURING MEASUREMENT OF RESONANCE EXCITATION	EIR72 1	46
	FUNCTION.	EIR72 1	47
CORRECTION	A CORRECTION WAS NEEDED TO ACCOUNT FOR THE > 88%	EIR72 1	48
	DECAY BRANCH OF THE 810-KEV GAMMA RAY ASSOCIATED WITH	EIR72 1	49
	THE DECAY OF THE 3.371-MEV RESONANCE.	EIR72 1	50
ERR-ANALYS	UNCERTAINTIES ARE GIVEN IN EACH OF THE TABLES WHERE	EIR72 1	51
	DATA WERE FOUND, BUT NO EXPLANATIONS OF HOW THESE	EIR72 1	52
	ERROR ANALYSES WERE PERFORMED ARE GIVEN.	EIR72 1	53
STATUS	DATA PUBLISHED IN PHYSICAL REVIEW C. THIS SUPERSEDES	EIR72 1	54
	ALL EARLIER REPORTS FROM THIS LABORATORY.	EIR72 1	55
ENDBIB	53	EIR72 1	56
ENDSUBENT	1	EIR72 199999	
SUBENT	EIR72 2 0	EIR72 2	1
BIB	2 9	EIR72 2	2
REACTION	$^{32}\text{S}(p,\gamma)^{33}\text{Cl}$	EIR72 2	3
COMMENT	DATA FROM TABLE I OF PAPER. RESONANCES IN THE REACTION	EIR72 2	4
	$^{32}\text{S}(p,\gamma)^{33}\text{Cl}$ WERE IDENTIFIED. EP = RESONANCE	EIR72 2	5
	INCIDENT LAB. PROTON ENERGY. ERR-EP = ERROR IN EP. EX	EIR72 2	6
	= ^{33}Cl LEVEL EXCITATION ENERGY. ERR-EX = ERROR IN EX.	EIR72 2	7
	GAMMA = TOTAL WIDTH OF RESONANCE. NO ERROR IS GIVEN	EIR72 2	8
	FOR GAMMA. NOTE THAT VALUES GIVEN FOR GAMMA FOR THE	EIR72 2	9
	RESONANCES AT EP = 3.371, 4.045, 4.102, 5.282 AND	EIR72 2	10
	5.373 MEV ARE UPPER LIMITS.	EIR72 2	11
ENDBIB	9	EIR72 2	12
DATA	5 16	EIR72 2	13
EP	ERR-EP EX ERR-EX GAMMA	EIR72 2	14
MEV	KEV MEV KEV KEV	EIR72 2	15
3.371	5. 5.550 7. 2.	EIR72 2	16
3.525	9. 5.699 10.	EIR72 2	17
3.716	9. 5.884 10. 15.	EIR72 2	18
3.987	9. 6.147 10. 13.	EIR72 2	19
4.045	6. 6.203 8. 10.	EIR72 2	20
4.102	6. 6.259 8. 6.	EIR72 2	21
4.158	9. 6.313 10.	EIR72 2	22
4.489	9. 6.634 10. 33.	EIR72 2	23
4.534	9. 6.678 10.	EIR72 2	24

4.723	9.	6.861	10.		EIR72 2	25
4.808	9.	6.943	10.		EIR72 2	26
4.856	9.	6.990	10.		EIR72 2	27
5.161	9.	7.286	10.	29.	EIR72 2	28
5.226	9.	7.349	10.		EIR72 2	29
5.282	6.	7.402	8.	2.	EIR72 2	30
5.373	6.	7.491	8.	8.	EIR72 2	31
ENDDATA		18			EIR72 2	32
ENDSUBENT		2			EIR72	299999
SUBENT	EIR72	3	0		EIR72 3	1
BIB		2	9		EIR72 3	2
REACTION	32S(P,GAMMA)33CL				EIR72 3	3
COMMENT	DATA TAKEN FROM TABLE II OF THE PAPER. ENERGIES AND ABSOLUTE RESONANCE STRENGTHS OF T = 3/2 STATES IN 33CL FROM THE 32S(P,GAMMA)33CL REACTION ARE GIVEN. EP = RESONANCE LAB. INCIDENT PROTON ENERGY. ERR-EP = ERROR IN EP. STRENG = ABSOLUTE RESONANCE STRENGTH AS DEFINED IN THE PAPER. ERR-STRENG = ERROR IN STRENG. NOTE THAT VALUE OF STRENG FOR EP = 4856 KEV IS AN UPPER LIMIT.				EIR72 3	4
					EIR72 3	5
					EIR72 3	6
					EIR72 3	7
					EIR72 3	8
					EIR72 3	9
					EIR72 3	10
					EIR72 3	11
ENDBIB		9			EIR72 3	12
DATA		4	3		EIR72 3	13
EP	ERR-EP	STRENG	ERR-STRENG		EIR72 3	14
KEV	KEV	EV	EV		EIR72 3	15
3371.	5.	0.76	0.18		EIR72 3	16
4856.	9.	0.29			EIR72 3	17
5282.	6.	1.50	0.37		EIR72 3	18
ENDDATA		5			EIR72 3	19
ENDSUBENT		3			EIR72	399999
SUBENT	EIR72	4	0		EIR72 4	1
BIB		2	11		EIR72 4	2
REACTION	32S(P,GAMMA)33CL				EIR72 4	3
COMMENT	GAMMA-RAY WIDTHS FOR THE M1 DECAYS OF THE 1/2+,3/2 LEVELS OF 33CL. VALUES FROM TABLE III OF PAPER. EI = ENERGY OF INITIAL LEVEL OF GAMMA-RAY TRANSITION. EF = ENERGY OF FINAL LEVEL OF GAMMA-RAY TRANSITION. BRANCH = BRANCHING RATIO FOR THIS TRANSITION. NOTE THAT FOR THE 5.550 TO 0.810 TRANSITION BRANCH IS A LOWER BOUND WHILE FOR THE 5.550 TO 0.0 TRANSITION BRANCH IS AN UPPER BOUND. GAMMAM1 = M1 GAMMA-RAY WIDTH, ERR-GAMMAM1 = ERROR IN GAMMAM1. GAMMAM1 FOR THE 5.550 TO 0.0 TRANSITION IS AN UPPER BOUND.				EIR72 4	4
					EIR72 4	5
					EIR72 4	6
					EIR72 4	7
					EIR72 4	8
					EIR72 4	9
					EIR72 4	10
					EIR72 4	11
					EIR72 4	12
					EIR72 4	13
ENDBIB		11			EIR72 4	14
DATA		5	2		EIR72 4	15
EI	EF	BRANCH	GAMMAM1	ERR-GAMMAM1	EIR72 4	16
MEV	MEV	PERCENT	EV	EV	EIR72 4	17
5.550	0.810	88.	0.34	0.09	EIR72 4	18
5.550	0.	12.	0.05		EIR72 4	19
ENDDATA		4			EIR72 4	20
ENDSUBENT		4			EIR72	499999
SUBENT	EIR72	5	0		EIR72 5	1
BIB		2	9		EIR72 5	2
REACTION	32S(P,GAMMA)33CL				EIR72 5	3
COMMENT	M1 AND E2 STRENGTHS FOR DECAY TRANSITIONS ARE OBTAINED FROM TABLE IV OF THE PAPER. EI = ENERGY OF INITIAL LEVEL OF GAMMA-RAY TRANSITION. EF = ENERGY OF FINAL LEVEL OF GAMMA-RAY TRANSITION. MULT = CHOICE(S) FOR TRANSITION MULTIPOLARITY. STRNGM1 = M1 TRANSITION STRENGTH. ERR-STRNGM1 = ERROR IN STRNGM1. NOTE THAT VALUE OF STRNGM1 FOR 5.550 TO 0.0 TRANSITION IS AN UPPER BOUND.				EIR72 5	4
					EIR72 5	5
					EIR72 5	6
					EIR72 5	7
					EIR72 5	8
					EIR72 5	9
					EIR72 5	10
					EIR72 5	11
					EIR72 5	12
ENDBIB		9			EIR72 5	13
DATA		5	2		EIR72 5	14
EI	EF	MULT	STRNGM1	ERR-STRNGM1	EIR72 5	15
MEV	MEV	W.U.	W.U.		EIR72 5	16
5.550	0.810	M1	0.15	0.04	EIR72 5	17
5.550	0.	M1,E2	0.014		EIR72 5	17
ENDDATA		4			EIR72 5	18

ENDSUBENT 5
 ENDBENTRY 5

EIR72 599999
 EIR72999999

I+92

ENTRY	I+92	0	I+92	0	1
SUBENT	I+92	1	0	I+92	1
BIB	13	41	I+92	1	2
INSTITUTE	(USACAL)		I+92	1	3
REFERENCE	(J,NP/A,A539,97,1992)		I+92	1	4
AUTHORS	(C.ILIADIS,U.GIESEN,J.GORRES,M.WIESCHER,S.M.GRAFF, R.E.AZUMA,C.A.BARNES)		I+92	1	5
TITLE	DIRECT PROTON CAPTURE ON 32S		I+92	1	7
FACILITY	3-MV PELLETRON TANDEM ACCELERATOR, KELLOGG RADIATION LABORATORY, CALIFORNIA INSTITUTE OF TECHNOLOGY, CALIFORNIA, U.S.A.		I+92	1	8
INC-PART	(P) PROTONS.		I+92	1	9
TARGET	32S IONS IMPLANTED AT 80-KEV ONTO A 0.5 MM TA BACKING. USED SNICS SOURCE AT UNIVERSITY OF NOTRE DAME. TARGET THICKNESS APPROX. 5 KEV AT EP = 1760 KEV. RATIO OF SULPHUR TO TANTALUM ATOMS WAS 1.0+-0.2. TARGET WAS WATER COOLED AND VERY STABLE UNDER PROTON BOMBARDMENT.		I+92	1	10
METHOD	PROTON-ENERGY RANGE 0.4-2.0 MEV. BEAM CURRENTS UP TO 65 MICROAMP. BEAM ENERGY RESOLUTION 2 KEV BASED ON MEASUREMENT WITH 27AL(P,GAMMA)28SI SHARP RESONANCE AT EP = 991.88 KEV. GAMMA-RAY YIELD MEASUREMENTS PERFORMED WITH A GE DETECTOR ON THE KNOWN RESONANCES AND ALSO OFF THE RESONANCES IN THE RANGE EP = 1.38-1.93 MEV TO SEARCH FOR DIRECT CAPTURE. NARROW RESONANCES WERE FOUND AT 5 PROTON ENERGIES. GAMMA-RAY YIELD AND ANGULAR DISTRIBUTION MEASUREMENTS PERFORMED AT THESE ENERGIES. ESTIMATED STRENGTH OF 77-KEV RESONANCE BY INDIRECT MEANS SINCE THE GAMMA-RAY YIELD WAS TOO LOW TO MEASURE FOR THIS RESONANCE. THICK-TARGET YIELD MEASUREMENTS ON THE WELL-KNOWN 32S(P,GAMMA)33CL RESONANCE AT 1757.2 KEV WERE USED TO NORMALIZE DATA.		I+92	1	11
DETECTOR	(GE) 35-PERCENT GE DETECTOR SHIELDED BY 5 CM OF LEAD.		I+92	1	12
MONITOR	(CI) CURRENT INTEGRATOR USED TO RECORD BEAM CHARGE. SUPPRESSOR RING WITH NEGATIVE BIAS ELIMINATED SECONDARY ELECTRON EMISSION EFFECTS.		I+92	1	13
CORRECTION	ENERGIES OF GAMMA-RAY TRANSITIONS CORRECTED FOR DOPPLER SHIFTS. GAMMA-RAY SPECTRA ON THE RESONANCES WERE CORRECTED FOR NON-RESONANT CONTRIBUTIONS.		I+92	1	14
ERR-ANALYS	RESONANCE STRENGTH ERROR SOURCES: EFFECTIVE STOPPING POWER (18 PERC), GAMMA RAY EFFICIENCY (6 PERC), CHARGE MEASUREMENTS (10 PERC), STANDARD ERROR AND ERROR IN NUMBERS OF TARGET NUCLEI WERE NOT GIVEN EXPLICITLY. RESULTS PUBLISHED IN NUCLEAR PHYSICS A.		I+92	1	15
STATUS			I+92	1	16
ENDBIB	41		I+92	1	17
ENDSUBENT	1		I+92	199999	
SUBENT	I+92	2	0	I+92	2
BIB	2	5	I+92	2	2
REACTION	32S(P,GAMMA)33CL		I+92	2	3
COMMENT	RESONANCE ENERGIES AND STRENGTHS FROM TABLE 1 OF PAPER. ER = RESONANCE ENERGY, ERR-ER = ERROR IN ER. OMEGGAM = ABSOLUTE RESONANCE STRENGTH AS DEFINED IN TABLE 1 OF THE PAPER. ERR-OMEGGAM = ERROR IN OMEGGAM.		I+92	2	4
ENDBIB	5		I+92	2	5
DATA	4	6	I+92	2	6
ER	ERR-ER	OMEGGAM	ERR-OMEGGAM	I+92	2
				I+92	2

KEV	KEV	EV	EV		I+92 2	11
77.3	0.8	3.5000E-17			I+92 2	12
424.	2.	3.7000E-05	0.8000E-05		I+92 2	13
589.	1.	1.3000E-01	0.3000E-01		I+92 2	14
1589.	1.	2.7000E-02	0.6000E-02		I+92 2	15
1749.	1.	4.5000E-02	0.9000E-02		I+92 2	16
1899.	2.	8.9000E-02	4.0000E-02		I+92 2	17
ENDDATA		8			I+92 2	18
ENDSUBENT		2			I+92	200000
SUBENT	I+92	3			I+92 3	1
BIB		2	8		I+92 3	2
REACTION	32S(P,GAMMA)33CL				I+92 3	3
COMMENT	GAMMA-RAY BRANCHING IN THE DECAY OF RESONANT STATES				I+92 3	4
	IN 33CL. ER = RESONANCE (INCIDENT PROTON) ENERGY, EXI =				I+92 3	5
	EXCITATION ENERGY OF INITIAL LEVEL IN 33CL FOR GAMMA-RAY				I+92 3	6
	TRANSITION. EXF = EXCITATION ENERGY OF FINAL LEVEL IN				I+92 3	7
	33CL FOR GAMMA-RAY TRANSITION. BRANCH = BRANCHING				I+92 3	8
	FACTOR. ERR-BRANCH = ERROR IN BRANCH. DATA FROM TABLE				I+92 3	9
	2 OF PAPER.				I+92 3	10
ENDBIB		8			I+92 3	11
DATA		5	20		I+92 3	12
ER	EXI	EXF	BRANCH	ERR-BRANCH	I+92 3	13
KEV	KEV	KEV	PERCENT	PERCENT	I+92 3	14
422.	2685.	0.	34.	6.	I+92 3	15
422.	2685.	1986.	66.	11.	I+92 3	16
588.	2846.	0.	45.	3.	I+92 3	17
588.	2846.	811.	55.	4.	I+92 3	18
1588.	3816.	0.	16.	3.	I+92 3	19
1588.	3816.	811.	2.0	0.7	I+92 3	20
1588.	3816.	1986.	24.	4.	I+92 3	21
1588.	3816.	2352.	40.	7.	I+92 3	22
1588.	3816.	2839.	18.	2.	I+92 3	23
1748.	3972.	0.	26.	6.	I+92 3	24
1748.	3972.	811.	39.	8.	I+92 3	25
1748.	3972.	1986.	15.	3.	I+92 3	26
1748.	3972.	2352.	9.	3.	I+92 3	27
1748.	3972.	2839.	11.	3.	I+92 3	28
1757.	3980.	0.	88.	13.	I+92 3	29
1757.	3980.	1986.	5.0	0.8	I+92 3	30
1757.	3980.	2685.	2.3	0.5	I+92 3	31
1757.	3980.	2846.	4.7	0.8	I+92 3	32
1898.	4117.	0.	26.	8.	I+92 3	33
1898.	4117.	811.	74.	10.	I+92 3	34
ENDDATA		22			I+92 3	35
ENDSUBENT		3			I+92	399999
SUBENT	I+92	4			I+92 4	1
BIB		2	11		I+92 4	2
REACTION	32S(P,GAMMA)33CL				I+92 4	3
COMMENT	SINGLE-PARTICLE SPECTROSCOPIC FACTORS FOR EXCITED				I+92 4	4
	STATES IN 33CL. EX = 33CL EXCITATION ENERGY. JPI =				I+92 4	5
	SPIN/PARITY. POSITIVE VALUES IMPLY POSITIVE PARITY.				I+92 4	6
	NEGATIVE VALUES IMPLY NEGATIVE PARITY. IF MORE THAN				I+92 4	7
	ONE VALUE IS GIVEN, THIS INDICATES UNCERTAINTY OVER THE				I+92 4	8
	ASSIGNMENT. NL(J) = SINGLE-PARTICLE STATE OF CAPTURED				I+92 4	9
	PROTON. C2S = SINGLE-PARTICLE SPECTROSCOPIC FACTOR				I+92 4	10
	AS DEFINED IN THIS PAPER. ERR-C2S = ERROR IN C2S.				I+92 4	11
	DATA OBTAINED FROM TABLE 3 OF PAPER. C2S VALUES FOR				I+92 4	12
	EX = 1986, 2352, 2685 AND 2839 KEV ARE UPPER BOUNDS.				I+92 4	13
ENDBIB		11			I+92 4	14
DATA		5	7		I+92 4	15
EX	JPI		C2S	ERR-C2S	I+92 4	16
KEV	NO-DIM	NL(J)	NO-DIM	NO-DIM	I+92 4	17
0.	1.5	1D(3/2)	0.84	0.21	I+92 4	18
811.	0.5	2S(1/2)	0.28	0.05	I+92 4	19
1986.	2.5	1D(5/2)	0.26		I+92 4	20
2352.	1.5	1D(3/2)	0.66		I+92 4	21
2685.	-2.5,-3.5	1F(7/2)	3.8		I+92 4	22
2839.	2.5	1D(5/2)	0.47		I+92 4	23

2846.	-1.5	2P(3/2)	0.77	0.13	I+92 4	24	
ENDDATA		9			I+92 4	25	
ENDSUBENT		4			I+92 499999		
SUBENT	I+92	5			I+92 5	1	
BIB		2	13		I+92 5	2	
REACTION		32S(P,GAMMA)33CL			I+92 5	3	
COMMENT		TEMPERATURE DEPENDENT STELLAR REACTION RATES FOR			I+92 5	4	
		32S(P,GAMMA)33CL. VALUES OBTAINED FROM TABLE 4 OF			I+92 5	5	
		PAPER. REACTION RATES (RR) ARE DEFINED IN THE PAPER.			I+92 5	6	
		T9 = STELLAR TEMPERATURE IN 10*9 DEG. KELVIN (10**9K).			I+92 5	7	
		RR(422) = REACTION RATE BASED ONLY ON KNOWN RESONANCES			I+92 5	8	
		WITH ENERGIES GREATER THAN OR EQUAL TO 422 KEV (INCIDENT			I+92 5	9	
		PROTONS). RR(77) = REACTION RATE CONTRIBUTION OBTAINED			I+92 5	10	
		SOLELY FROM THE 77-KEV RESONANCE (INCIDENT PROTON			I+92 5	11	
		ENERGY). RR(DC) = REACTION RATE SOLELY DUE TO DIRECT			I+92 5	12	
		CAPTURE PROCESS. RR(TOTAL) = TOTAL REACTION RATE BASED			I+92 5	13	
		ON ALL KNOWN PROCESSES. RR = NA<SIG*V> AS INDICATED IN			I+92 5	14	
		THE TABLE. REACTION RATES IN CM**3/MOL/SEC (CM3/MOL/S).			I+92 5	15	
ENDBIB		13			I+92 5	16	
DATA		5	10		I+92 5	17	
T9		RR(422)	RR(77)	RR(DC)	RR(TOTAL)	I+92 5	18
10**9K		CM3/MOL/S	CM3/MOL/S	CM3/MOL/S	CM3/MOL/S	I+92 5	19
0.05		3.1600E-39	1.3900E-17	5.2100E-22	1.3900E-17	I+92 5	20
0.08		4.5100E-24	4.7000E-15	1.3800E-17	4.7100E-15	I+92 5	21
0.1		4.5900E-19	2.9600E-14	1.0100E-15	3.0600E-14	I+92 5	22
0.14		2.1700E-13	2.1500E-13	3.5600E-13	7.8800E-13	I+92 5	23
0.2		4.8000E-09	8.1300E-13	8.8100E-11	4.8800E-09	I+92 5	24
0.3		5.2900E-05	1.8900E-12	2.1000E-08	5.2900E-05	I+92 5	25
0.5		1.4700E-01	2.8000E-12	7.2600E-06	1.4700E-01	I+92 5	26
0.8		1.0100E+01	2.6600E-12	6.2300E-04	1.0100E+01	I+92 5	27
1.0		3.7600E+01	2.3600E-12	3.8500E-03	3.7600E+01	I+92 5	28
2.0		3.6000E+02	1.2900E-12		3.6000E+02	I+92 5	29
ENDDATA		12			I+92 5	30	
ENDSUBENT		5			I+92 599999		
ENDENTRY		5			I+92999999		

KRA75

ENTRY	KRA75	0	KRA75 0	1
SUBENT	KRA75	1	KRA75 1	1
BIB	12	41	KRA75 1	2
INSTITUTE	(SFHLS)		KRA75 1	3
REFERENCE	(J,PS,12,280,1975)		KRA75 1	4
AUTHORS	(J.KEINONEN,M.RIIKONEN AND A.ANTTILA)		KRA75 1	5
TITLE	STRENGTHS OF ANALOGUE RESONANCES IN (P,GAMMA)		KRA75 1	6
	REACTIONS ON SULPHUR ISOTOPES		KRA75 1	7
FACILITY	(VDG) 2.5-MV VAN DE GRAAFF ACCELERATOR, DEPARTMENT OF		KRA75 1	8
	PHYSICS, UNIVERSITY OF HELSINKI, HELSINKI, FINLAND.		KRA75 1	9
INC-PART	(P) PROTONS.		KRA75 1	10
TARGET	150 MICROGRAM/CM**3 NATURAL ZNS TARGET MADE BY VACUUM		KRA75 1	11
	EVAPORATION ONTO TANTALUM BACKING. THIS MATERIAL WAS		KRA75 1	12
	CHOSEN BECAUSE IT DOES NOT DISSOCIATE DURING		KRA75 1	13
	EVAPORATION AND THEREFORE REDUCES UNCERTAINTY IN		KRA75 1	14
	TARGET STOICHIOMETRY. TARGETS OF ZNS EVAPORATED ONTO		KRA75 1	15
	CARBON WERE ALSO PREPARED UNDER THE SAME CONDITIONS.		KRA75 1	16
	THIS ALLOWED THE RATIO OF ZN TO S TO BE DETERMINED BY		KRA75 1	17
	THE METHOD OF ALPHA-PARTICLE BACKSCATTERING.		KRA75 1	18
	PROTON BEAM CURRENTS WERE KEPT BELOW 5 MICROAMPERES		KRA75 1	19
	IN ORDER TO AVOID DETERIORATION OF THE TARGET.		KRA75 1	20
METHOD	THE ABSOLUTE STRENGTH OF THE EP = 588 KEV RESONANCE		KRA75 1	21
	IN THE 32S(P,GAMMA)33CL REACTION WAS DETERMINED BY		KRA75 1	22

	OBSERVING THE STEP IN THE THICK-TARGET YIELD CURVE.	KRA75 1	23
	OBSERVED THE GAMMA-RAYS CORRESPONDING TO THE 2846- TO	KRA75 1	24
	810-KEV TRANSITION WHICH DE-EXCITE THIS RESONANT	KRA75 1	25
	STATE IN 33CL. THESE GAMMA-RAYS WERE MEASURED WITH	KRA75 1	26
	A LARGE GE(LI) DETECTOR AT 55 DEG. THE ABSOLUTE	KRA75 1	27
	RESONANCE STRENGTH WAS DEDUCED FROM GAMMA-RAY YIELD	KRA75 1	28
	DATA USING KNOWLEDGE OF THE TARGET ELEMENTAL SULPHUR	KRA75 1	29
	CONTENT, THE PROTON STOPPING POWER FOR THE ZNS	KRA75 1	30
	TARGET, THE INTEGRATED PROTON CHARGE AND THE DETECTOR	KRA75 1	31
	EFFICIENCY. THE METHOD WAS CHECKED BY ALSO MEASURING	KRA75 1	32
	THE ABSOLUTE STRENGTH OF THE WELL-KNOWN RESONANCE AT	KRA75 1	33
	EP = 633 KEV IN 27AL(P,GAMMA)28SI.	KRA75 1	34
DETECTOR	{GEL1} 120 CM**3 GE(LI) DETECTOR PLACED AT 55 DEG.	KRA75 1	35
	TO INCIDENT PROTON BEAM. DETECTOR WAS CALIBRATED	KRA75 1	36
	USING 22NA, 60CO, 88Y AND 137CS GAMMA-RAY SOURCES.	KRA75 1	37
MONITOR	(C1) CURRENT INTEGRATOR.	KRA75 1	38
ERR-ANALYS	2 PERCENT UNCERTAINTY IN STOPPING POWER OF ZN AND	KRA75 1	39
	15 PERCENT UNCERTAINTY IN STOPPING POWER OF S LEAD	KRA75 1	40
	TO AN OVERALL UNCERTAINTY OF 5 PERCENT IN ZNS.	KRA75 1	41
	NO EXPLICIT MENTION IN PAPER OF OTHER ERROR SOURCES.	KRA75 1	42
STATUS	RESULTS PUBLISHED IN PHYSICA SCRIPTA.	KRA75 1	43
ENDBIB	41	KRA75 1	44
ENDSUBENT	1	KRA75	199999
SUBENT	KRA75 2 0	KRA75 2	1
BIB	2 9	KRA75 2	2
REACTION	32S(P,GAMMA)33CL	KRA75 2	3
COMMENT	ABSOLUTE RESONANCE STRENGTH IS GIVEN IN TABLE I OF	KRA75 2	4
	THE PAPER. EP = RESONANCE INCIDENT PROTON ENERGY.	KRA75 2	5
	EI = INITIAL STATE FOR GAMMA-RAY TRANSITION THAT	KRA75 2	6
	DE-EXCITES THE RESONANCE. EF = FINAL STATE FOR	KRA75 2	7
	GAMMA-RAY TRANSITION THAT DE-EXCITES THE RESONANCE.	KRA75 2	8
	BRANCH = GAMMA-RAY TRANSITION BRANCHING RATIO	KRA75 2	9
	STRENG = ABSOLUTE RESONANCE STRENGTH. ERR-STRENG =	KRA75 2	10
	ERROR IN STRENG.	KRA75 2	11
ENDBIB	9	KRA75 2	12
DATA	6 1	KRA75 2	13
EP	EI EF BRANCH STRENG ERR-STRENG	KRA75 2	14
KEV	KEV KEV PERCENT EV EV	KRA75 2	15
588.	2846. 810. 55. 0.20 0.04	KRA75 2	16
ENDDATA	3	KRA75 2	17
ENDSUBENT	2	KRA75	299999
ENDENTRY	2	KRA75	999999

K+85

ENTRY	K+85	0	K+85 0	1
SUBENT	K+85 1	0	K+85 1	1
BIB	12	32	K+85 1	2
INSTITUTE	(HUNDEB)		K+85 1	3
REFERENCE	(J,JRC,89,1,123,1985)		K+85 1	4
AUTHORS	(A.Z.KISS,E.KOLTAY,B.NYAKO,E.SOMORJAI,A.ANTTILA, J.RAISANEN)		K+85 1	5
TITLE	MEASUREMENTS OF RELATIVE THICK TARGET YIELDS FOR PIGE ANALYSIS ON LIGHT ELEMENTS IN THE PROTON ENERGY INTERVAL 2.4-4.2 MEV		K+85 1	7
FACILITY	(VDG) 5-MV VAN DE GRAEFF ACCELERATOR, INSTITUTE OF NUCLEAR RESEARCH, HUNGARIAN ACADEMY OF SCIENCES, DEBRECEN, HUNGARY.		K+85 1	10
INC-PART	(P) PROTONS.		K+85 1	11
TARGETS	VARIOUS CHEMICAL COMPOUNDS. FABRICATED BY PRESSING INTO PELLETS. NO OTHER DETAILS ARE GIVEN.		K+85 1	12
			K+85 1	13
			K+85 1	14
			K+85 1	15

METHOD	RELATIVE THICK TARGET YIELD DETERMINED. MEASURED WITH AN INCIDENT PROTON BEAM FROM A 5-MV VAN DE GRAAFF ACCELERATOR. INTENSITY OF THE BEAM WAS ADJUSTED SO THAT THE DEAD TIME WOULD BE CONSTANT FOR THE DIFFERENT TARGETS THAT WERE USED. THE BEAM PASSED THROUGH A 50-CM-LONG LIQUID-NITROGEN TRAP BEFORE IMPINGING ON TARGET PLACED AT AN ANGLE OF 45 DEG. GAMMA-RAY SPECTRA MEASURED WITH A GE(LI) DETECTOR. SPECTRAL DATA WERE RECORDED WITH A 4K CHANNEL ANALYZER AND THEN TRANSFERRED TO A PDP/I-16K COMPUTER. DATA NORMALIZED TO RESULTS FROM AN EARLIER EXPERIMENT IN THIS LABORATORY. USED PUBLISHED STOPPING POWER VALUES IN THE ANALYSIS.	K+85 1 16 K+85 1 17 K+85 1 18 K+85 1 19 K+85 1 20 K+85 1 21 K+85 1 22 K+85 1 23 K+85 1 24 K+85 1 25 K+85 1 26 K+85 1 27
DETECTOR	(GELI) 25 CM**3 GE(LI) DETECTOR SITUATED AT AN ANGLE OF 55 DEG. AND A TARGET-TO-DETECTOR DISTANCE OF 10 CM.	K+85 1 28 K+85 1 29 K+85 1 30
CORRECTION	DATA CORRECTED FOR DETECTOR DEAD TIME.	K+85 1 31
ERR-ANALYS	NO ERRORS ARE DISCUSSED IN THE PAPER.	K+85 1 32
STATUS	RESULTS PUBLISHED IN J. OF RADIOANALYTICAL AND NUCLEAR CHEMISTRY.	K+85 1 33 K+85 1 34
ENDBIB	32	K+85 1 35
ENDSUBENT	1	K+85 199999
SUBENT	K+85 2 0	K+85 2 1
BIB	2 6	K+85 2 2
REACTION	32S(P,GAMMA)33CL	K+85 2 3
COMMENT	GAMMA-RAY YIELDS ARE GIVEN IN TABLE 1 OF THE PAPER. EGAMMA = OBSERVED GAMMA-RAY. EP = PROTON ENERGY. NGMCSR = YIELD OF GAMMA RAYS PER MICROCOULOMB PER STERADIAN (1/MC/SR). THIS IS A RELATIVE UNIT TO COMPARE THE YIELDS FOR VARIOUS ENERGIES, TARGETS AND REACTIONS.	K+85 2 4 K+85 2 5 K+85 2 6 K+85 2 7 K+85 2 8
ENDBIB	6	K+85 2 9
DATA	3 2	K+85 2 10
EGAMMA	EP NGMCSR	K+85 2 11
KEY	MEV 1/MC/SR	K+85 2 12
811.	2.4 45.	K+85 2 13
811.	3.1 120.	K+85 2 14
ENDDATA	4	K+85 2 15
ENDSUBENT	2	K+85 299999
SUBENT	K+85 3	K+85 3 1
BIB	2 6	K+85 3 2
REACTION	32S(P,P'GAMMA)32S	K+85 3 3
COMMENT	GAMMA-RAY YIELDS ARE GIVEN IN TABLE 1 OF THE PAPER. EGAMMA = OBSERVED GAMMA-RAY. EP = PROTON ENERGY. NGMCSR = YIELD OF GAMMA RAYS PER MICROCOULOMB PER STERADIAN (1/MC/SR). THIS IS A RELATIVE UNIT TO COMPARE THE YIELDS FOR VARIOUS ENERGIES, TARGETS AND REACTIONS.	K+85 3 4 K+85 3 5 K+85 3 6 K+85 3 7 K+85 3 8
ENDBIB	6	K+85 3 9
DATA	3 3	K+85 3 10
EGAMMA	EP NGMCSR	K+85 2 11
KEY	MEV 1/MC/SR	K+85 2 12
2230.	3.1 5300.	K+85 3 13
2230.	3.8 150000.	K+85 3 14
2230.	4.2 890000.	K+85 3 15
ENDDATA	5	K+85 3 16
ENDSUBENT	3	K+85 399999
ENDENTRY	3	K+85999999

RWK87

ENTRY	RWK87	0	RWK87 0	1
SUBENT	RWK87	1	RWK87	1 1
BIB	11	20	RWK86	1 2

INSTITUTE	(SFHLS)			RWK86 1	3
REFERENCE	(J,NIMB,B28,199,1987)			RWK86 1	4
AUTHORS	(J.RAISANEN,T.WITTING,J.KEINONEN)			RWK86 1	5
TITLE	ABSOLUTE THICK-TARGET GAMMA RAY YIELDS FOR ELEMENTAL ANALYSIS BY 7 AND 9 MEV PROTONS			RWK86 1	6
FACILITY	5-MV TANDEM ACCELERATOR, ACCELERATOR LABORATORY, UNIVERSITY OF HELSINKI, HELSINKI, FINLAND.			RWK86 1	8
INC-PART	(P) PROTONS.			RWK86 1	9
TARGET	PBS IN THE FORM OF 1-MM THICK BY 6-MM DIA. PELLETS.			RWK86 1	11
METHOD	PROTON BEAM DIRECTED ON TARGETS. GE(LI) DETECTOR WAS LOCATED 27 CM DISTANT FROM TARGET AT 55 DEG. NEUTRONS WERE MEASURED WITH A BF3 COUNTER LOCATED 30 CM FROM THE TARGET. MEASURED ACCUMULATED PROTON CHARGE.			RWK86 1	12
DETECTORS	(GELI) 80 CM**3 GE(LI) GAMMA-RAY DETECTOR. CALIBRATED USING 60CO, 56CO AND 152EU GAMMA-RAY SOURCES. EFFICIENCY 18 PERCENT FOR 1.3-MEV GAMMA RAY. (PROPC) BF3 NEUTRON DETECTOR.			RWK86 1	13
MONITOR	(CI) CURRENT INTEGRATOR. SUPPRESSOR USED TO ELIMINATE CURRENT LOSSES DUE TO SECONDARY ELECTRON EMISSION.			RWK86 1	14
STATUS	PUBLISHED IN NUCLEAR INSTRUMENTS AND METHODS B.			RWK86 1	15
ENDBIB	20			RWK86 1	16
ENDSUBENT	1			RWK86 199999	17
SUBENT	RWK87 2	0		RWK86 2	18
BIB	2	6		RWK86 2	19
REACTION	32S(P,P')32S			RWK86 2	20
COMMENT	ABSOLUTE GAMMA RAY YIELD IS GIVEN. UNITS ARE GAMMA RAYS PER MICROCOULOMB PER STERADIAN (1/MC/SR). EGAMMA = GAMMA-RAY ENERGY, EP = INCIDENT PROTON ENERGY. NGMCSR = NUMBER OF GAMMA RAYS PER MICROCOULOMB PER STERADIAN.			RWK86 2	21
ENDBIB	6			RWK86 2	22
DATA	3	4		RWK86 2	23
EGAMMA	EP	NGMCSR		RWK86 2	24
KEV	MEV	1/MC/SR		RWK86 2	25
2230.	7.	6.1700E+07		RWK86 2	26
2230.	9.	1.4800E+08		RWK86 2	27
4282.	7.	5.9900E+06		RWK86 2	28
4282.	9.	3.6600E+07		RWK86 2	29
ENDDATA	6			RWK86 2	30
ENDSUBENT	2			RWK87 299999	31
ENDENTRY	2			RWK879999999	32

S83

ENTRY	S83	0		S83 0	1
SUBENT	S83 1	0		S83 1	1
BIB	7	16		S83 1	2
INSTITUTE	(AULAML)			S83 1	3
REFERENCE	(J,AUJ,36,583,1983)			S83 1	4
AUTHOR	(D.G.SARGOOD)			S83 1	5
TITLE	EFFECTS OF EXCITED STATES ON THERMONUCLEAR REACTION RATES			S83 1	6
METHOD	THIS PAPER IS A COMPILATION OF CALCULATED VALUES FOR THE RATIO OF THERMONUCLEAR REACTION RATES WITH TARGET NUCLEI IN A THERMAL DISTRIBUTION OF ENERGY STATES TO REACTION RATES WITH ALL TARGET NUCLEI IN THEIR GROUND STATES. USE IS MADE OF THE STATISTICAL MODEL IN THESE CALCULATIONS. NO EXPERIMENTAL DATA WERE ACQUIRED IN THIS WORK. ONLY RESULTS FOR 32S(P,GAMMA)33CL ARE GIVEN HERE.			S83 1	7
COMMENT	THE CALCULATIONS REPORTED IN THIS ARTICLE INVOLVE A NUMBER OF REACTIONS WITH NEUTRONS, PROTONS, AND ALPHA			S83 1	8
				S83 1	9
				S83 1	10
				S83 1	11
				S83 1	12
				S83 1	13
				S83 1	14
				S83 1	15
				S83 1	16

STATUS	PARTICLES IN BOTH THE INCIDENT AND EXIT CHANNELS.	S83 1	17
ENDBIB	PUBLISHED IN AUSTRALIAN JOURNAL OF PHYSICS	S83 1	18
ENDSUBENT	16	S83 1	19
SUBENT	1	S83 199999	
BIB	S83 2 0	S83 2	1
REACTION	2 10	S83 2	2
COMMENT	32S(P,GAMMA)33CL	S83 2	3
	THE FOLLOWING VALUES ARE TAKEN FROM TABLES 1-4 OF THE	S83 2	4
	PAPER. RATIOS OF THERMONUCLEAR REACTION RATES FOR FOUR	S83 2	5
	DIFFERENT STELLAR TEMPERATURES ARE INCLUDED. T9 =	S83 2	6
	STELLAR TEMPERATURE IN UNITS OF 10**9 DEG. KELVIN	S83 2	7
	(10**9K). RATIO = RATIO OF REACTION RATE WITH TARGET	S83 2	8
	NUCLEI OCCUPYING A STATISTICAL DISTRIBUTION OF EXCITED	S83 2	9
	STATES AT THE GIVEN TEMPERATURE TO THE SAME REACTION	S83 2	10
	RATE CALCULATED ASSUMING ALL TARGET NUCLEI ARE IN THE	S83 2	11
	GROUND STATE.	S83 2	12
ENDBIB	10	S83 2	13
DATA	2 4	S83 2	14
T9	RATIO	S83 2	15
10**9K	NO-DIM	S83 2	16
1.	1.00	S83 2	17
2.	1.00	S83 2	18
3.5	0.996	S83 2	19
5.	0.980	S83 2	20
ENDDATA	6	S83 2	21
ENDSUBENT	2	S83 299999	
ENDENTRY	2	S839999999	

Appendix B: Unused References from NSR

The individual references which were identified in our survey of Nuclear Science References (NSR), but were not found and used in the present compilation, are listed below for the convenience of readers of this report who might wish to try and locate and consider them. The entries appearing here are in exactly the same format in which there were extracted from NSR.

70EsZV

CONF Madurai(Nucl,Solid State Phys),Vol2,P37

<KEYWORDS>NUCLEAR REACTIONS $^{32}\text{S}(p,\gamma)$, $E=3.37$ MeV; measured $\sigma(E;E\ \gamma)$. ^{33}Cl deduced resonance,level-width,lowest $T=3/2$ state.

71AIZN

THESIS Univ Kansas,L A Alexander,DABBB 32B 2334,11/24/71

<KEYWORDS>NUCLEAR REACTIONS $^{32}\text{S}(p,\gamma)$, $E=1755-2917$ keV; measured Q , $\sigma(E;E\ \gamma)$, $\gamma\text{-}\gamma(\theta)$,Doppler shift attenuation, triple correlations. ^{33}Cl deduced resonances,levels, $J,\pi,T-1/2$, γ -multipolarity.

71BiZQ

REPT 1970/1971 Annual,Laboratori Nazionali di Legnaro(Padova),P14,M Bi

<KEYWORDS>NUCLEAR REACTIONS $^{32}\text{S}(p,\gamma)$, $E=1.905$ MeV; measured DSA. ^{33}Cl level deduced $T-1/2$.

71EsZS

REPT BARC-553,P1,3/21/72

<KEYWORDS>NUCLEAR REACTIONS $^{32}\text{S}(p,\gamma)$, $E=2.4-3.4$ MeV; measured $\sigma(E;E\ \gamma)$. ^{33}Cl deduced resonance,level-width, γ -branching.

71EsZT

REPT INDC(SEC)-18/L,P42,12/30/71

<KEYWORDS>NUCLEAR REACTIONS $^{32}\text{S}(p,\gamma)$, $E=2-4$ MeV; measured $\sigma(E;E\ \gamma)$. ^{33}Cl deduced isobaric analog resonance, level-width, γ -branching.

72Bi19

Nuovo Cim. 12A, 215 (1972)
M.Bini, P.G.Bizzeti, A.M.Bizzeti-Sona
M1 Transitions in the Isospin Doublet $A = 33$

<KEYWORDS>NUCLEAR REACTIONS $^{32}\text{S}(p,\gamma)$, E not given; measured DSA.
 ^{33}Cl level deduced $T=1/2$.

72EsZS

REPT BARC-614,P1

<KEYWORDS>NUCLEAR REACTIONS $^{32}\text{S}(p,\gamma)$; measured σ .

72EsZU

REPT INDC(SEC)-28/L,P72,11/29/72

<KEYWORDS>NUCLEAR REACTIONS $^{32}\text{S}(p,\gamma)$, $E=3.36-5.41$ MeV; measured
 $\sigma(E)$. ^{33}Cl deduced resonances, isobaric analogs.

74Ab06

Lett.Nuovo Cim. 11, 481 (1974)
U.Abbondanno, G.Pioani, P.Biasi
Gamma-Decay of the Lowest $T = 3/2$ -State of ^{33}Cl

<KEYWORDS>NUCLEAR REACTIONS $^{32}\text{S}(p,\gamma)$, $E=5.5$ MeV; measured E γ ,
I γ . ^{33}Cl deduced level, J, π , level-width, M1 strength.

74InZT

CONF Vienna(Charged-Particle-Induced Rad Capture), Proc P71

<KEYWORDS>NUCLEAR REACTIONS $^{20,22}\text{Ne}, ^{24,26}\text{Mg}, ^{28,30}\text{Si}, ^{32,34,36}\text{S}, ^{36},$
 $^{40}\text{Ar}(p,\gamma)$; measured $\sigma(E, E \gamma, \theta)$. $^{21,23}\text{Na}, ^{25,27}\text{Al}, ^{29},$
 $^{31}\text{P}, ^{33,35,37}\text{Cl}, ^{37,41}\text{K}$ deduced levels, J, π . Review paper.