ANL/NDM-143

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

by

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DATA COMPILATION. Nuclear reaction $^{32}S(p,\gamma)^{33}Cl$. Nuclear properties ^{33}Cl. Astrophysics. Resonance properties (p + ^{32}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}S).

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

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Abstract

This report documents a survey of the literature, and provides a compilation of data contained therein, for the $^{32}S(p,\gamma)^{33}Cl$ 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 $^{32}S + p$ 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 novas and supernovas [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 $^{32}S(p,\gamma)^{33}Cl$ reaction. A total of 27 reference citations pertaining to the $^{32}S(p,\gamma)^{33}Cl$ 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 $^{32}S(p,\gamma)^{33}Cl$ 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 *et al.*	X	X	
A+76	Aleonard *et al.*	X	X	
EE66	Engelbertink and P.M. Endt	X	X	
EIR72	Eswaran *et al.*	X	X	
ERI73	Eswaran *et al.*	X		
E+72	Eswaran *et al.*			Related to EIR72
E+74	Eswaran *et al.*			Related to E+75
E+75	Eswaran *et al.*	X (A)[a]		
H+72	Hubert *et al.*	X (A)		Related to A+74
I+92	Iliadis *et al.*	X	X	
KRA75	Keinonen *et al.*	X	X	
K+85	Kiss *et al.*	X	X	
PGA70	Prosser *et al.*	X (A)		
RWK87	Raisanen *et al.*	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. Mennrath, Physics Letters **49B**, No. 1, 40 (1974).

ABSTRACT

Absolute strength measurements have been performed for the E_p = 580 and 588 keV $^{32}S(p,\gamma)^{33}Cl$, E_p = 1214 keV $^{34}S(p,\gamma)^{35}Cl$ and E_p = 633 and 744 keV $^{27}Al(p,\gamma)^{28}Si$ 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

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

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: $^{32}S(p,\gamma)^{33}Cl$ (E_p = 580 and 588 keV), $^{34}S(p,\gamma)^{35}Cl$ (E_p = 1214 keV) and $^{27}Al(p,\gamma)^{28}Si$ (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-cm^3 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 $^{27}Al(p,\gamma)^{28}Si$ 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}S(p,γ)^{33}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}S(p,γ)^{33}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

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

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 $^{32}S(p,\gamma)^{33}Cl$ 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 $^{32}S(p,\gamma)^{33}Cl$ 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 $\mu g/cm^2$ 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 $\mu g/cm^2$) onto the surface of these targets insured a better tolerance to the proton beam. The excitation function was measured using a NaI (12.7 x 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 Ge(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 furthermost accessible back angle, namely, 132°. Finally, a 60-cm^3 Ge(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-cm^3 Ge(Li) detector and 2.7 keV for the 60-cm^3 Ge(Li) detector, both for the 1.3-MeV ^{60}Co line. The $^{32}S(p,\gamma)^{33}C$ excitation function was measured in the range E_p = 560-2600 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 $\mu g/cm^2$ thick. The accelerator energy calibration was achieved using the following well-known resonances: $^{34}S(p,\gamma)^{35}Cl$ (E_p = 1213.7±1.0 keV), $^{27}Al(p,\gamma)^{28}Si$ (E_p = 632.6±0.2 and 773.70±0.03 keV) and $^{13}C(p,\gamma)^{14}N$ (E_p = 1747.6±0.9 keV). The state of the targets was examined periodically by looking at the 588-, 1757- and 2547-keV resonances in $^{32}S(p,\gamma)^{33}Cl$. 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-cm^3 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-cm^3 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 $^{32}S(p,\gamma)^{33}Cl$ 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 $^{32}S(p,\gamma)^{33}Cl$ 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

^{33}Cl), Table 3 (lifetimes of levels in ^{33}Cl), Table 4 (angular distribution coefficients), Table 5 (spins and parities of ^{33}Cl 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 $^{32}S(p,\gamma)^{33}Cl$ 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 ^{23}Na, $^{24-26}$Mg, ^{27}Al, $^{28-30}$Si, ^{31}P, ^{32,34}S, ^{35,37}Cl, ^{39,41}K and ^{40}Ca 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 $^{30}Si(p,\gamma)^{31}P$ resonance of which the strength is known from a γ-ray resonant absorption experiment, was used to convert the relative into absolute strengths.

REACTION

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

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 $^{30}Si(p,\gamma)^{31}P$ (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 Ultrecht 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 $^{26}Mg(p,\gamma)^{27}Al$ 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 $^{26}Mg(p,\gamma)^{27}Al$ 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 $^{29}Si(p,\gamma)^{30}P$ and 621 keV $^{30}Si(p,\gamma)^{31}P$ 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 $^{30}Si(p,\gamma)^{31}P$ ($E_p = 621$ 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 $^{32}S(p,\gamma)^{33}Cl$ 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 $^{32}S(p,\gamma)^{33}Cl$

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 $^{32}S(p,\gamma)^{33}Cl$ 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±0.005 MeV, E_x = 5.550±0.007 MeV and at E_p = 5.282±0.006 MeV, E_x = 7.402±0.008 MeV have been located with the resonance strengths $(2J+1)\Gamma_{p0}\Gamma_\gamma/\Gamma$ = 0.76±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

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

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 $^{32}S(p,\gamma)^{33}Cl$ 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 $^{32}S(p,\gamma)^{33}Cl$ 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 $^{27}Al(p,\gamma)^{28}Si$ 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 $^{32}S(p,\gamma)^{33}Cl$ reaction at E_p = 3.377 MeV. A water-cooled 300 μg/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 μA 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 $^{32}S(p,\gamma)^{33}Cl$ 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-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 $^{32}S(p,\alpha)^{29}P$ reaction (Q = -4.20 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-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-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 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 $^{32}S(p,\gamma)^{33}Cl$. 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 μg/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

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

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 $^{32}S(p,\gamma)^{33}Cl$ (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 μg/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 $^{32}S(p,\gamma)^{33}Cl$. 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 $^{28}Si(p,\gamma)^{29}P$ 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 $^{32}S(p,\gamma)^{33}C$ 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}S(p,γ)^{33}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}S(p,γ)^{33}Cl and ^{32}S(p,p')^{32}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 $^{34}S(p,\gamma)^{35}Cl$, 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 $^{34}S(p,\gamma)^{35}Cl$ resonances in the range E_p = 700-2100 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 ± 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 $^{32}S(p,\gamma)^{33}Cl$ reaction has been measured in the proton-energy range E_p = 0.4-2.0 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 $^{32}S(p,\gamma)^{33}Cl$ reaction are also discussed.

REACTION

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

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 = 0.05-2.0. 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 μA. The beam energy resolution was 2 keV, as measured using the well-known narrow $^{27}Al(p,\gamma)^{28}Si$ resonance at E_R = 991.88±0.04 keV. The proton energy was calibrated using this resonance as well as the $^{32}S(p,\gamma)^{33}Cl$ resonance at E_R = 1757.2±0.9 keV. Sulphur targets were prepared by implanting 80-keV ^{32}S ions into a 0.5-mm Ta backing using the SNICS source at the University of Notre Dame. The incident dose was 120 μA·h This process yielded well-defined targets with thickness ~5 keV at E_p = 1760-keV bombarding energy. The ratio of sulphur to tantalum in these targets was determined via thick-target yield measurements on the well-known $^{32}S(p,\gamma)^{33}Cl$ (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_γ = 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±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}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}S(p,γ)^{33}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}S(p,γ)^{33}Cl reaction and of the E_p = 1214 keV resonance in the ^{34}S(p,γ)^{35}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}S(p,γ)^{34}Cl reaction and the E_p = 1887 keV resonance in the ^{36}S(p,γ)^{37}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}S(p,γ)^{35}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 $^{34,35\,36}$Cl is discussed.

REACTION

^{32}S(p,γ)^{33}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 $^{32}S(p,\gamma)^{33}Cl$ and $^{34}S(p,\gamma)^{35}Cl$ were correct. An attempt was also made to redetermine the strengths of the resonances at E_p = 1887 and 1542 keV in the reactions $^{36}S(p,\gamma)^{37}Cl$ and $^{33}S(p,\gamma)^{34}Cl$, 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-cm^3 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. It's 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 mm^2 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 μg/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 μg/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 $^{32}S(p,\gamma)^{33}Cl$, $^{33}S(p,\gamma)^{34}Cl$, $^{34}S(p,\gamma)^{35}Cl$ and $^{36}S(p,\gamma)^{37}Cl$. 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 $^{34,35,36}Cl$. 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 $^{32}S(p,\gamma)^{33}Cl$.

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

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

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-cm^3 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 cm^3) 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 μA 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 cm^3 and the 100 cm^3 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-cm^3 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 $3 \le Z \le 21$ elements (except for neon and argon) in the bombarding proton energy interval $1 \le E_p \le 4.2$ 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 ^{33}Cl Excited Via the $^{32}S(p,\gamma)^{33}Cl$ 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 $^{32}S(p,\gamma)^{33}Cl$ reaction has been determined in this way to be Q = 2277.6±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-cm^3 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 ^{60}Co, ^{56}Co and ^{152}Eu standard gamma-ray sources. A BF_3 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-cm^2 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 μC-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 $^{32}S(p,\gamma)^{33}Cl$ 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 (x 10^9) °K. The ratios are determined from reaction rates based on statistical model cross sections.

REACTION

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

FACILITY

None. This work is an analytical study.

EXPERIMENT

None. This paper deals only with theoretical calculations of the thermonuclear reaction rates $<\sigma v>^*$ corresponding to target nuclei in a thermal distribution of energy states and corresponding reaction rates $<\sigma v>^0$ 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.

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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 $^{32}S(p,\gamma)^{33}Cl$ 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 multipolarities, and iv) data of an engineering nature which can be used in applications of the $^{32}S(p,\gamma)^{33}Cl$ 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 determintion 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 $^{32}S(p,\gamma)^{33}Cl$ 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 $^{32}S(p,\gamma)^{33}Cl$ 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	$(9\pm4) \times 10^{-5}$
	I+92	424±2 [f]	$(7.4\pm1.6) \times 10^{-5}$ [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	$(1.4\pm0.6) \times 10^{-4}$
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 $^{32}S(p,\gamma)^{33}Cl$ 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 $^{32}S(p,\gamma)^{33}Cl$ resonance.
[d] Resonance strength for the $^{32}S(p,\gamma)^{33}Cl$ 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 $^{32}S(p,\gamma)^{33}Cl$ resonance is too weak to 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 $^{32}S(p,\gamma)^{33}Cl$ 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.

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NSR97

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PGA70

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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).

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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

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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     A+74 1    6
           28SI.                                                   A+74 1    7
FACILITY   (VDG) 4-MV VAN DE GRAAFF ACCELERATOR, C.E.A. CENTRE     A+74 1    8
           D'ETUDES NUCLEAIRES DE BORDEAUX-GRADIGNAN, FRANCE.      A+74 1    9
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           WAS SHIELDED FROM BEAM-DEFINING SLITS TO REDUCE THE     A+74 1   16
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           MEASUREMENT AND DATA ANALYSIS PROCEDURES. THE DETAILS   A+74 1   29
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           PAPER BUT THERE IS A REFERENCE TO EARLIER WORK.         A+74 1   31
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           (NAICR) A NAI SCINTILLATION DETECTOR WAS USED TO CHECK  A+74 1   36
           THE CONDITION OF THE TARGETS BEFORE AND AFTER THE       A+74 1   37
           ABSOLUTE RESONANCE STRENGTH MEASUREMENTS.               A+74 1   38
MONITOR    (CI) CURRENT INTEGRATOR. CONSISTENCY CHECKED USING      A+74 1   39
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           A CURRENT GENERATOR.                                   A+74 1    40
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           DISCREPANCIES, THERE WERE RELATIVE (P,GAMMA) STRENGTH  A+74 1    42
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           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+749999999
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A+76

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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,A257,490,1976)                                 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
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            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 34S, 27AL AND 13C. 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 32S 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 AG2S, 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    32S(P,GAMMA)33CL                                        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 33CL.       A+76 2    6
            ERR-EX = ERROR IN EXCITATION ENERGY IN 33CL.            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 (AG2S, 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   15
KEV         KEV         KEV         KEV         EV          EV          A+76 2   16
421.8       0.6         2865.5      0.4          9.0000E-05 4.0000E-05  A+76 2   17
579.8       0.6         2838.7      0.8         0.08        0.01        A+76 2   18
587.9       0.5         2846.6      0.7         0.21        0.03        A+76 2   19
720.7       0.6         2975.4      0.3          1.4000E-04 0.6000E-04  A+76 2   20
1587.8      1.1         3816.2      1.2         0.053       0.007       A+76 2   21
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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     A+76 3      4
           33CL WERE DEDUCED IN THE PRESENT WORK AS A                A+76 3      5
           CONSEQUENCE OF MEASURING THE RESONANCE EXCITATION         A+76 3      6
           FUNCTION AND OF DETERMINING RESONANCE LIFETIMES BY        A+76 3      7
           THE DOPPLER-SHIFT ATTENUATION METHOD AS APPLIED TO        A+76 3      8
           GAMMA RAYS WHICH DE-EXCITE THE RESONANCE STATES. EX =     A+76 3      9
           EXCITATION ENERGY IN 33CL. ERR-EX = ERROR IN EXCITATION   A+76 3     10
           ENERGY IN 33CL. VALUES OBTAINED FROM TABLE 2 OF PAPER.    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-      A+76 4      4
           SHIFT ATTENUATION METHOD. EX = 33CL LEVEL EXCITATION      A+76 4      5
           ENERGY. EI = INITIAL 33CL LEVEL FOR GAMMA-RAY             A+76 4      6
           TRANSITION. EF = FINAL 33CL LEVEL FOR GAMMA-RAY           A+76 4      7
           TRANSITION. EP = ENERGY OF RESONANCE WHERE LIFETIME       A+76 4      8
           MEASUREMENT WAS PERFORMED. TAU = MEAN LIFETIME OF 33CL    A+76 4      9
           LEVEL. ERR-TAU = ERROR IN MEAN LIFETIME OF 33CL LEVEL.    A+76 4     10
           MEASUREMENTS INDICATE THAT MEAN LIFETIME OF THE 2846-     A+76 4     11
           KEV LEVEL IN 33CL IS < 1 FS. VALUE IS NOT INCLUDED IN     A+76 4     12
           THE DATA BLOCK BELOW. VALUES FROM TABLE 3 OF THE PAPER.   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       A+76 5      4
           TRANSITIONS THAT DE-EXCITE THE SELECTED RESONANCE STATE   A+76 5      5
           OF 33CL. THESE ARE COEFFICIENTS A2 AND A4 OF A LEGENDRE   A+76 5      6
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           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
KEV                                                                 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
KEV        KEV        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
KEV                                                                 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
KEV        KEV        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
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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       A+76 8      4
           TRANSITIONS THAT DE-EXCITE THE SELECTED RESONANCE STATE   A+76 8      5
           OF 33CL. THESE ARE COEFFICIENTS A2 AND A4 OF A LEGENDRE   A+76 8      6
           POLYNOMIAL EXPANSION. VALUES FROM TABLE 4 OF THE PAPER.   A+76 8      7
           COMMON RESONANCE PROTON ENERGY EP IS INDICATED. EI =      A+76 8      8
           INITIAL 33CL LEVEL FOR GAMMA-RAY TRANSITION. EF =         A+76 8      9
           FINAL 33CL LEVEL FOR GAMMA-RAY TRANSITION. A2 =           A+76 8     10
           COEFFICIENT OF P2 TERM IN LEGENDRE EXPANSION. ERR-A2 =    A+76 8     11
           ERROR IN A2. A4 = COEFFICIENT OF P4 TERM IN LEGENDRE      A+76 8     12
           EXPANSION. ERR-A4 = ERROR IN A4.                          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-       A+76 9      4
           RAY TRANSITIONS. EI = INITIAL 33CL LEVEL FOR GAMMA-       A+76 9      5
           RAY TRANSITION. EF = FINAL 33CL LEVEL FOR GAMMA-RAY       A+76 9      6
           TRANSITION. JIPI = ASSUMED SPIN/PARITY OF INITIAL         A+76 9      7
           33CL LEVEL. JFPI = ASSUMED SPIN/PARITY OF FINAL 33CL      A+76 9      8
           LEVEL. POSITIVE VALUE INDICATES POSITIVE PARITY AND       A+76 9      9
           NEGATIVE VALUE INDICATES NEGATIVE PARITY. DELTA =         A+76 9     10
           MULTIPOLE MIXING RATIO. ERR-DELTA = ERROR IN              A+76 9     11
           MULTIPOLE MIXING RATIO. IDENT = IDENTIFICATION            A+76 9     12
           OF DATA ENTRY AS DEFINED IN COMMON BLOCK. MULT1 =         A+76 9     13
           FIRST MULTIPOLARITY. MULT2 = SECOND MULTIPOLARITY.        A+76 9     14
           SOMETIMES ONLY ONE MULTIPOLARITY (MULT1) APPEARS.         A+76 9     15
           WHEN MORE THAN ONE ENTRY APPEARS FOR THE SAME             A+76 9     16
           TRANSITION, THIS REFLECTS UNCERTAINTY IN THE SPIN/        A+76 9     17
           PARITY ASSIGNMENTS. IN SOME CASES MORE THAN ONE VALUE     A+76 9     18
           OF MIXING RATIO IS GIVEN FOR THE SAME TRANSITION AND      A+76 9     19
           ASSUMED SPIN/PARITY ASSIGNMENTS. INFORMATION FROM         A+76 9     20
           TABLE 6 OF THE PAPER.                                     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
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          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
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          TRANSITION. JIPI = ASSUMED SPIN/PARITY OF INITIAL         A+7610
          33CL LEVEL. JFPI = ASSUMED SPIN/PARITY OF FINAL 33CL      A+7610
          LEVEL. POSITIVE VALUE INDICATES POSITIVE PARITY AND       A+7610
          NEGATIVE VALUE INDICATES NEGATIVE PARITY. MULT1 =         A+7610
          FIRST MULTIPOLARITY. MULT2 = SECOND MULTIPOLARITY.        A+7610
          ME1 = REDUCED MATRIX ELEMENT FOR MULT1. ERR-ME1 =         A+7610
          ERROR IN ME1. ME2 = REDUCED MATRIX ELEMENT FOR MULT2.     A+7610
          ERR-ME2 = ERROR IN ME2. IDENT = DATA ENTRY                A+7610
          IDENTIFICATION FOR DATA ENTRY AS DEFINED IN COMMON        A+7610
          BLOCK. SOMETIMES ONLY ONE MULTIPOLARITY (MULT1)           A+7610
          APPEARS. WHEN MORE THAN ONE ENTRY APPEARS FOR THE         A+7610
          SAME TRANSITION THIS REFLECTS UNCERTAINTY IN THE          A+7610
          ASSUMED SPIN/PARITY ASSIGNMENTS. INFORMATION FROM         A+7610
          TABLE 6 OF THE PAPER. NOTE INEQUALITY SIGNS FOR           A+7610
          MATRIX ELEMENTS WITH IDENT = 9-13, 16-22 AND 28.          A+7610
ENDBIB              19                                              A+7610
COMMON               6          31                                  A+7610
IDENT     EI         EF         JIPI       JFPI                     A+7610
NO-DIM    KEV        KEV        NO-DIM     NO-DIM     MULT1,MULT2   A+7610
         1 1986.     0.         2.5        1.5        M1,E2         A+7610
         2 1986.     0.         2.5        1.5        M1,E2         A+7610
         3 2352.     0.         1.5        1.5        M1,E2         A+7610
         4 2352.     811.       1.5        0.5        M1,E2         A+7610
         5 2685.     1986.      -2.5       2.5        E1            A+7610
         6 2685.     1986.      -3.5       2.5        E1            A+7610
         7 2839.     0.         2.5        1.5        M1,E2         A+7610
         8 2975.     0.         3.5        1.5        E2            A+7610
         9 3816.     0.         2.5        1.5        M1,E2         A+7610
        10 3816.     1986.      2.5        2.5        M1,E2         A+7610
        11 3816.     2352.      2.5        1.5        M1,E2         A+7610
        12 3816.     2839.      2.5        2.5        M1,E2         A+7610
        13 3972.     0.         1.5        1.5        M1,E2         A+7610
        14 3972.     811.       1.5        0.5        M1            A+7610
        15 3972.     811.       1.5        0.5        M1,E2         A+7610
        16 3980.     0.         -2.5       1.5        E1            A+7610
        17 3980.     2685.      -2.5       -2.5       M1,E2         A+7610
        18 3980.     2685.      -2.5       -3.5       M1,E2         A+7610
        19 3980.     2685.      -2.5       -3.5       M1,E2         A+7610
        20 3980.     2839.      -2.5       2.5        E1            A+7610
        21 3980.     2846.      -2.5       -1.5       M1,E2         A+7610
        22 3980.     2846.      -2.5       -1.5       M1,E2         A+7610
        23 4117.     0.         -1.5       1.5        E1            A+7610
        24 4117.     811.       -1.5       0.5        E1            A+7610
        25 4117.     2846.      -1.5       -1.5       M1            A+7610
        26 4775.     2685.      -3.5       -2.5       M1,E2         A+7610
        27 4775.     2685.      -3.5       -3.5       M1,E2         A+7610
        28 4775.     2839.      -3.5       2.5        E1,M2         A+7610
        29 4775.     2846.      -3.5       -1.5       E2            A+7610
ENDCOMMON            6          31                                  A+7610
DATA                 5          29                                  A+7610
IDENT     ME1        ERR-ME1    ME2        ERR-ME2                  A+7610
NO-DIM    W.U.       W.U.       W.U.       W.U.                     A+7610
         1 4.0000E-03 2.0000E-03 65.       17.                      A+7610
         2 5.3000E-02 1.4000E-02 15.       5.                       A+7610
         3 2.5000E-03 1.2000E-03 3.1       1.1                      A+7610
         4 5.8000E-02 1.7000E-02 19.       6.                       A+7610
         5 6.0000E-05 3.0000E-05                                    A+7610
         6 4.4000E-05 2.2000E-05                                    A+7610
         7 0.29       0.08       1.4       0.7                      A+7610
         8 3.6        0.8                                           A+7610
         9 1.4000E-04            0.23                               A+7610
        10 1.4000E-04            0.9                                A+7610
        11 0.6                   3.3                                A+7610
        12 4.6000E-02            42.                                A+7610
        13 3.3000E-03 1.8000E-03 1.                                 A+7610
        14 1.4000E-02 0.4000E-02                                    A+7610
        15 3.4000E-03 0.9000E-03 4.1       0.9                      A+7610
        16 9.0000E-04                                               A+7610
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          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
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EE66

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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             EE66 1     6
           S-D SHELL.                                                       EE66 1     7
FACILITIES (VDG) 3-MV VAN DE GRAAFF ACCELERATOR.                            EE66 1     8
           (C-W) 850-KV COCKCROFT-WALTON GENERATOR.                         EE66 1     9
           FYSISCH LAB., UTRECHT, RIIKSUNIVERSITEIT, NETHERLANDS.           EE66 1    10
INC-PART   (P) PROTONS.                                                     EE66 1    11
TARGETS    THE FOLLOWING SULPHUR-BEARING COMPOUNDS WERE USED:               EE66 1    12
           NA2S2O7, MGSO4, P4S6, ZNS, K2SO4 AND CASO4. MATERIALS            EE66 1    13
           CONTAINED ELEMENTS WITH NATURAL ISOTOPIC ABUNDANCES.             EE66 1    14
           THESE TARGETS WERE PREPARED BY VACUUM EVAPORATION ONTO           EE66 1    15
           0.3-MM TANTALUM BACKINGS. MATERIALS WERE SELECTED THAT           EE66 1    16
           WOULD NOT DECOMPOSE DURING THE EVAPORATION PROCESS.              EE66 1    17
METHOD     RELATIVE STRENGTH DETERMINATIONSS MADE BY COMPARISON OF          EE66 1    18
           THICK-TARGET YIELD MEASUREMENTS USING TARGETS OF VARIOUS         EE66 1    19
           CHEMICAL COMPOUNDS. USE OF A VARIETY OF TARGET MATERIALS         EE66 1    20
           AVOIDED SYSTEMATIC ERRORS DUE TO TARGET STOICHIOMETRY            EE66 1    21
           UNCERTAINTY. TARGETS WERE WATER COOLED TO MINIMIZE               EE66 1    22
           DETERIORATION. PROTON CHARGE MEASURED WITH A CURRENT             EE66 1    23
           INTEGRATOR. NEGATIVELY BIASED SUPPRESSOR RING PREVENTED          EE66 1    24
           LOSSES DUE TO SECONDARY ELECTRON EMISSION. RESONANCE             EE66 1    25
           STRENGTH RATIOS WERE MEASURED USING A NAI                        EE66 1    26
           SCINTILLATION DETECTOR. RATIO DATA WERE NORMALIZED BY            EE66 1    27
           USING ABSOLUTE STRENGTH OF A 30SI(P,GAMMA)31P RESONANCE          EE66 1    28
           WHICH HAD BEEN DETERMINED IN AN EARLIER EXPERIMENT.              EE66 1    29
           RESONANCE STRENGTHS FOR 32P(P,GAMMA)33CL WERE OVER-              EE66 1    30
           DETERMINED. FINAL BEST VALUES DETERMINED BY A LEAST              EE66 1    31
           SQUARES ANALYSIS.                                                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              EE66 1    35
           MADE FOR COINCIDENCE AND RANDOM SUMMING EFFECTS.                 EE66 1    36
ERR-ANALYS DATA UNCERTAINTIES ARE INCLUDED FOR STRENGTH OF STANDARD         EE66 1    37
           RESONANCE (8.4 PERC) AND ESTIMATED ERROR FOR UNKNOWN             EE66 1    38
           GAMMA RAY SPECTRUM (7 PERC). TOTAL ERROR OF 15 PERC IS           EE66 1    39
           ASSIGNED TO THE FINAL RESULTS.                                   EE66 1    40
STATUS     PUBLISHED IN NUCLEAR PHYSICS.                                    EE66 1    41
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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-       EE66 2     4
           KEV RESONANCE IN THE 32S(P,GAMMA)33CL REACTION TO           EE66 2     5
           THE STRENGTHS FOR SEVERAL OTHER RESONANCE REACTIONS.        EE66 2     6
           VALUES ARE EXPRESSED IN FORM INDICATED, WHERE THE           EE66 2     7
           SULPHUR VALUE IS IN THE DENOMINATOR. THESE MEASURED         EE66 2     8
           DATA ARE OBTAINED FROM TABLE 1 OF THE PAPER.                EE66 2     9
           RATIO = DEFINITION OF STRENGTH RATIOS. STRENGR =            EE66 2    10
           MEASURED STRENGTH RATIO FOR 588-KEV RESONANCE IN THE        EE66 2    11
           32S(P,GAMMA)33CL REACTION. ERR-STRENGR = ERROR IN           EE66 2    12
           STRENGR. TARGET = TARGET MATERIAL USED IN THE RATIO         EE66 2    13
           MEASUREMENT. THE VALUES GIVEN ARE AVERAGE VALUES            EE66 2    14
           BASED ON SEVERAL MEASUREMENTS WITH DIFFERENT TARGET         EE66 2    15
           THICKNESSES. SEE PAPER FOR FURTHER DISCUSSION.              EE66 2    16
ENDBIB              14                                                 EE66 2    17
DATA                 4          6                                      EE66 2    18
                     STRENGR    STRENGR-ERR                            EE66 2    19
TARGET     RATIO     NO-DIM     NO-DIM                                 EE66 2    20
NA2S2O7    23NA/32S  6.6        0.7                                    EE66 2    21
MGSO4      26MG/32S  6.6        0.7                                    EE66 2    22
P4S6       31P/32S   3.80       0.38                                   EE66 2    23
ZNS        34S/32S   150.       15.                                    EE66 2    24
K2SO4      39K/32S   230.       50.                                    EE66 2    25
CASO4      40CA/32S  2.02       0.20                                   EE66 2    26
ENDDATA              8                                                 EE66 2    27
ENDSUBENT            2                                                 EE66 299999
SUBENT         EE66  3          0                                      EE66 3     1
BIB                  2          4                                      EE66 3     2
REACTION   32S(P,GAMMA)33CL                                            EE66 3     3
COMMENT    STRENG = ABSOLUTE RESONANCE STRENGTH CALCULATED             EE66 3     4
           FROM MEASURED RELATIVE STRENGTHS. ERR-STRENG = ERROR        EE66 3     5
           IN STRENG. VALUE IS TAKEN FROM TABLE 2 OF PAPER.            EE66 3     6
ENDBIB               4                                                 EE66 3     7
DATA                 3          1                                      EE66 3     8
EP         STRENG    ERR-STRENG                                        EE66 3     9
KEV        KEV                                                         EE66 3    10
588.       0.14      0.02                                              EE66 3    11
ENDDATA              3                                                 EE66 3    12
ENDSUBENT            3                                                 EE66 399999
ENDENTRY             3                                                 EE669999999
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EIR72

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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       EIR72 1    6
           RESONANCES IN THE REACTION 32S(P,GAMMA)33CL                 EIR72 1    7
FACILITY   (VDG) 5-MV VAN DE GRAAFF ACCELERATOR, NUCLEAR PHYSICS       EIR72 1    8
           DIVISION, BHABHA ATOMIC RESEARCH CENTRE, TROMBAY,           EIR72 1    9
           BOMBAY, INDIA.                                              EIR72 1   10
INC-PART   (P) PROTONS                                                 EIR72 1   11
TARGET     300-MICROGRAM SB2S3 ON THICK GOLD BACKING. NATURAL          EIR72 1   12
           ISOTOPIC ABUNDANCE. PREPARED BY VACUUM EVAPORATION.         EIR72 1   13
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            TARGET WAS WATER COOLED.                                   EIR72 1    14
METHOD      (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 27AL(P,GAMMA)28SI             EIR72 1    23
            RESONANCE AT EP = 991.91 KEV. 33CL 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 33CL ACTIVITY TO DISCRIMINATE AGAINST         EIR72 1    30
            BACKGROUND EVENTS. ABSOLUTE STRENGTH OF RESONANCES         EIR72 1    31
            WAS DETERMINED BY NORMALIZING TO THE 32S(P,GAMMA)33CL      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
            AT VARIOUS OTHER PROTON ENERGIES ON AND OFF RESONANCES.    EIR72 1    38
DETECTORS   (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 32S(P,GAMMA)33CL.                             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    32S(P,GAMMA)33CL                                           EIR72 2     3
COMMENT     DATA FROM TABLE I OF PAPER. RESONANCES IN THE REACTION     EIR72 2     4
            32S(P,GAMMA)33CL WERE IDENTIFIED. EP = RESONANCE           EIR72 2     5
            INCIDENT LAB. PROTON ENERGY. ERR-EP = ERROR IN EP. EX      EIR72 2     6
            = 33CL 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
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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    EIR72 3     4
           ABSOLUTE RESONANCE STRENGTHS OF T = 3/2 STATES IN      EIR72 3     5
           33CL FROM THE 32S(P,GAMMA)33CL REACTION ARE GIVEN.     EIR72 3     6
           EP = RESONANCE LAB. INCIDENT PROTON ENERGY. ERR-EP =   EIR72 3     7
           ERROR IN EP. STRENG = ABSOLUTE RESONANCE STRENGTH AS   EIR72 3     8
           DEFINED IN THE PAPER. ERR-STRENG = ERROR IN STRENG.    EIR72 3     9
           NOTE THAT VALUE OF STRENG FOR EP = 4856 KEV IS AN      EIR72 3    10
           UPPER LIMIT.                                           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     EIR72 4     4
           LEVELS OF 33CL. VALUES FROM TABLE III OF PAPER. EI =   EIR72 4     5
           ENERGY OF INITIAL LEVEL OF GAMMA-RAY TRANSITION. EF =  EIR72 4     6
           ENERGY OF FINAL LEVEL OF GAMMA-RAY TRANSITION. BRANCH = EIR72 4    7
           BRANCHING RATIO FOR THIS TRANSITION. NOTE THAT FOR THE EIR72 4     8
           5.550 TO 0.810 TRANSITION BRANCH IS A LOWER BOUND WHILE EIR72 4    9
           FOR THE 5.550 TO 0.0 TRANSITION BRANCH IS AN UPPER     EIR72 4    10
           BOUND. GAMMAM1 = M1 GAMMA-RAY WIDTH, ERR-GAMMAM1 =     EIR72 4    11
           ERROR IN GAMMAM1. GAMMAM1 FOR THE 5.550 TO 0.0         EIR72 4    12
           TRANSITION IS AN UPPER BOUND.                          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          EIR72 5     4
           OBTAINED FROM TABLE IV OF THE PAPER. EI = ENERGY OF    EIR72 5     5
           INITIAL LEVEL OF GAMMA-RAY TRANSITION. EF = ENERGY OF  EIR72 5     6
           FINAL LEVEL OF GAMMA-RAY TRANSITION. MULT = CHOICE(S)  EIR72 5     7
           FOR TRANSITION MULTIPOLARITY. STRNGM1 = M1 TRANSITION  EIR72 5     8
           STRENGTH. ERR-STRNGM1 = ERROR IN STRNGM1. NOTE THAT    EIR72 5     9
           VALUE OF STRNGM1 FOR 5.550 TO 0.0 TRANSITION IS AN     EIR72 5    10
           UPPER BOUND.                                           EIR72 5    11
ENDBIB                9                                           EIR72 5    12
DATA                  5          2                                EIR72 5    13
EI         EF                    STRNGM1    ERR-STRNGM1           EIR72 5    14
MEV        MEV        MULT       W.U.       W.U.                  EIR72 5    15
5.550      0.810      M1         0.15       0.04                  EIR72 5    16
5.550      0.         M1,E2      0.014                            EIR72 5    17
ENDDATA               4                                           EIR72 5    18
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ENDSUBENT          5                                            EIR72 599999
ENDENTRY           5                                            EIR729999999
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I+92

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ENTRY            I+92          0                                I+92 0     1
SUBENT         I+92  1         0                                I+92 1     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,   I+92 1     5
           R.E.AZUMA,C.A.BARNES)                                I+92 1     6
TITLE      DIRECT PROTON CAPTURE ON 32S                         I+92 1     7
FACILITY   3-MV PELLETRON TANDEM ACCELERATOR, KELLOGG RADIATION I+92 1     8
           LABORATORY, CALIFORNIA INSTITUTE OF TECHNOLOGY,      I+92 1     9
           CALIFORNIA, U.S.A.                                   I+92 1    10
INC-PART   (P) PROTONS.                                         I+92 1    11
TARGET     32S IONS IMPLANTED AT 80-KEV ONTO A 0.5 MM TA BACKING. I+92 1  12
           USED SNICS SOURCE AT UNIVERSITY OF NOTRE DAME.       I+92 1    13
           TARGET THICKNESS APPROX. 5 KEV AT EP = 1760 KEV.     I+92 1    14
           RATIO OF SULPHUR TO TANTALUM ATOMS WAS 1.0+-0.2.     I+92 1    15
           TARGET WAS WATER COOLED AND VERY STABLE UNDER PROTON I+92 1    16
           BOMBARDMENT.                                         I+92 1    17
METHOD     PROTON-ENERGY RANGE 0.4-2.0 MEV. BEAM CURRENTS UP TO I+92 1    18
           65 MICROAMP. BEAM ENERGY RESOLUTION 2 KEV BASED ON   I+92 1    19
           MEASUREMENT WITH 27AL(P,GAMMA)28SI SHARP RESONANCE   I+92 1    20
           AT EP = 991.88 KEV. GAMMA-RAY YIELD MEASUREMENTS     I+92 1    21
           PERFORMED WITH A GE DETECTOR ON THE KNOWN RESONANCES I+92 1    22
           AND ALSO OFF THE RESONANCES IN THE RANGE EP = 1.38-1.93 I+92 1 23
           MEV TO SEARCH FOR DIRECT CAPTURE. NARROW RESONANCES  I+92 1    24
           WERE FOUND AT 5 PROTON ENERGIES. GAMMA-RAY YIELD AND I+92 1    25
           ANGULAR DISTRIBUTION MEASUREMENTS PERFORMED AT THESE I+92 1    26
           ENERGIES. ESTIMATED STRENGTH OF 77-KEV RESONANCE BY  I+92 1    27
           INDIRECT MEANS SINCE THE GAMMA-RAY YIELD WAS TOO LOW I+92 1    28
           TO MEASURE FOR THIS RESONANCE. THICK-TARGET YIELD    I+92 1    29
           MEASUREMENTS ON THE WELL-KNOWN 32S(P,GAMMA)33CL      I+92 1    30
           RESONANCE AT 1757.2 KEV WERE USED TO NORMALIZE DATA. I+92 1    31
DETECTOR   (GE) 35-PERCENT GE DETECTOR SHIELDED BY 5 CM OF LEAD. I+92 1   32
MONITOR    (CI) CURRENT INTEGRATOR USED TO RECORD BEAM CHARGE.  I+92 1    33
           SUPPRESSOR RING WITH NEGATIVE BIAS ELIMINATED SECONDARY I+92 1 34
           ELECTRON EMISSION EFFECTS.                           I+92 1    35
CORRECTION ENERGIES OF GAMMA-RAY TRANSITIONS CORRECTED FOR DOPPLER I+92 1 36
           SHIFTS. GAMMA-RAY SPECTRA ON THE RESONANCES WERE     I+92 1    37
           CORRECTED FOR NON-RESONANT CONTRIBUTIONS.            I+92 1    38
ERR-ANALYS RESONANCE STRENGTH ERROR SOURCES: EFFECTIVE STOPPING I+92 1    39
           POWER (18 PERC), GAMMA RAY EFFICIENCY (6 PERC),      I+92 1    40
           CHARGE MEASUREMENTS (10 PERC), STANDARD ERROR AND ERROR I+92 1 41
           IN NUMBERS OF TARGET NUCLEI WERE NOT GIVEN EXPLICITLY. I+92 1  42
STATUS     RESULTS PUBLISHED IN NUCLEAR PHYSICS A.              I+92 1    43
ENDBIB             41                                           I+92 1    44
ENDSUBENT           1                                           I+92 199999
SUBENT         I+92  2         0                                I+92 2     1
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. I+92 2  4
           ER = RESONANCE ENERGY, ERR-ER = ERROR IN ER. OMEGGAM = I+92 2   5
           ABSOLUTE RESONANCE STRENGTH AS DEFINED IN TABLE 1 OF THE I+92 2 6
           PAPER. ERR-OMEGGAM = ERROR IN OMEGGAM.               I+92 2     7
ENDBIB              5                                           I+92 2     8
DATA                4          6                                I+92 2     9
ER         ERR-ER     OMEGGAM    ERR-OMEGGAM                    I+92 2    10
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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 299999
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
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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+929999999
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KRA75

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ENTRY            KRA75            0                                    KRA75 0     1
SUBENT        KRA75  1            0                                    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.RIIHONEN 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
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            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    (GELI) 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     (CI) 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                                              KRA759999999
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K+85

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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,         K+85 1     5
            J.RAISANEN)                                              K+85 1     6
TITLE       MEASUREMENTS OF RELATIVE THICK TARGET YIELDS FOR         K+85 1     7
            PIGE ANALYSIS ON LIGHT ELEMENTS IN THE PROTON             K+85 1     8
            ENERGY INTERVAL 2.4-4.2 MEV                              K+85 1     9
FACILITY    (VDG) 5-MV VAN DE GRAAFF ACCELERATOR, INSTITUTE OF       K+85 1    10
            NUCLEAR RESEARCH, HUNGARIAN ACADEMY OF SCIENCES,         K+85 1    11
            DEBRECEN, HUNGARY.                                       K+85 1    12
INC-PART    (P) PROTONS.                                             K+85 1    13
TARGETS     VARIOUS CHEMICAL COMPOUNDS. FABRICATED BY PRESSING INTO  K+85 1    14
            PELLETS. NO OTHER DETAILS ARE GIVEN.                     K+85 1    15
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METHOD     RELATIVE THICK TARGET YIELD DETERMINED. MEASURED WITH    K+85 1    16
           AN INCIDENT PROTON BEAM FROM A 5-MV VAN DE GRAAFF        K+85 1    17
           ACCELERATOR. INTENSITY OF THE BEAM WAS ADJUSTED SO       K+85 1    18
           THAT THE DEAD TIME WOULD BE CONSTANT FOR THE DIFFERENT   K+85 1    19
           TARGETS THAT WERE USED. THE BEAM PASSED THROUGH A 50-    K+85 1    20
           CM-LONG LIQUID-NITROGEN TRAP BEFORE IMPINGING ON TARGET  K+85 1    21
           PLACED AT AN ANGLE OF 45 DEG. GAMMA-RAY SPECTRA MEASURED K+85 1    22
           WITH A GE(LI) DETECTOR. SPECTRAL DATA WERE RECORDED      K+85 1    23
           WITH A 4K CHANNEL ANALYZER AND THEN TRANSFERRED TO A     K+85 1    24
           PDP/I-16K COMPUTER. DATA NORMALIZED TO RESULTS FROM      K+85 1    25
           AN EARLIER EXPERIMENT IN THIS LABORATORY. USED PUBLISHED K+85 1    26
           STOPPING POWER VALUES IN THE ANALYSIS.                   K+85 1    27
DETECTOR   (GELI) 25 CM**3 GE(LI) DETECTOR SITUATED AT              K+85 1    28
           AN ANGLE OF 55 DEG. AND A TARGET-TO-DETECTOR             K+85 1    29
           DISTANCE OF 10 CM.                                       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   K+85 1    33
           CHEMISTRY.                                               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.      K+85 2     4
           EGAMMA = OBSERVED GAMMA-RAY. EP = PROTON ENERGY.         K+85 2     5
           NGMCSR = YIELD OF GAMMA RAYS PER MICROCOULOMB PER        K+85 2     6
           STERADIAN (1/MC/SR). THIS IS A RELATIVE UNIT TO COMPARE  K+85 2     7
           THE YIELDS FOR VARIOUS ENERGIES, TARGETS AND REACTIONS.  K+85 2     8
ENDBIB               6                                              K+85 2     9
DATA                 3          2                                   K+85 2    10
EGAMMA     EP         NGMCSR                                        K+85 2    11
KEV        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.      K+85 3     4
           EGAMMA = OBSERVED GAMMA-RAY. EP = PROTON ENERGY.         K+85 3     5
           NGMCSR = YIELD OF GAMMA RAYS PER MICROCOULOMB PER        K+85 3     6
           STERADIAN (1/MC/SR). THIS IS A RELATIVE UNIT TO COMPARE  K+85 3     7
           THE YIELDS FOR VARIOUS ENERGIES, TARGETS AND REACTIONS.  K+85 3     8
ENDBIB               6                                              K+85 3     9
DATA                 3          3                                   K+85 3    10
EGAMMA     EP         NGMCSR                                        K+85 2    11
KEV        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+859999999
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RWK87

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ENTRY           RWK87           0                                  RWK87 0     1
SUBENT        RWK87  1          0                                  RWK87 1     1
BIB                 11         20                                  RWK86 1     2
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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   RWK86 1      6
           ANALYSIS BY 7 AND 9 MEV PROTONS                        RWK86 1      7
FACILITY   5-MV TANDEM ACCELERATOR, ACCELERATOR LABORATORY,       RWK86 1      8
           UNIVERSITY OF HELSINKI, HELSINKI, FINLAND.             RWK86 1      9
INC-PART   (P) PROTONS.                                           RWK86 1     10
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   RWK86 1     12
           LOCATED 27 CM DISTANT FROM TARGET AT 55 DEG. NEUTRONS  RWK86 1     13
           WERE MEASURED WITH A BF3 COUNTER LOCATED 30 CM FROM    RWK86 1     14
           THE TARGET. MEASURED ACCUMULATED PROTON CHARGE.        RWK86 1     15
DETECTORS  (GELI) 80 CM**3 GE(LI) GAMMA-RAY DETECTOR.             RWK86 1     16
           CALIBRATED USING 60CO, 56CO AND 152EU GAMMA-RAY        RWK86 1     17
           SOURCES. EFFICIENCY 18 PERCENT FOR 1.3-MEV GAMMA RAY.  RWK86 1     18
           (PROPC) BF3 NEUTRON DETECTOR.                          RWK86 1     19
MONITOR    (CI) CURRENT INTEGRATOR. SUPPRESSOR USED TO ELIMINATE  RWK86 1     20
           CURRENT LOSSES DUE TO SECONDARY ELECTRON EMISSION.     RWK86 1     21
STATUS     PUBLISHED IN NUCLEAR INSTRUMENTS AND METHODS B.        RWK86 1     22
ENDBIB             20                                             RWK86 1     23
ENDSUBENT           1                                             RWK86 199999
SUBENT        RWK87 2          0                                  RWK86 2      1
BIB                 2          6                                  RWK86 2      2
REACTION   32S(P,P')32S                                           RWK86 2      3
COMMENT    ABSOLUTE GAMMA RAY YIELD IS GIVEN. UNITS ARE GAMMA     RWK86 2      4
           RAYS PER MICROCOULOMB PER STERADIAN (1/MC/SR). EGAMMA  RWK86 2      5
           = GAMMA-RAY ENERGY, EP = INCIDENT PROTON ENERGY.       RWK86 2      6
           NGMCSR = NUMBER OF GAMMA RAYS PER MICROCOULOMB PER     RWK86 2      7
           STERADIAN.                                             RWK86 2      8
ENDBIB              6                                             RWK86 2      9
DATA                3          4                                  RWK86 2     10
EGAMMA     EP         NGMCSR                                      RWK86 2     11
KEV        MEV        1/MC/SR                                     RWK86 2     12
2230.      7.          6.1700E+07                                 RWK86 2     13
2230.      9.          1.4800E+08                                 RWK86 2     14
4282.      7.          5.9900E+06                                 RWK86 2     15
4282.      9.          3.6600E+07                                 RWK86 2     16
ENDDATA             6                                             RWK86 2     17
ENDSUBENT           2                                             RWK87 299999
ENDENTRY            2                                             RWK879999999
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S83

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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      S83 1      6
           RATES                                                    S83 1      7
METHOD     THIS PAPER IS A COMPILATION OF CALCULATED VALUES FOR     S83 1      8
           THE RATIO OF THERMONUCLEAR REACTION RATES WITH TARGET    S83 1      9
           NUCLEI IN A THERMAL DISTRIBUTION OF ENERGY STATES TO     S83 1     10
           REACTION RATES WITH ALL TARGET NUCLEI IN THEIR GROUND    S83 1     11
           STATES. USE IS MADE OF THE STATISTICAL MODEL IN THESE    S83 1     12
           CALCULATIONS. NO EXPERIMENTAL DATA WERE ACQUIRED IN THIS S83 1     13
           WORK. ONLY RESULTS FOR 32S(P,GAMMA)33CL ARE GIVEN HERE.  S83 1     14
COMMENT    THE CALCULATIONS REPORTED IN THIS ARTICLE INVOLVE A      S83 1     15
           NUMBER OF REACTIONS WITH NEUTRONS, PROTONS, AND ALPHA    S83 1     16
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           PARTICLES IN BOTH THE INCIDENT AND EXIT CHANNELS.        S83 1    17
STATUS     PUBLISHED IN AUSTRALIAN JOURNAL OF PHYSICS               S83 1    18
ENDBIB              16                                              S83 1    19
ENDSUBENT            1                                              S83 199999
SUBENT         S83   2          0                                   S83 2     1
BIB                  2         10                                   S83 2     2
REACTION   32S(P,GAMMA)33CL                                         S83 2     3
COMMENT    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
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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 32S(p,gamma),E=3.37 MeV; measured sigma(E;E gamma). 33Cl deduced resonance,level-width,lowest T=3/2 state.

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

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

71BiZQ
REPT 1970/1971 Annual,Laboratori Nazionali di Legnaro(Padova),P14,M Bi

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

71EsZS
REPT BARC-553,P1,3/21/72

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

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

<KEYWORDS>NUCLEAR REACTIONS 32S(p,gamma),E=2-4 MeV; measured sigma(E;E gamma). 33Cl deduced isobaric analog resonance, level-width,gamma-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 32S(p,gamma),E not given; measured DSA.
33Cl level deduced T-1/2.

72EsZS

REPT BARC-614,P1

<KEYWORDS>NUCLEAR REACTIONS 32S(p,gamma); measured sigma.

72EsZU

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

<KEYWORDS>NUCLEAR REACTIONS 32S(p,gamma),E=3.36-5.41 MeV; measured

sigma(E). 33Cl deduced resonances,isobaric analogs.

74Ab06

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

<KEYWORDS>NUCLEAR REACTIONS 32S(p,gamma),E=5.5 MeV; measured E gamma,
I gamma. 33Cl deduced level,J,pi,level-width,M1 strength.

74InZT

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

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