

Differential Cross Sections of (p, p) and (p, p') Scattering from Several Odd A Nuclei in the Energy Range of 6 to 7.5 Mev

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A compiled table of numerical differential cross sections of elastic and inelastic scattering of protons from several odd-even nuclei is presented, of which measurements were carried out by the Kyoto group using a 105cm cyclotron of Kyoto University. The incident energy of protons was changed by stacked aluminium foils in the energy range of 6 MeV to 7.5 MeV. Targets nuclei are B^{11} , C^{13} , F^{19} , Mg^{25} , Al^{27} , P^{31} and Cl^{35} .

The purpose of the experiment is to investigate the reaction mechanisms and the relation to the structure of nuclei. Discussions on the results are described briefly.

1. INTRODUCTION

Elastic and inelastic scattering of protons had been reported by many authors in the mass region from light to intermediately heavy nuclei and in the energy range from several to a few tens MeV mainly on even-even nuclei.

Important informations have been obtained by their works about scattering mechanisms, energy dependences of the cross section and of the shape of the angular distribution, the optical model parameters and the level structure.

However, the scattering from odd-A nuclei in the mass region less than $A \sim 40$ had been studied relatively little, in spite of their interesting characteristics compared with that of even-even nuclei. These are: (1) the excitation of the compound nucleus which may be formed by a target nucleus and an incident proton, is considerably higher than that of neighbouring even-even nuclei. (2) Thresholds of the (p, n) reaction are lower than that of nearby even-even nuclei. (3) Relatively many levels of different spin and parity of the residual nucleus could be excited so that it would be possible to study the structure of the nucleus and scattering mechanisms by comparing the yields from these levels, because the unified model¹⁾ has shown considerable success in understanding the level structure of odd-A nuclei. (4) The (p, p') scattering of odd-even nuclei is the mirror reaction of the (p, n) reaction of the same nucleus. It seems to be very interesting to compare these two reactions, because the residual two nuclei (in mirror nucleus) have the same spin and parity in corresponding low-lying levels.

The angular distribution and differential cross-sections and their energy dependences have been measured in the present work for nuclei, B^{11} , C^{13} , F^{19} , Mg^{25} , Al^{27} , P^{31} and Cl^{35} in the energy range of 6 to 7.5 MeV.

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2. EXPERIMENTAL PROCEDURES

A deflected beam of protons accelerated up to about 7.5 MeV by a 105cm F.F. cyclotron in our laboratory was led to a 52cm scattering chamber through a pair of quadrupole magnets.

The scattered protons were detected with a NaI or CsI scintillation counter or a solid state detector. In some case the competing (p, α) reaction can occur so that the alpha-particles were absorbed with an Al-foil in front of the detector to prevent the overlapping of peaks in pulse height spectrum. Usual electronics were used to analyze the energy spectrum.

The incident energy of the beam was determined by measuring the range in aluminium²⁾. The incident energy was changed by stacked aluminium foils through which the beam emerge into the scattering chamber.

The energy spread of the beam, not defined with a magnetic beam analyzer, seems to be about 50 keV.

The target of boron was made by sedimentation of B¹¹ powder (96.7% enriched, obtained from ORNL, USA) on a thin gold foil of which thickness was 0.2mg/cm². The thickness of the boron target was ranging 0.5 to 4mg/cm² from target to target.

The target of C¹³ was made by a craking method³⁾ from 56% enriched methane gas. The thickness was 0.38mg/cm².

As for F¹⁹, a poly-tetra-fluorethylene (teflon) foils were used (2 to 2.5mg/cm² in thickness).

Mg²⁵ was enriched to about 96% by a mass-separator in Department of Physics, Kyoto University, on a thin gold foil of which thickness was 0.2mg/cm². The amount of Mg²⁵ was not known so that the absolute cross-section was determined by a comparison with the yields from a natural magnesium target with the thickness of 1.00mg/cm².

The target of aluminium was a commercial foil of which thickness was 0.60mg/cm².

For P³¹, targets were made by sedimentation of redphosphorous powder in alcohol on a thin gold foil. The thickness was ranging 1 to 3mg/cm².

For chlorine, natural gas in a gas target chamber was used.

3. DISCUSSIONS ON THE RESULTS

Detailed discussions on the results had been reported elsewhere^{2,4)}. A rather brief discussion is made here.

Numerical values of the differential cross section are given in the following tables.

The discussion for the elastic scattering is summarized in conclusive remarks.

3-1. On the Result of B¹¹

The angular distribution of inelastically scattered protons from the first excited state at 2.13 MeV is considerably energy-dependent. The level can be considered to be a level not belonging to the rotational band of the ground state⁵⁾. The reaction mechanism is considered to be probably the compound nuclear reaction

process in the energy region of 6.5 to 7.5 MeV²³.

3-2. On the Result of C¹³

Inelastically scattered protons from the lowest three levels were observed. The yield from the second level (3/2⁻) is predominant. This level can be considered to be a collective level from the result of the (α, α') scattering recently carried out by our group⁶³. Therefore, the relatively large yield from this level in the (p, p') scattering is considered to show that the low energy protons excite collective levels with some enhancement over single particle excitations, as well as alpha-particles of a few tens MeV.

These aspects show themselves the existence of direct interactions between the target nucleus and the incident particle. As the energy dependence of the angular distribution of this collective level is considerably large, the interference between the direct interactions and the compound nuclear process may have to be taken into consideration.

3-3. On the Result of F¹⁹

Proton groups scattered from three levels (not resolved) at about 1.4 MeV and one level at 2.78 MeV were measured. The angular distribution had little energy dependence. This is very interesting in comparison with the energy dependence of nearby even-even nuclei, for example, Ne²⁰, which showed a violent energy dependence in this energy region⁷³. The reason may be explained by the difference in the height of the compound excitation (see ref. 2).

3-4. On the result on Mg²⁵

The angular distribution was measured only at the incident energy of 7 MeV. According to the Nilsson model⁸³, this nucleus has the same level structure of Al²⁷ which has the same number of nucleons, 13⁹³. The relative yield from lower several levels was observed to be qualitatively same as that of aluminium. This could be an evidence supporting the Nilsson model in these nuclei and the rotational excitation by low energy protons.

3-5. The Result on Al²⁷

Proton groups from low-lying six levels were observed.

Some energy dependences in the angular distribution were observed though they are not so violent in even-even nuclei in this energy region⁷³. It should be noted that the summed angular distribution of p_1' ($Q = -2.73$ Mev) is very close to 90° symmetry. This may suggest that the yield from this level was mainly brought from the compound process according to the theory of Ericson¹⁰³. For other groups of protons, it seems to be probable that there is a mixing of direct interactions and the compound nuclear process. A discussion on this problem will be published elsewhere in detail.

3-6. On the Result of P³¹

The energy dependence of the angular distribution of p_1' and p_2' are relatively little. In higher energy regions (8 to 14 MeV) both angular distributions take a resembled figure with each other¹¹³. The momentum transfer in the excitation of both levels is equally two. Thus the resemblance suggest an excitation by direct

interactions. The shape of both angular distributions have also some resemblance in the result of present experiment. It could be considered that in this energy range the both direct and compound nuclear reactions are mixed, and the rate of the latter process would be increasing at lower incident energies.

3-7. On the Result of Cl^{35}

At present, the number of data is quite few so that no discussion can be made.

3-8. Conclusive Remarks

The energy dependence of the angular distribution of the elastic scattering is little compared with that of even-even nuclei in the same energy region. This fact was clarified by the present investigation⁴⁾. The reasons can be considered to be the relative height of the compound nucleus and the (p, n) thresholds. The former is in general considerably high in odd-even nuclei compared with even-even nuclei. The latter is low in odd-even nuclei compared with even-even nuclei. Thus the compound nucleus decays less in the ingoing channel in odd-even nuclei than in even-even nuclei. In the latter nuclei the compound nucleus has relatively a small number of out-going channels other than a rejection to the ingoing channel so that the probability of decaying through the same channel as ingoing channel, i.e. the elastic scattering, would be relatively large in its amount in the elastic scattering in low energy protons (see ref. 4). This would cause the relatively large energy dependence of the elastic scattering in even-even nuclei compared with that in odd-even nuclei.

The integrated cross-section of the inelastic scattering is not strongly energy-dependent with few exceptions in this energy region. This aspect is also characteristic point in comparison with that of even-even nuclei and with that of another type of reactions.

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(p, p), (p, p') Scattering from 6 to 7.5 Mev

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY	
B ¹¹	7.45	0	3/2	—
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error*		
21.5	423.	6.		
29.2	251.	4.		
46.3	79.7	1.2		
53.6	45.2	0.3		
64.3	22.8	0.1		
74.5	17.5	0.1		
85.1	21.4	0.1		
95.1	27.7	0.2		
105.1	31.3	0.2		
114.5	32.2	0.2		
124.3	30.1	0.2		
134.0	27.8	0.2		
143.2	26.6	0.2		
152.4	26.4	0.2		
161.5	28.2	0.2		

* Errors are statistical.

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY	
B ¹¹	7.45	-2.13	1/2	—
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error		
22.1	2.77	0.38		
29.5	3.58	0.26		
47.2	4.27	0.15		
54.5	4.28	0.11		
65.3	4.13	0.09		
75.6	3.78	0.08		
86.1	3.73	0.08		
96.2	4.24	0.09		
106.1	4.82	0.09		
115.7	5.76	0.10		
125.3	6.07	0.11		
134.5	6.25	0.12		
144.0	6.29	0.15		
152.3	5.86	0.12		
162.1	5.46	0.12		

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY	
B ¹¹	7.27	0	3/2	—
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error		
21.5	431.	6.		
27.1	270.	4.		
28.2	252.	4.		
46.3	117.	1.		
35.6	56.7	0.5		
64.3	30.3	0.2		
74.5	17.6	0.1		
85.1	21.2	0.2		
95.1	26.8	0.2		
105.1	31.9	0.3		
114.5	32.2	0.3		
124.3	32.0	0.3		
134.0	30.4	0.3		
143.2	31.7	0.3		
152.3	31.8	0.3		
161.5	34.1	0.3		

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY	
B ¹¹	7.27	-2.13	1/2	—
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error		
47.2	4.79	0.19		
54.5	3.95	0.15		
65.3	4.38	0.11		
75.6	4.45	0.11		
86.2	4.68	0.11		
96.2	5.57	0.12		
106.2	6.55	0.12		
115.6	7.23	0.14		
125.3	7.11	0.14		
134.5	7.26	0.14		
144.1	7.38	0.14		
152.3	6.77	0.18		
162.1	6.66	0.16		

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
B ¹¹	7.22	-2.13	1/2 -
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
25.3	3.62	0.72	
27.4	3.07	0.49	
47.2	3.00	0.17	
54.5	3.16	0.15	
65.3	3.19	0.10	
75.6	3.43	0.08	
86.2	3.77	0.09	
96.2	4.15	0.09	
106.2	4.72	0.09	
115.6	5.31	0.14	
125.3	6.01	0.14	
134.5	6.12	0.14	
144.1	6.32	0.14	
152.3	5.91	0.15	
162.1	5.61	0.14	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
B ¹¹	6.94	0	3/2 -
θ_{cm} in degrees	$(d\sigma/d\Omega)_{cm}$ in mb/ster.	Error in mb/ster.	
24.1	446.	7.	
27.1	684.	10.	
47.4	116.	1.	
50.5	97.9	0.8	
53.6	78.4	0.6	
64.3	38.5	0.3	
74.5	25.6	0.2	
85.1	25.5	0.2	
95.1	30.3	0.2	
105.1	35.2	0.3	
114.5	37.1	0.3	
124.3	36.1	0.3	
134.0	34.6	0.3	
143.2	33.6	0.3	
148.0	32.9	0.3	
152.4	34.8	0.3	
161.5	36.8	0.3	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
B ¹¹	6.94	-2.13	1/2 -
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
23.5	6.48	0.60	
48.4	3.84	0.15	
51.4	3.73	0.12	
54.6	3.92	0.11	
65.3	4.42	0.10	
76.0	4.93	0.10	
86.2	5.29	0.13	
96.3	5.22	0.12	
106.2	5.01	0.14	
116.0	5.38	0.15	
125.4	4.81	0.14	
134.6	4.91	0.14	
144.1	4.37	0.18	
153.1	4.53	0.15	
162.1	4.38	0.15	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
B ¹¹	6.81	-2.13	1/2 -
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
25.3	3.17	0.52	
27.4	3.20	0.34	
49.3	3.34	0.19	
54.6	3.53	0.11	
65.3	4.21	0.13	
76.0	4.61	0.13	
86.2	4.94	0.10	
96.3	5.25	0.22	
106.2	5.39	0.11	
116.0	5.03	0.16	
125.4	4.69	0.20	
134.6	4.47	0.15	
144.1	4.64	0.18	
153.1	3.64	0.15	
162.1	3.66	0.12	

(p, p), (p, p') Scattering from 6 to 7.5 Mev

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
B ¹¹	6.55	0	3/2 —
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
25.0	430.	6.	
30.3	345.	5.	
47.4	128.	1.	
53.6	83.6	0.4	
64.3	43.6	0.2	
74.5	33.3	0.2	
85.1	34.1	0.2	
95.1	41.2	0.2	
105.1	45.7	0.2	
114.5	42.6	0.2	
124.3	40.4	0.2	
134.0	36.6	0.2	
143.2	39.4	0.2	
152.4	40.6	0.2	
161.5	49.3	0.2	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
B ¹¹	6.55	-2.13	1/2 —
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error in mb/ster.	
25.3	3.43	0.33	
31.0	3.47	0.16	
46.0	3.42	0.09	
54.6	3.50	0.08	
65.4	3.51	0.07	
76.1	3.44	0.07	
86.3	3.50	0.07	
96.3	3.45	0.07	
106.3	3.41	0.08	
116.1	3.30	0.10	
125.4	3.36	0.09	
134.6	3.39	0.10	
144.1	4.19	0.12	
153.2	3.94	0.12	
162.1	4.75	0.14	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
B ¹¹	6.14	0	3/2 —
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
25.0	433.	6.	
30.3	328.	5.	
47.4	121.	1.	
53.6	80.9	0.4	
64.3	43.5	0.2	
74.5	30.9	0.2	
85.1	32.8	0.2	
95.1	39.6	0.2	
105.1	44.7	0.2	
114.5	48.8	0.2	
124.3	49.7	0.2	
134.0	51.5	0.3	
143.2	50.1	0.3	
152.4	59.1	0.3	
161.5	66.2	0.3	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
B ¹¹	6.14	-2.13	1/2 —
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
25.4	4.07	0.26	
31.1	4.23	0.15	
46.1	4.58	0.14	
55.1	4.52	0.08	
65.5	4.42	0.07	
76.2	3.49	0.06	
86.3	3.23	0.06	
96.4	3.44	0.06	
106.3	3.54	0.07	
116.2	3.91	0.12	
125.5	4.70	0.09	
135.1	5.02	0.09	
144.2	5.26	0.10	
153.2	5.86	0.10	
162.2	5.62	0.10	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
C ¹³	7.05	-3.09	1/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
22.1	1.92	0.84	
27.5	3.98	0.54	
33.0	3.44	0.28	
43.9	3.89	0.20	
54.6	3.59	0.12	
65.2	3.47	0.15	
75.7	2.92	0.07	
85.9	2.76	0.10	
96.0	2.02	0.07	
105.9	1.44	0.13	
115.7	1.40	0.14	
125.2	1.51	0.10	
134.6	2.13	0.14	
143.9	3.17	0.16	
153.0	3.12	0.15	
162.1	3.66	0.17	
166.6	3.87	0.18	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
C ¹³	7.05	-3.68	3/2 -
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
22.3	—	—	
27.9	7.96	0.58	
33.4	6.46	0.29	
44.4	9.12	0.28	
55.2	8.92	0.18	
65.9	7.41	0.22	
76.4	6.57	0.11	
86.7	6.50	0.10	
96.8	7.35	0.12	
106.7	9.00	0.16	
116.4	10.2	0.2	
125.9	11.5	0.2	
135.2	12.7	0.3	
144.4	13.1	0.3	
153.4	13.2	0.3	
162.3	13.0	0.3	
166.8	13.0	0.3	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
C ¹³	7.05	-3.85	5/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
22.3	—	—	
27.9	2.10	0.62	
33.4	3.11	0.34	
44.4	4.20	0.25	
55.2	3.50	0.10	
65.9	3.26	0.17	
76.4	3.10	0.08	
86.7	2.98	0.08	
96.8	3.13	0.08	
106.7	2.75	0.10	
116.4	2.81	0.12	
125.9	3.58	0.11	
135.2	3.07	0.15	
144.4	4.10	0.16	
153.4	4.29	0.18	
162.3	4.41	0.17	
166.8	4.29	0.17	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
C ¹³	6.89	-3.09	1/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
33.1	2.54	0.24	
44.0	2.83	0.21	
54.7	2.92	0.16	
65.3	2.77	0.15	
76.8	2.45	0.14	
86.0	2.53	0.11	
96.2	2.34	0.10	
106.1	1.87	0.18	
115.8	1.78	0.19	
125.3	2.12	0.16	
134.7	2.73	0.18	
143.9	2.82	0.16	
153.1	3.36	0.18	
162.1	3.58	0.19	
166.6	4.03	0.15	

(*p, p*), (*p, p'*) Scattering from 6 to 7.5 Mev

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY	
C ¹³	6.89	-3.68	3/2	-
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.		
33.5	8.01	0.31		
44.4	7.93	0.32		
55.3	7.32	0.31		
66.0	7.07	0.23		
76.5	5.72	0.21		
86.8	5.12	0.20		
97.4	5.41	0.21		
106.8	6.03	0.21		
116.5	6.68	0.22		
126.0	6.80	0.22		
135.3	7.16	0.23		
144.4	7.44	0.22		
153.5	6.75	0.21		
162.4	6.28	0.21		
166.8	6.85	0.21		

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY	
C ¹³	6.89	-3.85	5/2	+
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.		
33.5	2.29	0.28		
44.4	3.54	0.25		
55.3	3.70	0.22		
66.0	4.34	0.16		
76.5	2.50	0.16		
86.8	2.91	0.15		
97.4	2.57	0.16		
106.8	2.44	0.16		
116.5	2.38	0.17		
126.0	2.27	0.18		
135.3	2.57	0.15		
144.4	2.34	0.15		
153.5	2.42	0.16		
162.4	2.05	0.15		
166.8	2.25	0.15		

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY	
C ¹³	6.60	-3.09	1/2	+
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.		
33.1	2.01	0.28		
44.0	1.44	0.16		
54.8	2.04	0.16		
65.4	2.06	0.12		
75.9	1.97	0.14		
86.2	2.58	0.16		
96.3	2.21	0.16		
106.2	2.15	0.21		
115.9	2.90	0.24		
125.4	3.45	0.29		
134.8	3.58	0.19		
144.0	4.27	0.24		
153.1	4.43	0.24		
162.2	5.12	0.26		

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY	
C ¹³	6.60	-3.68	3/2	-
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.		
33.6	12.7	0.1		
44.6	9.12	0.30		
55.5	9.39	0.32		
66.2	7.17	0.23		
76.7	6.54	0.24		
87.0	5.57	0.22		
97.2	4.65	0.22		
107.0	4.63	0.31		
116.7	6.00	0.31		
126.2	5.39	0.32		
135.5	4.70	0.21		
144.6	4.34	0.26		
153.6	4.52	0.26		
162.4	4.48	0.25		

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY	TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
C^{13}	6.60	-3.85	5/2 +	F^{19}	7.42	-1.35 -1.46 -1.56	5/2 - 3/2 - 3/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.		θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
33.6	4.25	0.43		31.4	4.68	0.17	
44.6	2.87	0.21		42.1	6.40	0.12	
55.5	3.14	0.20		46.2	7.34	0.08	
66.2	3.69	0.19		52.4	8.11	0.09	
76.7	3.32	0.19		62.6	9.54	0.09	
87.0	3.29	0.20		73.1	10.0	0.1	
97.2	3.58	0.26		83.2	10.3	0.1	
107.0	3.37	0.26		93.2	10.4	0.1	
116.7	2.74	0.26		103.2	10.2	0.1	
126.2	2.23	0.24		113.2	9.52	0.11	
135.5	2.76	0.20		122.6	8.87	0.10	
144.6	2.13	0.21		132.4	7.03	0.10	
153.6	2.04	0.22		141.1	6.03	0.10	
162.4	1.76	0.21		151.4	4.31	0.10	
				161.1	4.12	0.09	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY	TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
F^{19}	7.41	-2.78	(7/2, 9/2)	F^{19}	7.27	-1.35 -1.46 -1.56	5/2 - 2/2 - 3/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.		θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
31.6	1.90	0.10		31.4	5.24	0.19	
42.3	2.14	0.07		42.1	6.18	0.10	
46.4	1.94	0.04		46.2	7.11	0.14	
52.6	1.78	0.05		52.4	7.83	0.08	
63.2	1.55	0.05		62.6	9.20	0.08	
73.4	1.37	0.05		73.1	10.6	0.1	
83.5	1.12	0.05		83.2	10.6	0.1	
93.5	1.03	0.05		93.2	11.0	0.1	
103.5	1.05	0.04		103.2	10.6	0.1	
113.4	0.991	0.054		113.1	9.98	0.07	
123.2	1.01	0.05		122.6	8.75	0.08	
132.6	0.912	0.054		132.4	7.57	0.08	
142.3	0.973	0.054		141.1	6.23	0.08	
151.6	1.02	0.059		151.4	5.05	0.08	
161.2	0.870	0.060		161.1	4.44	0.08	

(p, p), (p, p') Scattering from 6 to 7.5 Mev

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
F ¹⁹	7.27	-2.78	(7/2, 9/2)
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
31.6	2.35	0.13	
42.3	1.85	0.07	
46.4	1.76	0.08	
52.6	1.62	0.05	
63.2	1.22	0.05	
73.4	1.04	0.04	
83.5	0.997	0.050	
93.5	0.845	0.034	
103.5	0.782	0.040	
113.4	0.705	0.043	
123.2	0.753	0.047	
132.6	0.633	0.047	
142.3	0.563	0.051	
151.6	0.560	0.055	
161.2	0.746	0.064	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
F ¹⁹	7.02	-1.35 -1.46 -1.56	5/2 - 3/2 - 3/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
31.4	8.74	0.23	
42.1	9.70	0.15	
52.4	11.0	0.2	
62.6	12.8	0.14	
73.1	14.6	0.2	
83.2	15.0	0.15	
93.3	14.6	0.13	
103.2	13.7	0.14	
113.1	11.8	0.17	
122.6	10.4	0.12	
132.4	8.92	0.12	
142.1	7.26	0.12	
151.4	6.57	0.21	
161.1	4.55	0.22	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
F ¹⁹	7.02	-2.78	(7/2, 9/2)
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
31.6	1.45	0.14	
42.3	1.32	0.08	
53.4	1.08	0.08	
63.3	0.990	0.069	
73.4	0.853	0.066	
83.5	0.805	0.071	
93.6	0.794	0.050	
103.5	0.717	0.050	
113.4	0.758	0.068	
123.3	0.795	0.064	
133.0	0.770	0.066	
142.3	0.598	0.118	
151.6	0.521	0.113	
161.2	0.279	0.130	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
F ¹⁹	6.78	-1.35 -1.46 -1.56	5/2 - 3/2 - 3/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
31.4	10.0	0.3	
42.1	11.3	0.3	
52.4	12.9	0.2	
62.6	14.7	0.2	
73.1	15.2	0.5	
83.2	15.4	0.2	
93.3	14.9	0.2	
103.2	14.2	0.2	
113.1	12.3	0.2	
122.6	11.0	0.2	
132.4	9.54	0.26	
142.1	9.07	0.27	
151.4	8.14	0.21	
161.1	6.72	0.26	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY	TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
F ¹⁹	6.78	-2.78	(7/2, 9/2)	Mg ²⁵	7.0	0	5/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.		θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
32.0	2.19	0.25		62.0	107.3	0.6	
42.4	1.99	0.17		72.2	68.3	0.5	
53.1	1.63	0.09		82.3	45.1	0.4	
63.3	1.38	0.10		92.3	33.9	0.3	
73.5	1.24	0.18		102.3	27.6	0.2	
83.6	1.04	0.08		112.2	22.8	0.3	
94.1	0.817	0.075		122.0	22.2	0.3	
103.6	0.644	0.068		131.8	24.8	0.4	
113.5	0.713	0.088		141.5	22.0	0.3	
123.3	0.811	0.097		151.2	20.7	0.3	
133.0	0.557	0.081		156.0	24.4	0.3	
142.3	0.726	0.166					
152.0	0.651	0.120					
161.2	0.714	0.160					

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY	TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
Mg ²⁵	7.0	-0.584	1/2 +	Mg ²⁵	7.0	-0.976	3/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.		θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
51.9	3.17	0.26		36.4	4.13	0.50	
62.1	2.73	0.25		41.6	2.30	0.40	
72.3	2.17	0.26		51.9	2.73	0.19	
				62.1	3.12	0.12	
				72.3	2.78	0.12	
				82.4	2.28	0.13	
				92.5	2.26	0.10	
				102.4	2.39	0.17	
				112.3	2.74	0.31	
				122.1	2.19	0.41	

(p, p), (p, p') Scattering from 6 to 7.5 Mev

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
Mg ²⁵	7.0	-1.611	(7/2) +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{cm}$ in mb/ster.	Error in mb/ster.	
36.5	10.2	0.5	
41.7	10.1	0.4	
52.0	11.5	0.3	
62.4	9.88	0.23	
72.5	7.45	0.19	
82.6	5.07	0.11	
92.6	4.77	0.12	
102.6	4.83	0.14	
112.5	5.63	0.20	
122.4	7.81	0.23	
132.0	8.15	0.34	
141.7	7.99	0.21	
151.3	6.57	0.13	
156.1	6.30	0.21	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
Mg ²⁵	7.0	-1.962	5/2 +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{cm}$ in mb/ster.	Error in mb/ster.	
36.6	6.44	0.76	
41.8	4.61	0.34	
52.1	4.54	0.22	
62.4	3.80	0.15	
72.6	3.22	0.14	
82.7	2.59	0.13	
92.7	1.96	0.09	
102.7	1.85	0.11	
112.6	2.26	0.16	
122.4	2.68	0.16	
132.1	3.02	0.30	
141.8	2.29	0.14	
151.4	2.03	0.17	
156.6	2.08	0.17	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
Mg ²⁵	7.0	-2.565	1/2 +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{cm}$ in mb/ster.	Error in mb/ster.	
36.7	1.94	0.49	
41.9	—	—	
52.2	1.16	0.18	
62.5	1.14	0.15	
72.7	0.919	0.113	
82.9	0.852	0.151	
92.9	0.759	0.081	
102.9	0.788	0.137	
112.7	0.910	0.143	
122.5	0.986	0.153	
132.2	1.11	1.23	
141.9	0.999	0.145	
151.5	0.617	0.159	
156.2	0.919	0.153	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
Mg ²⁵	7.0	-2.736 -2.803	(7/2) + (3/2, 5/2)
θ_{cm} in degrees	$(d\sigma/d\Omega)_{cm}$ in mb/ster.	Error in mb/ster.	
36.8	4.81	0.47	
42.0	—	—	
52.3	5.78	0.22	
62.6	4.89	0.19	
72.8	4.90	0.17	
82.9	4.02	0.16	
93.0	3.49	0.11	
102.9	3.40	0.14	
112.8	3.69	0.13	
122.6	4.92	0.20	
132.3	4.82	0.32	
141.9	3.89	0.18	
151.5	2.94	0.17	
156.2	2.86	0.17	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
Mg ²⁵	7.0	-3.399 -3.408	(9/2) + 3/2 -
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
36.8	4.20	0.40	
42.1	4.46	0.34	
52.5	6.28	0.22	
62.8	8.29	0.24	
73.1	5.91	0.16	
83.2	4.34	0.15	
93.3	3.41	0.10	
103.2	3.50	0.13	
113.1	4.21	0.19	
122.8	5.23	0.23	
132.5	4.67	0.30	
142.1	4.12	0.17	
151.6	3.33	0.17	
156.4	3.97	0.17	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
Al ²⁷	7.35	0	5/2 +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{cm}$ in mb/ster.	Error in mb/ster.	
25.5	1130.	2.	
31.0	590.	2.	
41.2	254.	0.6	
51.4	136.	0.4	
61.5	83.1	0.3	
72.0	57.0	0.3	
82.1	39.5	0.2	
92.1	29.1	0.2	
102.1	21.1	0.2	
112.0	17.3	0.2	
121.5	16.7	0.2	
131.4	19.8	0.2	
141.2	25.1	0.2	
151.0	30.3	0.2	
160.4	34.7	0.2	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
A1 ²⁷	7.35	-0.842 -1.013	1/2 + 3/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
31.1	6.39	0.33	
41.3	6.59	0.18	
51.5	6.21	0.13	
61.6	5.99	0.12	
72.1	5.66	0.11	
82.2	5.36	0.11	
92.2	5.19	0.11	
102.2	5.25	0.11	
112.1	5.09	0.14	
121.6	4.92	0.14	
131.5	4.69	0.15	
141.3	4.03	0.15	
151.1	3.80	0.15	
160.5	3.36	0.15	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
Al ²⁷	7.35	-2.208	7/2 +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error in mb/ster.	
31.2	7.39	0.31	
41.4	6.12	0.16	
51.6	5.56	0.12	
62.1	5.20	0.11	
72.2	4.56	0.11	
82.3	4.54	0.11	
92.3	4.21	0.10	
102.3	4.27	0.10	
112.2	4.26	0.15	
122.1	4.44	0.15	
131.6	4.22	0.15	
141.4	4.25	0.16	
151.2	4.17	0.16	
160.5	3.43	0.15	

(p, p), (p, p') Scattering from $\bar{6}$ to 7.5 Mev

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
A1 ²⁷	7.35	-2.729	5/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
31.2	3.42	0.23	
41.5	—	—	
52.0	2.64	0.08	
62.2	2.60	0.07	
72.3	3.00	0.09	
82.4	2.81	0.08	
92.4	3.06	0.08	
102.4	3.06	0.13	
112.3	3.07	0.13	
122.2	3.13	0.12	
132.1	2.95	0.12	
141.4	3.31	0.14	
151.2	3.64	0.13	
160.6	3.13	0.13	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
A1 ²⁷	7.35	-2.976 -3.000	3/2 + 9/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
31.2	7.81	0.30	
41.5	8.86	0.16	
52.1	6.88	0.12	
62.3	6.33	0.11	
72.4	6.05	0.12	
82.5	5.89	0.11	
92.5	5.68	0.11	
102.5	5.30	0.10	
112.4	5.12	0.15	
122.3	5.06	0.15	
132.1	4.66	0.15	
141.5	4.63	0.16	
151.2	4.59	0.15	
160.6	4.44	0.15	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
A1 ²⁷	7.14	0	5/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
25.5	1172.	3.	
31.0	616.	1.3	
41.2	252.2	0.7	
51.4	136.1	0.6	
61.5	83.1	0.5	
72.0	59.7	0.4	
82.1	41.6	0.4	
92.1	28.3	0.3	
102.1	20.6	0.3	
112.0	16.0	0.2	
121.5	17.0	0.2	
131.4	21.1	0.3	
141.2	27.2	0.3	
151.0	33.2	0.3	
160.4	40.9	0.4	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
A1 ²⁷	7.14	-0.842 -1.013	1/2 + 3/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
25.6	7.42	0.58	
31.1	6.75	0.30	
41.3	7.12	0.19	
51.5	6.40	0.19	
61.6	6.00	0.17	
72.1	5.84	0.16	
82.2	5.67	0.16	
92.2	5.77	0.13	
102.2	5.93	0.16	
112.1	6.07	0.18	
121.6	5.74	0.22	
131.5	5.91	0.23	
141.3	5.70	0.19	
151.1	5.37	0.20	
160.5	4.70	0.21	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
A1 ²⁷	7.14	-2.208	7/2 +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error in mb/ster.	
26.1	5.98	0.57	
31.2	4.62	0.27	
41.4	5.78	0.18	
51.6	5.41	0.18	
62.1	5.18	0.17	
72.3	5.14	0.16	
82.3	5.02	0.15	
92.3	4.81	0.13	
102.3	4.91	0.16	
112.3	5.31	0.21	
122.1	5.47	0.21	
141.4	5.92	0.22	
151.2	6.17	0.24	
160.5	5.90	0.23	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
A1 ²⁷	7.14	-2.729	5/2 +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error in mb/ster.	
26.1	2.26	0.47	
31.2	1.92	0.19	
41.5	3.68	0.15	
52.1	2.31	0.13	
62.2	2.28	0.13	
72.3	2.52	0.13	
82.4	2.53	0.12	
92.4	2.73	0.10	
102.4	3.06	0.14	
112.3	2.99	0.18	
122.2	2.69	0.16	
132.1	2.63	0.16	
141.5	2.28	0.18	
151.2	2.14	0.17	
160.6	2.45	0.19	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
A1 ²⁷	7.14	-2.975 -3.000	3/2 + 9/2 +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error in mb/ster.	
26.1	7.30	0.53	
31.3	8.11	0.29	
41.5	8.42	0.18	
52.1	7.83	0.20	
62.3	6.73	0.18	
72.4	6.22	0.18	
82.5	5.41	0.17	
92.5	5.54	0.15	
102.5	4.87	0.18	
112.4	4.63	0.22	
122.3	5.43	0.23	
132.1	6.20	0.24	
141.5	6.06	0.26	
151.3	6.48	0.27	
160.6	6.40	0.26	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
A1 ²⁷	6.95	0	5/2 +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error in mb/ster.	
25.5	1285.	2.	
31.0	645.	2.	
41.2	267.	2.	
51.4	141.3	0.7	
61.5	85.9	0.5	
72.0	60.3	0.5	
82.1	45.6	0.4	
92.1	33.2	0.3	
102.1	25.3	0.3	
112.0	21.6	0.3	
121.5	21.9	0.3	
131.4	26.1	0.3	
141.2	31.9	0.4	
151.0	39.0	0.4	
160.4	45.1	0.4	

(p, p), (p, p') Scattering from 6 to 7.5 Mev

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
A1 ²⁷	6.95	-0.842 -1.013	1/2 + 3/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
25.6	—	—	
31.1	5.93	0.30	
41.3	6.19	0.18	
51.5	5.57	0.19	
61.6	5.02	0.17	
72.1	4.96	0.16	
86.2	4.60	0.16	
92.2	4.63	0.16	
102.2	5.00	0.15	
112.1	5.27	0.19	
122.0	5.38	0.20	
131.5	5.60	0.21	
141.3	5.00	0.22	
151.1	4.80	0.21	
160.5	4.45	0.21	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
A1 ²⁷	6.95	-2.208	7/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
26.1	8.33	0.40	
31.2	8.23	0.31	
41.4	7.96	0.17	
51.6	7.67	0.19	
62.1	7.02	0.19	
72.3	5.94	0.18	
82.3	5.36	0.17	
92.4	5.24	0.17	
102.3	4.82	0.15	
112.3	4.68	0.21	
122.2	4.35	0.20	
131.6	5.05	0.23	
141.4	4.92	0.22	
151.2	5.40	0.23	
160.5	4.84	0.22	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
A1 ²⁷	6.95	-2.729	5/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
26.1	3.07	0.32	
31.2	3.32	0.21	
41.5	4.00	0.13	
52.1	3.12	0.14	
62.2	2.64	0.12	
72.4	2.85	0.13	
82.4	2.92	0.13	
92.5	2.69	0.14	
102.4	2.19	0.12	
112.4	2.19	0.16	
122.2	2.28	0.18	
132.1	3.07	0.19	
141.5	2.47	0.19	
151.2	2.08	0.18	
160.6	2.61	0.18	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
A1 ²⁷	6.95	-2.976 -3.000	3/2 + 9/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
26.1	14.7	0.5	
31.3	12.0	0.3	
41.5	10.8	0.2	
52.1	8.46	0.20	
62.3	6.95	0.18	
72.4	5.92	0.18	
82.5	5.89	0.19	
92.5	5.69	0.20	
102.5	6.61	0.21	
112.4	7.86	0.26	
122.3	8.44	0.19	
132.1	8.95	0.29	
141.5	9.20	0.30	
151.3	9.81	0.33	
160.6	9.55	0.31	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY	TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
A1 ²⁷	6.71	0	5/2 +	A1 ²⁷	6.71	-0.842 -1.013	1/2 + 3/2 +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error in mb/ster.		θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error in mb/ster.	
25.5	1432.	2.		25.6	5.41	0.52	
31.0	743.	2.		31.1	5.29	0.36	
41.2	317.	1.		41.3	5.49	0.25	
51.4	171.	0.8		51.5	6.03	0.22	
61.5	105.3	0.7		62.0	5.95	0.21	
72.0	69.3	0.5		72.1	5.96	0.19	
82.1	50.7	0.4		82.2	5.76	0.19	
92.1	39.0	0.4		92.2	5.57	0.18	
102.1	30.0	0.3		102.2	5.14	0.17	
112.0	25.6	0.3		112.1	4.76	0.19	
121.5	23.7	0.3		122.0	5.11	0.20	
131.4	27.1	0.3		131.5	5.08	0.21	
141.2	32.3	0.4		141.3	5.23	0.21	
151.0	40.1	0.4		151.1	4.90	0.22	
160.4	46.3	0.4		160.5	4.88	0.22	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY	TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
A1 ²⁷	6.71	-2.208	7/2 +	A1 ²⁷	6.71	-2.729	5/2 +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error in mb/ster.		θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error in mb/ster.	
26.1	6.14	0.53		26.1	2.17	0.43	
31.2	5.47	0.36		32.2	1.25	0.26	
41.4	5.81	0.25		41.5	3.71	0.22	
52.0	5.94	0.22		52.1	2.29	0.15	
62.2	6.01	0.22		62.3	2.45	0.18	
72.3	6.65	0.21		72.4	2.82	0.17	
82.3	6.24	0.20		82.5	3.43	0.18	
92.4	6.12	0.21		92.5	3.36	0.18	
102.3	5.50	0.18		102.5	2.99	0.16	
112.3	5.23	0.24		112.4	3.51	0.18	
122.2	4.75	0.24		122.3	2.77	0.18	
132.0	4.16	0.23		132.1	3.10	0.18	
141.4	4.33	0.23		141.5	3.01	0.21	
151.2	3.74	0.24		151.2	3.03	0.21	
160.5	3.55	0.23		160.6	3.28	0.21	

(p, p), (p, p') Scattering from 6 to 7.5 Mev

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
A1 ²⁷	6.71	-2.976 -3.000	3/2 + 9/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
26.1	5.23	0.54	
31.3	5.18	0.33	
41.5	5.74	0.24	
52.1	5.51	0.22	
62.3	5.60	0.24	
72.4	5.77	0.22	
82.5	5.51	0.23	
92.5	5.90	0.24	
102.5	5.54	0.19	
112.4	5.22	0.24	
122.3	5.54	0.35	
132.1	5.08	0.22	
141.5	4.83	0.23	
151.3	5.12	0.24	
161.0	4.54	0.24	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
A1 ²⁷	6.57	0	5/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
25.5	—	—	
31.0	715.	2.	
41.2	292.	1.	
51.4	158.	0.9	
61.5	96.8	0.7	
72.0	61.5	0.6	
82.1	41.9	0.5	
92.1	29.5	0.4	
102.1	22.9	0.4	
112.0	20.1	0.3	
121.5	22.4	0.4	
131.4	26.9	0.4	
141.2	34.1	0.3	
151.0	41.1	0.5	
160.4	46.6	0.5	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
A1 ²⁷	6.57	-0.842 -1.013	1/2 + 3/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
25.6	—	—	
31.1	5.54	0.37	
41.3	5.98	0.28	
51.5	5.50	0.25	
62.0	5.91	0.23	
72.1	6.00	0.21	
82.2	5.88	0.22	
92.2	6.15	0.23	
102.2	6.42	0.23	
112.1	6.92	0.26	
122.0	7.04	0.26	
131.5	6.89	0.26	
141.3	6.25	0.21	
151.1	6.21	0.28	
160.5	6.80	0.27	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
A1 ²⁷	6.57	-2.208	7/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
26.1	—	—	
31.2	4.94	0.35	
41.4	4.98	0.26	
52.0	4.93	0.24	
62.2	5.57	0.23	
72.3	5.52	0.23	
82.4	6.58	0.24	
92.4	6.66	0.24	
102.4	5.70	0.23	
112.3	5.50	0.31	
122.2	5.35	0.30	
132.1	4.42	0.29	
141.4	4.80	0.24	
151.2	4.47	0.32	
160.6	4.95	0.32	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
A1 ²⁷	6.57	-2.729	5/2 +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error in mb/ster.	
26.1	—	—	
32.2	2.97	0.30	
41.5	5.98	0.26	
52.1	3.41	0.22	
62.3	3.46	0.20	
72.4	3.72	0.22	
82.5	3.45	0.22	
92.5	3.60	0.26	
102.5	3.40	0.25	
112.4	4.16	0.30	
122.3	4.69	0.33	
132.1	3.52	0.31	
141.5	—	—	
151.2	4.28	0.38	
160.6	5.01	0.41	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
A1 ²⁷	6.57	-2.976 -3.000	3/2 + 9/2 +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error in mb/ster.	
26.1	—	—	
31.3	6.59	0.30	
41.5	5.74	0.28	
52.1	5.31	0.25	
62.3	5.38	0.26	
72.4	5.02	0.28	
82.5	6.21	0.32	
92.5	6.40	0.37	
102.5	7.21	0.38	
112.4	7.05	0.42	
122.3	6.66	0.43	
132.1	6.72	0.46	
141.5	—	—	
151.3	—	—	
161.0	—	—	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
P ³¹	7.35	0	1/2 +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error in mb/ster.	
25.5	995.9	6.5	
34.0	434.3	2.7	
41.1	249.2	1.5	
51.3	150.2	1.5	
61.4	97.0	0.6	
71.4	58.6	0.4	
81.5	36.0	0.2	
91.5	19.1	0.2	
101.5	12.4	0.1	
111.4	9.11	0.11	
121.4	10.4	0.1	
131.3	16.3	0.2	
141.1	26.6	0.2	
150.6	41.6	0.2	
160.4	57.3	0.3	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
P ³¹	7.35	-1.265	3/2 +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error in mb/ster.	
34.1	5.77	0.38	
41.2	5.34	0.20	
51.3	5.11	0.16	
61.5	4.76	0.11	
71.6	4.46	0.10	
82.0	3.58	0.08	
92.0	3.25	0.08	
102.0	2.98	0.08	
111.6	3.08	0.11	
121.5	3.23	0.11	
131.3	3.90	0.24	
141.2	3.86	0.34	
151.0	3.62	0.52	
160.4	3.54	0.32	

(p, p), (p, p') Scattering from 6 to 7.5 Mev

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
P ³¹	7.35	-2.232	5/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
25.6	4.22	0.68	
28.0	4.36	0.44	
41.3	4.50	0.17	
51.4	4.60	0.15	
61.6	4.63	0.10	
72.1	4.39	0.10	
82.1	4.52	0.10	
92.1	4.25	0.10	
102.1	4.08	0.09	
112.1	3.60	0.15	
121.6	3.19	0.14	
131.4	3.00	0.14	
141.3	2.79	0.13	
151.1	2.39	0.13	
160.5	2.64	0.13	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
P ³¹	7.10	0	1/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
27.5	1112.	6.	
34.0	679.	4.	
43.2	349.	2.	
51.3	227.	1.3	
61.4	130.	1.	
71.4	81.9	0.7	
81.5	50.9	0.5	
91.5	33.1	0.4	
101.5	20.6	0.2	
111.4	15.0	0.2	
121.4	17.1	0.2	
131.3	28.8	0.3	
141.1	48.5	0.3	
150.6	71.9	0.4	
160.4	96.4	0.5	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
P ³¹	7.10	-1.265	3/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
34.1	4.33	0.47	
43.2	4.45	0.25	
51.3	4.78	0.20	
61.5	5.06	0.18	
71.6	5.42	0.15	
82.0	5.94	0.14	
92.0	6.50	0.13	
102.0	4.57	0.12	
111.6	4.22	0.18	
121.5	3.42	0.16	
131.3	3.32	0.15	
141.2	3.28	0.13	
151.0	3.27	0.13	
160.4	3.46	0.20	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
P ³¹	7.10	-2.232	5/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
27.6	4.47	0.64	
43.2	4.86	0.23	
51.3	4.94	0.20	
61.5	5.31	0.18	
71.6	5.60	0.16	
82.0	5.88	0.14	
92.0	6.02	0.13	
102.0	5.91	0.14	
111.6	5.59	0.14	
121.5	4.80	0.17	
131.3	4.31	0.22	
141.2	3.70	0.21	
151.0	3.28	0.19	
160.4	3.26	0.20	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
P ³¹	6.95	0	1/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
28.5	993.	15.	
34.0	578.	9.	
41.1	354.	5.	
51.3	202.	3.	
61.4	124.	2.	
71.4	74.2	1.1	
81.5	43.5	0.3	
91.5	24.2	0.2	
101.5	11.6	0.2	
111.4	6.20	0.10	
121.4	8.13	0.11	
131.3	15.8	0.2	
141.1	27.5	0.2	
150.6	42.0	0.3	
160.4	53.7	0.3	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
P ³¹	6.95	-1.265	3/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
34.1	4.65	0.26	
41.2	4.34	0.18	
51.3	4.41	0.15	
61.5	4.18	0.13	
71.6	3.88	0.11	
82.0	3.39	0.11	
92.0	3.37	0.10	
102.0	3.34	0.11	
111.6	3.45	0.14	
121.5	3.89	0.15	
131.3	4.45	0.20	
141.2	4.98	0.15	
151.2	5.27	0.15	
160.4	5.45	0.15	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
P ³¹	6.95	-2.232	5/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
29.0	3.87	0.34	
41.3	4.25	0.19	
51.4	4.60	0.13	
61.6	4.59	0.12	
72.1	4.75	0.11	
82.1	4.78	0.13	
92.2	4.60	0.13	
102.1	4.63	0.13	
112.1	4.64	0.17	
121.6	4.43	0.16	
131.4	4.04	0.18	
141.3	3.52	0.15	
151.1	2.93	0.16	
160.5	2.34	0.16	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
P ³¹	6.71	0	1/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
27.5	943.	14.	
34.0	593.	9.	
43.2	294.	5.	
51.3	182.	3.	
61.4	119.	2.	
71.4	68.5	1.0	
81.5	43.8	0.7	
91.5	27.3	0.3	
101.5	16.5	0.2	
111.4	11.7	0.2	
121.4	14.2	0.2	
131.3	23.8	0.2	
141.1	36.7	0.3	
150.6	50.9	0.4	
160.4	64.6	0.4	

(p, p), (p, p') Scattering from 6 to 7.5 Mev

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
P ³¹	6.71	-1.265	3/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
34.1	4.63	0.40	
43.2	4.33	0.21	
51.3	4.45	0.17	
61.5	4.21	0.14	
71.6	3.81	0.13	
82.0	3.92	0.11	
92.0	3.70	0.16	
102.0	3.74	0.11	
111.6	3.82	0.15	
121.5	4.17	0.15	
131.3	4.64	0.14	
141.2	4.98	0.16	
151.0	5.12	0.14	
160.4	5.05	0.14	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
P ³¹	6.71	-2.232	5/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
28.0	5.38	0.80	
42.2	5.59	0.20	
51.4	6.38	0.18	
61.5	5.80	0.16	
72.1	5.84	0.15	
82.1	5.93	0.14	
92.2	5.62	0.14	
102.1	5.37	0.13	
112.1	5.16	0.19	
121.6	4.93	0.20	
131.4	4.66	0.19	
141.3	4.48	0.19	
151.1	4.54	0.19	
160.5	4.44	0.19	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
P ³¹	6.54	0	1/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
28.5	1824.	27.	
30.6	1699.	26.	
36.0	507.	8.	
41.1	360.	5.	
44.2	320.	5.	
51.3	212.	3.	
61.4	128.	2.	
71.4	75.8	0.9	
81.5	46.6	0.7	
91.5	27.5	0.5	
101.5	14.5	0.3	
111.4	7.84	0.11	
121.3	8.22	0.10	
131.3	13.2	0.1	
141.1	20.3	0.2	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
P ³¹	6.54	-1.265	3/2 +
θ_{em} in degrees	$(d\sigma/d\Omega)_{em}$ in mb/ster.	Error in mb/ster.	
36.1	4.85	0.33	
41.2	4.80	0.35	
44.2	5.07	0.22	
51.4	5.10	0.18	
61.5	4.55	0.15	
71.6	4.47	0.15	
82.0	4.23	0.14	
92.0	4.37	0.16	
102.0	4.30	0.13	
111.6	3.91	0.17	
121.5	4.16	0.18	
131.4	4.31	0.17	
141.2	4.60	0.16	
151.0	4.95	0.13	
160.4	4.50	0.12	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
P ³¹	6.54	-2.232	5/2 +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error in mb/ster.	
29.1	5.26	0.61	
31.1	4.63	0.79	
44.3	4.52	0.20	
51.5	4.89	0.18	
61.6	5.45	0.17	
72.1	5.57	0.17	
82.2	5.48	0.17	
92.2	5.09	0.19	
102.2	5.02	0.17	
112.1	4.59	0.24	
122.0	3.74	0.21	
131.5	2.88	0.21	
141.3	2.45	0.20	
151.1	3.09	0.23	
160.5	2.24	0.21	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
Cl ³⁵⁺³⁷	7.0	0	3/2 +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error in mb/ster.	
20.5	4687.	19.	
30.8	1051.	5.	
46.1	381.5	2.9	
61.4	144.7	6.6	
71.5	84.6	0.5	
81.6	52.3	0.4	
91.6	27.3	0.3	
106.6	12.0	0.2	
121.4	13.9	0.2	
136.1	28.5	0.3	
150.8	39.1	0.4	
160.5	46.8	0.4	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
Cl ³⁵	7.0	-1.22	+
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error in mb/ster.	
30.9	3.84	0.34	
46.3	2.46	0.37	
61.6	2.46	0.28	
71.7	1.59	0.12	
81.8	1.15	0.11	
91.8	1.34	0.12	
106.8	1.53	0.18	
121.6	2.59	0.12	
136.3	3.40	0.11	
150.9	3.79	0.14	
160.6	4.09	0.15	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
Cl ³⁵⁺³⁷	6.7	0	3/2 +
θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error in mb/ster.	
25.7	1618.	15.	
30.8	806.	5.	
41.0	380.	2.	
56.3	153.	0.7	
71.5	68.4	0.6	
86.6	26.0	1.6	
101.6	10.6	0.3	
116.5	8.84	0.22	
131.2	14.4	0.3	
145.9	29.9	0.4	
160.6	41.0	0.3	

TARGET NUCLEUS	INCIDENT ENERGY (MeV)	Q-VALUE OF THE LEVEL (MeV)	SPIN & PARITY
Cl ³⁵	6.7	-1.22	+
	θ_{cm} in degrees	$(d\sigma/d\Omega)_{\text{cm}}$ in mb/ster.	Error in mb/ster.
	25.8	—	—
	30.9	4.37	0.78
	41.2	2.65	0.27
	56.5	2.06	0.15
	71.7	1.48	0.13
	86.8	1.31	0.12
	101.8	1.10	0.11
	116.6	—	—
	131.4	2.31	0.14
	146.0	3.60	0.17
	160.6	3.71	0.12

REFERENCES

- (1) A. Bohr and B. R. Mottelson, "Beta- and Gamma-Ray Spectroscopy", North-Holland Publishing Co., p. 468 (1955).
- (2) J. Kokame, *J. Phys. Soc. Japan*, **16**, 2101 (1961).
- (3) H. Taketani, "Genshikaku Kenkyu" -circular in Japan- **8**, 604 (1964).
- (4) K. Kimura, Y. Uemura, R. Ishiwari, J. Kokame, K. Fukunaga, A. Katase, J. Muto, I. Kumabe, H. Ogata, T. Ohama and Y. Ohmori, *J. Phys. Soc. Japan*, **17**, 9 (1962).
- (5) A. B. Clegg, *Nuclear Physics*, **38**, 353 (1962); *Phil. Mag.* **6**, 1207 (1961).
- (6) J. Kokame, K. Fukunaga, H. Nakamura and N. Inoue, to be published in *J. Phys. Soc. Japan*.
- (7) K. Matsuda, "Proc. Internat. Conf. Nuclear Struct., Kingston, North-Holland Publishing Co., p. 228 (1960).
- (8) S. G. Nilsson, *Danske Vid. Selsk. Fys. Mat. Medd.* **29**, No. 16 (1955).
- (9) H. E. Gove, "Proc. Internat. Conf. Nuclear Struct., Kingston," North-Holland Publishing Co., p. 438 (1960).
- (10) T. Ericson, *Advances in Phys.* **9**, 415 (1960).
- (11) J. Kokame, R. Ishiwari, K. Miyake, J. Muto, H. Itoh, T. Ohama, K. Ueda, S. Tahira and K. Baba, "Genshikaku Kenkyu" -circular in Japan- **7**, 73, 340 (1963).