The Measurement By Activation of Excitation Function for The Reaction Al^{27} (n, p) Mg^{27} in the Range 13-15 MeV

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ABSTRACT

Relative cross section of $Al^{27}(n, p)Mg^{27}$ reaction have been measured in the neutron energy range between 13 - 15 MeV by measuring the gamma ray activity with the Beta decay of the residual nucleus.

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Many data on activation cross section of 14 MeV neutron induced reaction have been obtained. The impetus for measuring reaction cross section in the medium and heavy elements is that such measurements are capable of giving us information about mechanisms by which the interaction between the incident and target nucleus proceeds. The reaction cross section also can be used as a flux monitor i.e. fast neutron fluxes are frequently measured by using monitor foils.

The measurement of reaction cross section of $Al^{27}(n, p)Mg^{27}$ in 13 - 15 MeV regions is done by activation technique. Deuterons bombard a tritium target to produce neutrons. The Al^{27} samples are placed at diffetritium target to produce neutrons. The Al^{27} samples are placed at different neutron energies. After bombardment the radioactivity induced in the samples is measured by gamma ray counter. From these data relative cross section is determined.

Many nuclear cross sections fluctuate rapidly with neutron energy, even at energies corresponding to compound nucleus excitation of the order of 20 MeV.

The variation of cross section of $Al^{27}(n, p)Mg^{27}$ reaction in the 10 -

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20 MeV range have been measured previously by several workers. Some of the workers observed that the cross sections are approximately constant (Partington et al, 1970) or no significant fluctuation (Bonnazzola et al, 1964; Gsikai, 1965) and others showed variations (Mani et al, 1960) with energy.

The aim of the present work is to study the excitation function for the reaction $Al^{27}(n, p)Mg^{27}$ using neutrons with energies between approximately 13 - 15 MeV. The relative cross sections in the above neutron energy ranges have been determined by measuring the gamma ray activity associated with the Beta decay of the residual nucleus.

EXPERIMENTAL PROCEDURE

Fast neutrons were produced by irradiating thick trintiated titanium with 300 KeV deuterons from a small Van de Graaff accelerator. The neutron energy was varied by making the measurements at different angles with respect to the deuteron beam. The neutron energies vary from 15.144 MeV to 13.293 MeV as thc angle varies from 0 to 160° after making appropiate corrections for the energy loss of the deuterons in the target and the energy spread due to the finite angle subtended by the specimen at the target.

In each run samples were exposed at different angles with respect to the deutron beam, corresponding to different neutron energies. Each sample was an Aluminium disc 2 csm. in diameter and 7 cms tick. The samples were placed on the sample holder which is circular brass rings concentric with the target, with the deuteron beam. The average distance between the samples and the target was 10 cms.

In a typical run four samples were irradiated simultaneously for 30 mins. to produce saturation activity since the half life of the residual nucleus is 9.5 mins., and then were counted for four mins. each, after each measurement a background count was taken for the same time 4 mins. The relative cross sections were determined by measuring the activity of the gamma rays emitted by the residual nelceiusing a 3×3" Nal (Ti) crystal and photomultipier assembly coupled to a 400 channel pulse hight analyser. 200 only were used.

The samples were counted for a finite time after irradiation and the activity calculated by determining the area under the 84 MeV photo peak which avoid automatically most impurities.

RESULTS

Table (1) : summarizes all the measurements obtained in all the runs.

Table. 1.

θ	RELATIVE CROSS SECTION			E_n MeV
	Run 1	Run 2	Run 3	
0°	1 ± .03	1 ± .05	1 ± .02	15.144
90°	1 ± .02	.98 ± .04	1.02 ± .02	14.4
140°	1.06 ± .03	1.11 ± .02	1.05 ± 04	13.45
0°	1 ± .009	1 ± .02	1 ± .02	
130°	1.19 ± .02	1.20 ± .03	1.17 ± .03	13.562
150°	1.35 ± .02	1.41 ± .04	1.35 ± .04	13.356
160°	1.52 ± .04	1.58 ± .07	1.61 ± .05	13.291
0°	1 ± .02	1 ± .02	1 ± .02	
100°	1.13 ± .03	1.15 ± .03	1.14 ± .03	14.232
120°	1.24 ± .04	1.29 ± .04	1.25 ± .04	13.692
150°	1.37 ± .06	1.42 ± .06	1.38 ± .06	

After correcting for anisotospy and energy spread, table 2 summarizes the final results.

Table. 2.

E_m MeV	15.4	14 4	14.23	13.692	13.56	13.45	13.36	13.291
Relative σ	1 ±.008	1.086 ±.024	1.248 ±.031	1.401 ±.049	1.326 ±.039	1.204 ±.036	1.582 ±.061	1.288 ±.072

DISCUSSION

There is generally poor agreement among reported experimental cross section data. Gardner (1962) in his study on experimental values of all reported (n, p) cross section induced by neutron approx. 14 MeV energy, showed that there is a widely varying values of cross section of the reaction of Al^{27} (n, p) in the neutron energy range about 14 MeV. These values vary from 52 ± 10 to 140 ± 30 mb. The reported maximum mins. limits are 170 and 42 respectively. Gardener considered that the discrepancies of the experimental values may be due to :

(1) Measurement of cross section relative to another reaction considered as a standard.

(2) The uncertainty of the standard values is usually ignored.

(3) The reported error limits have little, if any, meaning.

He added that at best the error may represent the experimentor's considered opinion as to what the probable error on the standard deviation on the 95 % confidence level might be (rarely is it stated what type of limit is meant).

The discrepancies in the reported experimental cross section data is not at specific energy i.e. 14 MeV but to the extent that some of the working deserved that the cross section are approximately constant (Partington et al, 1970) or no significcant fluctuation (Benazzola et al, 1964; Ssikai, 1965) and others (Mani et al, 1960) with whom we agree showed variation with energy.

Crumpton et al (1971) after summarising the information on excitation function of the reaction used as monitors for 14 MeV flux measurements they ended to the conclusion that for low mass number nuclei the (n, p) cross sections commonly fall is less marked for heavier nuclei and for mass numbers above about 70 the cross sections frequently increase with energy.

The data within the present work which is 23 % at 14.5 MeV agree with the conclusion of Crumpton et al (1971) in the form that the cross section of Al^{27} fall by between 13.5 - 15 MeV as it is one of the low mass number nuclei.

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