(He^3, α) *REACTION ON* C^{12} *AND* Mg^{24} *NUCLEI*

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The differential cross sections for the $C^{12}(He^3, \alpha)C^{11}$ and $Mg^{24}(He^3, \alpha)Mg^{23}$ reactions are measured for six ion energies between 26 and 33 MeV. It is shown that the angular dependences are different for these reactions, and this may be regarded as an indication that the mechanisms of the two reactions are different.

THE mechanism of the reaction (He^3, α) at large values of He^3 energy (~ 30 MeV) has hardly been investigated. An analysis of the available data indicates only that the direct process apparently predominates. On the other hand, no definite conclusions can be drawn from this data whether this process is a simple Butler pickup, or whether it has a more complicated character. To disclose the distinguishing features of the mechanisms of such reactions it would be very useful to have information on the angular distributions at different energy values. In the present investigation we measured the differential cross sections of two reactions: $C^{12}(He^3, \alpha)C^{11}$ and $Mg^{24}(He^3, \alpha)Mg^{23}$ at six values of the energy in the 26—33 MeV range. The first reaction has already been investigated in sufficient detail at energies 2—10 MeV [1,2]. For higher energy values, the only published results are for 28.5 MeV [3]. The second reaction was investigated only for 5.5 MeV [4].

The measurements were made with an extracted beam of He^3 ions in a vacuum scattering chamber. The targets used were a graphite film 1.15 mg/cm^2 thick and a natural-magnesium foil 0.97 mg/cm^2 thick. The detector was a telescope consisting of a proportional counter and a scintillation spectrometer with CsI(Tl) crystal. This procedure was described in greater detail earlier [5]. The differential cross sections for C^{12} were measured every 5° in an interval 20—120° in the c.m.s. and for Mg^{24} every 3° in the c.m.s. interval 20—70°. In the latter case the interval of the angles was determined by the possibility of reliably separating from the spectrum the corresponding group of α particles.

Figure 1a shows the angular distributions obtained for the reaction $C^{12}(He^3, \alpha)C^{11}$ (Q = 1.86 MeV) at different energies. All the curves have clearly pronounced diffraction structures which are more distinct at lower energy values. The absolute values of the cross sections at small angles increase noticeably with decreasing energy (for example, for $\theta = 23°$ we have $d\sigma/d\Omega \approx 8$ mb/sr for 32.6 MeV and $d\sigma/d\Omega \approx 14$ mb/sr for 26.1 MeV). All curves show a decrease in the cross section up to an angle ~ 80°, after which it becomes approximately constant in the measured interval and the same for all energies. The absolute values of the cross sections for 28.6 MeV, obtained in the present investigation, are in good agreement with the cross sections measured at 28.5 MeV [4].

Figure 1b shows a series of curves for the $Mg^{24}(He^3, \alpha)Mg^{23}$ reaction. Owing to the insufficient resolution of the spectrometer (~ 3%), it was impossible to separate the group of α particles corresponding to the production of Mg^{23} in the ground and first excited (0.45 MeV) states. The curves for all energies have a clearcut diffraction structure. The absolute value of the cross sections at identical angles changes very slightly over the entire range of energies. A weak increase in the cross sections is observed for small angles with decreasing energy, while the character of the fall-off is practically the same for all curves (for example, at $\theta = 20°$ we have $d\sigma/d\Omega \approx 4.4$ mb/sr for 32.6 MeV and $d\sigma/d\Omega \approx 6.2$ mb/sr for 26.1 MeV; for $\theta = 40°$ the values are $d\sigma/d\Omega \approx 2$ and 1.8 mb/sr for 32.6 and 26.1 MeV, respectively).

Direct comparison of the experimental curves with those calculated by Butler's theory is made difficult by the fact that the principal maxima of both series of curves are outside the investigated angle interval.

The character of the variation of the angular distributions with energy is shown more clearly in Fig. 2. It shows the positions (that is, the values of the momentum transfer q_{extr}) of the first minimum and the first maximum of the angular distributions of both reactions as a function of the energy. The values of q_{extr} in the 6—10 MeV interval were calculated for the $C^{12}(He^3, \alpha)C^{11}$ reaction from the data of Hinds and Middleton [2]. It

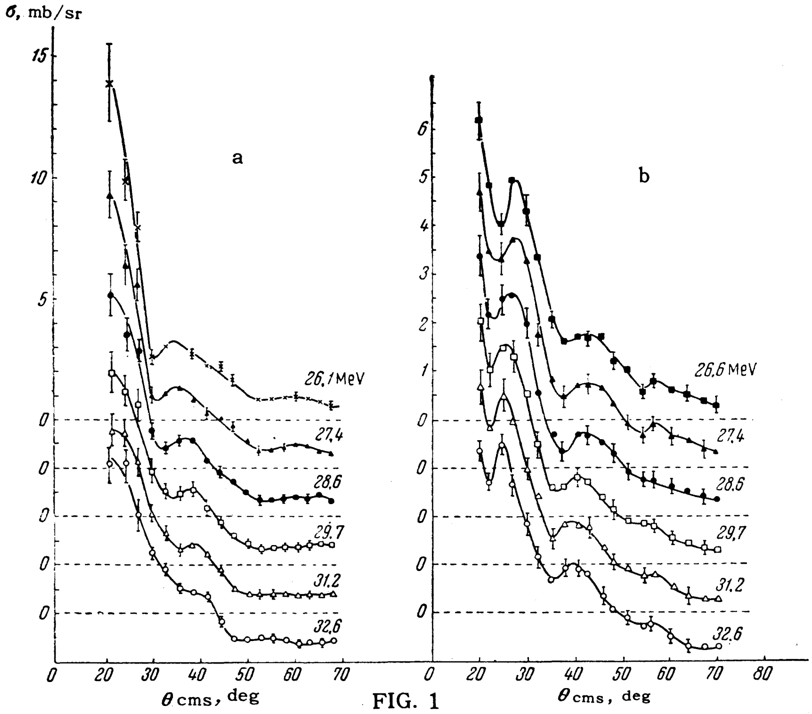

FIG. 1

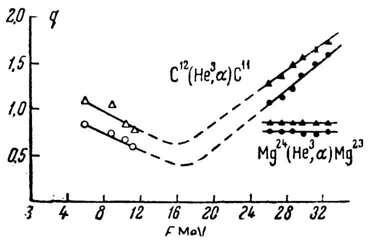

FIG. 2

FIG. 1. Differential cross sections of the reactions C^{12} (He^3, α)C^{11} (a) and Mg^{24}(He^3, α)Mg^{23} (b); the dashed lines are the abscissas for the corresponding curves, starting with an energy of 31.2 MeV.

FIG. 2. Positions ●, ○ of the first minimum and ▲,△ of the second maximum of the angular distributions in the reactions C^{12} (He^3, α)C^{11} and Mg^{24}(He^3, α)Mg^{23} as a function of the energy of the incoming He^3 ions. The light points are taken from [2].

is seen that with increasing energy the value of q_{extr} in the C^{12}(He^3, α)C^{11} reaction first decreases and then increases, while in the Mg^{24}(He^3, α)Mg^{23} reaction it remains constant in the high-energy region. A different energy dependence of q_{extr} for the investigated reactions may indicate that they have different mechanisms. It must also be noted that the behavior of q_{extr} in these reactions differs from that observed in the pickup reactions (p, d) and (d, t) on light nuclei, where, as a rule, the value of q_{extr} increases with increasing energy for all maxima and minima [6].

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