at 0.685 Mev would be $(g_{9/2}d_{5/2})$, since the isomeric transition would then involve a change in the state of only one nucleon. The transition to the 0.247-Mev state, involving a change in the state of both nucleons, should be considerably weaker than that to the state at 0.203 Mev. No 0.247-Mev gamma ray with an intensity greater than 1% of the 0.203 was observed in the present work.

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Nuclides Ar^{42} and Cl^{39}†

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The masses of Cl^{39} and Ar^{42} and the energies of their first excited states have been determined by an investigation of the reactions $Ar^{40}(t,\alpha)Cl^{39}$ and $Ar^{40}(t,p)Ar^{42}$. Charged reaction products were analyzed with a high-resolution magnetic spectrometer. The experimental results for Ar^{42} are: mass excess $(M-A)=-34.423\pm0.040$ Mev ($C^{12}=0$) or -21.990 ± 0.040 Mev ($O^{16}=0$); energy of first excited state $=1.138\pm0.030$ Mev. The experimental results for Cl^{39} are: mass excess $(M-A)=-29.772\pm0.040$ Mev ($C^{12}=0$) or -18.227 ± 0.040 Mev ($O^{16}=0$); energy of first excited state $=0.364\pm0.030$ Mev. The Q values of $Ar^{40}(t,p)Ar^{42}$ and $Ar^{40}(t,\alpha)Cl^{39}$ were found to be 7.046 ± 0.040 and 7.259 ± 0.040 Mev, respectively.

INTRODUCTION

THE masses and energy levels of a number of light nuclei have been measured at this laboratory in the past few years in experiments[1] using gas targets with tritons as the bombarding particles. The present experiment uses a triton beam to bombard an argon gas target in order to study the reactions $Ar^{40}(t,p)Ar^{42}$ and $Ar^{40}(t,\alpha)Cl^{39}$. A study of the proton and alpha energy spectra of these reactions should yield information on the masses of Ar^{42} (heretofore unknown) and Cl^{39} along with data on their energy levels. The information previously known about these nuclides mostly concerns the mass of Cl^{39} and the half-lives of the two nuclides.[2]

EXPERIMENTAL APPARATUS AND PROCEDURE

The experimental setup is identical with previous studies[1] and will not be described in detail. Briefly, a 2.6-Mev triton beam from an electrostatic accelerator bombarded a natural argon gas target. The reaction products emerging at a laboratory angle of 30° were analyzed with high resolution in a 16-in. double-focusing magnetic spectrometer and detected by a CsI scintillation counter. Mass-spectrometric analysis of the target gas showed that the argon concentration was always greater than 98 atom percent. Background runs were taken with nitrogen, oxygen, air, neon, and carbon dioxide. Energy determinations and other procedures are discussed in the previous papers.

RESULTS

Two alpha and two proton groups were observed that were assignable to the argon target. Energetic considerations eliminate all the argon isotopes except Ar^{40} as being responsible for these reactions. The peaks were about one-tenth the size of peaks seen[1] in reactions with targets of $Z=8$ or 10. This reduction in cross section is about what would be expected on the basis of Coulomb barrier penetration of the target nucleus by the incident triton. The peaks of interest were close to the ground-state alpha group from the $O^{16}(t,\alpha)N^{15}$ reaction and a small amount of oxygen was added to the target gas to provide an energy calibration. Analysis of the data has led to the results shown in Table I. No attempt was made to search for energy levels higher in excitation than the first excited states because of the increased complexity of background groups in the proton and alpha spectra. The estimates of errors are standard deviations. Values of known masses used in the calculations were taken from Everling *et al.*[3]

If one assumes that the even-even nuclide Ar^{42} has zero spin and even parity, then the beta decay to K^{42} (which has a 2^- ground state) is once forbidden. Only

† Work performed under the auspices of the U. S. Atomic Energy Commission.
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TABLE I. Experimental results. Given are the Q's for each reaction, the mass, the mass excesses $(M-A)$, and the energy of the first excited state.

	Ar^{42}	Cl^{39}
Q value	7.046±0.040 Mev [$Ar^{40}(t,p)$]	7.259±0.040 Mev [$Ar^{40}(t,\alpha)$]
Mass ($C^{12}=12$)	41.963043±0.000043 amu	38.968037±0.000043 amu
Mass ($O^{16}=16$)	41.976384±0.000043 amu	38.980425±0.000043 amu
$(M-A)$ ($C^{12}=0$)	−34.423±0.040 Mev	−29.772±0.040 Mev
$(M-A)$ ($O^{16}=0$)	−21.990±0.040 Mev	−18.227±0.040 Mev
First excited state	1.138±0.030 Mev	0.364±0.030 Mev

the ground-state decay is energetically favorable. A rough calculation using this assumption, a reasonable ft value (10^{-7} or 10^{-8}), and a value for the half-life of 10 to 100 years (compatible with the known value[2] of "greater than 3.5 years") leads to a prediction for the $(M-A)$ of Ar^{42} in the range from −34.0 to −34.4 Mev ($C^{12}=0$), in good agreement with our measured value of −34.42 Mev. Even larger values of the half-life do not significantly change this result. Our measurements predict a beta-decay energy of 0.583±0.045 Mev.

To eliminate the possibility that we had missed the ground-state group for Ar^{42}, a search was made for a higher-energy proton group. No proton groups were found for several Mev higher than the assigned ground-state group; if the ground-state group were higher than the range of our search, Ar^{42} would have to be stable with respect to beta decay to K^{42}. Our value for the mass excess ($C^{12}=0$) of Cl^{39} of −29.772±0.040 Mev agrees with the previously determined value of −29.803±0.021 Mev.[3]

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Protons from Alpha-Induced Reactions*

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The results of proton energy spectra measured at several angles from 30.5-Mev alpha particle induced reactions on Al^{27}, V^{51}, Co^{59}, As^{75}, Nb^{93}, Rh^{103}, In^{115}, and Ta^{181} were analyzed using the statistical model. The analysis yielded the differential cross section $d^2\sigma/d\Omega dE$ and the relative level density $\omega(E)$ of the residual nucleus as a function of proton and excitation energy of the residual nucleus. The nuclear temperature $1/T\equiv d(\ln\omega)/dE$ and the level density parameter a of $\omega=C\exp[(aE)^{\frac{1}{2}}]$ were obtained. The energy and angular dependence of the spectra are adequately described by the statistical model at back angles, with the indication of the presence of a direct-reaction mechanism contribution at forward angles, which extends to high excitation energies.

1. INTRODUCTION

A VARIETY of nuclear reaction mechanisms have been proposed to implement the understanding of medium-energy nuclear reactions. In particular, descriptions such as the compound nucleus model and direct reaction mechanisms have enjoyed varying amounts of success for different reaction particles and conditions. The direct (fast) interaction description and the compound nucleus model (slow) are logical extreme limits of reactions proceeding through a compound nuclear system as visualized by Weisskopf[1] as an intermediate stage between the initial independent particle stage and the final emission stage. Once the compound system has been formed by the removal of a particle from the entrance channel, the reaction may proceed to the final emission stage by one of two courses. It may lead to compound nucleus formation and subsequent decay, or it may proceed by a direct-reaction mechanism to the final stage.

The description of an actual reaction, the present experiment being no exception, lies rarely on one of these limits but usually somewhere between them.

If it is desired to obtain information about one of these limits (compound nuclear process in this experi-

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[1] V. F. Weisskopf, Revs. Modern Phys. **29**, 174 (1957).