would still remain. Also, the experiments of Ghoshal[9] lend strong support to the general validity of the compound nucleus model at these energies.

The only remaining alternative that seems obvious is to retain the compound nucleus model, but abandon (16) in favor of the more general formula (12). If the $\partial \log\eta/\partial E$ term in (12) is to contribute appreciably, it must be of the order of an inverse nuclear temperature; that is, η must decrease by a factor of $e(2.7)$ for a decrease in the emitted particle energies of a few Mev. In view of (5) and (8), this would mean that there are selection rules operating in nuclear transitions such as to make transitions between distant levels more probable than transitions between levels of nearly equal energy.

One objection to this alternative is that the many published measurements of total reaction cross sections for neutrons, protons, alphas, and pi mesons are actually direct measurements of the sticking probability, η; and in every case, they indicate that η is its maximum theoretical value, unity. In these cases, of course, only ground-state nuclei were bombarded whereas the η in (12), which entered through the reciprocity theorem, is the sticking probability when excited nuclei are bombarded. Obviously, there can be no direct experimental measurements of η for such cases.

Another objection to this alternative, pointed out by Weisskopf,[18] is that it requires that sticking probabilities be less for excited than for ground state nuclei, whereas according to current theories of nuclear structure, the opposite should be the case.

On the other hand, Wigner[22] has pointed out independent evidence for the selection rule mentioned above in heavy elements from comparison of known absolute level densities with Gugelot's data.[3]

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[22] E. P. Wigner (private communication).

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The Radionuclides of Arsenic Produced by Deuteron Bombardment of Germanium*

H. J. WATTERS†,‡ AND J. F. FAGAN, JR.‡,§
Department of Physics and Radioactivity Center, Laboratory for Nuclear Science, Massachusetts Institute of Technology, Cambridge, Massachusetts

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The arsenic produced by a deuteron bombardment of germanium has been studied to determine the nuclides present in the mixture. Identification of the isotopes was made by comparing measured values of half-life and maximum β energy with published values. Counting rates were measured with 4π and coincidence counters, obtaining half-lives which indicated that the nuclidic mixture was made up of As^{71}, As^{72}, As^{73}, As^{74}, and As^{77}. These findings were confirmed by maximum β energy values obtained by absorption measurements and by γ-energy values found using a γ-ray scintillation spectrometer. Measurements indicated that the 40-hr half-life reported for As^{77} is in error by a significant amount, and that no As^{76} was obtained from this bombardment. Thick target yield data were determined for each nuclide from the 4π counter measurements.

AN investigation was made of the radionuclides of arsenic produced by the cyclotron bombardment of a thick germanium target with 15-Mev deuterons. After chemical separation of the arsenic,[1] identification of the isotopes present was made by correlating measured values of γ, β^+, and total β half-lives with maximum β energy and γ-ray energy.

Arsenic activity was measured continuously for a period of 53 days with a 4π proportional counter, a γ-γ coincidence counter, and with a thin end-window Geiger Muller tube using calibrated aluminum absorbers. Gamma-ray energy measurements were made using a thallium-activated sodium iodide scintillation spectrometer. The energy spectrum up to 3 Mev was scanned continuously for the first 72 hours (Fig. 1) and an additional spectrum was obtained 52 days after bombardment.

By application of the method of least squares to 4π and coincidence counter data, the decay curves were analyzed in a total of four periods: 25.8 hours, 48.2 hours, 17.8 days, and 88.9 days. Comparison of total β-decay curves with those due only to positron disintegration yielded an additional period slightly greater

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† Lieutenant Commander, U. S. Navy.

‡ Now on sea duty, U. S. Navy. Investigation performed while a U. S. naval postgraduate student at Massachusetts Institute of Technology, Cambridge, Massachusetts.

§ Lieutenant, U. S. Navy.

[1] Brownell, Backofen, White, and Irvine, Massachusetts Institute of Technology Progress Report, May 1953 (unpublished).

than 70 hours. These values were verified by analysis of decay curves obtained with the end-window β counter. The four experimental components shown in Fig. 2 were obtained from analysis of total β decay observed with the 4π counter.

The energy of the hardest γ ray detected with the scintillation spectrometer was 0.85 Mev, with a half-life of about 29 hours. An additional γ-ray energy of 0.60 Mev was resolved several weeks after bombardment.

Maximum β energies were found from absorption curves obtained with the end-window β counter. From measurements of maximum range made at various times, the energy of the most energetic β was determined for both the 25.8-hour and the 17.8-day isotopes. In addition mass-absorption coefficients were determined

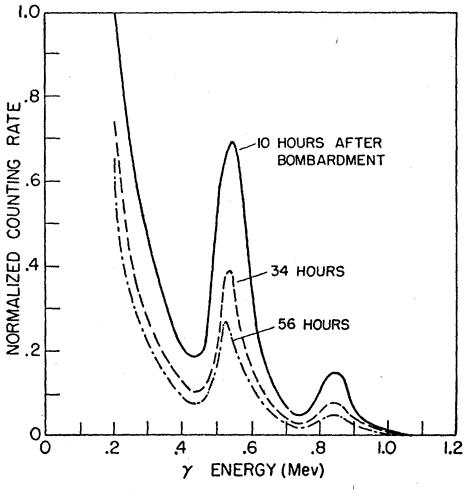

FIG. 1. γ-ray energy spectrum of arsenic produced by 15-Mev deuteron bombardment of germanium.

from semilog plots of counting rate *vs* absorber thickness taken at various times. Using these values, maximum β energies were computed for the 48.2-hour and the 17.8-day isotopes. Close agreement was found for the 17.8-day isotope by both methods.

Correlation of data indicated that the nuclidic mixture consisted of As^{71}, As^{72}, As^{73}, As^{74}, and As^{77}. Because of the absence of γ-ray energies greater than 0.85 Mev it was concluded that As^{76} was not present in the mixture.

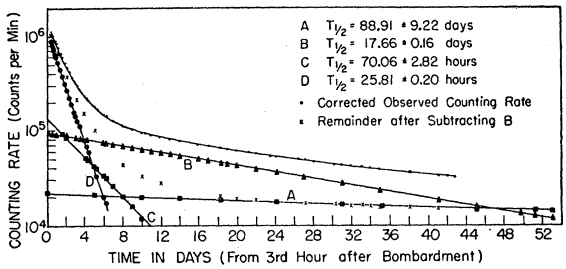

FIG. 2. Data of counting rate *vs* time, taken with 4π counter, showing half-life values determined by method of least squares.

Since the efficiency of the 4π solid-angle β counter constructed for this investigation was shown to be very nearly 100 percent for particles which escape the source, these data were used to determine absolute β activities. These activities were corrected to the time of completion of bombardment and the results specified in terms of yield for each isotope.

A summary of the results of this investigation is given in Table I.

The Master's thesis submitted by these writers to the Massachusetts Institute of Technology contains details of the investigation and a complete treatment

TABLE I. Summary of the characteristics of the mixture of radionuclides determined by this investigation.

Isotope	Method of decay	Energy (Mev)	$T_{\frac{1}{2}}$[a]	Thick-target yield[b] (μC/μa-hr)
As^{71}	β^+	0.66	48.2 ±1.2 hr	7.6
As^{72}	β^+	3.25	25.8 ±0.2 hr	64.9
	γ	0.85		
As^{73}	β^-	$0.11 > E_{max} > 0.02$	86.9 ±9.2 days	1.1
As^{74}	β^+	0.99, 1.49	17.82±0.13 days	5.2
	β^-			
As^{76}		Not present in the mixture		
As^{77}	β^-	<0.7	>70 hours	5<yield<15[c]

[a] Half-lives are stated with their respective standard errors.
[b] The thick-target yield values specified apply if the deuteron beam current was exactly 36 μa and if the arsenic separation efficiency was 100 percent. Yield values quoted are based on β counting only and do not include orbital electron capture.
[c] Based on ratios of total β to β^+ counting rates.

of the construction and operating technique of the 4π β counter. This investigation was suggested by Dr. Gordon L. Brownell of the Massachusetts General Hospital and was conducted under the supervision of Professor Robley D. Evans.