TABLE I. Conversion electrons accompanying alpha-decay.

Isotope	Alpha-events observed	% having conversion electrons	Electron energies (kev)	Shell of conversion	Gamma-energy (kev)
Cm^{242}	5250	23±3	25±5(19%)	*L*	~45
			40±5 (4%)	*M*	~45
Am^{241}	2600	56±5	⩽20(12%)		several levels,
			20–35(31%)		highest at least
			35–60 (9%)		65 kev above the
			two electron coincidences (4%)		ground level
Pu^{239}	8100	12±2	30±5	*L*	~50
			45±5	*M*	~50
			20±5	*L*	~35
			30±5	*M*	~35
			100±20(0.5%)		origin uncertain
Pu^{238}	5700	23±3	20±5	*L*	~40
			35±5	*M*	~40
Pu^{236}	7000	20±3	25±5(17%)	*L*	~45
			40±5 (3%)	*M*	~45
Np^{237}	3500	80±5	⩽20(10%)		several levels,
			20–40(38%)		highest at least
			40–65(20%)		65 kev above the
			two electron coincidences (11%)		ground level
			three electron coincidences (1%)		
U^{238}	6300	22±3	25±5	*L*	~45
			40±5	*M*	~45
U^{235}	9700	27±3	30±5(23%)	*L*	~50
			45±5 (4%)	*M*	~50
U^{232}	8000	30±3	40±5	*L*	~60
			55±5	*M*	~60
Th^{232}	5100	24±3	35±5	*L*	~55
			50±5	*M*	~55
Sm^{147}	7500	0			

corresponding nuclear energy level since the unconverted gamma-rays are not measured by this technique.

Fresh plates were ordered frequently and used within three to eight weeks after the time of manufacture in order that no eradication of electron background (with associated densitization of the emulsion) would be required. Because of residual acidity left in the emulsion with the radioactivity through use of citrate or acetate complexing agents (to aid penetration of the radioactivity into the emulsion), a 30-minute presoaking of the plates in dilute Na_2CO_3 solution preceded normal development with Eastman D-19 solution. The customary period of exposure was 66 hours; where the daughter was a beta-emitter of sufficiently short half-life, appropriate corrections were made in the percentages of electron abundance. Alpha-particle emitting contaminants were negligible (0–1 percent) in all cases except U^{238} for which an isotopically enriched sample was used and appropriate corrections made for U^{234} and U^{235}. Close agreement was found between the present results and those of Asaro and co-workers in earlier work on the two nuclides Cm^{242} [1] and Pu^{238} [2] using the alpha-magnetic spectrometer; this was regarded as indicating satisfactory efficiency of the emulsion method in estimating both electron abundances and energies.

The results are summarized in Table I, where the gamma-ray energies are probably accurate to about 5 kev. As can be seen, in the case of the even-even emitters, the alpha-decay in every case divides between the ground state and one higher energy level of the daughter nucleus. Since the conversion coefficient for the gamma-ray seems to be high for all such daughter nuclei of the even-even type where this has been measured, it seems reasonable to assume that the percentages of conversion electrons listed in Table I correspond essentially to the percentages of the alpha-decays to the level above the ground state. For all the even-even nuclides both the low and high energy alpha-particle groups obey the relationship between energy and half-life quite well; that is, neither group exhibits appreciably the hindered decay characteristic of nuclides containing odd nucleons.[3,4] On the other hand, each of the nuclides with odd nucleons exhibits alpha-decay to several energy levels with widely varying percentages; for these, the decay to one of the excited states is in each case less hindered than the corresponding decay to the ground state, in agreement with the view that the conditions for the assembly of the outgoing alpha-particle can be more favorable in certain instances when the highest lying odd nucleon need not be included.[3]

Results similar to those presented here have been reported for U^{238} [5,6] and Pu^{239} [7] using the same technique.

This work will be reported in more detail in a forthcoming publication.

The authors wish to express their appreciation to Dr. J. O. Rasmussen, Jr., for many helpful comments and to R. H. Shudde for considerable assistance in the alpha-counting. They also wish to thank Dr. B. B. Cunningham, E. H. Fleming, A. Ghiorso, R. A. Glass, G. H. Higgins, and L. M. Slater for provision of some of the isotopes used.

* This work was performed under the auspices of the AEC.
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Mass of V^{50}†

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(Received May 19, 1952)

HESS and Ingham[1] and Leland[2] have found recently that vanadium has a naturally occurring odd-odd isotope at mass 50, having an abundance of 0.24 percent. Titanium and chromium also have isotopes at mass 50, and the question of radioactivity of V^{50} immediately arises. At least one unsuccessful search[2] for activity has been reported. One reason for the lack of an observable activity could be small energy differences between V^{50}, Cr^{50}, and Ti^{50}. In order to investigate the energy differences, I have determined the masses by the doublet method using a double-focusing mass spectrometer.[3,4]

The technique used in measuring the V^{50} doublet is the same as was used for other metals in this mass region. A normal vanadium metal sample of about 0.5 mg, was spot welded to a tungsten ribbon. The ribbon was then mounted in the source and heated, evaporating vanadium which was ionized by an electron beam. The comparison peak was a fragment C_4H_2 obtained from butadiene. The average of five runs yields a mass difference

$$C_4H_2-V^{50}=683.6\pm1.2\times10^{-4}\text{ amu.}$$

Each run consisted of 10 separate doublet tracings and required a small correction for C^{13} which was never greater than 0.07 percent of the doublet difference. Several hydrogen mass doublets ($C_4H_3-C_4H_2$) measured during the same period had an error less than 0.03 percent. Using $H^1=1.008146\pm3$ and $C^{12}=12.003842\pm4$ we compute the mass of V^{50} as 49.96330 ± 12.

The mass doublets $C_4H_2-Cr^{50}$ and $C_4H_2-Ti^{50}$ were measured under the same experimental conditions as the doublet $C_4H_2-V^{50}$. Four runs were made for each of these doublets and the results obtained agreed closely with those previously found.[5] The new data combined with the old yield

$$C_4H_2-Ti^{50}=709.27\pm0.27;$$
$$C_4H_2-Cr^{50}=696.34\pm0.46.$$

These can be compared directly with the V^{50} doublet to get the energy level diagram shown in Fig. 1. Because the largest error occurs in the V^{50} doublet, it mattered little whether we used the new Ti^{50} and Cr^{50} doublets alone or the combined results in making the energy comparisons.

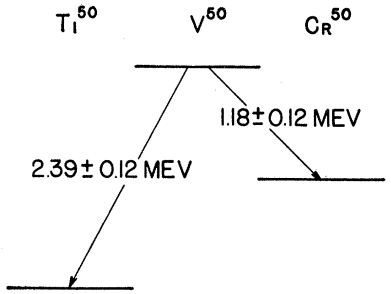

FIG. 1. Energy differences for isobars at mass 50.

It is apparent that ample energy is available for decay of V^{50} to Cr^{50} or Ti^{50}, and failure to detect this activity must be attributed to long half-life.

The writer wishes to thank Dr. A. O. Nier and Dr. T. L. Collins for many valuable suggestions in connection with this experiment.

† Research supported by the joint program of the ONR and AEC.
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Thermal Neutron Flux Measurements in Graphite Using Gold and Indium Foils

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THE observed activations of measuring foils in thermal neutron flux determinations in diffusing media must be corrected for the attenuation of the neutron flux in the foil and for the flux depression caused by the presence of the foil. In considering these corrections, previous workers[1] have counted the β^- particles from the foils and compared their results with a correction obtained from diffusion theory as worked out by Bothe.[2]

In the present experiments the γ-rays with indium and gold foils were counted. The advantage of counting the γ-rays rather than the β^- particles is that the absorption of the γ's by the measuring foil is a small effect, and the observed activities give information directly about the perturbation of the flux by the foil.

A series of indium and one of gold foils, $1\frac{1}{2}$ inches in diameter and ranging from 1 to 5 mils in thickness, was exposed in a slot

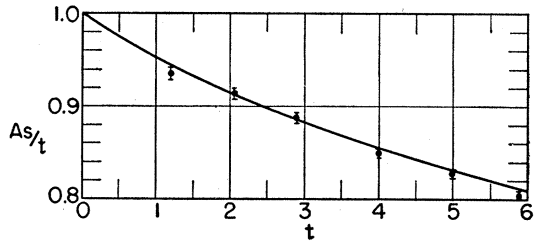

FIG. 1. The circled points represent the relative saturated activities per unit thickness of indium foils in graphite plotted as a function of their thickness in mils. The errors shown are the standard errors of counting. The solid curve is obtained from the theory of Bothe.

of the Oak Ridge Standard Graphite Pile in which the cadmium ratio as measured with indium foils is greater than 300. The foils were counted with a sodium iodide crystal and a 5819 photomultiplier through a layer of aluminium of sufficient thickness to absorb all the β^- particles.

Figure 1 shows the saturated activity per unit thickness of the indium foils plotted against the thickness in mils. Figure 2 shows

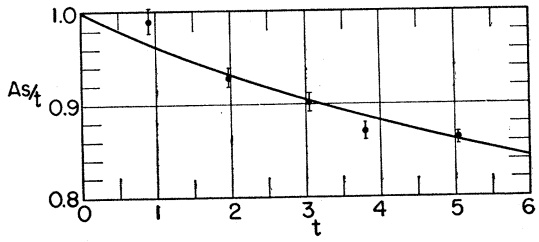

FIG. 2. The circled points represent the relative saturated activities per unit thickness of gold foils in graphite plotted as a function of their thickness in mils. The errors shown are the standard errors of counting. The solid curve is obtained from the theory of Bothe.

the same quantity for the set of gold foils. The data have been normalized arbitrarily since the point at zero thickness is not available. The solid lines have been computed from the theory of Bothe. The transport mean free path of thermal neutrons in graphite has been taken as 2.5 cm.[3]

A transport theory correction for this effect has been given by Skyrme.[4] For the thicknesses of foils used in these experiments, Bothe's theory and Skyrme's theory lead to essentially the same correction factors.

We wish to thank Mr. D. G. Ott, who carried out the initial experiments.

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