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SOME PILE NEUTRON CROSS SECTIONS OF ISOTOPES OF AMERI-CIUM, BERKELIUM, CALIFORNIUM, AND ELEMENT 99

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April 20, 1954

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April 20, 1954

In recent experiments[1-4] designed to produce new isotopes of the heaviest elements by neutron bombardments in the Materials Testing Reactor, approximate values have been obtained for several neutron capture cross-sections. Neutron flux values were obtained from measurements made by the MTR operating staff. However, the neutron flux in a given position in the reactor is by no means constant, so that, as always, flux uncertainties represent the greatest source of error in most of the measurements.

After bombardment, the target material and products were carefully separated from activities due to fission products and impurities. The chemical separation methods, involving both precipitation and ion-exchange techniques, will be described in a separate report.[5] The product nuclei whose yields were measured were in all cases properly identified by means of their chemical and nuclear properties.

In some cases, the amount of the nuclide being bombarded changed drastically during the course of the experiment, since it was itself being produced from lighter nuclei. In these cases, the (otherwise laborious) calculations were made with the electronic analog computer GADAC developed for this purpose in this laboratory.[6]

The results are summarized in Table 1.

Table 1

Nuclide bombarded	Target	Product measured	Number of experiments	σ (barns)
Am^{243}	Almost mono-isotopic Am^{243}	Am^{244}	3	140 ± 50
Bk^{249}	Mono-isotopic Bk^{249}	Bk^{250}	2	1100 ± 300
Bk^{249}	"	Bk^{249} (i.e., Bk^{249} destruction)	1	
Cf^{249}	Mono-isotopic Cf^{249}	Cf^{250}	1	270
Cf^{249}	Mixed Cf isotopes, $Cf^{249,250,251,252}$	Cf^{249} (i.e., Cf^{249} destruction)	1	~900 (fission plus capture)
Cf^{252}	"	99^{253}	1	30
Cf^{254}	Long bombardment of Pu^{239}	100^{255}	1	<2
99^{253}	Mixed Cf isotopes, $Cf^{249,250,251,252}$	100^{254}	1	160
99^{254}	Long bombardment of Pu^{239}	100^{255}	1	<15

The fission cross section of Cf^{249}, by difference between its total and capture cross-sections, is about 630 barns. The ratio of $\sigma f/\sigma c$ is thus about 2.3. This number is entirely consistent with the calculated binding energy, 6.33 Mev,[7] of the ingoing neutron.[8,9]

The cross-sections of Cf^{254} and 99^{254} are given only as limits because it is not known how much of the 100^{255} is formed by $Cf^{254}(n,\gamma)Cf^{255} \xrightarrow{\beta^-} 99^{255} \xrightarrow{\beta^-} 100^{255}$ and how much by $99^{254}(n,\gamma)99^{255} \xrightarrow{\beta^-} 100^{255}$.

If the capture cross-section of 99^{254} is zero, then that of Cf^{254} would need to be approximately 2 barns, while if the cross-section of Cf^{254} is zero, then that of 99^{254} would need to be approximately 15 barns. The yield of 100^{255} is accounted for by cross-sections which are related by the approximate equation $\sigma_{Cf^{254}} + 0.1\sigma_{99^{254}} = 1.4$.

We wish to express our gratitude to Professor Glenn T. Seaborg for his interest in this work. We are particularly indebted to the staff of the Phillips Petroleum Company at the MTR for their assistance in making neutron bombardments. This work was performed under the auspices of the U. S. Atomic Energy Commission.

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