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PRELIMINARY DETERMINATION OF THE NEUTRON ABSORPTION CROSS SECTION OF LONG-LIVED I^{129}

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Abstract

The slow neutron absorption cross section of long-lived I^{129} was found to be about 8 barns, correct to within a factor of ten. This was done by bombarding, at the Omega water boiler, some iodine which had been isolated from an irradiated uranium slug. Then the amount of 12.6h I^{130} formed was measured.

The following chain of mass number 129 is known to occur in fission:

$$4.2h\ \ Sb \longrightarrow \begin{matrix} 72m\ Te \longrightarrow \text{long } I \longrightarrow \text{stable } Xe \\ \uparrow \\ 32d\ Te \end{matrix}$$

An attempt was made by J. Seiler (Report CN-1998, p. 2) to detect by radiochemical means the long-lived I^{129}. He isolated the iodine from a uranium slug which had undergone irradiation in the Clinton pile for 123 days. The sample decayed exponentially, essentially down to background, with a half-life of 8.0 days which is characteristic of I^{131}. This indicated that the half-life of I^{129} was extremely long, or that its radiations were extremely soft, or both.

Arrol, Chackett, and Epstein (Report BM-1248) isolated the xenon and krypton formed in fission, from an old uranium slug which had been irradiated in the Clinton pile. They then submitted their gas samples to Thode and Graham (Reports BM-1120 and BM-1149) for investigation in a mass spectrometer. All of the stable krypton and xenon isotopes which can result from fission, except Xe^{129}, were found in the expected yields. Since Xe^{129}, was not found at all, this must mean that its parent, I^{129}, is very long-lived.

In the present experiment, the iodine sample which had been isolated by Seiler was irradiated for 12.8 hours, along with two normal iodine samples, in the Omega water boiler, just outside the BeO reflector. Normal iodine consists of one isotope of mass number 127. Slow neutron irradiation should give only 25m I^{128}. However, a sample which contains also some long-lived I^{129} should give, after neutron irradiation, some

12.6h I^{130}. This latter activity was easily detected (Fig. 1). After the irradiation, all three samples were purified by means of four oxidation-extraction-reduction cycles. They were then mounted as AgI and their decay followed with a thin window GM counter. All samples decayed initially with a 25m half-period. However, the decay of the sample containing I^{129} tailed off to an activity of several thousand counts per minute which decayed with a half-life of 12.6h , characteristic of I^{130}. Absorption of the radiations with aluminum absorbers indicated two beta-rays with energies of 0.54 and 1.02 Mev. This compares favorabl with the values reported in the literature, 0.61 and 1.03 Mev.

The neutron absorption cross section of I^{129} could be calculated from the data of this experiment if the number of I^{129} atoms in the sample were known. Unfortunately, this number can be found only roughly because the original isolation of the iodine from the uranium slug by Seiler was not done quantitatively. There are two methods of making this estimate. The first is based on the weight of the uranium slug (1183 gm.), the fission cross section of uranium (3.91 barns), the fission yield of chain of mass 129 (0.7%), the time of irradiation (123 days), and the following three assumptions: (1) the uranium slug was in a flux of 1.0×10^{11} n/cm^2/sec (this is about 2/3 of maximum flux at an average pile power of 698KW.) (2) about 30% of the iodine in the slug was extracted and (3) the chemical yield was also about 30%. This leads to a value of 7.6×10^{15} for the number of I^{129} atoms and to a value of 2.5 barns for the cross section.

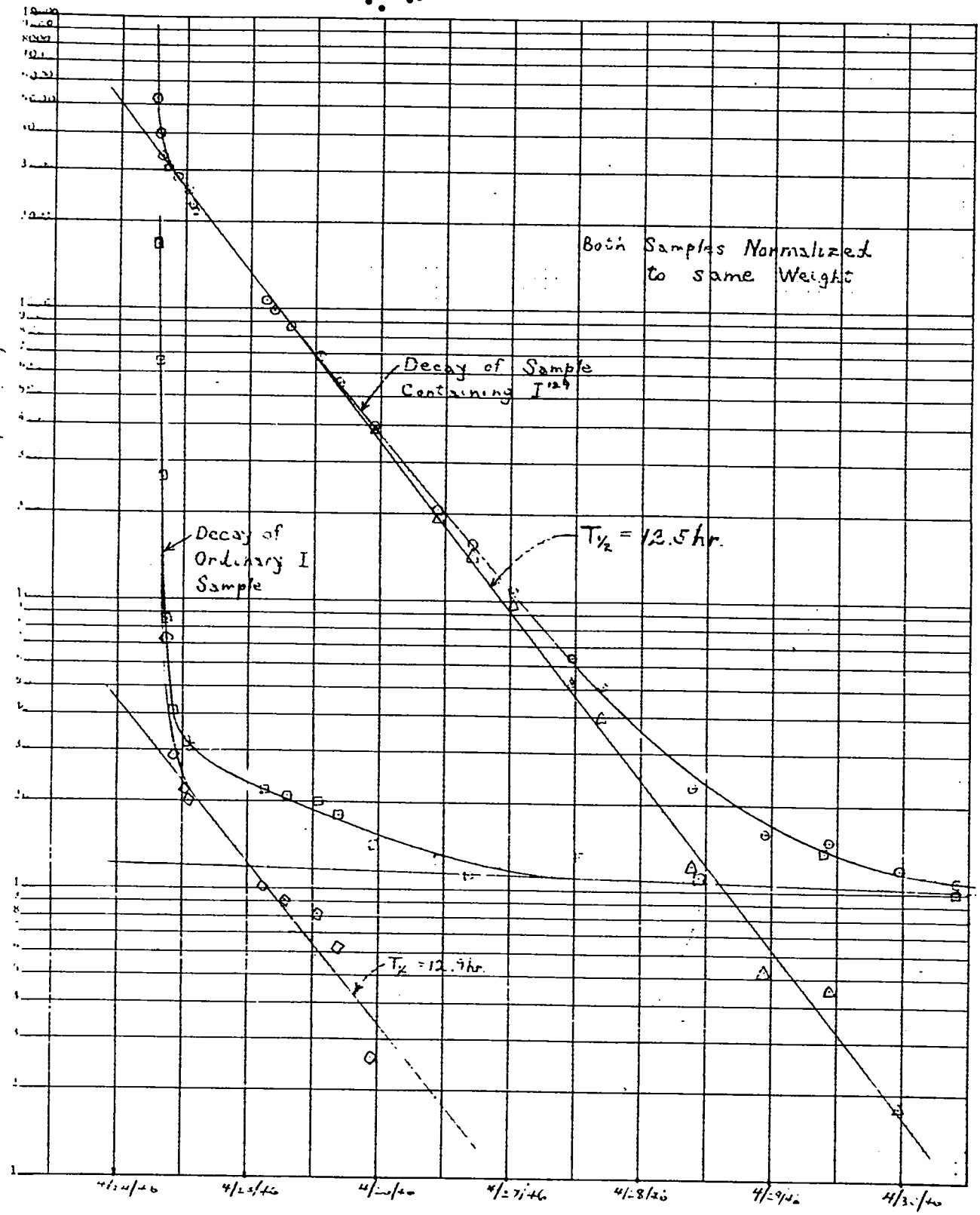

Fig. 1. Decay of 12.6h I^{130} Produced by Neutron Bombardment of Long-Lived I^{129}.

The other method of estimation is based on a rough measurement by Seiler of the 8d I^{131} activity which was present in the sample used here. This assumes that the bombardment of the uranium was steady, especially near the end. The formula used was

$$N_{129} = \frac{A_{131} Y_{129} t}{Y_{131}}$$

where N_{129} is the number of I^{129} atoms, A_{131} is the activity of the 8d I^{131} at the end of bombardment, Y_{129} and Y_{131} are the fission yields of chains 129 and 131 respectively, and t is the irradiation time (123 days). N_{129} comes out to be 1.9×10^{15} atoms and the cross section of I^{129}, 10 barns. This value is probably more reliable than the first value (2.5 barns) because it is based on fewer assumptions. A weighted average of the two values is about 8 barns which is very probably correct to within a factor of ten.

The neutron flux passing through the iodine samples during their irradiation at the water boiler was calculated from the activity of the 25m I^{128} and the cross section of stable I^{127} (6.25 barns). This flux was 8.7×10^{10} $n/cm^2/sec$. In all of the calculations the observed activities were corrected to 100 counter geometry, to 100% chemical yield, to zero absorber, and for decay.

A half-life of 10^8 years, or longer, for I^{129} is not inconsistent with the results of Seiler's experiment. Such a long period would make it possible for I^{129} to exist in nature. In fact, the two normal iodine samples used in this experiment did show a small amount of residual

acitivity after the decay of the 25m I^{128} (see Fig. 1). Some of this may be due to 13.1 I^{126} formed by an (n, 2n) reaction and to impurities. However, there is some indication of the presence of a 12.9h period which may be due to 12.6h I^{130}. This sets an upper limit to the amount of I^{129} that might be present in normal iodine, i.e., 3×10^{-4}%. This point can be investigated further by bombarding larger samples of normal iodine in a higher thermal neutron flux and then subjecting them to more extensive purification.

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