Title

Hf175, A New Radioactive Isotope of Hafnium

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Publication Date

1948-11-01

UNIVERSITY OF CALIFORNIA

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BERKELEY, CALIFORNIA

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November 29, 1948

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Hf^{175}, A NEW RADIOACTIVE ISOTOPE OF HAFNIUM

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ABSTRACT

A new light isotope of hafnium, Hf^{175} has been produced by deuteron and proton bombardments of natural lutecium. Radiation characteristics, half-life, and chemical separations are discussed.

For declassification
November 29, 1948.

Hf^{175}, A NEW RADIOACTIVE ISOTOPE OF HAFNIUM

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A study has been made of hafnium activities produced by bombardment of lutecium with 19 Mev deuterons and 10 Mev protons from the 60-inch Crocker Laboratory cyclotron.

The lutecium used for bombardment was Johnson and Matthey's "Specpure" oxide, prepared by Professor Marsh of Oxford University, and purified in this laboratory by ion-exchange resin column separation. Spectroscopic analysis[1] showed absence of yttrium and rare earth contamination. The oxide, with sodium silicate as a binder, was bombarded on a platinum interceptor target placed in the cyclotron beam. After bombardment, the target material was dissolved in boiling, concentrated nitric acid and the insoluble silica residue discarded. After addition of a few milligrams hafnium carrier, the hot solution was adjusted to 3N in nitric acid and the lutecium precipitated by addition of hydrofluoric acid. After centrifuging, the filtrate containing hafnium was scavenged repeatedly by addition of lanthanum carrier solution in order to remove any rare earth contamination. Hold-back carriers for the various radioactivities likely to be formed from the target materials, copper, sodium silicate, etc. were added and the solution adjusted to 3N in both nitric and hydrofluoric acids. Excess barium nitrate solution was then added to precipitate barium hafnium fluoride. The washed precipitate was dissolved in hot 8N nitric acid saturated with boric acid, and the hafnium hydroxide recovered by addition of ammonium hydroxide. The hydroxide was dissolved in nitric acid, and barium hafnium fluoride reprecipitated. The precipitation of the barium metal fluoride from strongly acid solutions is specific for hafnium and zirconium.

The lutecium and hafnium were finally converted to the oxides for weighing and estimation of chemical yields.

The chemically separated hafnium has been found to contain a single radioactivity, emitting electrons and γ radiations, which decays with a half-life of 70 ± 2 days. No evidence of zirconium contamination, or shorter lived activities was seen. Standard 3 mg/cm^2 mica window counters filled with argon-alcohol mixture were used in the measurements.

An aluminum absorption curve of an "infinitely thin" hafnium sample, mounted on thin mica, is shown in Fig. I.; the soft quantum radiation background was determined after removal of electrons by a 100 mg/cm^2 beryllium absorber. The lead absorption curve (Figure II) was measured using an unshielded counter. The radiations consist of electrons range 82 ± 2 mg/cm^2 (300 Kev); electromagnetic radiation of half-thicknesses 14.5 ± 0.3 mg/cm^2 aluminum (8.2 Kev), 100 ± 5 mg/cm^2 lead (55 Kev), 2.2 ± 0.1 g/cm^2 lead (350 Kev), and 13.3 ± 0.2 g/cm^2 lead (1.5 Mev). The energies of the two soft components agree well with those to be expected for lutecium L and K x-radiation.

From the measurements, the intensity ratios of the various radiations were estimated. Corrections were made for absorption of electrons in the counter window, air gap, etc., and counting efficiencies for the 8.2 Kev, 55 Kev, 350 Kev and 1.5 Mev γ-rays were taken as 5%, 0.5%, 0.5% and 1.5%, respectively. A fluorescence yield of 0.5 for L and 0.8 for K x-radiation was assumed. The fully corrected ratios obtained are:

e^-: L x-rays: K x-rays: 350 Kev γ: 1.5 Mev γ = 0.1:0.1:1:0.2:0.05

While it is realized that such ratios may be in error by factors of two or more, more accurate information being difficult, if not impossible, to obtain by the simple counting techniques used, it seems justifiable to attempt to estimate

the radiations arising from one disintegration, in order to allow calculation of cross sections of reactions producing the isotope. The isotope thus probably decays by electron capture, mainly to the ground state, and also to two or more excited or metastable levels. The transition from the lower excited state is accompanied by conversion, the coefficient for which is 0.4. The measured energies of the conversion electrons agree with K shell conversion. It is assumed that about 0.1 of the observed K x-rays arise from conversion, and accordingly one disintegration by orbital electron capture is represented by 0.9 K quanta corrected for counting efficiency, etc. Using this value, the measured chemical yields, and bombardment data from the cyclotron instruments, the cross sections for the formation of the isotope were calculated. For 10 Mev protons and 19 Mev deuterons on natural lutecium, the cross sections are respectively 3×10^{-2} barns and 5×10^{-2} barns. These values are reasonable for the p,n and d,2n reactions, and agree with other measurements for similar reactions in this region.

The new isotope is allocated to mass 175.

We are greatly indebted to Dr. J. G. Hamilton, Mr. T. Putnam, Mr. B. Rossi and the crew of the 60-inch Crocker Laboratory cyclotron for their cooperation in making bombardments; we also wish to thank Professors G. T. Seaborg, I. Perlman and B. B. Cunningham for their continued interest and advice.

This work was carried out under the auspices of the United States Atomic Energy Commission.

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[1] We are indebted to Mr. J. G. Conway of this laboratory for spectroscopic analyses.

Figure I:

Aluminum absorption of Hf^{175}; curve A represents K x-rays and γ radiation; curve B, K x-rays, L x-rays and γ radiation; and curve C, electrons.

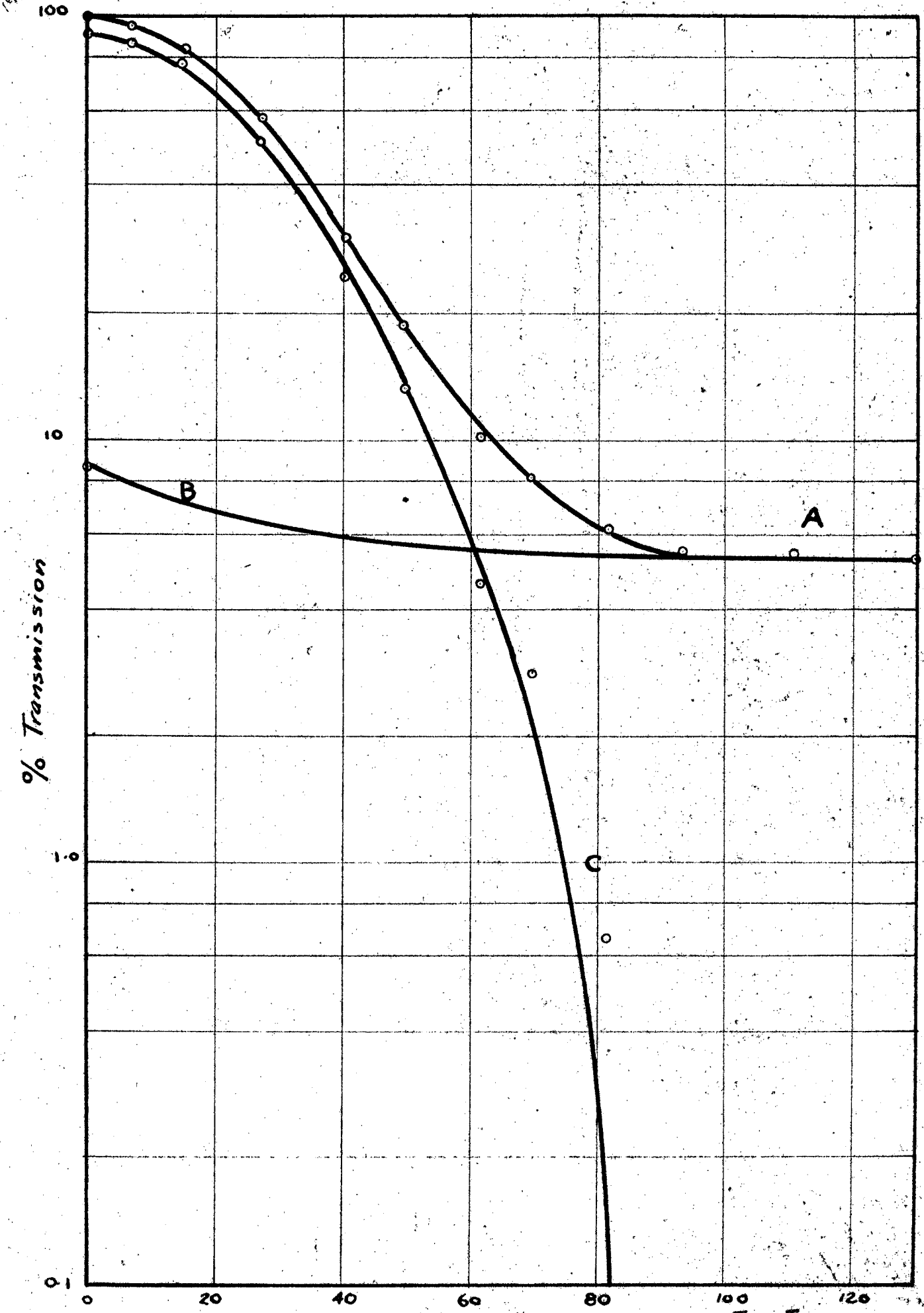
100
10
1.0
0.1
% Transmission
A
B
C
0
20
40
60
80
100
120
mg/cm² Al Absorber

Fig. I

Figure II:

Lead absorption of Hf^{175}; curve A represents the hard γ-radiation; curve B, the soft, partially converted γ-ray; and curve C shows the presence of K x-rays.

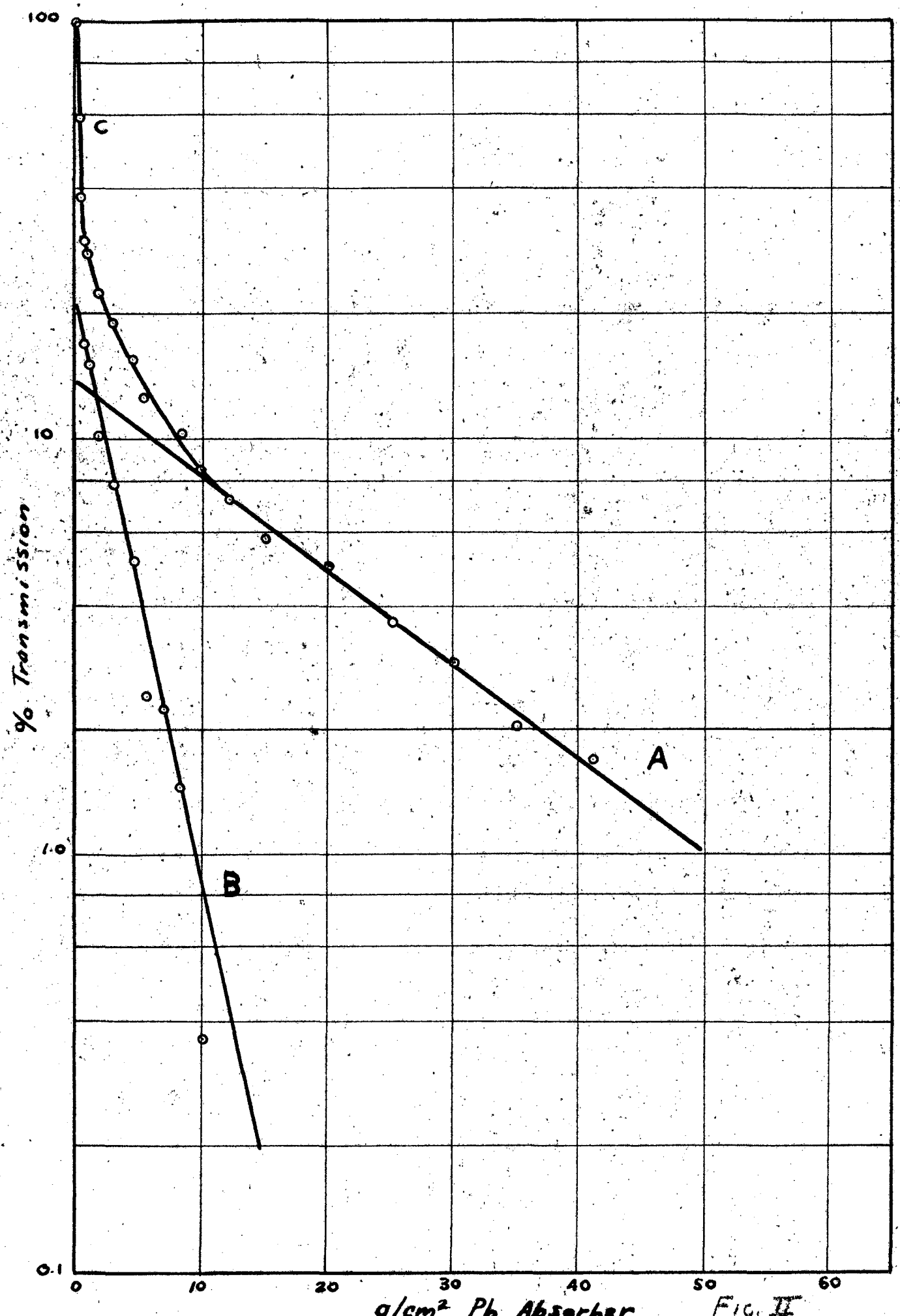
100
10
1.0
0.1
% Transmission
C
A
B
0
10
20
30
40
50
60
g/cm² Pb Absorber

Fig. II