the branching percentage of a (7.24±0.25)-Mev beta transition, β_1. (6) Two gamma transitions, having energies of 2.26±0.03 Mev and 3.52±0.05 Mev are associated with the decay of Al^{30}. The intensity of the 3.51-Mev gamma ray relative to that of the 2.24-Mev gamma ray was measured to be 0.64±0.06. (7) Since limited source strength prevented coincidence measurements, the Al^{30}-Si^{30} mass difference is either (5.05±0.25) Mev or (7.29±0.25) Mev with the latter value more consistent with nuclear systematics and indirect experimental results. (8) Shell-model considerations yield alternative Al^{30} ground-state spin assignments 1 through 5 and even parity. Although no further reduction in the spin ambiguity can be made directly from the present experimental results, reasonable arguments can be made to reduce the choice to the values 1, 2, or 3 with 1 being the least probable. (9) The proposed decay scheme for Al^{30} is shown in Fig. 6.

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New Hafnium Isotope, Hf^{182}†

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A new isotope of hafnium, Hf^{182}, has been produced by double neutron capture in Hf^{180} in the intense neutron flux of the materials testing reactor (MTR). Mass spectrometric analysis of the irradiated hafnium gave a Hf^{182}/Hf^{180} atom ratio of 0.00147±0.00001. The new isotope decays with a half-life of $(9\pm2)\times10^6$ years by β^- emission predominantly to a 271-kev level in Ta^{182}. The number of 271-kev gamma rays per β^- disintegration is 0.84±0.10. The log *ft* for the beta transition to the Ta^{182} ground state is >15 indicating that this transition is at least third forbidden. The neutron capture cross section of Hf^{181} is 40_{-20}^{+40} barns.

IN a continued search for extinct radioactivities, several nuclides were exposed to the high neutron flux of the materials testing reactor in September, 1956, for a one-year irradiation. One of these targets was 300 mg of HfO_2, enriched in Hf^{180} to 93%. Approximately three years after the completion of the irradiation, when the Hf^{181} and Hf^{175} activities had decayed by factors of many thousands, the sample was dissolved by fusion with $K_2S_2O_7$. Following several chemical purifications of the hafnium, a small sample was isotopically analyzed in a 12-in., 60° mass spectrometer with a multiple-rhenium-filament ionization source. The hafnium isotope Hf^{182} was detected in the amount given in Table I.

The radiations of Hf^{182} were examined with 3×3-in. NaI(Tl) and ¼-in. thick anthracene crystal detectors coupled with conventional amplifiers and multichannel analyzer. The γ ray spectrum of the chemically purified hafnium sample contained, in addition to the photopeaks characteristic of the decay of Hf^{181} (45 days) and Hf^{175} (70 days), a 271-kev γ ray which is associated with the decay of Hf^{182}. The intensity of the 271-kev γ ray is 0.84±0.10 per Hf^{182} disintegration.

The results of the measurement on the beta spectrum are indefinite due to the Hf^{181} contribution, although an upper limit of 0.4 Mev can be placed on the beta particles of Hf^{182}.

The half-life of Hf^{182} was determined from the growth rate of Ta^{182}. In order to discriminate against the Hf^{175} and Hf^{181} activities, the Ta^{182} was detected by its gamma rays with energy greater than 1 Mev. The absolute counting efficiency of Ta^{182} gamma rays in the energy range selected in our experiment was established by comparing the gamma-ray counting rate of a pure Ta^{182} activity in our arrangement with its beta counting rate in a 4-π beta counter. The amount of Hf^{182} was calculated from the mass spectrometric analysis and the

TABLE I. Isotopic content of hafnium sample enriched in Hf^{180} and irradiated in the MTR for 1 year.

Isotope	Atom percent
182	0.138±0.001
180	93.80 ±0.04
179	3.16 ±0.03
178	2.67 ±0.03
177	0.098±0.002
176	0.114±0.005
174	0.023±0.001

† Based on work performed under the auspices of the U. S. Atomic Energy Commission.

weight of the hafnium sample which was determined as HfO_2. This information and the least-squares analysis of the growth curve of Ta^{182} give a value of $(9\pm2)\times10^6$ years for the half-life of Hf^{182}. Two recent communications[1,2] give the half-life as 8.5×10^6 and $(8\pm5)\times10^6$ years, respectively, in agreement with our measurement.

The experimental lower limits placed on both the lifetime and the decay energy (>271 kev) of the beta transition to the Ta^{182} ground state enables one to calculate a lower limit for the log ft value of this transition of 15. Since the beta transition to the Ta^{182} ground state is at least third forbidden and the ground state spin and parity of the even-even nucleus Hf^{182} is expected to be 0+, spins of 2 or less (either parity) and 3+ assignments for the Ta^{182} ground state are not likely. This conclusion is consistent with a recent survey[3] of the evidence about the spin of Ta^{182} obtained from studies of the beta decay of Ta^{182} and the gamma-ray spectrum following neutron capture in Ta^{181} which favors a Ta^{182} ground-state spin assignment of 3 or greater.

Two low-lying excited states of Ta^{182} with energies of 147 and 319 kev have been observed in the decay of 16-minute Ta^{182m} and their spins[3] are $I+1$ and $I+2$, respectively, where I is the ground-state spin. The absence of these levels in the beta decay of Hf^{182} is consistent with their assigned spins. In the neutron capture gamma-ray spectrum of Ta^{181} the three highest energy transitions which are observed have energies of 6.060 ± 0.008, 5.961 ± 0.008 and 5.782 ± 0.010 Mev. If the 6.060-Mev γ ray represents the transition[4] to the Ta^{182} ground state, the other two γ rays populate levels of 99 ± 16 and 278 ± 18 kev. Excited levels in Ta^{182} with higher energies are also populated in the neutron capture but will not be discussed here. The capturing state in Ta^{182} can be either 3 or 4, and the parity, like that of Ta^{181} is positive. If the high-energy gamma rays observed in the neutron capture are dipole transitions, the 99 ± 16 and 278 ± 18-kev levels in Ta^{182} will each have a spin of 2 or greater.

From the lifetime of the Hf^{182} beta transition which populates the 271-kev excited level of Ta^{182} and the upper limit placed on the maximum energy of the beta transition, it follows that the spin and parity of the 271-kev level may be 3+, $2\pm$, $1\pm$, or $0\pm$. The conversion coefficient of the 271-kev gamma ray is less than 0.35 (for the calculation of this limit we assume that all the beta decay populates the 271-kev level) and on this basis one eliminates all multipolarity assignments for the 271-kev transition except $E1$, $E2$, and $M1$. Such an argument in conjunction with the knowledge that the Ta^{182} ground-state spin is at least 3 eliminates the $0\pm$ assignments for the 271-kev level.

On the basis of present experimental knowledge the 271-kev level observed in the Hf^{182} beta decay and the 278 ± 18 kev level observed in the neutron-capture gamma-ray spectrum of Ta^{181} may be the same excited level of Ta^{182}. The absence of beta branching (<20%) to the 99 ± 16 kev level indicates that the spin of this level is larger than that of the 271-kev level. The cascade gamma rays with energies of 172 and 99 kev have not been observed at this time and from our experiment an upper limit of about 0.2 gamma ray per Hf^{182} beta disintegration is placed on each of their intensities. Arguments can be made from this information in conjunction with other data[3,4] to indicate that the spin of the 99-kev level is probably the same as the Ta^{182} ground state and two units greater than the spin of the 271-kev level.

The neutron capture cross section of Hf^{181} in the neutron spectrum of the MTR reactor has been estimated from our data to be 40_{-20}^{+40} barns. This assumes that the activation cross section of Hf^{180} is 10 barns.[5]

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