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July 14, 1954

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Several new isotopes of curium, berkelium, and californium have been produced by charged particle bombardments of pile produced transplutonium isotopes, and their nuclear properties studied. The chemical procedures and counting methods used were essentially the same as those used in prior work of this nature at Berkeley.[1,2]

The existence of Cm^{245} was first proved by mass spectrographic analysis[3] of samples of curium subjected to long neutron irradiations in the Chalk River reactor. However, the electron capture decay of Bk^{245}, produced by helium ion bombardment of Cm^{242}, results in the formation of pure but small samples of Cm^{245}. This nuclide was found to decay by emitting alpha particles of 5.36 ± 0.05 Mev as measured by alpha particle pulse height analysis.[4] The energy measured probably does not represent the transition to the ground state of Am^{241}, but higher energy alpha particle groups were undetected in the samples of such low counting rates. The best approximation for the half-life of Cm^{245} is 20,000 years. This value is based on the counting of K and L x-rays arising from orbital electron capture by Bk^{245}, the use of approximate Auger conversion factors,[5,6] and the measurement of the alpha disintegration rate of the daughter. Elution of the material emitting 5.36 Mev alpha particles in the curium position (with Cm^{242}) from a cation exchange column with buffered ammonium citrate eluant proved that this new alpha particle emitter is an isotope of curium.

A previously unknown isotope of californium, Cf^{248}, was made by helium ion bombardment of curium containing a small percentage of Cm^{245}.[3] This isotope decays by emission of 6.26 ± 0.03 Mev alpha particles with a half-life of 250 ± 20 days. Decay of the alpha radioactivity of the above energy was followed through two half-lives. A spontaneous fission half-life of about 7000 years was also measured, but this value is rather uncertain because of the extremely slow spontaneous fission rate of the sample. Observation of the growth of the 5.80 Mev alpha particles of Cm^{244} in the above sample proved the mass assignment of the Cf^{248}.

The bombardment of various mixtures of Am^{241} and Am^{243} with 27 Mev helium ions is believed to have produced a 1.8 day electron capture isotope of berkelium which is tentatively assigned to Bk^{246}. The 1.8 day period was observed in the berkelium fraction from three different bombardments. A different chemical separation procedure was used in each case. This intermediate period was resolved from the 4.5 hour Bk^{243} (and Bk^{244}) and the 4.95 day Bk^{245} periods after following the decay in a windowless proportional counter. An 820 ± 10 kev gamma ray decaying with a 1.7 day half-life was observed in the berkelium fraction using a sodium iodide crystal scintillation counter connected to a 50-channel pulse height analyzer.[7] It appeared that between 20 and 50 percent of the Bk^{246} electron capture disintegrations passed through this 820 kev excited state of Cm^{246} based on the total disintegration rate from the estimated counting yield of the windowless proportional counter and the best value[8,9] for the photoelectric yield from the sodium iodide crystal. K x-rays resulting from the berkelium

decay were followed for decay with the sodium iodide scintillation counter and the L x-rays with a small xenon-filled proportional counter (90 percent xenon and 10 percent methane, at 1 atm) connected to the 50-channel pulse height analyzer. The approximate Bk^{246} decay period could be resolved from the 4.95 day component in both the K and L x-ray decay curves. A total disintegration energy of approximately 1.4 Mev is estimated from energy balances within closed decay cycles[10] to be available for orbital electron capture by Bk^{246}. The half-life thought to be associated with Bk^{246} seems reasonable for either a highly forbidden ground state transition or if a large percentage of the disintegrations are forced to pass through a high energy level of Cm^{246}.

Helium ion bombardment of curium containing a high percentage of Cm^{244} followed by a fast chemical separation of the californium fraction resulted in the detection of an orbital electron capture isotope of californium, Cf^{247}. This isotope was also observed in the products from nitrogen ion bombardments of U^{238} metal foils.[11] Decay of the K x-rays of this nuclide (followed in the presence of interfering Cf^{246} alpha radioactivity) with the above mentioned sodium iodide crystal scintillation spectrometer gave a half-life of 2.5 hours. A rough 3 hour half-life was obtained by resolving the decay curve of the L x-rays associated with the orbital electron capture of Cf^{247} and the alpha decay of Cf^{246}. The measured energies of the L x-rays (L_α = 15.1, L_β = 19.7, and L_γ = 24.1 kev) agree well with those expected from berkelium. No radioactivity could be detected from the daughter of Cf^{247}, namely, Bk^{247}.

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