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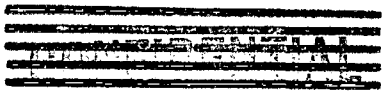

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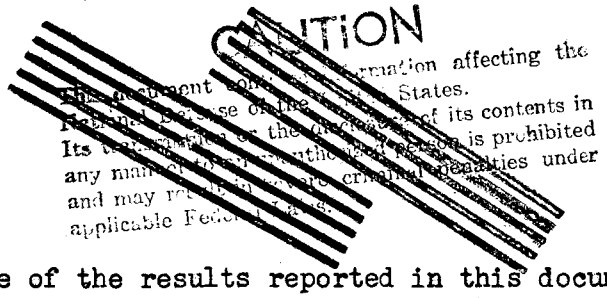
Contract No. W-7405-eng-48

SUMMARY OF THE RESEARCH PROGRESS MEETING

of April 6, 1950

Henry P. Kramer

May 11, 1950



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SUMMARY OF THE RESEARCH PROGRESS MEETING

of April 6, 1950

Henry P. Kramer

The New Element Berkelium. S. Thompson.

The speaker, A. Ghiorso, and G.T. Seaborg have discovered an isotope of element 97. They received help from Professor B. B. Cunningham, K. Hulet, the Health Chemistry group under the direction of N. Garden and the crew of the 60-inch cyclotron.

The work that culminated in this discovery was motivated by interest in the systematics of α and β decay, in actinide chemistry, and in this connection, in the extension of the analogy between rare earths and actinide elements. The possibility of discovering more stable configurations of neutrons and protons and thus extending knowledge of the variation of stability with atomic and mass numbers was a further spur to the research.

By extrapolating the analogy between the rare earth elements and the existing actinides to the element with atomic number 97, a guess was made that the chemical properties of 97 should in the main correspond to those of terbium of the lanthanides. One can understand the analogy in properties by considering that in the rare earth series the 4f shell is being filled whereas in the actinides the 5f shell is being completed. For example, $_{96}$Cm has 7 electrons in the 5f shell. Its analogue $_{64}$Gd has 7 electrons in the 4f shell. Element 97 has 8 electrons in the 5f shell while its expected analogue $_{65}$Tb has the same number of electrons in the 4f shell.

Several methods for the preparation of 97 were tried. It is conveivable that each of the following three nuclear reaction sequences may result in the production of isotopes of 97:

$$Am^{241}(\alpha, 2n)97^{243}$$

$$Cm^{242}(d,n)\ 97^{243}$$

$Am^{241}(n,\gamma)Am^{242}(n,\gamma)Am^{243}(n,\gamma)Am^{244}(\beta^-\text{decay})Cm^{244}(n,\gamma)Cm^{245}(n,\gamma)Cm^{246}$
$Cm^{246}(n,\gamma)Cm^{247}(\beta^-\text{decay})97^{247}$.

Sufficient quantities of americium were obtained by neutron bombardment of Pu^{239} resulting in the production of Pu^{241} which transmutes by beta decay to Am^{241}.

At present only the methods involving cyclotron bombardment have met with success. The bombardment in the cyclotron presented the problem of containing the sample in a target holder constructed in such a way that no radioactivity might leave it to contaminate the cyclotron. To keep the target from melting, a water cooling system was incorporated in the target holder. The bombardments were carried out with 35 Mev alpha particles accelerated in the 60-inch cyclotron.

Before doing the experiments, estimates were made of the nuclear properties of some isotopes of element 97. The alpha energy and half-life were estimated by extrapolating the graphical compilation of alpha energy versus mass number and atomic number, which has been published by Seaborg, Perlman and Ghiorso, and by closing energy cycles. The energy obtained from the closed cycles was used to estimate the half-life for electron-capture using an empirical relationship established for the heavy isotopes.

Americium was bombarded as the oxide. After the bombardment it was dissolved in strong HNO_3 and precipitated as the hydroxide. The hydroxide was dissolved and oxidized to the +VI oxidation state. The portion of

Americium in the +III state was then precipitated as the fluoride, converted to the hydroxide and dissolved in $HClO_4$. By oxidizing about 99% of the americium to its +VI state the americium fraction remaining in the +III state and containing 97 was reduced in bulk.

The rare earths were eliminated by adsorbing the mixture of radioactivities on Dowex 50 resin, transferring the resin to a column packed with the same resin and eluting with 13M HCl which removes actinides faster than rare earths. The actinide fraction was run through another Dowex 50 resin column with ammonium citrate for elution. The temperature was maintained at $87^{\circ}C$ in order to reduce the time of separation. Element 97 was obtained in the neighborhood of the fortieth drop in a position relative to Cm and Am corresponding to the position of its rare earths analogue, terbium, relative to Gd and Eu.

The activity was placed in the pulse analyzer and three alpha groups were found of energies 6.20 Mev, 6.55 Mev, and 6.72 Mev. The half-life for α- decay was $\sim$1 year. The electromagnetic radiation was examined in an x-ray proportional counter. In this way the branching ratio, i.e., the ratio between the number of decays by alpha emission and the number of decays by electron capture was determined to be 0.001. The half-life of 97^{243} was 4.6 hours.

The electron-capture-decay daughter of 97^{243}, Cm^{243}, was observed to grow into the sample. Cm^{243} emits alpha particles of energy of 5.84 Mev. The α-decay daughter of 97^{243}, Am^{239} was also observed.

To establish the chemical properties of 97 a number of experiments have been carried out. They show among other things that the oxidation potential of the couple $97(+3) \rightarrow 97(+4)$ is of approximately the same magnitude as that of the couple $Ce(+3) \rightarrow Ce(+4)$, namely $\sim$ 1.6 volts.

Photon Coincidences from Proton Bombardment. B. Moyer.

The high energy γ rays that have been observed by Moyer and York have been tentatively explained as arising from the decay of a neutral meson into two photons. In order to test this hypothesis measurements have been instituted with a view to observing two γ ray photons in coincidence at the 184-inch cyclotron. For this purpose the equipment designed by J. Steinberger for use in similar measurements of γ rays produced by the action of the high energy x-ray beam of the synchrotron was used. The apparatus is sketched in Fig. 1. Its dominant characteristic is its extremely short resolution time of 1 microsecond. The gain in resolution that is to be had by the use of the high-speed coincidence-anti-coincidence apparatus is off-set to a certain extent by the small solid angle subtended by the crystals. This factor reduces the counting rate which is critically low in the small intensity deflected proton beam. The background is strongly target-dependent, consisting in the main of neutrons converted to protons in the converter and is primarily directed forward. In order to reduce the background counting rate, therefore, the counter telescopes were tilted somewhat backward of the target plane.

Because of the low counting rates the statistics are as yet very sparse and are of a very preliminary nature.

Converter I	Converter II	Accidentals Measured	Accidentals Predicted	Counts/Min Total Count	Net Count Measured	Net Count Predicted
Pb	Pb	.17 0.09 .1 .15		0.41 .05	.24 .10	.72
Pb	none	3 counts in 22 min.				
none	none	2 counts in 51 min.				
Cu	Cu	.13 .07		0.26 .07	.13 .10	

The large difference between actual and predicted count is thought to be due in part to the scattering of electrons arising from converted γ -rays.

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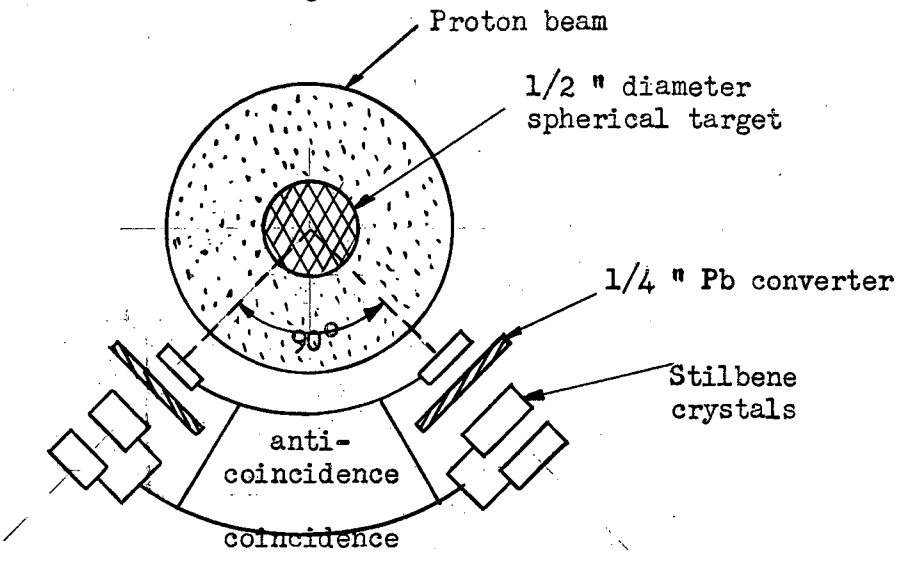

Apparatus for Measuring γ -rays from π^0 Meson Decay.

Fig. 1