Radioactive Y^{84}, Y^{88}, and Zr^{87}

B. E. ROBERTSON,* W. E. SCOTT,* AND M. L. POOL
Ohio State University, Columbus, Ohio

(Received August 24, 1949)

A 3.7-hour activity, assigned to Y^{84}, has been obtained by bombardment of Sr^{84} with 10-Mev deuterons. Characteristic radiations are 2.0-Mev positrons, x-rays, and gamma-rays. A 2.0-hour activity, assigned to Zr^{87}, has been obtained by bombarding natural strontium and Sr^{84} with 20-Mev alpha-particles. Characteristic radiations are 2.0-Mev positrons, x-rays, and gamma-rays. Bombardments of $Sr^{87}+d$, $Y+n'$, and $Rb+\alpha$ are in agreement with the assignment of a 105-day activity to Y^{88} but show no evidence of a 2.0-hour positron activity previously assigned to Y^{88}.

I. 3.7-HOUR Y^{84}

WITH electromagnetically enriched isotopes of strontium now available, activities in the strontium, yttrium, and zirconium region have been investigated.

Bombardment of enriched** $Sr^{84}O$ with 10-Mev deuterons yielded a 3.7±0.1-hour positron activity which was followed through ten half-lives on a calibrated spectrometer counter.[1] The $Sr^{84}O$ was enriched to 27.7 percent strontium 84 as compared with the 0.56 percent strontium 84 found in natural strontium. The 3.7-hour activity was also produced by bombardment of $Sr^{84}O$ with 5-Mev protons. The 3.7-hour activity was not brought out by deuterons on $Sr^{86}O$ or $Sr^{87}SO_4$, which contained 0.3 percent and 0.2 percent strontium 84 respectively. To confirm the chemical identity of the 3.7-hour activity, normal SrO was bombarded with deuterons and an yttrium fraction extracted. The 3.7-hour activity was then observed in the yttrium fraction. Its abundance relative to that produced by $Sr^{84}O+d$ was in close agreement with the relative percentages of strontium 84 in SrO and $Sr^{84}O$. Total activity and x-ray activity as measured on a Wulf electrometer are shown in Fig. 1 for $Sr^{84}O+d$. The well-known 55-day and 65-day activities of Sr^{89} and Sr^{85} and the 14-hour, 3.3-day activities of the isomer Sr^{87} may also be seen.[2] Presence of the 3.7-hour x-ray activity indicates that K-capture decay is associated with this activity. A 3.7-hour gamma-decay was also noted. By aluminum-absorption measurements taken during the 3.7-hour activity the energy of the positrons was found to be 2.0±0.1 Mev.

To eliminate the possibility that the 3.7-hour positron activity could be the 3.92-hour scandium 43 activity and the 3.9-hour scandium 44 activity produced by deuterons on a possible calcium impurity in the enriched strontium 84, one-milligram samples of normal CaO and $Sr^{84}O$ were bombarded simultaneously on a manually rotated target. Initial intensities of the 3.9-hour scandium activities from deuterons on calcium and of the 3.7-hour activity from deuterons on strontium 84 were 6600 counts per minute and 100,000 counts per minute respectively. Energies of the scandium positrons as measured on the spectrometer counter were in agreement with the reported energies of 1.13 and 1.3 Mev as opposed to the much higher energy of 2.0 Mev determined for the 3.7-hour yttrium positron.

On the basis of these data the 3.7-hour activity is assigned to yttrium. Since the daughter products from an Y^{85} activity were not observed and inasmuch as the yield from p,n reactions on strontium 86 and 87 is found to be approximately six times that of p,γ reactions on the same isotopes, the abundance of the 3.7-hour activity from protons on strontium 84 indicates that placement at Y^{84} is preferable to placement at Y^{85}.

II. 2.0-HOUR Zr^{87}

A bombardment of normal SrO with 20-Mev alpha-particles revealed a 2.0±0.1-hour positron activity present in the zirconium fraction. To determine which of the stable isotopes of strontium contribute to the formation of the 2.0-hour positron activity, a simultaneous alpha-bombardment of enriched $Sr^{84}O$ and $Sr^{86}O$ was made. The $Sr^{84}O$ contained 27.7 percent strontium 84 and 29.9 percent strontium 86. The $Sr^{86}O$ contained 0.3 percent strontium 84 and 69.9 percent strontium 86.

The decay of the positron activity from $Sr^{84}O+\alpha$, as measured on the spectrometer counter, consisted of a 2.0-hour decay through five half-lives and a longer activity of 3.25-days. The decay of the $Sr^{86}+\alpha$-sample consisted of the 3.25-day positron activity of zirconium 89 and the yttrium 91 activity of 57-days.[2] No 2.0-hour activity was observed in the $Sr^{86}O+\alpha$-decay. From the percent composition of the strontium in each of the two samples, one is led to conclude that the 2.0-hour activity is caused by the strontium 84 and should be assigned to zirconium 87. The reaction is $Sr^{84}(\alpha,n)Zr^{87}$.

From aluminum-absorption measurements taken in the 2.0-hour activity, the energy of the positron was determined as 2.0±0.1 Mev. A lead-absorption measurement taken in the 2.0-hour activity showed the existence of two gamma-rays of nearly equal intensity.

* Captain, U. S. Air Forces, research done under auspices U.S.A.F., Institute of Technology, Wright Field, Dayton, Ohio.

** Supplied by the Y-12 Plant, Carbide and Carbon Chemicals Corporation, through the Isotope Division, AEC, Oak Ridge, Tennessee.

[1] L. L. Woodward and D. A. McCown, Rev. Sci. Inst. **19**, 823 (1948).

[2] G. T. Seaborg and I. Perlman, Rev. Mod. Phys. **20**, 585 (1948).

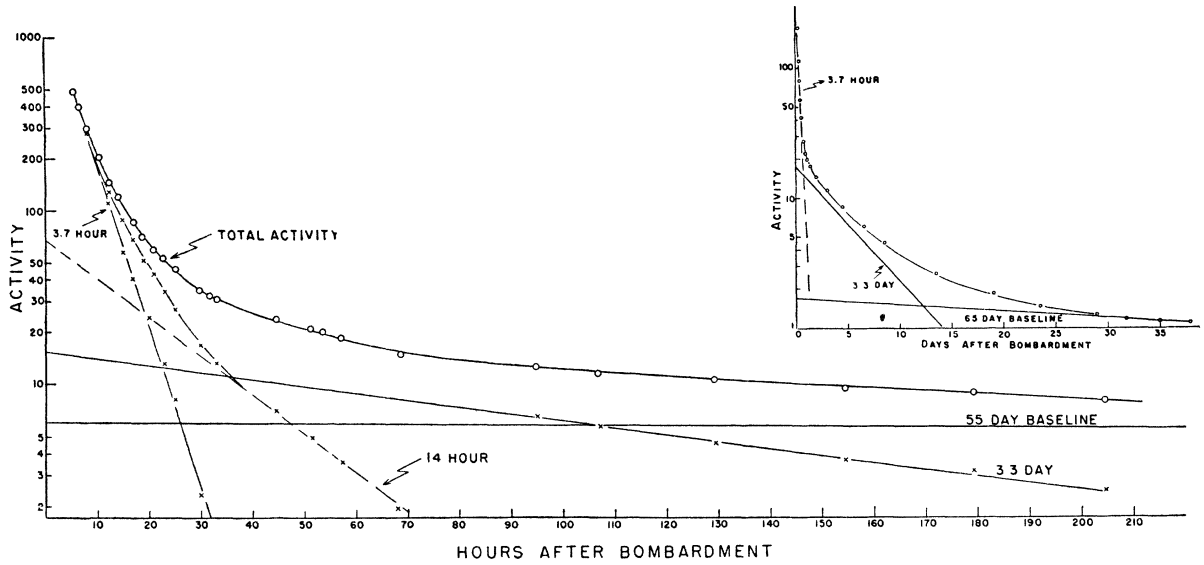

FIG. 1. Decay of $Sr^{84}O+d$. The 55-day activity corresponds to Sr^{89} from $Sr^{88}(d,p)Sr^{89}$. Inset: Decay of electromagnetic radiation as measured on Wulf electrometer equipped with magnet above chamber to deflect charged radiation. The 65-day activity corresponds to Sr^{85} from $Sr^{84}(d,p)Sr^{85}$.

Their energies correspond to 0.35 ± 0.05 Mev and 0.65 ± 0.05 Mev. Both are associated with the 2.0-hour activity. By aluminum-absorption measurements, x-rays, indicating decay by K-capture, were found associated with the 2.0-hour activity.

III. 2.0-HOUR Y^{88} REMOVED

In previous work on yttrium a 2.0-hour activity decaying by positron emission was reported as resulting from deuteron bombardment of strontium,[3-5] and fast neutron bombardment of yttrium.[3] The activity was assigned to yttrium 88. Later this positron activity was reported in the yttrium fraction from a bombardment of strontium with protons.[3] The determinations of the energy of the positrons varied from 1.2 Mev according to cloud-chamber observations to 1.65 Mev by aluminum-absorption measurements.

A 105-day activity of yttrium characterized by K-capture decay has been assigned to yttrium 88.[6] Its formation by a fast neutron bombardment of yttrium has been reported. Recent mass spectrographic analysis indicates that yttrium 88 is the correct mass assignment for this activity.[7]

A bombardment of Hilger Y_2O_3 with fast neutrons from $Li+d$ was made in order to study these reported activities of yttrium 88. The resultant decay of the yttrium fraction gave periods of 2.7-days and 105-days but no 2.0-hour activity. The only particle radiation observed was negative in sign. The 2.7-day activity is in agreement with that of the well-known yttrium 90 activity.

Bombardment of normal SrO with deuterons did not yield a 2.0-hour activity. With enriched strontium no 2.0-hour activity was noted for $Sr^{87}SO_4+d$ or for $Sr^{86}O+d$. To further determine the activities associated with yttrium 88, a bombardment of Hilger RbCl with alpha-particles was made. In the decay of the yttrium fraction no 2.0-hour activity was observed. The 2.7-day activity of yttrium 90 and the 105-day activity of yttrium 88 were both observed, however.

It is concluded that the 2.0-hour positron activity previously observed is not an activity of yttrium 88 which is found to exhibit a 105-day activity.

IV. ACKNOWLEDGMENTS

Grateful acknowledgment is made for the support received from the Ohio State Development Fund and the Graduate School.

[3] D. W. Stewart, Phys. Rev. **56**, 629 (1939).
[4] L. A. Dubridge and J. Marshall, Phys. Rev. **58**, 7 (1940).
[5] R. T. Overman, MDDC 354, AEC.
[6] A. C. Helmholz, Phys. Rev. **62**, 301 (1942).
[7] R. J. Hayden, Phys. Rev. **74**, 652 (1948).