# Radioactive Isotopes of Ag and Cd

JANE R. GUM AND M. L. POOL
*Ohio State University, Columbus, Ohio*
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$Ag^{105}$: An activity with a half-life of 40 days, has been produced by the following reactions: Rh($\alpha$,2$n$), Pd($\alpha$,$p$), Pd($d$,2$n$) and Pd($p$,$n$). This activity decays by $K$-electron capture only.

$Ag^{110}$: An activity with a half-life of 270 days previously reported as 225 days, has been produced by Pd($d$,$n$) and $Ag^{109}$($d$,$p$) reactions.

$Cd^{105}$: An activity with a half-life of 57 minutes has been produced by the Cd($n$,2$n$) and Pd($\alpha$,$n$) reactions. Decay is accompanied by a 1.5-Mev positron and $K$-capture.

$Cd^{109}$: An activity with a half-life of 470 days, previously reported as 330 days, has been produced by the Ag($d$,2$n$) and Pd($\alpha$,$n$) reactions.

## I. 40-DAY $Ag^{105}$

AN activity with a 45-day half-life has been reported[1] as resulting from a 6.3-Mev proton bombardment of Pd. The decay of this activity was by $K$-capture with associated gamma-rays ranging in energies[2] from 0.28 to more than 1.0 Mev. The mass assignment of this activity in Ag was indefinite.

It seems reasonable to expect that the mass assignment could be arrived at by bombarding in a cyclotron the neighboring isotopes with the various projectiles available. When Rh is bombarded with 20-Mev alpha-particles a 40±0.7-day half-life activity was found produced[3] in Ag. This activity was confirmed by a 5.0-Mev proton bombardment of Pd. A Pd($\alpha$,$p$) reaction also produced the 40-day half-life. Fast neutron bombardment of Ag does not produce this activity. Thus, the mass assignment is $Ag^{105}$.

Figure 1 shows an electromagnetic absorption of the radiation of the 40-day activity obtained from a deuteron bombardment of Pd. The measuring technique employed a Wulf unifilar electrometer attached to a Freon filled ionization chamber. A magnetic field was placed between the radioactive source and the electrometer; all charged particles, if any, were deflected. Extrapolating the gamma-ray base line to zero thickness of absorber and subtracting from the total x-ray and gamma-ray activity, the net amount of radiation due to x-ray only is then obtained. The intensity of the x-ray ionization for zero absorption was determined from similar absorption curves at various intervals over a period of 300 days. These intensity values are plotted in Fig. 2. The point $A$ of Fig. 1 is plotted as point $A$ in Fig. 2. It is thus seen that an x-ray activity is decaying with a half-life of 40 days. Confirmation of the x-rays was made with a Cauchois spectrograph. A photographic exposure beginning 5 days after the Pd was bombarded with deuterons and extending 44 days showed the presence of the Pd $K_\alpha$ line. The ratio of the number of gamma-rays to x-rays is approximately two.

Beta-activities produced when Pd is bombarded with deuterons were measured concurrently during the 300-day interval and did not show a 40-day half-life. Therefore this 40-day activity decays by $K$-capture only.

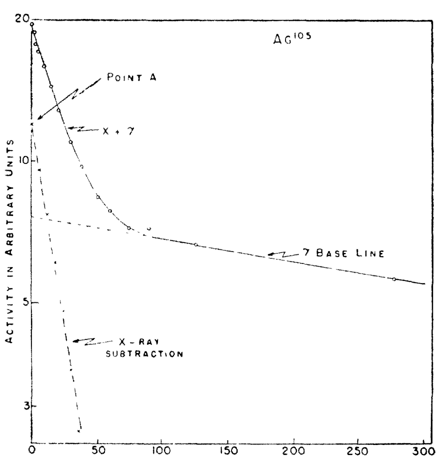


FIG. 1. Aluminum absorption taken during the decay of the 40-day half-life activity of $Ag^{105}$. A magnetic field prevented all charged particles from entering the ionization chamber.

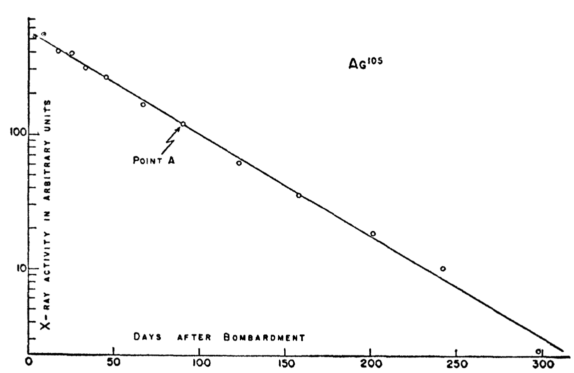


FIG. 2. Decay curve of the x-ray activity of the 40-day Ag material from a Pd+$d$ bombardment. The point $A$ of this figure is the same as point $A$ of Fig. 1.

[1] T. Enns, Phys. Rev. **56**, 872 (1939).
[2] Deutsch, Roberts, and Elliott, Phys. Rev. **61**, 389 (1942).
[3] Gum, Thompson, and Pool, Phys. Rev. **76**, 184 (1949).

## II. 270-DAY $Ag^{110}$

An isotope of Ag with a half-life activity of 225 days has long been known to be produced when Ag is bombarded with deuterons[4] or slow neutrons.[5]

Evidence is now available that the half-life value of this activity should be lengthened. After the previously discussed 40-day activity had decayed, a 270±4-day half-life was observed when Hilger Pd sponge was activated with deuterons. The Ag fraction of this bombardment was removed and the activity of the 270-day half-life material, as shown in the lower half of Fig. 3, followed a straight line decay for 5 years.

Ag enriched[6] in isotope 109 from 49 percent to about 92 percent, was bombarded with deuterons and the 270-day half-life was again found in the Ag fraction. This, together with the $Ag^{109}(n,\gamma)$ reaction,[7] adds to the evidence for the $Ag^{110}$ mass assignment of the 270-day activity.

## III. 57-MINUTE $Cd^{105}$

An activity with a half-life of 33 minutes has been reported[8] in Cd resulting from a Cd$(n,2n)$ reaction. No definite assignment was given to this activity.

A Cd activity with a 57±2-min. half-life was produced when Pd was activated with 20-Mev alpha-particles. The decay of the positron activity resulting from the Pd$(\alpha,n)$ reaction is shown in the upper curve of Fig. 4. A magnet was placed between the Geiger tube and the sample to separate positrons and electrons.

Cd bombarded with fast neutrons also yielded this activity. However, the activity is not observed when Ag is bombarded with deuterons or when Cd is bombarded with slow neutrons. These observations lead to the mass assignment of 105 for the 57-min. half-life activity.

In the lower curve of Fig. 4 an aluminum absorption is shown which was taken in the 57-min. half-life. A beta-end point was obtained at 0.7 g/cm² of aluminum,

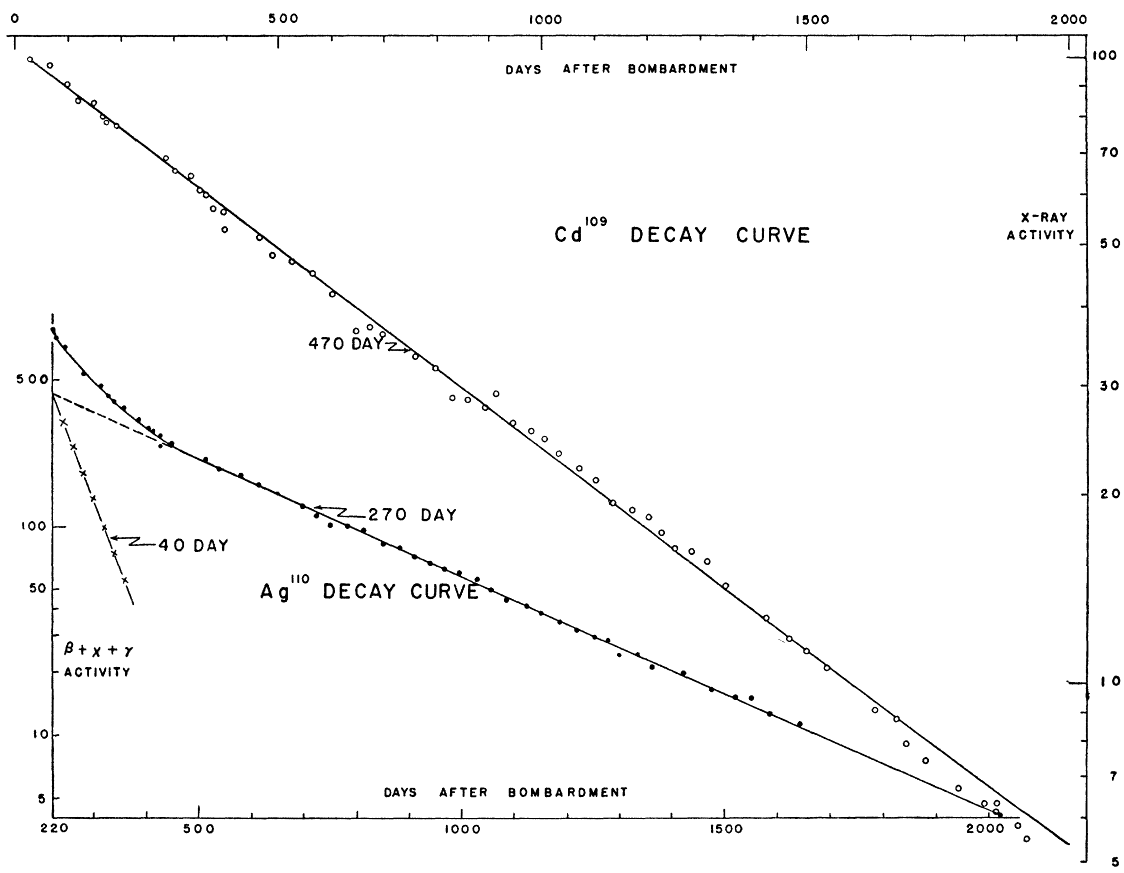


FIG. 3. Lower: Decay curve of the 270-day half-life activity of Ag produced by a Pd+$d$ bombardment. Upper: Decay curve of the 470-day half-life activity of Cd produced by a Ag+$d$ bombardment.

[4] R. S. Krishman, and D. H. T. Gant, Nature **144**, 547 (1939).
[5] J. J. Livingood, and G. T. Seaborg, Phys. Rev. **54**, 88 (1938); H. Reddemann, and F. Strassmann, Naturwiss. **26**, 187 (1938).
[6] Supplied by the Y-12 Plant, Carbide and Carbon Chemicals Corporation through the Isotope Division, AEC, Oak Ridge, Tennessee.
[7] Goldhaber, Jacobs, and Williams, reported in Plutonium Project Report CP-3647 (October, 1946), p. 24 (unpublished).
[8] Pool, Cork, and Thornton, Phys. Rev. **52**, 239 (1937).

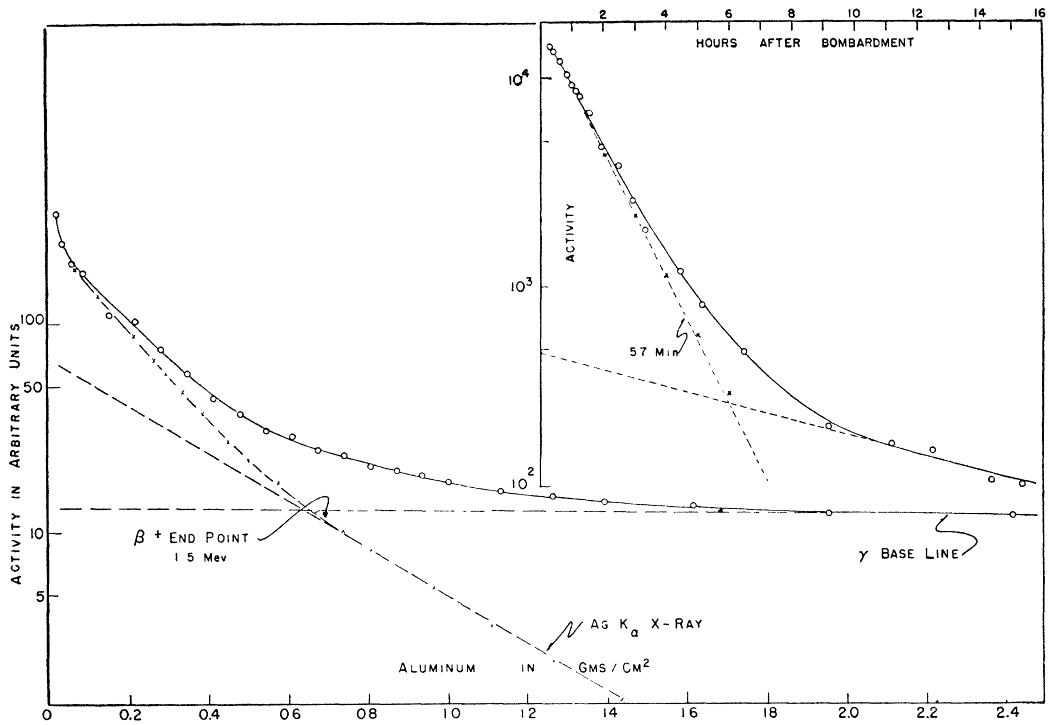


FIG. 4. Upper: Decay curve of the 57-minute Cd activity produced by a Pd+α bombardment. Lower: Aluminum absorption taken during the decay of the 57-minute Cd activity.

which corresponds to 1.5 Mev. In addition to the positron emission there is an x-ray and a gamma-ray associated with the activity. From the relative intensities of the beta-emission to that of x-ray, it is evident from Fig. 4 that the $K$-capture decay process is the most probable. With each $K$-capture process there is approximately one gamma-ray.

### IV. 470-DAY $Cd^{109}$

A 330-day half-life has been reported[9] in Cd. This activity was found to decay by $K$-capture and assignment was made to $Cd^{109}$.

The value of this half-life seems to be appreciably longer as based on observations made over a period of 5 years. The upper half of Fig. 3 shows the decay of the Cd fraction of a deuteron bombardment of Ag. The activity which was measured on a Wulf electrometer decays with a 470±8-day half-life.

The Cd fraction from an alpha-bombardment of Pd also gives evidence of the 470-day half-life activity.

Observations made in a cloud chamber show that decay is accompanied by $K$-capture. Confirmation of $K$-capture was made by an aluminum absorption taken in the 470-day half-life. Beta-rays and gamma-rays were not observed; and if present, were very weak compared with the x-ray radiation.

Based upon the intensities of x-ray observations, the relative yields per atom of the following activities for the bombarding energy used are: $Pd(\alpha,n)Cd^{105}$, 57-min.:

$$Pd(\alpha,n)Cd^{107},\ 6.7\text{-hour}:\ Pd(\alpha,n)Cd^{109},\ 470\text{-day}:\ Pd(\alpha,n+\alpha,p)Ag^{105},\ \ 40\ \text{day}=1:4.5:1.7:23.7.$$

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[9] Bradt, Gugelot, Huber, Medicus, Preiswerk, Scherrer, and Steffen, Helv. Phys. Acta 19, 218 (1946).