becomes

$$h=(1-t^2)[1+0.17932t^2-(0.37407t^2/1+t)]. \quad (23)$$

The last two terms in the parenthesis compensate so well that they scarcely differ by 0.015 at the worst.

σ is very sensitive to the second derivative of H^2. For example, a deviation of only 1.5 percent in H between the parabola relation and the polynomial, given by Misener for indium, causes σ to fluctuate as much as 100 percent from the values computed from Eq. (15). It seems, therefore, that the error which still remains in the best available data is too great for a reliable use of the various polynomials in finding σ, and therefore, λ/λ_0.

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Artificially Radioactive Se^{73} and Se^{75}

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A radioactive isotope of 7.1-hour half-life has been produced by alpha-particle bombardment of germanium. Assignment of the isotope is made to Se^{73}. Absorption measurements indicate the presence of a positron end point of 1.29 Mev. Aluminum x-ray absorption measurements indicate an x-ray emission with a mass absorption coefficient of 22.1 cm^2/g, corresponding to 1.17A. Bombardment with alpha-particles of Ge^{70}, enriched electromagnetically from 21.2 percent to 90 percent, further confirms the assignment of the activity to Se^{73}. The half-life of Se^{75} is found to be 127 ± 2 days over a decay period of 1000 days. In this activity K-capture and gamma-radiations of 0.22 Mev and 0.43 Mev are observed.

A SELENIUM activity of 160-days half-life has been reported;[1] several electron groups were observed of energies less than 300 kev, corresponding to internally converted gamma-rays. This activity was the result of the bombardment with deuterons of the stable arsenic isotope of mass 75. The decay period of Se^{75}, produced by an (n,γ) reaction of selenium irradiated in the Argonne pile, has been observed[2] to be 115 ± 5 days. This activity was found to decay by K-capture to stable As^{75}, accompanied by a 0.4-Mev gamma-ray. A period of 125 days has also been reported[3] as the half-life of the Se^{75} isotope. The decay is by K-capture with the emission of conversion electrons and gamma-rays of 0.18 Mev and 0.35 Mev.

Inasmuch as the long period in selenium has not been reported in the literature as resulting from alpha-particle bombardment of germanium, such a bombardment was done. As a result of these experiments a strong activity of short half-life was found in selenium in addition to the long period. It is the purpose of this paper to report the characteristic radiations of this short period. Observations, extending over a period of some three years, on the decay and characteristic radiations of the long period will also be described.

I. THE 7.1-HOUR Se^{73} ISOTOPE

The germanium targets were prepared for alpha-particle bombardment by placing finely ground Hilger germanium powder in a thin-bottom copper target holder and carefully heating until a eutectic with the copper was formed.

Figure 1 shows the decay curves of the selenium fraction obtained from the Ge+α-

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[1] C. V. Kent, J. M. Cork, and W. G. Wadey, Phys. Rev. 61, 389 (1942).
[2] H. N. Friedlander, L. Seren, and S. H. Turkel, Phys. Rev. 72, 23 (1947).
[3] Isotope Committee, Science 103, 697 (1946).

bombardment. The total decay curve represents decay of combined $\beta+X+\gamma$-radiation. This activity decayed initially on a period of 7.1 hours for about 14 half-lives. The gamma-radiation, determined by the insertion of a $\frac{1}{4}$-inch aluminum absorber between the sample and the ionization chamber, shows the same period. Cloud-chamber observations of the radiation were taken at 12-hour intervals throughout the 7.1-hour activity. The total beta-particle activity was found to consist of positrons.

Figure 2 shows aluminum absorption measurements of the activity taken in the 7.1-hour period. The sample was first placed between the poles of an electromagnet with the field adjusted to be neutral. The total activity obtained in the ionization chamber then consisted of $\beta+X+\gamma$-radiation. The curve representing the absorption of this activity is plotted as "total activity" in Fig. 2. A beta-end point of 0.59 g/cm^2, corresponding to approximately 1.29 Mev as determined by the Sargent range-energy relation, is shown as a result of the absorption measurements.

A magnetic field was then applied between the poles of the electromagnet, of sufficient strength to prevent all beta-particles from entering the ionization chamber, and measurements of only the electromagnetic activity were taken. For purposes of comparison with the total activity absorption curve, the resulting electromagnetic radiation is also shown on Fig. 2, plotted as "electromagnetic radiation."

Figure 3 shows in more detail the results of absorption of the electromagnetic radiation in aluminum. As above, beta-radiations were prevented from entering the ionization chamber by the application of a magnetic field. Electromagnetic radiation was absorbed by the insertion of aluminum foils between the sample and the ionization chamber. The presence of x-ray activity is shown by the subtraction of gamma-emission background from the total electromagnetic activity. The result of the subtraction, as shown in Fig. 3, is a straight line indicating a half-thickness corresponding to an absorption coefficient of 22.1 cm^2/g. By use of the ordinary x-ray absorption formula, it is found that this coefficient in aluminum is the result of x-ray emission of a wave-length of 1.17A. Since the

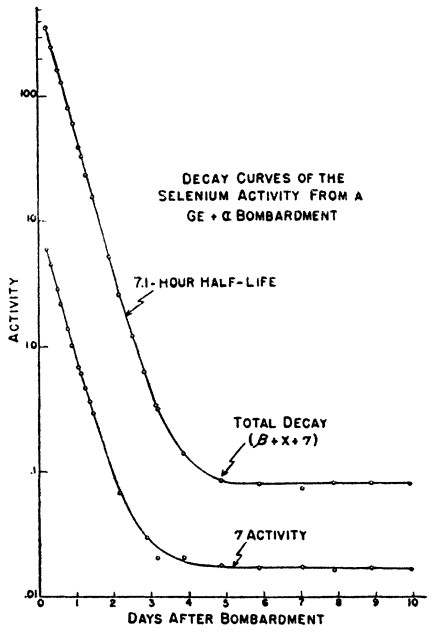

FIG. 1. Decay curves of selenium fraction of a Ge+α-bombardment, showing the 7.1-hour half-life.

$K_{\alpha 1}$ line of arsenic is 1.173A, it is evident that the K-capture process takes place in the activity.

The decay of this x-ray radiation was observed in the following manner. With the field of the electromagnet, as used above, so adjusted as to remove all the beta-particle radiation, a curve representing the decay of the entire electromagnetic radiation was obtained. This radiation consisted of both x-ray and gamma-activity. With a $\frac{1}{4}$-inch aluminum absorber inserted to

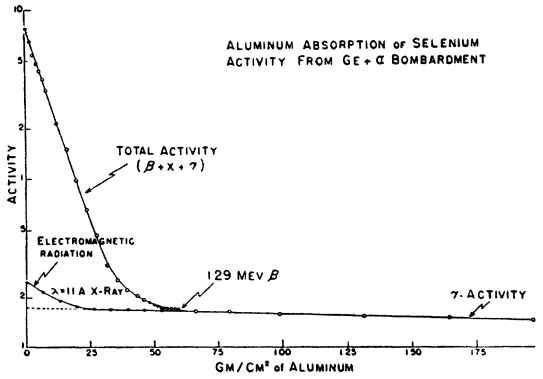

FIG. 2. Aluminum absorption measurements of beta-particle and electromagnetic radiations in a selenium fraction of Ge+α-bombardment. Electromagnetic radiation consists of activity after beta-particle radiations have been removed by a magnetic field.

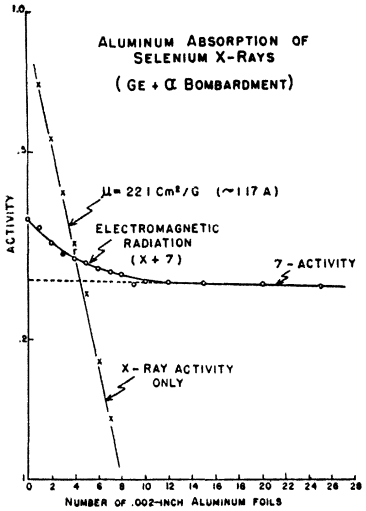

FIG. 3. Aluminum absorption measurements of x-ray activity in a selenium fraction of Ge+α-bombardment. In obtaining measurements of electromagnetic radiation beta-particle activity was removed by a magnetic field.

remove the x-ray radiation, the decay of the gamma-radiation was simultaneously observed. A subtraction of the two curves gives the decay of the x-ray radiation present. This procedure showed that the x-ray activity decayed in the 7.1-hour period.

Taking into account the relative ionizations produced by x-rays and positrons in the ionization chamber used, it is concluded that the ratio of the number of x-rays to positrons emitted in this period is approximately one.

Lead absorption measurements of the activity showed that the principal gamma-radiation is due to annihilation radiation. Possibly a weak gamma-radiation of higher energy is also present.

Because of the positron emission, the 7.1-hour activity could be placed in mass 73 or 75 of selenium. An attempt was made to produce this short period by bombardment of As^{75} with deuterons. Since this period was not found as a result of such bombardments, mass 73 is most probable.

II. BOMBARDMENT OF ELECTROMAGNETICALLY ENRICHED STABLE Ge^{70}

The stable isotope of germanium of mass 70, enriched electromagnetically from 21.2 percent to about 90 percent,† was also bombarded with alpha-particles. The germanium, in the form of

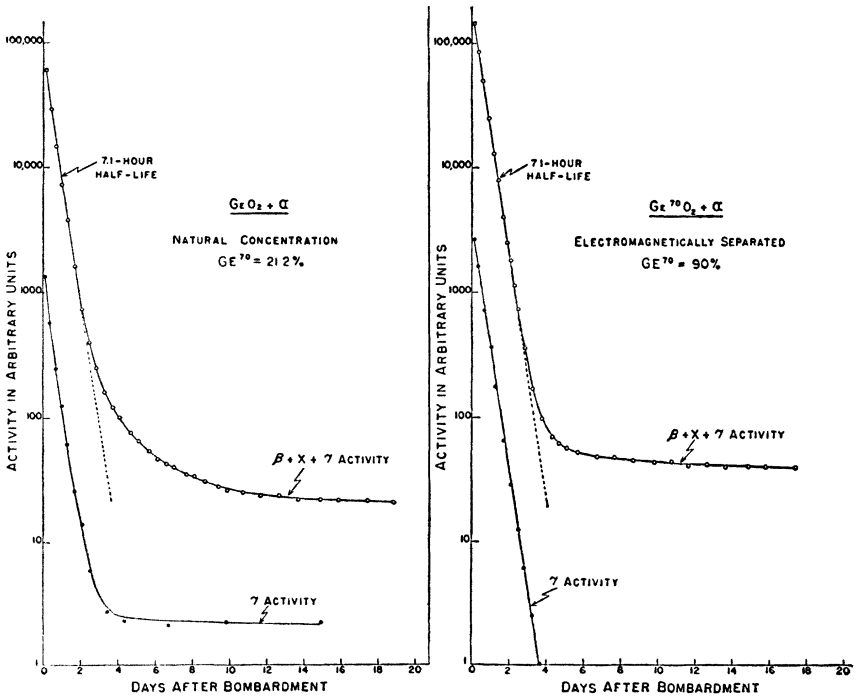

FIG. 4. A comparison of decay curves of germanium of natural isotopic constituency and Ge^{70} enriched electromagnetically to 90 percent. The enriched germanium sample shows a much stronger initial intensity of activity in the 7.1-hour period.

† Supplied by the Y-12 plant, Carbide and Carbon Chemicals Corporation, through the Isotopes Division, U.S.A.E.C., Oak Ridge, Tennessee.

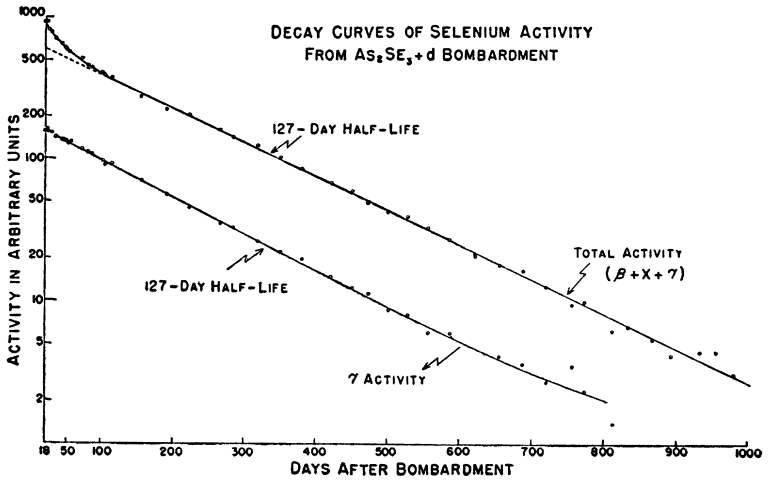

FIG. 5. Decay curves of the selenium fraction from bombardment of arsenic triselenide with deuterons. Decay over 1000 days after bombardment shows a period of 127±2 days.

GeO_2 powder, was prepared for bombardment by pressing the oxide into the bottom of a copper target holder under 5000 pounds of pressure. For comparison purposes germanium oxide of ordinary isotopic constituency and enriched germanium oxide were bombarded simultaneously. This was done by placing the two samples on opposite sides of the cyclotron probe and rotating the probe to obtain equal bombardment times and intensities. Equal amounts of germanium by weight were used in the two samples.

Figure 4 shows a comparison between the decay curves of the ordinary germanium oxide sample and the germanium oxide sample containing the enriched Ge^{70}. Both curves show a strong 7.1-hour activity. However, the initial total activity of the Ge^{70} sample was observed to be about three times that of the ordinary germanium sample. Since this is the order of magnitude of enrichment of the Ge^{70}, and since equal amounts of germanium were used, it may be concluded that the Ge^{70} isotope produces the 7.1-hour selenium activity under alpha-particle bombardment. The assignment of the 7.1-hour activity to Se^{73} is thus confirmed.

III. THE Se^{75} PERIOD

The long period in selenium of mass 75 has also been investigated. Arsenic triselenide was bombarded with deuterons and the selenium activity extracted. Figure 5 shows the total decay curve of this fraction, consisting of beta-particles and electromagnetic radiation, and also the gamma-activity decay curve. Both curves were taken over a period of 1000 days and show a half-life of 127±2 days.

Aluminum absorption measurements of the activity show that x-ray emission is present, with a wave-length corresponding to the arsenic K_α lines. This indicates that the K-capture process occurs in this period and that the active material decays into the stable As^{75} isotope. Decay by means other than K-capture is very improbable. The assignment of the period to Se^{75} is thus confirmed. By absorption measurements in lead, gamma-radiation energies of 0.22 Mev and 0.43 Mev were observed.

IV. ACKNOWLEDGMENTS

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