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Radioactive Scandium and Vanadium

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An activity with a half-life of 33.0±0.5 minutes was produced by the reaction $Ti^{47}(p,n)$ with approximately 10 times the intensity which was produced by the reaction $Ti^{46}(p,\gamma)$ and is assigned to V^{47}. It was found that V^{47} decays by the emission of a γ-ray and a positive β-particle of 1.65 Mev. Assignment of the 3.43±0.03 day half-life to Sc^{47} was definitely confirmed by comparing the reactions $Ti^{49}(d,\alpha)$ and $Ti^{50}(d,\alpha)$. Sc^{47} decays to stable Ti^{47} by the emission of a γ-ray and a negative β-particle of 0.61 Mev. The $Ti^{50}(d,\alpha)$ reaction was found to give the 1.83-day half-life of Sc^{48}.

I. INTRODUCTION

IT is the purpose of this paper to report a series of experiments which give additional information about the radioactive isotopes of scandium and vanadium. All radioactivities shown in the following figures were produced by cyclotron bombardment. Electromagnetically enriched isotopes of Ti^{46}, Ti^{47}, Ti^{49}, and Ti^{50} were used to compare the intensity of a given activity produced in each enriched sample as an aid in isotopic assignment.** In order to obtain this comparison, two samples of material enriched in different isotopes were weighed and mounted on opposite faces of the cyclotron internal probe. During bombardment the probe was rotated so that each sample was subjected to the same time of bombardment and as nearly as possible to the same beam intensity. Whenever TiO_2 samples were bombarded and no subsequent chemistry performed, the activity produced from the oxygen served as a control for the resulting comparison since the amount of oxygen present was independent of the isotopic composition.

II. THE 33-MINUTE V^{47} ACTIVITY

A proton bombardment of titanium of standard isotopic composition and subsequent chemical

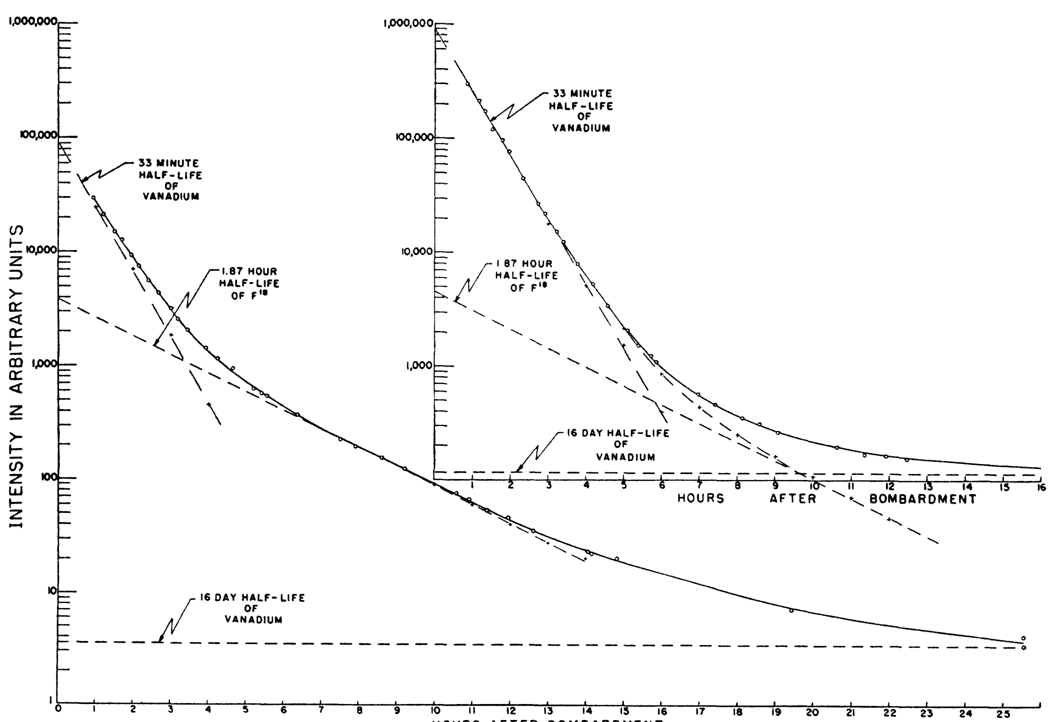

FIG. 1. Decay of the β-particle activity produced by proton bombardments of enriched $Ti^{46}O_2$ and $Ti^{47}O_2$ respectively. Note the 1:1 ratio of the F^{18} intensities and the 10:1 ratio of the 33-minute half-life intensities.

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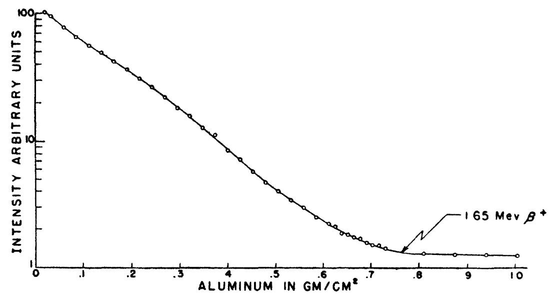

FIG. 2. Aluminum absorption taken while a Ti+p bombardment was decaying with a half-life of 33 minutes.

separation showed the vanadium fraction to decay with the previously reported half-lives of 33 minutes and 16 days.[1,2] From these earlier experiments it was not possible to definitely assign a mass number to the 33-minute half-life. This activity was not observed when either titanium or scandium was bombarded with α-particles. Nor was it observed when a large sample of vanadium was exposed to an intense flux of fast neutrons. This activity, however, was produced by a proton bombardment of enriched $Ti^{49}O_2$ and $Ti^{50}O_2$ with the same intensity in both samples. When the bombardment was performed using $Ti^{46}O_2$ and $Ti^{47}O_2$ it was found that the 33-minute period was ten times as intense in the Ti^{47} sample as it was in the Ti^{46}, as shown in Fig. 1. The 1.87-hour half-life of F^{18} produced by the reactions, $O^{17}(p,\gamma)F^{18}$ and $O^{18}(p,n)F^{18}$, appeared with approximately equal intensity in both compared samples of each set. The 33-minute activity was found to decay by the emission of a positive β-particle and an associated γ-ray. By means of aluminum absorption measurements the energy of the positive β-particle was found to be 1.65 Mev as shown in Fig. 2.

Figure 3 shows the region of the isotope chart in which the experiments described in this paper were performed. All results reported here are indicated by heavy line.

Since the 33-minute activity was not observed from an α-particle bombardment of titanium, possible assignment to V^{48}, V^{49}, and V^{50} is eliminated. The elimination of V^{48} and V^{50} as possible assignments is also confirmed by the fact that this activity was not observed from an α-particle bombardment of scandium or a fast neutron bombardment of vanadium. The elimination of V^{49} was confirmed by the fact that proton bombardments of titanium enriched with Ti^{49} and Ti^{50} respectively produced this activity with equal intensity in both samples. Since a proton bombardment of Ti^{47} produced the 33-minute half-life with ten times the intensity that a proton bombardment of Ti^{46} produced it, assignment is made to V^{47} as shown in Fig. 3.

III. THE 3.7-HOUR V^{50} ACTIVITY

A 3.7-hour half-life[1] emitting a positive β-particle has been assigned to V^{50}. The ionization chamber used for all measurements presented in this paper is filled with freon to a pressure of two atmospheres and has an aluminum window of 20 mg/cm². This chamber is efficient for the detection of γ-rays and any annihilation radiation should therefore be observed. X-rays produced by elements in the vanadium region have a half-thickness of approximately 3.65 mg/cm² of aluminum. In order to observe these possible x-rays a Geiger tube was used with a quartz window of 2.5 mg/cm². This Geiger tube had previously been successfully used for observing titanium x-rays from the 600-day activity of vanadium which is known to decay by K-electron capture. Measurements to observe the 3.7-hour half-life were made on activities resulting from deuteron and α-particle bombardments of titanium and fast neutron bombardments of vanadium. In addition attempts were made to observe this vanadium activity by bombarding $Ti^{49}O_2$ and $Ti^{50}O_2$ with protons. No activity with a 3.7-hour half-life was observed in the vanadium fractions of any of the above bombardments and it is concluded that the 3.7-hour half-life is not an activity of vanadium. In accordance with the above results no activity is shown for V^{50} in Fig. 3. It is suggested that the previously observed 3.7-hour half-life may have been due to Sc^{44}.

IV. THE 1.83-DAY Sc^{48} ACTIVITY

Figure 4 shows the decay of the scandium fractions obtained from deuteron bombardments of titanium enriched with Ti^{49} and Ti^{50} respectively. The left-hand side of Fig. 4 shows an activity with a half-life of 1.83 days which is produced by bombarding Ti^{50} with deuterons. By means of spectrographic observations the 1.83-day half-life was found to decay by the emission of negative β-particles. Aluminum absorption measurements showed the energy of this β-particle to be 0.57 Mev.

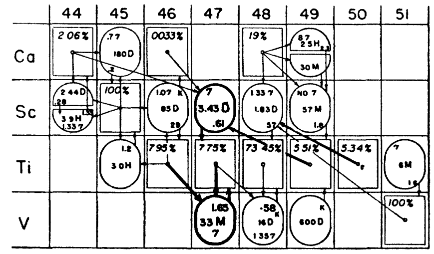

FIG. 3. Isotope chart of the region in which the experiments of this paper were performed. Results discussed in the text are indicated by heavy line.

[1] H. Walke, Phys. Rev. **52**, 777 (1937).
[2] J. J. O'Connor, M. L. Pool, and J. D. Kurbatov, Phys. Rev. **62**, 413 (1942).

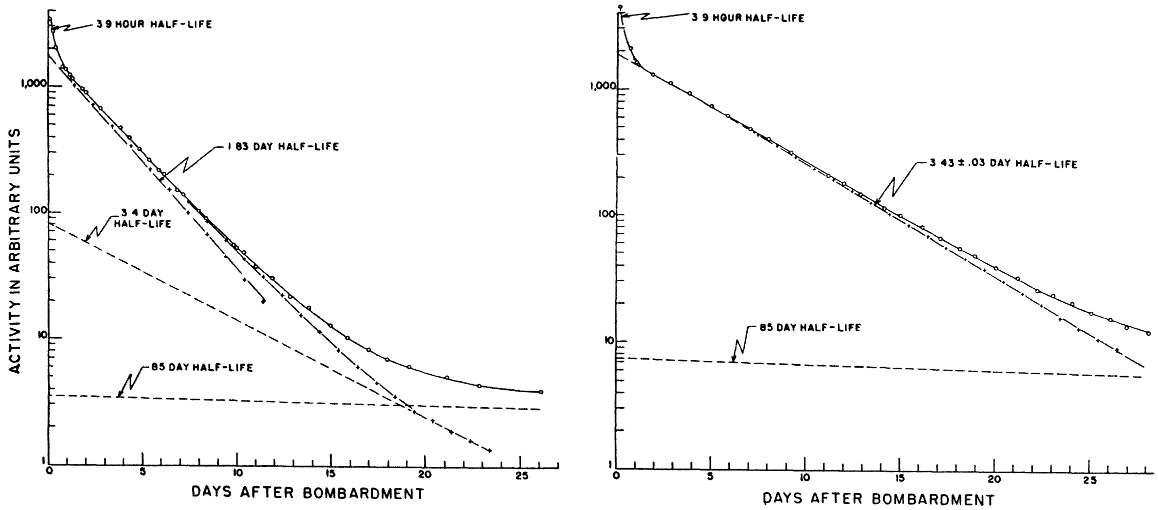

FIG. 4. Decay of the β-activity produced in the scandium fractions of deuteron bombardments of TiO_2 enriched with $Ti^{49}O_2$ and $Ti^{50}O_2$ respectively. The comparison is used to confirm the half-lives assigned to Sc^{47} and Sc^{48}.

These observations are in agreement with the characteristics of Sc^{48} previously observed[3,4] and the 1.83-day half-life is therefore produced by the reaction $Ti^{50}(d,\alpha)Sc^{48}$.

V. THE 3.43-DAY Sc^{47} ACTIVITY

As shown in Fig. 4, an activity with a half-life of 3.4 days was observed in the scandium fractions of deuteron bombardments of titanium enriched with Ti^{49} and Ti^{50} respectively. This activity was observed to be over twenty times as intense when enriched Ti^{49} was bombarded as it was when Ti^{50} was used. Observations over seven half-lives, as shown on the right side of Fig. 4, determined the half-life to be 3.43 ± 0.03 days. The activity was found to decay by the emission of a negative β-particle and an associated γ-ray. By means of aluminum absorption measurements the energy of the negative β-particle was found to be 0.61 Mev as shown in Fig. 5.

This activity has been assigned to Sc^{47} by means of α-particle and deuteron bombardment of calcium.[4,5] The above data serves to confirm the earlier assignment of this activity by the reaction $Ti^{49}(d,\alpha)Sc^{47}$.

[3] H. Walke, Phys. Rev. **57**, 163 (1940).
[4] C. T. Hibdon and M. L. Pool, Phys. Rev. **67**, 313 (1945).
[5] C. T. Hibdon, M. L. Pool, and J. D. Kurbatov, Phys. Rev. **63**, 462 (1943).

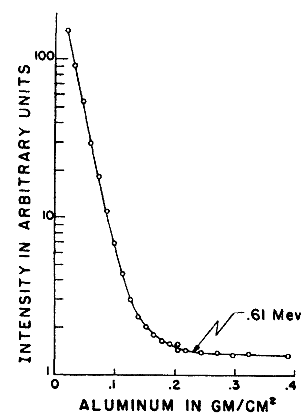

FIG. 5. Aluminum absorption taken while the activity shown on the right side of Fig. 4 was decaying with a half-life of 3.43 days.

When isotopic concentrations for the enriched samples used in these experiments are known the above data can be used to compute the relative reaction cross sections for all activities referred to in this paper.

VI. ACKNOWLEDGMENTS

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