

Artificial Alpha-Active Bismuth Isotopes

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WHEN lead was bombarded with approximately 200-Mev deuterons in the 184-inch cyclotron, a great variety of nuclear reactions were noted. Fission has been demonstrated by the identification of radioactive fission products,¹ and a mixture of isotopes from Bi (element 83) to Au (element 79) has been partially identified. These were produced by reactions analogous to those reported from other irradiations with high energy particles.²

This report has to do with some new short-lived emitters of alpha-particles produced from high energy deuterons on lead. The alpha-activity was in very low abundance compared with the Geiger counter activity and was first observed in the unseparated target material. The decay curves could be resolved into 2-min., 9-min., 27-min., and 1-2-hr. components. The longest period was too weak for accurate half-life determination. The three longest periods were chemically identified with the bismuth fraction, but the chemical separation was too slow to permit observation of the 2-min. period. Lead which was bombarded with 100-Mev deuterons showed the 1-2-hr. and 27-min. periods, but the shorter periods could not be detected. Therefore, the 2-min. and 9-min. activities are probably of lower mass number than the longer-lived ones. All of these isotopes of bismuth are believed to be of lower mass number than 203 since lead, enriched in Pb²⁰⁴, did not show any alpha-activity when bombarded with 20-Mev deuterons.³

The alpha-particle energies of the three longer periods were all in the range of 5.5 ± 0.3 Mev, as measured by an alpha-particle pulse analyzer.⁴ The lack of precision was caused by the high background of electrons and by the inability to prepare extremely thin samples. Because these energies seem to low for alpha-particle half-lives of the order of minutes and since the bismuth fraction showed a great preponderance of electrons over alpha-particles, it is concluded that the alpha-emission represents but a small branching in the predominantly orbital electron capture decay. For example, a 30-min. period and a 100-min. period could be resolved out of the Geiger counter decay curve and, under the assumption that these are the same as the 27-min. and 1-2-hr. alpha-periods, alpha-particle to electron ratios of 7×10^{-4} and 6×10^{-5} , respectively, were calculated. The half-lives for alpha-decay for the 27-min. and 1-2-hr. activities then become about 1 month and 3 years if it is assumed that there is almost one electron emitted per orbital electron capture disintegration.

These data show that alpha-instability as reflected by the alpha-particle half-lives follows the same trend in the case of bismuth isotopes as that noted for the isotopes of polonium. In the case of polonium it has long been noted that there is a minimum half-life at ThC' (Po²¹²) and that the half-lives increase both toward lower and higher mass numbers. This curve has been extended⁵ to show that the half-life for Po²⁰⁸ is even longer than for Po²¹⁰ but that the

partial alpha-half-life then decreases again at lower mass numbers as exemplified by Po²⁰⁶. In the case of bismuth, the earlier noted half-lives showed a decrease from heavier masses toward AcC (Bi²¹¹) which has a 3-min. half-life. Recently Broda and Feather⁶ reported that RaE (Bi²¹⁰) undergoes rare alpha-branching corresponding to a partial alpha-half-life of about 10^4 - 10^5 yr. Below RaE the half-life increases still further, as shown by the failure to detect alpha-activity in Bi²⁰⁹. However, the present studies show that very light isotopes of bismuth (Bi^{<203}) again have measurable alpha-half-lives.

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² Cunningham, Hopkins, Lindner, Miller, O'Connor, Perlman, Seaborg, and Thompson, *Phys. Rev.* **72**, 739 (1947).

³ D. H. Templeton, J. J. Howland, and I. Perlman, *Phys. Rev.* **72**, 766 (1947).

⁴ Ghiorso, Jaffey, Robinson, and Weissbourd, *An Alpha-Pulse Analyzer Apparatus*, Plutonium Project Record, 1413, 17.3 (1946) (to be issued).

⁵ D. H. Templeton, J. J. Howland, and I. Perlman, *Phys. Rev.* **72**, 758 (1947).

⁶ E. Broda and N. Feather, *Proc. Roy. Soc. London* **A190**, 20 (1947).

Decay Scheme of 62-Day Isotope of Element 43 (Tc)

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THE disintegration of the 62-day isotope of element 43 (technetium), which is believed to have the mass number 95,¹ has been investigated. In addition to the known γ -lines at (0.201 ± 0.002) Mev² and (0.810 ± 0.005) Mev,¹ we found by measurements in a magnetic lens spectrometer³ conversion, photo-, and Compton recoil electrons arising from two new γ -lines of (0.570 ± 0.002) Mev and (1.017 ± 0.010) Mev. Absorption measurements of the electrons and γ -rays showed that the 201-keV γ -line has a conversion coefficient of 0.044 ± 0.008 . The relative intensities of the γ -lines were determined by analyzing the absorption curve in lead; the sensitivity of the counter⁴ has been accounted for. The absorption coefficients for the experimental arrangement were determined empirically by means of standard γ -ray emitters. The strengths of the γ -lines were found to have the following ratios: $N_{201} : N_{810} : N_{570} : N_{1017} = 0.7 : 0.4 : 0.3 : 0.03$. From the γ - γ -coincidence counting rate it follows that the 570-keV and 810-keV radiations are in coincidence with the 201-keV line. Up to now the disintegration had been assumed to take place only by orbital electron capture.⁵ Cloud-chamber photographs also showed, however, positrons with energies up to 0.4 Mev. Comparing the number of positron tracks