On the Existence of a Calcium Isotope with an 8.5 Day Period†

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WALKE, Thompson, and Holt,[1] in a study of the radioactive isotopes of calcium, have reported an isotope with an 8.5 day half-life which they have given the assignment of Ca^{41}. It was prepared in greatest yield by the bombardment of calcium metal with 8 Mev deuterons. Also, very low yields of the isotope were prepared by bombarding calcium oxide with fast neutrons. The authors conclude that Ca^{41} decays to K^{41} by K-electron capture, emitting primarily x-rays (3500 ev) but some gamma-rays and conversion electrons of high energy (1.1 Mev).

An attempt to produce Ca^{41} has been made in this laboratory using higher energy particles. Although the reported fraction of gamma-rays and conversion electrons is small, it was thought that sufficiently high yields of the isotope could be obtained with 20 Mev deuterons to make feasible its use as a tracer in biological work. The following reactions were tried:

(a) $Ca^{40}(d, p)Ca^{41}$: $CaCl_2$ was bombarded with 20 Mev deuterons to the extent of 40 microampere hours. No activity with a half-life in the neighborhood of 8.5 days and electron energy greater than about 0.05 Mev (limit of the electroscope) was found in the calcium fraction. Approximately 0.3 μc of long-lived activity (>60 days) was found which presumably was due to Ca^{45}. This result was unexpected in view of the fact that high yields are obtained for the reaction $K^{41}(d, p)K^{42}$ at these energies (107 μc per microampere hour).

(b) $K^{41}(d, 2n)Ca^{41}$: KCl was bombarded with 20 Mev deuterons to the extent of 135 microampere hours. Thirty-six hours after the bombardment the purified calcium fraction was examined for activity. The thickness of the sample was 0.75 milligrams per square centimeter. No activity could be detected upon placing the sample inside an ionization chamber. Also the calcium fraction was examined with negative results by means of a thin window electroscope and a GM counter (window thickness = 2 mg/cm²). As a final check, an x-ray film was placed over the sample for several days. No darkening was observed.

(c) $A^{40}(\alpha, 3n)Ca^{41}$: Argon gas (2.5 liters) was bombarded with 40 Mev alpha-particles to the extent of 20 microampere-hours. The radioactive products were collected on a negatively charged copper wire extending into the gas. No measurable amount of radioactive calcium was produced. The only activity found on the wire was due to K^{42}. This isotope was produced in surprisingly good yield by means of the reaction $A^{40}(\alpha, pn)K^{42}$. The yield was 80 μc per microampere-hour.

In each of the above preparations appropriate inert carriers were added, and calcium was finally isolated as the oxalate. As a special precaution, barium and strontium precipitations were made in all cases. All precipitations were repeated several times in the presence of hold-back carriers in order to insure clean separations. Activities were measured with a Lauritzen electroscope. The air gap plus the electroscope window was equivalent to 4 mg/cm² of aluminum.

On the basis of the experiments described, it must be concluded that if a Ca^{41} isotope exists that emits beta or gamma-rays or energetic conversion electrons, its half-life must be considerably less than one day or longer than one year. The possibility of an isotope that decays by means of K-electron capture to the ground state of the product nucleus K^{41}, thus emitting only very soft x-rays (3500 ev) and no gamma-rays or detectable electrons, also seems to be ruled out. On the basis of the observed yield of Ca^{45} from the (d, p) reaction, an 8.5 day Ca^{41} should have been produced by the same bombardment in a yield of ~300 μc. This amount of activity presumably would have been detected by the instruments used, in view of the fact that 3500 ev x-rays have a half-thickness of ~1.5 mg Al/cm² or ~6 mg air/cm².

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[1] H. Walke, F. C. Thompson, and J. Holt, Phys. Rev. **57**, 177 (1940).

A New Naturally Occurring Lanthanum Isotope at Mass 138

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LANTHANUM was studied with a Nier-type mass spectrometer, using a thermal ionization source coated with the oxide, and a vibrating reed electrometer. It was known from previous experiments that the heated oxide emits primarily oxide ions at mass 155. Peaks at masses 154, 155, 156, and 157 were observed. The 155, 156, and 157-peaks were present in relative abundances characteristic of $La^{139}O^{16}$, $La^{139}O^{17}$ and $La^{139}O^{18}$. The peak at 154 was unexpected but was always present to the same relative amount in four different lanthanum samples. The possibilities that this new peak might be due to $Ce^{138}O^{16}$, $Ba^{138}O^{16}$, Sm^{154}, or Gd^{154} were ruled out because these elements would also have given other lines. We are obliged to attribute the 154 line to an isotope of lanthanum, La^{138}, which is present to 0.089 ± 0.002 percent. This La^{138} isotope has an odd number of neutrons and an odd number of protons, similar to the K^{40} and Lu^{176} isotopes, which are naturally radioactive. Because of this fact an investigation of the activity of normal lanthanum was made. Lanthanum oxide samples were counted with a counter with window thickness 2.6 mg/cm². The purest sample, especially purified from the usual radioactive contaminations found in the rare earths, showed no activity when 200 mg were spread over 5 square centimeters and counted at 25 percent geometry. A more complete description of this investigation will be published in the near future.