The Alpha Particle Bombardment of Magnesium

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The artificial radioactivity of magnesium produced by alpha particles was reported in 1934 by the Joliets (1) in their first paper on artificial radioactivity. It was subsequently shown that the main effect is the production of Al^{28} with a half life of 2.35 min. This has been verified from the work with deuterons and neutrons. Magnesium has three stable isotopes and beyond the formation of Al^{28} by

$$Mg^{25}_{12} + He^{4}_{2} \longrightarrow Al^{28}_{13} + H^{1}_{1}$$

there is the possibility of forming unstable Si^{27} and Al^{29} as follows:

$$Mg^{24}_{12} + He^{4}_{2} \longrightarrow Si^{27}_{14} + N^{1}_{0}$$

$$Mg^{26}_{12} + He^{2}_{4} \longrightarrow Al^{29}_{13} + H^{1}_{1}$$

It has been reported that three periods do result from this bombardment (2). They are given as 2.3 min., 7 min., and a period measured as being greater than 11 min. The measurements were made, using alpha particles from naturally radioactive bodies, and, as a consequence, the energy was very much below that available at present. We have used the identical piece of magnesium from which these measurements were made and have bombarded it with the 16 MV alpha particles from the Purdue cyclotron. This stream of particles is equivalent in numbers to

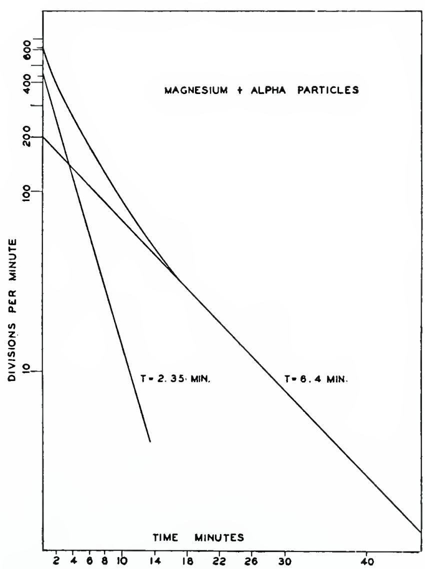

Fig. 1.

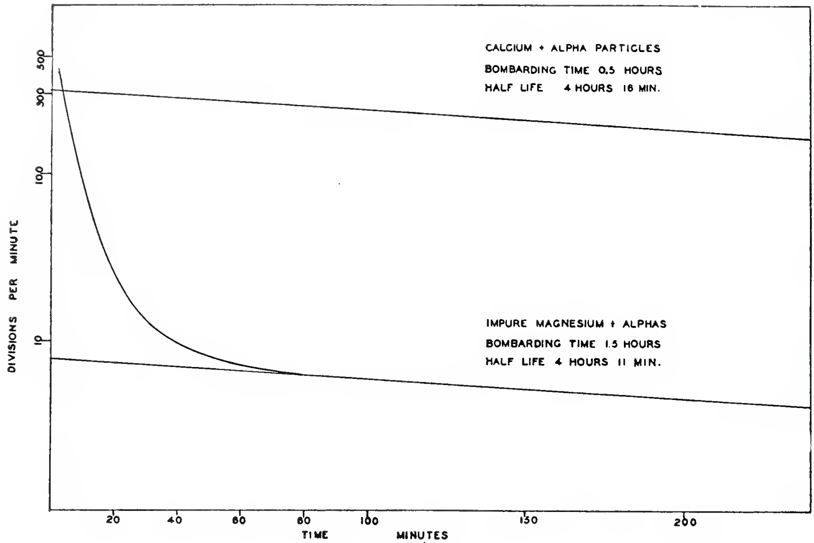

Fig. 2.

that from two or three grams of radium but of very much greater energy. The periods of decay are found to be 2.35 min., 6.4 min., and 4 hr. 11 min.

However, measurements taken from a very pure piece of magnesium supplied by Dow Chemical Company show that under alpha particle bombardment only the periods 2.35 and 6.4 min. are present. Figure 1 shows the decay curve from the pure sample of Mg. The fact that the 4-hour period could not be found suggests that it was due to an impurity in the original sample. Of the likely impurities in Mg, calcium produces

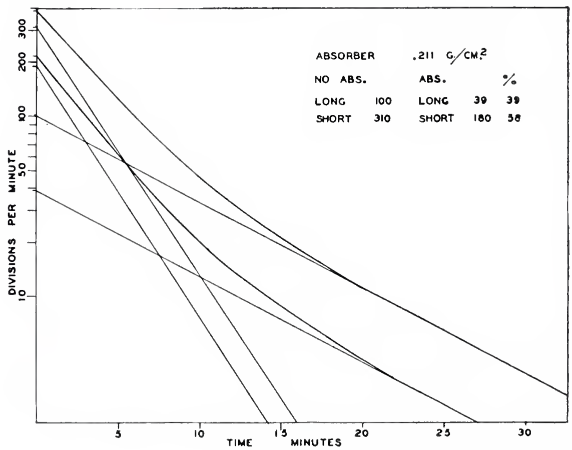

Fig. 3.

this period under the bombardment of alpha particles. Radioactive scandium[43] is produced in this reaction (3) and decays with a period of 4 hr. 16 min. With a pure calcium target, the 4-hour activity is found to be 300 times greater than in the impure Mg target. An impurity of ⅓ of 1% of calcium in the magnesium would explain the presence of the 4-hour activity in the original sample. In figure 2 a comparison of the 4-hour activities in pure calcium and the impure Mg is shown.

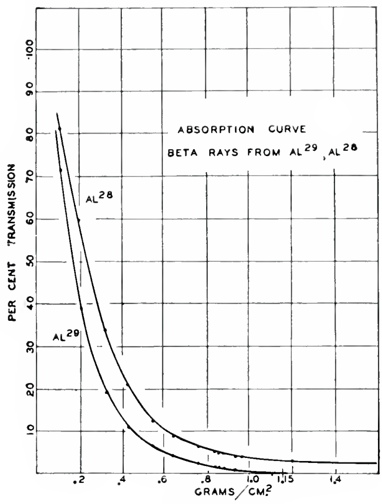

Fig. 4.

Cloud chamber tracks and magnetic analysis show that the emitted particles are beta particles. The decay of Al^{28} with the emission of beta particles has been definitely shown to have a half-life of 2.35 min. (4). The fact that we do have beta particle emission corresponding to the 6.4-minute decay means that this period is due to the Al^{29} decay. Just recently it has been shown by proton bombardment of Al that Si^{27} has a half-life of 3.7 sec. (5). In the present experiment, such a short lifetime would not be observed, but there are theoretical reasons to believe that the formation of Si^{27} will not take place at the present energy of alpha particles.

Absorption measurements were made to determine the upper limit of the beta ray energies, using an electroscope and aluminum absorbers. In plotting this absorption curve, a special technique must be used because we are working with two radioactive bodies whose half-life periods are comparable. Otherwise, one could read the absorption data directly. It was necessary that each point on the absorption curve be made with a new target. For each, target readings were taken alternately with and without the absorber. One curve shows the activity with the absorber in place, and one shows the activity without the absorber. This would eliminate the error due to different bombardment conditions for different sources. The 6.4 min. and 2.35 min. decay lines could be drawn on the curve and extrapolated to zero recording time, that is, the end of bombardment. Thus, for one particular thickness of absorber, we would know what activity was due to each period with no absorber and also the activity for the absorber in place. The absorption for that point would then be the ratio of the two activities for the 6.4 min. period and a similar ratio for the 2.35 min. period. A sample point is calculated for .211 gm/cm^2 of absorber in figure 3.

The resulting absorption curves in figure 4 show in the case of Al^{28} the absorption of the beta rays on a gamma ray background. For Al^{29} the beta absorption is all that is evident. Apparently, no gamma rays are connected with this reaction, or, if any at all, they are too weak to be detected by this method. The maximum range of the beta particles from Al^{29} is approximately 1.15 gm/cm^2. This, according to Feather's Rule (6) corresponds to an energy of 2.4 MV. This value is checked within the limits of experimental error by the mass absorption coefficient of beta rays in Al. This value of 5.35 corresponds to an upper limit of 2.3 MV. From cloud chamber photographs (7) the beta ray spectrum is shown to be continuous and of a maximum value of 2.5 MV. We conclude, therefore, that the maximum energy of the beta rays from Al^{29} is $2.4 \pm .2$ MV.

References

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