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Gamma-Rays from As^{76}

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The recoil electron spectrum of the gamma-rays from As^{76} has been examined in a magnetic spectrograph. The spectrum was found to be composed of two electron groups corresponding to quantum energies of 0.83 ± 0.02 and 1.94 ± 0.04 Mev, the intensity ratio being 3.8 : 1. These results suggest excitation levels at 0.8 Mev and 2.8 Mev in the Se^{76} residual nucleus. No contributions to the spectrum of gamma-rays of energy greater than 1.94 Mev were observable.

INTRODUCTION

THE nuclear radiation of As^{76} has been the subject of a number of recent experiments,[1–5] and numerous conjectures have been made as to the energy levels of the Se^{76} residual nucleus resulting from beta-decay by As^{76}. A gamma-ray spectrograph[6] has been employed in examining the energies and relative intensities of the gamma-rays arising from the de-excitation of Se^{*76}.

PROCEDURE AND RESULTS

As_2O_3 of chemical purity 99.95 percent was activated by slow neutrons, the reaction being $As^{75}-n-\gamma$. As^{75} is the only stable isotope of arsenic. Of the known impurities in the chemically pure As_2O_3, none can form a radioactive isotope when irradiated by neutrons with a half-period which differs from that of As^{76} by less than a factor of two. The gamma-ray activity of the irradiated As_2O_3 was noted from time to time by means of an electroscope while the momentum distribution of the Compton recoils of the gamma-rays was being observed repeatedly in the gamma-ray spectrograph. The decay curve was followed for about 100 hours, and the activity was observed to decay with a half-life of 26.9 ± 0.3 hr. in agreement with previously determined values[1–5] running from 26 to 27 hr. The decay as observed in the electroscope is plotted in Fig. 1. Before being placed in the spectrograph, the As_2O_3 was compressed into small cylindrical pellets so as to obtain a considerable concentration of activity, the effective width of the source remaining small.

A typical curve of the momentum distribution of the Compton secondaries of the gamma-rays from As^{76} is given in Fig. 2. It is there apparent that the spectrum has two strong components. The end points of the electron groups correspond to gamma-ray energies of 0.83 ± 0.02 Mev and 1.94 ± 0.04 Mev, respectively. The ratio of the intensity of the gamma-ray at 0.83 Mev to that of the harder one is about 3.8 : 1. This momentum distribution was obtained at a number of different times over the 100-hr. period in which the gamma-ray activity was likewise being observed in the electroscope as previously mentioned. The shape of the curve was found to remain unchanged with time, suggesting the presence of only one half-life, in agreement with the decay curve of the electroscope. Moreover, ordinates corresponding to the same $H\rho$ value were observed to decrease in magnitude in accordance with a half-period of 27 ± 1.0 hr., associating the gamma-rays with the decay of As^{76} with certainty. A marked advantage of this method over the cloud-chamber technique when sources of sufficient strength are available is that a curve such as that of Fig. 2 may be completed in 3 or 4 hr. with high statistical accuracy whereas cloud-chamber methods require a much longer period.

DISCUSSION OF RESULTS

Harteck, Knauer, and Schaeffer[1] have reported gamma-rays at 1.50, 2.15, and 3.1 Mev using

[1] P. Harteck, F. Knauer, and W. Schaeffer, Zeits. f. Physik **109**, 153 (1938).
[2] F. Norling, Zeits. f. Physik **111**, 158 (1938).
[3] W. Schaeffer and P. Harteck, Zeits. f. Physik **113**, 287 (1939).
[4] A. C. G. Mitchell, L. M. Langer, and P. W. McDaniel, Phys. Rev. **57**, 1107 (1940).
[5] G. L. Weil, Phys. Rev. **62**, 229 (1942).
[6] C. E. Mandeville, Phys. Rev. **62**, 309 (1942).

the method of cloud-chamber pairs. Mitchell, Langer, and McDaniel[4] have reported a maximum gamma-ray energy of 2.05 Mev as a result of absorption experiments. It is, of course, not surprising that the intense gamma-ray at 0.83 Mev was not observed in the two foregoing experiments, since its energy is not sufficient to produce the rest masses of a positron-electron pair, and it is well known that absorption methods give only the value of the energy of the

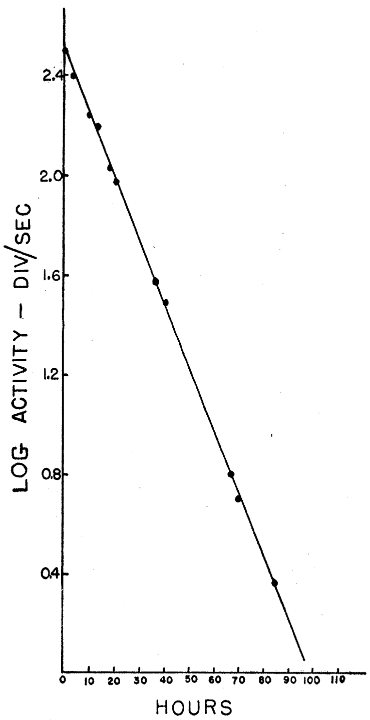

FIG. 1. Gamma-ray activity of As_2O_3 irradiated by slow neutrons. The half-life taken from the slope of this curve is 26.9±0.3 hr. The activity is therefore ascribed to As^{76} ($T=27$ hr.).

hardest gamma-ray present with any accuracy. No gamma-rays were observable in the neighborhood of 3 Mev. Statistical accuracy was very poor in that region, however, so that the possibility of the presence of radiation of low intensity at about 3 Mev is not excluded by this experiment. The quantum energy and intensity of the gamma-ray at 0.83 Mev, coupled with the results of previous experiments,[1–5] suggest immediately the level diagram for Se^{76} given in Fig. 3. γ_A and γ_B are there given the values reported in this experiment, and γ_C is suggested as corresponding to the 3-Mev radiation observed by Harteck, Knauer, and Schaeffer.[1]

It is to be noted that the level arrangement of Fig. 3 agrees in a qualitative sense with the $\beta-\gamma$ and $\gamma-\gamma$ coincidence experiments of Norling[2] and of Mitchell, Langer, and McDaniel[4] in that γ_A is associated with the beta-ray spectrum of high maximum energy and two quanta are emitted per disintegration in cascade with the beta-ray spectrum of low maximum energy. The level diagram also eliminates the association of γ_C with a very soft beta-ray spectrum, in agreement with the findings of Schaeffer and Harteck.[3]

The maximum energies of the two beta-ray spectra have been tentatively assumed to be 1.0 and 3.0 Mev; these are means of the various observed and extrapolated values which have been previously reported. Any change in the assumed values would of course result in only a slight readjustment in the level diagram. The suggested arrangement of levels and the relative intensities of γ_A and γ_B are in approximate agreement with the value 3.5 : 1 given by Weil[5] for the ratio of the intensity of the beta-ray distribution of maximum energy about 3 Mev to the intensity of the less probable distribution of lower maximum energy.

ACKNOWLEDGMENTS

The author wishes to express appreciation for the preparation of the radioactive As^{76} by

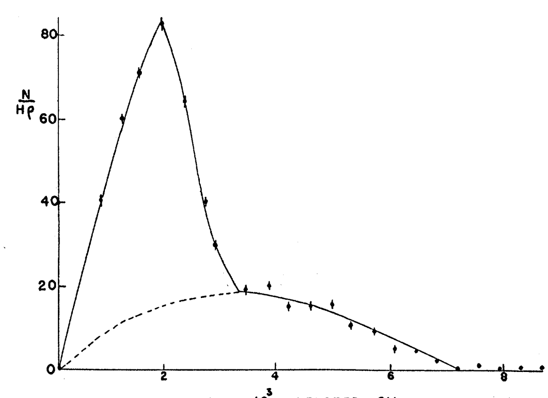

FIG. 2. Momentum distribution of the Compton recoils of the gamma-rays from As^{76}. The decay of the ordinates of this curve in the spectrograph was found to correspond to a half-life of 27±1.0 hr.

Professor A. L. Hughes and the cyclotron group of Washington University, St. Louis, Missouri.

Note added in proof: This experiment has been recently repeated. Cacodylic acid (Kahlbaum) in the form of an aqueous solution has been irradiated by slow neutrons, the Washington University cyclotron again being the neutron source. H_2S was passed into the solution, precipitating the activated As ions as a sulfide. $AsCl_3$ and HCl had been previously added.

The results were essentially the same, γ_A and γ_B again being present in about the same relative intensities. A better value of γ_B appears, however, to be 2.00 ± 0.04 Mev. Although the source was stronger and more highly concentrated, statistical uncertainty was still rather large in the neighborhood of 3 Mev, thus preventing any conclusive statement with regard to presence or absence of γ_C. Had γ_C been present with an intensity less than 20 percent of that of γ_B, it would have very probably escaped detection.

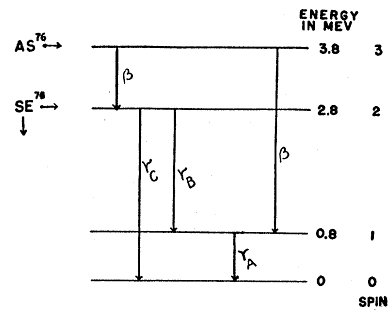

FIG. 3. Level scheme for Se^{76}.

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The Search for Element No. 87

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An attempt to secure the element 87 $L\alpha_{1,2}$ x-ray lines in fluorescence spectra is made with negative results: no trace of the line sought for was found. The fluorescent material was $CsHSO_4$ derived from lepidolite, in which free thallium has been found. The writer suggests that the free thallium is derived from unstable element 87 atoms which had been present in the lepidolite molecule.

INTRODUCTION

THE status of the search for element 87 was fully discussed by the present writer in a previous paper.[1] Since then, there has been little further work done on the subject. Hulubei[2] has published x-ray spectrograms which reveal little or nothing. Moreover, the present writer's objections[1] to Hulubei's wave-length measurements still hold: the wave-lengths are far from the correct value; neither is the frequency separation of the "87" $L\alpha_{1,2}$ lines correct as given by Hulubei. As Hulubei admits,[3] they are "mésures très difficiles" and "raies très faibles."

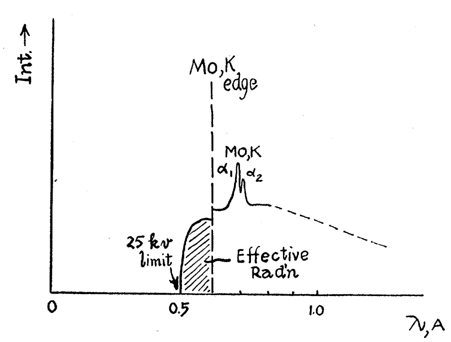

FIG. 1. Schematic spectral diagram showing effective portion of continuous spectrum emitted by molybdenum primary anticathode which might cause fluorescence of Mo portion of fluorescent target to effect registration of Mo K lines on plate.

One might possibly assume, then, that there is no evidence for the existence of element 87. There is, however, ample evidence for the existence of the unstable atom. J. A. Cranston,[4] in 1913, found that three atoms in 10^5 of $MsTh_2(89)$ emitted alpha-particles to form element 87 (see Fig. 4). He used the Geiger-Nuttall method. G. Guében,[5,6] of Liège, using the Geiger-Nuttall

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