is formed both by this reaction and the more probable $(\alpha, pn)$. Bombardment of Ag with approximately 40 Mev $\alpha$-particles produced a good yield of the long-lived Cd, a small or possibly zero yield of the 6.7 hr. Cd. This latter yield will be further checked.

The bombardment of Ag with approximately 20-Mev deuterons also produced in the surface layers of the target a Pd activity of 13 hr. half-life. Rall[4] has assigned this activity to $Pd^{109}$, so in this case it is formed by the reaction $Ag(d, 2p)Pd$. An absorption measurement gave 1.0 Mev as the upper limit of the $\beta$-spectrum, in satisfactory agreement with the 1.08 Mev reported by Kraus and Cork.[5] The threshold of the reaction is $E_{max}+2M_H-M_D$ or about 2.5 Mev. However, the low probability that protons be ejected through the barrier with low energy explains the fact that Krishnan[6] with 9-Mev deuterons observed no Pd activity, and that the yield here was observable only at high bombarding energies. No other Pd activity was found. $Pd^{107}$ must have a very short half-life to have escaped detection in other investigations, or a half-life greater than 25 years to be undetected in this case.

I wish to thank Dr. Moyer for the use of the enriched samples and Dr. J. G. Hamilton and the members of the 60″ cyclotron crew for the bombardments.

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## Beta- and Gamma-Ray Energies of Several Radioactive Isotopes*

L. C. Miller and L. F. Curtiss
*Clinton Laboratories, Oak Ridge, Tennessee*
October 24, 1946

THE thin magnetic lens spectrometer constructed by Wilkinson and Rall at the Metallurgical Laboratory and now in use at Clinton Laboratories has been used to obtain data on the beta- and gamma-ray energies of several additional radioactive isotopes.

All activities were produced by slow neutron irradiation of the elements or their compounds in the Clinton pile. All samples, with the exception of the dysprosium compound, were spectroscopically analyzed for impurities. In no cases did the combination of factors, such as amount of impurity, cross section of impurity for slow neutron capture, and period of any activity due to the impurity, appear to be such that the impurity could be responsible for any observed gamma-rays.

Table I summarizes the results obtained. The gamma-ray energies are probably correct within 2 percent except where the approximation sign indicates less reliable data. The last column gives rough estimates on the relative intensities of gamma-rays from most of the isotopes. These may be in error by as much as 50 percent.

TABLE I. Energies of beta- and gamma-rays.

| Isotopes | Beta-ray End points (Mev) | Gamma-rays (Mev) | Rel. intensities of gamma-rays |
|---|---|---|---|
| 26.8 hr. $As^{76}$ | | 0.57 | 5 |
| | | 1.25 | 2 |
| | | 1.84 | very weak |
| | | 2.15 | very weak |
| 24.1 hr. $W^{187}$ | 0.6 and 1.3 | 0.48 | 3 |
| | | 0.69 | 2 |
| 14.1 hr. $Ga^{72}$ | | 0.64 | 1 |
| | | 0.84 | 6 |
| | | 2.25 | 6 |
| 26.5 d. $Cr^{51}$ | | 0.32 | |
| 18 hr. $Re^{188}$ | | 0.16 | 4 |
| | | 0.48 | 1 |
| | | 0.64 | 2 |
| | | 0.94 | 2 |
| | | 1.43 | 1 |
| 51.5 d. $Hg^{203 \text{ or } 205}$ | <0.3 | 0.28 | |
| 40 hr. $La^{140}$ | | 0.335 | 1 |
| | | 0.49 | 10 |
| | | 0.83 | 20 |
| | | 1.63 | 100 |
| | | ~2.3 | 5 |
| 46 hr. Sm | | 0.11 | |
| | | ~0.6 | |
| 60 d. $Sb^{124}$ | 0.53 and 2.25 | | |
| 2.8 d. $Sb^{122}$ | 1.36 and 1.94 | | |
| 11 d. $Ge^{71}$ | ~0.6[a] | ~0.5[b] | |
| 67 hr. $Mo^{99}$ | | 0.24[c] | |
| | | 0.75 | |
| 2.5 hr. $Dy^{165}$ | | 0.37[d] | |
| | | ~1.0 | |

[a] Probably positrons.
[b] Possibly annihilation radiation.
[c] Preliminary data; no chemical separation, but these gamma-rays are probably not from 6.1-hr. activity of element 43. Data indicate that other gamma-rays may also be present.
[d] Preliminary data; other gamma-rays may also be present.

Details of these studies will appear in the *Volume of Collected Papers on Nuclear Physics of the Plutonium Project Record.*

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## The Abundance of $He^3$ in Atmospheric and Well Helium

L. T. Aldrich and Alfred O. Nier
*University of Minnesota, Minneapolis, Minnesota*
December 2, 1946

BY means of a 60° mass spectrometer we have just completed an investigation of the relative abundances of the helium isotopes. The average value for the $He^4/He^3$ ratio in two samples of atmospheric helium from the Air Reduction Sales Company was found to be $9\times10^5$,[1] and that for two samples of well helium $7\times10^6$. These values should not be in absolute error by more than 25 percent. The relative $He^3$ concentrations are within 10 percent. The $He^3$ peak was completely resolved from HD. In all cases the $He^4/He^3$ ratio was independent of pressure and amount of hydrogen impurity. The ionization efficiency curve for the $He^3$ peak agreed within experimental error with that for $He^4$ and was distinctly different from that for HD.

Alvarez and Cornog[2] have reported the existence of $He^3$ as a result of observation of a mass three beam in the Berkeley 60″ cyclotron and gave $He^4/He^3$ ratios of $10^8$