The Induced Radioactivity of Krypton

An investigation has been made of the induced radioactivity of krypton. The gas was irradiated in a glass chamber, one end of which was closed by an aluminum window one mil in thickness. A molybdenum cup at the other end of the chamber served to prevent the bombarding particles from striking the glass. Activities were measured by introducing the gas into an ionization chamber which was connected to a d.c. amplifier with an automatic recording mechanism.

Irradiation of krypton with deuterons of 11 Mev energy from the Harvard cyclotron produced strong activities with periods of 102 minutes and 4.0 hours, and a weak activity of about 35 hours. To obtain further information, selenium was irradiated with alpha-particles of 22 Mev energy. At the end of the bombardment, the selenium was placed in a tube which was then evacuated. After boiling the selenium to drive out the active krypton, the tube was cooled in CO_2-acetone slush, and then the krypton was allowed to flow into the ionization chamber. A strong activity with a period of 114 minutes was observed, and also a weak activity of about 33 hours. The former may be assigned to Kr^{83*}, since the period coincides with that reported for this isotope by Langsdorf and Segrè.[1] These investigators found a radioactive Kr^{83}, of 113-minute period, growing out of Br^{83*}. Tests are now being made to determine to what extent the Kr^{83*} in the present work is formed directly from Se^{80}, by an (α, n) reaction, and indirectly from the decay of Br^{83*} produced by an (α, p) reaction.

The 102-minute period observed in deuteron irradiation of krypton is obtained upon the second subtraction from the decay curve, and the margin of error is therefore likely to be large. It is probable that this activity is really that of Kr^{83*}, formed by a (d, p) or (d, d) reaction. The 4.0-hour period is not observed in the alpha-particle bombardment of selenium, and hence must be assigned to Kr^{87*}, an isotope which cannot be formed from alpha-particle reactions with selenium.

Barkas, Creutz, Delsasso, and Sutton[2] irradiated bromine with protons, separated the krypton product, and observed a long period of about 23 hours due to Kr^{79*} or Kr^{81*}. The weak 35-hour period found in the present investigation can probably be assigned to the same isotopes.

In the alpha-particle irradiation of selenium, Kr^{85} ought to appear from Se^{82} as a result of an (α, n) reaction. Since no third activity appeared in this bombardment, the period of Kr^{85} is presumably long or very short.

Attempts to produce krypton activities by irradiating rubidium and strontium with fast neutrons were unsuccessful.

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[1] Alexander Langsdorf, Jr. and Emilio Segrè, Phys. Rev. **57**, 105 (1940).
[2] W. H. Barkas, E. C. Creutz, L. A. Delsasso, and R. A. Sutton, Phys. Rev. **57**, 1087 (1940).

Comparative Efficiencies of Radioactive Neutron Sources

We have measured the comparative neutron-producing efficiencies of several radium-beryllium and radon-beryllium neutron sources in order to determine whether these efficiencies are proportional to the gamma-ray activities of the sources. Neutron production from such sources has been customarily assumed proportional to the gamma-ray intensity, and furthermore it has been stated that radon-beryllium sources are more efficient than radium-beryllium sources.

Four radium-beryllium and two radon-beryllium sources were compared by placing the sources successively in a paraffin block, near which was located a boron-trifluoride-filled detecting chamber connected to a linear amplifier. Care was taken that the geometry should be the same in each measurement. The counting rate of the chamber, with and without a half-millimeter-thick cadmium shield, gave a measure of the slow neutron intensity. By establishing that there was no observable change in counting rate when 200 milligrams of radium without beryllium were brought up, it was ascertained that the strong gamma-ray intensity from these sources did not influence the detecting efficiency. The gamma-ray strengths of the several sources had been previously determined by standard procedures.

TABLE I. *Observed yields of neutrons per millicurie of gamma-ray activity in the source.*

TYPE	APPROXIMATE STRENGTH (GAMMA-RAY)	NEUTRONS/MG-EQUIV. (RELATIVE)
Ra-Be	200 mg	1
Ra-Be	200 mg	0.97
Ra-Be	200 mg	0.85
Ra-Be	9.87 mg	0.88
Rn-Be	60 mC	0.55
Rn-Be	30 mC	0.76

Table I shows the relative neutron yield per milligram-equivalent for the various sources. It will be observed that the yield is different for each of the five sources, and furthermore that the radon sources are considerably less efficient than the radium-beryllium sources. It is therefore evident that serious error may be made by assuming the neutron yield to be proportional to the gamma-ray intensity. The beryllium content of the above sources varies between 0.1 gram and 5 grams, the large radium sources containing the greater quantities of beryllium. More details of these measurements and a discussion of the efficiency variations will be published in a forthcoming issue of the *Journal of the Franklin Institute.*

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