

Purification and Spectroscopic Evidence for He³

Following the procedure outlined in a previous letter¹ deuterium was circulated through a large canal-ray discharge tube. The discharge ran at an average of 75 kv and 10 m.a. exhibiting an intense canal-ray beam which was, however, of a slightly green color due to a trace of mercury vapor which had entered the system. The discharge tube was filled twice and each time a run of 4 hours was made. After this treatment the two samples, which amounted to 5 cc at N.T.P. of deuterium and its disintegration products, were combined together and sealed off in a bulb having a magnetic break seal.

After transportation to the Massachusetts Institute of Technology it was sealed by means of the magnetic break-off to a purifying apparatus designed by one of us (W.D.U.) for the isolation of small quantities of helium. After flushing the entire apparatus with air-free oxygen the gas mixture was introduced and purified. The complete process used is described by Paneth and Peters.² Owing to the inaccuracy of McLeod gauge measurements with such small quantities of gas a modified Pirani-Stern manometer system developed by Paneth and Urry³ was used to measure the quantity of helium contained in the sample.

It was found after purification that 1.1×10^{-5} cc at N.T.P. of gas remained. From the nature of the purifying process this could be only helium and neon, and the lines due to these gases were the only ones which could be observed spectroscopically. The spectroscopic examination was made with a calibrated D-77 Hilger spectrograph. The gas was compressed into a capillary tube 0.000132 sq. cm in internal cross section and the discharge was excited by means of a leak-tester in contact with an external electrode of thin copper wire wound around the gas-filled space. An estimate of the intensities of the helium and neon lines showed that the neon was present to at most ten percent of the mixture (see Paneth and Peters). The neon present was presumably of atmospheric origin and had diffused through the hot glass during sealing off from the canal-ray tube or had been driven out of the walls or metal parts of the apparatus during the bombardment process. A certain amount of ordinary atmospheric helium would be expected to be associated with this neon. As the neon-to-helium ratio in air is 18 : 5 an amount of helium equal to $0.28 \times 0.1 \times 1.1 \times 10^{-5}$ cc or about 3×10^{-7} cc was probably present as an impurity. No appreciable amount of helium can have been introduced during the purifying process for a control run the previous day agreed with weekly controls over a period of two years in giving only about 10^{-8} cc of neon and helium in atmospheric proportions. Atmospheric helium is therefore expected to be present to the extent of at most three percent, and neon to a maximum of ten percent; hence at least 9.6×10^{-6} cc at N.T.P. was the helium disintegration product from the deuterium reaction. Previously reported⁴ results obtained with the mass-spectrograph from samples which have been subjected to the same canal-ray bombardment have shown this helium to be of mass three. None of the helium isotope of mass four has ever been found by the mass-

spectrograph in these samples except when it has been deliberately admitted to the analyzing apparatus for comparison purposes. The three percent attributed to atmospheric helium in this sample is too small an amount to have been detected and identified as of mass four by the mass-spectrograph.

The quantitative agreement between the amount of helium isolated from this sample and the He³ peak obtained with the mass-spectrograph is also satisfactory. The estimate by the latter method of the He³ content of comparable samples varies from about 10^{-4} to 10^{-5} cc at N.T.P. depending on the discharge conditions. Because of the trace of mercury vapor present in the discharge from which this helium was isolated there is reason to believe that the discharge conditions were not the optimum ones. As it has not as yet been possible to measure the number of D-D collisions during a run no quantitative estimate of the yield can be given, though it is certainly very large.

In an attempt to remove the helium from the purifying system the specimen was lost. It is hoped that with future samples the mass may be further verified by a thermal-conductivity method and the spectroscopic characteristics such as fine structure and isotopic shift studied. We are indebted to the Princeton Department of Chemistry for supplying us with the deuterium used.

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¹ Harnwell, Smyth, Van Voorhis and Kuper, *Phys. Rev.* **45**, 655 (1934).

² Paneth and Peters, *Zeits. f. physik. Chemie* **134**, 353 (1928).

³ Paneth and Urry, *Zeits. f. physik. Chemie* **152**, 110 (1931).

⁴ Bleakney, Harnwell, Lozier, Smith and Smyth, *Phys. Rev.* **46**, 81 (1934).

The Production of Radioactive Oxygen

Since the preliminary report¹ from this laboratory on the radioactivity induced in certain substances by deuteron bombardment, the apparatus has been changed so as to bring the ion beam outside the apparatus through a thin aluminum window. Both solid and gaseous targets can be exposed to the beam, and then removed to a quartz-fiber electroscopes for measurement of the induced activity. For these experiments 1 microampere of 2 million-volt deuterons was used.

With this arrangement, carbon and aluminum targets were bombarded and found to give the activities already reported.¹ When a carefully cleaned platinum target was bombarded in air, a much smaller but accurately measurable positron activity with a half-life of 126 ± 5 sec. was observed. Both clean and oxidized copper targets gave the same effect. When the target was bombarded in N₂ gas the same activity was found, but it was not present when O₂, H₂ or A were used. In CO₂ an activity of the same