A Mass-Spectrographic Determination of the Mass Difference $N^{14}+H^1-N^{15}$ and the Nitrogen Disintegration Reactions

The rare isotopic ion of nitrogen, N^{15+}, has been matched in intensity with the molecular ion $(N^{14}H^1)^+$ and photographed by means of a high resolving power, high dispersion linear scale mass spectrograph.[1] The doublets were photographed in several different plate positions and a line density sufficiently great for accurate measurement was obtained with exposure times of four to six minutes. Measurements of the doublet separations were made on a comparator and checked by means of calibrated microphotometer curves. The agreement was within 0.005 mm in every case.

With these measured doublet separations in conjunction with the known dispersion curve for the plate, the following mass difference was obtained.

$$N^{14}H^1-N^{15}=0.01074\pm0.0002 \text{ mass unit.}$$

This value, in combination with the mass difference previously reported[2] for the $[{}_1H^2-D^2]$ doublet allows us to compute a value for the energy release in the deuteron nitrogen disintegration in which long range protons are emitted. This reaction

$$N^{14}+D^2\rightarrow N^{15}+H^1+Q_1$$

can be expressed in the following form

$$Q_1=[N^{14}H^1-N^{15}]-[{}_1H^2-D^2]$$

in which the terms included within the brackets are the mass differences of the doublets which have been measured on the mass spectrograph and reported above. Thus from mass considerations alone, the magnitude of the energy release is $Q_1=8.57\pm0.2$ MEV, which agrees within the limits of error with the value 8.53 MEV obtained from disintegration experiments.[3, 4]

The reactions involving the production of radio-oxygen[5]

$$N^{14}+D^2\rightarrow O^{15}+{}_0n^1+Q_2$$
$$O^{15}\rightarrow N^{15}+e^++\mu+Q_3,$$

can be written in an analogous manner. The mass of the neutrino is considered less than the probable error in the nitrogen doublet mass determination. Thus

$$Q_2+Q_3=[N^{14}H^1-N^{15}]-\text{Binding Energy of Deuteron}-[e^++(e^-)].$$

$$Q_2+Q_3=6.82 \text{ MEV.}$$

A direct measurement of Q_3 has been made,[6] thus the expected value of the neutron energy can be calculated for any given deuteron energy. An absolute check on this equation awaits the direct determination of Q_2.

The nitrogen deuteron reaction in which alpha-particles are released

$$N^{14}+D^2\rightarrow C^{12}+He^4+Q_4$$

can be combined with the oxygen deuteron reaction $O^{16}+D^2\rightarrow N^{14}+He^4+Q_5$ and be written in the following form

$$Q_4-Q_5=[C^{12}H_4-O^{16}]-2[C^{12}H_2-N^{14}].$$

The mass differences of the doublets which appear in the brackets on the right-hand side have been reported[7] and give us the value $Q_4-Q_5=10.14\pm0.3$ MEV. Here again the agreement with the disintegration value[3, 4] for this difference is quite good. It must be noticed, however, that this is not a check on either Q_5 or Q_4 individually, since both may be in error in such a way that (Q_4-Q_5) remains unchanged. A check on the individual reactions can only be obtained by measuring all the mass differences involved.

Harvard University,
June 15, 1936.

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The Isotopic Constitution of Iron and Nickel

Using a discharge in iron carbonyl, J. de Gier and P. Zeeman have recently observed four isotopes in iron[1] with atomic masses 54, 56, 57, and 58. The observations of Dr. Aston[2] had given only the first three. With a spark between pure electrolytic iron electrodes (Hilger spectroscopic brand) the four masses mentioned all appeared with great intensity the heaviest at 58 being the weakest. No line at 60 was observable. A very faint line at 59 could be ascribed to cobalt as the report of the spectroscopic investigation of this iron recorded a trace of cobalt.

The isotopic constitution of nickel is still uncertain. Dr. Aston considered masses at 56 and 64 as possibly due to some element or component other than nickel.[3] J. de Gier and P. Zeeman[1] were unable to find the isotope at 61 reported by Aston. This is possibly due to insufficient resolving power in their parabola method. With nickel the question of the purity of the metal is of very great importance as the impurities are very likely to be the neighboring elements and to give lines at 54, 56, 57 (Fe), 59 (Co), 63 (Cu), and 64 (Zn). In the nickel of exceptional purity made by fractionating nickel carbonyl, as supplied by Hilger & Company, zinc, cobalt, and copper are eliminated although a trace of iron is still present. A photograph made with electrodes of this iron is shown in Fig. 1. There can be no doubt that the masses at 58, 60, 61, 62, and 64 are all isotopes of nickel. The lines at 61 and 64 were of approximately equal intensity in all the photographs. The trace of iron still present in the nickel gave a mass at 56 and a very faint mass at 54. The relative intensity of these with respect to the other lines differed on different photographs, and was different with other samples of nickel, so that there is every reason to suppose that these masses are due to iron.

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June 12, 1936.

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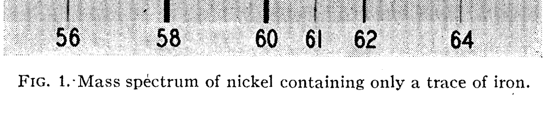

FIG. 1. Mass spectrum of nickel containing only a trace of iron.

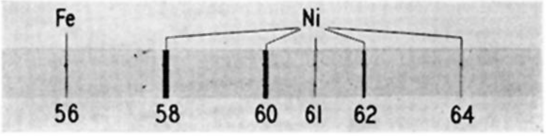

FIG. 1. Mass spectrum of nickel containing only a trace of iron.