In marked contrast to this is the conductivity of a rod of microcrystalline graphite which has also been measured. Over the whole temperature region below 90°K the mean free path is limited by the grain size, which is of the order of 100A. The specific heat is lower than that of quartz glass owing to the high Debye temperature. As a result of these two factors, the conductivity at 90°K is about 80 times greater, while at 1°K it would be about 50 times less than that of glass. This may be of practical interest for the temperature region obtained by magnetic cooling.

A fuller account of these experiments will be given elsewhere. Theoretical work on the conductivity of glasses at low temperatures is being carried out in this laboratory.

I wish to thank Professor F. E. Simon for his interest and advice.

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Energy Levels in N^{15} and N^{16}

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THE experimentally determined mass values of N^{16} have shown large discrepancies. The latest values[1,2] as determined from the ground state Q-value of the $F^{19}(n,\alpha)N^{16}$ reaction and from the maximum β-decay energy of N^{16} still show differences of 0.7 mMU. An independent determination of this mass has been made from a study of the $N^{15}(d,p)N^{16}$ reaction. In connection with their photographic work on the scattering of 6.5-Mev deuterons by nitrogen, Guggenheimer, Heitler and Powell[3] found proton groups corresponding to new higher excitation levels in the N^{15} nucleus. A check of these excitation levels has been made using the counters described by Martin[4] for proton detection.

Ammonium nitrate containing 61.5 atom percent of N^{15} in the ammonium radical was obtained from the Eastman Kodak Company. The ammonia was released by reaction in an evacuated system with an aqueous solution of sodium hydroxide. The resulting ammonia gas so obtained was dried with potassium hydroxide to remove the water vapor. The first runs were taken at an observation angle of 90° using a target gas pressure of 20 cm of Hg. The results obtained for both a normal ammonia target and the enriched target at ranges beyond the alpha-particle groups arising from the associated $N^{14}(d,\alpha)C^{12}$ reaction are shown in Fig. 1. It is evident that no proton groups attributable to the $N^{15}(d,p)N^{16}$ reaction are present in this absorption interval. However, a proton group from this reaction has been found at shorter ranges as shown in Fig. 2. The proton group was deduced by normalizing the unenriched target data to the enriched target data and subtracting the former from the latter. The normalization factor was the ratio of the N^{14} present in the enriched target to that in the unenriched target; the numerical value was obtained from the relative heights of 7.2-Mev excitation proton groups and the long range alpha-particle groups. It will be noticed that there is good evidence that the group is double with the higher state at approximately 0.3-Mev excitation. Other data taken at 30° and 90° did not show the two groups as well resolved as shown in Fig. 2; however, all data did show evidence that the group is double. Using the longest range component an average ground state Q-value of 0.23 ± 0.15 Mev is obtained for the $N^{15}(d,p)N^{16}$ reaction. If the mass values of Flugge and Mattauch[5] are used for proton, deuteron, and N^{15} a mass value of 16.01121 ± 0.00023 MU is obtained for N^{16}.

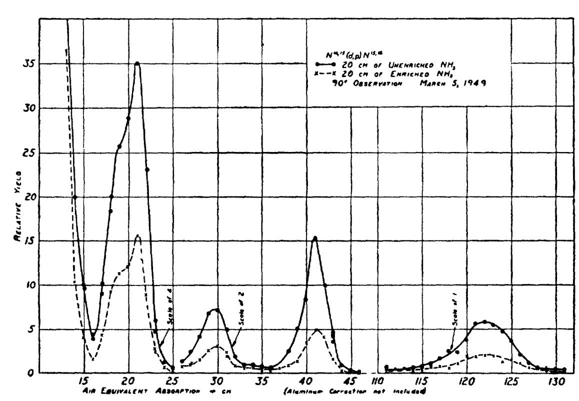

FIG. 1. The atom percent of N^{15} in the enriched target was 61.5 percent. Deuteron bombarding energy was 3.32 Mev.

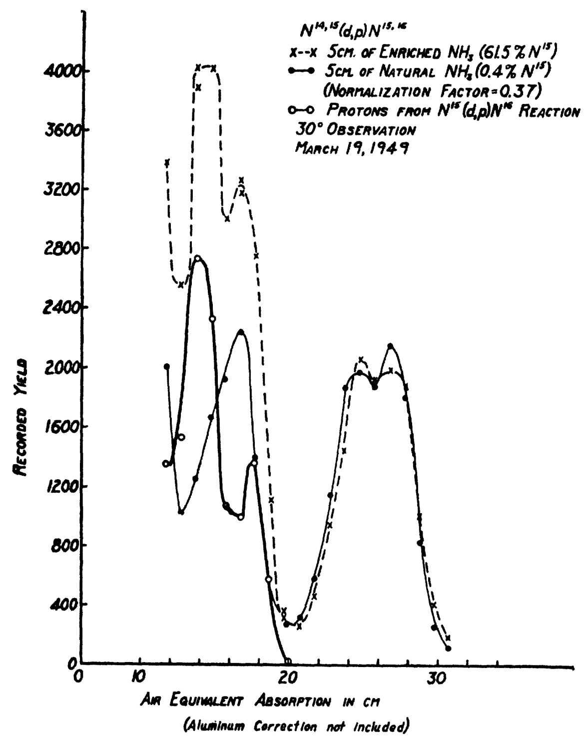

FIG. 2. Deuteron bombarding energy was 3.38 Mev.

The average Q-values for the $N^{14}(d,p)N^{15}$ reaction are given in Table I together with those reported by Guggenheimer, Heitler, and Powell. It is to be noted that the 6-Mev level is confirmed as well as the fact that the 7.2-Mev level is double (see Fig. 2).

TABLE I. Q-values for the $N^{14}(d,p)N^{15}$ reaction.

Present work	Guggenheimer, Heitler, and Powell
8.61 ± 0.1 Mev	8.55 Mev
3.29 ± 0.1 Mev	3.5 Mev
2.30 ± 0.1 Mev	2.5 Mev?
1.40 ± 0.1 Mev	1.3 Mev (double?)
	0.3 Mev (double?)

Furthermore there is good evidence for the proton group at an excitation of 8.2 Mev (see Fig. 2).

I am indebted to Professor E. C. Pollard, who suggested the investigation, for many helpful discussions.

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Ionization Measurement of $He^3(np)$ and $N^{14}(np)$ and the Neutron-Hydrogen Mass Difference

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A cylindrical ionization chamber with a fine axial wire collector was filled with a highly purified mixture of two atmospheres of argon, one-tenth atmosphere of nitrogen and one-half atmosphere of helium enriched in He^3. The pulse size distribution arising from electron collection of the ionization produced by the reactions $He^3(np)H^3$ and $N^{14}(np)C^{14}$ induced by slow neutrons was observed. With a model 100-linear amplifier, modified to have a "rise time" of 16 microseconds, a "clipping time" of 5 microseconds and using an input capacity of 16 micro-microfarads, it was possible to achieve a noise equivalent to 8 kev of ionization in argon (corresponding to an r.m.s. input voltage of 2.3 microvolt). Pulses were recorded by photographing an oscillograph tube. The linearity of the system was checked by means of a precision pulser and an electronic discriminator. The system was calibrated with alpha-particles from a thin polonium source mounted on a platinum foil which could be positioned at the chamber wall or retracted.

The absence of electron capture in the gas was checked by observing the dependence of pulse height on collecting voltage. Saturation was complete at 100 volts with less than one percent variation in pulse height as the applied potential was increased from 100 to 1000 volts.

Figure 1 displays the pulse size distribution obtained from $He^3(np)$ and $N^{14}(np)$ observed simultaneously and from polonium alpha-particles observed in the same gas mixture. The observed distributions agree closely with the distributions expected for a ratio of 400 between outer and inner radii of the ionization chamber and disintegration tracks short compared to the diameter of the chamber.[3] The alpha-particle distribution is narrower due to the localization of the source. On the high energy side, all the distributions fall off sharply, the rate of fall being limited mainly by amplifier noise. This sharp cut-off and the similarity of the curves allow a precise comparison of the ionizations.

If a linear relation between energy and ionization is assumed in argon, in accordance with the results of Jesse,[4] then the energy equivalents of the total ionization produced in $He^3(np)$ and $N^{14}(np)$ are 764±10 kev and 628±4 kev, respectively, when a direct comparison is made with polonium alpha-particles (assumed to have an energy of 5298.4 kev).[5] A correction of −0.3 percent has been applied to these values to account for the effect of the presence of one-tenth atmosphere nitrogen. This correction is derived from the results of a separate experiment in which the total ionization due to $N^{14}(np)$ was studied as a function of nitrogen concentration in purified nitrogen-argon mixtures.

The difference in the energy values for $N^{14}(np)$ and $He^3(np)$ checks closely with the difference between the end-points of the beta-spectra of C^{14}, 156±1 kev,[6] and H^3, 18±1 kev,[7] and their ratio agrees with the ratio of the total ionizations of the two reactions considered independently. This agreement supports the assumption of a constant average energy per ion pair in argon. The errors quoted on the energy values are based on internal consistency and the uncertainty due to statistics alone and do not take into account any systematic errors arising from the method of calibration.

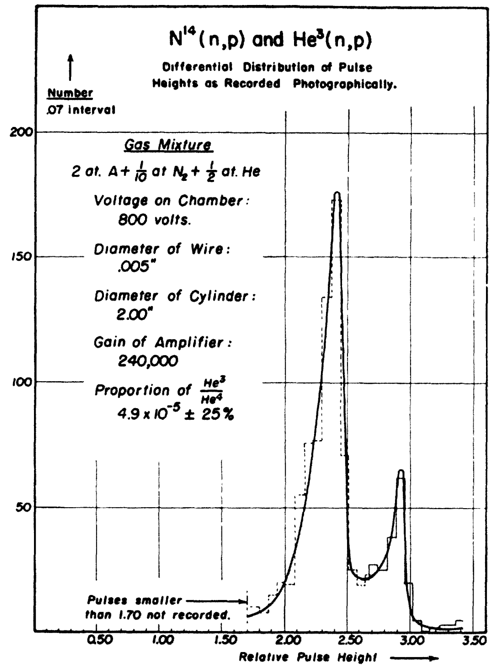

FIG. 1A. Distribution of pulse heights due to $N^{14}(np)$ and $He^3(np)$.

The energies obtained agree well with the thresholds for the inverse (pn) reactions, 620±9 kev[8] and 764±1 kev,[9] respectively, and an ionization determination of $N^{14}(np)$ using total ion collection, 630±10 kev.[10] Assuming zero neutrino mass, our results lead to a neutron-hydrogen mass-difference of 783±4 kev. This value is higher than previously supposed,[11] but agrees well with a value of 789±6 kev deduced from the $D[(dn)(dp)\beta^-]$ cycle.[12] However, it is smaller than the value of 804±5 kev obtained by Bell and Elliott[13] from measurement of $H(n\gamma)$ and the HH−D mass doublet.

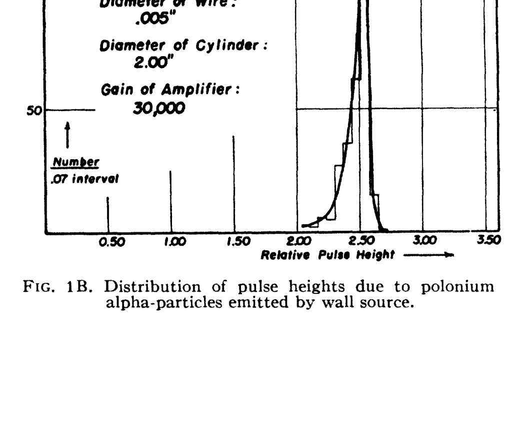

FIG. 1B. Distribution of pulse heights due to polonium alpha-particles emitted by wall source.