protons having ranges of about 1.4 and 0.5 cm. (ii) The groups (a), (c) correspond to the disintegration II→O′ and II→I′, while the groups (b), (d) to I→O′ and I→I′, respectively. On this assumption, we find

$$Q_0(\text{a}) = -1.24\times 10^6 \text{ e.v.};\quad Q_0(\text{b}) = -1.08\times 10^6 \text{ e.v.}$$

$$Q_1(\text{c}) = -2.1\times 10^6 \text{ e.v.};\quad Q_1(\text{d}) = -2.01\times 10^6 \text{ e.v.}$$

With these values of the Q's, one finds that the ranges of the recoiled protons of the neutrons arising from α-particles entering through level III are roughly 22 and 13 cm. If the idea of these assignments is correct at all, the detection of either two short groups or two long groups will decide between the two possibilities. Professor Mott-Smith kindly communicated to the writer that while they found no evidence for such long groups, they actually found a group of 1.5 cm range. Thus the first assignment above seems very probable. The consistency of this assignment lends further support to the results of Chadwick and Constable and it seems very desirable to carry out a similar investigation on the neutrons from Al whose proton emission has been studied by many investigators with not entirely identical results.

It is of some interest to estimate the mass of Na_{11}^{22} as the result of the disintegration

$$F_9^{19}+He_2^4\rightarrow Na_{11}^{22}+n_0^1. \qquad (2)$$

For this purpose one needs the mass of F_9^{19} which may be calculated from the data in Table I for the disintegration

$$F_9^{19}+He_2^4\rightarrow Ne_{10}^{22}+H_1^1. \qquad (3)$$

Taking $H=1.0072$, $Ne=21.9893$, $He=4.0011$, $Q=0.0018$, then for the three long-range groups I(l), II(l), III(l), one finds for the nuclear mass of F 18.9972. Using this in Eq. (2) and taking $n_0=1.0065$, one gets for the scheme (i) the nuclear mass of Na_{11}^{22} 21.9942, the mean value of $Q_0=-2.22\times 10^6$ e.v. being used. The negative sign of the Q_0's shows that part of the K. E. of the α-particle goes into the mass of Na_{11}^{22} which may be radioactive with positron emission.

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The Prediction of Isotopes

As a result of the work of Aston[1] and others, we now have extensive information about the isotopes associated with the various chemical elements. The writer[2] has attempted to explain the regularities observed for the lighter nuclei. For nuclei of mass number $M>36$, it is known[3] that regularities exist, but the general character of the pattern is still much of a mystery. It is the purpose of the present note to point out further regularities, and to attempt to put the prediction of new isotopes on a somewhat more systematic basis than it is at present.

Beck[4] has emphasized that there are many sequences of isotopes such that, between two successive members of a sequence, $\Delta Z=2$ and $\Delta M=4$. If a member of the sequence be missing, then it may be supposed that this is merely a stable isotope which remains to be discovered. That is, one may interpolate with some degree of confidence.

The isotope pattern is, however, a two-dimensional affair and the above sequences run in one direction only. Since H 3 particles are known to be stable (and might conceivably have an independent existence within the nucleus), it has seemed worthwhile to investigate the sequences of the type $(\Delta M/\Delta Z)=3$. In fact, a very convenient way of representing the isotope pattern is by means of a plot in which the sequences $(\Delta M/\Delta Z)=2$ run vertically, and the sequences $(\Delta M/\Delta Z)=3$ run horizontally. (A "sequence" will be supposed to contain at least three members.)

The horizontal sequences contain, as a rule, more members than do the vertical sequences, and should, therefore, be more useful for the purposes of prediction. Some of them follow: S 34, Cl 37, A 40; A 36, K 39, (Ca 42), Sc 45, Ti 48, V 51, Cr 54; Cr 52, (Fe 58), (Ni 64), Zn 70, Ge 76, Se 82; Fe 56, Co 59, (Ni 62), Cu 65, Zn 68, Ga 71, Ge 74; Ni 60, Cu 63, Zn 66, Ga 69, Ge 72, As 75, Se 78, Br 81, Kr 84, Rb 87, (Sr 90); Ni 58, Zn 64, Ge 70, Se 76, Kr 82, Sr 88, Zr 94, Mo 100, (Ru 106), (Pd 112), Cd 118, Sn 124, Te 130, Xe 136; Mo 94, (Ma 97), Ru 100, (Rh 103), (Pd 106), Ag 109, Cd 112, In 115, Sn 118, Sb 121, Te 124, I 127, Xe 130, Cs 133, Ba 136, La 139, Ce 142; and Ru 96, (Pd 102), Cd 108, etc., clear to Pb 210. The others may be read from the pattern—the ones above are given to show that the sequences do extend over a wide range. (The parentheses indicate elements predicted). The sequence from Ru 96 to Pb 210 has only seven gaps, namely, Pd 102, Te 120, Ba 132, Ce 138, Sm 150, Hf 180, and Pt 198. Palladium, hafnium and platinum have not been analyzed, so that there may be only four gaps in the sequence of twenty members.

On the basis of this two-dimensional interpolation method, one may predict the following isotopes as reasonably probable (for $M>36$): Ca 42; Fe 57, 58; Ni 61, 62, 64; Sr 84, 90; Zr 91; Ma 97, 99; Pd 102, 104–8, 110, 112; Rh 101, 103; Ru 106; Te 118, 120; Ba 130, 132, 134, 140; La 137; Ce 136, 138, 139, 141, 144; Pr 143; Il 145, 147; Nd 148; Sm 150, 151; Gd 154; Tb 157; Dy 160; Ho 163; Hf 176–180; Ir 191, 193; Pt 192–196, 198; and Au 197, 199. It may be that more than this number will be found, but the writer believes this to be a fairly conservative estimate.

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May 15, 1934.

[1] F. W. Aston, *Mass Spectra and Isotopes*, 1933; Nature **132**, 930 (1933) and **133**, 327 (1934).
[2] J. H. Bartlett, Jr., Nature **130**, 165 (1932) and Phys. Rev. **41**, 370 (1932).
[3] H. A. Barton, Phys. Rev. **35**, 408 (1930).
[4] Guido Beck, Zeits. f. Physik **47**, 407 (1928).