Letters to the Editor

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Disintegration of Light Elements by Fast Protons

SINCE the publication of our paper[1] on the disintegration of elements by fast protons, we have examined some of the light elements more carefully, using much thinner mica windows than we had previously employed on the high voltage tube. With the present arrangement, we can count particles which have passed through only 6 mm. air equivalent of absorber on their way from the target to the ionisation chamber.

In the case of lithium, we have found, in addition to the α-particle group of 8·4 cm. range, another group of particles of much shorter range. The number of these is about equal to that of the long range particles and their maximum range is about 2 cm. The ionisation produced by them indicates that they are α-particles. It will be of interest to examine whether any γ-rays are emitted corresponding to the difference of the energies of the α-particles in the two groups, but on account of the smallness of the effect to be expected, a sensitive method will be necessary.

In the case of boron, the number of particles observed increases rapidly as the total absorption between the target and the ionisation chamber is reduced. The maximum range of these particles is about 3 cm. and in our earlier experiments we determined the number of particles only after passing through the equivalent of 2·9 cm. of air, so that we were very nearly at the end of the range. Decreasing the absorber to 6 mm. of air gives an enormous increase in the number of particles. In this way about twenty-five times as many particles have been obtained from boron as from lithium under the same conditions. We estimate that there is roughly one particle emitted per two million incident protons at 500 kilovolts. The ionisation produced by the particles suggests that they are α-particles, and the energy of the main group would support the assumption that a proton enters the B^{11} nucleus and the resulting nucleus breaks up into three α-particles. There also seem to be present a small number of particles with ranges up to about 5 cm.

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Dec. 22.

1 *Proc. Roy. Soc.*, A, **137**, 229; 1932.

The Neutron and Neuton, the New Element of Atomic Number Zero

SINCE neutrons were first recognised by Chadwick in the rays from the beryllium nucleus, it may be of interest to note that in 1915 the hydrogen-helium theory[1] considered this nucleus to consist of two doubly charged helium nuclei and a condensed or nuclear hydrogen atom, now called a neutron. In a paper written early in 1919, the formula of the beryllium nucleus was given as $\alpha_2(\eta\beta)$ which in more recent symbols is $\alpha_2(pe)$, where the parentheses were used to emphasise the idea that the proton p and the electron e are united to form a neutral group or neutron.

The suggestion that neutrons exist as separate atoms was made independently at practically the same time by Lord Rutherford (June 3, 1920) and myself (April 12, 1920).

The basis for my assumption of the existence of neutrons, was that it would be difficult for α-particles, on account of their double positive charge, to pass through the region of repulsion (now called the potential barrier) around nuclei of high positive charge in order to unite with the nucleus, but that electrically neutral particles "could easily pass into and through this region". "Such atoms might have masses 1, 2, 3 and 4, and possibly other values, and they would contain no non-nuclear electrons, so they would have no chemical, and almost none of the ordinary physical properties, aside from mass."[2]

While the question of stability is not discussed in this paper, it may be stated that at that time I did not consider any neutron of higher mass than 2 to exist more than momentarily except in a moderately heavy nucleus, but that the first quadruple neutron present in other nuclei is that in argon 40, the nuclear formula of which may be written $\alpha_9{+}{+}(pe)_4{}^{\circ}$ or $\alpha_9{+}{+}(\alpha e_2)^{\circ}$.

Since neutrons of unit mass (according to Chadwick about 1·006), and possibly those of mass two also, probably exist throughout space, and are concentrated by gravitation in the planets, and still more in the stars, they may be considered to constitute collectively an element. Since the atomic number of an element is determined by the magnitude of the charge on the nucleus of an atom of the element, the atomic number which corresponds to a neutron is zero; that is, the neutron is a nucleus with a zero charge. As a name for this new element, neutronium, neutronon, or neuteron have been suggested to me, but the name 'neuton' is more simple and preserves in it the suggestion of neutrality and also the final 'on' of the chemically indifferent elements.

To what extent the atoms of neuton partake in the partition of heat energy between molecules in general, is an interesting problem, since the collisions of the neutrons would be with nuclei and with electrons, rather than with atoms and molecules.

It is not improbable that the general formula for any nucleus, $(p_2e)_z(pe)_i$, proposed independently in 1921 by Masson and by me, may be shown to have a theoretical significance. If n represents a neutron, then this formula may be written $(pn)_z n_i$ in which z is the atomic, and i the isotopic number. For the neutron z is 0 and i is 1, for the proton z is 1, and i is -1, for oxygen 16, z is 8 and i is 0, and for the principal isotope of argon z is 18 and i is 4. It is evident that if all of the electrons are present as neutrons, then $z+i$ gives the number of neutrons, z the number of extra protons, and $2z+i$ the total number of protons. The numbers z and i are the most important in the classification of atomic species, and the value of i defines specifically the particular isotope, either known or unknown, of any element, either radioactive or non-radioactive.

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Nov. 8.

1 Harkins and Wilson, *J. Amer. Chem. Soc.*, **37**, 1396; 1915.
2 Harkins, *J. Amer. Chem. Soc.*, **42**, 1996 and 1964; 1920.