Letters to the Editor

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Radioactivity Induced by Neutron Bombardment

EXPERIMENTS have been carried out to ascertain whether neutron bombardment can produce an induced radioactivity, giving rise to unstable products which disintegrate with emission of β-particles. Preliminary results have been communicated in a letter to *La Ricerca Scientifica*, **5**, 282; 1934.

The source of neutrons is a sealed glass tube containing radium emanation and beryllium powder. The amount of radium emanation available varied in the different experiments from 30 to 630 millicuries. We are much indebted to Prof. G. C. Trabacchi, Laboratorio Fisico della Sanità Pubblica, for putting at our disposal such strong sources.

The elements, or in some cases compounds containing them, were used in the form of small cylinders. After irradiation with the source for a period which varied from a few minutes to several hours, they were put around a Geiger counter with walls of thin aluminium foil (about 0·2 mm. thickness) and the number of impulses per minute was registered.

So far, we have obtained an effect with the following elements:

Phosphorus—Strong effect. Half-period about 3 hours. The disintegration electrons could be photographed in the Wilson chamber. Chemical separation of the active product showed that the unstable element formed under the bombardment is probably silicon.

Iron—Period about 2 hours. As the result of chemical separation of the active product, this is probably manganese.

Silicon—Very strong effect. Period about 3 minutes. Electrons photographed in the Wilson chamber.

Aluminium—Strong effect. Period about 12 minutes. Electrons photographed in the Wilson chamber.

Chlorine—Gives an effect with a period much longer than that of any element investigated at present.

Vanadium—Period about 5 minutes.

Copper—Effect rather small. Period about 6 minutes.

Arsenic—Period about two days.

Silver—Strong effect. Period about 2 minutes.

Tellurium. Period about 1 hour.

Iodine—Intense effect. Period about 30 minutes.

Chromium—Intense effect. Period about 6 minutes. Electrons photographed in the Wilson chamber.

Barium—Small effect. Period about 2 minutes.

Fluorine—Period about 10 seconds.

The following elements have also given indication of an effect: sodium, magnesium, titanium, zirconium, zinc, strontium, antimony, selenium and bromine. Some elements give indication of having two or more periods, which may be partly due to several isotopic constituents and partly to successive radioactive transformations. The experiments are being continued in order to verify these results and to extend the research to other elements.

The nuclear reaction which causes these phenomena may be different in different cases. The chemical separation effected in the cases of iron and phosphorus seems to indicate that, at least in these two cases, the neutron is absorbed and a proton emitted. The unstable product, by the emission of a β-particle, returns to the original element.

The chemical separations have been carried out by Dr. O. D'Agostino. Dr. E. Amaldi and Dr. E. Segrè have collaborated in the physical research.

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April 10.

Induced Radioactivity

CURIE and Joliot[1] and Ellis and Henderson[2] have observed that positrons were emitted when aluminium, magnesium and boron were bombarded with high energy α-particles. They noted, further, that the positrons could be detected after the α-particle bombardment had ceased. It was therefore assumed that these electrons were produced by the radioactivity of the unstable nuclei resulting from the capture of the α-particle and the expulsion of the neutron. Danysz and Zwy[3] obtained similar results when they bombarded nitrogen with α-particles.

In order to account for the results obtained by bombarding certain ammonium salts in which hydrogen was in part replaced by diplogen with diplons, Oliphant, Harteck and Rutherford[4] assumed that a helium nucleus of mass 4 and charge 2 was formed by the union of two diplons, which differed from the ordinary α-particle in having a large excess energy and being in consequence unstable. It is the purpose of this note to point out that in a similar manner the radioactivity of the light elements is due to the formation, within their nuclei, of an unstable proton of excess energy which disintegrates by emitting a positron. It is suggested that the similarity of the disintegration phenomena observed is due to the radioactivity of this 'radioproton'.

It has been shown[5] that the emission of protons from neon, magnesium, silicon, sulphur and argon can be explained by assuming that pairs of electrons are formed by the interaction of α-particles and nuclei as suggested by a formula due to F. Perrin[6]. By assuming that the positron of the pair unites with a neutron to form a proton, it was found possible to retain the hypothesis of stability of nuclei of mass $4n$, the feeble proton emission of the elements mentioned being due to the less abundant isotopes. The mechanism was extended to the other proton-emitting elements and the conclusion arrived at in a previous paper[7] was confirmed, namely, that there are no 'free protons' in nuclei, these particles being combined with neutrons either as α-particles or diplons. This hypothesis will account for the induced radioactivity as follows.

Consider, for example, the case of aluminium. It is supposed that the proton emission is caused by the positron of the electron pair uniting with the free neutron, the negative electron combining with the positron of the diplon to produce a quantum of γ-radiation and leaving the stable nucleus ${}_{14}Si^{30}$. When the energy of the α-particle increases beyond a critical value, it is supposed that the neutron is emitted before the high energy positron unites with it. The radioproton is formed, however, as the positron unites with one of the two neutrons produced