I have found that both sodium and phosphorus become active after α-ray bombardment. Three different sodium compounds (NaCl, NaF, $Na_2C_2O_4$) have been investigated; they all showed a fairly strong activity, dying off very quickly. The half value period has been determined by recording the impulses on a rotating drum, the whole decay curve being recorded 21 times. The half value period was found to be 7 ± 1 seconds. Phosphorus (elementary red phosphorus) showed a very much longer lifetime. The half value period was found to be 40 ± 5 minutes.

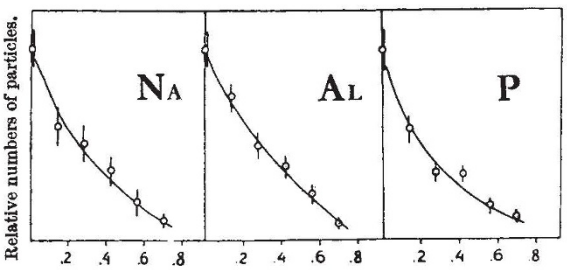

FIG. 1.

The initial activity of phosphorus was about one sixth that of aluminium. The initial activity of pure sodium under the same conditions was estimated, from the composition of the salts, to be about half that of aluminium.

The sign of the particles emitted by the substances was determined by deflection in a magnetic field. Both sodium and phosphorus were found to emit mainly positive electrons. In the case of sodium, no negative particles have been detected; there cannot be more than one fifth of the positives, if any. In the case of phosphorus, the results are not quite so definite; anyhow, the negative particles cannot be more than one third of the positives.

Some information about the energy of the particles was obtained by putting copper foils between the substance and the window of the counter. For a better comparison the same has been done with the particles emitted by aluminium. The three absorption curves are given in Fig. 1, the mean statistical error being indicated by the vertical lines. The range of the particles can be extrapolated to be about 0·8 gm./cm.² of copper, corresponding to an energy of $1{\cdot}8 \times 10^6$ e.v., for all three elements.

The nuclear reactions leading to the creation of these new active elements are very probably analogous to the production of radio-phosphorus by bombarding aluminium. In that case, the reaction is generally assumed to be $_{13}Al^{27} + \alpha = {}_{15}P^{30} +$ neutron, the $_{15}P^{30}$ disintegrating after a time according to the reaction $_{15}P^{30} = {}_{14}Si^{30} +$ positron. So for sodium and phosphorus the reactions would be $_{11}Na^{23} + \alpha = {}_{13}Al^{26} +$ neutron and $_{15}P^{31} + \alpha = {}_{17}Cl^{34} +$ neutron, respectively. In the last case, this view was confirmed by the chemical separation of the active chlorine. The active phosphorus was burned, the products of combustion dissolved in caustic soda. The solution was acidified with nitric acid, a trace of ammonium chloride added and then excess of silver nitrate. The silver chloride, filtered off and washed on a small disc of filter paper, was found to contain more than 50 per cent of the original activity, showing the same time decay.

By extrapolating the series of odd elements $_{15}P^{31}$, $_{13}Al^{27}$, $_{11}Na^{23}$, all of which show induced activity, one would anticipate that $_9F^{19}$ would show it too, especially since fluorine is known to emit neutrons under α-ray bombardment. On the other hand, the extrapolation of the periods: 40 min., 3 min., 7 sec., leads to a very short life for the hypothetical activity produced in fluorine. I have tested calcium fluoride in my apparatus, but have not been able to find definite evidence of an activity.

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[1] NATURE, **133**, 201, Feb. 10, 1934.

β-Emission of Positive Electrons

THE artificial production of radioactive isotopes recently discovered[1] has to be brought into connexion with the theoretical treatment of the β-type of radioactive transformation[2]. It is easily seen that the formulæ given for the β-decay of heavy elements apply to the emission of positive electrons by simply changing the sign of the charges involved. We have calculated the continuous energy spectra to be expected from N^{13} both according to the theory developed some time ago by ourselves and according to the assumption that a so-called 'neutrino' is emitted simultaneously with the electron. The curves obtained in this way are very similar and may be represented by Fig. 1, which has been drawn for a special case. It seems to us that it will be scarcely possible to distinguish between these two theories by measuring the shape of the energy spectrum.

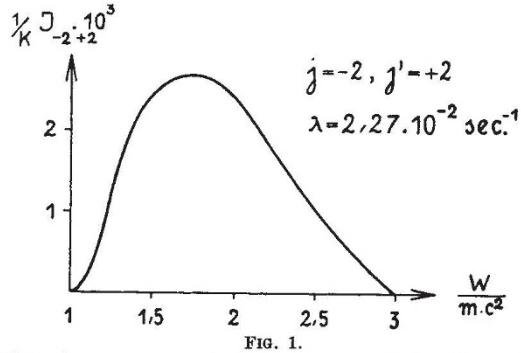

FIG. 1.

The decay constant, however, resulting from the extrapolation of the values known for the heavy radioactive β-bodies, fits very nicely the order of magnitude of the value of several minutes actually observed. (A more exact comparison cannot be made unless the upper energy limit of the continuous energy spectrum has been determined.) This fact seems to confirm the view previously taken by us, that the extremely long life period of the lighter β-bodies (potassium and rubidium) should not be compared with that of the other β-active substances. The extremely high values of the decay constants of these elements have evidently to be explained by a more complicated mechanism, possibly by a double process in which two electrons leave the nucleus simultaneously.

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March 15.

[1] I. Curie and F. Joliot, *C.R. Acad. Sci.*, **198**, 254; 1934. J. D. Cockroft, C. W. Gilbert and E. T. S. Walton, NATURE, **133**, 328, March 3, 1934.
[2] G. Beck and K. Sitte, *Z. Phys.*, **86**, 105; 1933. E. Fermi, *La Ricerca Scientifica*, **2**, No. 12.