Letters to the Editor.

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The Transmutation of Elements.

IN a letter to NATURE of January 2, 1926, Prof. Smits records the obtaining of evidence of the transmutation of lead into thallium and into mercury. One of our research students has been employed for some time in an attempt to detect the transmutation of lead into thallium, but up to the present the experimental difficulties have not been satisfactorily overcome, and we are not yet able to make a definite statement on the matter as a result of this work. The experiments so far attempted in this Laboratory, and those contemplated in future efforts, have been designed to facilitate the entry of an electron into the nucleus of a lead atom in the hope of effecting a transmutation into an isobare of another element (thallium), rather than to bring about a transmutation by the ejection of a proton or an α-particle from the nucleus of the lead atom.

We may perhaps be permitted to review the results of attempts at transmutation of elements which have been recently recorded in the light of these two alternative possibilities. In the case of the transmutation of mercury (atomic number 80) into gold (79) which has been announced by Miethe and Stammreich, and independently by Nagaoka, the change might conceivably be effected either by the entry of an electron into, or by the removal of a proton from, the nucleus of the mercury atom. The same alternatives present themselves in regard to the transformation of lead (82) into thallium (81).

Prof. Nagaoka, in attempting to bring about the transmutation of mercury into gold, designed his experiments with the view of facilitating powerful disturbance of the mercury nucleus which might lead to the ejection of a proton, because considerations of the satellites of the spectral lines of mercury had led him to the conclusion that in this element a proton is "slightly detached" from the central nucleus, and therefore possibly capable of removal. His experiments, which yielded a positive result, do not, however, enable us to distinguish conclusively between the two alternative methods of transmutation.

In Miethe and Stammreich's experiments the arrangement was entirely different, and the gold was obtained from mercury-vapour lamps using a heavy current, but requiring that the potential difference should exceed only 170 volts. In the account of these experiments given in NATURE of August 9, 1924, the possibility of the transmutation being due to the disruption of the mercury nucleus appears to be the only explanation considered; but, as Prof. Soddy has pointed out, an atomic disruption is not necessarily involved, and the alternative of attaching an electron to the mercury nucleus needs to be taken into account. Certainly the nature of the experiment does not preclude this possibility.

In essentials the experimental arrangement employed by Smits was similar to that of Miethe, for it consisted of a quartz lead-vapour lamp of special design run at voltages of less than 100 and with currents up to 100 amps. Smits records that initially the spectrum showed only one of the mercury lines, 2536, and that very weakly, but that after running the lamp for 10 hours the strongest mercury lines in the visible as well as the ultra-violet region of the spectrum had made their appearance, and that the most characteristic thallium line was also visible.

Now in the case of the transmutation of lead (82) into mercury (80), the change may occur either by the intermediate production of thallium by one of the processes already suggested, and the subsequent conversion of the thallium into mercury by a second similar process, or it can occur as a one-stage change by the ejection from the lead nucleus of either one doubly charged positive particle (presumably an α-particle) or two singly charged positive particles (presumably protons) simultaneously. If the process occurs by the intermediate production of thallium, one would expect to find evidence of a relatively large amount of thallium compared with the amount of mercury produced. Prof. Smits does not appear to have found such an effect, for he records stronger evidence of the production of mercury than of the production of thallium.

In the circumstances of Nagaoka's experiments, in which very intense electric fields were employed, it is conceivable that these fields brought about a disruption of the nucleus, and that, as a result, a portion of the nucleus was thrown off. In the cases both of Miethe's experiment and of Smits' experiment, if such a disruption occurs, it must be brought about by a different means. When atoms are bombarded by electrons, it is possible that in a few instances an electron penetrates within the K shell of extra-nuclear electrons, though it is certainly surprising that this is possible in the circumstances of these experiments. When such a penetration does occur, the electron will be attracted towards the nucleus and may possibly be absorbed by it. Even so, in some cases the absorption of an electron by the nucleus may render the latter unstable and disruption may occur with the ejection of a proton and an electron, either separately or together, in which case the final chemical state of the disturbed atom will be the same as if the electron had been absorbed by the nucleus and a stable condition attained.

If we adopt Nagaoka's view that there are "slightly detached" portions of the nucleus, disruption by the approach of an electron is perhaps more easily imagined. Moreover, since lead consists of several isotopes, it is not unreasonable to suppose that the close approach of an electron to the nuclei of different lead isotopes would have different results. It is possible that the production of thallium results from one isotope, and the production of mercury from another.

It must be remembered that if the transmutation of one element into another is brought about by the ejection of some part of the parent nucleus, something corresponding to the final state of the ejected portion must be present to the same extent as the element resulting from the changed condition of the main part of the nucleus of the parent atom. In the cases considered, if the thallium and mercury are produced in this way, one might expect to find hydrogen (or perhaps in the latter case, helium) present to corresponding extents, and it is possible that these might be detected by spectroscopic observations under appropriate conditions.

In the case of transmutation by absorption of electrons into the parent nuclei, one would not expect to find these other elements. It therefore appears that the most hopeful method of obtaining evidence as to the exact nature of transmutations such as those recently recorded is from attempts to detect the lighter products as well as the heavier products of possible transmutations.

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