LETTERS TO THE EDITOR.

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The Origin of Radium.

EIGHT months have elapsed since I wrote in your columns (NATURE, May 12, 1904) giving an account of some experiments designed to test the view advanced by Prof. Rutherford and myself that radium is a product of the radio-active change of uranium. I then stated that in 1 kilogram of uranium nitrate that had been under observation over a period of one year since it was completely freed from radium, the quantity of radium reproduced in that time was less than one-ten-thousandth of the quantity theoretically to be expected. This result has been widely quoted, more widely, perhaps, than I intended, for the result was a preliminary conclusion only, and, as I pointed out, obtained under very unfavourable conditions owing to the very powerful preparations of radium that had been in use in the laboratory for other researches. The necessity for publishing it was to a certain extent forced upon me by the attention the problem was beginning to attract from other investigators, and by the prospect of several months' absence abroad. I relied on the fact that the result being negative, the presence of the radium in the laboratory could have had no effect, but in this I was mistaken.

Since my return I have resumed the research in the new chemical laboratories recently erected here, into which no radium has so far been brought, and have found that the earlier result was affected by an error which invalidates the conclusion drawn. It is therefore my duty to point this out at once without waiting for any further results. I am now fairly satisfied that there is a steady production of radium from uranium, and although the quantity formed, as measured by the amount of radium emanation evolved, is of a lower order of magnitude than is indicated by the disintegration theory, it is much greater than the ten-thousandth part.

At the present time, about eighteen months since the commencement of the experiment, the kilogram of uranium nitrate in solution contains, so far as the amount of emanation evolved is a measure, about $1{\cdot}5\times10^{-9}$ gram of radium, and if the whole series of measurements from the commencement are re-calculated, eliminating the error alluded to, they are fairly consistent with there having been a steady production of radium at this rate continuously from the commencement. This gives the value 2×10^{-12} for the fraction of the uranium changing per year, whereas the most probable theoretical estimate is 10^{-9}. The new result is thus still only one-five-hundredth of the theoretical.

The error in the result published last May was not in the determination of the amount of radium emanation evolved from the uranium, but in the determination of the amount of emanation given by a known weight of radium, against which the first mentioned determination was compared. The measurements on the uranium are in good agreement with those recently obtained, whereas the comparative experiments with radium gave results too high owing to extraneous radium in the laboratory. For the effect from the uranium is so minute that to obtain a comparable effect with the radium emanation, the quantity of the latter obtainable from the smallest weighable quantity of pure radium bromide must be diluted and subdivided until only a millionth part at most remains. Thus if any emanation were present in the air of the laboratory used for the dilution, or if by mischance any of the gas apparatus, rubber tubing, or mercury had been used previously in experiments with powerful radium preparations, the results obtained would be completely false. It is now known (*vide* Rutherford, *Phil. Mag.*, November, 1904, p. 637) that even metals, as copper and silver, absorb the radium emanation appreciably and slowly evolve it. The utmost precautions have to be observed in standardising the rate of leak of the electroscope by the emanation from a known weight of radium, so that each successive dilution of the emanation is performed in an entirely new apparatus with new mercury and rubber connections. Otherwise emanation is absorbed from the gas rich in it and given out to the diluted gas, and when the final dilution should contain only one-millionth of the original emanation, as in these experiments, it will be in reality far richer. This explains the apparently paradoxical result I obtained that the determinations of the amount of radium produced were far too *low*, owing to the extraneous radium of the laboratory.

The research is being continued with the view of eliminating what appears a probable explanation of the too low rate of production. It may be that under the conditions of the experiment the greater part of the emanation is retained by the uranium solution and not evolved as gas. New methods are being tried, and it is hoped that they will give a positive answer to this question.

FREDERICK SODDY.

The University, Glasgow, January 20.

A New Radio-active Product from Actinium.

AT the suggestion of Prof. Rutherford, I have made an examination to see if there is any product in actinium corresponding to the product UrX in uranium or ThX in thorium. The investigations were made with a preparation of the emanating substance of Giesel (of activity 300 times that of uranium), which has been shown to be identical in radio-active properties with the actinium of Debierne.

Taking into consideration the similarity of actinium and thorium, both as regards their chemical and radio-active properties, I resolved to try if the method used by Rutherford and Soddy for the separation of ThX would not serve also to separate an analogous product from actinium. The experiments were at once successful. If ammonia was added to a solution of actinium in hydrochloric acid, the actinium was precipitated, while a small amount of a very active substance was left behind in the filtrate. This substance, which is so similar in properties to ThX, will be called actinium X (AcX).

The product AcX, immediately after its separation, weight for weight, was more than a hundred times more active than the original actinium. The activity increased in the first day after removal to about 15 per cent. of its original value, and then decayed with the time according to an exponential law, falling to half value in about ten days. The actinium from which the AcX had been removed, almost inactive immediately after separation, gradually recovered its lost activity. As in the case of thorium, the curve of recovery of the activity was complementary to the curve of decay of AcX.

The behaviour of the product AcX is thus completely analogous in all respects to that of ThX, only the constant of change has a different value, which is characteristic for AcX.

Special experiments, made for the purpose, showed that the emanation was produced from AcX, and not directly from the actinium. The latter, immediately after separation of AcX, gave off very little emanation, while AcX produces the emanation in large amount. The amount of emanation from AcX diminished with the time at the same rate that AcX loses its activity. At the same time the actinium gradually increased in emanating power, due to the production of fresh AcX, and finally reached an equilibrium value.

The product AcX gives out both α and β and probably γ rays. It is, however, difficult to determine whether the β rays arise directly from AcX or from the excited activity to which the emanation gives rise.

There is an interesting point of distinction between the radio-activity of thorium and actinium. After the separation of AcX, the actinium is almost completely inactive, only 4 per cent. of the maximum activity being observed. It is probable that this amount could be still further reduced by successive precipitations. Thorium and radium, on the other hand, always show a non-separable activity of about 25 per cent. of the maximum. This points to the fact that the activity from ordinary actinium is due entirely to AcX and its successive products, and that little,