

## Letters to the Editor.

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## On the Missing Element of Atomic Number 72.

SINCE Moseley's discovery of the fundamental laws of the X-ray emission, it has become quite clear that the most simple and conclusive characteristic of a chemical element is given by its X-ray spectrum. In addition, Moseley's laws allow us to calculate very accurately the wave-lengths of the X-ray spectral lines for any element in the periodic table, if those of the elements in its neighbourhood are known. Taking into account that the presence of a very small proportion of a definite element in any chemical substance suffices to give a good X-ray spectrum of this element, it is quite evident that for the eventual discovery of any unknown element X-ray spectroscopy, especially as it has been developed by Siegbahn, represents the most effective method.

In the *Comptes rendus* of the Paris Academy of Sciences for May 22, 1922, Dauvillier announced the detection by means of X-ray spectroscopy of the element 72 in a mixture of rare-earth metals. This element was identified by Urbain with a rare-earth element, which he called celtium, the presence of which he had previously suspected in the same sample. For different reasons, however, we think that Dauvillier's and Urbain's conclusions are not justified. It appears from Dauvillier's paper that at any rate the quantity of the element 72 in the sample, if present, must have been so small that it seems very improbable that the element 72 should be identical with the element which in former papers Urbain claims to have detected in the same sample by investigation of the optical spectrum and of the magnetic properties. The only lines which Dauvillier claims to have detected are the lines  $L\alpha_1$  and  $L\beta_2$ , both of which he finds to be extremely faint (*extrêmement faible*). The wave-lengths he gives, however, for these lines are about 4 X.u. (1 X.u. =  $10^{-11}$  cm.) smaller than those which are obtained by a rational interpolation in the wave-lengths tables of Hjalmar and Coster, for the elements in the neighbourhood of 72.

From a theoretical point of view it appears very doubtful that the element 72 should be a rare-earth. It was announced in 1895 by Julius Thomsen from Copenhagen that from general consideration of the laws of the periodic system we must expect between tantalum, which in many compounds possesses 5 valencies, and the trivalent rare-earths, a tetravalent element homologous to zirconium. The same view has also recently been put forward by Bury on the basis of chemical considerations, and by Bohr on the basis of his theory of atomic structure. It is one of the most striking results of the latter theory, that a rational interpretation of the appearance of the rare-earth metals in the periodic system could be given. For these elements, according to Bohr, we witness the gradual development of the group of 4-quantum electrons from a group containing 18 electrons into a group of 32 electrons, the numbers of electrons in the groups of 5- and 6-quantum electrons remaining unchanged. Bohr was able to conclude that in the element lutecium (71) the group of 4-quantum electrons is complete, and we consequently must expect that in the neutral atom of the next element (72) the number

of electrons moving in 5- and 6-quantum orbits must exceed that in the rare-earths by one. The element 72 can therefore not be a rare-earth but must be an homologue of zirconium.

In view of the great theoretical importance of the question we have tried to settle it by an experimental investigation of the X-ray spectrum of extractions of zirconium minerals. We have succeeded in detecting six lines which must be ascribed to the element 72 (in Siegbahn's notation  $L\alpha_1$ ,  $\alpha_2$ ,  $\beta_1$ ,  $\beta_2$ ,  $\beta_3$ , and  $\gamma_1$ ). The complication was met that the lines  $L\alpha_1$  and  $\alpha_2$  lie almost exactly in the place corresponding in the spectrum to the zirconium  $K\alpha_1$ , and  $\alpha_2$ , lines in the second order. Difficulties which might arise from this fact may easily be avoided by keeping the tension on the tube between the critical tension of the zirconium K-lines (18,000 volts) and that of the L-lines of the missing element (10,000 volts). Besides, the relative intensity of the  $K\alpha$  lines is so different from that of the two  $L\alpha$  lines that any ambiguity is already thereby excluded. Not only the  $L\alpha$  lines but also the lines  $L\beta_1$ ,  $\beta_2$ , and  $\beta_3$  were, as regards their mutual distance and their relative intensity, in exact agreement with the expectation. The values which we obtained for the wave-lengths of the six mentioned lines all agree within one X.u. with those found by interpolation. Between our values for the lines  $L\alpha_1$  and  $L\beta_2$ , and those published by Dauvillier, however, there exists the discrepancy referred to of about 4 X.u. (in general for other elements which have been measured by Dauvillier and by Coster the discrepancy is never more than 2 X.u.). Exposures under different conditions as well as a thorough discussion of the plates showed that the new lines found during our investigation cannot be ascribed to the first or higher order spectrum of any other known element. Our provisional results are:  $L\alpha_1 = 1565.5$ ;  $\alpha_2 = 1576$ ;  $\beta_1 = 1371.4$ ;  $\beta_2 = 1323.7$ ;  $\beta_3 = 1350.2$ ;  $\gamma_1 = 1177$  X.u. More accurate and complete data as well as photographs of the spectrum will soon be published.

In a Norwegian zirconium mineral the new lines were so intense that we estimate the quantity of the element 72 present in it to be at least equal to one per cent. Besides we investigated with low tension on the tube a sample of "pure zirconiumoxyde." Also with this specimen the  $L\alpha$  lines were found, but very faint. It seems to be very probable that ordinary zirconium contains at least from 0.01 to 0.1 per cent. of the new element. Especially the latter circumstance proves that the element 72 is chemically homologous to zirconium. Experiments are in progress to isolate the new element and to determine its chemical properties.

For the new element we propose the name Hafnium (Hafniae = Copenhagen).

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Copenhagen, January 2.

## Continental Flotation and Drift.

THE theory that the continents have shifted their positions during geological time and, possibly, are still in motion has lately excited much discussion. The principal obstacle to its acceptance is the difficulty of adducing a force adequate to bring about the movements. Many years ago Osmond Fisher ("Physics of the Earth's Crust" p. 339) ascribed general continental movements of this kind (accounting for the Atlantic rift, etc.) to the disturbance of the Pacific basin due to the genesis of the moon, on Darwin's well-known theory. Lately, Wegener has brought forward much evidence in favour of continental movements. But I do not think he has