Letters to the Editor.

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On the New Element Hafnium.

THROUGH the courtesy of the editor of NATURE we have been able to see an advance proof of the letter of MM. Urbain and Dauvillier (NATURE, February 17, p. 218), and are glad to have the opportunity to add the following comment:

Our main reasons for believing that the element celtium, the detection of which was announced by Urbain in 1911, is altogether different from the element detected by us and named hafnium, are:

1. Celtium and hafnium show very great differences in their chemical properties. While we have found no difficulty in purifying hafnium preparations from contents of rare earths, the separation of celtium from the rare earths was found by Urbain to be so difficult, that although the detection was announced in 1911, only samples of small concentration have been obtained up to the present time.

2. It has not been possible by means of highly concentrated hafnium preparations to reproduce the characteristic optical spectrum ascribed by Urbain to celtium, and which, together with an investigation of the magnetic properties of his preparation, was the basis of the announcement of the discovery of this element. The result of a closer investigation of the optical spectrum of hafnium will soon be published.

3. The X-ray spectrum of a preparation containing a percentage of an element high enough to measure magnetic properties should show the characteristic X-ray lines of this element in great intensity, altogether different from the exceedingly faint lines found by Dauvillier. Quite apart from the possibility of accounting for these lines as due to a higher order spectrum of other elements, it seems to be very unlikely that these lines should be due to a contamination of Urbain's preparation by a trace of hafnium. Not only as stated in our first letter (NATURE, January 20, p. 79) they do not coincide within the limit of experimental error with our measurements of the wave-lengths of the hafnium X-ray lines L_{α_1} and L_{β_2}, but also the reason given by Dauvillier for not detecting the line L_{β_1}, which is stronger than L_{β_2}, can scarcely be maintained. In fact, our measurements for this line give a value which differs about 3 X-units from the Lu-line denoted by Dauvillier as L_{β_2}', and with the dispersion used it should be easily separated from the latter line.

As stated in our letter in NATURE of February 10, p. 182, hafnium appears in large abundance in zirconium minerals, and we estimate the hafnium content of the earth's crust to be more than one part in 100,000. In the meantime we had the highly interesting information from Prof. V. Goldschmidt in Christiania, that in an investigation of zirconium minerals, in collaboration with Dr. Thomassen, he has discovered a mineral in which hafnium is a main metallic constituent. This has been verified by an X-ray investigation in this Institute of a sample kindly sent to us by Prof. Goldschmidt. On the other hand, an investigation of certain preparations extracted from a titanium mineral from New Zealand and kindly sent to us by Dr. Scott did not reveal any hafnium line. Taking the sensitiveness of the method into account, this mineral cannot contain appreciable amounts of hafnium.

The question discussed by MM. Urbain and Dauvillier which elements are to be ascribed in the family of rare earths, has hitherto been a matter of pure definition. The recent development of the theory of atomic structure, however, has given the question involved an entirely new aspect. The appearance of a group of elements in the 6th period in the periodic table exhibiting very similar chemical properties but quite different magnetic ones could be explained by Bohr on the basis of the fundamental principles of the quantum theory (for particulars cf. Bohr's Nobel lecture, shortly to appear in NATURE). For this atomic theory the properties of the elements in the 6th period of the periodic table have therefore become of great importance. The stimulus to our present investigations was provided by the great difficulty of reconciling this theory with the results announced six months ago by Dauvillier and Urbain. In fact, the existence of an element with atomic number 72 and the chemical properties ascribed to celtium cannot be reconciled with the theory. Our confidence in the theory, however, has been amply justified. For by following up the theoretical deductions we have been led to detect a new element, which is the proper analogue of zirconium and with atomic number 72, present in considerable abundance in the earth's crust. This confirmation of the theory was the deciding factor in our choice of the name hafnium for the new element.

D. COSTER.
G. HEVESY.

Copenhagen, February 9.

Hafnium and Titanium.

THE black iron sand from New Zealand examined by Dr. Scott in 1915 in which, as he informed the Chemical Society at its meeting on February 1, he found a substance which he is now inclined to regard as probably identical with an oxide of the new element recently discovered by Dr. Coster and Prof. Hevesy of Copenhagen, and named by them hafnium, was doubtless similar in character to the deposit observed to occur in the bed of a rivulet at Tregonwell Mill, near Menaccan, in the parish of St. Keverne, Cornwall, and also in a stream at Lenarth, in the same parish, and in which the Rev. William Gregor, the minister of that parish, who analysed the deposit in 1789, first detected the existence of the element now known as titanium.

The Cornish mineral, a titaniferous iron sand of variable composition, was known mineralogically as menaccanite, and the new element was consequently termed menachin. Similar deposits occur in other parts of the world, and, in fact, are widely distributed. Their characteristic constituents are known variously as ilmenite, iserine, thuenite, hystatite, washingtonite, crichtonite, etc.; the results of analyses of them by Mosander, Marignac and Kobell are to be found in Greg and Lettsom's "Mineralogy," and a list of localities in which they occur is given by Dana. Their composition is very variable, the amount of titanic acid, for example, ranging from 22·2 per cent. to 46·9 per cent. They are all essentially iron titanates, associated with variable amounts of oxides of iron, and, occasionally, of manganese and other substances.

The name titanium was given to the element by Klaproth as the result of his detection of it in rutile and ilmenite, and in ignorance, apparently, of Gregor's prior discovery, although this was announced in Crell's *Annalen* of 1791. Klaproth's experiments were confirmed by Vauquelin and Hecht in 1796. Klaproth subsequently examined menaccanite, and found that menachin and titanium were identical.

The atomic weight of titanium was made the subject of investigation by Rose in 1823, and again in 1829; by Mosander in 1830; by Dumas in the same year; by Pierre in 1847, and by Demoly in 1849. The methods employed were not identical, but they usually