change of products between cytoplasm and nucleus, or respiratory activity.

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A NEW TYPE OF ELECTRON SPECTROGRAPH

THE slit system of the instrument is essentially a Hull magnetron with a very narrow slit in the anode. This slit is parallel to the oxide coated filament which is mounted on the axis of the cylindrical anode and the whole is placed in a uniform magnetic field parallel to the filament. Before the electrons reach the anode they are acted on by both the radial electric field and the magnetic field as in the magnetron, but those which pass through the slit travel in circular paths under the action of the magnetic field alone. The condition for the focussing of the electrons is that they shall traverse a semi-circumference after passing the narrowest aperture in their path, and an analytical consideration of the angles of emergence from the slit shows that in a plane perpendicular to the filament, this condition is satisfied on the line through the filament perpendicular to that joining it and the slit. This focussing is very sharp, even for electrons accelerated by less than 30 volts if small electron currents are used, and it has been suggested that this may furnish an extremely accurate direct method of determining e/m.

With this apparatus, preliminary unpublished work, indicating that commercial photographic emulsions are very insensitive to electrons accelerated by about 30 volts or less, has been confirmed. It has been found, however, that when the emulsion is covered with a very thin film of fluorescent lubricating oil, it is sensitive to electrons of much lower velocities and its sensitivity to those of higher velocities is increased by 40 or 50 times.

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SPECIAL ARTICLES

ILLINIUM

AN important result of the development of Moseley's atomic number rule has been the impetus it gave to the search for missing elements. It is true that later arrangements of the Periodic Table indicated that eka-caesium, eka- and dwi-manganese, and eka-iodine were missing, but there were no theoretical grounds for supposing that eka-neodymium might exist, until Moseley's rule showed that element number 61 was still to be identified. Moseley's work was of inestimable value to one engaged in completing the list of chemical elements for several reasons: first, it gave definite information as to the existence and location of gaps in the Periodic Table; second, it gave a basis for the calculation, prior to its discovery, of the X-ray spectrum of an element and indicated a technique by which lines in that spectrum might be identified; and finally, it gave origin to a method of examination so searching that a mixture of two elements, so closely similar in chemical properties as to be almost inseparable, could be definitely analyzed. Were it not for the work of Coster and Hevesy on the X-ray examination of zirconiferous minerals, the presence in them of element number 72 would probably be still unsuspected and hafnium, or celtium, would still be listed among the rare earths. Chemical tests made on zirconium ores had frequently indicated the non-homogeneity of zirconium, but they could not give the definite proof afforded by an X-ray analysis.

The proof that a rare earth element was missing, whose atomic number would place it between neodymium and samarium, explained the sharp break in the sequence of properties that comes in the rare earth group between those two elements. The differences in solubilities of the double salts formed by rare earth nitrates with magnesium nitrate, appear to be quite uniform, excepting in the case of neodymium and samarium, since fractional recrystallization of that double salt will accomplish a strikingly sharp separation of those two elements. There is the same break in the sequence of solubilities of other salts, in basicity, as indicated by the rate of hydrolysis, etc. It also appears that the absorption spectra show the same general variation, and, as will be shown later, the absorption bands of number 61 seem to fit into the regular sequence.

Because element number 61 might be expected to share the striking similarity in properties and the common occurrence in minerals of the other members in the rare earth group, it seemed logical to institute a search for it in monazite sands, a mineral in which the first members of that family, the so-called cerium earths, predominate. Since that mineral is rich in neodymium, 60, and in samarium, 62, it would be surprising to learn of the absence of 61 there and its presence in a mineral containing little or none of 60 and 62.

The original material used in the investigation was the rare earth residue remaining from monazite sands after the extraction of thorium and part of the cerium for use in the manufacture of Welsbach mantles. It was donated to the laboratory by the Lindsay Light Company, of Chicago. After the remaining cerium was removed by the usual methods, the other rare earths were fractionally recrystallized as double magnesium nitrates. Very pure neodymium and samarium, the latter subjected to further purification by other methods, were sent to the Bureau of Standards at Washington for use in an extensive investigation being pursued on the infra-red arc spectra of the rare earths. It was found that a number of identical new lines were present in both samples and the suggestion was made that they might be due to the presence of a small amount of a new element. Eder had noted the same phenomenon. Later, when the ultra-violet arc spectra of neodymium, samarium, and of intermediate fractions containing both, were examined, lines common to all three were found. However, X-ray analysis of those same samples showed no indication of the presence of an element with atomic number 61. Prandtl and Grimm had subjected rare earth material to separation by the same method and then to a fractional precipitation with ammonia, and could find no evidence of the missing element by X-ray analysis.

It seemed that the solubility of the double magnesium salt of 61 is very similar to that of neodymium and its separation by recrystallization of that salt offered little hope of success. The order of solubility of the bromates of the cerium group earths is the reverse of the order obtaining with the double magnesium nitrates and that suggested a means of separating neodymium and thus concentrating 61. It is easier to separate a small amount of one element from a larger amount of a second, if the former is in the less soluble end of the series of recrystallizations. Accordingly the neodymium rich material thought to contain 61 was converted to bromate and again recrystallized.

A marked change in the absorption spectra of the solutions that began to appear after repeated recrystallization indicated the probable concentration of the missing element. Two bands, one at 5816A° and one at 5123A°, that had shown very faintly in supposedly pure neodymium, became stronger in some fractions as the other neodymium bands disappeared. Because these two bands, if assigned to number 61, find their places in a more or less regular sequence shown by bands of neighboring elements it was thought they might belong to that element.

X-ray analysis confirmed the theory and showed the presence of number 61 in those fractions. A mean value of five determinations of 2.2781A° was found for the $L\alpha_1$ line and one determination of 2.0770A° for the $L\beta_1$ line. A faint indication of the $L\beta_3$ line was also noted. It is assumed that these results prove the presence of element number 61.

The name assigned to the element is Illinium (Il).

There are several reasons that may be advanced to explain why the element escaped detection by means other than X-ray analysis. It must be extremely rare. Its solubility in a series of fractional recrystallization is next to that of the very abundant neodymium, which tends to spread into the illinium-rich members of a series. The large number of absorption bands exhibited by both neodymium and samarium would tend to mask its absorption spectrum. Finally the solubility of its double magnesium nitrate, which salt is commonly used for the separation of closely related elements, is close to that of neodymium. Evidence supporting this latter is found in the fact that the absorption bands at 5816A° and 5123A° found in supposedly pure neodymium purified by that method, are shown to belong to illinium.

The identification of illinium as the missing rare earth completes the list of rare earth elements. Work has been instituted involving the extraction of several hundred pounds of the crude material with the purpose in view of obtaining enough of the element in pure enough state to study its properties, its relationship to other members of the group and its atomic weight.

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THE EFFECT OF AN ELECTRIC FIELD APPLIED TO A PHOTOGRAPHIC PLATE DURING EXPOSURE[1]

Before the development of the modern silver bromide plate there were many attempts to increase the sensitivity of photographic processes by the application of an electric field or an electric current to the sensitive material during exposure.[2] In some of these attempts slight changes of sensitivity were detected, and in others no effect was observed. Because of astronomical and spectroscopic applications, it is important to know whether a really significant change of sensitivity can be obtained.

We have performed some experiments on the effect of an electric field applied perpendicular to the surface of the plate under conditions which, so far as we can learn, have not been utilized in previous investigations.

There are at least two ways in which we may hope to produce such a change in plate sensitivity. The first is based upon the fact that when light of sufficiently great frequency falls on silver halide crystals it increases their conductivity,[3] and on the fact that

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[1] Published by permission of the director of the Bureau of Standards.

[2] Eder, Handbuch der Photographie, Vol. 1, Part 2, p. 421, (3rd edition), gives references to all the earlier work.

[3] Arrhenius, Sitz. Ber. d. Wiener Akad., II Abteilung, 96, p. 831, 1887. Eder's Jahrb. 9, p. 201, 1895.