CHEMISTRY

Predicting Undiscovered Elements

Part One

"A Classic of Science"

Ekaboron and Ekaluminium are Scandium and Gallium; Mendelyev Lived to See His Predictions Verified

THE NATURAL SYSTEM OF ELEMENTS AND ITS USE FOR THE PREDICTION OF PROPERTIES OF THE UNDISCOVERED ELEMENTS. By D. Mendelyev, in Journal of the Russian Chemical Society, Vol. 3. St. Petersburg, 1871. Translated for the Science News Letter by Taisia Stadnichenko.

THE differences in value of the atomic weights of neighboring elements represent a gradual change in which we can follow their periodicity. This gives us the possibility of theoretical correction of the atomic weights of those elements which were determined with insufficient accuracy at first. This and some other conclusions based on the proposed system of elements forms the subject of my former contribution. I now want to clarify further some of the conclusions in regard to the properties, chemical as well as physical, of those elements which are lacking in the system and have not yet been discovered, but whose discovery is very probable. I think that heretofore there has been no possibility of foreseeing the absence of this or that element because we had no rigid system of elements and even more we had no reason to predict the properties of such elements. With the indications of the periodic and "atomological" relationships between the atomic weight and the properties of all the elements it becomes possible not only to show the absence of some of them but also to determine with greater certainty and positiveness the properties of the at present unknown elements. We can now state their atomic weights, their density in the free state or in the form of oxides, their acidity or alkalinity, their degree of oxidation, their capacities for reduction and the formation of double salts, indicating the properties of the metallo-organic compounds and chlorides of the given elements, and we are even able to describe in considerable detail the properties of some of the compounds of these unknown elements. I have the courage to do this because, at some time in the future, when one of the bodies predicted by me is discovered, I shall have the chance finally to assure myself and to make other chemists believe in the correctness of those propositions which lie at the root of the system proposed by me. Personally I have been thoroughly convinced of the theory since the suppositions for Indium, based on the periodic relationship that underlies all of this research, have been confirmed. . . .

Third Group Elements Lacking

In the list of ordinary elements, the absence of a large number of analogues of boron and aluminium is most striking, that is, elements that belong to the third group. The lack of an element from this group that ought to follow aluminium and ought to be found in the second series, following potassium and calcium, is quite evident. Since the atomic weight of the latter is close to 40, and since in this series we have an element of the fourth group, Titanium, Ti = 50, then the absent element must have an atomic weight of about 45. Due to the fact that this element belongs to the even series, it must show more basic properties than the lower elements of the third group, *i. e.*, boron and aluminium. Its oxide R_2O_3 must be more strongly basic. This can be proven by the fact that the oxide of titanium, TiO_2 has the properties of a very weak acid and also possesses many properties that are distinctly basic. However, the basic properties of this metal must be quite weak, because the basic properties of titanium are so weak; in comparison with aluminium oxide, this oxide will have a more basic character and therefore it will not form with alkalies a stable compound which is not decomposable with water, but with acids it will form stable salts. At any rate, it will not be soluble in ammonium, but it is possible that its hydroxide will be slightly soluble in potassium hydroxide, although this is uncertain at present, due to the fact that this element belongs to the second series and to the group of elements whose oxides contain a small amount of oxygen.

I propose to call this element ekaboron, deriving the name from the fact that it follows boron as the first element of the even group, and a prefix eka- from sanskrit meaning "one." Eb = 45. Ekaboron in the free state would be a metal with atomic volume of about 15, because in this series of elements as in all even series the atomic volume diminishes rapidly in transition from the first group to the following one. Thus the volume of potassium is close to 50, of calcium to 25, of titanium and vanadium to 9, of chromium, molybdenum and iron to 7. The specific weight of this metal must be close to 3 because its atomic weight is 45. This metal will not be volatile, because all the metals of the even series in all groups (except I) are not volatile. Therefore it is not likely that it will be discovered by the ordinary method of spectral analysis. It will not decompose water at ordinary temperatures, but will decompose it at a slightly elevated temperature, similarly to other metals in this region, and a basic oxide will be formed as a result. It will dissolve, of course, in acids, and the chloride $EbCl_3$ (maybe Eb_2Cl_6) will be volatile, but salt-like, because it corresponds to the basic oxide. Water will affect it in the way it affects chlorine compounds of calcium and magnesium, *i. e.*, ekabor chloride will form hygroscopic substances which will give HCl with water, but will have no chloranhydride character. Since the

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Ekasilicon

was the third element whose properties were predicted in detail by

MENDELYEV

It will complete this CLASSIC OF SCIENCE Next Week

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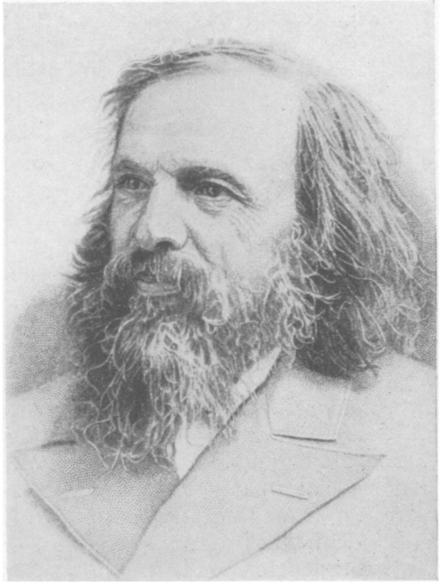
volume of $CaCl_2$ is 49, and $TiCl_4$ is 109, the volume of Ekabor chloride must be near 78, and consequently its specific weight will be close to 2.

The oxides of Ekaboron, Eb_2O_3, must be non-volatile, and possibly non-fusible, and insoluble in water, because even the oxide of calcium is only slightly soluble in water, but it will be soluble in acids. The specific volume of the oxide of Ekaboron must be close to 39, because in this series K_2O has a volume of 35, CaO of 18, TiO of 29 and CrO_3 of 36. That is, with a content of one atom of oxygen the volumes at first rapidly decrease and then slightly increase, as can be seen from the following: volume of $K = 35$, $Ca = 18$, $Ti = 10$, $Cr = 12$, therefore the volume for the oxide of Eb with a content for one equivalent of oxygen ought to be about 13. Consequently the formula Eb_2O_3 must correspond to a volume of about 39, and therefore the oxide of Eb in the dehydrated state will have a specific gravity of approximately 3.5. Being a rather active base, this oxide must show a slight tendency to the formation of alum, although it is possible that it will form alum-like compounds, that is, double salts with potassium sulphate. Ekaboron, of course, will not form metallo-organic compounds. From analogy with the elements of the even series, judging from the data at hand on the elements accompanying cerium, not one of them could fill the place of Ekaboron. Therefore this metal almost certainly does not belong to the number of satellites of cerium known at present.

Ekaluminium

This cannot be said of the remaining elements of the third group in the even series, because their equivalents nearly approach those which should be possessed by the following unknown members of this group. In this group the element in the third series following zinc is lacking. Its atomic weight must be close to 68. We will call this element Ekaluminium, $El = 68$, because it follows directly after aluminium in the third group. In distinction from Eb, it must possess the ability to form metallo-organic compounds, and because of its position between aluminium and indium it must have properties close to those two elements. Consequently it will form alums. Its hydroxide will be soluble in a water solution of potassium hydroxide. Its salts will be more stable than the salts of aluminium, thus Ekaluminium chloride will be more stable than aluminium chloride. Its atomic volume, based on consideration of the same characters as were applied in determination of the properties of Ekaboron, must be close to 11.5, hence the specific weight in the metallic state will be near 6.0. The properties of this metal in all respects must represent the transition from the properties of aluminium to the properties of indium. It is very likely that the metal will possess greater volatility than aluminium and therefore we may hope that it will be discovered by spectro-investigation in the way indium and thallium following it have been discovered, although it will be less volatile than either of them and therefore we must not expect such striking spectral phenomena as led to the discovery of the latter. Most probably this element also does not belong to the number of cerium's satellites, although its equivalent approaches the equivalent of Yttrium. But it has not the form of oxide typical of Yttrium with the molecular formula RO, nor do the distinct basic properties of its oxide permit us to consider Yttrium as belonging to this place in the system of elements; instead the next place, in the third series, position III-4, belongs to Yttrium. . . .



DMITRI MENDELYEV
(or Mendeleef), the Russian chemist who discovered the Periodic Law governing relationships between the chemical elements.

Science News Letter, October 31, 1931

MEDICINE

Machine Outdoes Physician In Detecting Artery Hardening

A SPECIAL machine which can determine the presence of hardening of the arteries when a physician cannot determine it by ordinary tests was demonstrated for the first time at the Graduate Fortnight of the New York Academy of Medicine.

This and other new instruments for diagnosing heart disease are included in the exhibit which is a special feature of this year's Graduate Fortnight. More than 2,500 physicians from all over the United States and from Canada and England are attending the Fortnight to learn the latest developments in the diagnosis and treatment of heart disease and disorders of the circulation.

The exhibit covers almost every known fact pertaining to the circulatory system, according to the director, Dr. Louis Gross, pathologist of Mount Sinai Hospital.

Another machine on exhibit automatically registers the heart beats of a patient undergoing an operation. This enables the physician or his assistant to tell just what condition the patient's heart is in without stopping to take the pulse or listen to the heart with a stethoscope.

Dr. Maude E. S. Abbott of McGill University and Dr. John L. Bremer of Harvard Medical School have arranged a special exhibit of hearts which traces the growth of the organ in the embryo. In addition, Dr. Abbott has an exhibit which displays all the known forms of congenital heart disease. In this display are hearts of persons who lived despite the fact that they had holes where heart muscle should be and despite the fact that they lacked an entire heart valve or the aorta, main blood vessel from which all the arteries rise.

Motion pictures showing the heart valves in action and showing studies under the microscope of the first heart beat of the embryo are other interesting features of the exhibit.

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