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Nobel Prize in Chemistry 1921

Frederick Soddy

The Nobel Prize in Chemistry 1921 was awarded to Frederick Soddy *"for his contributions to our knowledge of the chemistry of radioactive substances, and his investigations into the origin and nature of isotopes"*.

RESEARCH INFORMATION:

One of the most fruitful ideas in the chemical research of the last century was put forward in 1869, when the Russian scientist Dmitri Ivanovitch Mendeleev drew up the Periodical System named after him, which is now well known to every chemist.

This classification revealed in a convincing manner that the various physical and chemical qualities in the fundamental elements of nature are to be conceived as functions of the atomic weights of those elements, that is to say, the relative weights of their units of mass. At the same time it made clear the relationship between the then known elements, about seventy in number, by grouping them into a limited number of natural families, which in the tabular scheme stand out graphically as a corresponding number of vertical rows with a regular increase in atomic weights in each column.

In this system each element has its given place: and each place has a given element corresponding to it. At the time when the system was drawn up, most of the places were already occupied: oxygen had its place, just like carbon, phosphorus, gold, etc. each had their own place. But there were also a number of empty places to which as yet there was nothing known to correspond; and the system celebrated its greatest triumphs perhaps when one after another of these empty places was gradually filled by the discovery of hitherto unknown elements, the existence of which could be foreseen and the qualities of which could be calculated beforehand with satisfactory exactitude thanks to the Periodical System. This took place when, in the course of the seventies and the eighties, scandium was discovered by a Swede, germanium by a German, and gallium by a Frenchman.

Even when, late in the eighteen-nineties, Sir William Ramsay discovered a whole group of new elements, known as the inactive constituents of the atmosphere - a discovery which in due time earned him a Nobel Prize in Chemistry - all these newcomers could without any great difficulty be fitted into the Mendeleev Table, although, it is true, a new column had to be created on their account - the zero vertical column.

But no long time elapsed before difficulties began to appear.
For a long time it had been felt as an imperfection that the Periodical System, though it gave expression to en unmistakable regularity in the matter of the mutual relations of the magnitude of the atomic weights, was unable to give the key to the interpretation of this law. As it were behind a semitransparent veil, men believed that they could catch a glimpse of a genetic connection between all the various fundamental forms in which matter reveals itself to our observation; but every attempt to raise a corner of this Veil of Isis long appeared to be fruitless.

This chronic symptom of weakness was soon joined by another of a more acute kind. The principal cause of this was Madame Curie's brilliant discovery of radium - which also became in due time the subject of a Nobel Prize in Chemistry. Certainly it was easy enough to fit radium itself into the system; but things became worse when the continued study of radioactive phenomena led ere long to the knowledge of whole swarms - we now call them pleiads - of elements previously unknown, to say nothing of the fact that many of these elements, in consequence of their instability could not be isolated, and probably will

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never be able to be isolated in a form discernible by our external senses. The fact is that the span of their existence varies from milliards of years down to elusive fractions of a second. But their existence was in any case indisputable, and their rapid growth in number threatened to explode irremediably the whole of the Periodical System.

At that moment - just when the danger seemed to be greatest that the well-ordered regularity should be succeeded by an unintelligible chaos there appeared an eminent English scientist with the redeeming word isotopy.

This scientist was no stranger in the world of science. Many years before he had in a brilliant manner won his spurs by showing how helium comes from radium - the first clear experimental proof of the generation of one known element from another. And he was not one of those who idly rest upon their laurels. By a happy combination of experimental and speculative methods of investigation he was soon to attain still more important results.

What now occurred reminds one in certain respects of a previous episode in the history of chemistry. A hundred years ago it passed as an article of faith that in chemical compounds similarity in composition must also involve similarity in properties. Our countryman Berzelius upset this doctrine by his discovery of isomerism, in that he showed that two or more compounds may be completely identical in their composition, but may nevertheless diverge more or less in their chemical and physical relations.

In a similar way the people of our own day had laid it down as a kind of corollary, that the same place in the System must involve the same atomic weight and the same general properties, or, in other words, that every square in the Table could only contain one single element. The English scientist in question now showed that two or more elements might quite well be identical in a chemical respect and occupy the same place in the System - or, as he called it, be "isotopes" - but nevertheless be unlike one another as regards both atomic weight and certain physical properties. Taking his stand on the discovery of the material nature of the alpha-rays by the Nobel Prizeman Rutherford, he further laid down, by way of explanation of the mutual genetic connection between the elements, the proposition that every loss of an alpha-particle involves a shifting of the element in question two vertical columns to the left from its original place in the System: a proposition which was later supplemented by someone else to the effect that each loss of a beta-particle involves a shifting of one vertical column to the right. This law of shifting can be explained by Rutherford's well-known nucleus theory. According to this theory, if the positive charge of the nucleus is identical with the atomic number of the element in the System, the loss of an alpha-particle - that is to say, an atom of helium carrying two positive charges - must diminish the charge of the nucleus by 2, and consequently lower the atomic number by the same number of units; while on the other hand, the loss of a beta-particle, that is to say a negative electron, must increase the positive charge of the nucleus by 1 and thus raise the atomic number by one unit.

Now if an atom of a radioactive element simultaneously loses one alpha-particle and two beta-particles, its nuclear charge, and consequently its number in the System, clearly undergoes no change; and though the atomic weight is reduced by 4 units, by the loss of one atom of helium, the new element can neither chemically, not yet spectroscopically, be distinguished from the old one: they are isotopes. Conversely, two elements may have the same atomic weight, but different nuclear charges, from which follows a different place in the System and different chemical properties. Such elements are called "isobares", and they arise, one from the other, solely by beta-ray changes, whereby the mass is practically unaltered.

With regard to the theory of isotopes one can say with Hamlet: "This was sometime a paradox, but now the time gives it proof." On its first appearance the proposition undeniably took one by surprise owing to its boldness; but since then it has gained more and more firm support through numerous experiments, in which its author himself has played a leading part. Here there is no possibility of giving even the meagrest account of these investigations, which extend over a decade and a half. Let it suffice to call to mind how it proved possible to produce from certain thorium minerals lead with precisely the same chemical properties as ordinary lead, but with considerably higher atomic weight - that is to say, an isotope to lead.

The theory of isotopes, in fact, has proved to be extremely fruitful and has during the last two or three years led to results which place its importance in a yet clearer light. But more about this will be said in the following address. It now remains merely to mention the name of the foremost author of the theory. It is: Frederick Soddy.

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