Source : www.thehindu.com Date : 2019-06-16

AN ODE TO MENDELEEV AND HIS PERIODIC TABLE OF ELEMENTS

Relevant for: Pre-Specific Science | Topic: Chemistry related matters

Mankind has known materials such as gold, silver, mercury, iron, phosphorous, sulphur and others since antiquity. Alchemists tried making gold out of “base” metals — with no success. But we had to wait until the English school teacher John Dalton who in 1808 came up with his “new system of chemical philosophy”, where he proposed that chemical elements are made of atoms; any given element is made entirely of one kind of atom and that each atom has a characteristic weight; chemical reactions occur when atoms of different elements interact with one another. Dalton and Thomas Thomson from England and Berzelius from Europe defined the weight of a hydrogen atom as one, and the atomic weights of other elements were measured using this standard. By the 1860s, the atomic weights of a large number of elements were published.

The question that captured the minds of chemists at that time was: is there any pattern or logic that one can derive by looking at the similarity in the properties of certain classes of atoms (say, lithium, sodium and potassium) on one hand, and their atomic weights on the other? Johann Dobereiner of Germany in 1817 found that, if he took a triad of elements with similar properties, the atomic weight of the middle element is roughly midway between those of the other two [e.g., sodium with atomic weight 23 is midway between lithium (3) and potassium (39), or bromine (80) between chlorine (35) and iodine (127)]. And in 1865, the English chemist John Newlands stated his “law of octaves”: if elements are arranged in increasing atomic weight order, those with similar properties occur after each interval of seven elements (for example, lithium and sodium, or carbon and silicon), much as the notes in music.

It was against this background that we meet Professor Dimitri Mendeleev at St. Petersburg, Russia, in 1865. Not satisfied with existing text books, he wrote his own. In doing so, he had to organise the elements and arrange them in a logical order. Dr Tom Siegfried writes in ScienceNews on 9-1-2019 that Mendeleev wrote each of the 69 then known elements with their properties on a note card, arranged the cards in vertical columns from lower to higher atomic weights, and found that elements arranged according to the size of their atomic weights show clear periodic properties, and more importantly “the size of the atomic weight determines the nature of the elements”. He presented this discovery before the Russian Chemical Society on March 1, 1869. The periodic table was born. (Incidentally, Siegfried’s lucid essay: “How the periodic table went from a sketch to an enduring masterpiece”, mentioned above, is a free access article, highly recommended for reading).

This periodic table of Mendeleev not only confirmed the works of Dobereiner and Newlands (that every eighth element in the table resembles the first), but could go further. Given this repetition rule, he could predict that an element (he named it eka-silicon) will be discovered which will resemble silicon and have an atomic weight of 72. Sure enough it was found in 1886, and was named germanium. Likewise, his prediction of eka-aluminium too came true; gallium discovered in 1875 had all properties predicted by Mendeleev. Siegfried writes: “His [Mendeleev’s] table finished the transformation of chemical science from the medieval magical mysticism of alchemy to the realm of modern scientific rigor. The periodic table symbolizes not merely the constituents of matter, but the logical cogency and principled rationality of all science.”

While Dalton and Mendeleev believed that the atom is the ultimate indivisible particle of an element, modern physics, by the turn of the century, showed that atoms themselves are made up of a central nucleus, inside which “protons” (with a single positive charge and weighing that of

a hydrogen atom) and often also of “neutrons” (no charge but mass of a hydrogen atom) reside, and “electrons” (of negligible mass, but a single negative charge) spinning around the nucleus at various well-defined orbits of increasing radius, somewhat akin to the sun and its planets. This idea enabled chemists to arrange elements in such atomic models, and in orbits of increasing levels corresponding to the atomic number (protons in the nucleus). The electrons in the outermost orbits in an atom govern the chemical properties of the element.

Note that orbits arranged in increasing well-defined levels. This periodicity indeed concurs with Mendeleev’s periodic table arrangement and its predictions. In a sense, Mendeleev was “prescient.” This was his grand plan to arrange elements, whose 150th year we celebrate in 2019.

A poetic tribute to the Periodic Table has been written by Dr. Alok K. R. Paul, Principal Scientist at the Central Electrochemical Research Institute, Chennai Unit. This “ode to the periodic table” can be accessed at https://euroscientist.com/ode-to-the-periodic-table/. Read it and enjoy it!

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