THE PERIODIC TABLE OF ELEMENTS

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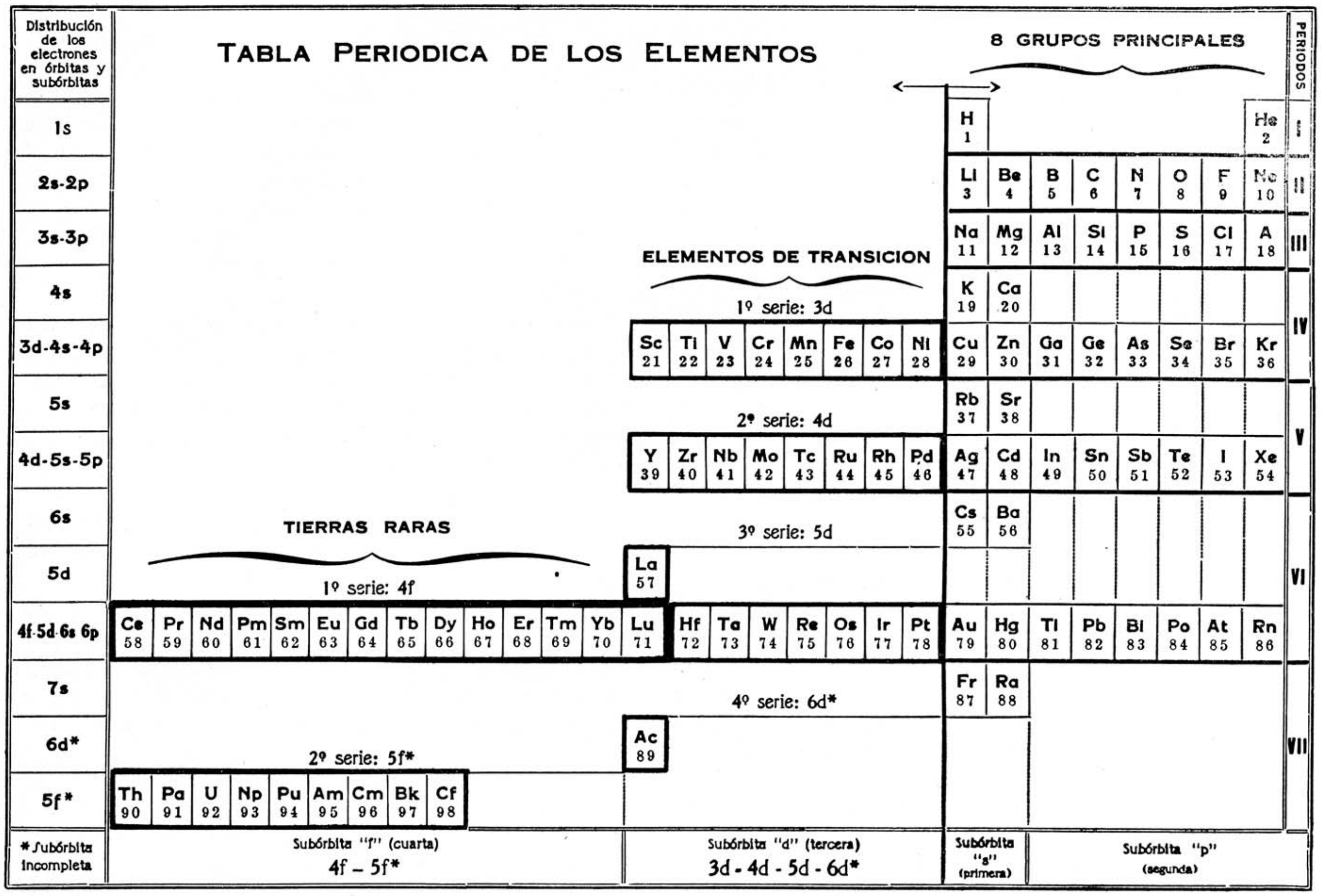

THE purpose of any periodic table is to arrange the elements according to some pattern so that elements that are similar in their properties are grouped or linked together, so as to make them easily distinguishable.

In the accompanying arrangement the elements are divided into three categories, namely: (1) *Regular Elements*, which constitute eight principal groups, (2) *Transition Elements*, which constitute three series plus a unique element of a supposedly fourth series, and (3) *Rare Earths*, divided into two series.

Regular Elements show similarities with one another along *"columns"* (vertical lines) whereas Transition Elements and particularly Rare Earths show similarities along *"rows"* (horizontal lines). This feature is taken care of by placing the Transition Elements and the Rare Earths in specific positions so that each element follows consecutively in order and yet does not intercept the principal groups nor needs to be placed in some unrelated position in the table.

The electronic configurations of the elements constitute the fundamental criterion for the accompanying arrangement. In comparing the distribution of electrons of any one element with that of the next element, a new *"differentiating"* electron is always found, on the location of which this pattern is based.

(1) As far as Regular Elements are concerned, the first column of elements, hydrogen, lithium, sodium, etc., possess one differentiating outermost electron in an *s* subshell. The elements beryllium, magnesium, etc., which constitute the second column, have two outermost electrons in an *s* subshell. (The noble gas helium with no *p* electrons, has been grouped with other noble gases.) Note that:

(*a*) Potassium and copper have *one* and calcium and zinc have *two 4s* electrons, which accounts for placing copper and zinc in the same groups as potassium and calcium, respectively. However, potassium and calcium have *no* electrons in the *3d* subshell whereas copper and zinc each has the maximum number of ten *3d* electrons.

(*b*) Similarly, rubidium and silver have *one* and strontium and cadmium have *two 5s* electrons, which also accounts for grouping rubidium and silver in the first column and strontium and cadmium in the second column. On the other hand, rubidium and strontium have no *4d* electrons at all, whereas in silver and cadmium the *4d* subshell is completely saturated with 10 electrons.

(*c*) Lastly, cesium and gold have *one* and barium and mercury have *two 6s* electrons and are correspondingly located in the first and second columns, but cesium and barium have neither *5d* nor *4f* electrons, while in gold and mercury these subshells are saturated with 10 and 14 electrons, respectively.

(2) The different Transition Series consist of elements that fill up a *d* subshell. In the first Series, elements from scandium to nickel progressively fill the *3d* subshell. With respect to the second and third Transition Series the *4d* and *5d* subshells are, respectively, filled and, finally, there is only one *6d* electron corresponding to the only element of a supposedly fourth Transition Series.

(3) The filling of the *5d* subshell is interrupted after the first electron is located in it. In fact, a second electron is not present in that subshell until the *4f* subshell has been saturated with 14 electrons. This gives rise to the first Rare Earth Series which is accordingly situated between the first and second elements of the third Transition Series. In lanthanum the differentiating electron is the only electron located in the *5d* subshell. In cerium, however, the differentiating electron is located in the *4f* subshell and, for that matter, the elements from cerium to lutetium (14 in number) progressively saturate the *4f* subshell. In hafnium the differentiating electron is again to be found in the *5d* subshell.

(4) In actinium the differentiating electron is located in the *6d* subshell, but in the nine elements that follow, thorium to californium, the differentiating electrons are to be found in the *5f* subshell, which gives rise to the second Rare Earth Series.

The predominant criterion for defining either a Regular Element, a Transition Element, or a Rare Earth is thus the particular location of the differentiating electron. In some cases uncertainty arises; copper, with *ten 3d* electrons and *one 4s* electron is considered here a Regular Element rather than a Transition Element. Divalent copper, with *nine 3d* electrons, shares some of the properties of the Transition Elements, which is not true of monovalent copper, with its *ten 3d* electrons. Also, lanthanum should not be included with the Rare Earths, since it has no *4f* electrons. The same is true of actinium with no *5f* electrons.

The four pairs of elements, potassium and calcium, rubidium and strontium, cesium and barium, and francium and radium, behave abnormally as far as the electronic structure is concerned, in that they possess electrons in external shells while some of the internal subshells are completely empty. Each pair of elements forms by itself a short two-element row in the fourth, fifth, sixth, and seventh periods.

The vertical column at the left of the table gives the order in which the different subshells are being filled up, and together with the line at the bottom of the table will permit one to obtain the electronic configuration of any element, except in the case of a few like chromium, palladium, and iridium which deviate somewhat from the general plan of electronic distribution in shells and subshells.

Other advantages of the table are:

(1) Each particular element, whether a Rare Earth or not, occupies a single place corresponding to its chemical individuality.

(2) The eight principal groups constitute a single block of eight *vertical* columns. In this case, the important historical feature of having vertical columns consist of similar elements is still maintained. Neither slanted, intercepting tie-lines nor other devices to point out similarities among elements are required.

(3) Progressive similarities of the elements in both the columns (groups) and the rows (series) can be pointed out easily.

(4) In the fourth, fifth, and sixth periods, which have more than eight elements, the fact is shown that the first two and the last eight elements of each period are the only elements whose properties are similar to those of the eight elements of the second and third periods.

Note: The table can be further clarified by adopting the familiar concept of A and B families in the case of the first two groups (columns).