methylaniline, ethylaniline, isobutyl acetate, carbon disulfide, and diphenylmethane. In the case of dimethylaniline the discrepancy in the values of t_c is 0.8 per cent., which is much too great for an experimental error, and can show that the molecular weight is only slightly abnormal, which may well be due to the fact that this liquid is very readily decomposed.

II. Of the value of t_c calculated for the above liquids, those for bromobenzene, bromine, ethylidene chloride, toluene, phosphorus trichloride, *o*-, *m*-, and *p*-xylene agree excellently with the observed values of critical temperature, while the disagreement with this value is below 1 per cent. for mesitylene, and but slightly above that for ethylbenzene and iodobenzene.

III. The agreement between the calculated values of t_c from drop weight and those from capillary rise, with the 11 liquids which have been studied by that method, is exceedingly good for toluene and phosphorus trichloride. In the other cases the mean of the t_c value from capillary rise agrees well with that for drop weight; and it is only for mesitylene and *m*-xylene that the values in mean from capillary rise disagree with those from drop weight. In the case of the latter liquid, however, this seems to mean little, as the values by two observers, although higher throughout, do not agree even fairly with one another.

IV. The values of t_c calculated by aid of the Walden relationship, without the aid of the molecular weight, in 8 cases (out of the 16 to which it could be applied) agree very well with those calculated from k_B, the variation in the others, however, indicating that probably this relationship is not as general as was at first thought.

LABORATORY OF PHYSICAL CHEMISTRY.

A MODIFICATION OF THE PERIODIC TABLE.

BY ELLIOT QUINCY ADAMS.

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This article is to set forth and discuss the theoretical basis of an arrangement of the periodic table of the elements.

The principal defect of the earlier forms of the table, those formulated by Mendeléeff, Lothar Meyer and others, was that they placed in the same "family," as entirely homologous, elements as dissimilar as sodium and silver.

The double periods, of sixteen columns, of the more recent tables are a recognition of the fact that the number of elements in the different horizontal rows, or periods, is not constant. In this way the table has been made complete up to xenon (130.2), all known elements of lower atomic weight being accounted for, and only one space in the table, that below manganese, being vacant. Of the elements following xenon, the first two, cesium and barium, are obviously homologous with rubidium and strontium, and will be placed below them, however the subsequent elements may have to be arranged, and the elements from tantalum to bismuth are completely homologous with those from columbium (niobium) to antimony.

The elements remaining fall naturally into two divisions: the rare earth metals—lanthanum, cerium, praseodymium, etc., with atomic weights intermediate between those of barium and tantalum—and the radioactive elements—uranium, radium, thorium, actinium and their decomposition products, with atomic weights greater than that of bismuth; that is to say, greater than that of any other element.

The question as to the place in the table for these elements can be answered from analogy with the preceding periods, as follows:

Most of the families—vertical columns—of the table contain only one element of each period, but in the iron family three elements enter at a time. The term "group of elements" will be used for this case.

The three elements of least atomic weight are, in order, hydrogen (1.008), helium (3.99) and lithium (6.94). The elements most resembling hydrogen in their chemical behavior are the alkali metals.

It follows that hydrogen and helium constitute the first period of the table and that the second period begins with lithium and ends with neon (20.2), the homolog of helium and the element just preceding sodium (23.00), which as the next homolog of lithium, begins the third period. In like manner the third period ends with argon (39.88), the fourth period extends from potassium (39.10) to krypton (82.92), the fifth from rubidium (85.45) to xenon (130.2), and cesium (132.81) begins the sixth.

The number of elements or "groups of elements" in the various horizontal rows, or periods, is respectively 2, 8, 8, 16 and 16 for the first five periods, and apparently more than 16 for the sixth.

These numbers it will be noticed are even and, in fact, powers of two. Further, each period contains homologs of the elements in the preceding period. The alternate periods introduce new families of elements.

The first period contains two elements whose homologs will not be adjacent in succeeding periods, symbolically $1 + 1$; the second period contains a homolog of hydrogen, three solid elements for which the product of atomic weight and specific heat is abnormal, three diatomic gases and a homolog of helium, that is, $1 + 3 + 3 + 1$; the third period contains homologs of the elements of the second period and may be divided into two groups of four families which will be separated in the next period, symbolically $4 + 4$; the fourth contains homologs of the elements of the third and in the middle eight new families, $4 + 8 + 4$.

The fifth period, if the yet undiscovered homolog of manganese be included, contains sixteen elements, or groups of elements, homologous with the preceding, of which the first, second, fifth, sixth, eighth to thirteenth are represented by homologs in the sixth period.

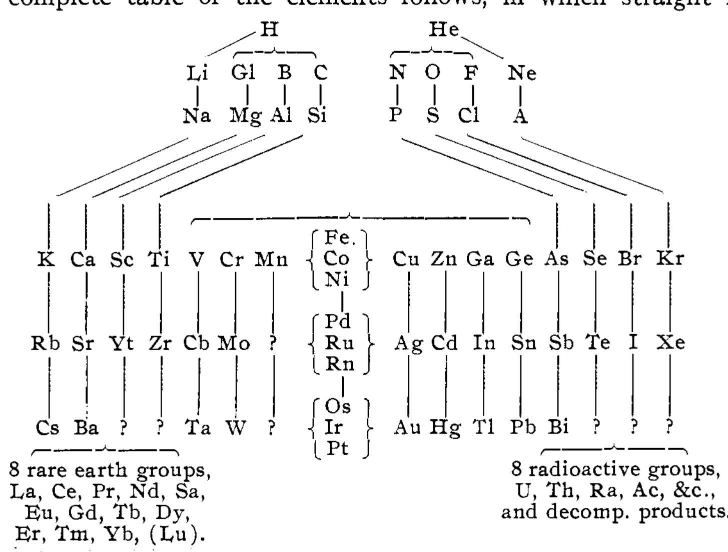
The arrangement of the groups of families in the preceding periods has been symmetrical, hence probably will be so in this period. If so the new families which appear in the sixth period will enter in two groups, the first being between barium and the homolog of yttrium or immediately after the latter. The number of families in the first group of families has been a power of two, or unity ($= 2^0$), in the preceding families, hence will in this case be two rather than three, symbolically, for the fifth period $2 + 12(?) + 2$, sixth $2 + x + 12 + x + 2$.

Inspection shows that in each of these symbolic expressions the g. c. d. of the terms is a power of two, and the quotient the expression resulting from raising the expression $(1 + 1)$ to some power by means of the binomial theorem, or:

Period.	Symbol.	Factors.
I	$1 + 1$	$1 \times (1 + 1)^1 = 2$
II	$1 + \overbrace{3 + 3} + 1$	$1 \times (1 + 1)^3 = 8$
III	$4 + 4$	$4 \times (1 + 1)^1 = 8$
IV	$4 + \overbrace{8} + 4$	$4 \times (1 + 1)^2 = 16$
V	$2 + 6 + 6 + 2$	$2 \times (1 + 1)^3 = 16$
VI	$2 + \overbrace{8} + 12 + \overbrace{8} + 2$	$2 \times (1 + 1)^4 = 32$

in which the number of elements in the period and the factor by which the appropriate power of the expression $(1 + 1)$ must be multiplied to obtain the division of the period into groups of families, alternately vary, both being powers of two.

The complete table of the elements follows, in which straight lines,



vertical or inclined as the case may be, connect homologs. The arrangement of the rare earths, and of the radioactive elements, among themselves, remains to be done. These two groups of families lie in the same horizontal row with cesium and bismuth, and are careted in only to save space.

Exclusive of yet undiscovered rare earth or radioactive elements, the number of gaps remaining in the table is seven, the missing elements being homologous respectively to:

Yt, Zr, Mn (two elements), Te, I and Xe, with atomic weights respectively 173, 177, 100, 188, 212, 252± and 256±.

It is quite likely that lutecium (174.0) is identical with the first of these.

The rare earth metals at present known may be grouped as follows:

1	2	3	4	5	6	7	8
La 139.0	Ce 140.25	?	Sa 150.4	Gd 157.3	Dy 162.5	Er 167.4	Yb 172.0
	Pr 140.6		Eu 152.0	Tb 159.2		Tm 168.5	(Lu 174.0)
	Nd 144.3						

The atomic weights of the radioactive elements are not yet known accurately enough to serve as a basis for separation into groups and the number of radioactive elements is still uncertain.

It will be seen that one or more elements at the right hand end of each period are gaseous. Regarding *bromine* as a gas and leaving out of account the radioactive *emanations*, the following interesting relation obtains:

Period No.	No. of elements.	No. of gases.	Ratio.
I	2	2	1
II	8	4	$^1/_2$
III	8	2	$^1/_4$
IV	16	2	$^1/_8$
V	16	1	$^1/_{16}$
VI	32	(1)	$^1/_{32}$

This relation is suggestive rather than significant, for the physical state of an element is dependent on temperature and pressure, and normal temperature and pressure are, so to speak, "accidental."

It is to be remarked that variation in valence from odd to even and color in simple compounds are practically unknown in the eight families represented in the second period, while both are the rule in the group which enters in the fourth period, and to some extent with the rare earth and radioactive elements. Whether these two phenomena are related in any other way than in their being found in the same parts of the table remains to be proved, but by the electron theory such other connection is very probable, since each requires one or more electrons whose connection with the atom differs from that of the normal electron.

The use of the term "radioactive elements" for the elements of atomic weight greater than that of bismuth is not intended to imply that no other elements are at all radioactive, although all the elements for which radioactivity has been observed do lie in the group in question. The term is used rather as the term "magnetic elements" would be applied to iron, cobalt and nickel.

The exponents for the expression $(1+1)$ in the first table fall to unity in the third period, as in the first, suggesting that the first two periods belong to one part of the table and the remaining periods to another, with some parameter different in the two parts, a difference which ought to show in the equations for the spectra of the elements. In fact, while the equations for the spectral series are similar in form for hydrogen and all the alkali metals, the lines of the last four are double, whereas those of hydrogen and lithium are single, so far as is known.

The answer to the question as to the possibility of other periods awaits a more thorough knowledge of the theoretical basis of the relation between properties and atomic weights. At the same time the sequence of coefficients in the first table suggests that the coefficients for the period before that of hydrogen and that after the sixth would be zero. If this is true, it probably means that elements of atomic weight greater than 256 or less than 1 do not exist.

Summary.

The elements can be arranged in six periods, each including *some power of two* elements, or groups of elements.

The natural divisions of each period are some power of two times the coefficients of some binomial expansion, $(1 + 1)^n$.

Each period contains homologs of all the elements of the preceding period.

Several new families of elements appear in alternate periods.

The rare earths proper, and the radioactive elements are not homologous to any previous elements, but are two groups of families which enter with the sixth period.

Aside from rare earth and radioactive elements, seven elements remain to be discovered.

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AURIC HYDROXIDE FORMED ON A GOLD ANODE. DEPORTMENT OF AURIC HYDROXIDE WHEN HEATED.

BY W. G. MIXTER.

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The writer was led to attempt the preparation of auric oxide by the electrolytic method for the purpose of using it in a determination of the heat evolved when it unites with sodium oxide. The investigation of