40. *Number of Electrons and α -Particles in Atomic Nuclei.*

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The number of electrons surrounding an atomic nucleus is determined by the atomic number, and is well known for all the chemical elements. The nuclei of the elements contain protons and electrons or are combined with them. The number of electrons in the nuclei is, however, not so definite as the atomic number, for the number of protons in the same element is often different on account of the isotopy. If we start from the assumption that each proton is accompanied by an electron, the said number is easily calculated; it seems probable that most elements have an even number of intra-nuclear electrons¹⁾, which is perhaps connected with the symmetric distribution of the electrons in the nuclei, in which an unknown law of force pervades.

For want of experiments on the isotopes, we have simply to rely on the results obtained by Aston. The isotopes for fifth-six elements were tabulated by the said experimenter. Subtracting the atomic number from the mass number, the values (column IV) of the number of intra-nuclear electrons were found. Column I of the table gives the atomic number, II the elements, III the number of isotopes, IV the number of intra-nuclear electrons, V the difference in the number of intra-nuclear electrons from that surrounding the nuclei, VI the number of α -particles on a special supposition, and VII the surplus of electrons in the nuclei based on VI.

The figures given in IV show at once how the intra-nuclear electrons occur in even numbers. This cannot be a chance coincidence and must have some connection with the distribution in the nucleus. The first number in this column refers to the most frequently occurring isotope of each element. They are all *even* with the exception of 75 for xenon among the elements with a number of isotopes, and 5 and 7 for

1) Aston: Isotopes, p. 133, London, 1924.

Atomic Number (I)	Element (II)	Number of Isotopes (III)	Number of Intra-nuclear Electrons (IV)	Surplus of Intra-nuclear Electrons over those surrounding the Nucleus (V)	Number of α -Particles (VI)	Surplus of Intra-nuclear Electrons on Special Supposition (VII)
1	H	1	0	-1		
2	He	1	2	0	1	0
3	Li	2	4, 3*	1, 0	0	1, 0
4	Be	1	5*	1	0	1
5	B	2	6, 5*	1, 0	0	1, 0
6	C	1	6	0	0	0
7	N	1	7*	0	0	0
8	O	1	8	0	0	0
9	F	1	10	1	0	1
10	Ne	2	10, 12	0, 2	0, 1	0, 0
11	Na	1	12	1	0	1
12	Mg	3	12, 13*, 14	0, 1, 2	0, 0, 1	0, 1, 0
13	Al	1	14	1	0	1
14	Si	3	14, 15*, 16	0, 1, 2	0, 0, 1	0, 1, 0
15	P	1	16	1	0	1
16	S	1	16	0	0	0
17	Cl	2	18, 20	1, 3	0, 1	1, 1
18	A	2	22, 18	4, 0	2, 0	0, 0
19	K	2	20, 22	1, 3	0, 1	1, 1
20	Ca	2	20, 24	0, 4	0, 2	0, 0
21	Sc	1	24	3	1	1
22	Ti	1	26	4	2	0
23	V	1	28	5	2	1
24	Cr	1	28	4	2	0
25	Mn	1	30	5	2	1
26	Fe	2	30, 28	4, 2	2, 1	0, 0
27	Co	1	32	5	2	1
28	Ni	2	30, 32	2, 4	1, 2	0, 0
29	Cu	2	34, 36	5, 7	2, 3	1, 1
30	Zn	4	34, 36, 38, 40	4, 6, 8, 10	2, 3, 4, 5	0, 0, 0, 0
31	Ga	2	38, 40	7, 9	3, 4	1, 1
32	Ge	3	42, 40, 38	10, 8, 6	5, 4, 3	0, 0, 0
33	As	1	42	9	4	1
34	Se	6	{46, 44, 42, 48, 43*, 40}	12, 10, 8, 14, 9, 6	6, 5, 4, 7, 4, 3	0, 0, 0, 0, 1, 0
35	Br	2	44, 46	9, 11	4, 5	1, 1
36	Kr	6	{48, 50, 46, 47*, 44, 42}	12, 14, 10, 11, 8, 6	6, 7, 5, 5, 4, 3	6, 0, 0, 1, 0, 0
37	Rb	2	48, 50	11, 13	5, 6	1, 1
38	Sr	2	50, 48	12, 10	6, 5	0, 0
39	Y	1	50	11	5	1
40	Zr	3(4)	50, 54, 52, (56)	10, 14, 12, (16)	5, 7, 6, (8)	0, 0, 0, (0)
47	Ag	2	60, 62	13, 15	6, 7	1, 1
48	Cd	6	{66, 64, 62, 65, 63*, 68}	{18, 16, 14, 17, 15, 20}	9, 8, 7, 8, 7, 5	0, 0, 0, 1, 1, 0
49	In	1	66	17	8	1
50	Sn	7(8)	{70, 68, 66, 74, 69*, 69*, 67*, 72, (71)}	{20, 18, 16, 24, 19, 17, 22, (21)}	{10, 9, 8, 12, 9, 8, 11, (10)}	{0, 0, 0, 0, 1, 1, 0, 1}
51	Sb	2	70, 72	19, 21	9, 10	1, 1
52	Te	3	76, 78, 74	24, 26, 22	12, 13, 11	0, 0, 0
53	I	1	74	21	10	1
54	X	7(9)	{75*, 78, 77*, 80, 82, 74, 76, (72, 70)}	{21, 24, 23, 26, 28, 20, 22, (18, 16)}	{10, 12, 11, 13, 14, 10, 16, (9, 8)}	{1, 0, 1, 0, 0, 0, 0, (0, 0)}
55	Cs	1	78	23	11	1
56	Ba	(1)	82	26	13	0
57	La	1	82	25	12	1
58	Ce	2	82, 84	24, 26	12, 13	0, 0
59	Pr	1	82	23	11	1
60	Nd	3(4)	82, 84, 86, (85*)	22, 24, 26, (25)	11, 12, 13, (12)	0, 0, 0, (1)
80	Hg	6	{122, 120, 119*, 118, 121*, 124}	{42, 40, 39, 38, 41, 44}	21, 20, 19, 20, 22	0, 0, 1, 0, 1, 0
83	Bi	1	126	43	21	1

beryllium and nitrogen among the simple elements. For isotopes whose quantity is tolerably small, a few odd numbers are found as marked by the asterisks. This fact may have some connection with the preponderating occurrence of elements with even atomic numbers. The law of force acting among the electric particles in the interior of the nuclei may be different from that outside them, but the arrangement would be similar, although the mutual distance is largely influenced by the law of force. This important point requires further investigation.

Next tabulating the difference between the numbers of intra-nuclear electrons and the atomic number (Column V), we find an increase with increasing atomic number. There is sometimes a sudden change, as for example with A (4), Ni (2), Zr (10), Cd (18), Te (24), Nd (22). Hydrogen atom has only one electron, which is external to the nucleus; this is very singular, as all the other elements do not enjoy this character. It may in some way account for the abnormality in the atomic weight. Starting from helium, the surplus of electrons in the nucleus is zero or one, seldom amounting to two in weak components of the isotopes. But with argon, it suddenly rises to four in the principal component; the explanation is rather difficult to give, but it may be due to the presence of α -particles in the nucleus. If the α -particle in the nucleus be charged with two quanta of electricity, such abnormal difference can be easily accounted for.

In the radioactive process, we have abundant proofs of the presence of α -particles in the nuclei, and there is probability of their being included even in elements of lower atomic weight. If we suppose an atom to be an electric system with invariable positive charge in the nucleus and a number of negatively charged particles surrounding it, then in the neutral and stable state, the charges must be in equilibrium. According to the hypothesis that *the atomic nucleus consists of protons and α -particles with double positive charges and mass equivalent to four protons*, the numbers given in the fifth column would be modified. The stated surplus can be made to 0 or 1 by introducing a number of α -particles, instead of considering the nuclei as composed solely of hydrogen protons. The number of α -particles to replace the protons is given by halving the numbers given in V if it is even; if it is odd, subtract unity from it and halve the remainder. In the latter case, there is one electron in excess of the external; for even number, the internal positive charge is equal to the external negative charge. The number of α -particles is given in VI, and the surplus of nuclear electrons in VII. If there is surplus in the number of the external electrons, the number in VI should be raised by

unity. There is a definite relation with the periodic arrangement of the elements as an inspection will show. The reason why α -particles are not associated with four electrons and the mass is nearly four times that of a proton will be given in a future communication.

Assuming the Bohr and Coster's scheme of the electron orbits, we notice that elements with single outermost electron orbits are generally characterised by having a surplus of intra-nuclear electrons over those external to the nuclei, as tabulated in the last column. The number of the outermost orbits is generally two, when there is no surplus. This fact is exemplified in the former case by Li, B, Na, Al, K, Cu, Ga, Rb, Ag, I, Cs; and in the latter by He, Mg, Ca, Ti, Zn, Sr, Zr, Cd, Ba, Ce, Pr, Hg. The apparent exceptions are only Be and La, of which the latter is rather questionable. With further extension of the scheme to elements not yet tabulated, this fact may become more definite. As the said orbits are described by the valence electrons, the tabulated surplus is intimately connected with the valency of these elements.

It is worthy of remark that the number of intra-nuclear electrons becomes greater than that of the external when we reach the atomic number 20, while in Rutherford's experiment of the bombardment of the nuclei by swiftly moving α -particles, proton of measurable speed ceases to appear with atomic number 19. Looking at VII, we notice an increase in the number of α -particles in the nuclei. This coincidence may have some signification in the theory of atomic nucleus.

In the primordial state of the chemical atoms, which are probably formed in the interior of hot stars, it seems quite likely that they are in a highly ionised state. The nuclei will be stripped of most of the surrounding electrons, as a remarkable example was found in Procyon by Eddington and Adams. In that state the nuclei are ready to catch such number of electrons as to neutralise their positive charge. Thus the surplus of the negative electrons from that surrounding the nuclei seems improbable. The result obtained for α -particles seems to represent the real components of the nuclei.