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Mendeleev as a Speculator

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Dmitri Ivanovich Mendeleev (1834–1907) is mainly known as the discoverer of the periodic system of chemical elements. Although he was not the only discoverer—we can distinguish six independent discoverers—Mendeleev was the one who supported his own discovery most strongly (*1*). On the basis of the system he formulated by himself, he had already made profoundly accurate predictions early on. This is especially true of the elements gallium (1875), scandium (1879), and germanium (1886). For some other elements, his predictions were not so detailed, but at least his 1871 system reserved space for the still-to-be discovered elements: e.g., rhenium (1925), francium (1939), technetium (1939), and astatine (1940). In 1889 he predicted polonium (1898).

Mendeleev correctly predicted the so-called ekacesium, ekaiodine, ekaniobium, ekatellurium, ekatantalum, ekacadmium, and dwimanganese. However, he did not reserve spaces in his periodic system for these, since the period of rare elements (lanthanides) was not incorporated in his system in a correct way.

As a matter of fact, all these predictions had a sound scientific basis. These non-occupied spaces could be logically deduced from the periodic system which was formulated inductively. Each place in Mendeleev's system represented an order number of an element with a specific atomic mass. In the year 1903, when Mendeleev was almost 70, he nearly broke out of his scientific base for predicting elements with his "elements" newtonium and coronium, which allegedly possessed atomic masses below the unit mass. Mendeleev (*2*, *3*) did not intend to neglect the scientific method with his hypothesis about the existence of these elements, but was treading on dangerous ground. The results of a number of experiments, mainly by others, led him to defend the existence of both of these hypothetical elements. Mendeleev had a very narrow scientific base, as he himself realized. He said of his own ideas, that, as a result of his great age, they were in an "immature state." Mendeleev claimed that when he designed his periodic system in 1869 he had already toyed with the idea of elements lighter than hydrogen, but now he had *two* reasons to develop this idea. First, the discovery made during the last decade of the 19th century of an entirely new group of unexpected elements, the noble gases led Mendeleev, in a system (see Figure 1) published by him, to predict two extra noble gases, the elements x and y, homologous, respectively, with helium and neon. Secondly, the ether theory, which was a success in those days, also pointed in that direction according to Mendeleev. As a matter of fact, the newly proposed element "newtonium" had to be nothing more than ether, to which Mendeleev ascribed *the charge* of zero. Accordingly it would be the lightest noble gas, occupying a place in the column of noble gases above helium.

Mendeleev also could predict the atomic mass of newtonium by using the ratio between the atomic masses of noble gases

$$\frac{\text{Xe}}{\text{Kr}} = 1.56; \quad \frac{\text{Kr}}{\text{Ar}} = 2.15; \quad \frac{\text{Ar}}{\text{He}} = 9.50; \quad \frac{\text{He}}{\text{Newt}} = 23.6,$$

from which an atomic mass for newtoniun of 0.17 can be deducted.

Series	Zero Group	Group I	Group II	Group III	Group IV	Group V	Group VI	Group VII	Group VIII
0	*x*								
1		Hydrogen H=1·008							
2	Helium He=4·0	Lithium Li=7·03	Beryllium Be=9·1	Boron B=11·0	Carbon C=12·0	Nitrogen N=14·04	Oxygen O=16·00	Fluorine F=19·0	
3	Neon Ne=19·9	Sodium Na=23·05	Magnesium Mg=24·1	Aluminium Al=27·0	Silicon Si=28·4	Phosphorus P=31·0	Sulphur S=32·06	Chlorine Cl=35·45	
4	Argon Ar=38	Potassium K=39·1	Calcium Ca=40·1	Scandium Sc=44·1	Titanium Ti=48·1	Vanadium V=51·4	Chromium Cr=52·1	Manganese Ma=55·0	Iron Fe=55·9 / Cobalt Co=59 / Nickel Ni=59 / (Cu)
5		Copper Cu=63·6	Zinc Zn=65·4	Gallium Ga=70·0	Germanium Ge=72·3	Arsenic As=75·0	Selenium Se=79	Bromine Br=79·95	
6	Krypton Kr=81·8	Rubidium Rb=85·4	Strontium Sr=87·6	Yttrium Y=89·0	Zirconium Zr=90·6	Niobium Nb=94·0	Molybdenum Mo=96·0	—	Ruthenium Ru=101·7 / Rhodium Rh=103·0 / Palladium Pd=106·5 / (Ag)
7		Silver Ag=107·9	Cadmium Cd=112·4	Indium In=114·0	Tin Sn=119·0	Antimony Sb=120·0	Tellurium Te=127	Iodine I=127	
8	Xenon Xe=128	Cæsium Cs=132·9	Barium Ba=137·4	Lanthanum La=139	Cerium Ce=140	—	—		— / — / — / (—)
9		—	—		—	—	—	—	
10	—	—	—	Ytterbium Yb=173	—	Tantalum Ta=183	Tungsten W=184	—	Osmium Os=191 / Iridium Ir=193 / Platinum Pt=194·9 / (Au)
11		Gold Au=197·2	Mercury Hg=200·0	Thallium Tl=204·1	Lead Pb=206·9	Bismuth Bi=208	—	—	
12	—	—	Radium Rd=224	—	Thorium Th=232	—	Uranium U=239		

Mendeleev's periodic system in 1904.

Mendeleev's brief remark that these numbers fulfilled a parabolic condition of the second order (he literally says "Thus we recover from a parabola of the second order the ratio He: X = 23.6:1, that is to say as He = 4, the atomic weight of X = 0.17, that has to be considered as the highest probable number" (*4*)), was detrimental to the credibility of his view and to the scientific character of the method applied by him. Taking $f(x) = ax^2 + bx + c$ as a formula for the parabola mentioned a fourth value for $f(x)$ viz., 23.6 does indeed appear. However, since three points always yield parabolas, this prediction had no significance. Even more remarkable, Mendeleev did not attach much importance to his own numerical series and thought it more likely that the atomic mass of newtonium *cum* ether was much smaller. He had to lower this estimated mass as much as possible, since ether has never been proven experimentally to be an element with mass. On other grounds, in connection with the speed and temperature of particles in space, Mendeleev was led to assume an atomic mass which lay between 9.6×10^{-7} and 5.3×10^{-11} g.

For the calculation of the other new predicted noble gas "coronium," element *y*, (a homologue of neon), Mendeleev also applied an arithmetrical relation. The atomic mass ratio of Li and H = 6.97:1. From this he concluded that the ratio He:coronum at least had to be 10:1. This led him to expect an atomic mass for coronium of at most 4/10 = 0.4. This element ought to be found in the solar corona, hence its name.

According to Mendeleev the solar spectrum also indicates the presence of coronium. The prediction of these noble gases were not the last elements predicted by Mendeleev. The discovery of 5 alkali metals with only 4 halogens led him to assume the existence of a halogen an atomic mass of 3—homologous with fluorine—between the elements hydrogen and helium. Here he was again wrong. Several investigators influenced by Mendeleev's authority have tried to prove these claims and those concerning other elements in which changes of the predicted atomic mass were bound to come. That these predictions were not verified is well known. It stands as a warning to the investigator when applying the deductive scientific method exclusively. It is too easy to get on the path of the speculator. As for Mendeleev, in spite of these scientific "wind eggs," he remains a very great figure in the development of as well theoretical as applied chemistry.

Literature Cited

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