

## PRIMARY DOCUMENTS

# ON THE ATOMIC VOLUME OF SIMPLE BODIES

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In an article published in the *Journal of the Russian Chemical Society* (Volume 1, page 60), I tried to show the periodic relationship between the properties of the elements and the magnitude of their atomic weight. In the present article I intend to supplement what has been previously said.

All groups of similar elements can be divided into two main categories: in one of the categories, similar

Li = 7	Be = 9.4	B = 11	C = 12	N = 14	O = 16	F = 19
Na = 23	Mg = 24	Al = 27.4	Si = 28	P = 31	S = 32	Cl = 35.5
K = 39	Ca = 40	—	—	—	—	—
Cu = 63.4	Zn = 65.2	—	—	As = 75	Se = 79.4	Br = 80
Rb = 85.4	Sr = 87.6	—	—	—	—	—
Ag = 108	Cd = 112	—	Sn = 118	Sb = 122	Te = 128?	J = 127
Cs = 133	Ba = 137	—	—	—	—	—

elements exhibit a significant difference in atomic weight; most simple bodies belong here and they can be distributed in terms of the atomic weight into completely symmetrical groups, clearly showing the periodic dependence of the properties on the atomic weight, as can be seen from the attached example.

These groups could be considered as homologous if there were no terms in them that break the sequence in changing properties. So, in the first group with alkali metals, copper and silver are placed between potassium, rubidium, and cesium. It is not possible to doubt that this placement accounts for much chemical data. Thus, it is known that silver in its oxidized state has many similarities with sodium: silver nitrate cannot be separated by crystallization from sodium nitrate. Isomorphism is also

manifested between the compounds cuprous oxide and silver oxide; cuprous chloride, like silver chloride and sodium chloride, crystallizes in cubes. We note that the relationship between zinc and cadmium and the alkaline earth metals is exactly the same as that between copper and silver on the one hand and the alkali metals on the other. They [zinc and cadmium] also have to be placed

between calcium, strontium, and barium, although they have a better resemblance to magnesium, like copper and silver do with sodium. If we could distinguish these two groups of elements from [those in] the first two rows, then we would have to significantly complicate the classification, without, at the same time, achieving any particular simplicity. With its specific features, however, the above comparison already furnishes a considerable number of benefits. They consist mainly of the following: 1) based on the magnitude of the atomic weight, such a system clearly expresses the chemical similarity and determines the degree of combining with oxygen (1); 2) it corresponds to the separation of elements into metals and metalloids, because on the one side the first classes of simple bodies [metals] are mainly grouped, with the other class [metalloids] on the other side; 3) it corresponds to the atomicity of the elements in the form in which it is usually recognized; indeed, the elements of the first column are monatomic, the second, third, and fourth represent di-, tri-, and tetraatomic elements; the elements of the fifth column are triatomic, sixth diatomic, and the seventh monatomic; 4) at the same time this system brings together similar elements of different groups, such as, for example, boron, carbon, silicon and aluminum; 5) to some extent, it clarifies the homology that has long been noted in the magnitude of atomic weights for the bodies of one particular group; 6) the elements most diverse in chemical character are also the most remote in this system.

Another category of groups of similar elements is composed of those that have close atomic weights. Between them, four groups are best known: 1) the cerium metals: cerium, lanthanum and didymium, mass 92-95; 2) metals of the iron group: chromium, manganese, iron, cobalt and nickel, having an atomic weight from 51 to 59; 3) metals similar to palladium, the atomic weight of which is 104-106, and 4) metals of the platinum group, to which—apart from platinum, iridium and osmium—it is fair to include gold, which is similar to them not only in terms of atomic weight (197-199), but also in most basic properties. These groups of metals have in the above-mentioned system a completely definite position based on their atomic weight and partly on the chemical nature of the compounds formed by them. The iron group is the transition from the missing members of the last columns to copper. Chromium can be conveniently placed in line with oxygen, between sulfur and selenium, just as copper is between potassium and rubidium. In fact, chromium in the form of chromic acid presents a remarkable resemblance to sulfuric acid, as is well known to everyone, which is particularly pronounced in

the significant similarity that  $\text{SO}_2\text{Cl}_2$  and  $\text{CrO}_2\text{Cl}_2$  have. The closest analog to chromium in the iron group is manganese. Its atomic weight is greater than chromium, and it can be placed in the series of halogens. Manganese presents with them [the halogens] the same similarity in its highest degree of oxidation as chromium does with sulfur. Indeed, the manganate potassium salt  $\text{KMnO}_4$  is known to be isomorphic and extremely similar, even in specific weight, to the chlorate potassium salt  $\text{KClO}_4$ . Manganese is followed by iron, cobalt, and nickel, representing, in both atomic weight and chemical properties, as well as the ability to form different degrees of oxidation, a clear transition to copper. The iron group is adjoined on the chromium side by two other elements, vanadium and titanium, the striking similarity of whose compounds with those of phosphorus and silicon is not subject to the slightest doubt.

The zirconium (90), niobium (96) and molybdenum (94) series exactly corresponds to that of titanium, vanadium and chromium and must be located in appropriate places below the named metals; and for rhodium, ruthenium and palladium one can hardly deny the analogy with iron, cobalt and nickel. By the magnitude of their atomic weights, these elements constitute a transition to silver, as elements of the iron group do to copper. Platinum, osmium, iridium and gold must be placed in the same position below these metals. The similarity is expressed not only in the similarity of their degrees of oxidation ( $\text{RO}$ ,  $\text{R}_2\text{O}_3$ ,  $\text{RO}_2$ ), but also in such traits as the ability to produce ammonium compounds, characterized by well-known traits belonging in the same measure to ammonia-cobalt, ammonia-ruthenium, and ammonia-platinum compounds.

It is very important to pay attention to the location that the groups of similar elements mentioned here acquire; It is absolutely determined in a number of groups of the first category. Therefore, there is no doubt that in principle the distribution of elements in terms of their atomic weights embodies the true guiding principle when studying the basic natures of the elements. In my treatise, entitled *Fundamentals of Chemistry*, I attach the described system to an elementary exposition of chemistry and present evidence of the similarities in the groups defined by the above-mentioned method, and therefore I do not cover this subject here. Now I will draw attention to the fact that the comparison of elements according to the principles mentioned here finds some confirmation in the comparison of the physical properties of simple bodies taken separately, and even more so in their respective chemical compounds. In this

article I will focus exclusively on the comparison of specific weights and specific volumes, especially since the comparison of other physical properties at present, due to lack of information, is almost impossible. As proof of the naturalness of the system proposed by me in relation to other properties, one can cite from the remarkable investigations of Wiedemann (*Pogg. Ann.* 1865 and 1869) that the elements of the group of cerium and the group of iron are magnetic in their compounds, and their atomic magnetism changes smoothly when going from one analogue to another. It would be most interesting to now investigate, in this respect, the elements of the platinum group and their compounds most similar in chemical characteristics to ceric and iron compounds.

As before, here is a table of elements, in which are inserted the bodies possessing similar atomic weights from the series of iron and platinum.

Li.	Be.	B.	C.	N.	O.	F.				
Na.	Mg.	Al.	Si.	P.	S.	Cl.				
K.	Ca.	—	Ti.	V.	Cr.	Mn.	Fe.	Co.	Ni.*	
*Cu.	Zn.	—	—	As.	Se.	Br.				
Rb.	Sr.	—	Zr.	Nb.	Mo.	—	Rh.	Ru.	Pl.*	
*Ag.	Cd.	—	Sn.	Sb.	Te.	I.				
Cs.	Ba.	—	—	—	Ta.	W.	—	Pt.	Ir.	

In order to clearly establish the dependence that exists between atomic weights and the specific volumes of various groups of elements, we shall first compare them in vertical and then in horizontal rows of the table. It has long been known that such homologous elements as potassium, rubidium, cesium,—or calcium, strontium, barium,—or phosphorus, arsenic, antimony, etc.,—display a gradual change in specific volumes with a change in atomic weight. This was exhibited for the first time, if we are not mistaken, [by] Dumas and Le Royer; they argued, justifiably in many cases, that similar elements and compounds display either closely related specific volumes or volumes that constantly increase with increasing atomic weight, which allows one to compare the last category of similar bodies with homologs for which the last kind of relation exists. Here are some examples of this: lithium has a specific weight of 0.594, and hence its volume = 11.2; potassium has an atomic volume equal to 44.8; rubidium 56.1; beryllium, corresponding to lithium in the series of alkaline earth metals, has a specific weight of 2.1, and therefore its volume is 4.5; it is less than the volume of lithium, just like the volumes of calcium and strontium are less than the atomic volumes of potassium

and rubidium. In fact, the specific weight of calcium = 1.58, and its volume = 25.5; the volume of strontium = 35.5, and barium about 30.

Here we notice that the increase in atomic volume is not so rapid as in the series of alkali metals. But as the atomic weight increases for both the first and the second [groups], the atomic volume and the energy [i.e., reactivity] of the element also increase. This latter [reactivity] is explained by the significant changes in their atomic distances as their atomic weights increase. Barium atoms, although they are heavier than calcium atoms, are, however, more distant [from other atoms] than the latter. The influence of the distances on the course of reactions, if I am not mistaken, was first pointed out by Avogadro. It manifests itself in the formation of the corresponding compounds of the two named elements. Thus, aqueous barium oxide (specific weight 4.5, and volume = 30) has a smaller volume than metallic barium itself, i.e., the two water residues, in joining the barium, not only did not move its atoms apart, but made them even closer. Hence, there was enough space between the barium atoms to place these elements. Calcium atoms have a much smaller volume and its aqueous oxide occupies a larger volume (34, because the specific weight is 2.2) than the metal itself, because calcium is less energetic than barium. The water components of its hydrate did not bring the metal atoms together, but pushed them apart. But in [potassium] oxide, as in calcium fluoride, there was still a contraction, as occurs with the formation of most potassium compounds. So potassium hydrate takes up a volume of 35, and metallic potassium, which is in it, has a volume of about 45. Lithium and beryllium are followed by boron in our system, but we do not know its true analogs. The volume of lithium is close to 12, beryllium 5; boron has a volume of about 4, because its specific weight is 2.68. Carbon, which follows boron in the series of elements above, has a specific weight that varies much, depending on the modification [i.e., allotrope]. Only in the form of diamond, whose specific weight = 3.54, is the volume of carbon less than that of boron; in the form of graphite, it is already greater, viz. = 5.7, because the specific weight of graphite is close to 2.1; in the form of coal, the volume of the carbon atom is even greater. Therefore, it is not possible to say with certainty whether the volume will increase or decrease when we pass along the first row of elements from carbon to nitrogen, oxygen and fluorine. By analogy with other rows, however, it is more likely to exhibit an increase, for example, similar to the one that exists in the transition from Si to P, S and Cl, or from Sn to Sb, Te and I.

The second series, or more correctly, the second row of elements, which contains sodium and chlorine, displays a special phenomenon, which we will consider next. Now we mention that in the horizontal rows to which potassium, rubidium and cesium belong, we know few reliable examples. But if we take the potassium row, we will find in it potassium, whose volume is close to 45, calcium, whose volume = 25, titanium, whose specific weight 5.3 indicates an atomic volume of about 7.5; then chromium, whose volume is about 7.4 and manganese, whose volume = 7.0, because the specific weight is about 8.0. This shows that in the potassium row, with an increase in the atom [i.e., atomic weight], the volume decreases, as we saw in the lithium series; but the reduction here is even faster than for the lithium row. In the rubidium row, this decrease is even more noticeable because rubidium has a volume of 56, strontium 34, molybdenum 8.5. Palladium is about the same. Thus, for the vertical series corresponding to lithium (Li, K, Rb, Cs; Be, Ca, Sr, Ba; Cr, Mo, W; Ni, Pt, Os), we notice an increase in volume with increasing atomic weight, and in horizontal rows corresponding to Li, K, Rb, Cs as the atomic weight increases, at first the volume decreases rapidly, and then remains almost constant. Special phenomena are seen for sodium and elements similar to it that stand in the same horizontal row.

The volume of sodium = 23.7 because the specific weight = 0.97; the volume of copper = 7.2, silver 10.3. The volume of magnesium = 13.7, [which is] much less than the volume of sodium. So far, the phenomena are the same as for the preceding, but there is further distinction. Zinc has an atomic volume of 9.1, i.e. greater than copper, just as cadmium, having a volume of 12.8, is greater than silver. In the silver row we notice the greatest density and moreover regularity in the following, namely: palladium, ruthenium and rhodium all having a similar volume of 9.1; silver 10.3; cadmium 12.8; tin, which, without a doubt, belongs to this series, as an analog of silicon, has a volume of 16.2; antimony from the phosphorus series has a volume of 18.1; tellurium from the sulfur series 20.7 and iodine from the chlorine series has a volume of 26, because its specific weight is 4.93. For this row, therefore, with an increase in the atom weight, the specific volume also increases, despite the difference in chemical character; hence here the change along the horizontal rows is different than what we noticed in the rows above the elements examined. This is even clearer in the row of heavy metals not listed in the table, viz: volume Pt =  $197/21 = 9.4$ ; Au =  $197/19.3 = 10.2$ ; Hg =  $200/13.6 = 14.7$ ; Tl =  $204/11.89 = 17.2$ ; Pb =  $207/11.35 = 18.2$ ; Bi =  $210/9.8 = 21.4$ , that is with the increase in

atomic weight along the horizontal row, the volume increases, and does not decrease or remain constant, as we saw for the horizontal rows corresponding to potassium, rubidium, [and] cesium.

For elements of the same category from the rows corresponding to copper and sodium, we see however the transition to the property of the rows corresponding to K, Rb, Cs. So for the elements that correspond to copper we do not notice a previous rapid increase, namely we see the following: iron, cobalt and nickel have close volumes, about 7.1; copper 7.2; zinc 9.1; we do not know the analogs of aluminum and silicon in this series, but from the phosphorus series we have arsenic, whose volume = 13 or 16, depending on whether we take the crystalline or amorphous state of arsenic. In any case, the volume is significantly increased. Selenium in the same row has an even larger volume—19.4, bromine is even greater—27, and therefore we first see an extremely slow increase in volume, and then an extremely rapid increase. For the series of silver we notice a continuous and regular decrease in the specific weight, starting from palladium to iodine. In fact, the specific weight of Pt = 11.7, Ag = 10.5, Cd = 8.6, Sn = 7.3, Sb = 6.7, Te = 6.2, I = 5.0, whereas in the copper series, a phenomenon of a different kind is seen: first, the specific weight increases, and then decreases; Fe has a specific weight of 7.8; Co = 8.6; Ni = 8.5; Cu = 8.8; Zn = 7.1; As = 5.7; Se = 4.3; Br = 3.0. It is obvious that the regularity that is so obvious in the silver series, is less apparent here, although there is still a continuous increase in the specific volume with an increase in the weight of the atom. Therefore, it is possible to say that the two elements which are not yet in the system should show similarity to aluminum and silicon and have atomic weights of about 70. They will have atomic volumes of about 10 or 15, i.e., they will have specific weights of about 6, and thus will occupy just the middle ground, in all respects, or they will constitute a transition in properties from zinc to arsenic.

It may be that indium occupies a place in the aluminum series, if, in determining the weight of an atom, it is possible to admit an error that might occur from incomplete purification from metals heavier than it (maybe cadmium). After what has been said, it will be clear that in the sodium row we encounter a phenomenon completely different from the previous ones. Indeed, sodium represents a volume of 24, magnesium 13.7, aluminum 10.3, i.e., up to now the volume of the atom decreases with increasing atomic weight, and the specific weight increases. Going further, we encounter a complication: silicon has a volume of a little more

than aluminum, namely about 11; phosphorus in its two forms [i.e., allotropes] displays a specific weight [of] 1.96 for red phosphorus and 1.83 for white phosphorus, i.e., atomic volumes of 15.8 and 17.0. The proportions of sulfur in its two modifications are almost the same as for the two modifications of phosphorus: prismatic sulfur has a specific weight of 1.96, and ordinary sulfur is 2.06, i.e., the volumes of the sulfur atoms in the two states = 15.5 and 16.3. For chlorine, which follows sulfur in this series, the volume of the atom is close to 26, because liquid chlorine has a specific weight close to 1.3.

So, starting from sodium to aluminum, we have a decrease in volume, and then an increase; but there is no real consistency. The latter is partly explained by the difference in the physical state that exists for the elements in this series, and which can not be assumed for the elements in the two preceding series, at least to as large an extent as here. Sodium and magnesium, at least the latter, probably contain one atom each in their particle; the analogy with cadmium, and [their] volatility, can confirm this. One could hardly doubt that a particle of silicon, like a carbon particle, contains a significant number of atoms; this explains the deviation that carbon and silicon exhibit from the law of Dulong and Petit, as I will try to prove in a special article (2).

Phosphorus in its particle contains at least 4 atoms; the red form is probably even more complex than the white; its atoms are even closer, the polymer state is even more complex. The same thing should be noted about sulfur. Prismatic sulfur is simpler than rhombic, but in the former there are at least 6 atoms in the particle, as can be seen from the density of sulfur vapor observed at a temperature of about 600°. Chlorine, in the same series, contains only 2 atoms in its particle. If sulfur were known in liquid form and in the same polymer [i.e., dimer] state as chlorine is known, it would probably exhibit a much larger atomic volume. Thus, elements that have very different numbers of atoms in their particles are grouped in the sodium-chlorine row. Therefore it is not surprising that we notice here a lack of the harmony that is characteristic of the other rows examined by us. If we take the extreme members of the rows examined by us, we note the following: silver has a volume significantly different from the volume of iodine; the volume of copper is even more different from the volume of bromine, but the volume of sodium differs little from the volume of chlorine. Does this not depend on the fact that the particles of sodium and copper are composed in different ways? Looking at the series of elements just described along vertical series, we note the following feature that

clearly distinguishes these series from the series of lithium, potassium, rubidium, cesium and similar ones, previously considered. There we saw an increase in both specific weight and atomic volume, coupled with an increase in atomic weight and chemical energy. Here, the opposite is seen: with increasing atomic weight, sodium, copper and silver exhibit a decrease in chemical energy, just like in the transition from magnesium to zinc and cadmium. The volume of the magnesium atom, 13.7, is greater than the volume of [both] zinc (9.1) and cadmium (12.8), just as the volume of sodium is larger than the volume of [both] copper and silver. Moreover, copper and zinc display a smaller volume than silver and cadmium, exactly as in the corresponding rows of the right side of the table. Phosphorus in both its modifications displays a larger volume than arsenic; but the volume of antimony is greater than the volume of arsenic, just as the volumes of cadmium and silver are greater than the volumes of zinc and copper. However, the volume of selenium is greater than [that of] sulfur, and [the volume] of tellurium is even greater than [that of] selenium. The volumes of the atoms of chlorine, bromine and iodine are known to be close to one another.

From what has been said, it is clear that there is some regularity in the change in the specific weights and atomic volumes in the series of elements distributed in a general system according to the magnitude of [their] atomic weights. But this regularity is upset by the changes in the physical and chemical nature of the elements: the number of their atoms in the particle and the quality of the atoms, or their ability to join [together in] chemical compounds, all depend on this. For example, if we turn our attention to the first series of elements, which include alkali metals, copper and silver, then we find the following numbers: Li = 11.8; Na = 23.7; K = 44.8; Cu = 7.2; Rb = 56.1; Ag = 10.3; .... Tl = 17.2, i.e. we see no regularity in the changes in the volumes of the atom. But, paying attention to the close similarity existing between lithium, potassium, rubidium and cesium on the one hand, and sodium, copper and silver on the other, we already see some regularity, absolutely clear in the first row but not visible in the second, that copper has the smallest volume; for elements below and above [copper], the volume of the atom is greater than for copper. This is completely parallel to the fact that in the series of magnesium, zinc and cadmium the volume of zinc is much less than that of magnesium, and even less than cadmium. Lead is larger than thallium, just as zinc is larger than copper, and [it is] more like cadmium than silver. Magnesium, however, has a volume less than sodium. In the phosphorus series, the volume of arsenic is less than that of phosphorus and less

than the volumes of antimony and bismuth; the volume of bismuth is greater than that of lead, just as the volume of antimony is greater than that of cadmium. These complex relations acquire a special meaning when we compare the properties of elements with the properties of their compounds and especially with the reactions in which they participate. These relations are set out by me in the second volume of my book *Fundamentals of Chemistry* and are not included in the purpose of the present article. But in order to supplement what was said above by pointing out the variety of relations that are observed in this case, I will add a few fragmentary remarks concerning the specific weight and volume of analogous compounds belonging to the series considered earlier.

The specific weight of potassium compounds is always slightly less than that of the corresponding sodium compounds; for example, potassium chloride has a specific weight of 1.9, and sodium chloride has a specific weight of 2.1; potassium nitrate 2.1, and sodium nitrate 2.2; caustic potassium 2.0, and caustic soda 2.1; potassium oxide 2.7, and sodium oxide 2.8; metallic potassium 0.87, and sodium 0.95. The relationship between magnesium and calcium is exactly the same: magnesium compounds are usually somewhat denser than calcium compounds. For example, calcium oxide has a specific weight of 3.2, and magnesium oxide is 3.7; slaked lime 2.2, and milk of magnesia 2.3; calcium chloride 2.1, and magnesium chloride 2.2 (3); calcium carbonate in the form of [Iceland] spar has a specific weight of 2.72, and magnesium carbonate in the form of spar 2.95; calcium has a specific weight of 1.58, and magnesium has a specific weight of 1.74. Thus, calcium compounds relate to magnesium compounds in exactly the same way as potassium compounds relate to sodium compounds; so with an increase in the [atomic] weight there will be an increase in volume. But if we go further, we note again a decrease in volumes; so analogous compounds of copper and sodium are close in volume. For example, sodium oxide  $\text{Na}_2\text{O}$  has a particle volume of 22, and cuprous oxide  $\text{Cu}_2\text{O}$  of 25; the volume of sodium chloride particles is 28, and of copper chloride corresponding to table salt, is also 28, because the specific weight is 3.5. This is despite sodium and copper in a free state displaying, as we have seen, a very significant difference in volumes; the specific gravities of copper and sodium compounds are very different.

Similarly, zinc in its compounds has a volume slightly smaller than calcium, namely, close to magnesium; zinc oxide has a volume of 45, because the specific weight is 5.6 and magnesium oxide has a volume of 11.

Zinc chloride exhibits a volume of 48, and magnesium chloride of 43; [that of] the sulfate salt of zinc in the anhydrous state is 43, and the sulfate salt of magnesium is 44. Therefore, the transition from sodium to copper (in the lower oxide salts) and from magnesium to zinc in the corresponding compounds does not entail a significant change in the volumes, despite the considerable difference in the volumes and in the energy of the free metals. The silver compounds in the oxide salts have almost the same volume as the copper compounds in the lower oxide salts, hence, the same as the sodium compounds. It is sufficient, for example, to indicate that silver nitrate has a partial volume of 39.0 (specific weight 4.34), whereas the cuprous nitrate salt has a partial volume of 37.9 and a specific weight of 2.24 [typo for 3.24]; copper chloride has a volume of 28.0, and silver chloride is 26.3. It is also remarkable that copper, in the salts of the oxide  $[\text{CuO}]$ , is isomorphous with the salts of magnesia, and shares with them a proximity in the magnitude of specific volumes. So, for example, anhydrous sulfate of magnesium has a volume of 44, and anhydrous sulfate of copper, 45. This is similar to the fact that the chromium [i.e., chromate,  $\text{CrO}_4$ ] salt has a volume [of] 72, the sulfate salt of potassium [has a volume of] 66, and the potassium manganate salt  $\text{KMnO}_4$  has a volume of 58.3, a little more than the potassium chlorate salt,  $\text{KClO}_3$ , whose volume = 54.6. The volume of chromium and manganese salts is greater here than the corresponding salts containing sulfur and chlorine, although the volume of chlorine and sulfur is much greater than that of chromium and manganese. It is clear from this that in compounds made analogously, one often observes the similarity in the magnitude of volumes and the volume ratio that is not at all anticipated and in no way agrees with the volumes that the participating elements have in a separate [i.e., free] state. From this it becomes clear that, in the system we have applied, based on the magnitude of the atomic weights and similarity in the chemical nature, the above deviations from the simple order are [actually] what one would expect. Atomic weights, like [chemical] analogies, are determined not by the properties of individual elements, but by the properties and composition of the compounds.

The remarks given above can serve as new evidence of the law which I defended in my article "specific volumes" and which can be formulated as follows: the volume of compounds can not be judged from the volume of their constituents. That is why it is necessary to treat with very great caution those systems of specific volumes, which are based on the assumption of the opposite statement.

**Note.** The foregoing was communicated by me at the Congress in August 1869. In 1870, in *Liebig's Annalen* (after this article was sent by me for printing), an article by Lothar Meyer appeared, dealing with the same subject. Mr. Meyer's conclusions are based on the assumption of the system of elements proposed by me and agree with those that I have made with respect to the volumes of atoms. He also pays special attention to the descending and ascending series of elements and to the sequence of volume changes. But the conclusions were increased in clarity by the graphic image attached to the article. By putting this postscript I have no desire to raise the issue of scientific priority, (in my opinion, these questions do not often have any academic interest), and I only want to point to the table attached to Mr. Meyer's article as a means of capturing and explaining those complex relations, which are indicated in the previous text.

### References and Notes

1. After the Congress, I made a special report on this subject in *J. Russ. Chem Soc.* **1870**. №1.
2. This article is already in the *J. Russ. Chem. Soc.* **1870**, vol. 2.
3. The sulfate salt of lime has a specific weight of 2.95, and the anhydrous sulfate salt of magnesium is 2.65. This apparent deviation depends, in my opinion, on the fact that the sulfate salt of lime in the anhydrous state is in two aggregated states. In the form obtained by calcining gypsum, it is able to combine with water and then probably has a smaller specific weight; it must be assumed that it will be about 2.5. In the form of anhydrite, the sulfate salt of lime does not have the ability to combine with water, and in this form it does not display an aggregated state like that in which it is found in alabaster, and in no way is analogous to an anhydrous sulfate salt of magnesium. However, the latter, after strong calcination, dissolves very slowly in water, which may depend on the molecular change occurring at the same time.

## 2020 Conferences in History and Philosophy of Chemistry

- International Society for the Philosophy of Chemistry: 24<sup>th</sup> annual meeting. July 21-23 in Buenos Aires, Argentina (<http://www.filoexactas.exactas.uba.ar/ispc2020/>)
- ACS Division of the History of Chemistry at the Spring 2020 National Meeting of ACS, Philadelphia, Pennsylvania, March 22-26 ([www.acs.org/content/acs/en/meetings/national-meeting.html](http://www.acs.org/content/acs/en/meetings/national-meeting.html)).
- European Society for the History of Science (ESHS): 9th International Conference, hosted by the Centre for the History of Universities and Science at the University of Bologna (CIS) and by the Italian Society for the History of Science (SISS), will take place in Bologna, Italy, August 31-September 3, 2020 (<https://sites.google.com/view/eshsbologna2020>)
- ACS Division of the History of Chemistry at the Fall 2020 National Meeting of ACS, San Francisco, California, August 16-20
- History of Science Society, October 7-11 in New Orleans, Louisiana, USA