Substantia
An International Journal of the History of Chemistry

Firenze University Press
www.fupress.com/substantia

Editorial

Water and the periodic table

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OPEN ACCESS

Citation: M. Henry (2019) Water and the periodic table. *Substantia* 3(2) Suppl. 3: 9-11. doi: 10.13128/Substantia-701

Data Availability Statement: All relevant data are within the paper and its Supporting Information files.

Competing Interests: The Author(s) declare(s) no conflict of interest.

Once upon a time, there was a Russian guy named Dmitri Mendeleev (1834-1907), who became Doctor of Science in 1865 at Saint Petersburg State University for his dissertation «*On the Combinations of Water with Alcohol*», a most important mixture in eastern European countries. After becoming a teacher in this university (1867), he planned to prepare a book for his teaching and after a dream, he has envisioned the complete arrangement of the elements as a 2D-table based on the "magic" integer 8. On 6 March 1869, he made a formal presentation to the Russian Chemical Society, describing elements according to both atomic weight and valence. The role of the magic number 8 was elucidated between 1923 and 1930 through the development of quantum mechanics and new magic electron count numbers were discovered: 2 (He), 10 (Ne), 18 (Ar), 36 (Kr), 54 (Xe), 86 (Rn) and 118 (Uuo). In October 1957, a most important paper was published showing that the three most abundant elements in the universe was in that order: H, He and O.[1] As helium is an inert and unreactive gas, it directly follows that the most abundant molecule in the universe should be a combination of hydrogen, a monovalent atom, with oxygen, a divalent atom, i.e. a substance having a H_2O stoichiometry and with a magic count of 10 electrons.

But, in order to get a better understanding of our universe, ordering chemical elements in a table is just the very first step and the next step is to consider relative chemical abundance, leading to the order: H > He > O > Ne > N > C > Si > Mg > Fe > S > Ar > Al > Ca > Na > Ni > P > Cl > Cr > Mn > K > Ti > Co. Hence, after water, we get the (H, O, N, C) quadruplet for building organic molecules followed by (O, N, C, Si, Mg, Fe) sextuplet for building meteorites. With water, organic matter and meteorites, everything is in place in the universe for the apparition of life. Obviously, as water is by far the most abundant molecule in any living cell (more than 99%), a good understanding of its physical and chemical properties becomes mandatory.

First, by looking at the ratio between Boyle temperature (temperature at which attractive and repulsive forces are in balance in gas) and molecular weight, the most cohesive molecules are found to be H_2O > HF > NH_3 > H_2

[1] E. M. Burbidge, G. R. Burbidge, W. A. Fowler, F. Hoyle, « Synthesis of the Elements in Stars », *Rev. Mod. Phys.*, **26** (1957) 547.

> HCl > H_3C-NH_2.[2] So, after being the mots abundant molecule of the universe, water is also the most cohesive one. Considering the two couples of conjugated thermodynamic variables (volume V, pressure p) and (entropy S, temperature T), liquid water is further characterized by many critical temperatures at a pressure close to 0,1 MPa:

T = -42°C: lowest limit temperature for super-cooled liquid water.

T = -13°C: isochoric heat capacity maximum, i.e. minimum $C_V = <(\delta T)^2>$ fluctuations.

T = 0°C: crystallization of hexagonal ice with a lower density than the liquid.

T = 4°C: liquid water density maximum, i. e. $\alpha_p = <(\delta S)\cdot(\delta V)> = <(\delta p)\cdot(\delta T)> = \gamma_V = 0$.

T = 37°C: isobaric heat capacity minimum, i.e. minimum $C_p = <(\delta S)^2>$ fluctuations.

T = 46°C: Isothermal compressibility minimum, i. e. minimum $\kappa_T = <(\delta V)^2>$ fluctuations.

T = 64°C: adiabatic compressibility minimum, i. e. maximum $\kappa_S = <(\delta p)^2>$ fluctuations.

T = 100°C: liquid water vaporization with very high latent heat of vaporization.

T = 280°C: highest limit temperature for superheated liquid water.

That water should be the cradle of life is thus easily understandable. So, it should be no surprise that water is also the most studied substance in science, literature and arts. Being involved in water science and research since about 40 years, I have asked to 5 scientists having a worldwide reputation to put the focus on domains where water is doomed to play major role for the next century.

I will begin by Dr. José Teixeira, a prominent scientist, expert in water physics. He will give us an overview of a highly debated issue concerning the existence of a second critical point in deeply super-cooled liquid water. Accordingly, if such a critical point really exist in the so-called "No man's land" (160 K ≤ T ≤ 232 K) not accessible to experiments owing to hexagonal ice nucleation, a direct consequence would be a theoretical justification for the occurrence of so many temperature minima and maxima for liquid water (see above). As a complementary reading on this crucial subject, see reference 2.

If you have never heard about *aquaphotomics*, you should read carefully the paper by E. B. van de Kraats, J. S. Munćan and R. N. Tsenkova. This novel field shifts the paradigm of seeing water in a system as a passive, inert molecule to one which can build various structures with various functionalities, giving water an active role in biological and aqueous systems. I sincerely think that it is one of the most promising techniques for characterizing watery systems in the very near future.

As we all know, human beings are currently facing a most prominent danger owing to large climate changes on Earth. After reading the contribution of Ernst Zürcher, you will probably understand why by firing forests for producing more food, we are putting all living beings on Earth, including ourselves, in great danger. You should be aware that the current water cycle on Earth is incomplete and time is ripe for revisiting it at the light of our current knowledge. As a complementary reading to this special issue, I would suggest considering Gerald Pollack's wonderful book about EZ-water.[3]

Since about 12 000 years, humanity is living near a river or a lake for agricultural as well as industrial reasons. The consequence for our very near future will be that the tiny amount of fresh liquid water on Earth will become more and more polluted. The discovery of the fact that rivers are able to undergo a self-purification process is thus of the utmost importance for future generations. More on this most fascinating subject in the contribution of W. Schwenk and C. Sutter. As a complementary reading concerning the importance of seawater, I would strongly recommend an amazing book devoted to René Quinton's life and works, the so-called "French Darwin" at the dawn of the XX^{th} century.[4]

Finally, our future is also deeply darkened by our inability to heal cancer and neurodegenerative diseases. I think that the main reason for such a failure despite billions and euros and dollars spent, is that we have not yet recognized the role played by water in a cell and that we ignore the basic physical laws responsible for life apparition on Earth. With the contribution of L. Schwartz, one of the best expert in the world in oncology, a new paradigm is proposed based on entropy and water. A possible scenario presenting how water and Earth and Sun have plotted several billions years ago for making life appear on this planet is discussed. Both authors of this contribution are fully convinced that by grounding biology into physics, new ideas for healing people will automatically emerge in the next few years.

Another subject that could have been developed in this special issue and that will take more and more importance over the next years, is related to the interaction of water with very low frequency electromagnetic fields. The scientific demonstration by experiments and theory that molecules are able to leave an electromag-

[2] M. Henry, *Inference : Int Rev. Sci.*, **4**, n°3, March 2019; available online.

[3] Pollack, G. H. (2013) : « *The Fourth Phase of Water - Beyond solid, liquid and vapor* », Ebner and Sons, Seattle, USA.

[4] Dray, J.-F., Quattrocchi-Woisson, D., Saint-Geours, Y. « *Sur les traces de René Quinton (1866-1925): sa vie, son œuvre, sa postérité en France et en Espagne* », AGAMI-Editions, Paris (2019).

netic signature in water was a real breakthrough,[5] as well as the confirmation by independent groups of this amazing phenomenon.[6] However, as we have not yet enough hindsight on such a very hot topic, I have make the choice to not include it in this special issue.

Now, going back to Mendeleev and to the celebration of the 150th anniversary of the periodic table, I would like stressing that water is probably the only substance on Earth able to carry the whole periodic table from our immediate environment into our body either as ionic species (minerals), nanobubbles (gases) or micelles (organic molecules). Consequently, a third step was needed in order to perpetuate Mendeleev's ideas by considering how water could interact with each element of the periodic table according to its oxidation state and electronegativity. This was the job of my PhD thesis[7] explaining how I was introduced in water chemistry and science some forty years ago. A prolongation of this work was that, in order to understand the crucial role played by water in many fields of science, a good understanding of quantum field theory was manadatory.[8] Accordingly, it is only by moving towards quantum field theory, that one could realize that vacuum is a more important stuff than matter. Accordingly, it is worth recalling that atoms were for Greek philosophers such as Leucippus and Democritus immaterial entities, in perfect harmony with quantum physics that see them either as waves packets (Schrödinger's viewpoint) or transcendental matrices (Heisenberg's viewpoint). Mendeleev was also on the same line of thought as the hydrogen atom hardly exists by itself. The fact that it is nevertheless potentially found in all atoms as the sole building block needed for producing the whole periodic table is then quite remarkable. If a single entity, hydrogen, is able to generate the whole material world, filled with so many different substances with quite different physical or chemical properties, a mandatory conclusion is that a hydrogen atom should be more a fruitful concept, a productive thought, than a material thing. If such is really the case, hydrogen and thus water should also have something to do with consciousness, a fascinating line of research that have started this year[9] and will be continued in this journal.[10] So stay tuned to the *Substantia* journal, as so many good things are coming very soon.

[5] L. Montagnier & al. (2017), « Water Bridging Dynamics of Polymerase Chain Reaction in the Gauge Theory Paradigm of Quantum Fields », *Water MDPI*, **9**, 339. doi:10.3390/w9050339.

[6] B. Ting Qang & al. (2019), « Rate limiting factors for DNA transduction induced by weak electromagnetic field », *Electromagnetic Biology and Medicine*, 38:1, 55-65, DOI: 10.1080/15368378.2018.1558064.

[7] J.-P. Jolivet, M. Henry, J. Livage (2000), « *Metal oxide chemistry and synthesis : from solution to solid state* », John Wiley & Sons, Chichester, New-York. Based on a French version published in 1994.

[8] M. Henry, « *The topological and quantum structure of zoemorphic water* », in Aqua Incognita: Why Ice Floats on Water and Galileo 400 Years on, P. Lo Nostro & B. W. Ninham Eds, Connor Court Pub., Ballarat (2014), chap IX, pp. 197-239. See also my book in French, « *L'Eau et la Physique Quantique* », Dangles, Escalquens (2016).

[9] J.-P. Gerbaulet, M. Henry (2019), «The 'Consciousness- Brain' relationship», *Substantia* **3**(1): 113-118. doi: 10.13128/Substantia-161.

[10] M. Henry, J.-P. Gerbaulet (2019) « A scientific rationale for consciousness », *Substantia* **3**(2): 37-54. doi: 10.13128/Substantia-508.