

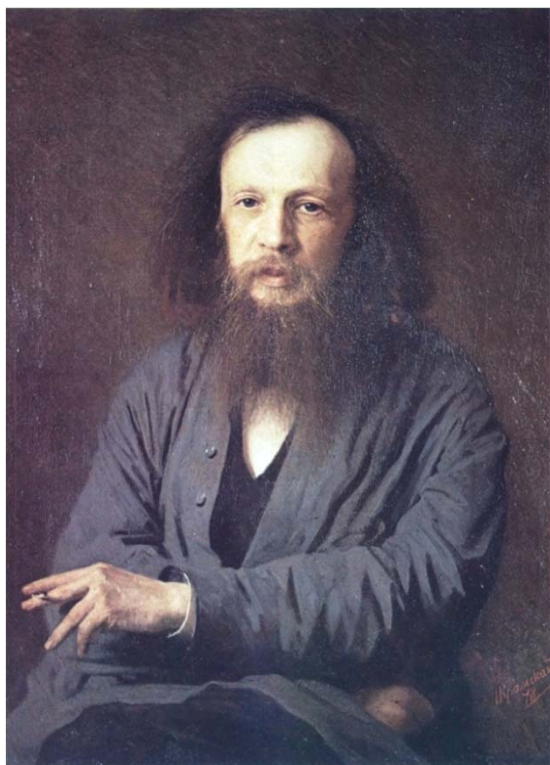


# PERIODIC TABLE OF ELEMENTS

a universal and limitless language for scientists' communication

*Dzmitry Hrynshpan, Tatsiana Savitskaya, Iryna Kimlenka  
Belarusian State University*

# Discovery of Periodic Law



It can be dated by 17<sup>th</sup> February 1869 year

«I wonder what I have done in my scientific life. And done, I think, not bad», " – D.Mendeleev

Portrait of a chemist D.I. Mendeleev,  
N. Kramskoy, 1878  
Museum-archive of DI Mendeleev (St. Petersburg State  
University)

Link: <https://runivers.ru/Runivers/calendar2.php?ID=61726&month=11&year=2009>





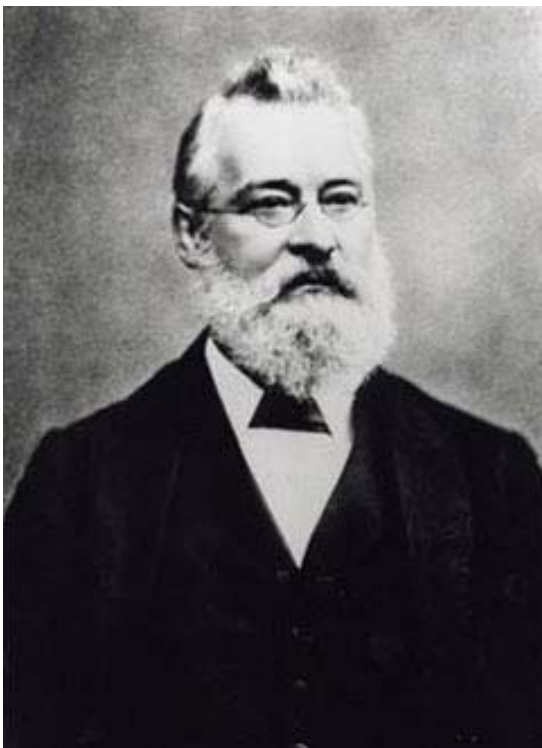
<https://www.technology.matthey.com/article/43/3/122-128-2/>

## «The law of triads»

by Johann Debereiner, 1829 year

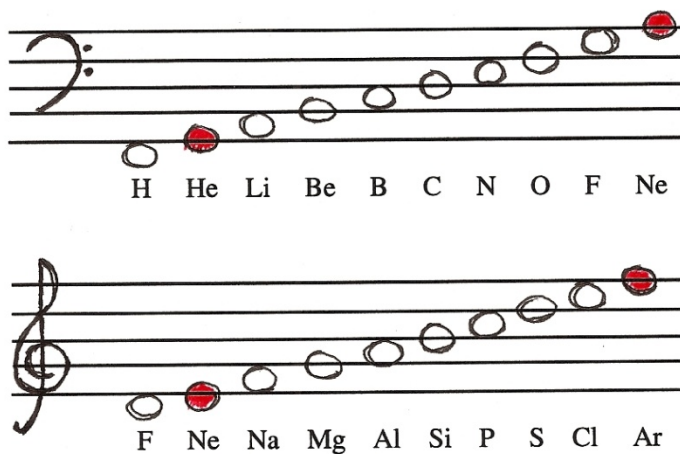
H						He	
Li	Be	B	C	N	O	F	Ne
Na	Mg	Al	Si	P	S	Cl	Ar
K	Ca	Ga	Ge	As	Se	Br	Kr
Rb	Sr	In	Sn	Sb	Te	I	Xe
Cs	Ba	Tl	Pb	Bi	Po	At	Rn

<http://www.physchem.chimfak.rsu.ru/Source/History/Persones/Doebereiner.html>



## «The law of Octaves»

By John Newlands., 1863 year



<http://www.oxforddnb.com/view/10.1093/ref:odnb/9780198614128.001.0001/odnb-9780198614128-e-37807?mediaType=Image>

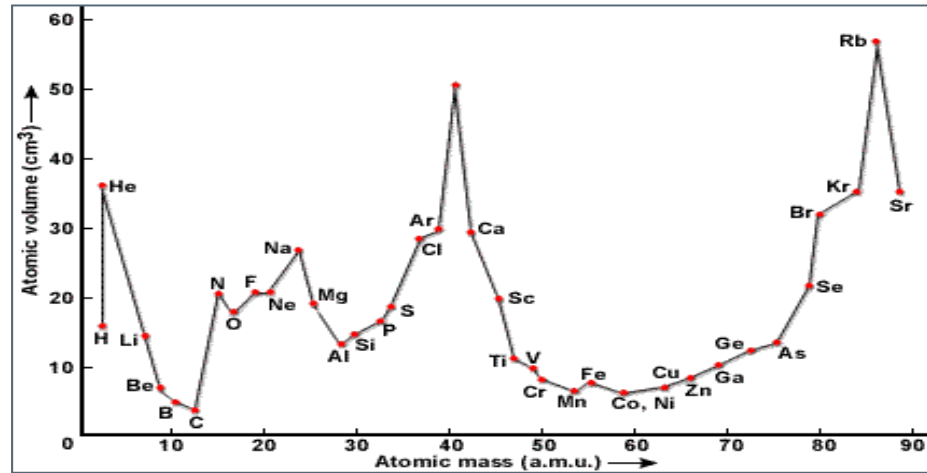
<http://new-periodic1.blogspot.com/2016/06/new-periodic-table-law-of-octaves.html>

# Table of the Elements

Julius Lothar Meyer, 1870 year



<https://www.entrancei.com/chapter-periodic-classification/need-for-classification>



## Julius Lothar Meyer (1830-1895)

Table from *Annalen der Chemie, Supplementband 7*, 354 (1870).

Periodic table according to Lothar Meyer, 1870								
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
	B=11,0	Al=27,3		--		?In=113,4	Tl=202,7	
	C=11,97	Si=28	--	--	--	Sn=117,8	--	Pb=206,4
	N=14,01	P=30,9	Ti=48	As=74,9	Zr=89,7	Sb=122,1	--	Bi=207,5
	O=15,96	31,98	V=51,2	Se=78	Nb=93,7	Te=128,7	Ta=182,2	--
--	F=19,1	Cl=35,38	Cr=52,4	Br=79,75	Mo=95,6	J=126,5	W=183,5	--
			Mn=54,8		Ru=103,5		Os=198,6 ?	
			Fe=55,9		Rh=104,1		Ir=196,7	
			Co=Ni=58,6		Pd=106,2		Pt=196,7	
Li=7,01	Na=22,99	K=39,04		Rb=85,2		Cs=132,7		--
			Cu=63,3		Ag=107,66		Au=196,2	--
?Be=9,3	Mg=23,9	Ca=39,9		Sr=87,0		Ba=136,8		--
			Zn=64,9		Cd=111,6		Hg=199,8	

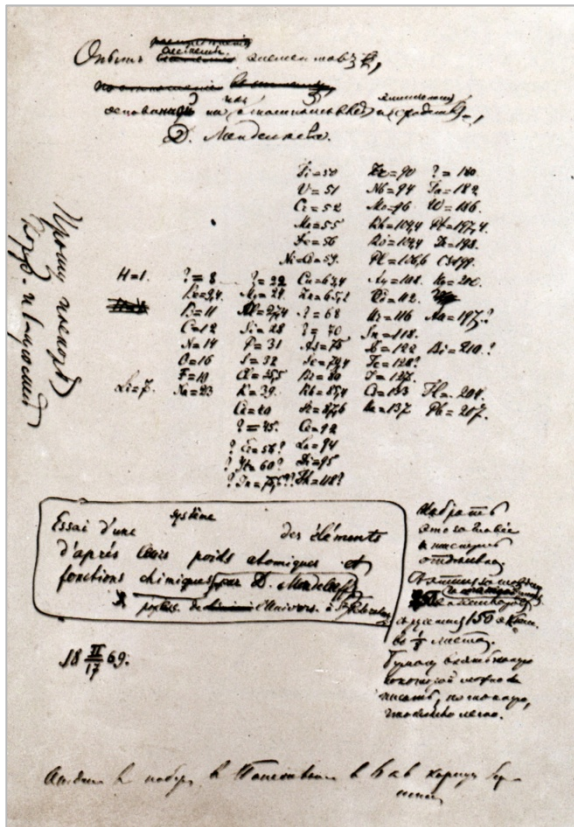
<http://educationbeach.blogspot.com/2013/07/mendeleefs-periodic-table-and.html>



## Textbook "FUNDAMENTALS OF CHEMISTRY"



Mendeleev began to create a system of elements in the connection with the preparation of the textbook "Fundamentals of Chemistry"



Experience of the system of elements

The initial version of the periodic system(1869)

◀ Handwriting option

▶ Published in the article "The ratio of properties with atomic weight of elements "

**ОПЫТЪ СИСТЕМЫ ЭЛЕМЕНТОВЪ**  
 ОСНОВАННОЙ НА ИХЪ АТОМНОМЪ ВѢСѢ И ХИМИЧЕСКОМЪ СХОДСТВѢ

	Ti = 50	Zr = 90	? = 180.			
	V = 51	Nb = 94	Ta = 182			
	Cr = 52	Mo = 96	W = 186.			
	Mn = 55	Rh = 104,4	Pt = 197,4			
	Fe = 56	Ru = 104,4	Ir = 198			
	Ni = 59	Co = 59	Pi = 106,6 Os = 199.			
	Cu = 63,4	Ag = 108	Hg = 200			
H = 1	Be = 9,4	Mg = 24	Zn = 65,2 Cd = 112			
	B = 11	Al = 27,4	? = 68	Uc = 116	Au = 197?	
	C = 12	Si = 28	? = 70	Sn = 118		
	N = 14	P = 31	As = 75	Sb = 122	Bi = 210?	
	O = 16	S = 32	Se = 79,4	Te = 128?		
	F = 19	Cl = 35	Br = 80	I = 127		
	Li = 7	Na = 23	K = 39	Rb = 85,4	Cs = 133	Tl = 204
			Ca = 40	Sr = 87,6	Ba = 137	Pb = 207
			? = 45	Ce = 92		
			?Er = 56	La = 94		
			?Yt = 60	Di = 95		
			?In = 75,6	Th = 118?		

И. Менделѣевъ

<https://muctr.ru/university/about/history/mendeleev/>

<http://www.himikatus.ru/art/chemistry/periodicl.php>



# Short form of the periodic table

		ПЕРИОДИЧЕСКАЯ СИСТЕМА ЭЛЕМЕНТОВ Д. И. МЕНДЕЛЕЕВА										VII (H)		VIII					
		II		III	IV	V	VI			атомный номер		обозначение элемента							
1	1	H <sup>1</sup> 1,01 ВОДОРОД												4,00	2 He ГЕЛИЙ				
2	2	Li <sup>3</sup> 6,94 ЛИТИЙ	Be <sup>4</sup> 9,01 БЕРИЛЛИЙ	10,81	12,01	14,01	16,00	19,00	20,18	35,45	39,95	6 C УГЛЕРОД 12,01	10 Ne НЕОН	18 Ar АРГОН	28 Ni НИКЕЛЬ				
3	3	Na <sup>11</sup> 22,99 НАТРИЙ	Mg <sup>12</sup> 24,31 МАГНИЙ	26,98	28,09	30,97	32,06	35,45	39,95	54,94	55,85	58,93	78 Ni НИКЕЛЬ	86 Kr КРИПТОН	83,80				
4	4	K <sup>19</sup> 39,10 КАЛИЙ	Ca <sup>20</sup> 40,08 КАЛЬЦИЙ	44,96	47,90	50,94	52,00	54,94	55,85	58,93	58,70	58,70	58,70	58,70	58,70				
5	5	63,55	65,38	69,72	72,59	74,92	78,96	79,90	83,80	85,47	87,62	88,91	91,22	92,91	95,94	98,91	101,07	102,91	106,42
6	6	Rb <sup>37</sup> 85,47 РУБИДИЙ	Sr <sup>38</sup> 87,62 СТРОНЦИЙ	88,91	91,22	92,91	95,94	98,91	101,07	102,91	106,42	106,42	106,42	106,42	106,42	106,42	106,42	106,42	106,42
7	7	107,87	112,41	114,82	118,69	121,75	127,60	126,90	131,30	131,30	131,30	131,30	131,30	131,30	131,30	131,30	131,30	131,30	131,30
8	8	Cs <sup>55</sup> 132,91 ЦЕЗИЙ	Ba <sup>56</sup> 137,33 БАРИЙ	138,91	178,49	180,95	183,85	186,21	190,20	192,22	195,09	195,09	195,09	195,09	195,09	195,09	195,09	195,09	195,09
9	9	196,97	200,59	204,37	207,20	208,98	[209]	[210]	[210]	[210]	[210]	[210]	[210]	[210]	[210]	[210]	[210]	[210]	[210]
10	10	Fr <sup>87</sup> [223] ФРАНЦИЙ	Ra <sup>88</sup> 226,03 РАДИЙ	[227]	[261]	[261]	[263]	[262]	[265]	[266]	[271]	[271]	[271]	[271]	[271]	[271]	[271]	[271]	[271]

* ЛАНТАНОИДЫ													
58	59	60	61	62	63	64	65	66	67	68	69	70	71
Ce 140,12 ЦЕРИЙ	Pr 140,91 ПРАЗЕОДИМ	Nd 144,24 НЕОДИМ	Pm [145] ПРОМЕТИЙ	Sm 150,40 САМАРИЙ	Eu 151,96 ЕВРОПИЙ	Gd 157,25 ГАДОЛИНИЙ	Tb 158,93 ТЕРБИЙ	Dy 162,50 ДИСПРОЗИЙ	Ho 164,93 ГОЛЬМИЙ	Er 167,26 ЭРБИЙ	Tm 168,93 ТУЛИЙ	Yb 173,04 ИТТЕРБИЙ	Lu 174,97 ЛОУТЦИЙ

** АКТИНОИДЫ													
90	91	92	93	94	95	96	97	98	99	100	101	102	103
Th 232,04 ТОРИЙ	Pa 231,04 ПРОТОАКТИНИЙ	U 238,03 УРАН	Np 237,05 НЕПТУНИЙ	Pu [244] ПЛУТОНИЙ	Am [243] АМЕРИЦИЙ	Cm [247] КУРИЙ	Bk [247] БЕРКЛИЙ	Cf [251] КАЛИФОРНИЙ	Es [254] ЭЙНШТЕЙНИЙ	Fm [257] ФЕРМИЙ	Md [258] МЕНДЕЛЕВИЙ	(No) [255] НОБЕЛИЙ	(Lr) [256] ЛОУРЕНСИЙ

<https://sunfreedomnu.weebly.com/blog/tablica-mendeleeva-v-uchebnike-po-himii>

# Long form of the periodic table

It was recommended by IUPAC in 1989

1 <b>H</b> hydrogen 1.008 [1.0078, 1.0082]																	2 <b>He</b> helium 4.0026
3 <b>Li</b> lithium 6.94 [6.938, 6.947]	4 <b>Be</b> beryllium 9.0122											5 <b>B</b> boron 10.81 [10.808, 10.821]	6 <b>C</b> carbon 12.01 [12.009, 12.012]	7 <b>N</b> nitrogen 14.007 [14.006, 14.008]	8 <b>O</b> oxygen 15.999 [15.999, 16.000]	9 <b>F</b> fluorine 18.998	10 <b>Ne</b> neon 20.180
11 <b>Na</b> sodium 22.990	12 <b>Mg</b> magnesium 24.305 [24.304, 24.307]											13 <b>Al</b> aluminium 26.982	14 <b>Si</b> silicon 28.086 [28.084, 28.088]	15 <b>P</b> phosphorus 30.974	16 <b>S</b> sulfur 32.06 [32.059, 32.076]	17 <b>Cl</b> chlorine 35.45 [35.446, 35.457]	18 <b>Ar</b> argon 39.95 [39.962, 39.963]
19 <b>K</b> potassium 39.098	20 <b>Ca</b> calcium 40.078(4)	21 <b>Sc</b> scandium 44.956	22 <b>Ti</b> titanium 47.867	23 <b>V</b> vanadium 50.942	24 <b>Cr</b> chromium 51.996	25 <b>Mn</b> manganese 54.938	26 <b>Fe</b> iron 55.845(2)	27 <b>Co</b> cobalt 58.933	28 <b>Ni</b> nickel 58.693	29 <b>Cu</b> copper 63.546(3)	30 <b>Zn</b> zinc 65.38(2)	31 <b>Ga</b> gallium 69.723	32 <b>Ge</b> germanium 72.630(8)	33 <b>As</b> arsenic 74.922	34 <b>Se</b> selenium 78.971(8)	35 <b>Br</b> bromine 79.904 [79.901, 79.907]	36 <b>Kr</b> krypton 83.798(2)
37 <b>Rb</b> rubidium 85.468	38 <b>Sr</b> strontium 87.62	39 <b>Y</b> yttrium 88.906	40 <b>Zr</b> zirconium 91.224(2)	41 <b>Nb</b> niobium 92.906	42 <b>Mo</b> molybdenum 95.95	43 <b>Tc</b> technetium 98.906	44 <b>Ru</b> ruthenium 101.07(2)	45 <b>Rh</b> rhodium 102.91	46 <b>Pd</b> palladium 106.42	47 <b>Ag</b> silver 107.87	48 <b>Cd</b> cadmium 112.41	49 <b>In</b> indium 114.82	50 <b>Sn</b> tin 118.71	51 <b>Sb</b> antimony 121.76	52 <b>Te</b> tellurium 127.60(3)	53 <b>I</b> iodine 126.90	54 <b>Xe</b> xenon 131.29
55 <b>Cs</b> caesium 132.91	56 <b>Ba</b> barium 137.33	57-71 lanthanoids	72 <b>Hf</b> hafnium 178.49(2)	73 <b>Ta</b> tantalum 180.95	74 <b>W</b> tungsten 183.84	75 <b>Re</b> rhenium 186.21	76 <b>Os</b> osmium 190.23(3)	77 <b>Ir</b> iridium 192.22	78 <b>Pt</b> platinum 195.08	79 <b>Au</b> gold 196.97	80 <b>Hg</b> mercury 200.59	81 <b>Tl</b> thallium 204.38 [204.38, 204.39]	82 <b>Pb</b> lead 207.2	83 <b>Bi</b> bismuth 208.98	84 <b>Po</b> polonium	85 <b>At</b> astatine	86 <b>Rn</b> radon
87 <b>Fr</b> francium	88 <b>Ra</b> radium	89-103 actinoids	104 <b>Rf</b> rutherfordium	105 <b>Db</b> dubnium	106 <b>Sg</b> seaborgium	107 <b>Bh</b> bohrium	108 <b>Hs</b> hassium	109 <b>Mt</b> meitnerium	110 <b>Ds</b> darmstadtium	111 <b>Rg</b> roentgenium	112 <b>Cn</b> copernicium	113 <b>Nh</b> nihonium	114 <b>Fl</b> flerovium	115 <b>Mc</b> moscovium	116 <b>Lv</b> livermorium	117 <b>Ts</b> tennessine	118 <b>Og</b> oganesson

Key:  
atomic number  
Symbol  
name  
conventional atomic weight  
standard atomic weight

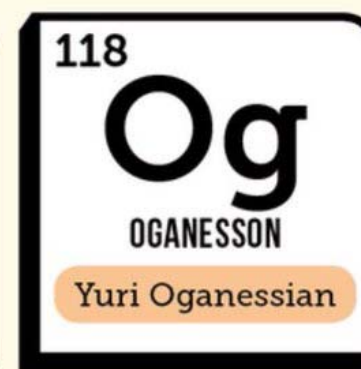
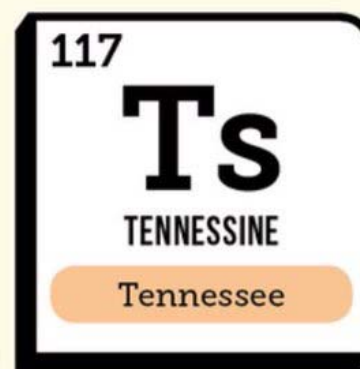


57 <b>La</b> lanthanum 138.91	58 <b>Ce</b> cerium 140.12	59 <b>Pr</b> praseodymium 140.91	60 <b>Nd</b> neodymium 144.24	61 <b>Pm</b> promethium	62 <b>Sm</b> samarium 150.36(2)	63 <b>Eu</b> europium 151.96	64 <b>Gd</b> gadolinium 157.25(3)	65 <b>Tb</b> terbium 158.93	66 <b>Dy</b> dysprosium 162.50	67 <b>Ho</b> holmium 164.93	68 <b>Er</b> erbium 167.26	69 <b>Tm</b> thulium 168.93	70 <b>Yb</b> ytterbium 173.05	71 <b>Lu</b> lutetium 174.97
89 <b>Ac</b> actinium	90 <b>Th</b> thorium 232.04	91 <b>Pa</b> protactinium 231.04	92 <b>U</b> uranium 238.03	93 <b>Np</b> neptunium	94 <b>Pu</b> plutonium	95 <b>Am</b> americium	96 <b>Cm</b> curium	97 <b>Bk</b> berkelium	98 <b>Cf</b> californium	99 <b>Es</b> einsteinium	100 <b>Fm</b> fermium	101 <b>Md</b> mendelevium	102 <b>No</b> nobelium	103 <b>Lr</b> lawrencium

For notes and updates to this table, see [www.iupac.org](http://www.iupac.org). This version is dated 1 December 2018.  
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[https://iupac.org/wp-content/uploads/2018/12/IUPAC\\_Periodic\\_Table-01Dec18.jpg](https://iupac.org/wp-content/uploads/2018/12/IUPAC_Periodic_Table-01Dec18.jpg)

# PROPOSED NEW ELEMENT NAMES



These are the proposed symbols and names for elements 113, 115, 117 and 118, along with their origins. After a five month public review period, they will be officially confirmed.



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# Extra long form of the Table

s-Block																d-Block										p-Block										
H																Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	B	C	N	O	F	Ne					
Li	Be															Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	Al	Si	P	S	Cl	Ar					
Na	Mg																Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Ga	Ge	As	Se	Br	Kr					
K	Ca																Rf	Db	Sg	Bh	Hs	Mt	Uun	Uuu	Uub	In	Sn	Sb	Te	I	Xe					
Rb	Sr																									Tl	Pb	Bi	Po	At	Rn					
Cs	Ba	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu																				Uuq
Fr	Ra	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr																				

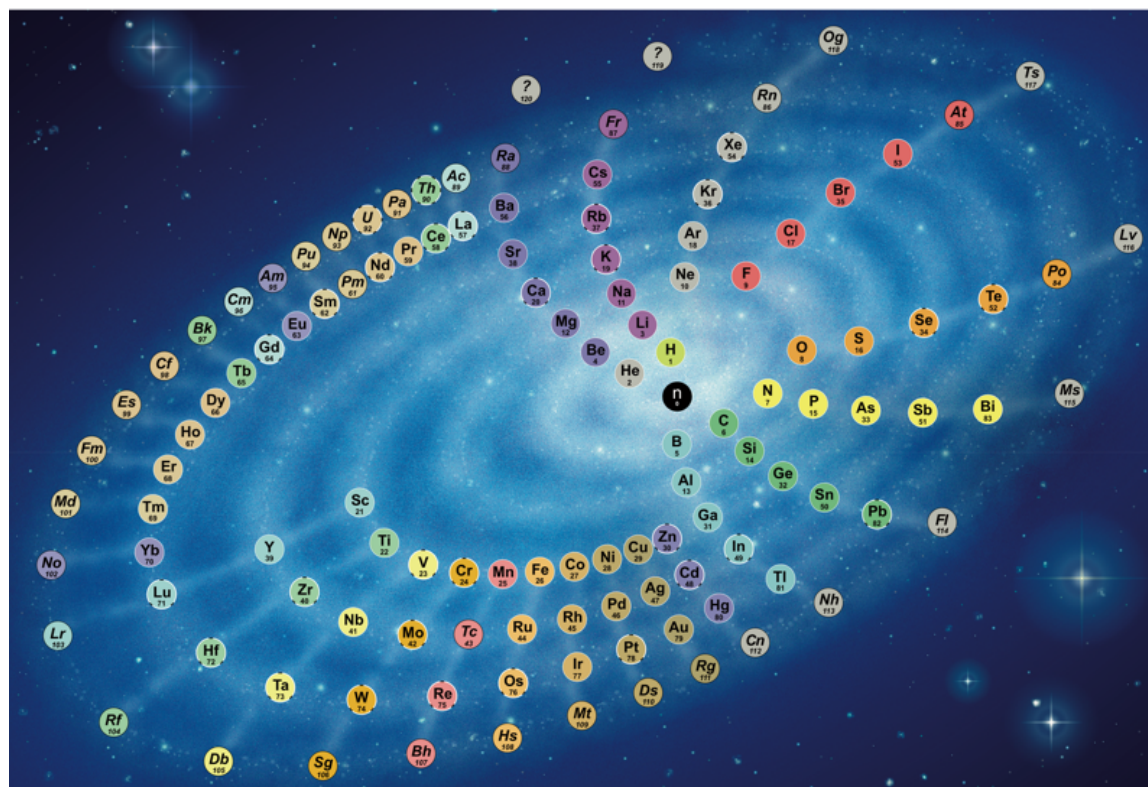
# The Pyramidal Form by Baley-Thomson-Bor

ns																																
1	H	He																														
		np																														
2	Li	Be	B	C	N	O	F	Ne																								
3	Na	Mg	Al	Si	P	S	Cl	Ar																								
		(n-1)d																														
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr														
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe														
		(n-2)f																														
6	Cs	Ba	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
7	Fr	Ra	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr	Rf	Db	Sg	Bh	Hs	Mt	110	111	112	113	114	115	116	117	118
ns		(n-2)f														(n-1)d						np										

# «Chemical Galaxy» by Philip Stewart

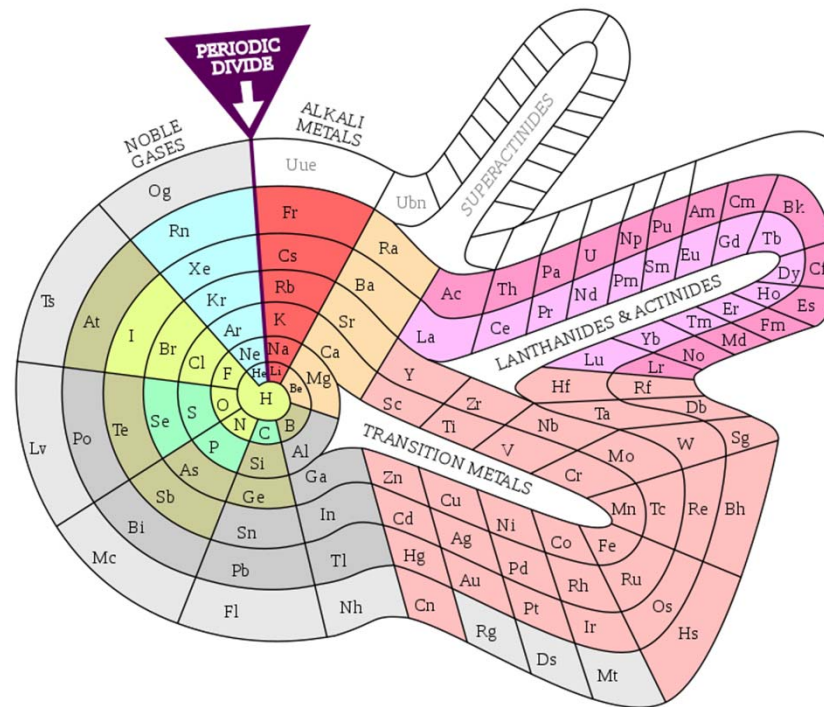
## CHEMICAL GALAXY III

A NEW VISION OF THE PERIODIC SYSTEM OF THE ELEMENTS



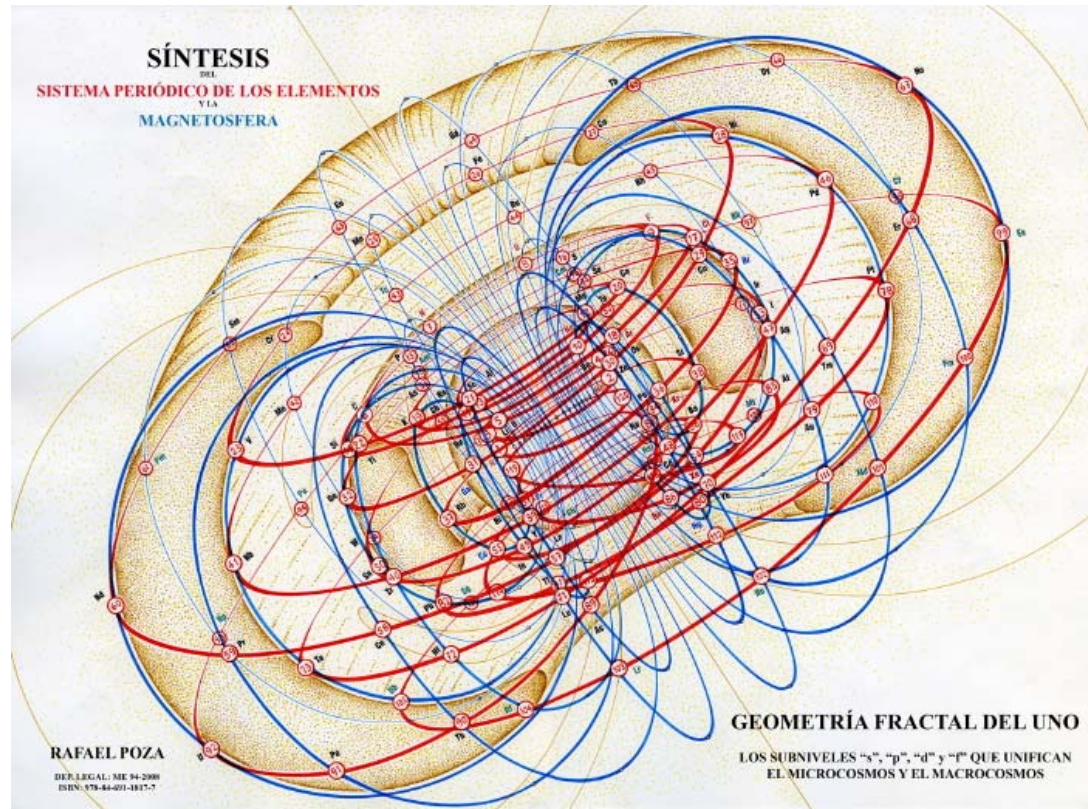
[https://www.meta-synthesis.com/webbook/35\\_pt/pt\\_database.php?Button=2010-Present+Formulations](https://www.meta-synthesis.com/webbook/35_pt/pt_database.php?Button=2010-Present+Formulations)

# Spiral system form by Theodore Benfli



[https://www.meta-synthesis.com/webbook/35\\_pt/pt\\_database.php?Button=2010-Present+Formulations](https://www.meta-synthesis.com/webbook/35_pt/pt_database.php?Button=2010-Present+Formulations)

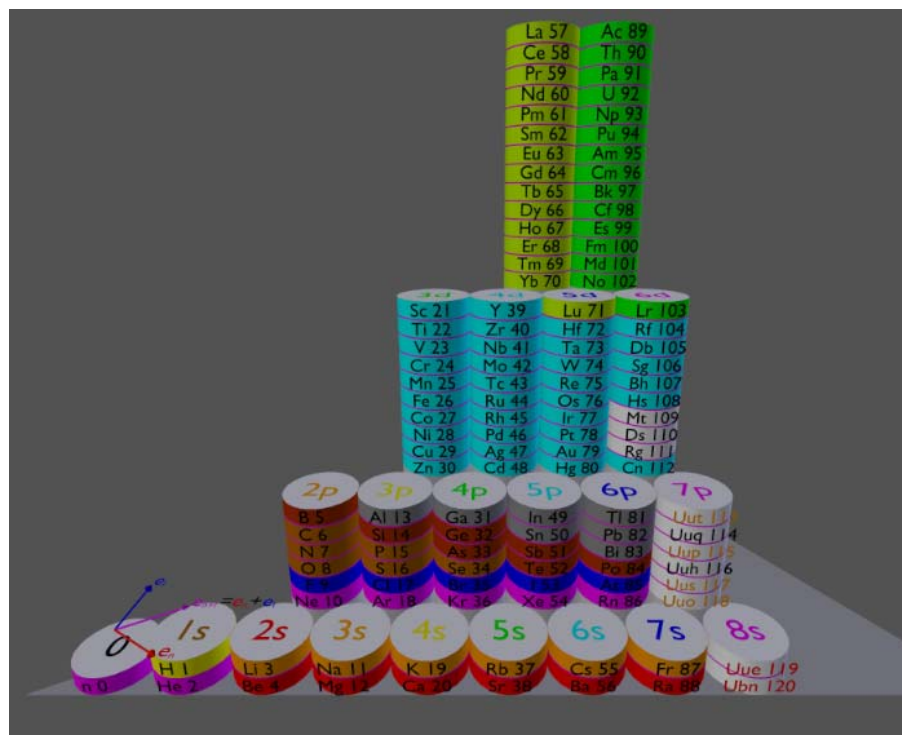
# Periodic system superimposed on the magnetosphere



[https://www.meta-synthesis.com/webbook/35\\_pt/pt\\_database.php?Button=2010-Present+Formulations](https://www.meta-synthesis.com/webbook/35_pt/pt_database.php?Button=2010-Present+Formulations)



# 3D Periodic Table



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[https://www.meta-synthesis.com/webbook/35\\_pt/pt\\_database.php?Button=2010-Present+Formulations](https://www.meta-synthesis.com/webbook/35_pt/pt_database.php?Button=2010-Present+Formulations)

# Inverted Periodic Table

**a**

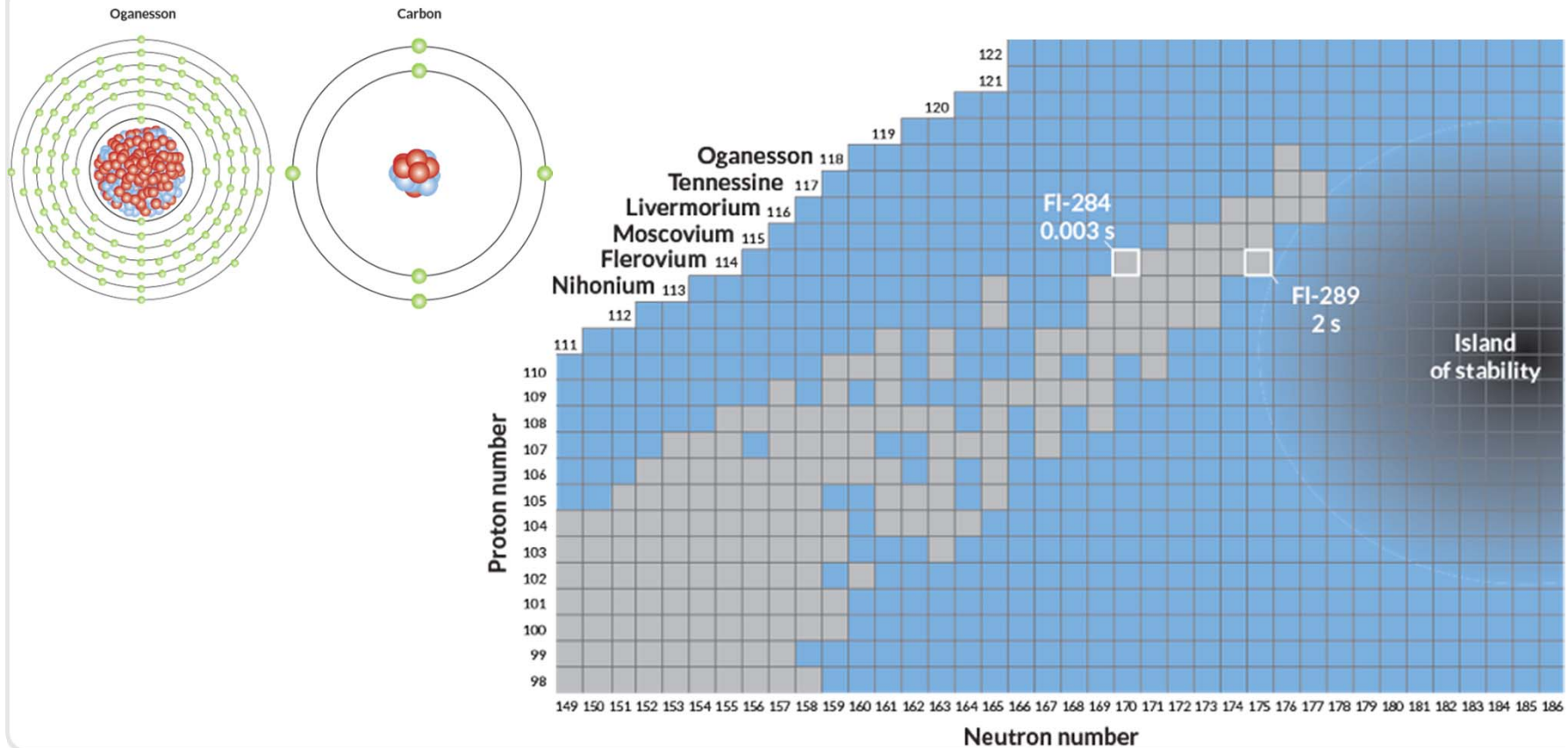
7	89	90	91	92	93	94	95	96	97	98	99	100	101	102				
	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No				
6	57	58	59	60	61	62	63	64	65	66	67	68	69	70				
	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb				
7	87	88	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118
	Fr	Ra	Lr	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og
6	55	56	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
	Cs	Ba	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
5	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
4	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
3	11	12	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	Na	Mg											Al	Si	P	S	Cl	Ar
2	3	4											5	6	7	8	9	10
	Li	Be											B	C	N	O	F	Ne
1	1	2											13	14	15	16	17	2
	H												He					
	1												18					

# The Upper boundary of the periodic table

1 H																	18 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og
119	120																
		57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb		
		89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No		

<https://www.sciencenews.org/article/physics-periodic-table-future-superheavy-elements>

# The Upper boundary: Islands of stability



<https://www.sciencenews.org/article/physics-periodic-table-future-superheavy-elements>

# International Student Practice on the basis of the Joint Institute for Nuclear Research (Dubna)

Mass Analyzer of Super Heavy Atoms



**St. Petersburg University. In this building he taught (1857–1890) and lived (1866–1890). DI Mendeleev**



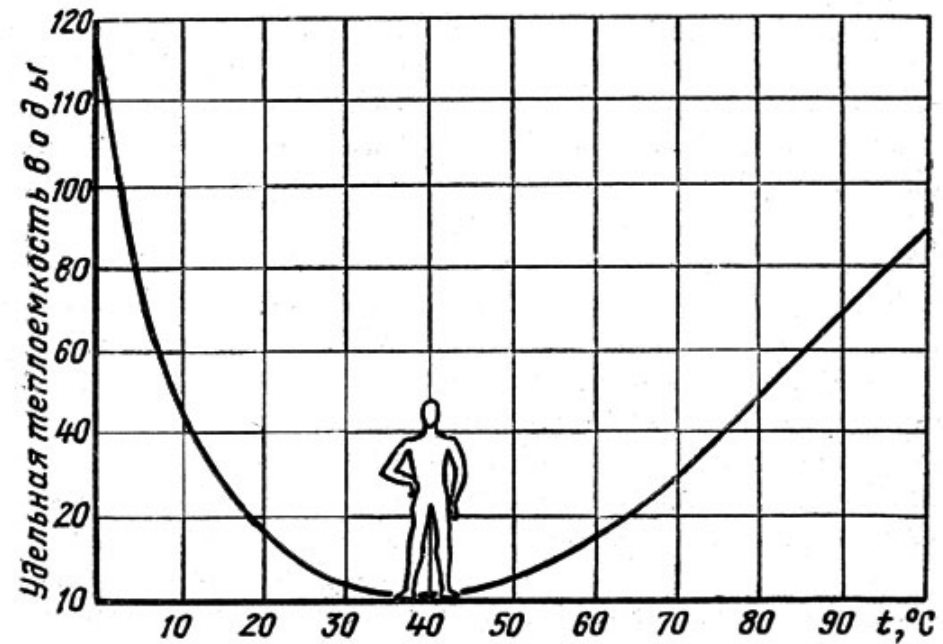
**1865 - D.I. Mendeleev (31) defended his doctoral thesis “On the combination of alcohol with water” and was elected an ordinary professor of physical chemistry at St. Petersburg University.**

**175 years since the birth of D.I. Mendeleev**

# WATER riddles

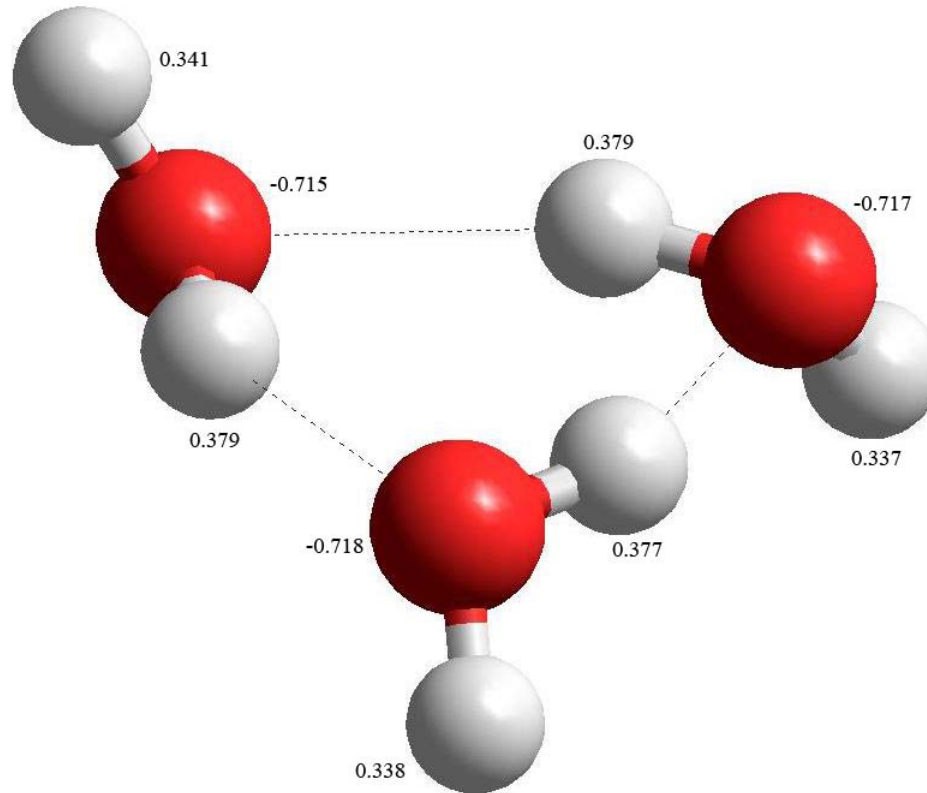


# Anomaly of the specific heat of water

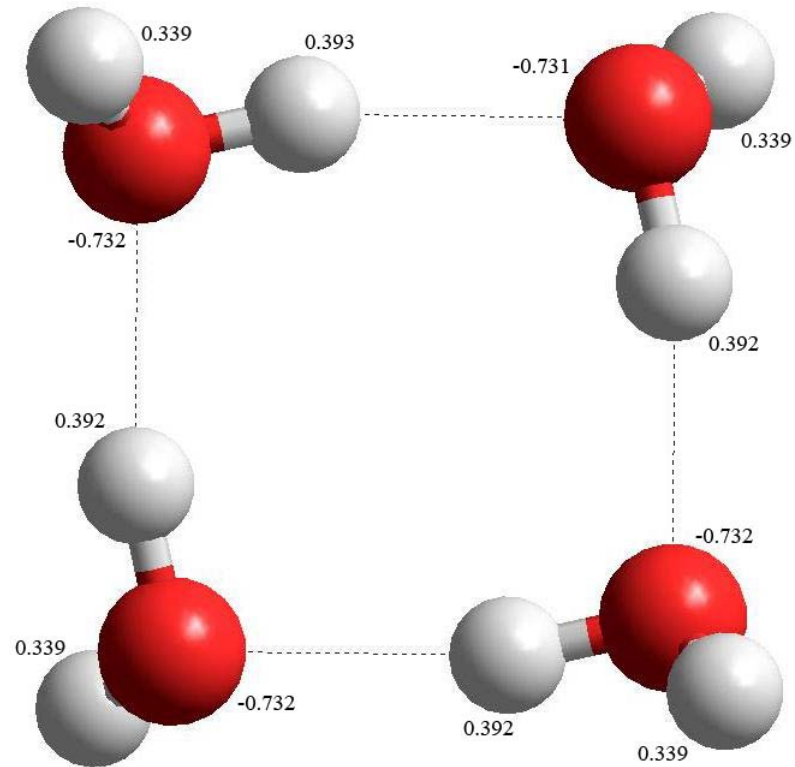




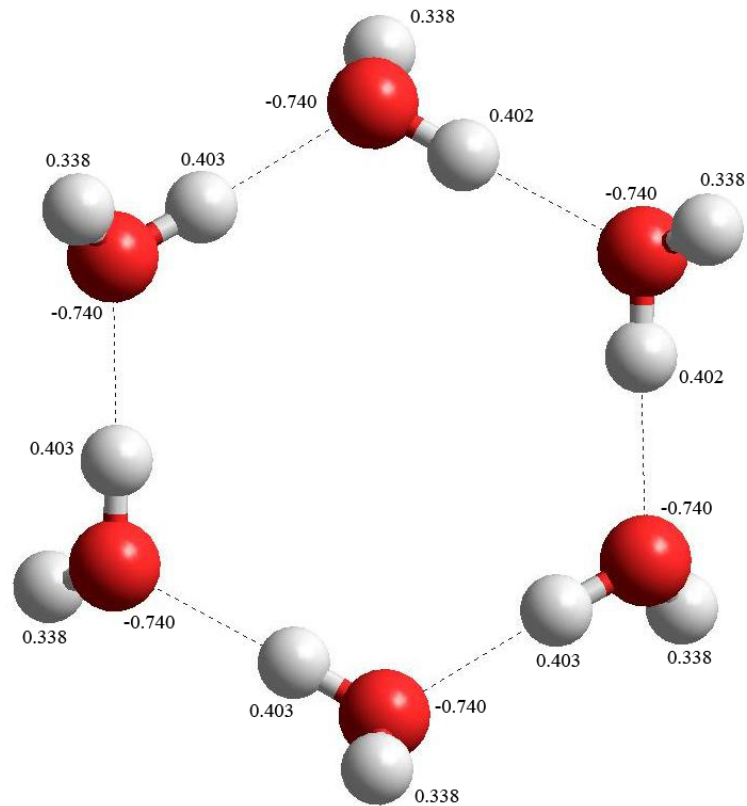
# Water associates: Trimer



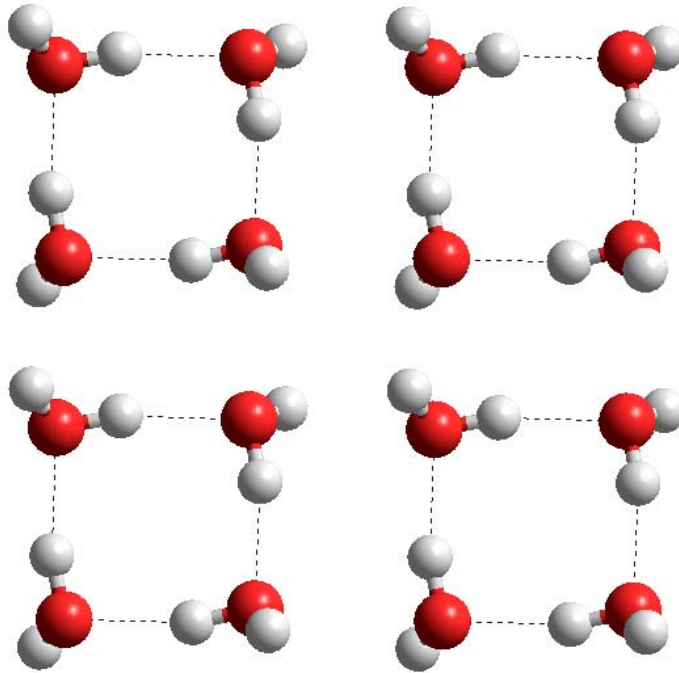
# Water associates: Tetramer



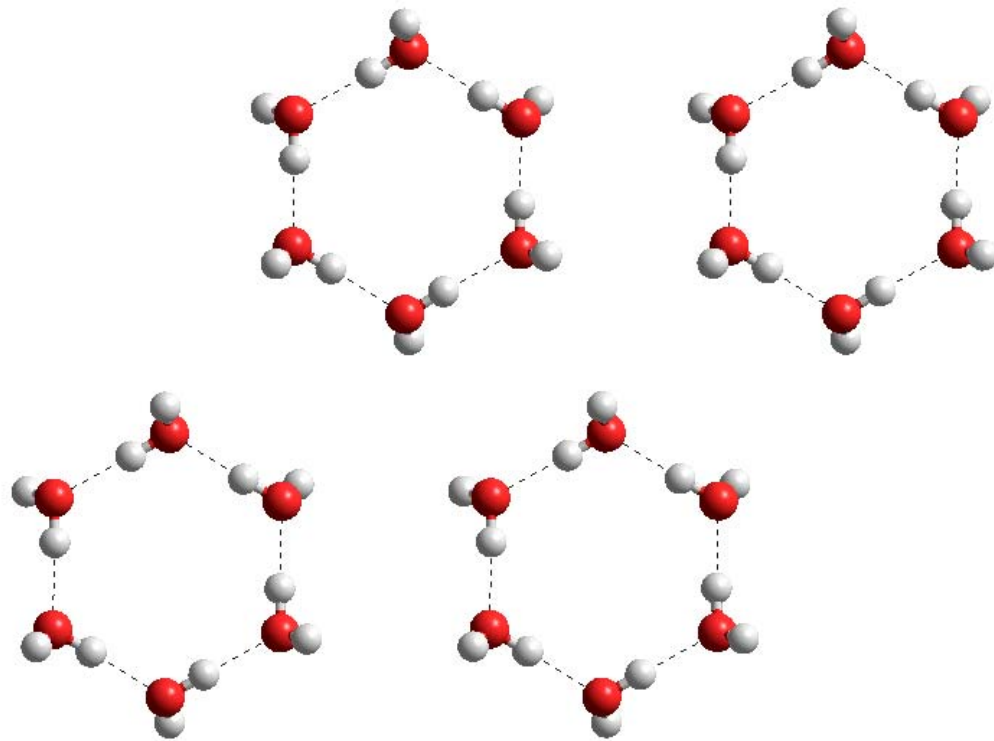
# Water associates: hexamer



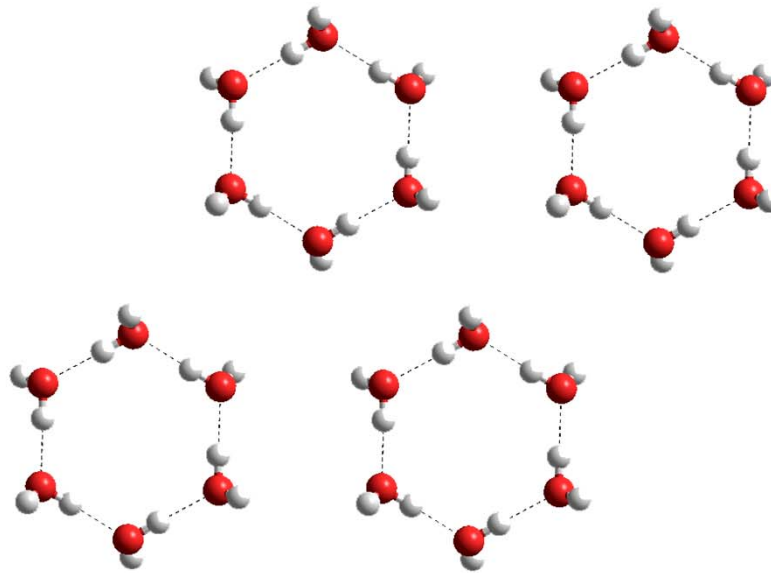
4°C ( $\rho=1.0000 \text{ g/cm}^3$ )

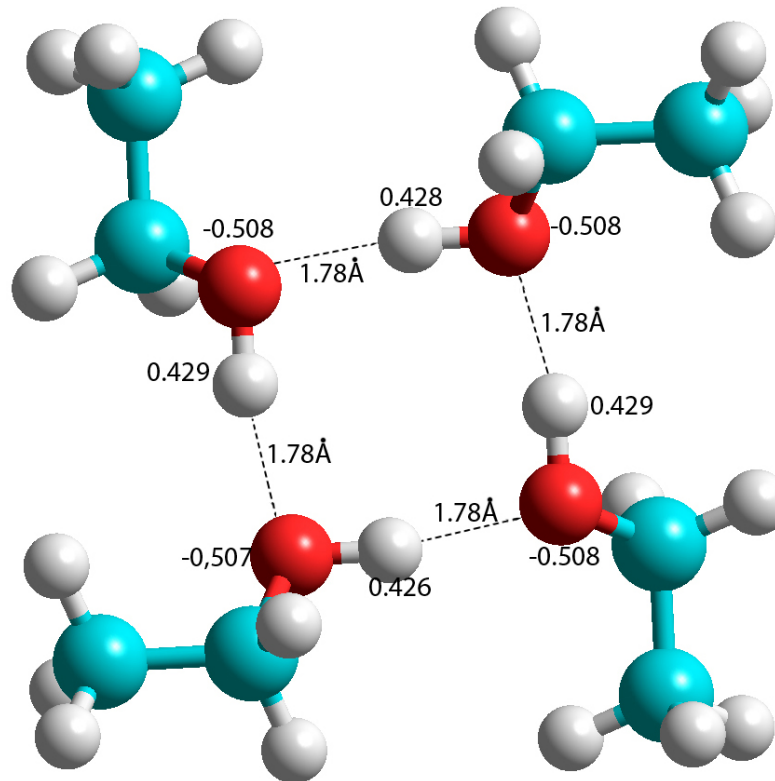


0°C ( $\rho=0.9998 \text{ g/cm}^3$ )



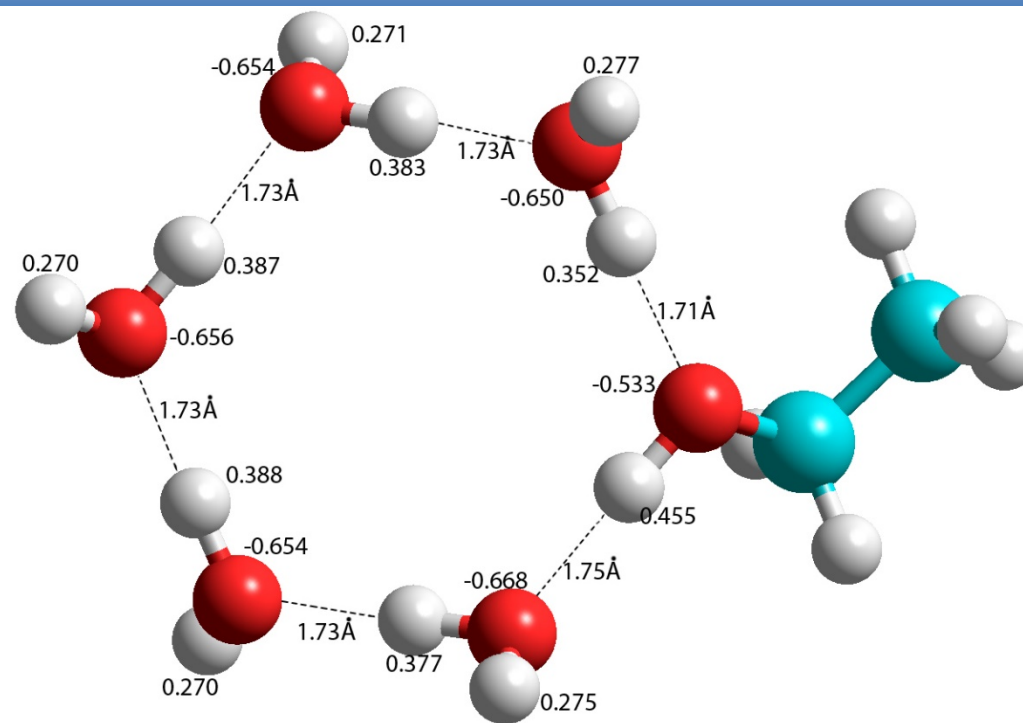
## Packaging of hexamers





Associate of ethanol,  
structural unit of alcohol

# “Formula of vodka” (40°)







**Thank you for the attention!**

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