

EPFL

Chimie des Éléments s et p

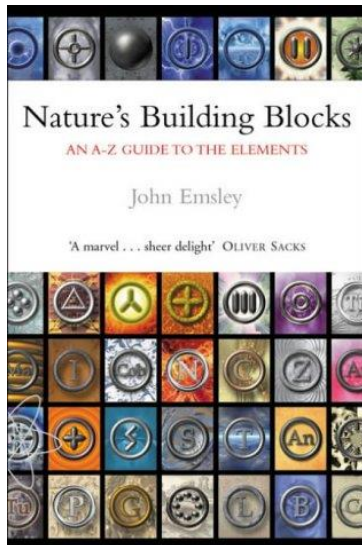
Kay Severin

Content

- Introduction
- Structures
- Hydrogen
- Alkali Metals
- Earth Alkaline Metals
- Group 13 Elements
- Group 14 Elements
- Group 15 Elements
- Group 16 Elements
- Halogens
- Nobel Gases

Group Period →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	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
5	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
6	55 Cs	56 Ba	57 La *	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
7	87 Fr	88 Ra	89 Ac *	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
				* 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	71 Lu	
				* 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	103 Lr	

Literature



« Nature's Building Blocks »

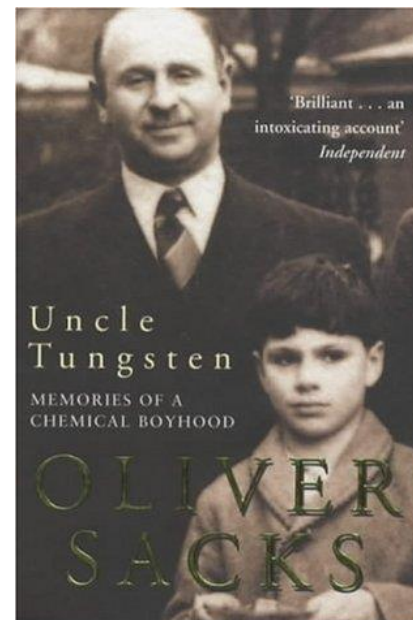
John Emsley

Comment: Very interesting facts about the history and the economics of the elements.

« Uncle Tungsten – Memoires of a Chemical Boyhood »

Oliver Sacks

Comment: Autobiography with lots of chemistry anecdotes and history.



Websites

THE PERIODIC TABLE OF VIDEOS  The University of Nottingham

Extra videos Molecules Roadtrips Photos YouTube Twitter Physics Email  7K  79

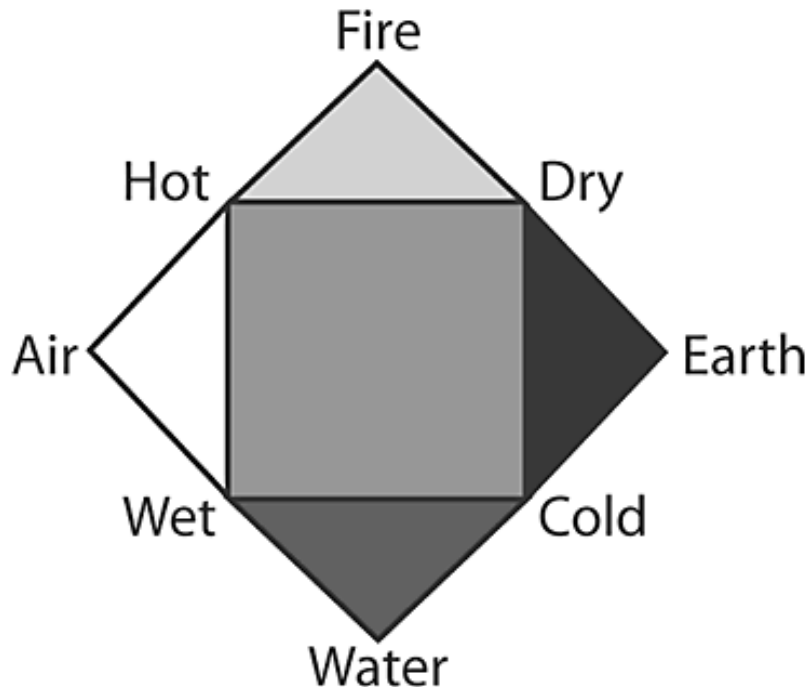
NEW VIDEOS:       

 = recently updated

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

<http://www.periodicvideos.com>

The Four Elements



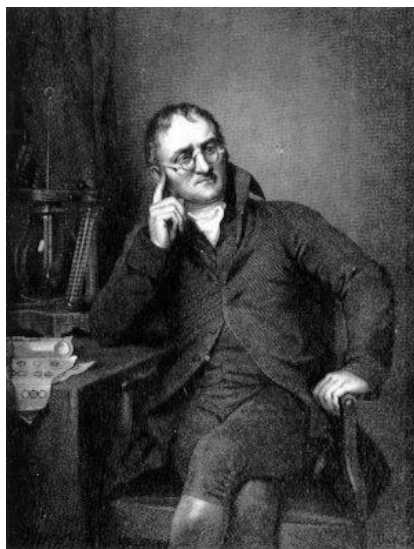
All material things are made up of these four substances in some proportions. They were not thought of as elements in the modern sense of the word. "Water" could apply to other liquid substances, "earth" to any of several solid materials, and "air" to any gas. Associated with the four primordial substances are four primary qualities: heat, cold, moisture, and dryness.

In 1624 the French chemist Étienne de Clave was arrested because he questioned this scheme!

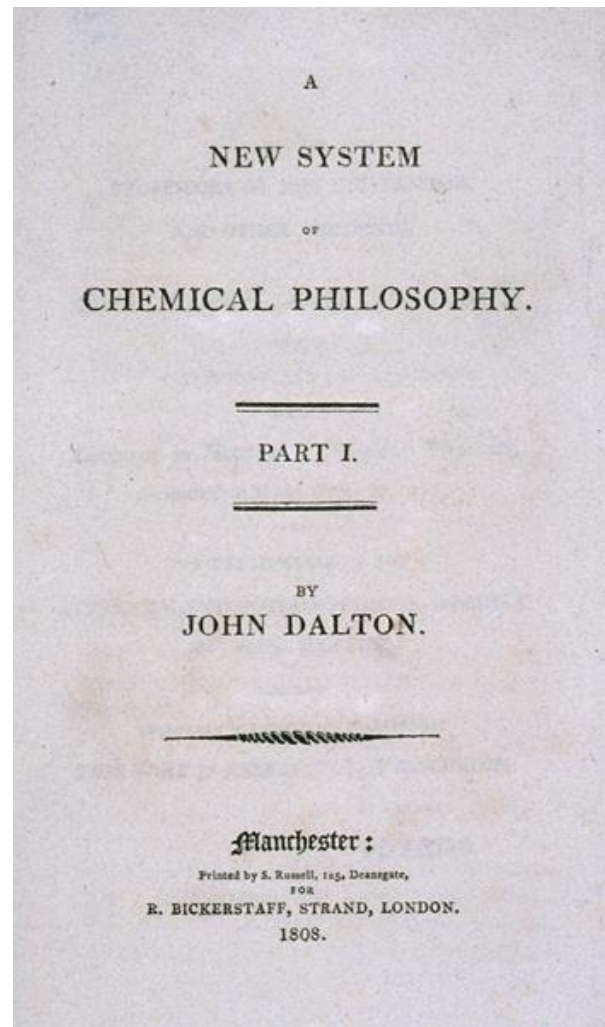
Empedocles (c. 490 – 430 BC) → Aristotle (384 – 322 BC)

The Atomic Theory

- Dalton's presented his atomic theory in his book « A New System of Chemical Philosophy » in 1808.
- He assumed atoms (from the Greek *atomos*) with a certain weight, which are identical for the same element.



John Dalton
(1766 – 1844)



Dalton's Atomic Symbols

HO
and not
H₂O !

ELEMENTS.								Plate IV.
Simple								
1	2	3	4	5	6	7	8	
9	10	11	12	13	14	15	16	
		17	18	19	20			
Binary								
21	22	23	24	25				
Ternary								
26	27	28	29					
Quaternary								
30	31	32	33					
Quinquenary & Sexternary								
34	35							
Septenary								
36	37							

EXPLANATION OF THE PLATES. 219

PLATE IV. This plate contains the arbitrary marks or signs chosen to represent the several chemical elements or ultimate particles.

Fig.		Fig.	
1	Hydrog. its rel. weight 1	11	Strontites - - - 46
2	Azote, - - - 5	12	Barytes - - - 68
3	Carbon or charcoal, - 5	13	Iron - - - 38
4	Oxygen, - - - 7	14	Zinc - - - 56
5	Phosphorus, - - - 9	15	Copper - - - 56
6	Sulphur, - - - 13	16	Lead - - - 95
7	Magnesia, - - - 20	17	Silver - - - 100
8	Lime, - - - 21	18	Platina - - - 100
9	Soda, - - - 28	19	Gold - - - 140
10	Potash, - - - 42	20	Mercury - - - 167
21	An atom of water or steam, composed of 1 of oxygen and 1 of hydrogen, retained in physical contact by a strong affinity, and supposed to be surrounded by a common atmosphere of heat; its relative weight = - - - 8		
22	An atom of ammonia, composed of 1 of azote and 1 of hydrogen - - - 6		
23	An atom of nitrous gas, composed of 1 of azote and 1 of oxygen - - - 12		
24	An atom of olefiant gas, composed of 1 of carbone and 1 of hydrogen - - - 6		
25	An atom of carbonic oxide composed of 1 of carbone and 1 of oxygen - - - 12		
26	An atom of nitrous oxide, 2 azote + 1 oxygen - 17		
27	An atom of nitric acid, 1 azote + 2 oxygen - 19		
28	An atom of carbonic acid, 1 carbone + 2 oxygen 19		
29	An atom of carburetted hydrogen, 1 carbone + 2 hydrogen - - - 7		
30	An atom of oxy-nitric acid, 1 azote + 3 oxygen 26		
31	An atom of sulphuric acid, 1 sulphur + 3 oxygen 34		
32	An atom of sulphuretted hydrogen, 1 sulphur + 3 hydrogen - - - 16		
33	An atom of alcohol, 3 carbone + 1 hydrogen - 16		
34	An atom of nitrous acid, 1 nitric acid + 1 nitrous gas - - - 31		
35	An atom of acetous acid, 2 carbone + 2 water - 26		
36	An atom of nitrate of ammonia, 1 nitric acid + 1 ammonia + 1 water - - - 33		
37	An atom of sugar, 1 alcohol + 1 carbonic acid - 35		

Dalton's symbols for the atoms of various elements and their compounds.

The Periodic Table – Mendeleev

- Russian chemist who worked in St. Petersburg
- Arranged the 63 known elements into a periodic table based on atomic mass, which he published in 1869.
- Similar attempts were presented by other scientists at around the same time.
- Predicted the existence and properties of new elements and pointed out accepted atomic weights that were in error.
- His table did not include any of the Noble Gases, which had not yet been discovered.



Dimitri Ivanovitch Mendeleev
(1834-1907)

The Periodic Table – Mendeleev

Tabelle II.

Reihen	Gruppe I. — R ⁰	Gruppe II. — R ⁰	Gruppe III. — R ⁰	Gruppe IV. RR ⁴ R ⁰	Gruppe V. RR ⁴ R ⁰	Gruppe VI. RR ⁴ R ⁰	Gruppe VII. RR ⁴ R ⁰	Gruppe VIII. — R ⁰
1	H=1							
2	Li=7	Bc=9,4	B=11	C=12	N=14	O=16	F=19	
3	Na=23	Mg=24	Al=27,3	Si=28	P=31	S=32	Cl=35,5	
4	K=39	Ca=40	—=44	Ti=48	V=51	Cr=52	Mn=55	Fe=56, Co=59, Ni=59, Cu=63.
5	(Cu=63)	Zn=65	—=68	—=72	As=75	Se=78	Br=80	
6	Rb=85	Sr=87	?Yt=88	Zr=90	Nb=94	Mo=96	—=100	Ru=104, Rh=104, Pd=106, Ag=108.
7	(Ag=108)	Cd=112	In=113	Sn=118	Sb=122	Te=125	J=127	
8	Cs=133	Ba=137	?Di=138	?Co=140	—	—	—	—
9	(—)	—	—	—	—	—	—	—
10	—	—	?Er=178	?La=180	Ta=182	W=184	—	Os=195, Ir=197, Pt=198, Au=199.
11	(Au=199)	Hg=200	Tl=204	Pb=207	Bi=208	—	—	—
12	—	—	—	Th=231	—	U=240	—	—

Mendeleev's Periodic Table in Modern Form

[illegible]

1869 Symbol		modern Symbol
Yt	becomes	Y
J	becomes	I
Di	mixture of Pr, Nd, Pm, Sm, Eu & Gd	
La	incorrect mass, 139 not 180	

Mendeleev's Predictions	Element
Eka-aluminium	Gallium
Eka-boron	Scandium
Eka-silicon	Germanium
Eka-manganese	Technetium
Tri-manganese	Rhenium
Dvi-tellurium	Polonium
Dvi-caesium	Francium
Eka-tantalum	Protactinium

The Periodic Table – Today

Group Period ↓	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	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
5	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
6	55 Cs	56 Ba	57 La *	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
7	87 Fr	88 Ra	89 Ac *	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
				* 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	71 Lu	
				* 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	103 Lr	

Elements are arranged by increasing atomic numbers and not by their weight.

Metals and Non-Metals

	1	2	13	14	15	16	17	18
H ⁺ ←	H							He
He ←	Li	Be	B	C	N	O	F	Ne
Ne ←	Na	Mg	Al	Si	P	S	Cl	Ar
Ar ←	K	Ca	Ga	Ge	As	Se	Br	Kr
Kr ←	Rb	Sr	In	Sn	Sb	Te	I	Xe

Metals tend to lose electrons to attain noble gas electronic configuration.

	1	2	13	14	15	16	17	18
	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

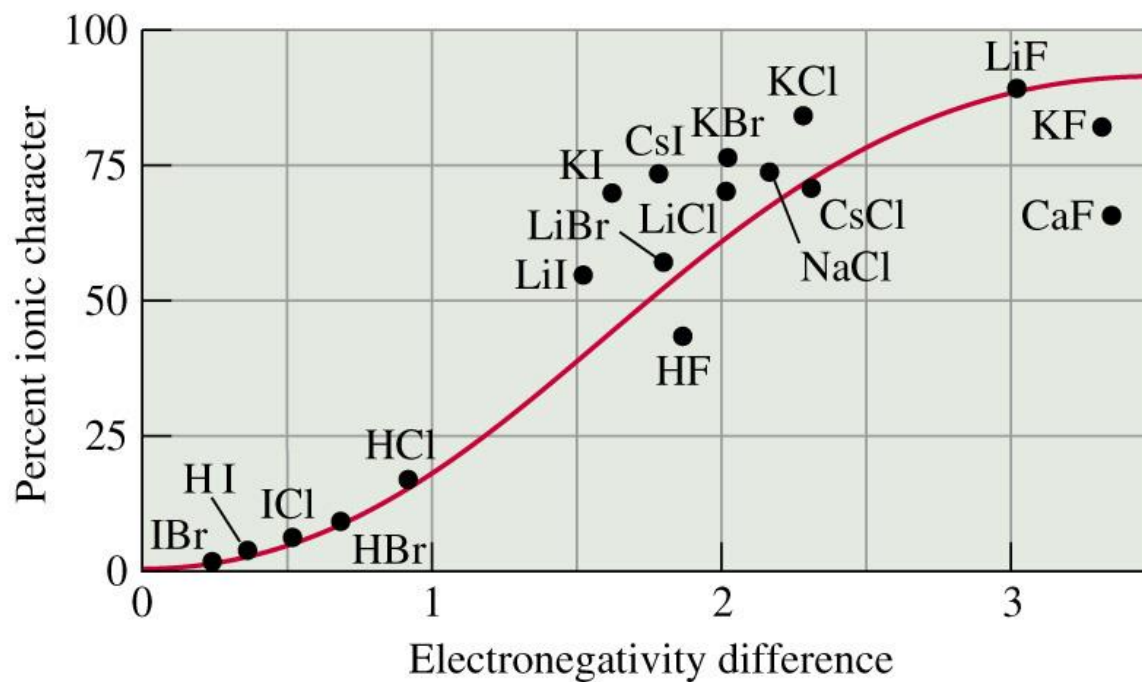
Non-metals tend to gain electrons to attain noble gas electronic configuration.

The Pauling Scale of Electronegativity

1												13	14	15	16	17
H 2.1	2											B 2.0	C 2.5	N 3.0	O 3.5	F 4.0
Li 1.0	Be 1.5											Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0
Na 0.9	Mg 1.2	3	4	5	6	7	8	9	10	11	12	Ga 1.6	Ge 1.8	As 2.0	Se 2.4	Br 2.8
K 0.8	Ca 1.0	Sc 1.3	Ti 1.5	V 1.6	Cr 1.6	Mn 1.5	Fe 1.8	Co 1.8	Ni 1.8	Cu 1.9	Zn 1.6	In 1.7	Sn 1.8	Sb 1.9	Te 2.1	I 2.5
Rb 0.8	Sr 1.0	Y 1.2	Zr 1.4	Nb 1.6	Mo 1.8	Tc 1.9	Ru 2.2	Rh 2.2	Pd 2.2	Ag 1.9	Cd 1.7	Tl 1.8	Pb 1.8	Bi 1.9	Po 2.0	At 2.2
Cs 0.8	Ba 0.9	La[*] 1.1	Hf 1.3	Ta 1.5	W 2.4	Re 1.9	Os 2.2	Ir 2.2	Pt 2.2	Au 2.4	Hg 1.9	Tl 1.8	Pb 1.8	Bi 1.9	Po 2.0	At 2.2
Fr 0.7	Ra 0.9	Ac[†] 1.1	[*] Lanthanides: 1.1–1.3 [†] Actinides: 1.3–1.5													

Electronegativities of the elements. As a general rule, electronegativities decrease from top to bottom in a group and increase from left to right in a period of elements. The values are from L. Pauling, '*The Nature of the Chemical Bond*'. They may be somewhat different from values based on other scales.

Ionic vs. Covalent Bonds



Percent ionic character of a chemical bond as a function of electronegativity difference.

Some Representative Atomic & Ionic Radii

1A	2A
 Li 152  59 Li ⁺	 Be 111  31 Be ²⁺
 Na 186  99 Na ⁺	 Mg 160  65 Mg ²⁺
 K 227  138 K ⁺	 Ca 197  99 Ca ²⁺
 Rb 248  148 Rb ⁺	 Sr 215  113 Sr ²⁺
 Cs 265  169 Cs ⁺	 Ba 217  135 Ba ²⁺

3A	4A	5A	6A	7A
 B 80  20 B ³⁺	 C 77	 N 75  N ³⁻ 171	 O 73  O ²⁻ 140	 F 71  F ⁻ 133
 Al 143  50 Al ³⁺	 Si 118	 P 110  P ³⁻ 212	 S 103  S ²⁻ 184	 Cl 99  Cl ⁻ 181
 Ga 122  62 Ga ³⁺	 Ge 123	 As 125  69 As ³⁺	 Se 116  Se ²⁻ 198	 Br 114  Br ⁻ 196
 In 163  92 In ³⁺	 Sn 141  93 Sn ²⁺	 Sb 145  89 Sb ³⁺	 Te 143  Te ²⁻ 221	 I 133  I ⁻ 220
 Tl 170  149 Tl ⁺	 Pb 175  132 Pb ²⁺	 Bi 155  96 Bi ³⁺		

Summary of Trends in the Periodic Table

