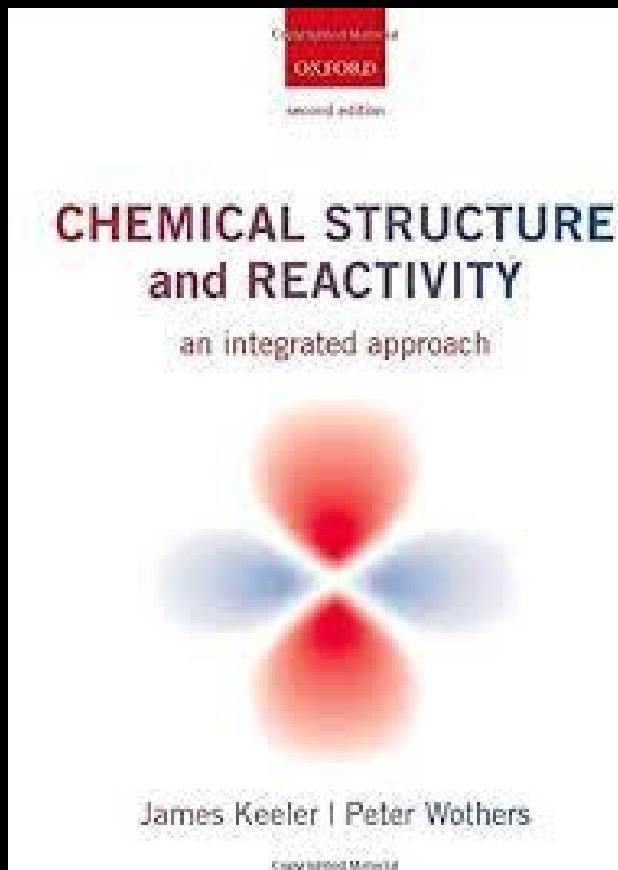


CH1101: Elements of Chemistry



Instructors: Soumyajit Roy & Supratim Banerjee

Teaching Assistants (Tas):

Group 1 (Roll No. 1-49): Nidhi and Khokan

Group 2 (Roll No. 50-94): Rounak and Pavithra

Group 3 (Roll No. 95-145): Vidhul and Suryagayathri

Group 4 (Roll No. 146-196): Isha and Tousif

Group 5 (Roll No. 197-247): Aritra and Debjyoti

**Overall Class, Attendance, Office hours Arrangement:
Nidhi, Khokan, Tousif and Isha.**

Soumyajit Roy, Material Science Center.
Supratim Banerjee, W328, Third Floor TRC, X13121
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Office Hour: S.Roy on Tuesday 14:00-15:00 (By Appointment Please)

CH 1101: Elements of Chemistry: Class Schedule

Class		
Mon (2-3 PM)	Wed (9-10 AM)	Thu (4-5 PM)
August		
21	23	24
28	30	31 (T&Q)
September		
4	6	7
11	13	14 (T&Q)
18	20	21
25	27	28
October		
Mid-Term Examination (3-7 October)		
9	11	12 (T&Q)
16	18	19
Autumn Break (21-29 October)		
30		
November		
	1	2
6 (T&Q)	8	9
13	15	16
20 (T&Q)		

Red denotes Holidays

Black: Classes by Soumyajit Roy

Blue: Classes by Supratim Banerjee

Q represents Quiz

SR 18 Classes

SB 9 Classes

Why Chemistry?

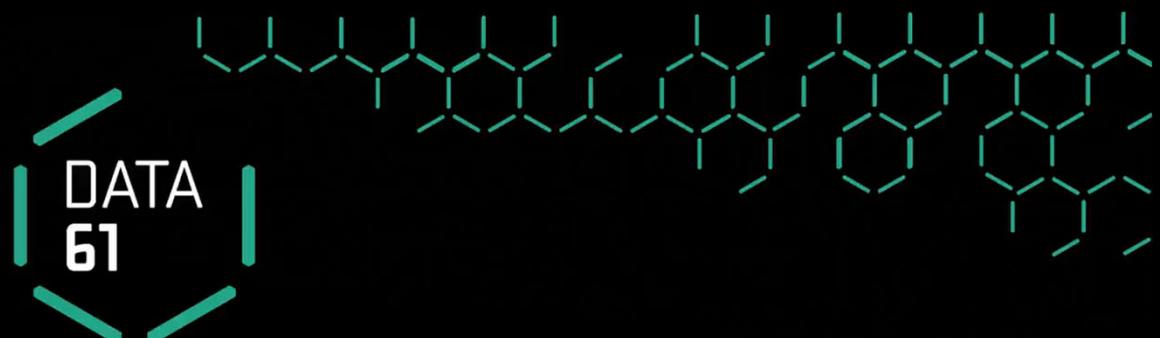
How Chemistry touches you?

How do you perceive Chemistry?

When did you touch Chemistry?

Chemistry touches you?

Chemistry relates to matter



**Simulation of water
turning to ice**

Molecular and Materials Modelling Group



Matter matters! Chemistry matters!

Why Chemistry?

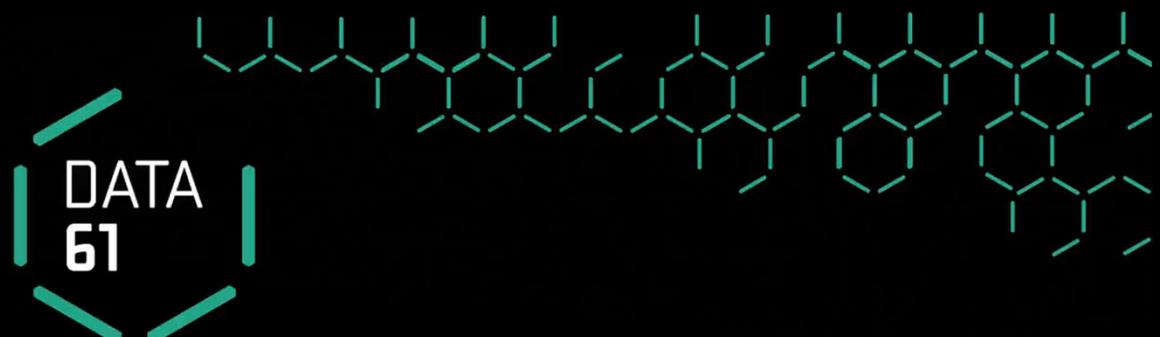
How Chemistry touches you?

How do you perceive Chemistry?

When did you touch Chemistry?

Chemistry touches you?

Chemistry relates to matter



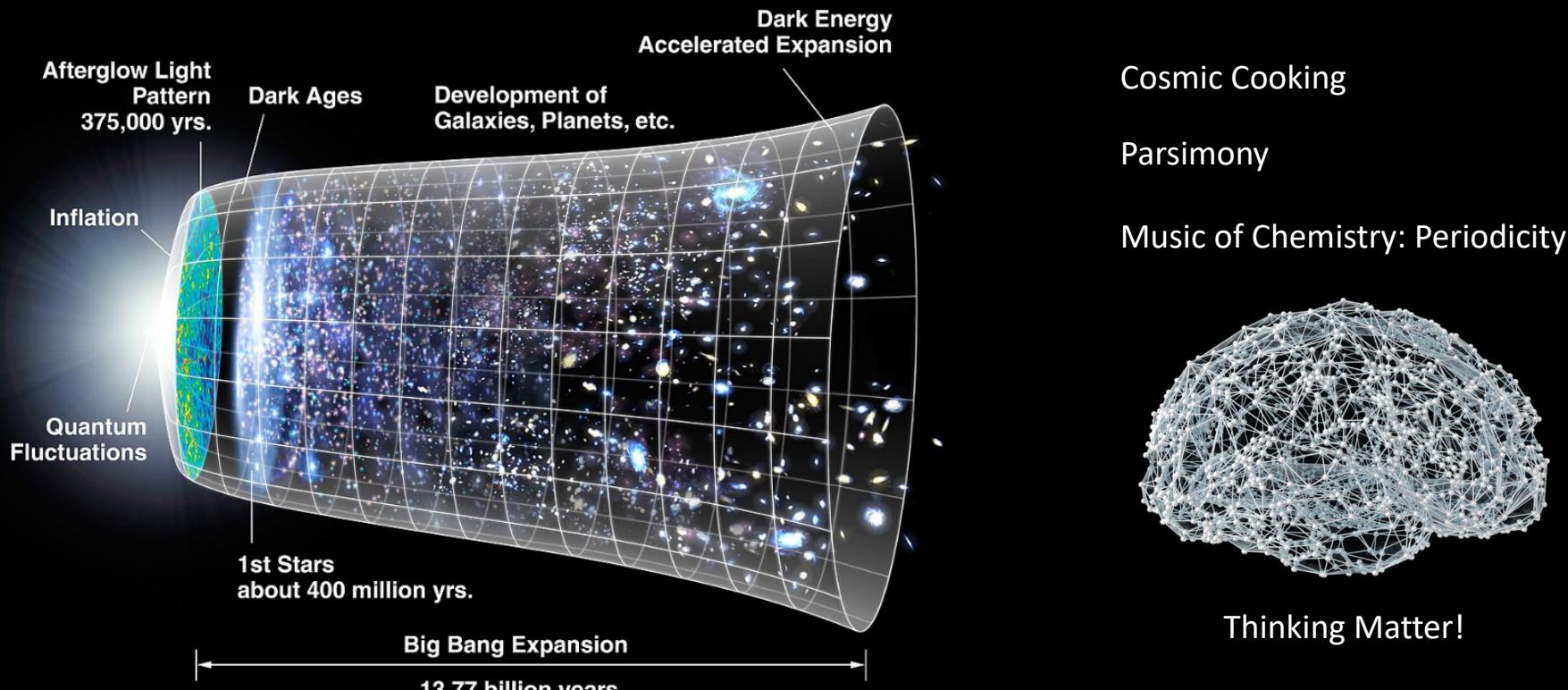
**Simulation of water
turning to ice**

Molecular and Materials Modelling Group



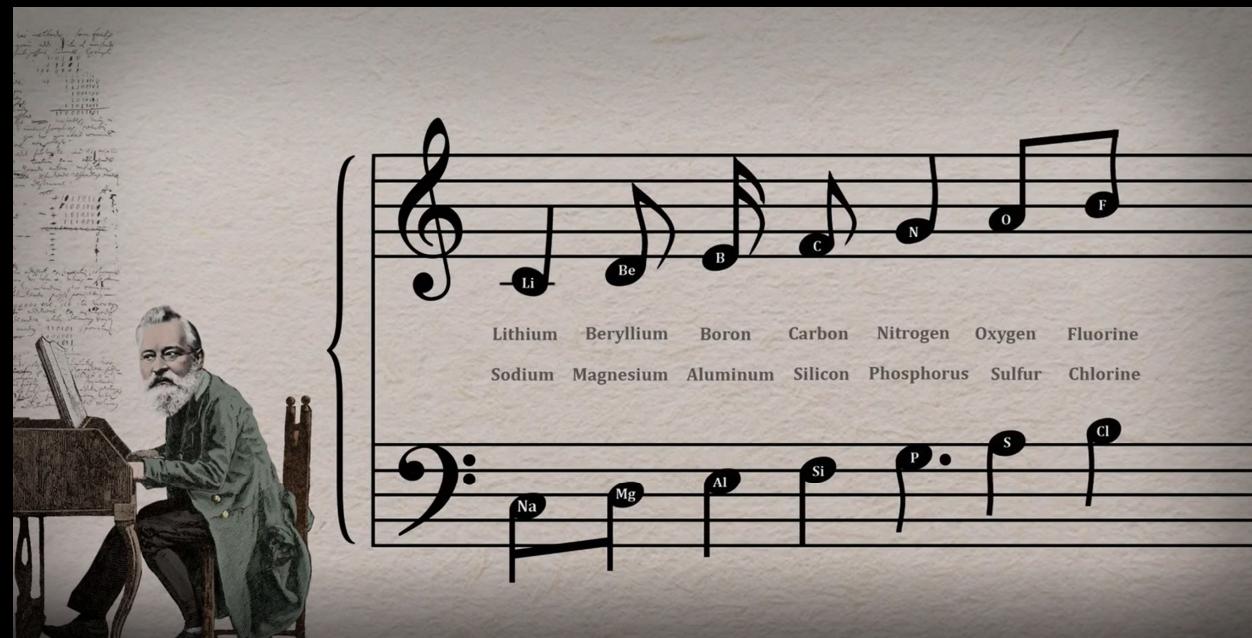
Matter matters! Chemistry matters!

What is Matter? How it came to being?



Matter matters! Chemistry matters!

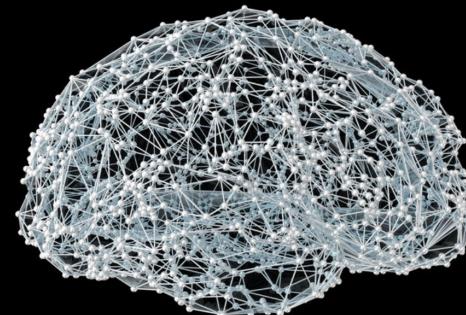
What is Matter? How it came to being?



Cosmic Cooking

Parsimony

Music of Chemistry: Periodicity



Thinking Matter!

Matter matters! Chemistry matters!

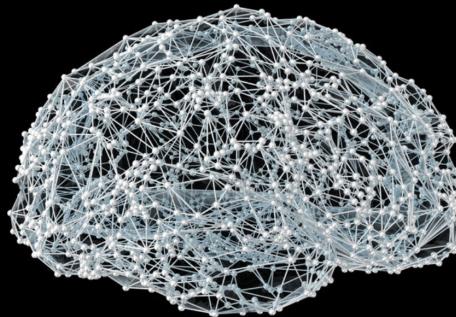
What is Matter? How it came to being?

1 1IA 11A		2 IIA 2A														18 VIIIA 8A			
1 H Hydrogen 1.0079		2 Be Beryllium 9.01218														2 He Helium 4.00260			
3 Li Lithium 6.941		4 Be Beryllium 9.01218		5 VB 5B	6 VI 6B	7 VII 7B	8	9 VIII 8	10	11 IB 1B	12 IIB 2B	13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A			
11 Na Sodium 22.98978	12 Mg Magnesium 24.305	3 IIIB 3B	4 IVB 4B	5 VB 5B	6 VI 6B	7 VII 7B	8	9 VIII 8	10	11 IB 1B	12 IIB 2B	13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	18 VIIIA 8A		
19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.95591	22 Ti Titanium 47.88	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938	26 Fe Iron 55.847	27 Co Cobalt 58.9332	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.732	32 Ge Germanium 72.64	33 As Arsenic 74.92159	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.80		
37 Rb Rubidium 85.4078	38 Sr Strontium 87.62	39 Y Yttrium 88.9065	40 Zr Zirconium 91.224	41 Nb Niobium 92.90658	42 Mo Molybdenum 95.94	43 Tc Technetium 98.9072	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.9055	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.71	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.90447	54 Xe Xenon 131.29		
55 Cs Cesium 132.90543	56 Ba Barium 137.327	57-71 Os Osmium 138.9055	72 Hf Hafnium 178.49	73 Ta Tantalum 180.9479	74 W Tungsten 183.85	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.9665	80 Hg Mercury 200.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.98037	84 Po Polonium [208.9824]	85 At Astatine 209.9871	86 Rn Radon 222.0178		
87 Fr Francium 223.0197	88 Ra Radium 226.0254	89-103 Rf Rutherfordium [261]	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Meitnerium [269]	109 Mt Mendelevium [269]	110 Ds Darmstadtium [280]	111 Rg Roentgenium [272]	112 Cn Copernicium [277]	113 Uut Ununtrium [289]	114 Uup Ununquadium [289]	115 Uuh Ununpentium [290]	116 Uuh Ununhexium [290]	117 Uus Ununseptium [290]	118 Uuo Ununoctium [290]		
Lanthanide Series																			
57 La Lanthanum 138.9055	58 Ce Cerium 140.115	59 Pr Praseodymium 140.90765	60 Nd Neodymium 144.24	61 Pm Promethium 144.9127	62 Sm Samarium 150.36	63 Eu Europium 151.9655	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92534	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93032	68 Er Erbium 167.26	69 Tm Thulium 168.93421	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.97					
89 Ac Actinium 227.0278	90 Th Thorium 232.0381	91 Pa Protactinium 231.03588	92 U Uranium 238.0289	93 Np Neptunium 237.0492	94 Pu Plutonium 244.0642	95 Am Americium 243.0614	96 Cm Curium 247.0703	97 Bk Berkelium 247.0703	98 Cf Californium 251.0796	99 Es Einsteiniium [254]	100 Fm Fermium 257.0951	101 Md Mendelevium 258.1	102 No Nobelium 259.1009	103 Lr Lawrencium [262]					
Actinide Series																			
Alkali Metal		Alkaline Earth		Transition Metal		Basic Metal		Semimetals		Nonmetals		Halogens		Noble Gas		Lanthanides		Actinides	

Cosmic Cooking

Parsimony

Music of Chemistry: Periodicity



Thinking Matter!

Matter matters! Chemistry matters!

- The periodic table of the elements is a wonderful mnemonic and a tool that serves to organize the whole of chemistry
- It is neither a “theory” nor a “model” but more akin to an “organizing principle”- a new scientific entity which does a lot of useful work without being a theory

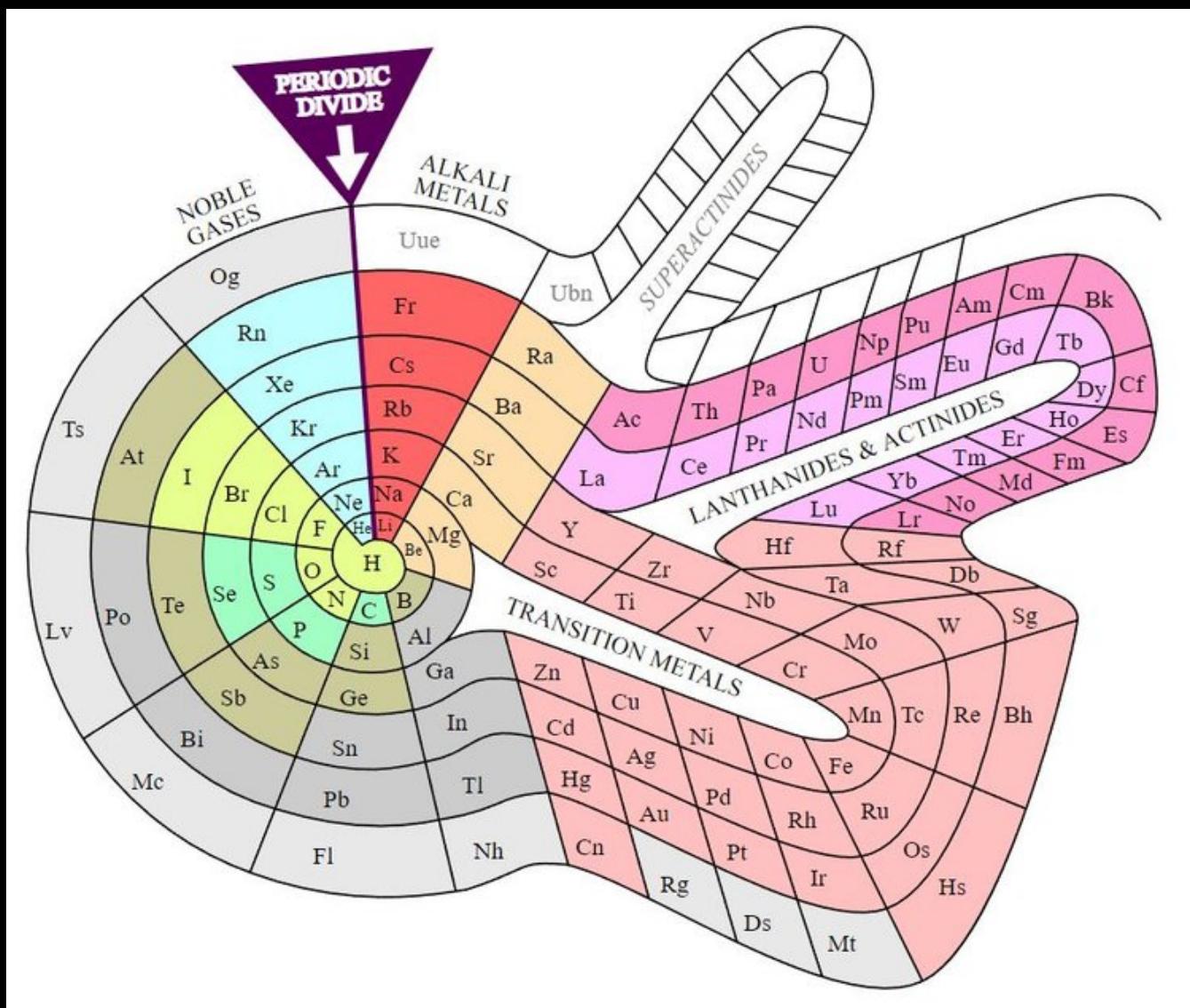
H 1		The Periodic Table @ 2019														He 2	
Li 3	Be 4																
Na 11	Mg 12																
K 19	Ca 20	Sc 21	Ti 22	V 23	Cr 24	Mn 25	Fe 26	Co 27	Ni 28	Cu 29	Zn 30	Ga 31	Ge 32	As 33	Se 34	Br 35	Kr 36
Rb 37	Sr 38	Y 39	Zr 40	Nb 41	Mo 42	Tc 43	Ru 44	Rh 45	Pd 46	Ag 47	Cd 48	In 49	Sn 50	Sb 51	Te 52	I 53	Xe 54
Cs 55	Ba 56	La 57	Hf 72	Ta 73	W 74	Re 75	Os 76	Ir 77	Pt 78	Au 79	Hg 80	Tl 81	Pb 82	Bi 83	Po 84	At 85	Rn 86
Fr 87	Ra 88	Ac 89	Rf 104	Db 105	Sg 106	Bh 107	Hs 108	Mt 109	Ds 110	Rg 111	Cn 112	Nh 113	Fl 114	Mc 115	Lv 116	Ts 117	Og 118
		Ce 58	Pr 59	Nd 60	Pm 61	Sm 62	Eu 63	Gd 64	Tb 65	Dy 66	Ho 67	Er 68	Tm 69	Yb 70	Lu 71		
		Th 90	Pa 91	U 92	Np 93	Pu 94	Am 95	Cm 96	Bk 97	Cf 98	Es 99	Fm 100	Md 101	No 102	Lr 103		

The Periodic Table in many ways

The Periodic Table @ 2019

A modern periodic table of elements, version 2019. The table is color-coded by element group: alkali metals (light red), alkaline earth metals (light blue), transition metals (light green), post-transition metals (light orange), noble gases (light yellow), halogens (light purple), chalcogens (light pink), and the nitrogen family (light teal). The table includes all elements from hydrogen (H) to oganesson (Og), with atomic numbers 1 through 118. A large central black rectangular area contains the text "P Table @ 2019".

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



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

<https://elements.wlonk.com/ElementsTable.htm>

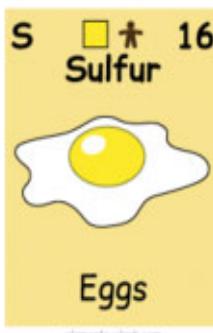
<https://www.ptable.com/>

Key Info

The Periodic Table of the Elements, in Pictures and Words

Click it!

H Hydrogen 1
Sun and Stars
Li Lithium 3
Batteries
Be Beryllium 4
Emeralds
Na Sodium 11
Sodium
Mg Magnesium 12
Chlorophyll
Al Salt 13
Airplanes
Cl Chlorine 16
Eggs



S 16
Sulfur
Eggs

elements.wlonk.com

elements.wlonk.com

Nonmetals, in their solid state, are usually brittle (they break rather than bend) and they are insulators of both heat and electricity.

elements.wlonk.com

B Boron 5	C Carbon 6	N Nitrogen 7	O Oxygen 8	F Fluorine 9
Al Aluminum 13	Si Silicon 14	P Phosphorus 15	Sulfur 16	Cl Chlorine 17
Li Batteries 18	Ge Germanium 19	As Arsenic 20	Br Bromine 21	Kr Krypton 22
Rb Rubidium 23	Sc Scandium 24	Ti Titanium 25	V Vanadium 26	Cr Chromium 27
Y Strontium 28	Zr Zirconium 29	Nb Niobium 30	Mo Molybdenum 31	Ta Technetium 32
Yttrium 33	Zr Zirconium 34	Nb Niobium 35	Mo Molybdenum 36	Ta Technetium 37
Pr Praseodymium 38	Yttrium 39	Zr Zirconium 40	Nb Niobium 41	Mo Molybdenum 42
Eu Europium 43	Tc Technetium 44	Ru Ruthenium 45	Pd Palladium 46	Ag Silver 47
Gd Gadolinium 48	In Indium 49	Sn Tin 50	Cd Cadmium 51	Sb Antimony 52
Lu Lanthanum 53	Ge Germanium 54	As Arsenic 55	Te Tellurium 56	Xe Xenon 57
Ba Barium 58	Ca Calcium 59	Ge Germanium 60	As Arsenic 61	Xe Xenon 62
Hf Hafnium 63	Hf Hafnium 64	Ta Technetium 65	Tl Thallium 66	Bi Bismuth 67
To Tantalum 68	W Tungsten 69	Os Rhenium 70	Pt Platinum 71	Pb Lead 72
Re Rhenium 73	W Tungsten 74	Os Rhenium 75	Iridium 76	Dt Darmstadtium 77
Os Osmium 78	Ir Iridium 79	Dt Darmstadtium 80	Os Osmium 81	Th Thallium 82
Os Osmium 83	Os Osmium 84	Th Thallium 85	Bi Bismuth 86	At Astatine 87
Pa Protactinium 88	Rf Rutherfordium 89	Db Dubnium 90	Sg Seaborgium 91	Bk Berkelium 92
Th Thorium 93	Pa Protactinium 94	U Uranium 95	Ne Neptunium 96	Cm Curium 97
U Uranium 96	Ne Neptunium 97	Am Americium 98	Bk Berkelium 99	Cf Einsteinium 100
Ne Neptunium 98	Am Americium 99	Pu Plutonium 100	Bk Berkelium 101	Md Mendelevium 102
Es Einsteinium 101	Fm Fermium 102	Es Einsteinium 103	Fr Fr 104	Lr Lawrencium 105

La Lanthanum 57	Ce Cerium 58	Pr Praseodymium 59	Nd Neodymium 60	Pm Promethium 61	Sm Samarium 62	Eu Europium 63	Gd Gadolinium 64	Tb Terbium 65	Dy Dysprosium 66	Ho Holmium 67	Er Erbium 68	Tm Thulium 69	Yb Ytterbium 70	Lu Lutetium 71	
Ac Actinium 89	Th Thorium 90	Po Protactinium 91	U Uranium 92	Ne Neptunium 93	Am Americium 94	Cm Curium 95	Bk Berkelium 96	Einsteinium 97	Cf Einsteinium 98	Fm Fermium 99	Md Mendelevium 100	Ts Tennessee 101	No Nobelium 102	Lr Lawrencium 103	
Fr Francium 87	Rf Rutherfordium 88	Db Dubnium 89	Sg Seaborgium 90	Bh Bohrium 91	Hs Hassium 92	Mt Meitnerium 93	Rg Rutherfordium 94	Rg Rutherfordium 95	Nh Nihonium 96	Fm Fermium 97	Mc Moscovium 98	Ls Livermorium 99	Ts Tennessee 100	Os Osmium 101	Fr Fr 102

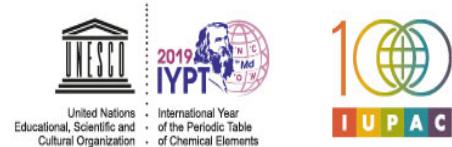
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1 1 H hydrogen 1.001 [1.0074, 1.0083]	2 3 Li lithium 6.94 [6.938, 6.997]	4 Be beryllium 9.0122	5 6 7 8 9 10 11 12 13 14 15 16 17 18 He helium 4.0026														
IUPAC Periodic Table of the Elements																	
19 K potassium 39.098	20 Ca calcium 40.078(4)	21 Sc scandium 44.956	22 Ti titanium 47.867	23 V vanadium 50.942	24 Cr chromium 51.996	25 Mn manganese 54.938	26 Fe iron 55.845(2)	27 Co cobalt 58.933	28 Ni nickel 58.693	29 Cu copper 63.546(3)	30 Zn zinc 65.38(2)	31 Ga gallium 69.723	32 Ge germanium 72.63(8)	33 As arsenic 74.922	34 Se selenium 78.971(8)	35 Br bromine 79.901	36 Kr krypton 83.79(2)
37 Rb rubidium 85.468	38 Sr strontium 87.62	39 Y yttrium 88.906	40 Zr zirconium 91.224(2)	41 Nb niobium 92.905	42 Mo molybdenum 95.95	43 Tc technetium 101.07(2)	44 Ru ruthenium 102.91	45 Rh rhodium 106.42	46 Pd paladium 107.87	47 Ag silver 112.41	48 Cd cadmium 114.82	49 In indium 118.71	50 Sn antimony 121.76	51 Te tellurium 127.60(3)	52 I iodine 126.90	54 Xe xenon 131.29	
55 Cs cesium 132.91	56 Ba barium 137.33	57-71 La lanthanoids 178.49(2)	72 Hf hafnium 180.95	73 Ta tantalum 183.64	74 W tungsten 186.21	75 Re rhenium 190.23(3)	76 Os osmium 192.22	77 Ir iridium 195.08	78 Pt platinum 196.97	79 Au gold 200.59	80 Hg mercury 204.59	81 Tl thallium 204.38	82 Pb lead 204.38	83 Bi bismuth 204.98	84 Po polonium 204.98	85 At astatine 204.98	86 Rn radon 222.01
87 Fr francium 223.01	88 Ra radium 226.02	89-103 Ac actinoids 223.04	104 Rf rutherfordium 231.04	105 Db dubnium 231.04	106 Sg seaborgium 238.03	107 Bh bohrium 238.03	108 Hs hassium 238.03	109 Mt meitnerium 238.03	110 Ds darmstadtium 238.03	111 Rg roentgenium 238.03	112 Cn copernicium 238.03	113 Nh nihonium 238.03	114 Fl flerovium 238.03	115 Mc moscovium 238.03	116 Lv livornium 238.03	117 Ts tennessine 238.03	118 Og oganesson 238.03



For notes and updates to this table, see www.iupac.org. This version is dated 1 December 2018.
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57 La lanthanum 138.91	58 Ce cerium 140.12	59 Pr praseodymium 144.24	60 Nd neodymium 144.24	61 Pm promethium 147.96	62 Sm samarium 150.36(2)	63 Eu europium 151.96	64 Gd gadolinium 157.25(3)	65 Tb terbium 159.93	66 Dy dysprosium 162.50	67 Ho holmium 164.93	68 Er erbium 167.26	69 Tm thulium 168.93	70 Yb ytterbium 173.05	71 Lu lutetium 174.97
89 Ac actinium 223.04	90 Th thorium 231.04	91 Pa protactinium 231.04	92 U uranium 238.03	93 Np neptunium 238.03	94 Pu plutonium 238.03	95 Am americium 238.03	96 Cm curium 238.03	97 Bk berkelium 238.03	98 Cf californium 238.03	99 Es einsteinium 238.03	100 Fm fermium 238.03	101 Md mendelevium 238.03	102 No nobelium 238.03	103 Lr lawrencium 238.03



Periodic Table of Vehicle Elements

'Endangered' elements used to make mobile phones
are running out quickly, scientists warn

1 H Hydrogen	4 Be Boron	2 He Helium
3 Li Lithium	5 B Boron	6 C Carbon
11 Na Sodium	12 Mg Magnesium	7 N Nitrogen
19 K Potassium	20 Ca Calcium	8 O Oxygen
21 Sc Scandium	22 Ti Titanium	9 F Fluorine
23 V Vanadium	24 Cr Chromium	10 Ne Neon
25 Mn Manganese	26 Fe Iron	13 Al Aluminum
27 Co Cobalt	28 Ni Nickel	14 Si Silicon
29 Cu Copper	30 Zn Zinc	15 P Phosphorus
31 Ga Gallium	32 Ge Germanium	16 S Sulfur
33 As Arsenic	34 Se Selenium	17 Cl Chlorine
35 Br Bromine	36 Kr Krypton	18 Ar Argon
37 Rb Rubidium	38 Sr Strontium	39 Y Yttrium
40 Zr Zirconium	41 Nb Niobium	42 Mo Molybdenum
43 Tc Technetium	44 Ru Ruthenium	45 Rh Rhodium
46 Pd Palladium	47 Ag Silver	48 Cd Cadmium
49 In Indium	50 Sn Tin	51 Sb Antimony
52 Te Tellurium	53 I Iodine	54 Xe Xenon
55 Cs Cesium	56 Ba Barium	57 Hf Hafnium
58 Ta Tantalum	59 W Tungsten	60 Re Rhenium
61 Os Osmium	62 Ir Iridium	63 Pt Platinum
64 Au Gold	65 Hg Mercury	66 Tl Thallium
67 Pb Lead	68 Bi Bismuth	69 Po Polonium
70 At Astatine	71 Rn Radon	72 Hf Hafnium
73 Ta Tantalum	74 W Tungsten	75 Re Rhenium
76 Os Osmium	77 Ir Iridium	78 Pt Platinum
79 Au Gold	80 Hg Mercury	81 Tl Thallium
82 Pb Lead	83 Bi Bismuth	84 Po Polonium
85 At Astatine	86 Rn Radon	87 Fr Francium
88 Ra Radium	89 Rf Rutherfordium	90 Db Dubnium
91 Pa Protactinium	92 U Thorium	93 Np Neptunium
94 Am Americium	95 Pu Curium	96 Cm Plutonium
97 Bk Berkelium	98 Cf Curium	99 Es Einsteinium
100 Fm Fermium	101 Md Mendelevium	102 No Nobelium
103 Lr Lawrencium		
57 La Lanthanum	58 Ce Cerium	59 Pr Praseodymium
60 Nd Neodymium	61 Pm Promethium	62 Sm Samarium
63 Eu Europium	64 Gd Gadolinium	65 Tb Terbium
66 Dy Dysprosium	67 Ho Holmium	68 Er Erbium
69 Tm Thulium	70 Yb Ytterbium	71 Lu Lutetium

57 La Lanthanum	58 Ce Cerium	59 Pr Praseodymium	60 Nd Neodymium	61 Pm Promethium	62 Sm Samarium	63 Eu Europium	64 Gd Gadolinium	65 Tb Terbium	66 Dy Dysprosium	67 Ho Holmium	68 Er Erbium	69 Tm Thulium	70 Yb Ytterbium	71 Lu Lutetium
89 Ac Actinium	90 Th Thorium	91 Pa Protactinium	92 U Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Curium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium

THE PERIODIC TABLE'S ENDANGERED ELEMENTS

¹H
HYDROGEN

³Li
LITHIUM

⁴Be
BERYLLOM

¹¹Na
SODIUM

¹²Mg
MAGNESIUM

¹⁹K
KALIUM

²⁰Ca
CALCIUM

²¹Sc
YTRIUM

²²Ti
TITANIUM

²³V
VANADIUM

²⁴Cr
CHROMIUM

²⁵Mn
MANGANESE

²⁶Fe
IRON

²⁷Co
COBALT

²⁸Ni
NIQUEL

²⁹Cu
COPPER

³⁰Zn
ZINC

³¹Ga
GALLIUM

³²Ge
GERMANIUM

³³As
ARSENIC

³⁴Se
SELENIUM

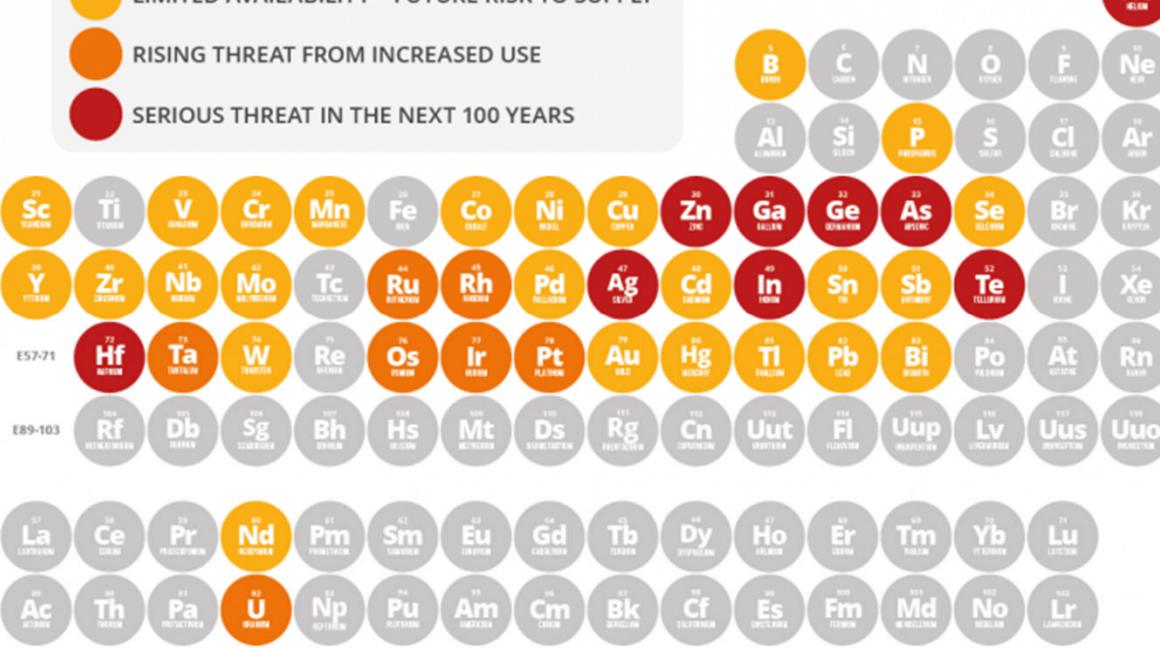
³⁵Br
BROMINE

³⁶Kr
KRYPTON

LIMITED AVAILABILITY – FUTURE RISK TO SUPPLY

RISING THREAT FROM INCREASED USE

SERIOUS THREAT IN THE NEXT 100 YEARS



SOURCE: CHEMISTRY INNOVATION KNOWLEDGE TRANSFER NETWORK



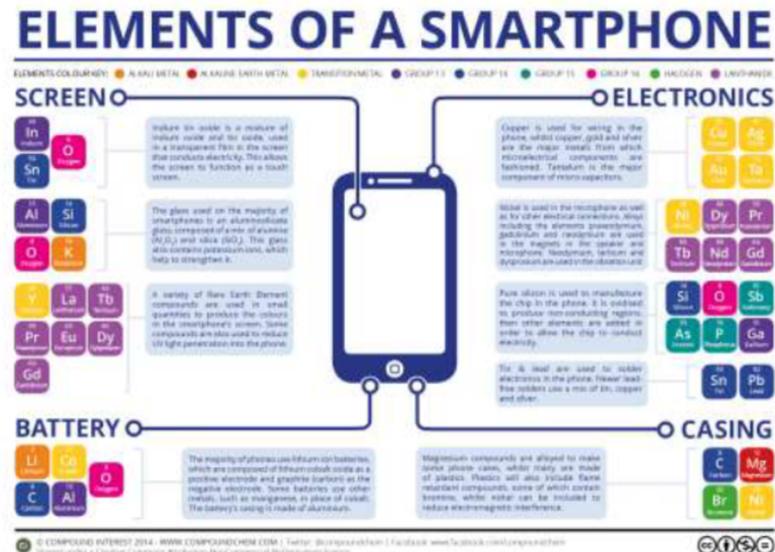
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Endangered METALS

- Endangered species : Cu, Zn, Pt
- Strategic Shortage : Ga, In, Hf, Li
- Geopolitical risks : Re, Co, Li, Pt (90% Re : China; 90 % Pt : S. Africa; 90 % Li : Chile; 90 % Co : Republic of Congo)
- Fuel Cell: Pt at cathode; 25 reactions /sec/site; Pt cost alone is \$3000 per cost of engine
- 36 mg of gold is contained in every iPhone
- Mobile phones : 40 elements
- A semiconductor chip on PC: 60 elements

One ton of mobile phones would deliver 300 times more gold than a ton of gold ore and 6.5 times more silver than a ton of silver ore



Endangered elements, critical raw materials and conflict minerals, C.J. Rhodes, Science Progress, 2019, 102(2), 304-350



United Nations
Educational, Scientific and
Cultural Organization

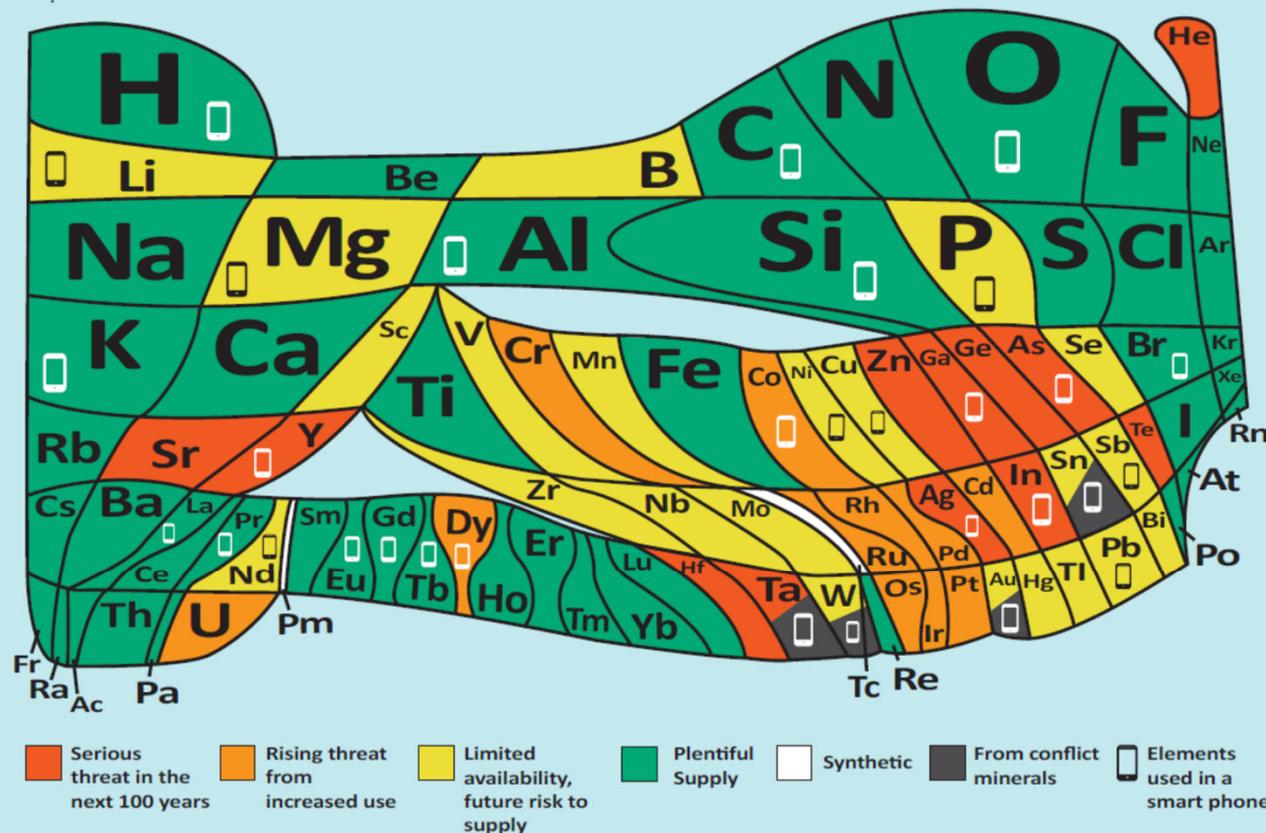


International Year
of the Periodic Table
of Chemical Elements

The 90 natural elements that make up everything

How much is there? Is that enough?

Inspired by WF Sheehan's 'A Periodic Table with Emphasis' published in Chemistry, 1976, 49, 17-18'



Read more and play the video game <http://bit.ly/euchems-pt>



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What is Matter? How it came to being?

H = 1	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 = Co = 59	Pd = 106,6	Os = 199
	Cu = 63,4	Ag = 108	Hg = 200
Be = 9,4	Mg = 24	Zn = 65,2	Cd = 112
B = 11	Al = 27,4	? = 68	Ur = 116
C = 12	Si = 28	? = 70	Sn = 118
N = 14	P = 31	As = 75	Sb = 122
O = 16	S = 32	Se = 79,4	Te = 128?
F = 19	Cl = 35,5	Br = 80	J = 127
Li = 7 Na = 23	K = 39	Rb = 85,4	Cs = 133
	Ca = 40	Sr = 87,6	Ba = 137
	? = 45	Ce = 92	
	?Er = 56	La = 94	
	?Yt = 60	Di = 95	
	?In = 75,6	Th = 118?	

Cosmic Cooking

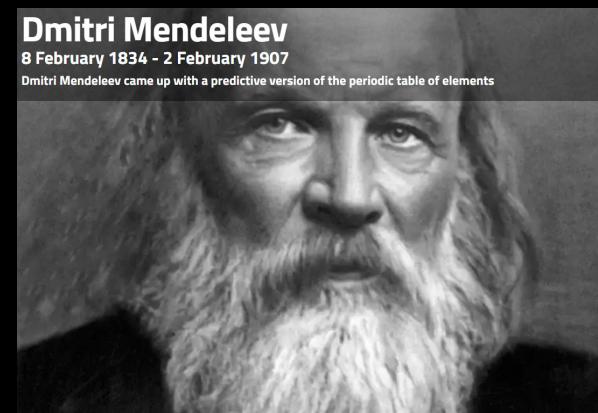
Parsimony

Music of Chemistry: Periodicity

Dmitri Mendeleev

8 February 1834 - 2 February 1907

Dmitri Mendeleev came up with a predictive version of the periodic table of elements



Matter matters! Chemistry matters!

Thinking Matter!