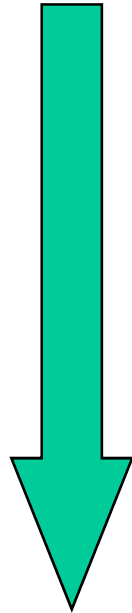


systematic table of elements



increasing number of electrons

increasing atomic mass

H	hydrogen (1 electron)
He	helium (2 electrons)
Li	lithium (3 electrons)
Be	beryllium (4 electrons)
B	boron (5 electrons)
C	carbon (6 electrons)
N	nitrogen (7 electrons)
O	oxygen (8 electrons)
F	fluorine (9 electrons)
Ne	neon (10 electrons)
Na	sodium (11 electrons)
Mg	magnesium (12 electrons)
	(...)

periodic table of elements (groups I_a to VIII_a)

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
I _a	II _a	III _a	IV _a	V _a	VI _a	VII _a	VIII _a

expected properties of the unknown element „eka-silicium“

atomic mass: 72
specific gravity: 5.5 g/cm^3
molar volume: $13.1 \text{ cm}^3/\text{mol}$
melting point: „high temp.“
specific heat: 0.305 J/(gK)
valences: 4
color: dark grey

chemical properties:

partially resistant against acids
resistant against alkalic media

sulfide is insoluble in water,
soluble in $(\text{NH}_4)_2\text{S}$ -solution

the chloride is volatile and has
a specific gravity of 1.9 g/cm^3

actual properties of the element germanium (Ge)

atomic mass: 72.59
specific gravity: 5.35 g/cm^3
molar volume: $13.57 \text{ cm}^3/\text{mol}$
melting point: $947 \text{ }^\circ\text{C}$
specific heat: 0.309 J/(gK)
valences: 4
color: greyish-white

chemical properties:

resistant against diluted acids
resistant against alkalic media

sulfide is insoluble in water,
soluble in $(\text{NH}_4)_2\text{S}$ -solution

the chloride evaporates at $84 \text{ }^\circ\text{C}$
specific gravity: 1.8443 g/cm^3

periodic table of elements (groups I_a to VIII_a)

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
I _a	II _a	III _a	IV _a	V _a	VI _a	VII _a	VIII _a

periodic table of elements

(groups I_a to VIII_a
and groups I_b to VIII_b)

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	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At		Rn
I _a	II _a											III _a	IV _a	V _a	VI _a	VII _a	VIII _a	
		III _b	IV _b	V _b	VI _b	VII _b	VIII _b			I _b	II _b							

+ lanthanides and actinides

1												18					
1 1 H											1 2 He						
2												13	14	15	16	17	18
2 3 Li	2 4 Be											2 5 B	2 6 C	2 7 N	2 8 O	2 9 F	2 10 Ne
3 11 Na	3 12 Mg											3 13 Al	3 14 Si	3 15 P	3 16 S	3 17 Cl	3 18 Ar
4		3	4	5	6	7	8	9	10	11	12						
4 19 K	4 20 Ca	4 21 Sc	4 22 Ti	4 23 V	4 24 Cr	4 25 Mn	4 26 Fe	4 27 Co	4 28 Ni	4 29 Cu	4 30 Zn	4 31 Ga	4 32 Ge	4 33 As	4 34 Se	4 35 Br	4 36 Kr
5 37 Rb	5 38 Sr	5 39 Y	5 40 Zr	5 41 Nb	5 42 Mo	5 43 Tc	5 44 Ru	5 45 Rh	5 46 Pd	5 47 Ag	5 48 Cd	5 49 In	5 50 Sn	5 51 Sb	5 52 Te	5 53 I	5 54 Xe
6 55 Cs	6 56 Ba	*	6 72 Hf	6 73 Ta	6 74 W	6 75 Re	6 76 Os	6 77 Ir	6 78 Pt	6 79 Au	6 80 Hg	6 81 Tl	6 82 Pb	6 83 Bi	6 84 Po	6 85 At	6 86 Rn
7 87 Fr	7 88 Ra	**	7 104 Rf	7 105 Db	7 106 Sg	7 107 Bh	7 108 Hs	7 109 Mt	7 110 Ds	7 111 Rg	7 112 Uub	7 113 Uut	7 114 Uuq	7 115 Uup	-	-	-

LANTHANIDE SERIES *

ACTINIDE SERIES **

6 57 La	6 58 Ce	6 59 Pr	6 60 Nd	6 61 Pm	6 62 Sm	6 63 Eu	6 64 Gd	6 65 Tb	6 66 Dy	6 67 Ho	6 68 Er	6 69 Tm	6 70 Yb	6 71 Lu
7 89 Ac	7 90 Th	7 91 Pa	7 92 U	7 93 Np	7 94 Pu	7 95 Am	7 96 Cm	7 97 Bk	7 98 Cf	7 99 Es	7 100 Fm	7 101 Md	7 102 No	7 103 Lr

periodic table of elements

(groups I_a to VIII_a
and groups I_b to VIII_b)

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	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At		Rn	
I _a	II _a											III _a	IV _a	V _a	VI _a	VII _a	VIII _a		
		III _b	IV _b	V _b	VI _b	VII _b	VIII _b			I _b	II _b								

+ lanthanides and actinides

alkali metals:

- one single valence
- easily oxidized
- react violently with water
- typical compounds: NaCl, K₂O

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	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn

earth alkali metals:

- two valences
- easily oxidized
- may react violently with water
- typical compounds: CaO , MgCl_2

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	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn

transition elements:

- always metals
- often two valences
- differ strongly in reactivity
- typical compounds: FeO, AgS

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	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn

halogens:

- mostly single valences
- very reactive, corrosive
- typical compounds: NaCl, HCl, HF

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	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn

noble gases:

- gaseous at room temperature
- very low reactivity
- few compounds known

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	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn

metals / non-metals

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	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn

1												18					
1 1 H											1 2 He						
2												13	14	15	16	17	18
2 3 Li	2 4 Be											2 5 B	2 6 C	2 7 N	2 8 O	2 9 F	2 10 Ne
3												3	3	3	3	3	3
3 11 Na	3 12 Mg											3 13 Al	3 14 Si	3 15 P	3 16 S	3 17 Cl	3 18 Ar
4		3	4	5	6	7	8	9	10	11	12						
4 19 K	4 20 Ca	4 21 Sc	4 22 Ti	4 23 V	4 24 Cr	4 25 Mn	4 26 Fe	4 27 Co	4 28 Ni	4 29 Cu	4 30 Zn	4 31 Ga	4 32 Ge	4 33 As	4 34 Se	4 35 Br	4 36 Kr
5												5	5	5	5	5	5
5 37 Rb	5 38 Sr	5 39 Y	5 40 Zr	5 41 Nb	5 42 Mo	5 43 Tc	5 44 Ru	5 45 Rh	5 46 Pd	5 47 Ag	5 48 Cd	5 49 In	5 50 Sn	5 51 Sb	5 52 Te	5 53 I	5 54 Xe
6												6	6	6	6	6	6
6 55 Cs	6 56 Ba	* 	6 72 Hf	6 73 Ta	6 74 W	6 75 Re	6 76 Os	6 77 Ir	6 78 Pt	6 79 Au	6 80 Hg	6 81 Tl	6 82 Pb	6 83 Bi	6 84 Po	6 85 At	6 86 Rn
7												7	7	7	7	7	7
7 87 Fr	7 88 Ra	** 	7 104 Rf	7 105 Db	7 106 Sg	7 107 Bh	7 108 Hs	7 109 Mt	7 110 Ds	7 111 Rg	7 112 Uub	7 113 Uut	7 114 Uuq	7 115 Uup	-	-	-

*
LANTHANIDE SERIES

6 57 La	6 58 Ce	6 59 Pr	6 60 Nd	6 61 Pm	6 62 Sm	6 63 Eu	6 64 Gd	6 65 Tb	6 66 Dy	6 67 Ho	6 68 Er	6 69 Tm	6 70 Yb	6 71 Lu
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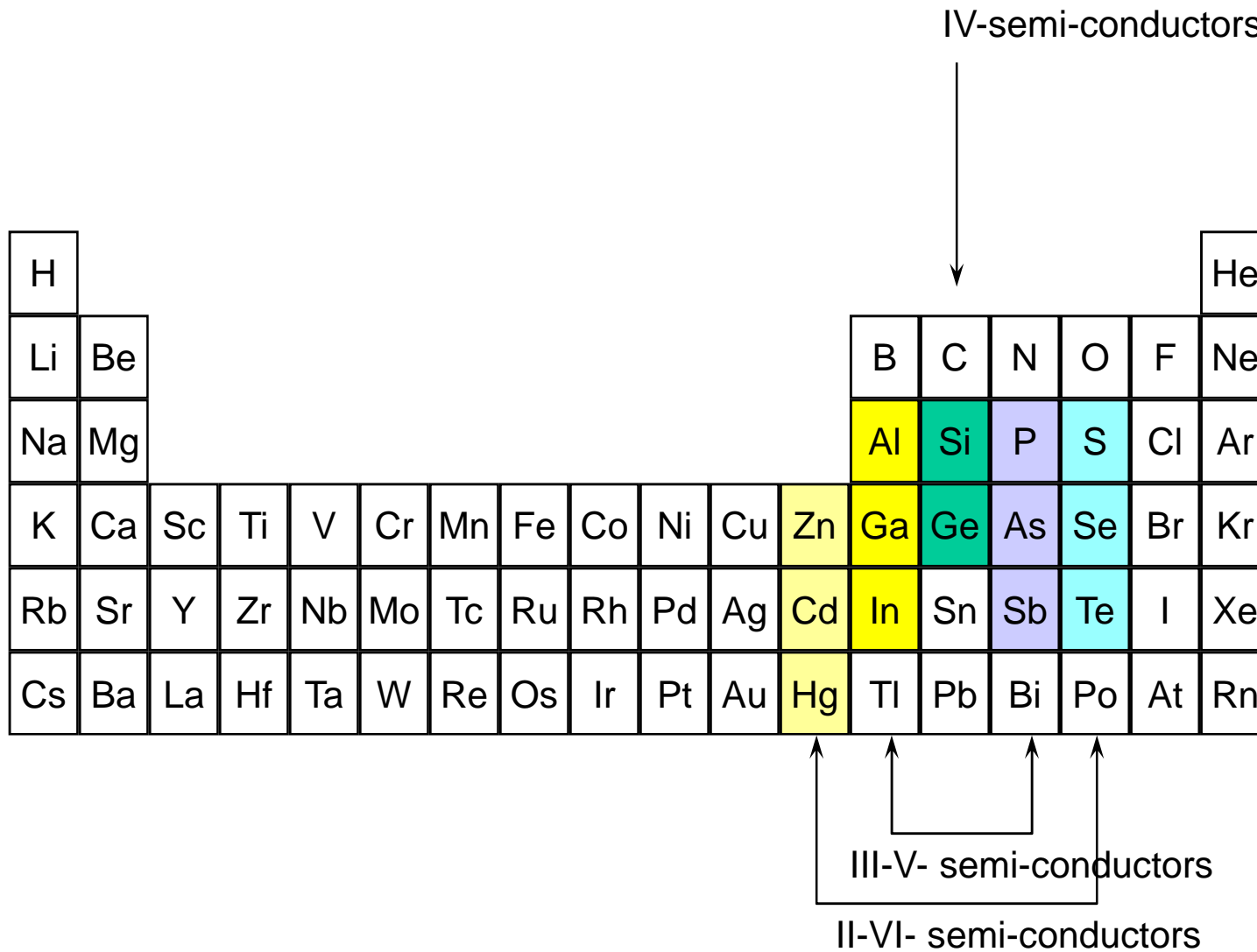
**
ACTINIDE SERIES

7 89 Ac	7 90 Th	7 91 Pa	7 92 U	7 93 Np	7 94 Pu	7 95 Am	7 96 Cm	7 97 Bk	7 98 Cf	7 99 Es	7 100 Fm	7 101 Md	7 102 No	7 103 Lr
------------	------------	------------	-----------	------------	------------	------------	------------	------------	------------	------------	-------------	-------------	-------------	-------------

best electric conductors

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	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn

semi-conductors



inert, corrosion-resistant metals

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	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn

toxic elements

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	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi			

abundant / rare elements

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	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi			

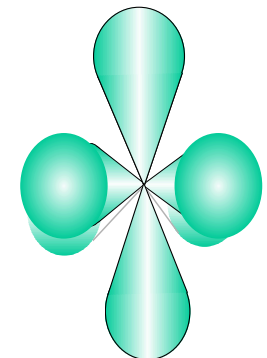
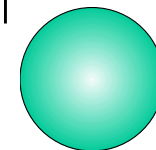
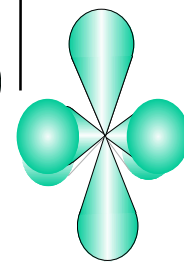
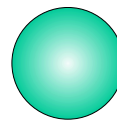
periodic table of elements

(groups I_a to VIII_a
and groups I_b to VIII_b)

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	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At				Rn
I _a	II _a											III _a	IV _a	V _a	VI _a	VII _a	VIII _a			
		III _b	IV _b	V _b	VI _b	VII _b	VIII _b			I _b	II _b									

+ lanthanides and actinides

atomic number	name	symbol	$n = 1$	$n = 2$ $l = 0$	$n = 2$ $l = 1$	$n = 3$ $l = 0$	$n = 3$ $l = 1$
1	hydrogen	H	1				
2	helium	He	2				
3	lithium	Li	2	1			
4	beryllium	Be	2	2			
5	boron	B	2	2	1		
6	carbon	C	2	2	2		
7	nitrogen	N	2	2	2	3	
8	oxygen	O	2	2	4		
9	fluorine	F	2	2	5		
10	neon	Ne	2	2	6		
11	sodium	Na	2	2	6	1	
12	magnesium	Mg	2	2	6	2	
13	aluminum	Al	2	2	6	2	1



periodic table of elements

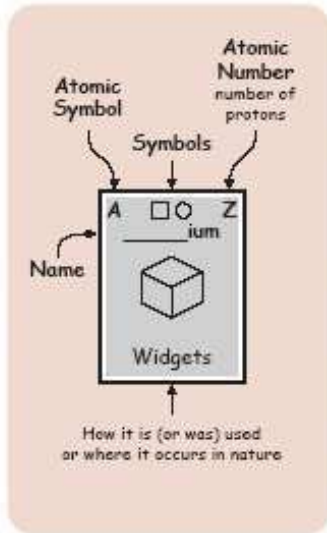
(groups I_a to VIII_a
and groups I_b to VIII_b)

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	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At				Rn
I _a	II _a											III _a	IV _a	V _a	VI _a	VII _a	VIII _a			
		III _b	IV _b	V _b	VI _b	VII _b	VIII _b			I _b	II _b									

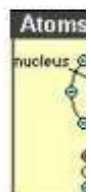
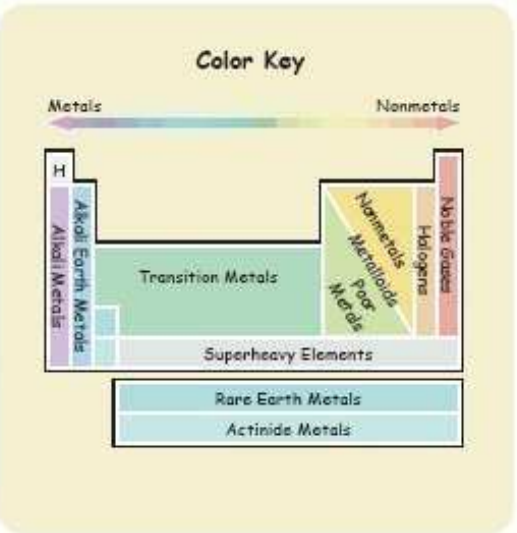
+ lanthanides and actinides

THE PERIODIC TABLE OF THE ELEMENTS, IN PROSE

Periods	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18			
1	Alkali Metals Group 1 H 1 Hydrogen Sun and Stars	Alkali Earth Metals Group 2 Be 4 Beryllium Emeralds																			
2	Li 3 Lithium Batteries	Be 4 Beryllium Emeralds																			
3	Na 11 Sodium Salt	Mg 12 Magnesium Chlorophyll																			
4	K 19 Potassium Fruits and Vegetables	Ca 20 Calcium Shells and Bones	Sc 21 Scandium Bicycles	Ti 22 Titanium Aerospace	V 23 Vanadium Springs	Cr 24 Chromium Stainless Steel	Mn 25 Manganese Earthmovers	Fe 26 Iron Steel Structures	Co 27 Cobalt Magnets	Ni 28 Nickel Coins	Cu 29 Copper Electric Wires	Zn 30 Zinc Brass Instruments	Ga 31 Gallium Light-Emitting Diodes (LEDs)	B 5 Boron Sports Equipment	C 6 Carbon Basis Molecules	N 7 Nitrogen Air	O 8 Oxygen Water	F 9 Fluorine Fluorine	Ne 10 Neon Noble Gas	Ar 18 Argon Noble Gas	
5	Rb 37 Rubidium Global Navigation	Sr 38 Strontium Fireworks	Y 39 Yttrium Lasers	Zr 40 Zirconium Chemical Pipelines	Nb 41 Niobium Mag Lev Trains	Mo 42 Molybdenum Cutting Tools	Tc 43 Technetium Radioactive Diagnosis	Ru 44 Ruthenium Electric Switches	Rh 45 Rhodium Searchlight Reflectors	Pd 46 Palladium Pollution Control	Ag 47 Silver Jewelry	Cd 48 Cadmium Paint	In 49 Indium Liquid Crystal Displays (LCDs)	Sn 50 Tin Piezoelectricity	Al 13 Aluminum Airplanes	Si 14 Silicon Semiconductors	P 15 Phosphorus Phosphorus	S 16 Sulfur Sulfur	Cl 17 Chlorine Chlorine	Kr 36 Krypton Noble Gas	
6	Cs 55 Cesium Atomic Clocks	Ba 56 Barium X-Ray Diagnosis	57 - 71 Rare Earth Metals	Hf 72 Hafnium Nuclear Submarines	Ta 73 Tantalum Mobile Phones	W 74 Tungsten Lamp Filaments	Re 75 Rhenium Rocket Engines	Os 76 Osmium Pen Points	Ir 77 Iridium Spark Plugs	Pt 78 Platinum Labware	Au 79 Gold Jewelry	Hg 80 Mercury Thermometers	Tl 81 Thallium Low-Temperature Thermometers	Pb 82 Lead Lead	Br 35 Bromine Bromine	Kr 36 Krypton Noble Gas	Xe 54 Xenon Noble Gas	Rn 86 Radon Noble Gas	At 85 Astatine Radioactive	Po 84 Polonium Radioactive	Bi 83 Bismuth Bismuth
7	Fr 87 Francium Laser Atom Traps	Ra 88 Radium Luminous Watches	89 - 103 Actinide Metals	Rf 104 Rutherfordium	Db 105 Dubnium	Sg 106 Seaborgium	Bh 107 Bohrium	Hs 108 Hassium	Mt 109 Meitnerium	Ds 110 Darmstadtium	Rg 111 Roentgenium	112 Copernicium	113 Nihonium	114 Flerovium	115 Moscovium	116 Livermorium	117 Tennessine	118 Oganesson	119 Ununennium	120 Unbinilium	



- Solid
 - Liquid
 - Gas at room temperature
 - Human Body: top ten elements by weight
 - Earth's Crust: top eight elements by weight
 - Magnetic: ferromagnetic at room temperature
 - Noble Metals: corrosion-resistant
 - Radioactive: all isotopes are radioactive
 - Only Traces Found in Nature: less than a millionth percent of earth's crust
 - Never Found in Nature: only made by people
- The color of the symbol is the color of the element in its most common pure form.
- Examples: metallic solid, red liquid, colorless gas



Boron Group 13

B 5
Boron
Sports Equipment

Al 13
Aluminum
Airplanes

Si 14
Silicon
Semiconductors

Ge 32
Germanium
Piezoelectricity

Sn 50
Tin
Tin

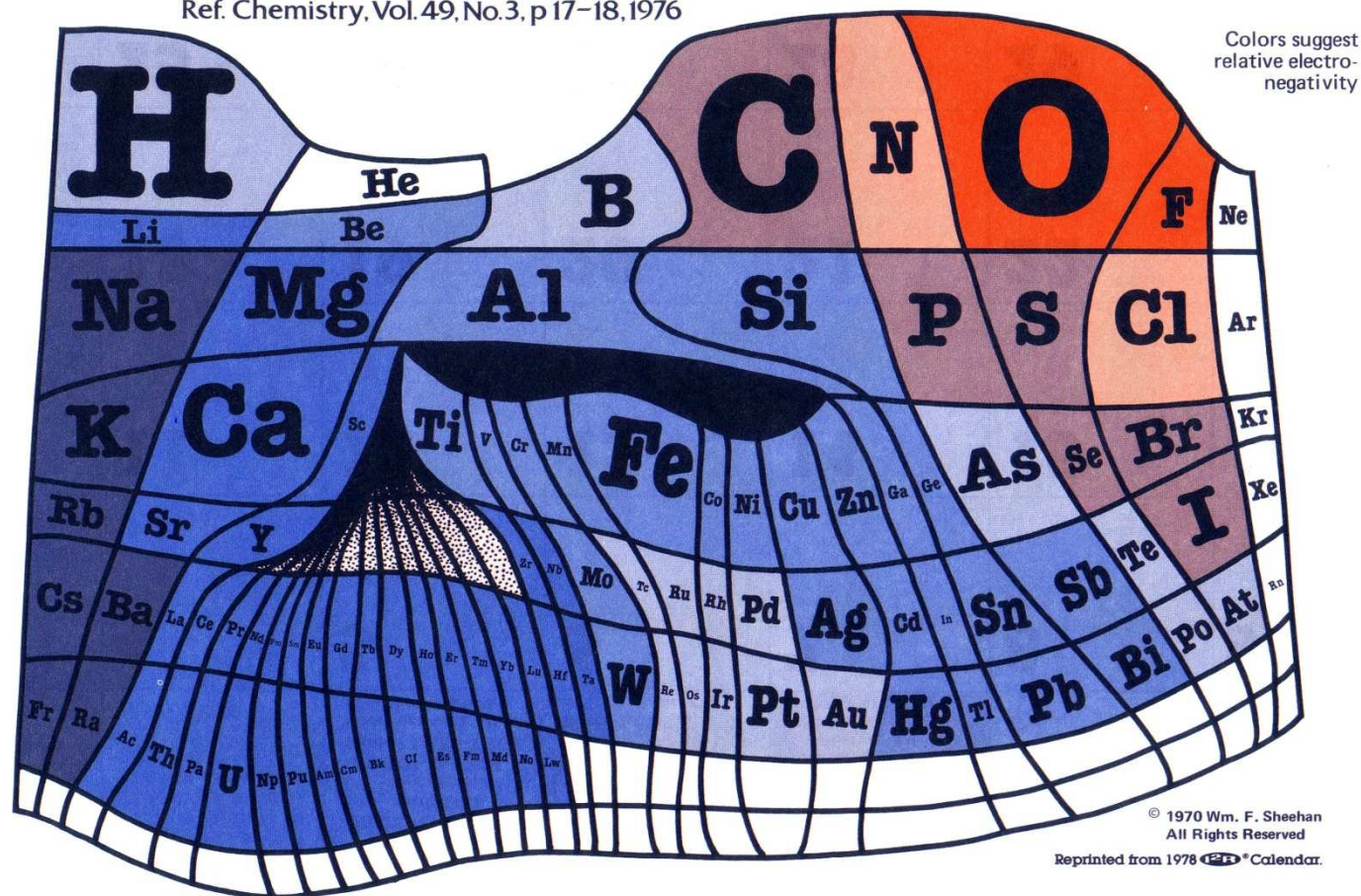
Pb 82
Lead
Lead

Superheavy Elements

radioactive, never found in nature, no uses except atomic research

The Elements According to Relative Abundance

A Periodic Chart by Prof. Wm. F. Sheehan, University of Santa Clara, CA 95053
 Ref. Chemistry, Vol. 49, No. 3, p 17-18, 1976



Roughly, the size of an element's own niche ("I almost wrote square") is proportioned to its abundance on Earth's surface, and in addition, certain chemical similarities (e.g., Be and Al, or B and Si) are sug-

gested by the positioning of neighbors. The chart emphasizes that in real life a chemist will probably meet O, Si, Al, . . . and that he better do something about it. Periodic tables based upon elemental abundance would, of course, vary from planet to planet. . . W.F.S.

NOTE: TO ACCOMMODATE ALL ELEMENTS SOME DISTORTIONS WERE NECESSARY, FOR EXAMPLE SOME ELEMENTS DO NOT OCCUR NATURALLY.