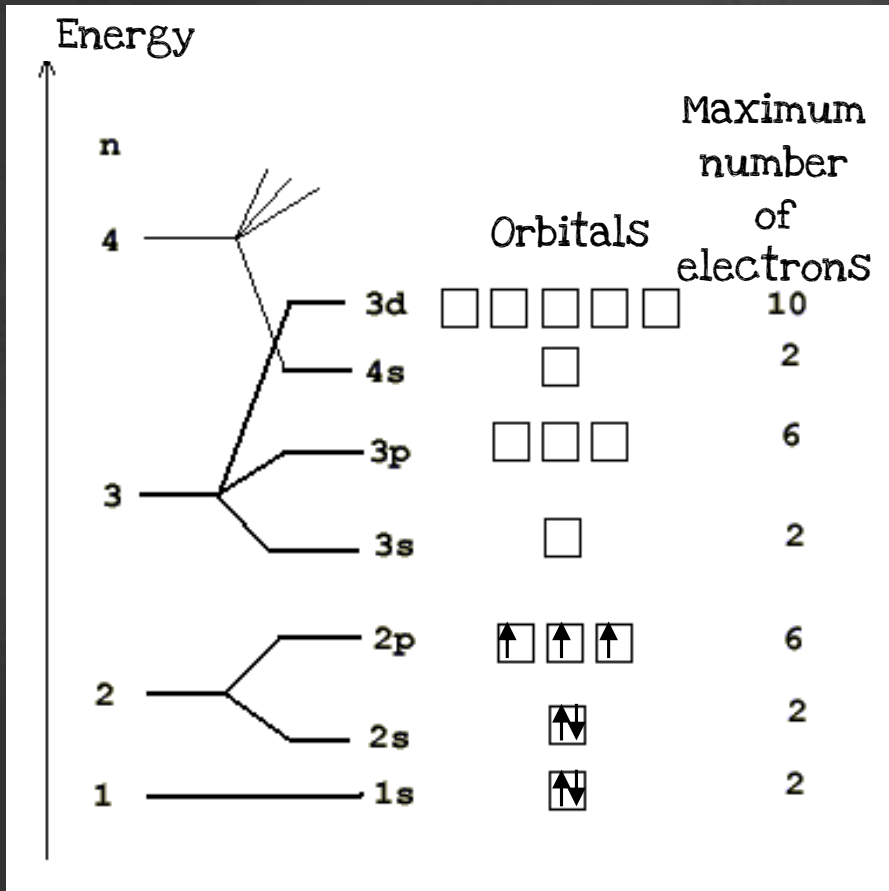
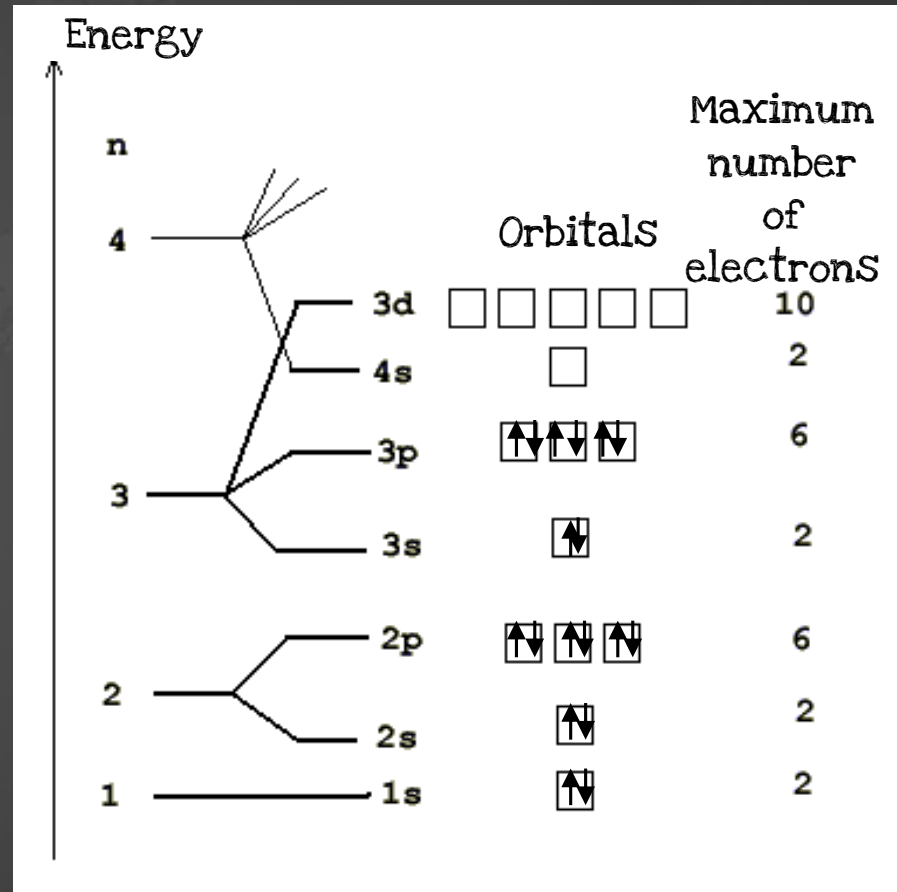
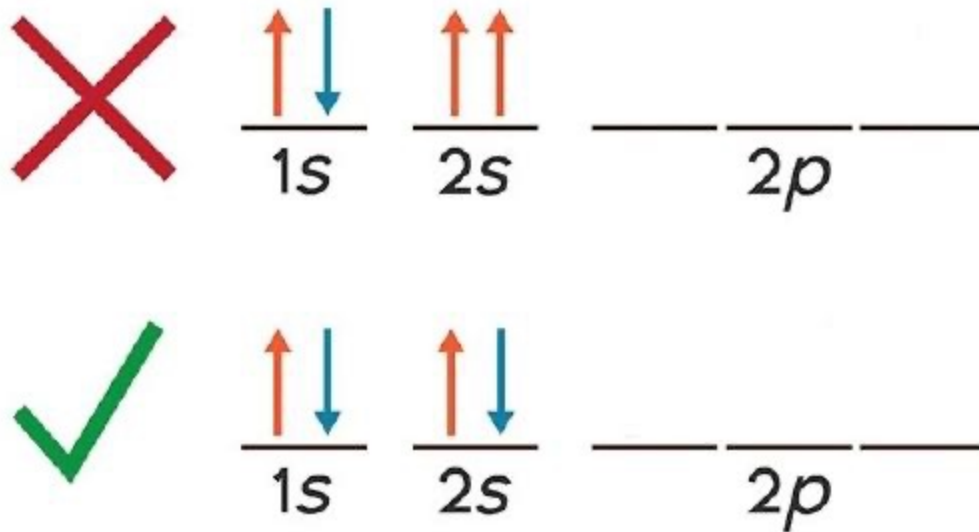


${}^7\text{N}$  ${}^{18}\text{Ar}$ 

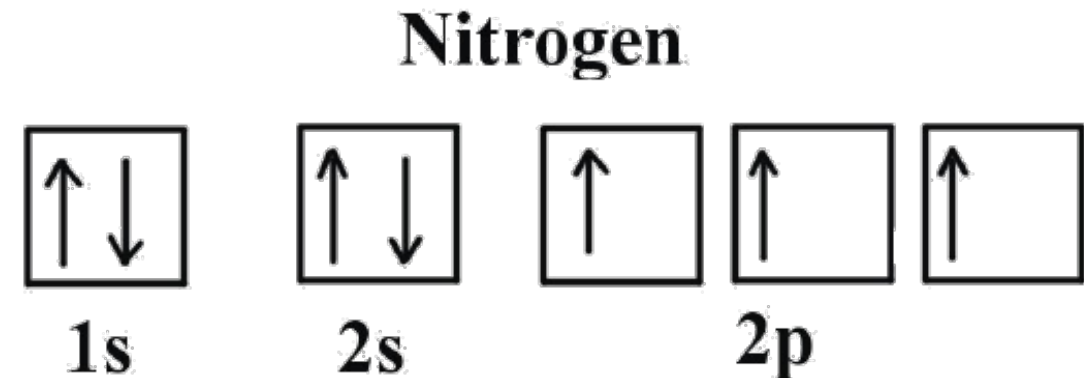
The further we go from the nucleus the smaller distances between levels and sublevels, they start to “overlap” each other.

Putting electrons into orbitals

1. The Pauli exclusion principle: the maximum number of electrons in an orbital is two. If there are two electrons in an orbital, they must have opposite spin.
2. Hund's rule: electrons fill orbitals of the same energy so as to give the maximum number of electrons with the same spin.

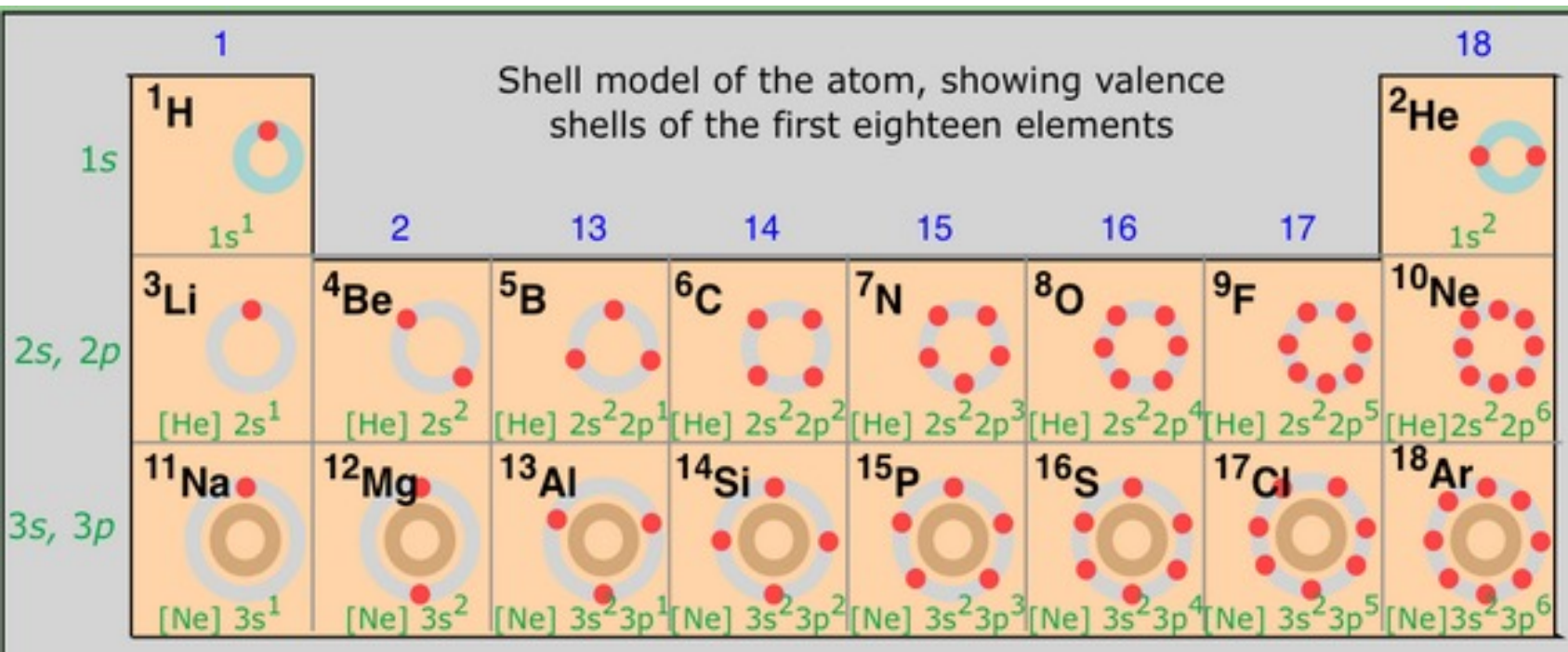


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^3Li $1s^2 2s^1$	^4Be $1s^2 2s^2$	^5B $1s^2 2s^2 2p^1$	^6C $1s^2 2s^2 2p^2$	^7N $1s^2 2s^2 2p^3$	^8O $1s^2 2s^2 2p^4$	^9F $1s^2 2s^2 2p^5$	^{10}Ne $1s^2 2s^2 2p^6$
^{11}Na $1s^2 2s^2 2p^6 3s^1$	^{12}Mg $1s^2 2s^2 2p^6 3s^2$	^{13}Al $[\text{Ne}] 3s^2 3p^1$	^{14}Si $[\text{Ne}] 3s^2 3p^2$	^{15}P $[\text{Ne}] 3s^2 3p^3$	^{16}S $[\text{Ne}] 3s^2 3p^4$	^{17}Cl $[\text{Ne}] 3s^2 3p^5$	^{18}Ar $[\text{Ne}] 3s^2 3p^6$
^{19}K $[\text{Ar}] 4s^1$	^{20}Ca $[\text{Ar}] 4s^2$	^1H $1s^1$		^2He $1s^2$			



Element	Charge of the nuclei	Outer shell
H	1	...1s ¹
Li	3	...2s ¹
Na	11	...3s ¹
K	19	...4s ¹
Rb	37	...5s ¹
Cs	55	...6s ¹
Fr	87	...7s ¹

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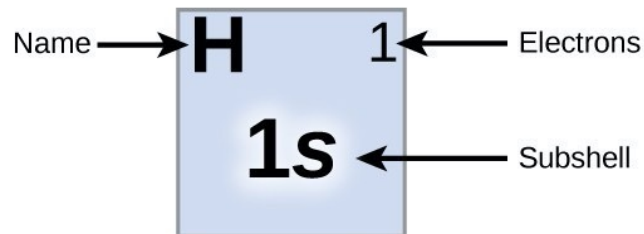
A complete outer shell, ns^2np^6 , is energetically more advantageous than an incomplete one.

We call it the RULE OF EIGHT: an atom tends to pick up or give away just enough electrons to make eight in its outer shell – AN ELECTRON OCTET.

Electrons in the outer shell (the highest main energy level) of an atom are called VALENCE ELECTRONS.

Electron Configuration Table

Period	Group																	18	
1	1																	18	
		H 1															He 1		
		1s															1s		
2	1 2	Li 1	Be 2											B 1	C 2	N 3	O 4	F 5	Ne 6
		2s	2s											← 2p →					
3	1 2	Na 1	Mg 2									Al 1	Si 2	P 3	S 4	Cl 5	Ar 6		
		3s	3s									← 3p →							
4	1 2	K 1	Ca 2	Sc 1	Ti 2	V 3	Cr 4	Mn 5	Fe 6	Co 7	Ni 8	Cu 9	Zn 10	Ga 1	Ge 2	As 3	Se 4	Br 5	Kr 6
		4s	4s	← 3d →									← 4p →						
5	1 2	Rb 1	Sr 2	Y 1	Zr 2	Nb 3	Mo 4	Tc 5	Ru 6	Rh 7	Pd 8	Ag 9	Cd 10	In 1	Sn 2	Sb 3	Te 4	I 5	Xe 6
		5s	5s	← 4d →									← 5p →						
6	1 2	Cs 1	Ba 2	La *1	Hf 2	Ta 3	W 4	Re 5	Os 6	Ir 7	Pt 8	Au 9	Hg 10	Tl 1	Pb 2	Bi 3	Po 4	At 5	Rn 6
		6s	6s	← 5d →									← 6p →						
7	1 2	Fr 1	Ra 2	Ac **1	Rf 2	Db 3	Sg 4	Bh 5	Hs 6	Mt	Ds	Rg	Cn	Uut	Fl	Uup	Lv	Uus	Uuo
		7s	7s	← 6d →															
		* Ce 1 Pr 2 Nd 3 Pm 4 Sm 5 Eu 6 Gd 7 Tb 8 Dy 9 Ho 10 Er 11 Tm 12 Yb 13 Lu 14																	
		← 4f →																	
		** Th 1 Pa 2 U 3 Np 4 Pu 5 Am 6 Cm 7 Bk 8 Cf 9 Es 10 Fm 11 Md 12 No 13 Lr 14																	
		← 5f →																	



For majority of atoms the electrons will occupy levels and orbitals as following:
 1s,2s,2p,3s,3p,4s,3d,4p,5s,4d,5p,6s,4f,5d,6p,7s,5f,6d...

Google 3D periodic table

<https://artsexperiments.withgoogle.com/periodic-table/>

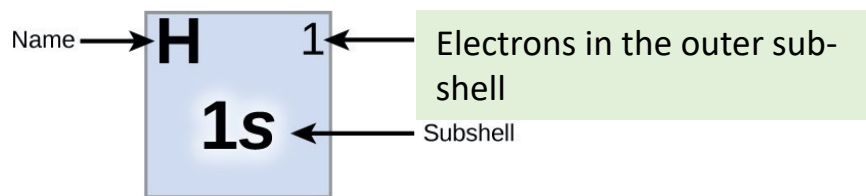
Electron Configuration Table

Period	Group																	18			
1	1	H																	He		
		1s																	1s		
2	1	Li	2													13	14	15	16	17	18
		2s														2p					
3	1	Na	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
		3s												3d							
4	1	K	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
		4s												4d							
5	1	Rb	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
		5s												5d							
6	1	Cs	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
		6s												6d							
7	1	Fr	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
		7s												7d							
		La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	In	Sn	Sb	Te	I	Xe				
		* Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu						
		** Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr						

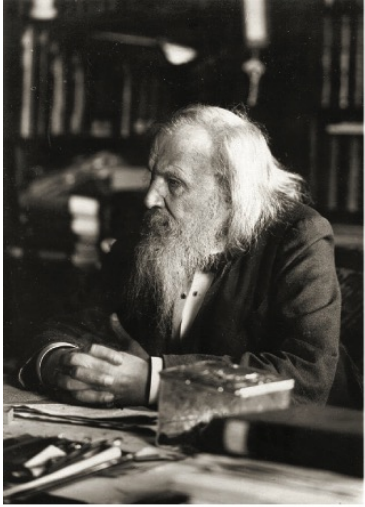
Electrons in the outer shell (the highest main energy level) of an atom are called VALENCE ELECTRONS. The elements in group 1 have 1 valence electron. The elements in group 2 have two valence electrons. The elements in groups 13-18 have valence electrons = group number – 10.

What can we tell about Sulfur (${}_{16}\text{S}$)?
 Valency?
 Energy level (shell)?
 Highest energy occupied subshell?
 Outer shell electron configuration?

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For majority of atoms the electrons will occupy levels and orbitals as following:
 1s,2s,2p,3s,3p,4s,3d,4p,5s,4d,5p,6s,4f,5d,6p,7s,5f,6d...



(a)

Reihen	Gruppe I. — R ⁰	Gruppe II. — R ⁰	Gruppe III. — R ^{0'}	Gruppe IV. RH ⁴ R ^{0''}	Gruppe V. RH ⁵ R ^{0'''}	Gruppe VI. RH ⁶ R ^{0''''}	Gruppe VII. RH ⁷ R ^{0'''''}	Gruppe VIII. — R ^{0''''''}
1	H=1							
2	Li=7	Be=9,4	B=11	C=12	N=14	O=16	F=19	
3	Na=23	Mg=24	Al=27,8	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	So=78	Br=80	
6	Rb=86	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	Su=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	—	—

(b)

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Periodic Table of Elements based on Mendeleev's Periodic Law

0	I	II	III	IV	V	VI	VII	VIII			
He 4.00	H 1.01	Li 6.94	Be 9.01	B 10.8	C 12.0	N 14.0	O 16.0	F 19.0			
Ne 20.2	Na 23.0	Mg 24.3	Al 27.0	Si 28.1	P 31.0	S 32.1	Cl 35.5				
Ar 40.0	K 39.1	Ca 40.1	Sc 45.0	Ti 47.9	V 50.9	Cr 52.0	Mn 54.9	Fe 55.9	Co 58.9	Ni 58.7	
Kr 83.8	Rb 85.5	Sr 87.6	Y 88.9	Zr 91.2	Nb 92.9	Mo 95.9	Tc (99)	Ru 101	Rh 103	Pd 106	
Xe 131	Ce 133	Ba 137	La 139	Hf 179	Ta 181	W 184	Re 180	Os 194	Ir 192	Pt 195	
Rn (222)	Fr (223)	Ra (226)	Ac (227)	Th 232	Pa (231)	U 238					

Dobereiner's triads

Known to Mendeleev

●

Lanthanide series

●

Actinide series

●

Known to Ancients

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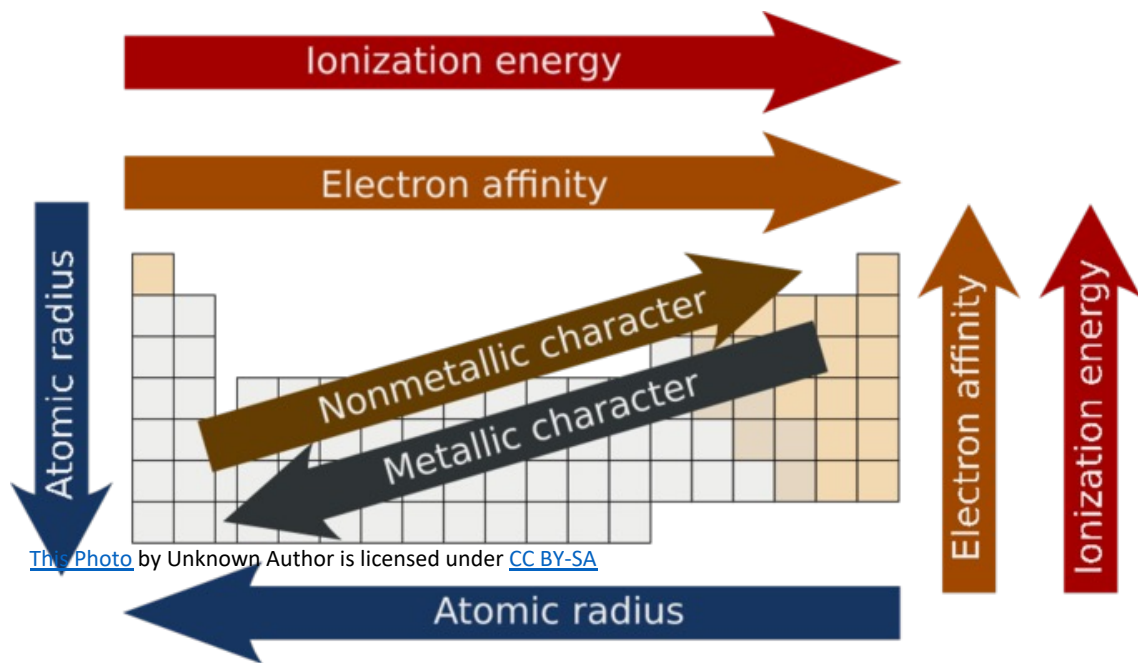
PERIODIC TABLE OF THE ELEMENTS

1	1 H Hydrogen 1.008																	18 He Helium 4.003															
2	3 Li Lithium 6.941	4 Be Beryllium 9.012											5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180															
3	11 Na Sodium 22.990	12 Mg Magnesium 24.305											13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.066	17 Cl Chlorine 35.453	18 Ar Argon 39.948															
4	19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.88	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.631	33 As Arsenic 74.922	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 83.798															
5	37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.414	49 In Indium 114.818	50 Sn Tin 118.711	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.904	54 Xe Xenon 131.294															
6	55 Cs Cesium 132.905	56 Ba Barium 137.328	57-71	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	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 196.967	80 Hg Mercury 200.59	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [208.982]	85 At Astatine 209.987	86 Rn Radon 222.018															
7	87 Fr Francium 223.020	88 Ra Radium 226.025	89-103	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [278]	110 Ds Darmstadtium [281]	111 Rg Roentgenium [280]	112 Cn Copernicium [285]	113 Nh Nihonium [286]	114 Fl Flerovium [289]	115 Mc Moscovium [289]	116 Lv Livermorium [293]	117 Ts Tennessine [294]	118 Og Oganesson [294]															
																			57 La Lanthanum 138.905	58 Ce Cerium 140.116	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.243	61 Pm Promethium 144.913	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.500	67 Ho Holmium 164.930	68 Er Erbium 167.259	69 Tm Thulium 168.934	70 Yb Ytterbium 173.055	71 Lu Lutetium 174.967
																			89 Ac Actinium 227.028	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium 237.048	94 Pu Plutonium 244.064	95 Am Americium 243.061	96 Cm Curium 247.070	97 Bk Berkelium 247.070	98 Cf Californium 251.080	99 Es Einsteinium [254]	100 Fm Fermium 257.095	101 Md Mendelevium 258.1	102 No Nobelium 259.101	103 Lr Lawrencium [262]
																			Alkali Metal	Alkaline Earth	Transition Metal	Basic Metal	Metalloid	Nonmetal	Halogen	Noble Gas	Lanthanide	Actinide					

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What is periodic law? The statement that the chemical and physical properties of the elements recur periodically when the elements are arranged in the order of their atomic weight.

Properties of elements down a group and across a period.



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	Family							
	1A	2A	3A	4A	5A	6A	7A	8A
1	H							He
2	Li	Be	B	C	N	O	F	Ne
3	Na	Mg	Al	Si	P	S	Cl	Ar
4	K	Ca	Ga	Ge	As	Se	Br	Kr
5	Rb	Sr	In	Sn	Sb	Te	I	Xe
6	Cs	Ba	Tl	Pb	Bi	Po	At	Rn

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Gonick and Graig Criddle “The cartoon guide to
chemistry”

Manyuilov and Rodionov “Chemistry for children and adults”

Steve Owen Chemistry for the IB diploma

