

The Periodic Table

Why is it called a *periodic* table?

The properties of the elements in the table repeat in a "periodic" way (specific pattern).

Periodic law: There is a periodic repetition of chemical and physical properties of the elements when they are arranged by increasing atomic number

Metals, nonmetals, and metalloids

hydrogen 1 H 1.0079																	helium 2 He 4.0026				
lithium 3 Li 6.941	beryllium 4 Be 9.0122															boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180
sodium 11 Na 22.990	magnesium 12 Mg 24.305															aluminum 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948
potassium 19 K 39.098	calcium 20 Ca 40.078	scandium 21 Sc 44.956	titanium 22 Ti 47.867	vanadium 23 V 50.942	chromium 24 Cr 51.996	manganese 25 Mn 54.938	iron 26 Fe 55.845	cobalt 27 Co 58.933	nickel 28 Ni 58.693	copper 29 Cu 63.546	zinc 30 Zn 65.39	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.80				
rubidium 37 Rb 85.468	strontium 38 Sr 87.62	yttrium 39 Y 88.906	zirconium 40 Zr 91.224	niobium 41 Nb 92.906	molybdenum 42 Mo 95.94	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.91	palladium 46 Pd 106.42	silver 47 Ag 107.87	cadmium 48 Cd 112.41	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29				
cesium 55 Cs 132.91	barium 56 Ba 137.33	57-70 *		lanthanum 57 La 138.91	cerium 58 Ce 140.12	praseodymium 59 Pr 140.91	neodymium 60 Nd 144.24	promethium 61 Pm [145]	samarium 62 Sm 150.36	europtium 63 Eu 151.96	gadolinium 64 Gd 157.25	terbium 65 Tb 158.93	dysprosium 66 Dy 162.50	holmium 67 Ho 164.93	erbium 68 Er 167.26	thulium 69 Tm 168.93	ytterbium 70 Yb 173.04				
francium 87 Fr [223]	radium 88 Ra [226]	89-102 * *		actinium 89 Ac [227]	thorium 90 Th 232.04	protactinium 91 Pa 231.04	uranium 92 U 238.03	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	einsteinium 99 Es [252]	fermium 100 Fm [257]	mendelevium 101 Md [258]	nobelium 102 No [259]				

*Lanthanide series

** Actinide series

lanthanum 57 La 138.91	cerium 58 Ce 140.12	praseodymium 59 Pr 140.91	neodymium 60 Nd 144.24	promethium 61 Pm [145]	samarium 62 Sm 150.36	europtium 63 Eu 151.96	gadolinium 64 Gd 157.25	terbium 65 Tb 158.93	dysprosium 66 Dy 162.50	holmium 67 Ho 164.93	erbium 68 Er 167.26	thulium 69 Tm 168.93	ytterbium 70 Yb 173.04
actinium 89 Ac [227]	thorium 90 Th 232.04	protactinium 91 Pa 231.04	uranium 92 U 238.03	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	einsteinium 99 Es [252]	fermium 100 Fm [257]	mendelevium 101 Md [258]	nobelium 102 No [259]

* Lanthanide series

** Actinide series

- stair steps separate metals from nonmetals
- metalloids line the stair-step line
 - > Semimetals: have properties in between metals and nonmetals

alkali metals alkaline earth metals halogens

metalloids

noble gases

s-block

d-block transition metals

p-block

lanthanides

actinides

f-block

Periodic Table Key

Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Period 1	1 H	2 He																
2	3 Li	4 Be																
3	11 Na	12 Mg																
4	19 K	20 Ca																
5	37 Rb	38 Sr																
6	55 Cs	56 Ba																
7	87 Fr	88 Ra																
			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
			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
			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
			89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Uut	114 Uuq	115 Uup	116 Uuh	117 Uus	118 Uuo
			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		

Metals, nonmetals, and metalloids

Metals	Metalloids	Nonmetals
Examples:	Examples:	Examples:

Periodic Table

Periods = rows

- 7 periods
- period equals the highest principal energy level and therefore, the principal energy level of the valence electrons.

Examples: Li, Na, K

hydrogen 1 H 1.0079																	helium 2 He 4.0026				
lithium 3 Li 6.941	beryllium 4 Be 9.0122															boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180
sodium 11 Na 22.990	magnesium 12 Mg 24.305															aluminum 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948
potassium 19 K 39.098	calcium 20 Ca 40.078	scandium 21 Sc 44.956	titanium 22 Ti 47.867	vanadium 23 V 50.942	chromium 24 Cr 51.996	manganese 25 Mn 54.938	iron 26 Fe 55.845	cobalt 27 Co 58.933	nickel 28 Ni 58.693	copper 29 Cu 63.546	zinc 30 Zn 65.39	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.80				
rubidium 37 Rb 85.468	strontium 38 Sr 87.62	ytrium 39 Y 88.906	zirconium 40 Zr 91.224	niobium 41 Nb 92.906	molybdenum 42 Mo 95.94	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.91	palladium 46 Pd 106.42	silver 47 Ag 107.87	cadmium 48 Cd 112.41	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.6	iodine 53 I 126.90	xenon 54 Xe 131.29				
cesium 55 Cs 132.91	barium 56 Ba 137.33	57-70 *		lutetium 71 Lu 174.97	hafnium 72 Hf 178.49	tantalum 73 Ta 180.95	tungsten 74 W 183.84	rhenium 75 Re 186.21	osmium 76 Os 190.23	iridium 77 Ir 192.22	platinum 78 Pt 195.08	gold 79 Au 196.97	mercury 80 Hg 200.59	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]		
francium 87 Fr [223]	radium 88 Ra [226]	89-102 **		actinium 89 Ac [227]	thorium 90 Th 232.04	protactinium 91 Pa 231.04	uranium 92 U 238.03	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	einsteinium 99 Es [252]	fermium 100 Fm [257]	mendelevium 101 Md [258]	nobelium 102 No [259]				
																			</		

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** Actinide series

lanthanum 57 La 138.91	cerium 58 Ce 140.12	praseodymium 59 Pr 140.91	neodymium 60 Nd 144.24	promethium 61 Pm [145]	samarium 62 Sm 150.36	europium 63 Eu 151.96	gadolinium 64 Gd 157.25	terbium 65 Tb 158.93	dysprosium 66 Dy 162.50	holmium 67 Ho 164.93	erbium 68 Er 167.26	thulium 69 Tm 168.93	ytterbium 70 Yb 173.04
actinium 89 Ac [227]	thorium 90 Th 232.04	protactinium 91 Pa 231.04	uranium 92 U 238.03	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	einsteinium 99 Es [252]	fermium 100 Fm [257]	mendelevium 101 Md [258]	nobelium 102 No [259]

Periodic Table

Report 1										Report 2									
H										He									
1.0079										4.0026									
Hydrogen										Helium									
Lithium										Boron									
3										4									
Li										Be									
6.941										9.0122									
Lithium										Beryllium									
Sodium										Magnesium									
11										12									
Na										Mg									
22.990										24.305									
Potassium										Calcium									
19										20									
K										Ca									
39.098										40.078									
Scandium										Titanium									
21										22									
Sc										Ti									
44.956										47.88									
Vanadium										Chromium									
23										24									
V										Cr									
50.942										52.00									
Manganese										Iron									
25										26									
Mn										Fe									
54.938										55.845									
Cobalt										Nickel									
27										28									
Co										Ni									
58.933										58.693									
Copper										Zinc									
29										30									
Cu										Zn									
63.546										65.38									
Gallium										Germanium									
31										32									
Ga										Ge									
69.723										72.64									
Arsenic										Selenium									
33										34									
Al										Si									
13										14									
Al										P									
26.982										30.974									
Sulfur										Chlorine									
16										17									
S										Cl									
32.06										35.45									
Potassium										Calcium									
19										20									
K										Ca									
39.098										40.078									
Scandium										Titanium									
21										22									
Sc										Ti									
44.956										47.88									
Vanadium										Chromium									
23										24									
V										Cr									
50.942										52.00									
Manganese										Iron									
25										26									
Mn										Fe									
54.938										55.845									
Cobalt										Nickel									
27										28									
Co										Ni									
58.933										58.693									
Copper										Zinc									
29										30									
Cu										Zn									
63.546										65.38									
Gallium										Germanium									
31										32									
Ga										Ge									
69.723										72.64									
Arsenic										Selenium									
33										34									
As										Se									
74.922										78.96									
Bromine										Krypton									
35										36									
Br										Kr									
79.904										83.80									
Rubidium										Strontium									
37										38									
Rb										Sr									
85.468										87.62									
Yttrium										Zirconium									
39										40									
Y										Zr									
88.906										91.224									
Niobium										Molybdenum									
41										42									
Nb										Mo									
92.906										95.94									
Technetium										Ruthenium									
43										44									
Tc										Ru									
98										101.07									
Rhodium										Palladium									
45										46									
Rh										Pd									
102.905										106.42									
Silver										Cadmium									
47										48									
Ag										Cd									
107.868										112.41									
Indium										Tin									
49										50									
In										Sn									
114.818										118.710									
Antimony										Tellurium									
51										52									
Sb										Te									
121.757										127.60									
Iodine										Xenon									
53										54									
I										Xe									
126.905										131.29									
Cesium										Barium									
55										56									
Cs										Ba									
132.905										137.327									
Lanthanum										Cerium									
57										58									
La										Ce									
138.905										140.12									
Praseodymium										Neodymium									
59										60									
Pr										Nd									
140.908										144.24									
Europium										Gadolinium									
63										64									
Eu										Gd									
151.964										157.25									
Terbium										Dysprosium									
65										66									
Tb										Dy									
158.925										162.50									
Holmium										Erbium									
67										68									
Ho										Er									
164.930										167.26									
Thulium										Ytterbium									
69										70									
Tm										Yb									
168.930										173.054									
Lutetium										Hafnium									
71										72									
Lu										Hf									
174.967										178.49									
Tantalum										Tungsten									
73										74									
Ta										W									
180.948										183.84									
Rhenium										Osmium									
75										76									
Re										Os									
186.207										190.23									
Iridium										Platinum									
77										78									
Ir										Pt									
192.222										195.084									
Gold										Mercury									
79										80									
Au										Hg									
196.967										200.59									
Thallium										Lead									
81										82									
Tl										Pb									
204.384										207.2									
Bismuth										Polonium									
83										84									
Bi										Po									
208.980										209									
Francium										Radium									
87										88									
Fr										Ra									
223.018										226.025									
Actinium										Thorium									
89										90									
Ac										Th									
227.028										232.038									
Protactinium										Uranium									
91										92									
Pa										U									
231.036										238.029									
Neptunium										Plutonium									
93										94									
Np										Pu									
237.048										244.064									
Americium										Curium									
95										96									
Am										Cm									
243.061										247.065									
Einsteinium										Fermium									
97										98									
Es										Fm									
252.083										257.105									
Mendelevium										Nobelium									
99										100									
Md										No									
258.103										259.108									
Lawrencium										Rutherfordium									
101										102									
Lr										Rf									
260.106										261.108									
Hassium										Dubnium									
103										104									
Db										Db									
262.109										263.109									
Bohrium										Hassium									
105										106									
Bh										Hs									
264.109										265.109									
Meitnerium										Darmstadtium									
107										108									
Mt										Ds									
268.109										269.109									
Bohrium										Hassium									
109										110									
Uu										Uu									
271.109										272.109									
Ununbium										Ununtrium									
111										112									
Uub										Uub									
274.109										275.109									
Ununquadium										Ununpentium									
113										114									
Uuq										Uuq									
277.109										278.109									
Ununseptium										Ununoctium									
115										116									
Uus										Uus									
279.109										280.109									
Ununseptium										Ununoctium									
117										118									
Uuh										Uuh									
281.109										282.109									
Ununseptium										Ununoctium									
119										120									
Uuo										Uuo									
283.109										284.109									
Ununseptium										Ununoctium									
121										122									
Uuq										Uuq									
285.109										286.109									
Ununseptium										Ununoctium									
123										124									
Uuq										Uuq									
287.109										288.109									
Ununseptium										Ununoctium									
125										126									
Uuq										Uuq									
289.109										290.109									
Ununseptium										Ununoctium									
127										128									
Uuq										Uuq									
291.109										292.109									
Ununseptium										Ununoctium									
129										130									
Uuq										Uuq									
293.109										294.109									
Ununseptium										Ununoctium									
131										132									
Uuq										Uuq									
295.109										296.109									
Ununseptium										Ununoctium									
133										134									
Uuq										Uuq									
297.109										298.109									
Ununseptium										Ununoctium									
135										136									
Uuq										Uuq									
299.109										300.109									
Ununseptium										Ununoctium									
137										138									
Uuq										Uuq									
301.109										302.109									
Ununseptium										Ununoctium									
139										140									
Uuq										Uuq									
303.109										304.109									
Ununseptium										Ununoctium									
141										142									
Uuq										Uuq									
305.109										306.109									
Ununseptium										Ununoctium									
143										144									
Uuq										Uuq									
307.109										308.109									
Ununseptium										Ununoctium									
145										146									
Uuq										Uuq									
309.109										310.109									
Ununseptium										Ununoctium									
147										148									
Uuq										Uuq									
311.109										312.109									
Ununseptium										Ununoctium									
149										150									
Uuq										Uuq									
313.109										314.109									
Ununseptium										Ununoctium									
151										152									
Uuq										Uuq									
315.109										316.109									
Ununseptium										Ununoctium									
153										154									
Uuq										Uuq									
317.109										318.109									
Ununseptium										Ununoctium									
155										156									
Uuq										Uuq									
319.109										320.109									
Ununseptium										Ununoctium									
157										158									
Uuq										Uuq									
321.109										322.109									
Ununseptium										Ununoctium									
159										160									
Uuq										Uuq									
323.109										324.109									
Ununseptium										Ununoctium									
161										162									
Uuq										Uuq									
325.109										326.109									
Ununseptium										Ununoctium									
163										164									
Uuq										Uuq									
327.109										328.109									
Ununseptium										Ununoctium									
165										166									
Uuq										Uuq									
329.109										330.109									
Ununseptium										Ununoctium									
167										168									
Uuq										Uuq									
331.109										332.109									
Ununseptium										Ununoctium									
169										170									
Uuq										Uuq									
333.109										334.109									
Ununseptium										Ununoctium									
171										172									
Uuq										Uuq									
335.109										336.109									
Ununseptium										Ununoctium									
173										174									
Uuq										Uuq									
337.109										338.109									
Ununseptium										Ununoctium									
175										176									
Uuq										Uuq									
339.109										340.109									
Ununseptium										Ununoctium									
177										178									
Uuq										Uuq									
341.109										342.109									
Ununseptium										Ununoctium									
179										180									
Uuq										Uuq									
343.109										344.109									
Ununseptium										Ununoctium									
181										182									
Uuq										Uuq									
345.109										346.109									
Ununseptium										Ununoctium									
183										184									
Uuq										Uuq									
347.109										348.109									
Ununseptium										Ununoctium									
185										186									
Uuq										Uuq									
349.109										350.109									
Ununseptium										Ununoctium									
187										188									
Uuq										Uuq									
351.109										352.109									
Ununseptium										Ununoctium									
189										190									
Uuq										Uuq									
353.109										354.109									
Ununseptium										Ununoctium									
191										192									
Uuq										Uuq									
355.109										356.109									
Ununseptium										Ununoctium									
193										194									
Uuq										Uuq									
357.109										358.109									
Ununseptium										Ununoctium									
195										196									
Uuq										Uuq									
359.109										360.109									
Ununseptium										Ununoctium									
197										198									
Uuq										Uuq									
361.109										362.109									
Ununseptium										Ununoctium									
199										200									
Uuq										Uuq									
363.109										364.109									
Ununseptium										Ununoctium									
201										202									
Uuq										Uuq									
365.109										366.109									
Ununseptium										Ununoctium									
203										204									
Uuq										Uuq									
367.109										368.109									
Ununseptium										Ununoctium									
205										206									
Uuq										Uuq									
369.109										370.109									
Ununseptium										Ununoctium									
207										208									
Uuq										Uuq									
371.109										372.109									
Ununseptium										Ununoctium									
209																			

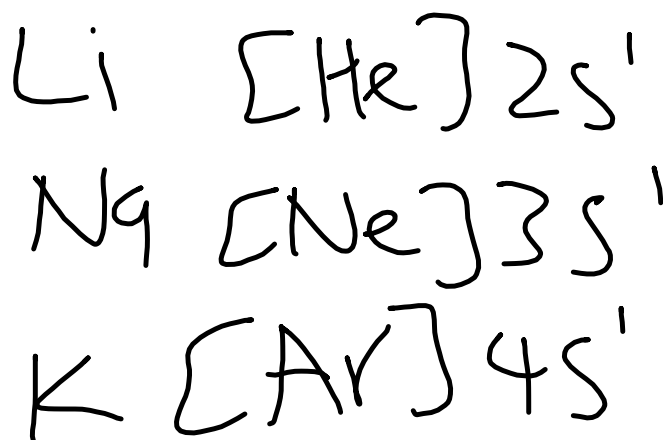
* Lanthanide series

La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb
138.91	140.12	140.91	144.24	144.91	150.36	151.96	157.25	158.93	162.50	164.93	167.26	168.93	173.05
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No
227.03	232.04	231.04	238.03	237.05	244.06	247.07	251.08	262.11	285.10	289.10	287.10	289.10	289.10

* * Actinide series

Groups = columns

- Elements in the same group have the same number of valence electrons.
- Number of groups in a block (s, p, d, f) corresponds to the maximum number of electrons that can occupy that sublevel.
- 18 labeled groups



Periodic Table

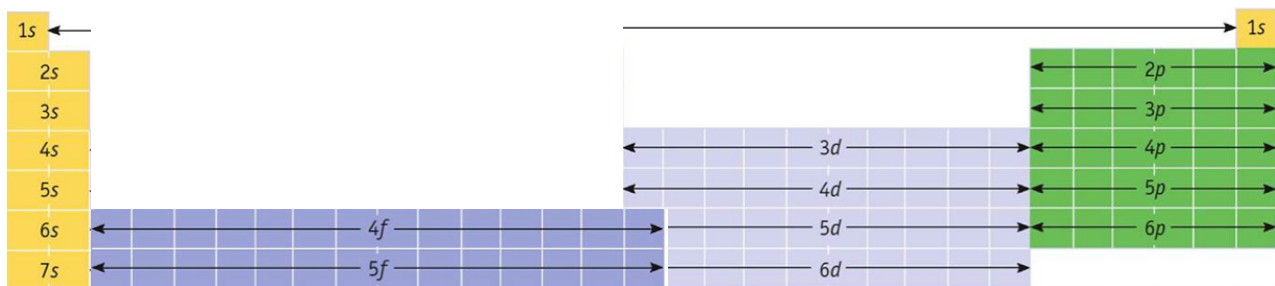
hydrogen 1 1.00794																																helium 2 He 4.00260															
lithium 3 Li 6.941		beryllium 4 Be 9.01218														boron 5 B 10.811		carbon 6 C 12.011		nitrogen 7 N 14.007		oxygen 8 O 15.999		fluorine 9 F 18.998		neon 10 Ne 20.180																					
sodium 11 Na 22.990		magnesium 12 Mg 24.305														aluminum 13 Al 26.982		silicon 14 Si 28.086		phosphorus 15 P 30.974		sulfur 16 S 32.06		chlorine 17 Cl 35.453		argon 18 Ar 39.948																					
potassium 19 K 39.098		calcium 20 Ca 40.078		scandium 21 Sc 44.956		titanium 22 Ti 47.88		vanadium 23 V 50.942		chromium 24 Cr 52.004		manganese 25 Mn 54.938		iron 26 Fe 55.845		cobalt 27 Co 58.933		nickel 28 Ni 58.693		copper 29 Cu 63.546		zinc 30 Zn 65.38		gallium 31 Ga 69.723		germanium 32 Ge 72.64		arsenic 33 As 74.922		selenium 34 Se 78.96		bromine 35 Br 79.904		krypton 36 Kr 83.80													
rubidium 37 Rb 85.468		strontium 38 Sr 87.62		yttrium 39 Y 88.906		zirconium 40 Zr 91.224		niobium 41 Nb 92.906		molybdenum 42 Mo 95.94		technetium 43 Tc [98]		ruthenium 44 Ru 101.07		rhodium 45 Rh 102.91		palladium 46 Pd 106.42		silver 47 Ag 107.87		cadmium 48 Cd 112.41		indium 49 In 114.82		tin 50 Sn 118.71		antimony 51 Sb 121.76		tellurium 52 Te 127.60		iodine 53 I 126.905		xenon 54 Xe 131.29													
cesium 55 Cs 132.91		barium 56 Ba 137.33		* 57-70		lanthanum 57 La 138.91		cerium 58 Ce 140.12		praseodymium 59 Pr 140.91		neodymium 60 Nd 144.24		promethium 61 Pm [145]		samarium 62 Sm 150.36		europium 63 Eu 151.96		gadolinium 64 Gd 157.25		terbium 65 Tb 158.93		dysprosium 66 Dy 162.50		holmium 67 Ho 164.93		erbium 68 Er 167.26		thulium 69 Tm 168.93		ytterbium 70 Yb 173.04															
francium 87 Fr [223]		radium 88 Ra [226]		89-102 * * *		actinium 89 Ac [227]		thorium 90 Th 232.04		protactinium 91 Pa 231.04		uranium 92 U 238.03		neptunium 93 Np [237]		plutonium 94 Pu [244]		americium 95 Am [243]		curium 96 Cm [247]		berkelium 97 Bk [247]		californium 98 Cf [251]		einsteinium 99 Es [252]		fermium 100 Fm [257]		mendelevium 101 Md [258]		nobelium 102 No [259]															

* Lanthanide series

* Actinide series

Groups = columns

- group 1 = alkali metals
- group 2 = alkaline earth metals
- group 17 = halogens
- group 18 = noble gases
- groups 3-12 = transition metals
- lanthanide and actinide series = "inner transition metals"



The Periodic Table

Why is it called a *periodic* table?

The properties of the elements in the table repeat in a "periodic" way (specific pattern).

Periodic law: There is a periodic repetition of chemical and physical properties of the elements when they are arranged by increasing atomic number

Periodic Law

- Physical properties of the alkaline metals
- Physical properties of the halogens

Periodic Trends: chemical properties of elements are determined by the # of valence electrons.

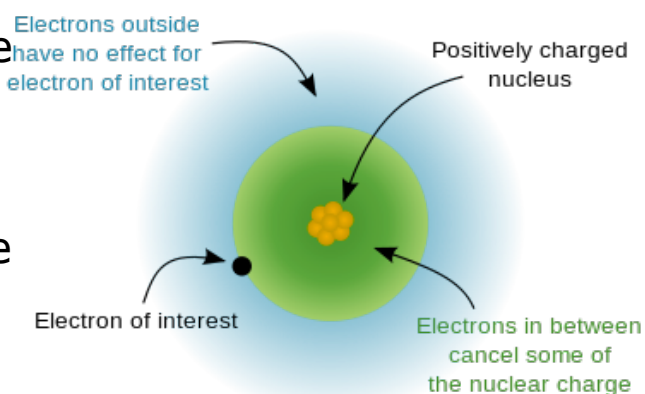
- Properties are periodic because the number of valence electrons is periodic.

1. Atomic Radius
2. Ionic Radius
3. Ionization energy
- ~~4. Electron Affinity~~
5. Electronegativity

Before we begin looking at the different periodic trends, we need to talk about a concept called **electron shielding effect**

Electrons and protons are attracted to one another because they have opposite charges.

Core electrons block some of the nuclear charge of the nucleus from the valence electrons.



http://en.wikipedia.org/wiki/Effective_nuclear_charge

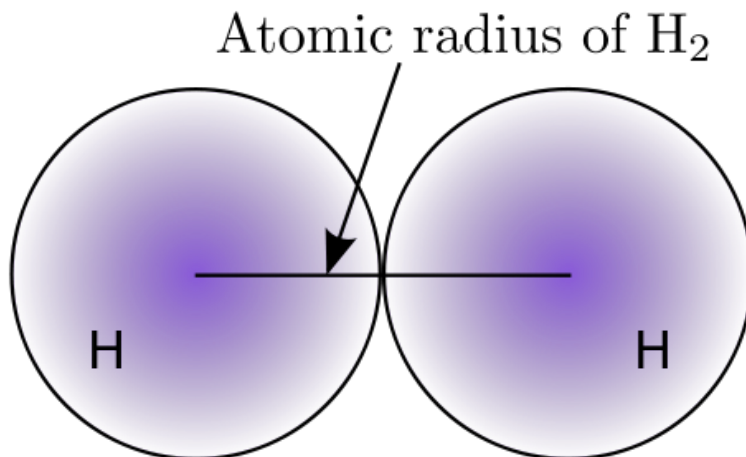
Effective nuclear charge (Z_{eff}) is the charge felt by the valence electrons after you have taken into account the number of **shielding electrons** that surround the nucleus.

$$Z_{\text{eff}} = Z - \# \text{ core e-}$$

1. Atomic Radius

The electron cloud surrounding a nucleus is based on *probability* and does not have a clearly defined edge.

- Atomic radius = half the distance between nuclei of adjacent identical atoms
 - > Adjacent nuclei in a crystal
 - > Nuclei of two atoms bonded together



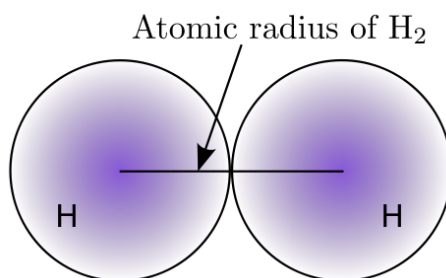
1. Atomic Radius

Atomic radius is determined by the strength of attraction between the valence electrons and the nucleus

$$\text{Coulombs Law: } E = k \frac{q_1 q_2}{d}$$

Greater charge = greater attraction

Greater distance = weaker attraction



http://en.wikibooks.org/wiki/High_School_Chemistry/Atomic_Size

Atomic Radius

Two factors determine the atomic radius:

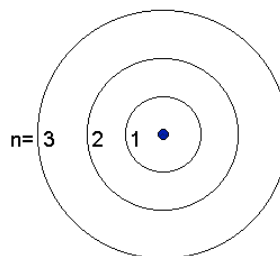
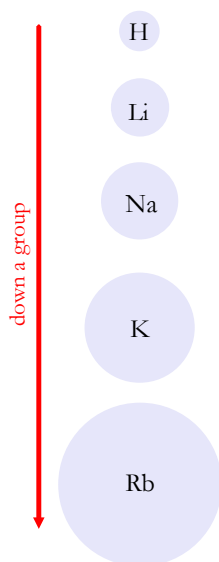
① the principal ~~quantum number~~ (n)
energy level

② effective nuclear charge which is the
amount of charge felt by the valence
e- after considering the shielding e-
(Z_{eff})
Z - #core e- (core e-)

Eq. $\frac{Q_1 Q_2}{d}$
energy to remove e-
according to Coulombs law

Atomic Radius

The larger the principal quantum number (n), the larger the region of space occupied by the electrons and the farther from the nucleus the e^- are found.



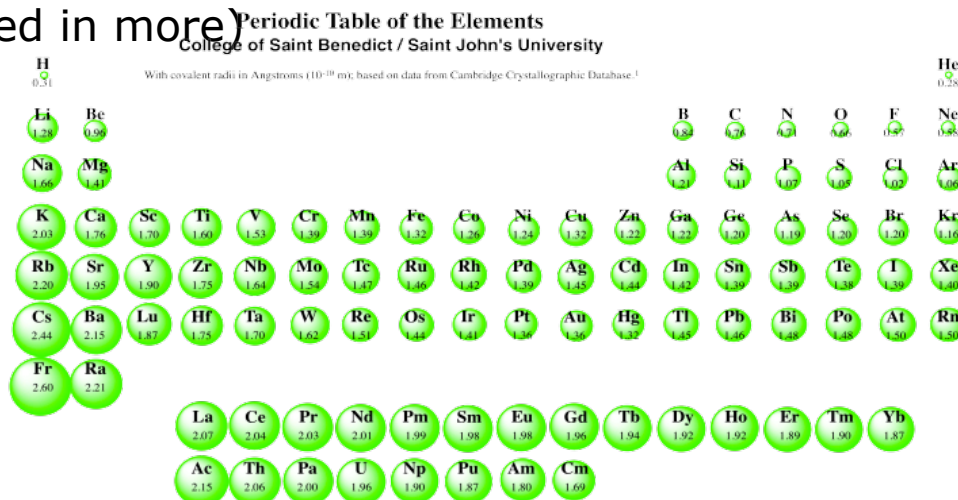
1. Atomic Radius

Moving down a group: Atomic radius increases

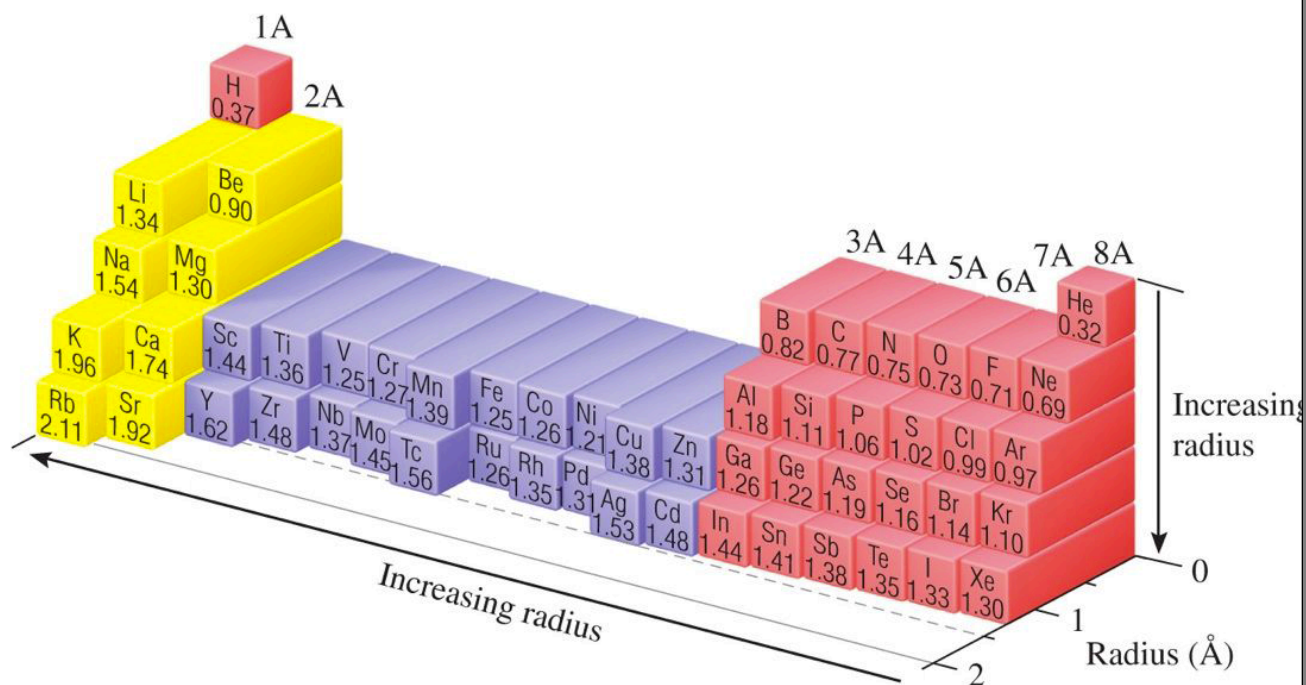
- Principal energy levels increase = increased orbital size, electrons are farther from nucleus

Moving across a period: Atomic radius decreases

- Principal energy level remains the same
- # of protons increases $\rightarrow Z_{\text{eff}}$ increases (electrons pulled in more)



1. Beatriz Cordero et al. *Dalton Trans.* **2008**, 21, 2832–2838.



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Order the following atoms from smallest to biggest atomic radius:

Ga, Se, K

I, F, Cl

2. Ionic Radius

Ion = atom that has gained or lost electrons

- $\#p \neq \#e^-$
- Has a positive or negative charge

2. Ionic Radius



















When an atom gains e^- (anion): radius increases

- # protons same, but electron cloud increases (electrons repel each other)

When an atom loses e^- (cation): radius decreases

- Loss of valence electron causes electron cloud to be pulled tighter by protons.

Atomic/Ionic Radii

5A		6A		7A	
 N 0.70	 N^{3-} 1.71	 O 0.66	 O^{2-} 1.40	 F 0.64	 F^- 1.36
		 S 1.04	 S^{2-} 1.84	 Cl 0.99	 Cl^- 1.81
		 Se 1.17	 Se^{2-} 1.98	 Br 1.14	 Br^- 1.85
		 Te 1.37	 Te^{2-} 2.21	 I 1.33	 I^- 2.16

2. Ionic Radius




















When an atom gains e^- (anion): radius increases

- # protons same, but electron cloud increases (electrons repel each other)

When an atom loses e^- (cation): radius decreases

- Loss of valence electron causes electron cloud to be pulled tighter by protons.

Atomic/Ionic Radii

1A		2A		3A	
	Li 1.52		Li⁺ 0.60		Be 1.11
	Na 1.86		Be²⁺ 0.31		Mg 1.60
	K 2.31		Mg²⁺ 0.65		Ca 1.97
	Rb 2.44		Ca²⁺ 0.99		Sr 2.15
			Sr²⁺ 1.13		Al 1.43
					Al³⁺ 0.50
					Ga 1.22
					Ga³⁺ 0.62
					In 1.62
					In³⁺ 0.81

2. Ionic Radius

When an atom gains e^- (anion): radius increases

- # protons same, but electron cloud increases (electrons repel each other)

When an atom loses e^- (cation): radius decreases

- Loss of valence electron causes electron cloud to be pulled tighter by protons.

Moving down a group: ionic radii increases

Moving across a period: ionic radii of cations decreases, ionic radii of anions decreases

