Explaining Periodic Trends

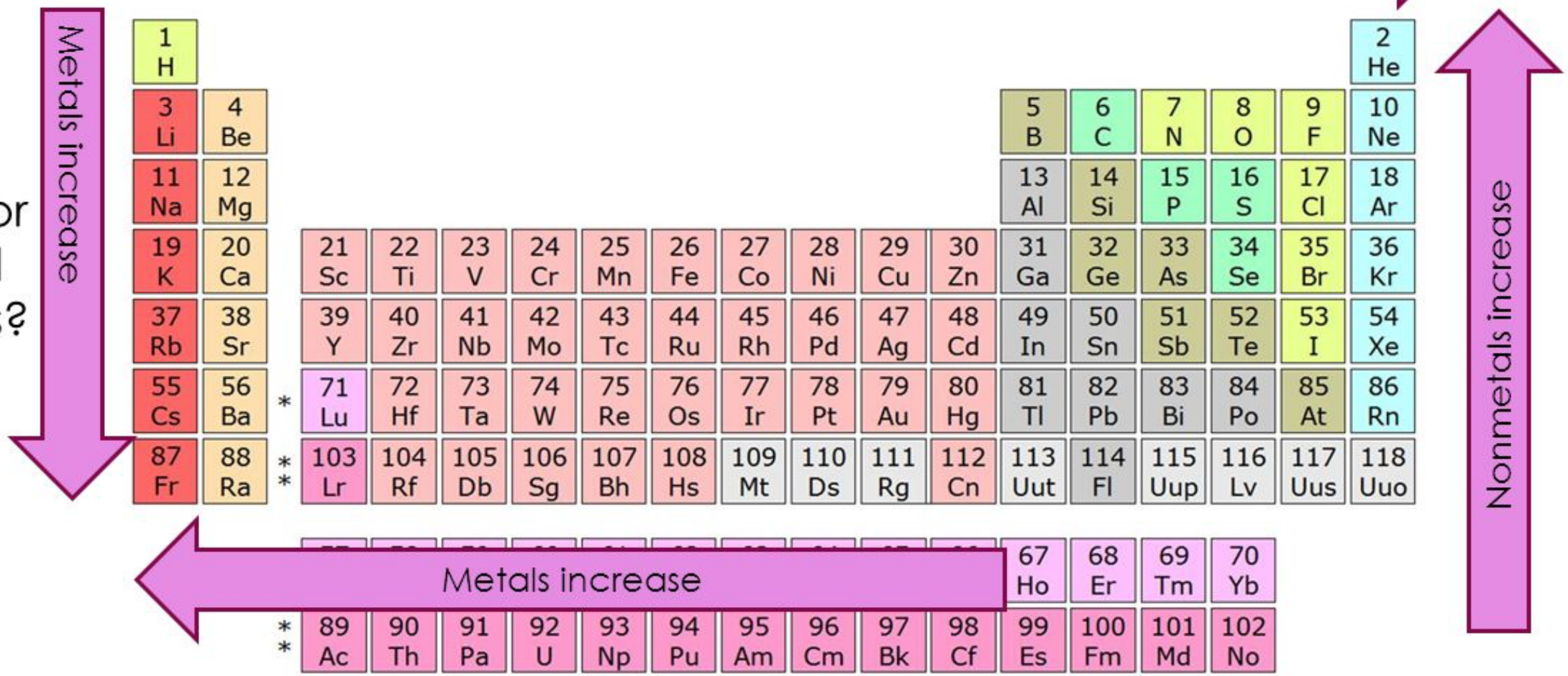
* Many observable trends in the chemical and physical properties of elements are observable in the periodic table.
* Let's review a trend that you should already be familiar with, REACTIVITY.

Reactivity

* On trends you may be familiar with is reactivity, which is high in Group 1 elements, lower in the middle of the table, and high again in group 17.
* Noble gases are the least reactive.

Reactivity Trend

Why is the trend in reactivity different for metal and nonmetals?



* In every trend we look at, there are two factors that are important to understand:
  * Shielding Effect
  * Net Nuclear Attraction

Shielding Effect

* shielding effect: the number of electrons in full shells between the nucleus and the valence electrons

Shielding Effect

* as you move from left to right across a period (→), shielding effect is constant

Shielding Effect

* As you move down a group, the shielding effect increases.
* There are more full electron shells, so atoms become larger and the valence electrons are further from the nucleus.
* This effectively decreases the attraction between the electrons and the nucleus.

Net Nuclear Attraction

* Is calculated by taking the nuclear charge (Z = the number of protons, or atomic number) and subtracting the shielding effect
* net nuclear attraction is a relative measure of the actual attraction between the nucleus and the valence electrons in an atom

Net Nuclear Attraction

* Net nuclear attraction measures the actual attraction between the nucleus and the valence electrons
* As you move from left to right across a period (→), net nuclear attraction increases.

Trends across a period are due to net nuclear attraction.

Trends down a group are due to increasing shielding effect.

Trend: Atomic Radius

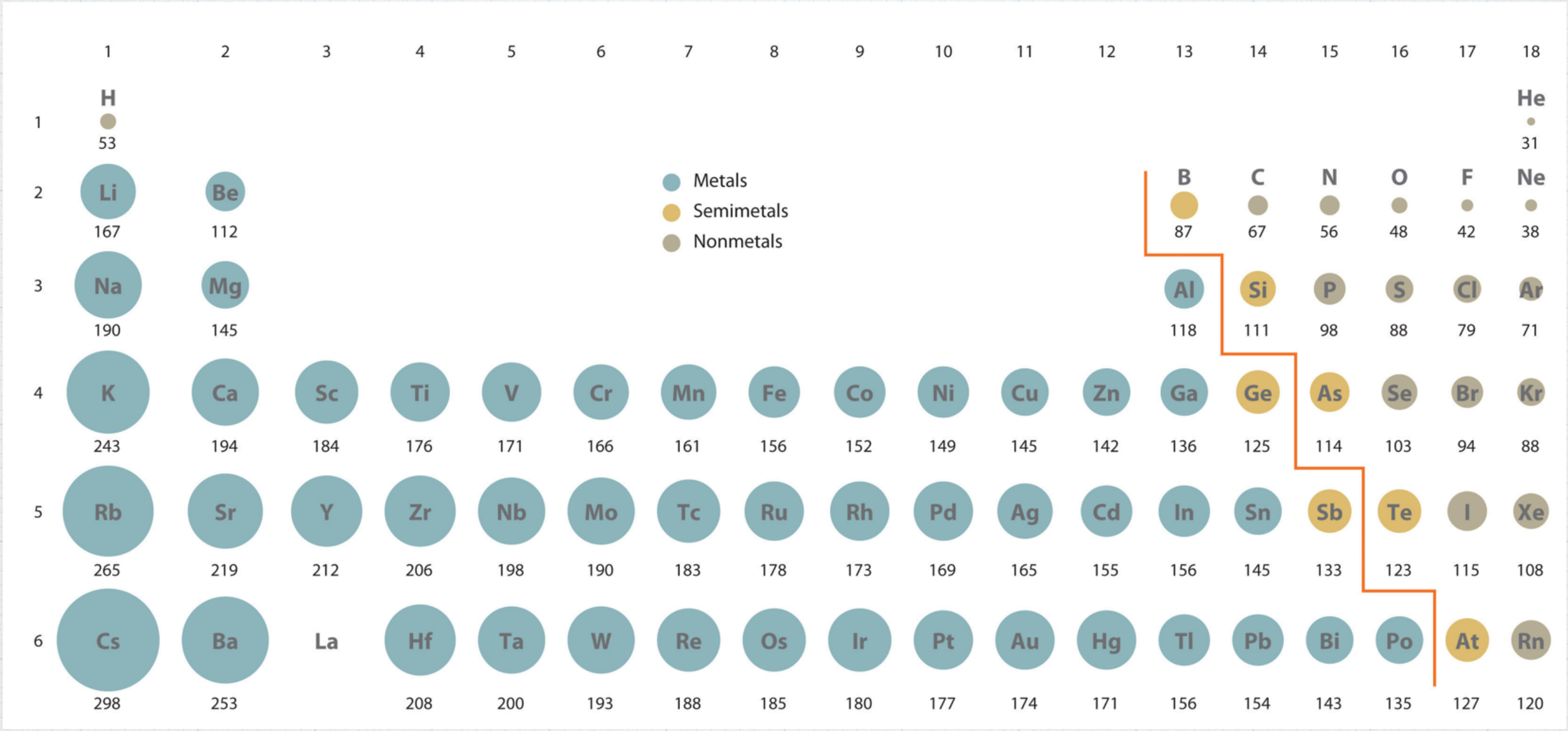
* Atomic radius (r): half the distance between two nuclei of adjacent atoms.

Trend: Atomic Radius

* The size of an atom decreases going from left to right across a period.
* This is because as you move down the period net nuclear attraction increases.

Trend: Atomic Radius

* The size of an atom increases as you go down a group.
* This is because as you move down the groups, the number of occupied electron shells increases.


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
1
H 53
He 31
2
Li 167
Be 112
B 87
C 67
N 56
O 48
F 42
Ne 38
3
Na 190
Mg 145
Al 118
Si 111
P 98
S 88
Cl 79
Ar 71
4
K 243
Ca 194
Sc 184
Ti 176
V 171
Cr 166
Mn 161
Fe 156
Co 152
Ni 149
Cu 145
Zn 142
Ga 136
Ge 125
As 114
Se 103
Br 94
Kr 88
5
Rb 265
Sr 219
Y 212
Zr 206
Nb 198
Mo 190
Tc 183
Ru 178
Rh 173
Pd 169
Ag 165
Cd 155
In 156
Sn 145
Sb 133
Te 123
I 115
Xe 108
6
Cs 298
Ba 253
La
Hf 208
Ta 200
W 193
Re 188
Os 185
Ir 180
Pt 177
Au 174
Hg 171
Tl 156
Pb 154
Bi 143
Po 135
At 127
Rn 120
Metals
Semimetals
Nonmetals

Trend: Ionic Radii

* The addition or removal of an electron from an atom results in an ion.

Trend: Ionic Radii

* Positive ions are always smaller than the neutral atom from which they are formed.
    * This is because nuclear attraction has increased.

Trend: Ionic Radii

* Negative ions are always larger than the neutral atom from which they are formed.
  * This is because nuclear attraction has decreased.

Trend: Ionization Energy

* The amount of energy required to remove an electron from an atom.
* The first ionization energy refers to the amount of energy required to remove the outermost electron.
* The second ionization energy refers to the amount of energy required to remove the second outermost electron and so on.

Trend: Ionization Energy

* The outermost electron is the easiest electron to remove. Removal of subsequent electrons requires more energy.
* In terms of increasing energy: 1st Ionization Energy < 2nd Ionization Energy < 3rd Ionization Energy.

Trend: Ionization Energy

* Ionization Energy increases as you move left to right across a period.
  * This is because as the atom gets smaller, the valence electrons become closer to the nucleus. This increases nuclear attraction.

Trend: Ionization Energy

* Ionization Energy decreases as you move down a group.
    * This is because of shielding. The inner shells that are filled shield the outer shells from the positive charge of the nucleus, making outer electrons easier to remove.

Increasing Ionization Energy

1 **H** Hydrogen 1.00794																	2 **He** Helium 4.003
3 **Li** Lithium 6.941	4 **Be** Beryllium 9.012182											5 **B** Boron 10.811	6 **C** Carbon 12.0107	7 **N** Nitrogen 14.00674	8 **O** Oxygen 15.9994	9 **F** Fluorine 18.9984032	10 **Ne** Neon 20.1797
11 **Na** Sodium 22.989770	12 **Mg** Magnesium 24.3050											13 **Al** Aluminum 26.981538	14 **Si** Silicon 28.0855	15 **P** Phosphorus 30.973761	16 **S** Sulfur 32.066	17 **Cl** Chlorine 35.4527	18 **Ar** Argon 39.948
19 **K** Potassium 39.0983	20 **Ca** Calcium 40.078	21 **Sc** Scandium 44.955910	22 **Ti** Titanium 47.867	23 **V** Vanadium 50.9415	24 **Cr** Chromium 51.9961	25 **Mn** Manganese 54.938049	26 **Fe** Iron 55.845	27 **Co** Cobalt 58.933200	28 **Ni** Nickel 58.6934	29 **Cu** Copper 63.546	30 **Zn** Zinc 65.39	31 **Ga** Gallium 69.723	32 **Ge** Germanium 72.61	33 **As** Arsenic 74.92160	34 **Se** Selenium 78.96	35 **Br** Bromine 79.904	36 **Kr** Krypton 83.80
37 **Rb** Rubidium 85.4678	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.90585	40 **Zr** Zirconium 91.224	41 **Nb** Niobium 92.90638	42 **Mo** Molybdenum 95.94	43 **Tc** Technetium (98)	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.90550	46 **Pd** Palladium 106.42	47 **Ag** Silver 107.8682	48 **Cd** Cadmium 112.411	49 **In** Indium 114.818	50 **Sn** Tin 118.710	51 **Sb** Antimony 121.760	52 **Te** Tellurium 127.60	53 **I** Iodine 126.90447	54 **Xe** Xenon 131.29
55 **Cs** Cesium 132.90545	56 **Ba** Barium 137.327	57 **La** Lanthanum 138.9055	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.9479	74 **W** Tungsten 183.84	75 **Re** Rhenium 186.207	76 **Os** Osmium 190.23	77 **Ir** Iridium 192.217	78 **Pt** Platinum 195.078	79 **Au** Gold 196.96655	80 **Hg** Mercury 200.59	81 **Tl** Thallium 204.3833	82 **Pb** Lead 207.2	83 **Bi** Bismuth 208.98038	84 **Po** Polonium (209)	85 **At** Astatine (210)	86 **Rn** Radon (222)
87 **Fr** Francium (223)	88 **Ra** Radium (226)	89 **Ac** Actinium (227)	104 **Rf** Rutherfordium (261)	105 **Db** Dubnium (262)	106 **Sg** Seaborgium (263)	107 **Bh** Bohrium (262)	108 **Hs** Hassium (265)	109 **Mt** Meitnerium (266)	110 (269)	111 (272)	112 (277)	113	114				

Increasing Ionization Energy

Trend: Electron Affinity

* The amount of energy released when an electron is added to an element.
* The higher an element's electron affinity the greater the attraction for an electron.

Trend: Electron Affinity

* Electron Affinity increase as you move left to right across a period.
* This is because as you move across a period, net attraction increases.

Trend: Electron Affinity

* Electron Affinity decreases as you move down a group.
    * This is because as you move down a group, the attraction for electrons decreases.

Increasing Electron Affinity

1 **H** Hydrogen 1.00794																	2 **He** Helium 4.003
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Increasing Electron Affinity

Trend: Electronegativity

* The ability of an atom to attract an electron away from another atom.

* Elements with high electronegativity have a strong tendency to gain an electron or electrons.

Trend: Electronegativity

* Electronegativity increases going from left to right across a period.
  * This is because nuclear attraction is increasing.

Trend: Electronegativity

* Electronegativity decreases going down a group.
    * This is because shielding increases down a group, making it easier to remove an electron.

Increasing EN

Highest Electronegativity

	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB		IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1	H																He
2	Li	Be										B	C	N	O	F	Ne
3	Na	Mg										Al	Si	P	S	Cl	Ar
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
6	Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
7	Fr	Rd	Ac															

Increasing EN

Lowest Electronegativity