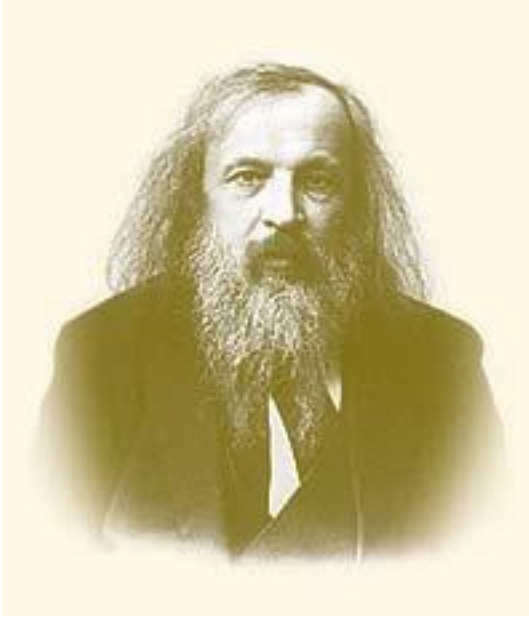
All About the Periodic Table

Essential Questions:

- **How are elements arraigned in the periodic table**
- **Why do elements in the same group have similar properties?**
- **How does the periodic table predict the properties and behavior of elements?**
- **How are the group and period trends in the periodic table related to electron configuration?**

Discovery of the Periodic Table

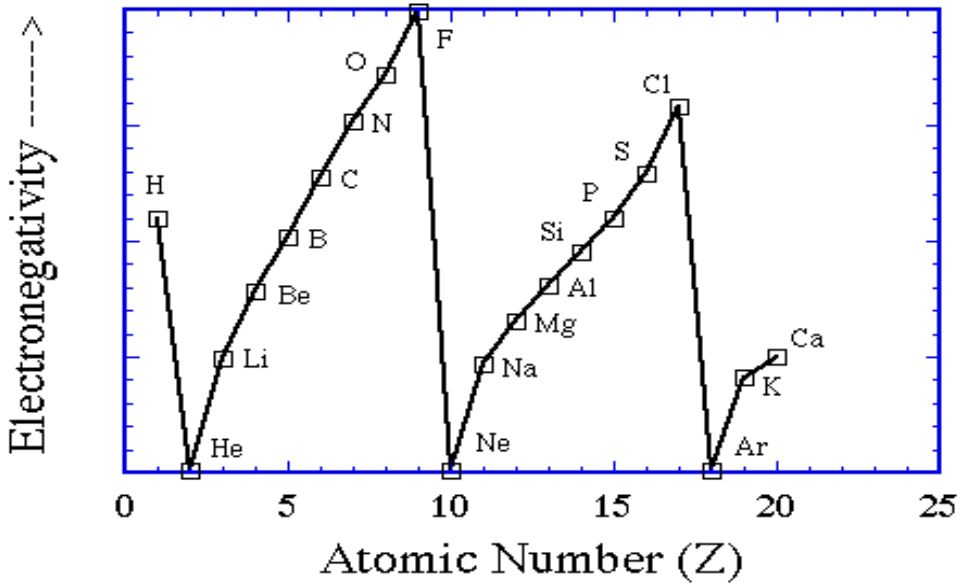
- **Dmitri Mendeleev is known as the *Father of the Periodic Table.***
- **In 1869) Organized elements according to atomic weights *BUT* switched numerous elements around to "fit" characteristics of a different group! (Te & I) Left gaps where he hypothesized new elements would be found and Fit IN (gallium & the Nobel Gases)**



Periodic Law

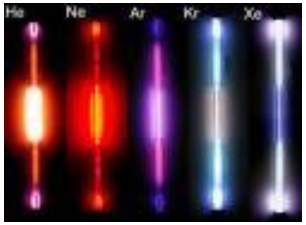
- ***states that when all atoms are arranged in order of increasing atomic numbers, elements with similar properties will occur at periodic, regularly recurring, intervals.***

Periodicity- Patterns evolve

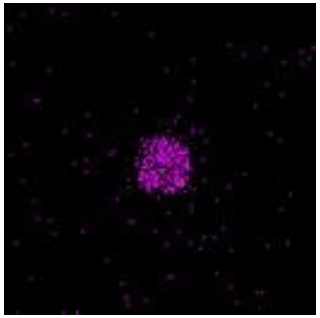


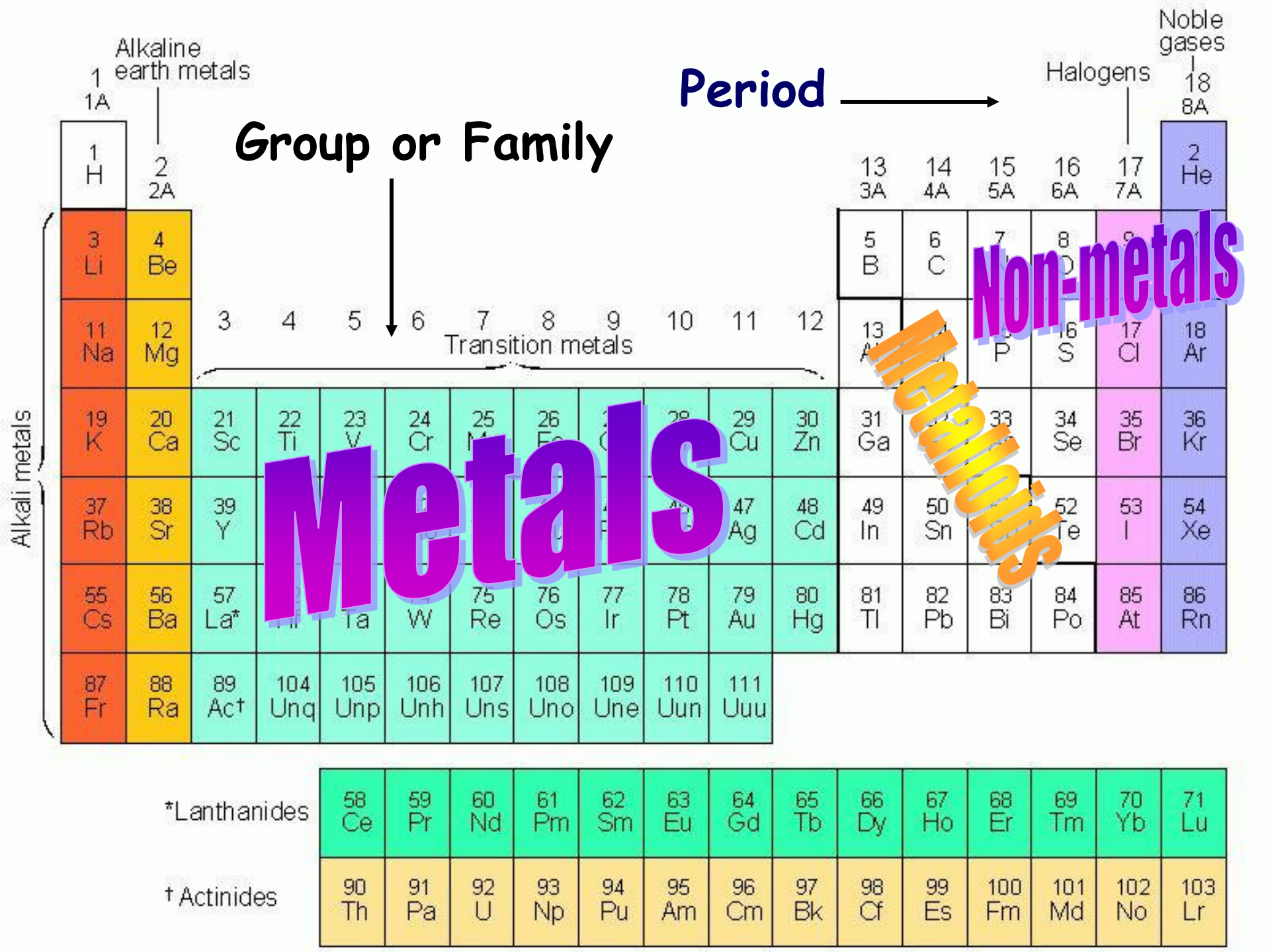
History Continues

- **Strutt and Ramsey-** (1894) Found Noble Gaes and add a new "group" to Periodic Table- Mendeleev hypothesized would be there



- **Mosely (1911)** used x-rays to count protons in nucleus added Atomic Number to table Gave Experimental justifications for Mendeleevs Table (switching elements around)




Alkaline earth metals
Noble gases
Period
Halogens
Group or Family
Non-metals
Metalloids
Metals
Transition metals
Alkali metals
*Lanthanides
† Actinides

Properties of Metals

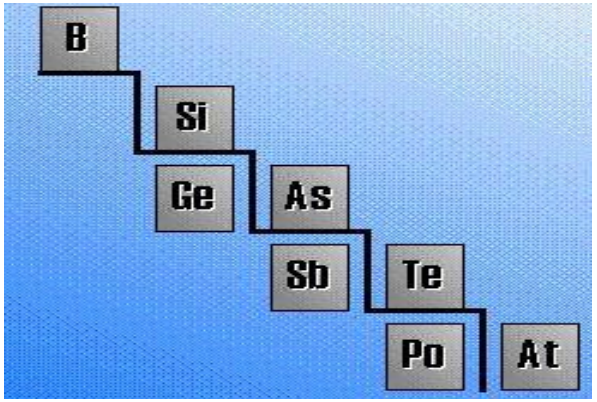
- Solid at room temperature
  - Except mercury which is a liquid
    - Ga melts in your hands!
- Conduct heat and electricity
- Malleable: hammered into thin sheets
- Ductile: drawn into wire
- Lustrous: shiny

Properties of Non-Metals

- Located to the right of the step-wise line
- General properties of non-metals:
  - C, P, S, Se & I are brittle, dull looking solids at room temperature
  - Bromine is the only non-metal that is a liquid at room temperature
  - All others are gases
  - Poor conductors of heat and electricity

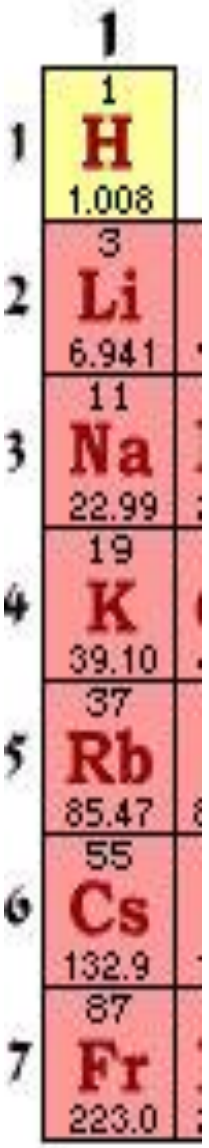
Properties of Metalloids

- Boron, Silicon, Germanium, Arsenic, Antimony, Tellurium, and Polonium.
- Semiconductors: have characteristics of conductors and insulators
  - Si & Ge are used in computer chips and other electronic devices



Alkali Metals

- Group 1
- Extremely reactive
- Not found free as elements in nature
- Explosive in water
  - (due to hydrogen gas production)
- Soft and can be cut with a knife
- All have 1 valence electron



- http://www.youtube.com/watch?v=uixxJtJPVXk

Alkaline Earth Metals

- **Group 2**
- **Very reactive**
  - **(**Less reactive than Alkali metals)
- **Not found freely as elements in nature**
- **Denser, harder & stronger than Alkali metals**
- **All have 2 valence electrons**

Groups 3-12 – Transitional Metals- ”typical” metals malleable, conductive, ductile- jewelry-Coins- fairly un-reactive (Au, Ag, Cu,Pt)

Halogens

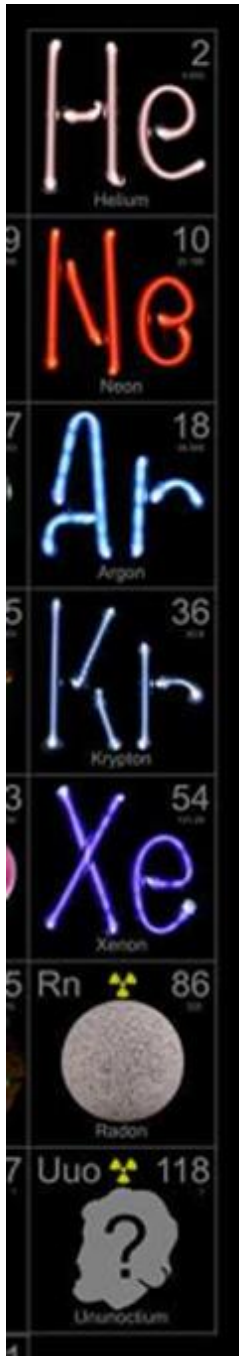
- **Group 7**
- **Very reactive**
  - **(react strongly with metals to form salts)**
- **Exist as diatomic molecules in standard form**
  - **diatomic molecule= two of the same atoms**
- **7 valence electrons**

Super 7

- **7 elements that exist as diatomic molecules**
  - **Hydrogen, nitrogen, oxygen, fluorine, chlorine, bromine and iodine**

Noble Gases

- **Group 8**
- **Also known as the Inert Gases**
- **All but He (2) have 8 valence electrons (full Octet)**
- **Unreactive**
  - **Only a few compounds exist with a noble Gases**
  - **Largely unreactive because they have a full outer shell of electrons**
  - **Gases at room temperature**



Periodic Trends

Objectives:

Define the properties of the elements that exhibit group and periodic trends.

Explain why these periodic trends exist.

Coulomb Force Law, Qualitatively

$$F = (k \cdot Q_1 \cdot Q_2) / r^2$$

- Double one of the charges
  - force doubles
- Change sign of one of the charges
  - force changes direction
- Change sign of *both* charges
  - force stays the same
- Double the distance between charges
  - force four times weaker
- Double *both* charges
  - force four times stronger

ALL Periodic Table Trends

- **Influenced by three factors:**

  1. <u>Energy Level</u>

  - **Higher energy levels are further away from the nucleus.**

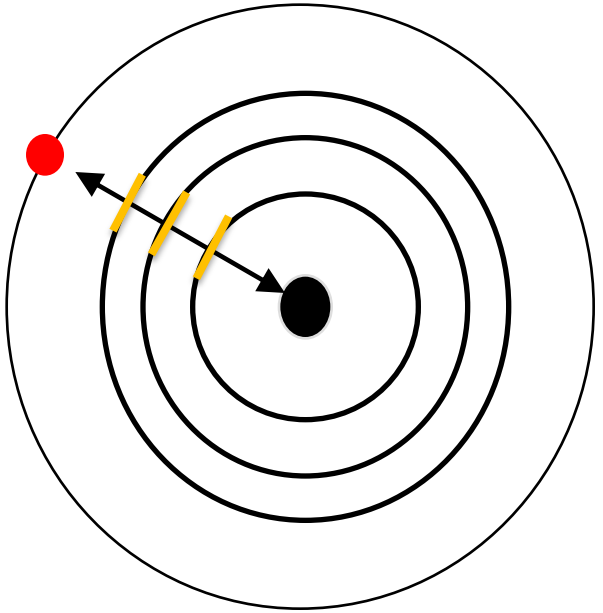
  2. <u>Charge on nucleus</u> (# protons)

  - **More charge pulls electrons in closer. (+ and – attract each other)**

- **3. <u>Shielding effect</u>** **(blocking effect?)**

Shielding

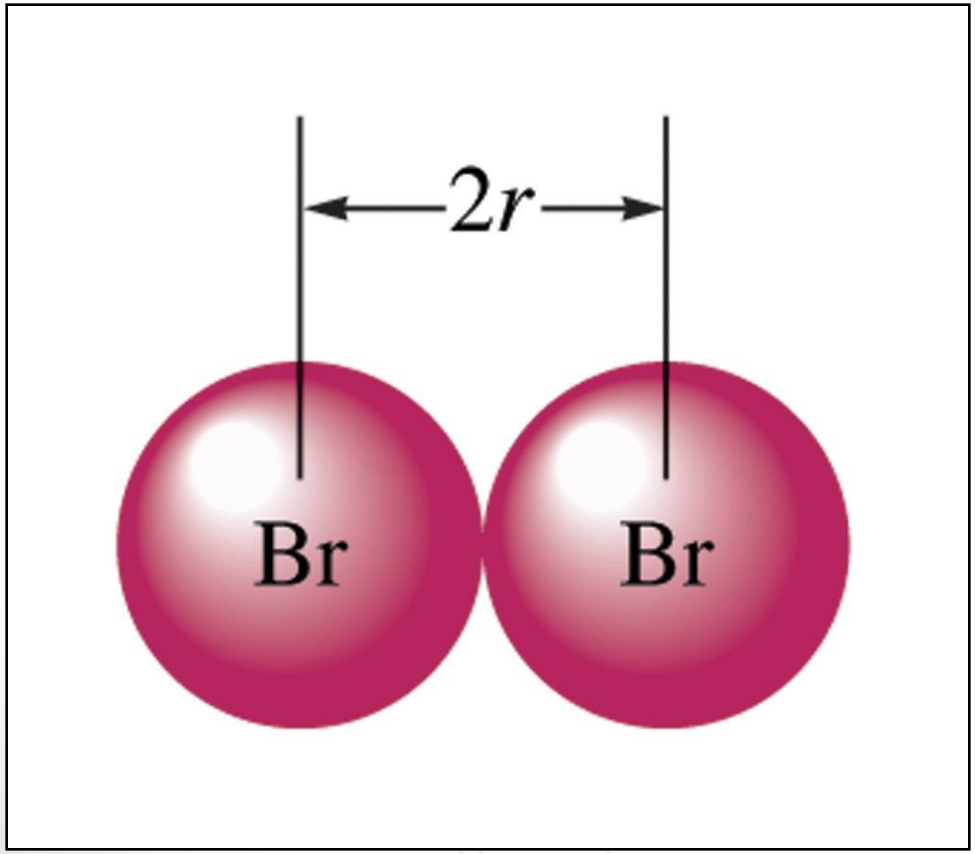
- **The electron on the outermost energy level has to look through all the other energy levels to see the nucleus.**



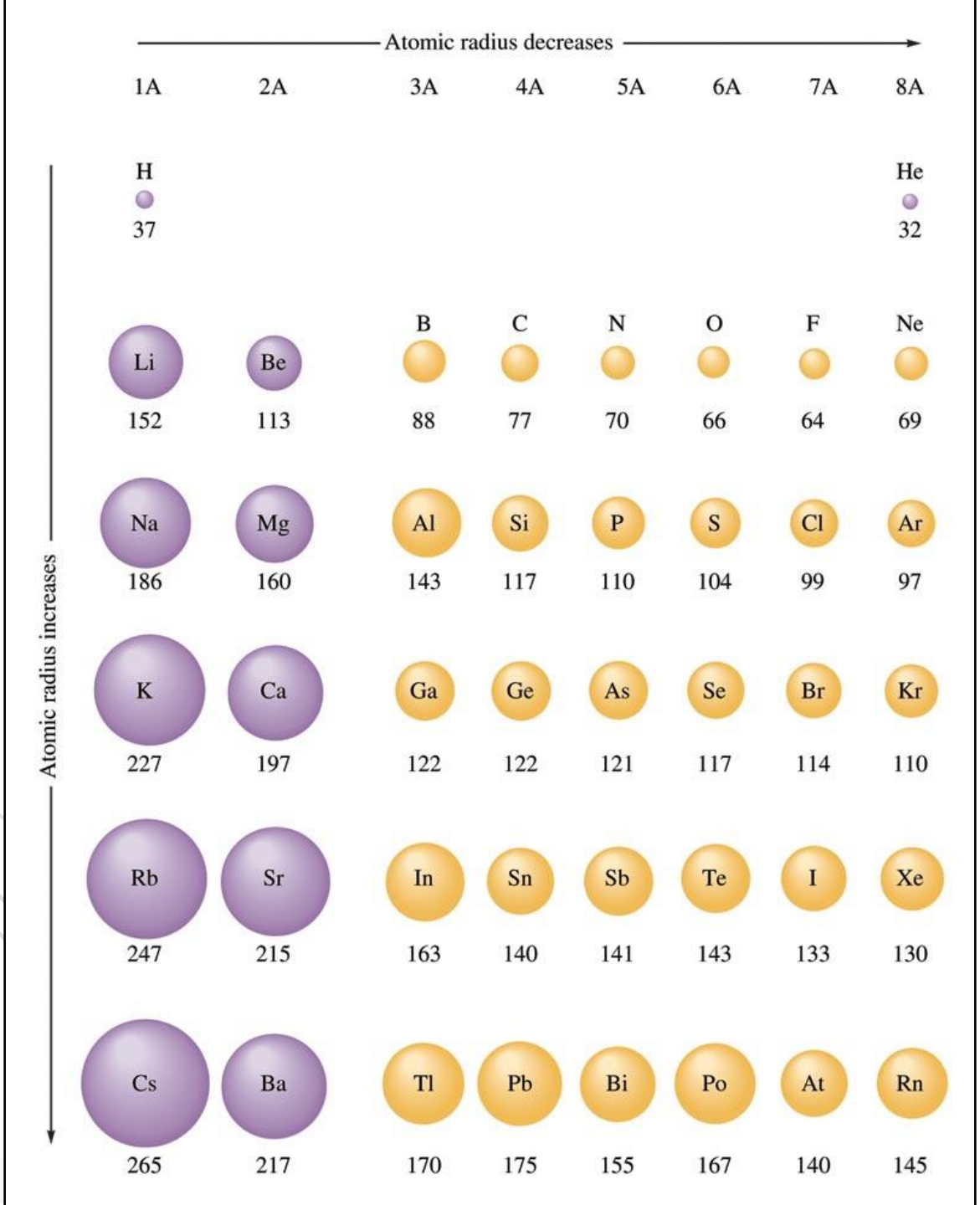
What do they influence?

- **<u>Energy levels</u> and <u>Shielding</u> have an effect on the *GROUP Trends***
- **<u>Nuclear charge</u> has an effect on a *PERIOD Trends***

Atomic Radius

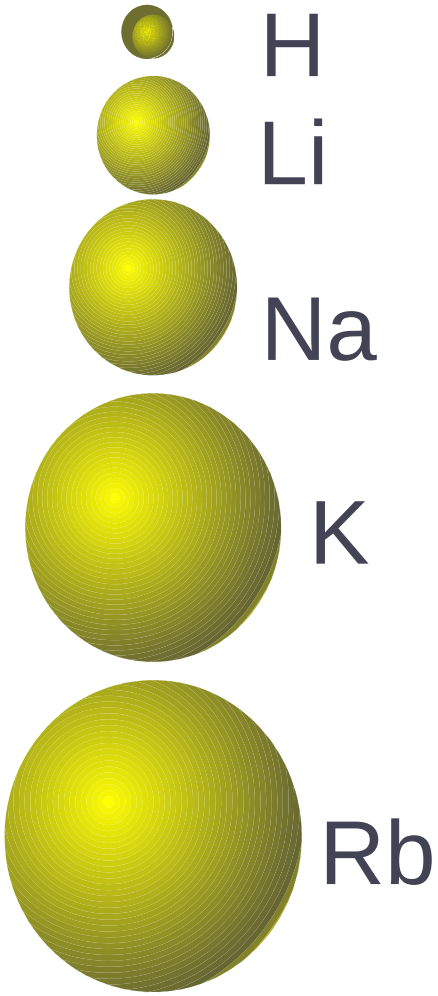


- **Half the Distance Between the Nuclei in a Molecule Consisting of Identical Atoms**
- **Increases down a group.**
- **Decreases left to right due to increased effective nuclear charge.**
- **Used to describe atoms size since electron cloud not well defined.**


Atomic radius decreases
1A
2A
3A
4A
5A
6A
7A
8A
H
37
He
32
B
C
N
O
F
Ne
Li
Be
152
113
88
77
70
66
64
69
Na
Mg
Al
Si
P
S
Cl
Ar
186
160
143
117
110
104
99
97
K
Ca
Ga
Ge
As
Se
Br
Kr
227
197
122
122
121
117
114
110
Rb
Sr
In
Sn
Sb
Te
I
Xe
247
215
163
140
141
143
133
130
Cs
Ba
Tl
Pb
Bi
Po
At
Rn
265
217
170
175
155
167
140
145
Atomic radius increases

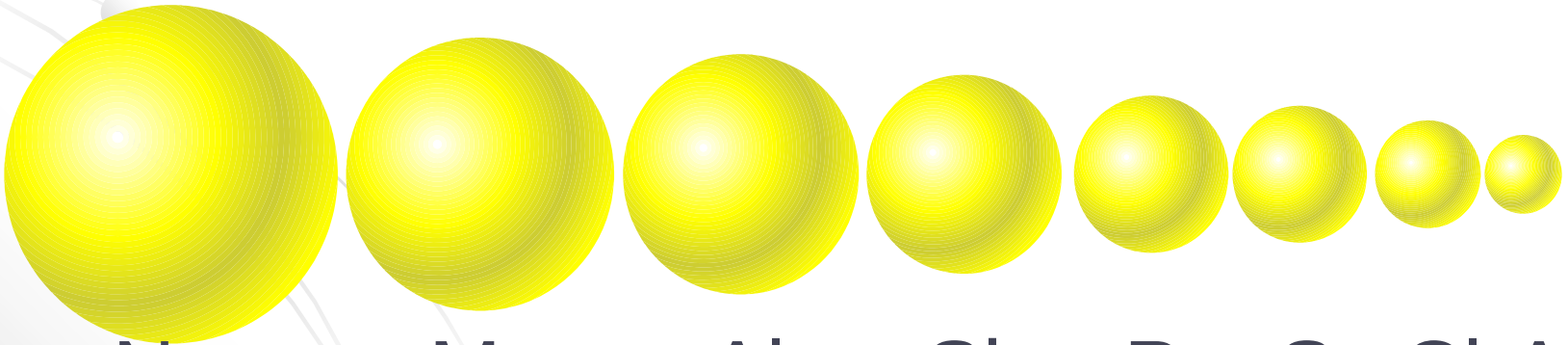
Atomic Size - Group trends

- As we increase the atomic number (or go down a group). . .
- each atom has another energy level,
- so the atoms get ***bigger***.



Atomic Size - Period Trends

- **Going from left to right across a period, the size gets smaller.**
- **Electrons are in the same energy level.**
- **But, there is more nuclear charge.**
- **Outermost electrons are pulled closer.**



DO YOU GET IT? QUESTION:

- Explain which atom has a larger atomic radii:
- Magnesium or Barium
- Calcium or Bromine

Ionization Energy

- **Energy required to remove an electron from a gaseous atom or ion.**

$$X_{(g)} \rightarrow X^{1+}_{(g)} + e^-$$

- **First Ionization increases left to right within a period. (Since there are more protons, there is stronger electron attractions)**
- **First Ionization decreases down a group. (Electrons are further away from protons plus more shielding from full energy levels)**
- **Successive ionizations require more energy than the previous ionization.**

Electronegativity

- Measure of an atoms desire to gain an electron.
  - Fluorine is the most EN
  - Francium is the least EN
- Increases left to right and up a group
- Consider the size of the atom and whether is wants to gain an electron to become a Noble gas.

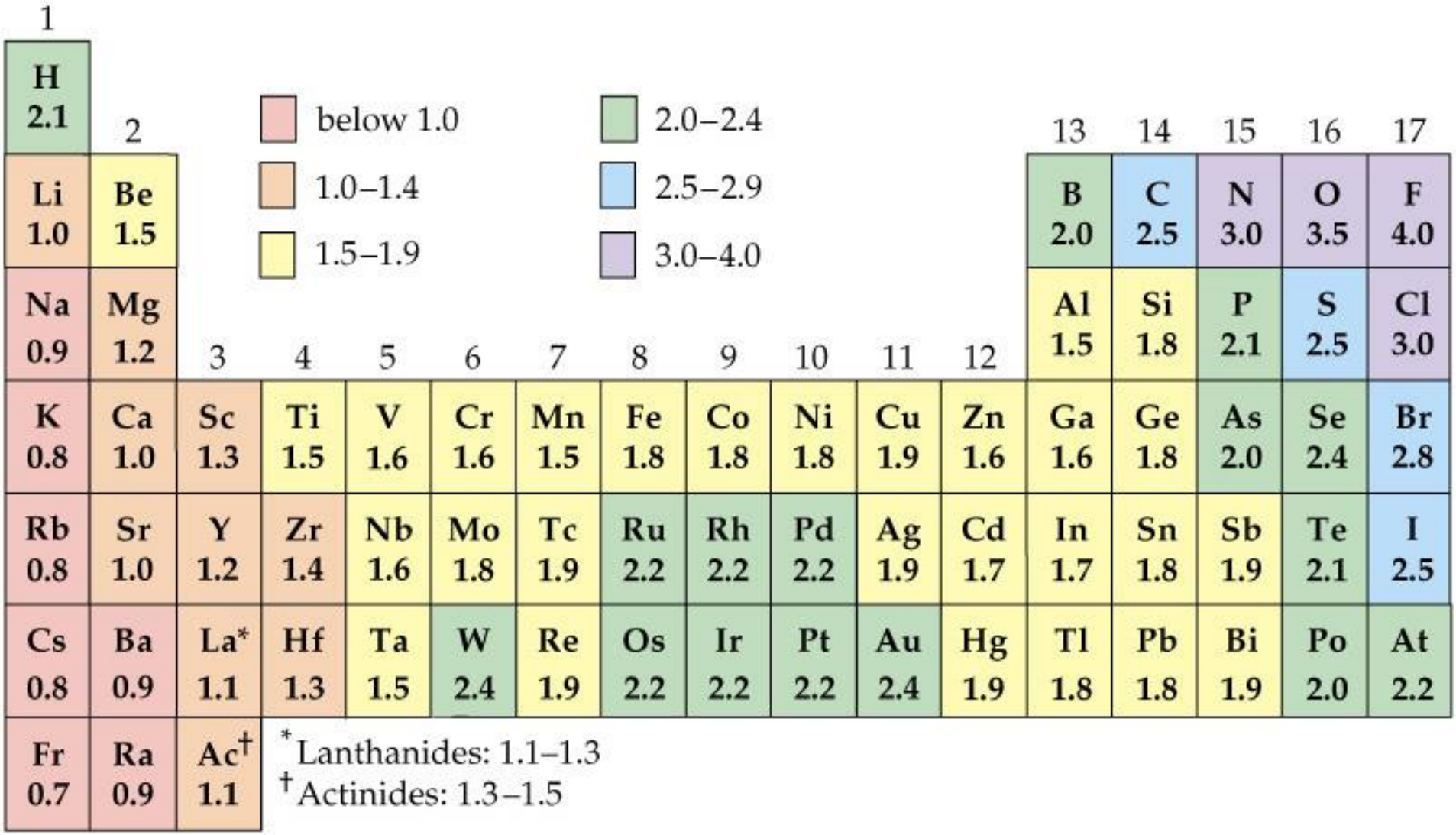
Electronegativity Trends

- **The further down a group, the farther the electron is away from the nucleus, and has more shielding so less attraction from the protons for electrons**
- **Going left to right across a period you are increasing the # of protons and shrinking the atoms size so increase the desire for more electrons.**

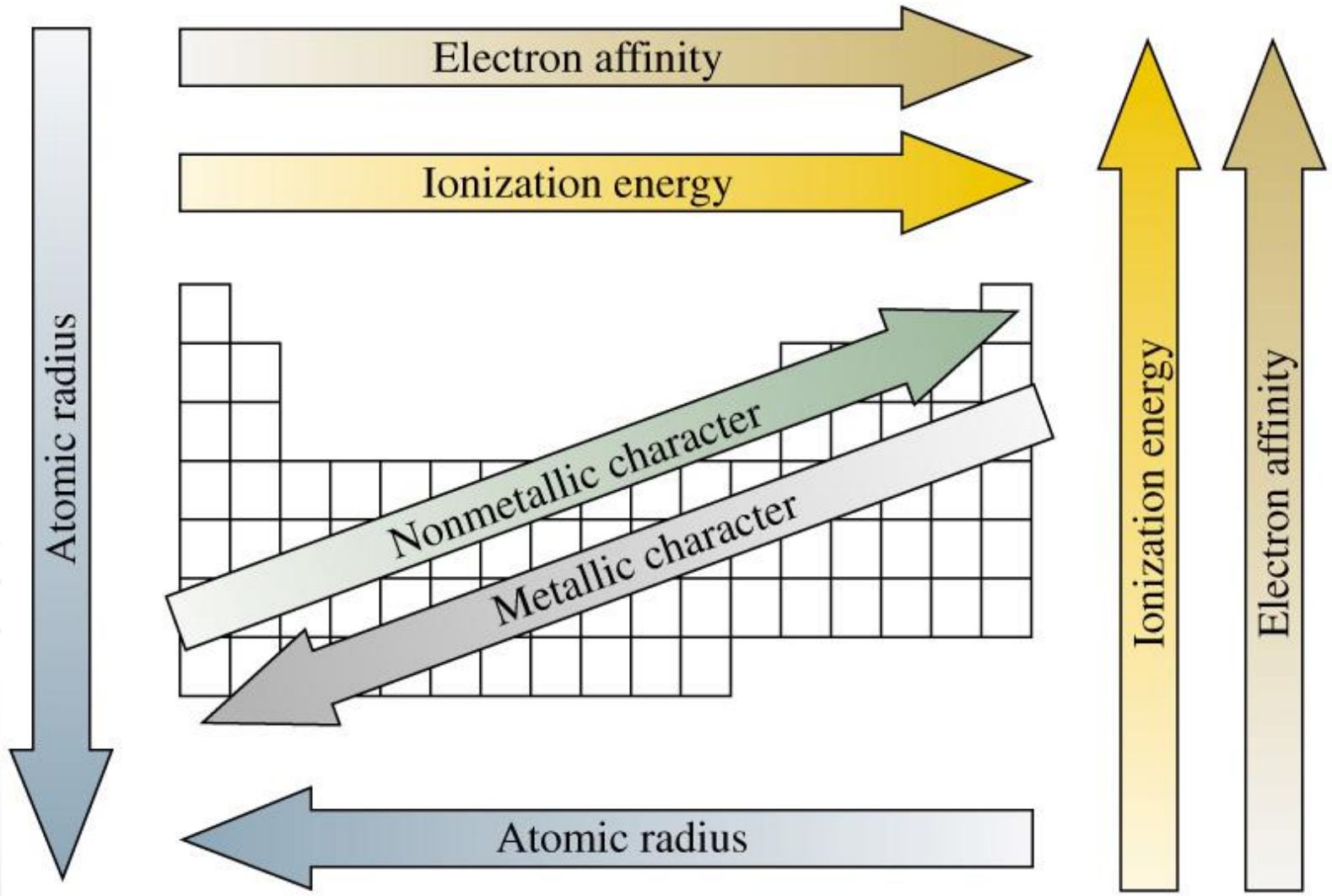
Do you get it? QUESTION:

- Explaine which element has a greater electronegativity?
- Lithium or Francium
- Magnesium or Chlorine

Periodic Table of Electronegativities



Summation of Periodic Trends



For Review:

Valence electrons

- Outermost electrons of the atom
- Responsible for reactivity of the atom
- Metals have low numbers, will tend to loose electrons to become stable with octet
- Nonmetals high number of valence electrons- tend to gain more to become stable with octet

Ions

- **Some compounds are composed of particles called “ions”**
  - **An ion is an atom (or group of atoms) that has a *positive or negative charge***
- **Atoms are neutral because the number of protons equals electrons**
  - **Positive and negative ions are formed when electrons are *transferred* (lost or gained) between atoms**

Cations

- **Metals tend to LOSE electrons, from their outer energy level**
  - **Sodium loses one: there are now more protons (11) than electrons (10), and thus a positively charged particle is formed = "cation"**
  - **The charge is written as a number followed by a plus sign: Na^{1+}**
  - **Now named a "sodium ion"**

Anions

- **Nonmetals tend to GAIN one or more electrons**
  - **Chlorine will gain one electron**
  - **Protons (17) no longer equals the electrons (18), so a charge of -1**
  - **Cl^{1-} is re-named a "chloride ion"**
  - **Negative ions are called "anions"**

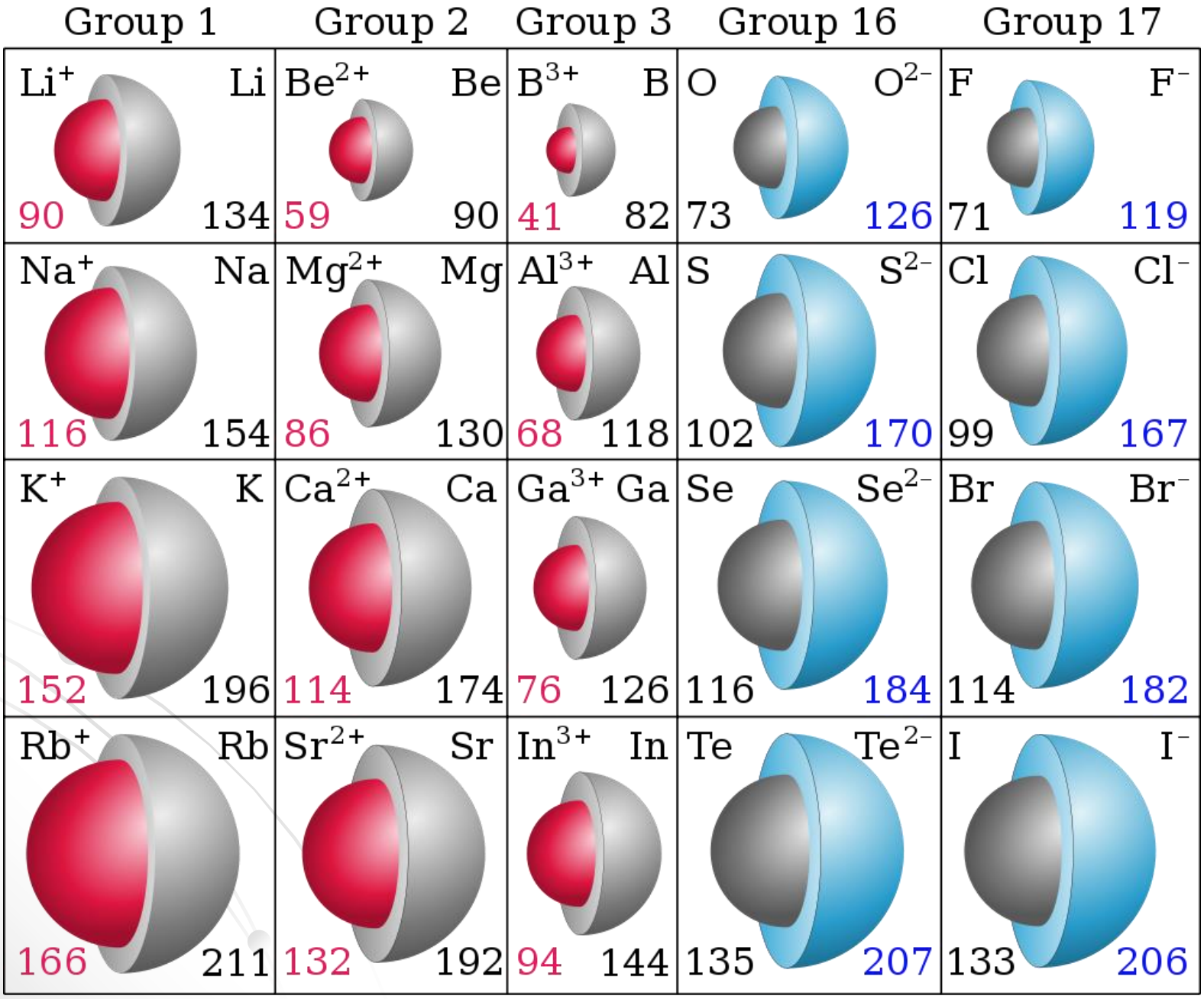
Trends in Ionic Size: Cations

- **Cations form by losing electrons.**
- **Cations are smaller than the atom they came from – not only do they lose electrons, they lose an *entire energy level*.**
- **Metals form cations.**
- **Follow same trends as Atomic Radii**

Ionic size: Anions

- **Anions form by gaining electrons.**
- **Anions are bigger than the atom they came from – have the same energy level, but a greater area the nuclear charge needs to cover**
- **Nonmetals form anions.**
- **Follow same trend as Atomic radii.**

Sizes of atoms and their ions in pm



Graphic courtesy Wikimedia Commons user Popnose

DO you get it? Questions:

- Create the ions of the following and compare the size of the atom to the ion created:

- Magnesium

- Sulfur

Oxidation Numbers

- Oxidation numbers are the charges on ions
- General trend
  - Group 1 = +1
  - Group 2 = +2
  - Group 3 = +3
  - Group 4 = +/- 4
  - Group 5 = -3
  - Group 6 = -2
  - Group 7 = -1
  - Group 8 = 0

More on Oxidation Numbers

- **These trends are base on the atoms trying to get to a stable** *"Noble Gas Configuration"*
- **There are exceptions to the general trend.**
  - **Bottom of group 5 contains metals which prefer to be cations…therefor they favor being a +5 vs. a -3**