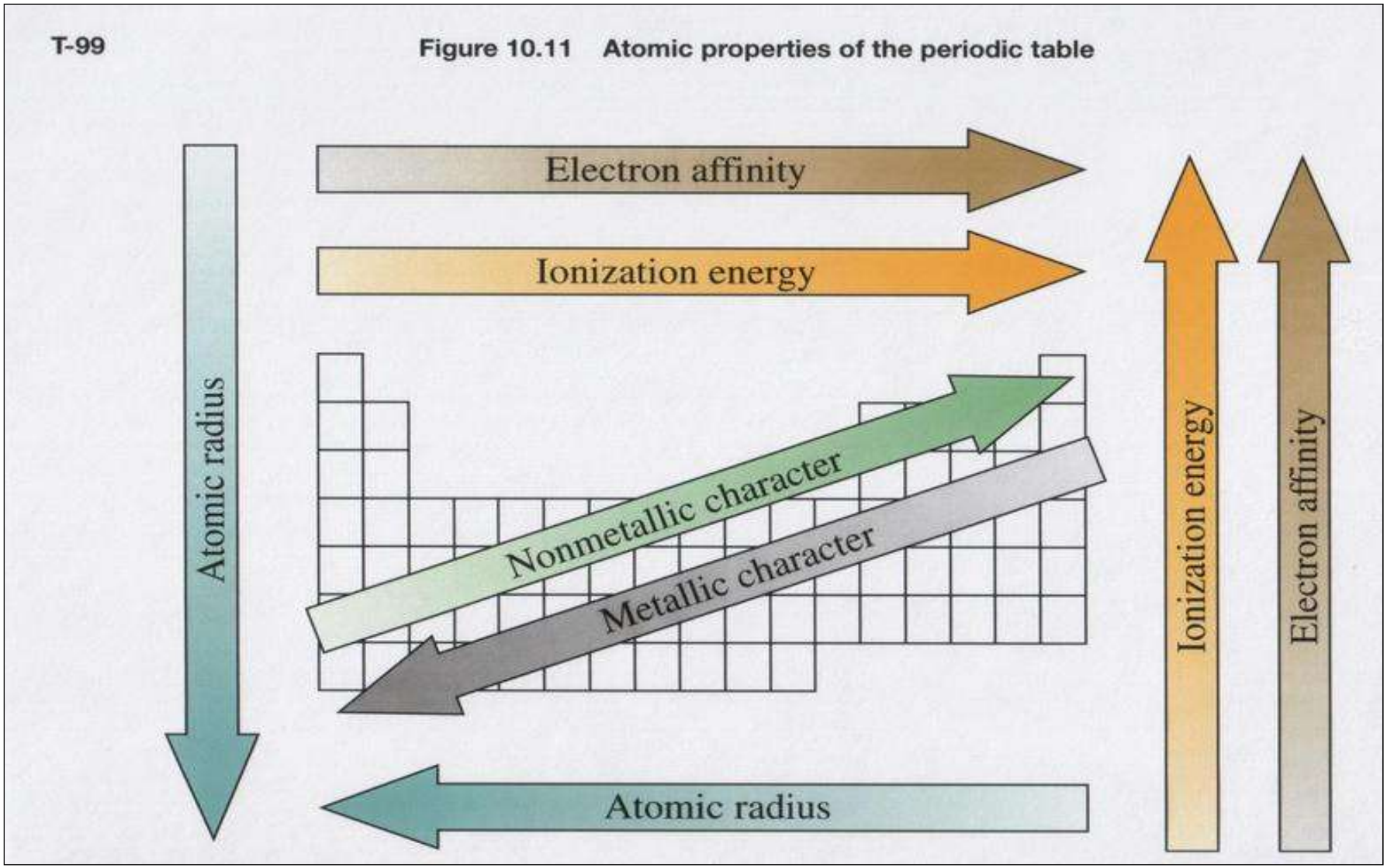
Periodic Table Trends

Periodic Trends

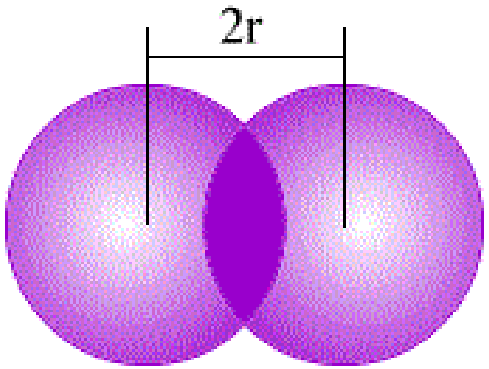
- Atomic Radius
- Ionization Energy
- Electron Affinity

The Trends in Picture



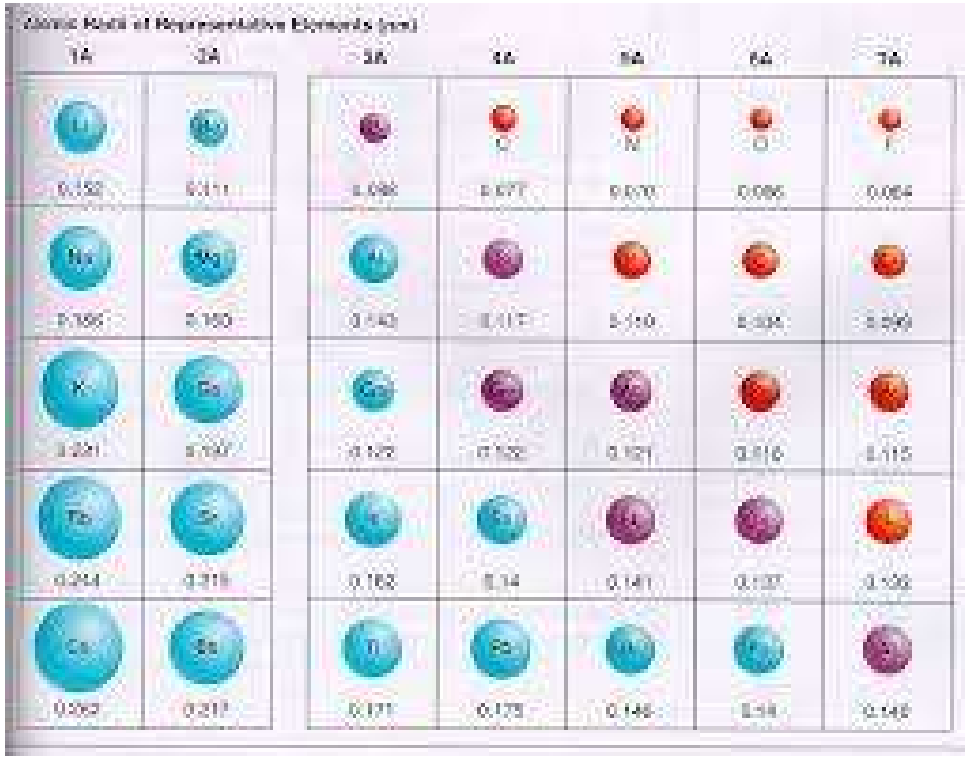
Atomic Radius

- Unlike a ball, an atom has fuzzy edges.
- The radius of an atom can only be found by measuring the distance between the nuclei of two touching atoms, and then dividing that distance by two.



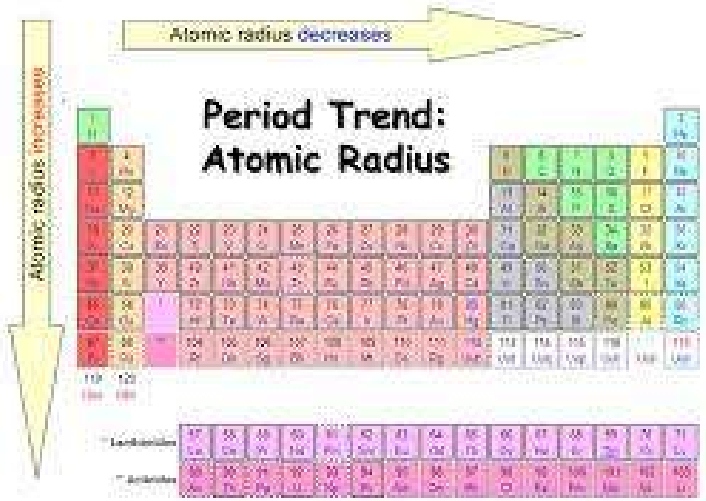
Atomic Radius

- Atomic radius is determined by how much the electrons are attracted to the positive nucleus.
- The fewer the electrons in each period, the lesser the attraction.
- Lesser attraction =
- larger nucleus



Atomic Radius Trend

- Period: in general, as we go <u>across a period</u> from left to right, the <u>atomic radius decreases</u>
  - Effective nuclear charge increases, therefore the valence electrons are drawn closer to the nucleus, decreasing the size of the atom
- Family: in general, as we <u>down a group</u> from top to bottom, the <u>atomic radius increases</u>
  - Orbital sizes increase in successive principal quantum levels

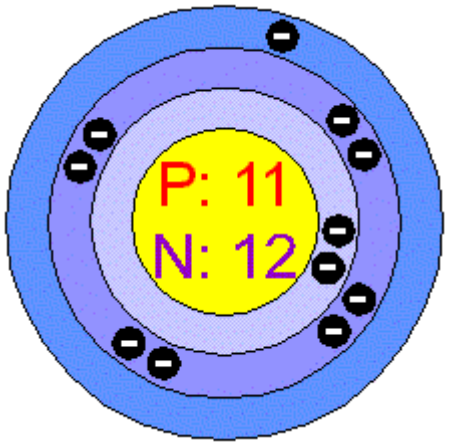


Concept Check

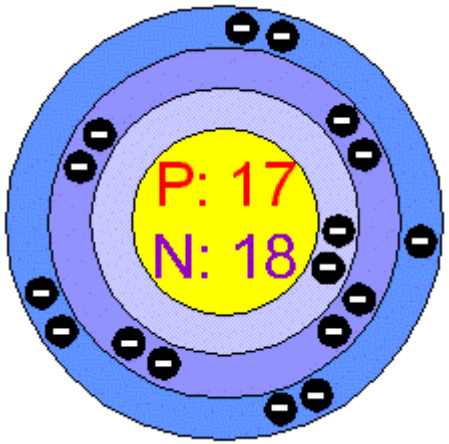
- Which should be the larger atom? Why?
- O or N N
- K or Ca K
- Cl or F Cl
- Be or Na Na
- Li or Mg Mg

Ionization Energy

- Energy required to remove an electron from an atom
- Which atom would be harder to remove an electron from?
- Na



Cl



Ionization Energy

- X + energy → X+ + e– X(g) → X+ (g) + e–
- First electron removed is IE1
- Can remove more than one electron

(IE2 , IE3 ,…)

Ex. Magnesium

Mg → Mg+ + e– IE1 = 735 kJ/mol

Mg+ → Mg2+ + e– IE2 = 1445 kJ/mol

Mg2+ → Mg3+ + e– IE3 = 7730 kJ/mol*

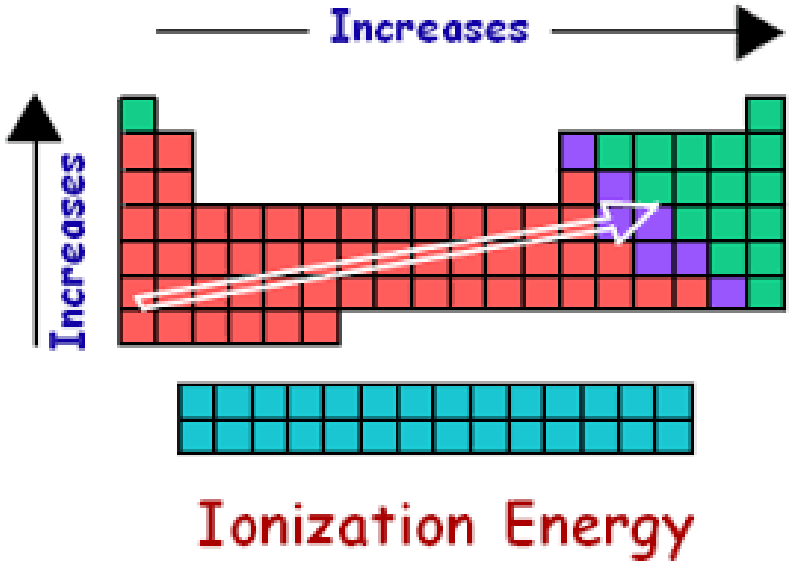
*Core electrons are bound much more tightly than valence electrons

Periodic Ionization Trend

- Trend:
- Period: in general, as we go across a period from left to right, the first ionization energy increases
- Electrons added in the same principal quantum level do not completely shield the increasing nuclear charge caused by the added protons
- Electrons in the same principal quantum level are generally more strongly bound from left to right on the periodic table

Group Trend

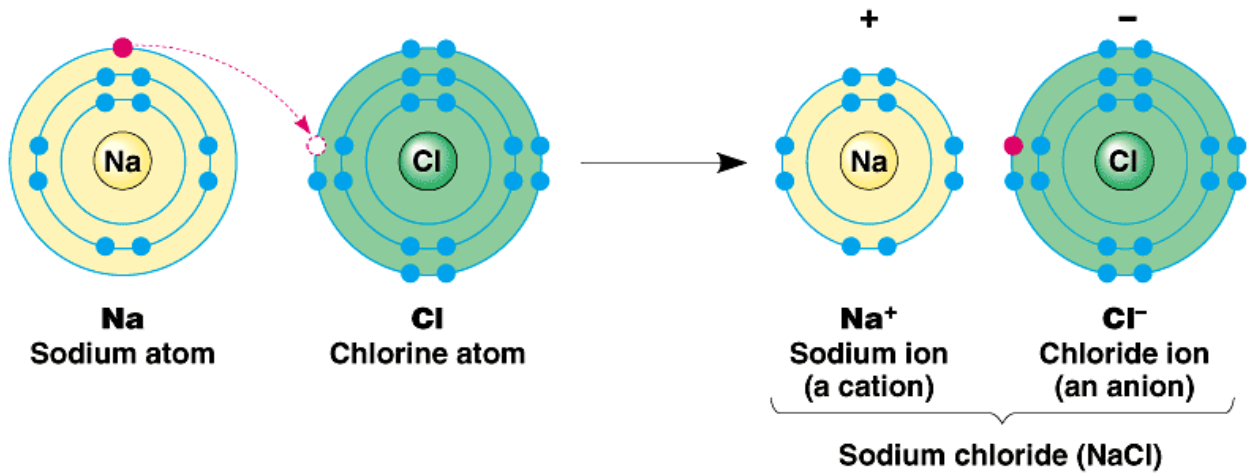
- Group: in general, as we go down a family from top to bottom, the first ionization energy decreases
- The electrons being removed are, on average, farther from the nucleus



Electronegativity

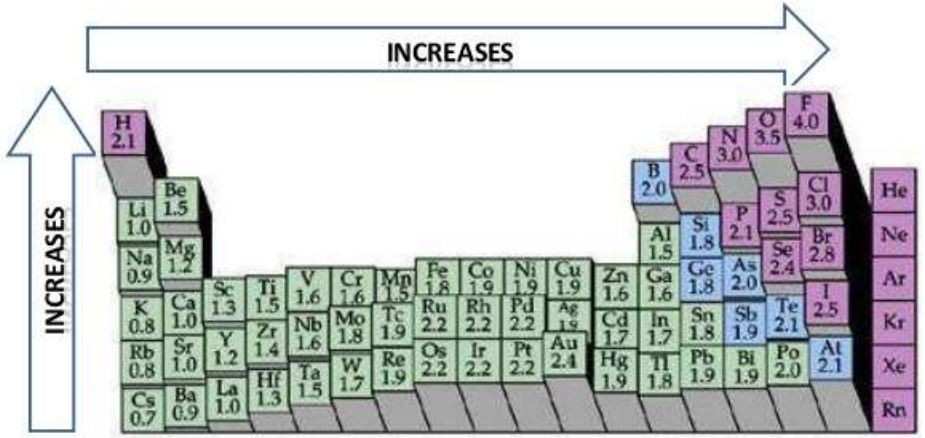
- Tendency of an atom to attract electrons

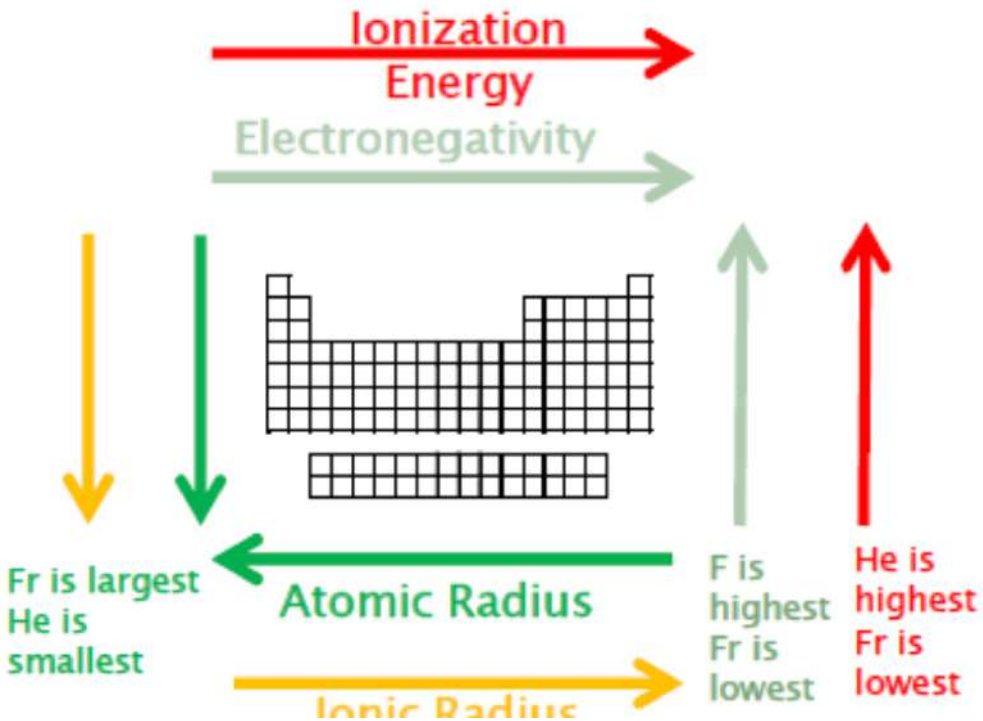
- Which atom would attract electrons more strongly?



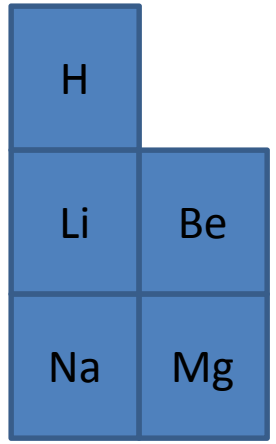
Electronegativity Trend

- Trend: Period: in general, as we go across a period from left to right, the electron affinities become more negative (larger meaning easier)
- Family: in general, electron affinity becomes more positive (smaller meaning harder) in going down a group but is not a regular trend

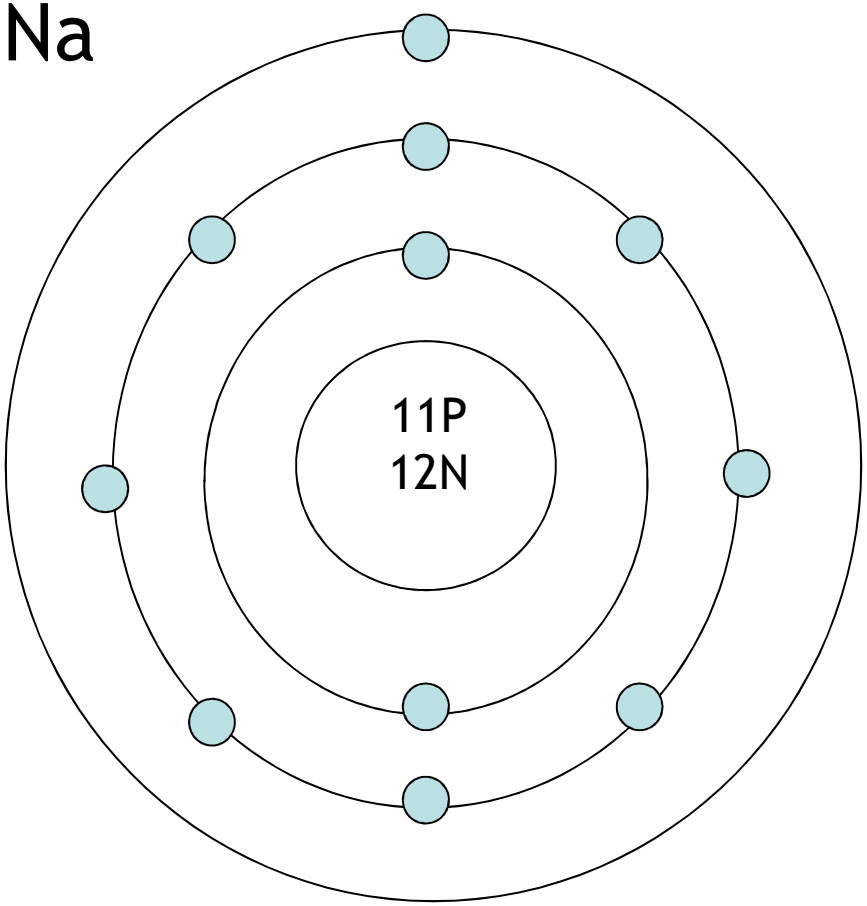



Ionization
Energy
Electronegativity
Fr is largest
He is
smallest
Atomic Radius
F is
highest
Fr is
lowest
He is
highest
Fr is
lowest
Ionic Radius

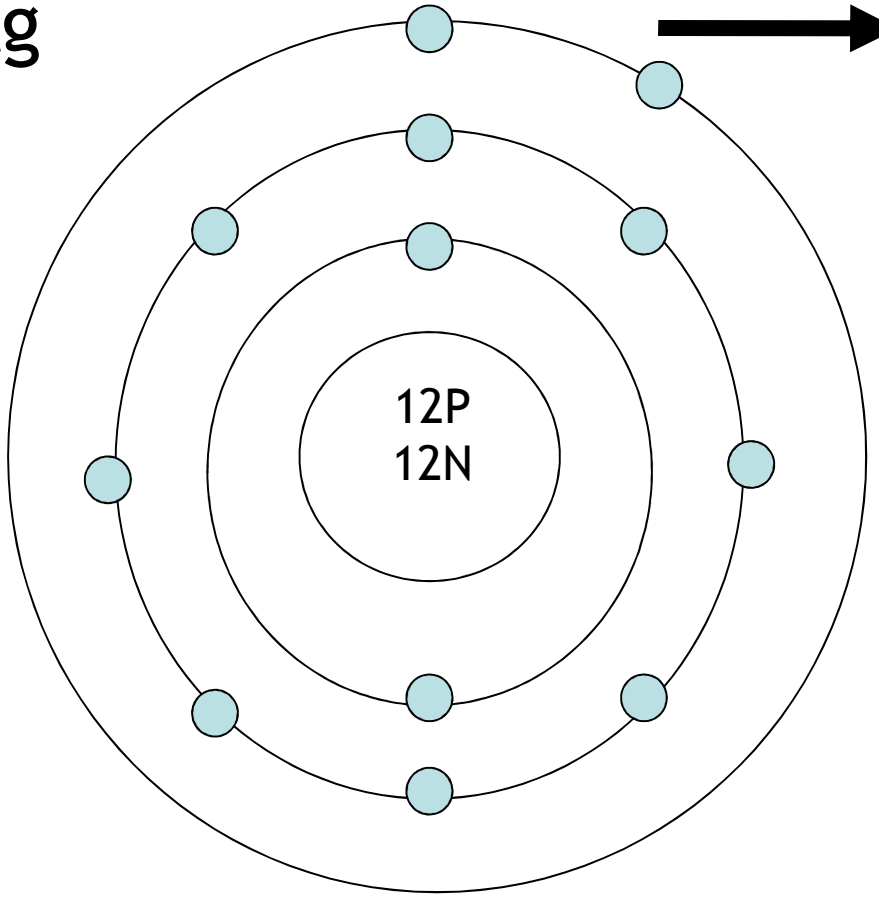
Visual: Across a Period…



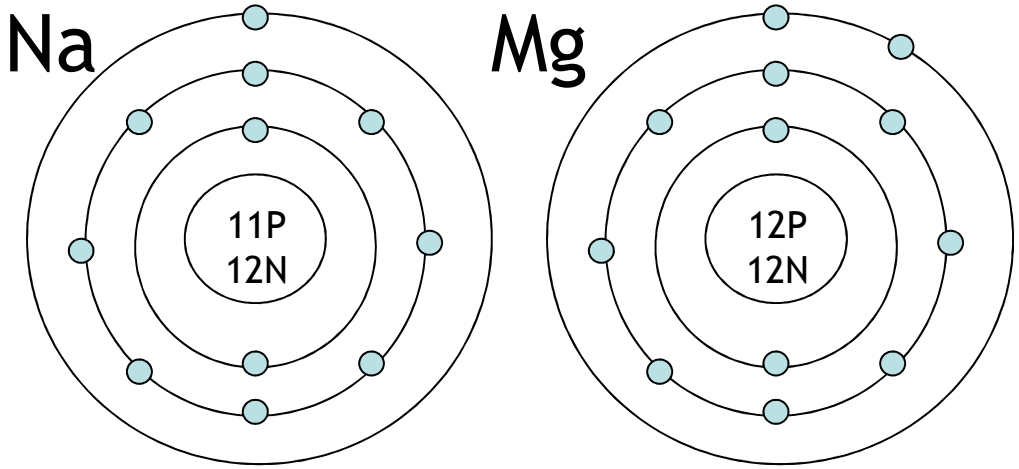
Na



Mg



Across A Period Review



ATOMIC RADIUS

- Adding one proton increases the charge of the nucleus to pull the electrons towards them, therefore across a period, the atomic size decreases

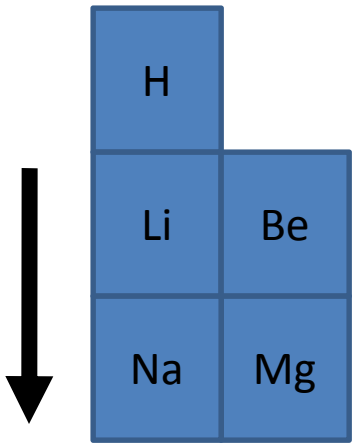
IONIZATION ENERGY

- It requires more energy to pull electrons that have been tightly held by the nucleus, therefore across a period, the ionization energy increases

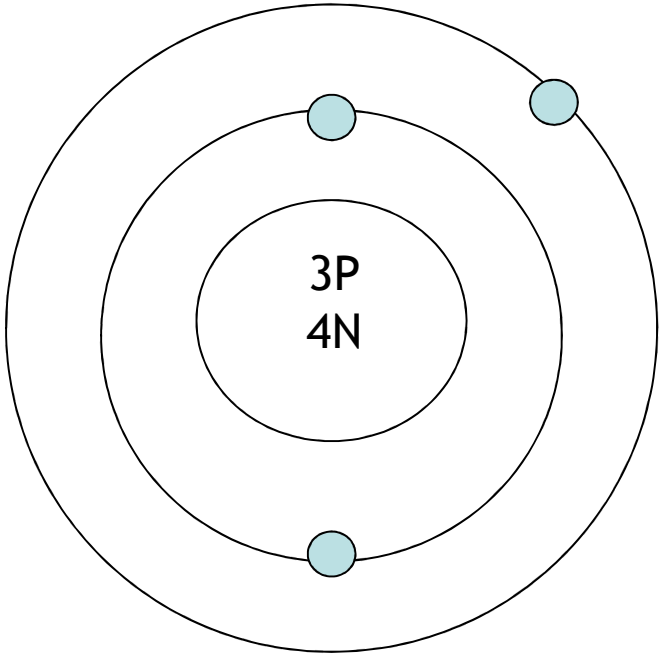
ELECTRON AFFINITY/ ELECTRONEGATIVITY

- Because the electrons are being tightly held by the nucleus, therefore across a period, electron affinity and electronegativity increases.

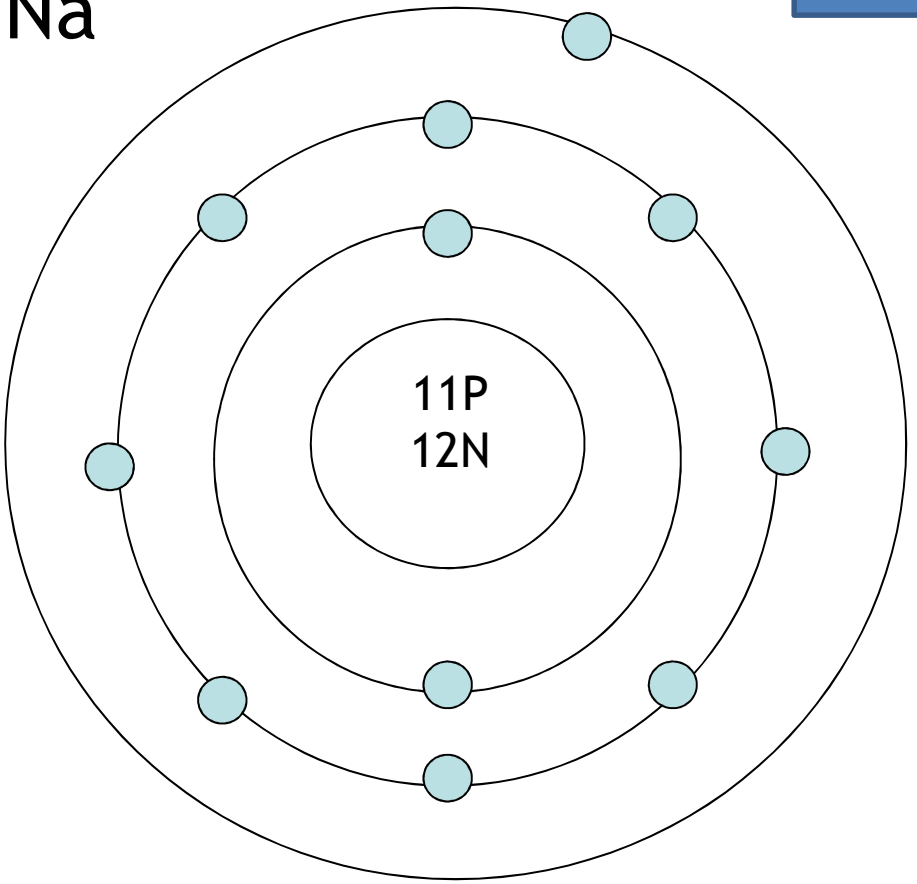
Visual: Down a Group…



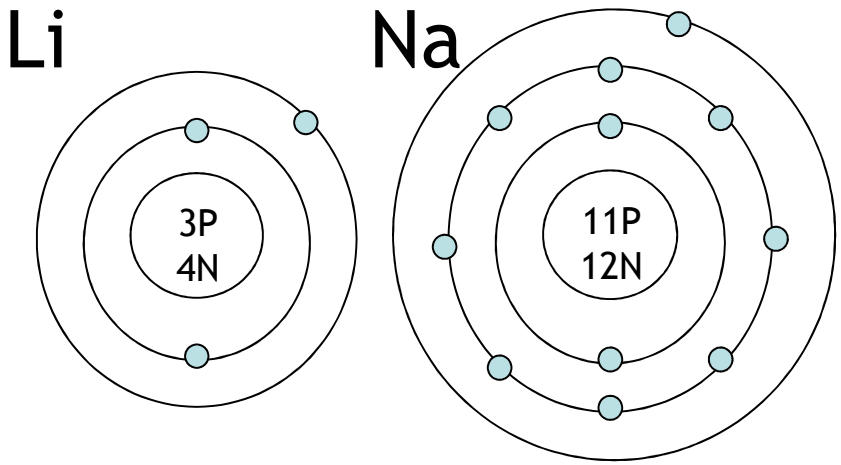
Li



Na



Down A Group Review



ATOMIC RADIUS
- Going down a period, there are additional energy levels to add to the size of the atom, thus the atomic radius increases

IONIZATION ENERGY
-It requires less energy to pull electrons that are not tightly held by the nucleus, therefore down a group, the ionization energy decreases

ELECTRON AFFINITY/ ELECTRONEGATIVITY
- The electrons are not being as tightly held by the nucleus, therefore across a period, electron affinity and electronegativity decreases.

Periodicity of Atomic Radius & Ionization Energy

PROBLEM: How are elements arranged on the periodic table according to atomic radius and ionization energy?

Atomic Number	Symbol	Atomic Radius (nanometers)	Ionization Energy (kilojoules)
1	H	0.032	1312
2	He	0.031	2372
3	Li	0.152	520
4	Be	0.089	899
5	B	0.082	801
6	C	0.077	1086
7	N	0.075	1402
8	O	0.073	1314
9	F	0.072	1681
10	Ne	0.071	2081
11	Na	0.186	496
12	Mg	0.136	738
13	Al	0.118	578
14	Si	0.111	786
15	P	0.106	1012
16	S	0.102	1000
17	Cl	0.099	1251
18	Ar	0.098	1521
19	K	0.227	419
20	Ca	0.174	590

QUESTIONS:

Questions for the atomic radius graph:

1) What is the term given to the horizontal row of the periodic table? The vertical row? (hint: yesterday's notes)

2) The section of the graph from element 3 to 10 represents one period, and the section of the graph from element 11 to 18 represents another period... How do these sections compare?

3) As you move across a period (e.g. 3 to 10 or 11 to 18) does the atomic radius get bigger or smaller?

4) Compare atomic radii for Li, Na, and K... As you go from Li to Na to K, does the atomic radius get bigger or smaller?

5) Compare atomic radii for He, Ne, and Ar... As you go from He to Ne to Ar, does the atomic radius get bigger or smaller?

6) What happens to the atomic radius as you go ***down*** a group? Is this the same for metals (Li, Na, K) and non-metals (He, Ne, Ar)?

Questions for the ionization energy graph:

1) The section of the graph from element 3 to 10 represents one period, and the section of the graph from element 11 to 18 represents another period... How do these sections compare?

2) As you move across a period (e.g. 3 to 10 or 11 to 18) does the ionization energy get bigger or smaller?

3) Compare ionization energies for Li, Na, and K... As you go from Li to Na to K, does the ionization energy get bigger or smaller?

4) Compare ionization energies for He, Ne, and Ar... As you go from He to Ne to Ar, does the ionization energy get bigger or smaller?

5) What happens to the ionization energy as you go ***down*** a group? Is this the same for metals (Li, Na, K) and non-metals (He, Ne, Ar)?

6) Group 1 elements lose their electrons most easily. Draw Bohr-Rutherford diagrams for any two elements in Group 1. Looking at their electron arrangement, why do you think these elements lose their electrons so easily?

7) Group 17 elements hold on to their electrons the most tightly. Draw Bohr-Rutherford diagrams for any two elements of Group 17. Looking at their electron arrangement, why do you think these elements hold on to their electrons so tightly?

8) If an element loses electrons easily, does it have a high or low ionization energy?

9) If an element holds on to its electrons tightly, does it have a high or low ionization energy?

Assignment

- Your best friend has missed the last two weeks of school while traveling through Europe with his/her family. You recently received a letter from him/her asking you to explain what we have been working on in class so s/he can be prepared for the test when s/he returns next week. Write a letter to your friend explaining atomic radii, ionization energy and electronegativity. Include an explanation of the trends for each as you move across and down the periodic table. Remember she is really behind so be thorough and in depth.