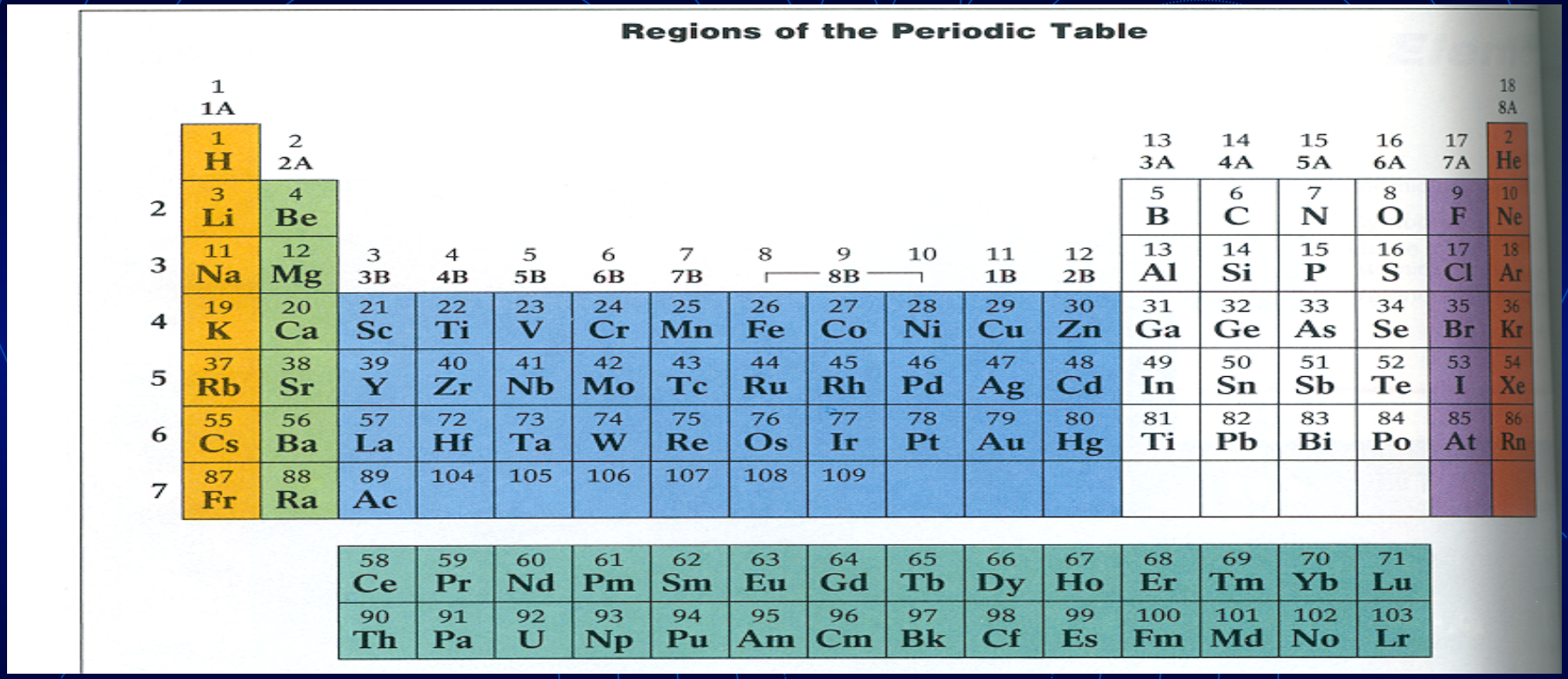
Periodic Table & Trends

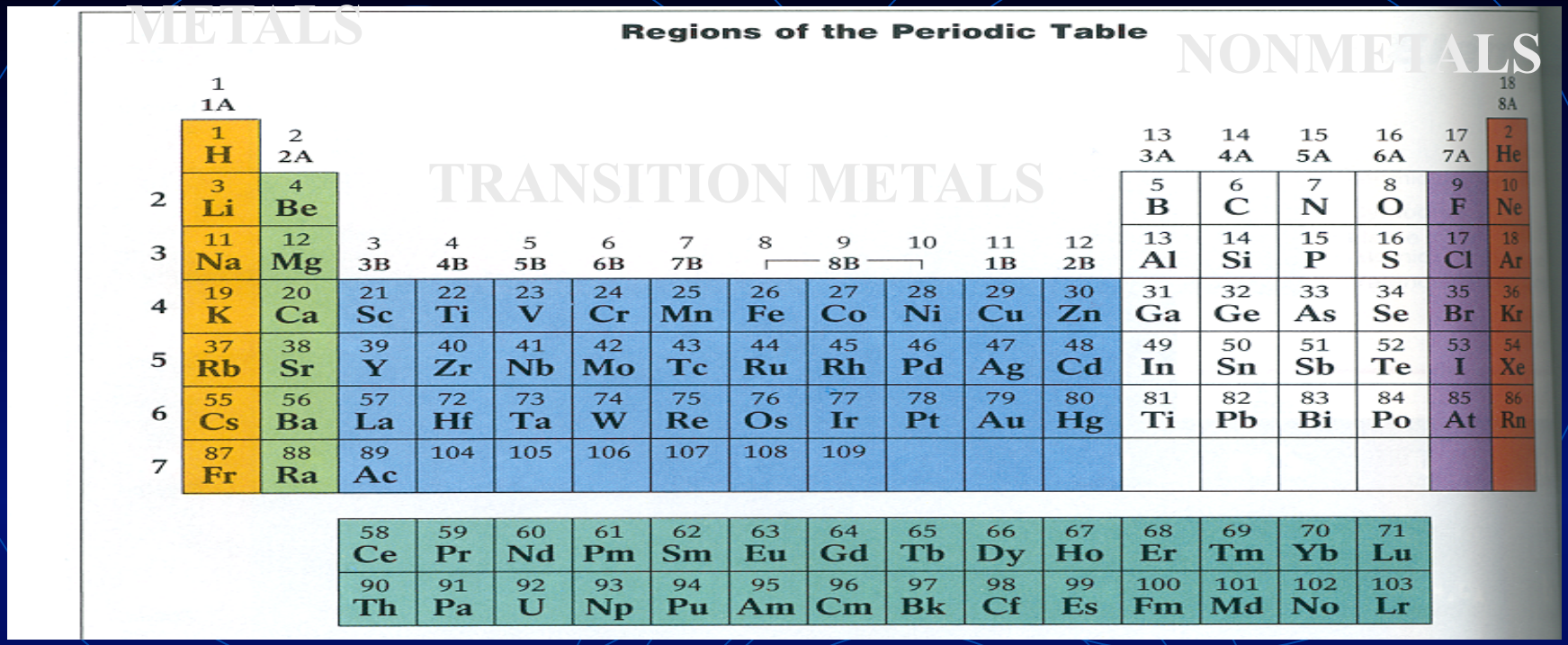


History of the Periodic Table

- 1871 – Mendeleev arranged the elements according to: 1. Increasing atomic mass 2. Elements w/ similar properties were put in the same row
- 1913 – Moseley arranged the elements according to: 1. Increasing atomic number 2. Elements w/ similar properties were put in the same column

Group Names

Alkali +1	Alkaline Earth Metals +2		+3		-3	-2	Halogen -1	Noble Gases 0
H 1								He 2
Li 3	Be 4		B 5	C 6	N 7	O 8	F 9	Ne 10
Na 11	Mg 12		Al 13	Si 14	P 15	S 16	Cl 17	Ar 18



S & P block – Representative Elements

Metalloids (Semimetals, Semiconductors) – B,Si, Ge, As, Sb, Te (properties of both metals & nonmetals)

Columns – groups or families Rows - periods

The Periodic Law

- Mendeleev understood the 'Periodic Law' which states:
- When arranged by increasing atomic number, the chemical elements display a regular and repeating pattern of chemical and physical properties.

The Periodic Law

- Atoms with similar properties appear in groups or families (vertical columns) on the periodic table.
- They are similar because they all have the same number of valence (outer shell) electrons, which governs their chemical behavior.

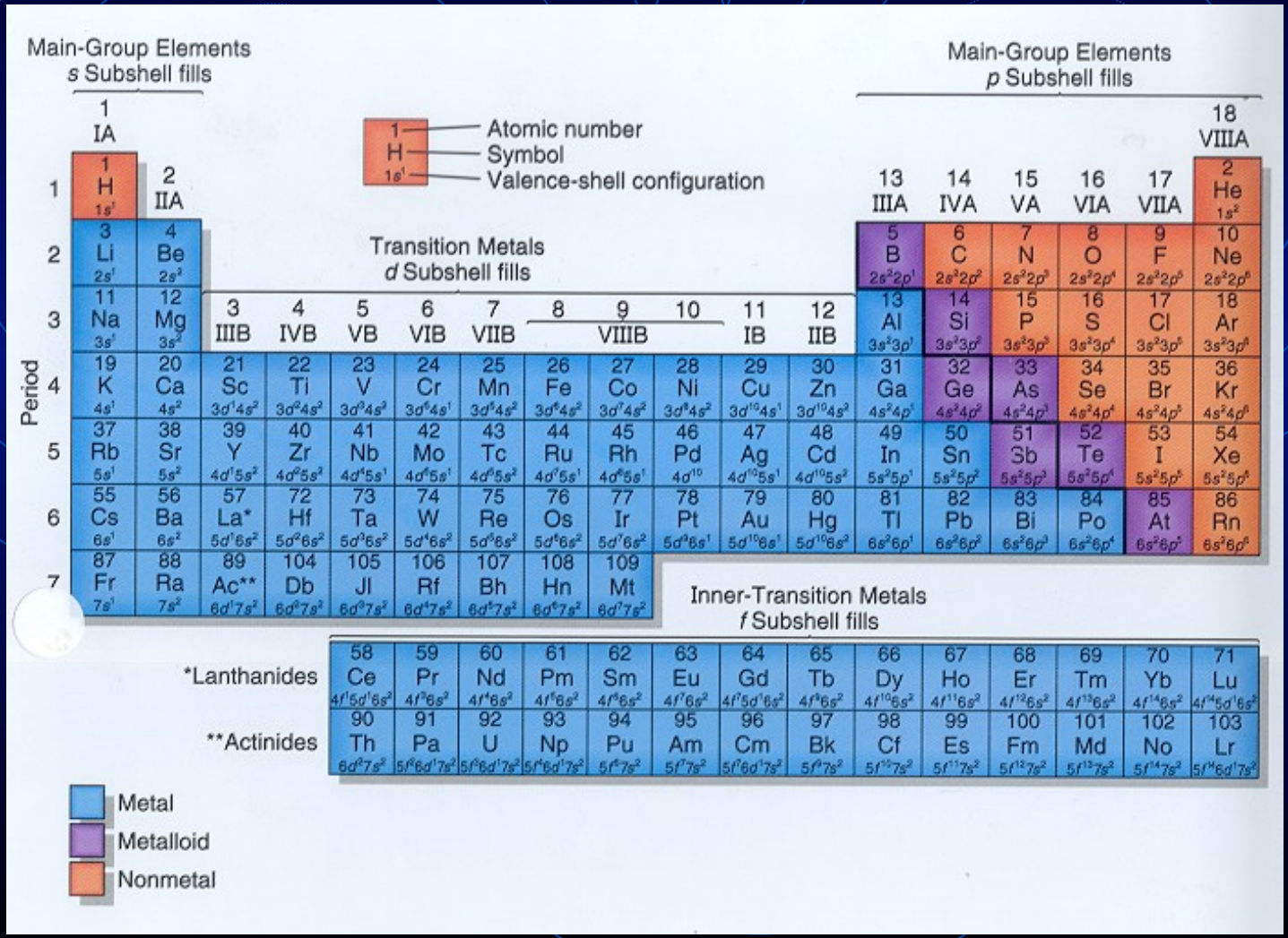
Valence Electrons

- Do you remember how to tell the number of valence electrons for elements in the s- and p-blocks?
- How many valence electrons will the atoms in the d-block (transition metals) and the f-block (inner transition metals) have?
- Most have 2 valence e-, some only have 1.

A Different Type of Grouping

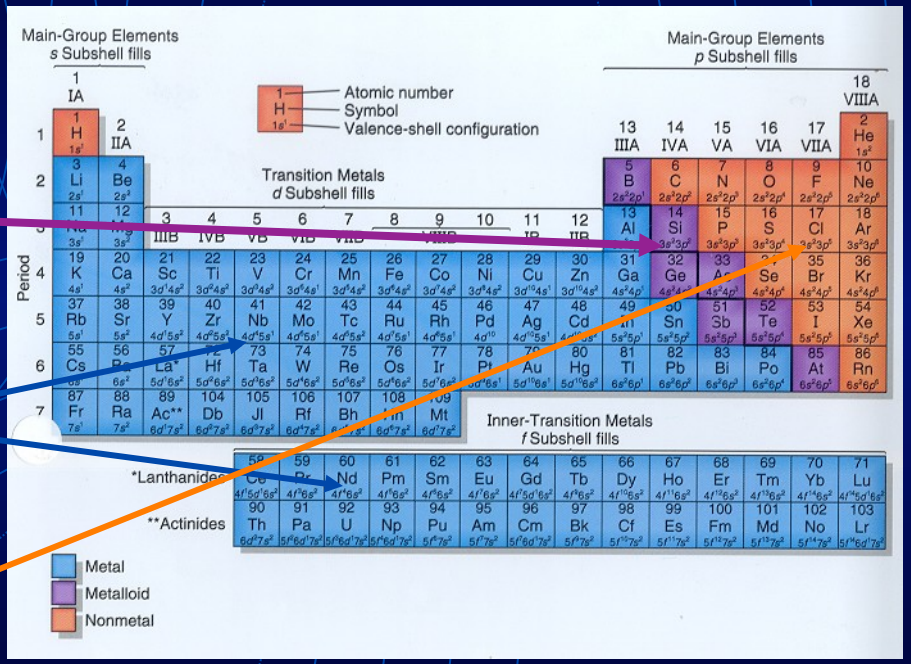
- Besides the 4 blocks of the table, there is another way of classifying element:
- Metals
- Nonmetals
- Metalloids or Semi-metals.
- The following slide shows where each group is found.

Metals, Nonmetals, Metalloids



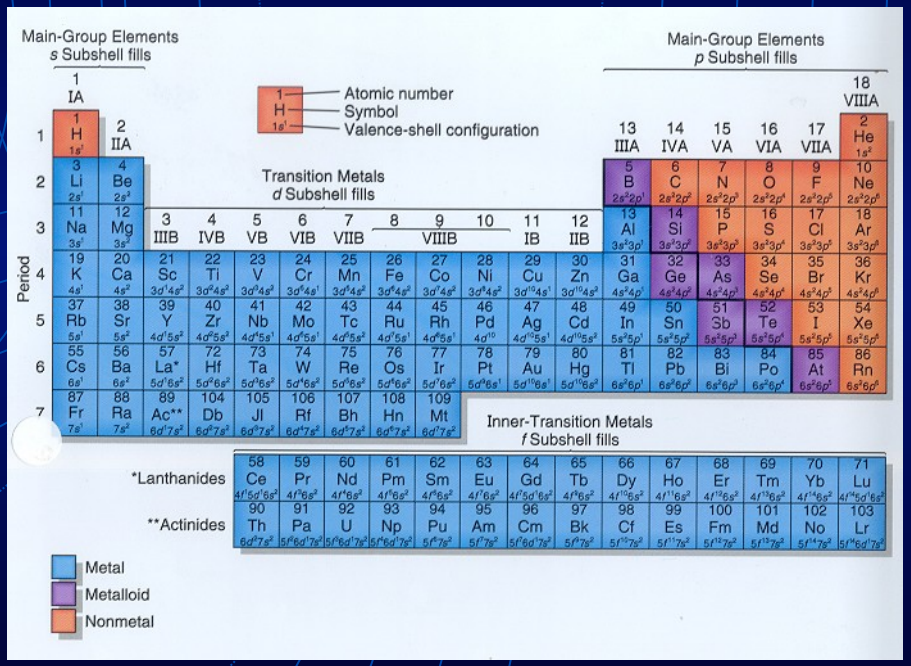
Metals, Nonmetals, Metalloids

- There is a zig-zag or staircase line that divides the table.
- Metals are on the left of the line, in blue.
- Nonmetals are on the right of the line, in orange.



Metals, Nonmetals, Metalloids

- Elements that border the stair case, shown in purple are the metalloids or semi-metals.
- There is one important exception.
- Aluminum is more metallic than not.



Metals, Nonmetals, Metalloids

- How can you identify a metal?
- What are its properties?
- What about the less common nonmetals?
- What are their properties?
- And what the heck is a metalloid?

Metals

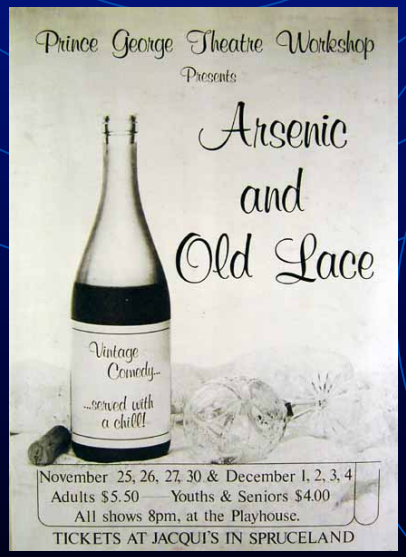
- Metals are lustrous (shiny), malleable, ductile, and are good conductors of heat and electricity.
- They are mostly solids at room temp.
- What is one exception?

Nonmetals

- Nonmetals are the opposite.
- They are dull, brittle, nonconductors (insulators).
- Some are solid, but many are gases, and Bromine is a liquid.

Metalloids

- Metalloids, aka semi-metals are just that.
- They have characteristics of both metals and nonmetals.
- They are shiny but brittle.
- And they are semiconductors.
- What is our most important semiconductor?



Periodic Trends

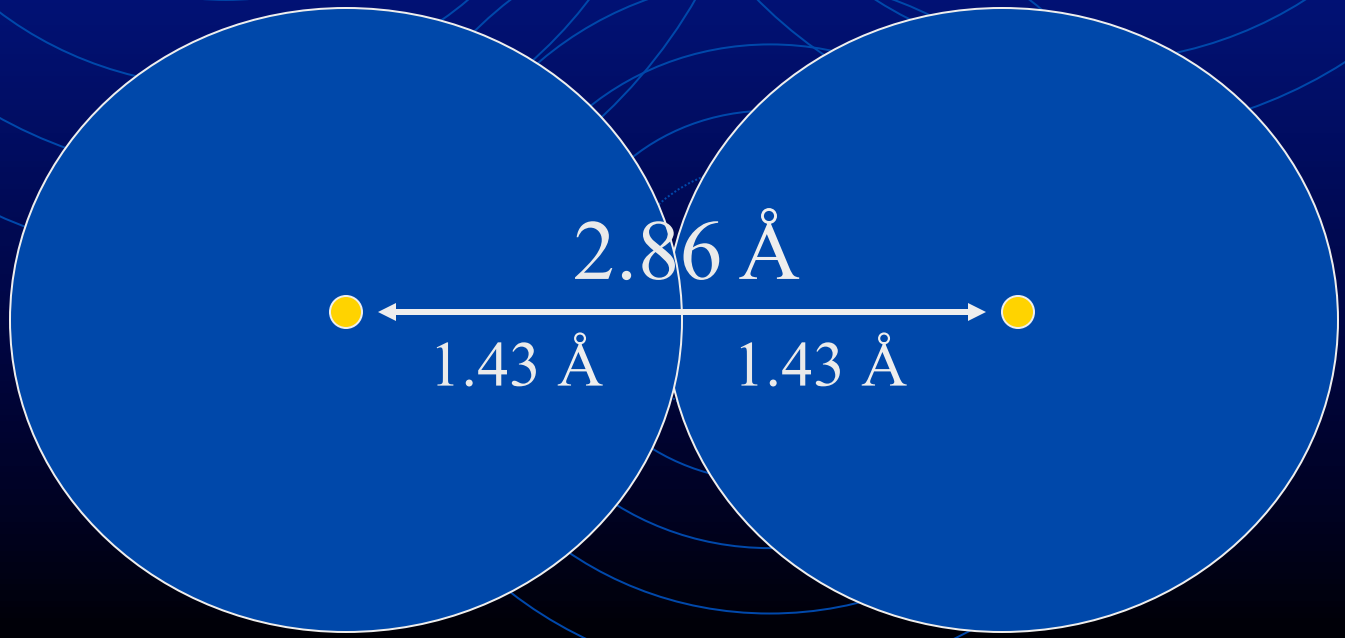
- There are several important atomic characteristics that show predictable trends that you should know.
- The first and most important is atomic radius.
- Radius is the distance from the center of the nucleus to the "edge" of the electron cloud.

Atomic Radius

- Since a cloud's edge is difficult to define, scientists use define covalent radius, or half the distance between the nuclei of 2 bonded atoms.
- Atomic radii are usually measured in picometers (pm) or angstroms (Å). An angstrom is 1×10^{-10} m.

Covalent Radius

- Two Br atoms bonded together are 2.86 angstroms apart. So, the radius of each atom is 1.43 Å.



Atomic Radius

- The trend for atomic radius in a vertical column is to go from smaller at the top to larger at the bottom of the family.
- Why?
- With each step down the family, we add an entirely new PEL to the electron cloud, making the atoms larger with each step.

Atomic Radius

- The trend across a horizontal period is less obvious.
- What happens to atomic structure as we step from left to right?
- Each step adds a proton and an electron (and 1 or 2 neutrons).
- Electrons are added to existing PELs or sublevels.

Atomic Radius

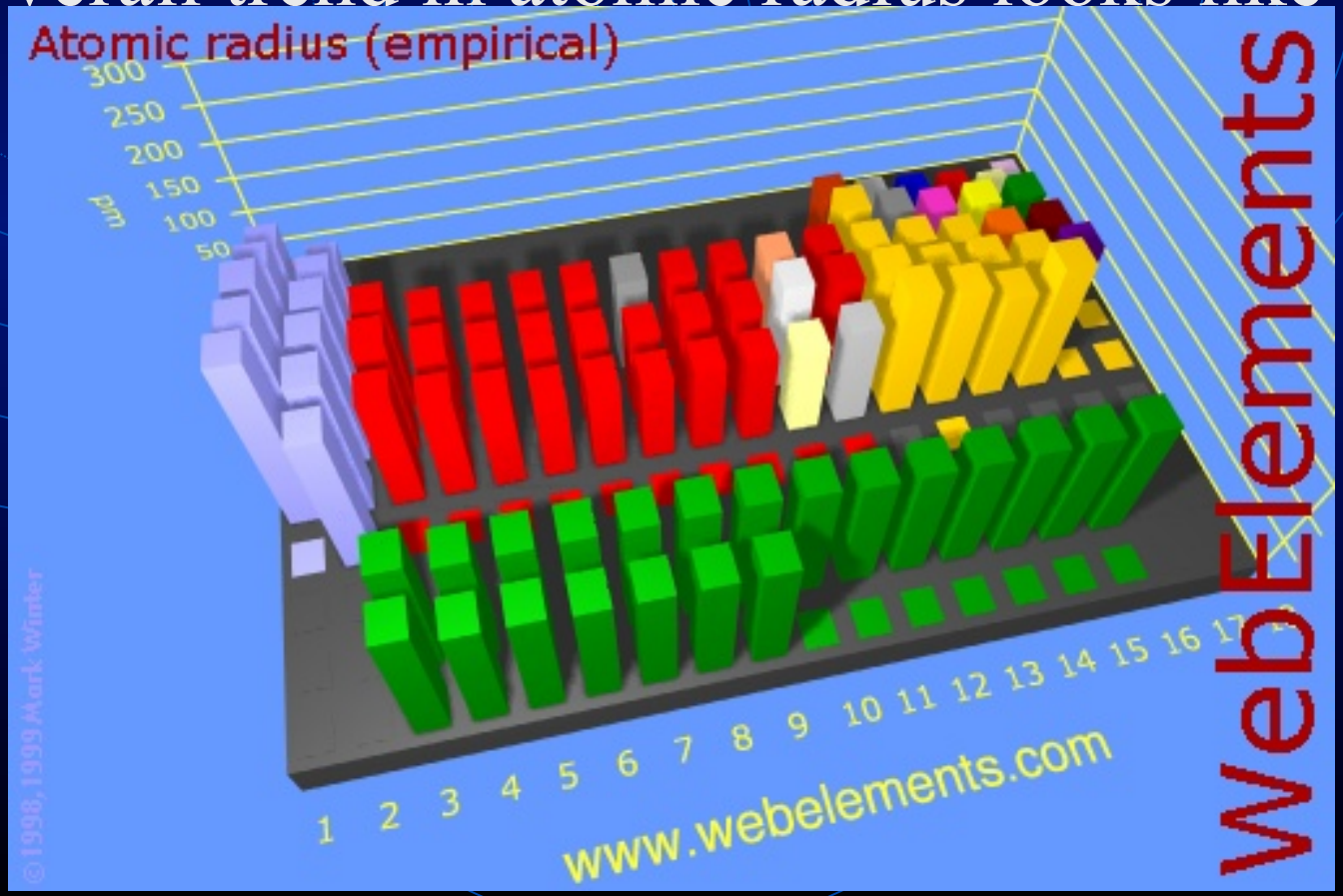
- The effect is that the more positive nucleus has a greater pull on the electron cloud.
- The nucleus is more positive and the electron cloud is more negative.
- The **increased attraction pulls the cloud in**, making atoms smaller as we move from left to right across a period.

Effective Nuclear Charge

- What keeps electrons from simply flying off into space?
- **Effective nuclear charge** is the pull that an electron "feels" from the nucleus.
- The closer an electron is to the nucleus, the more pull it feels.
- As effective nuclear charge increases, the electron cloud is pulled in tighter.

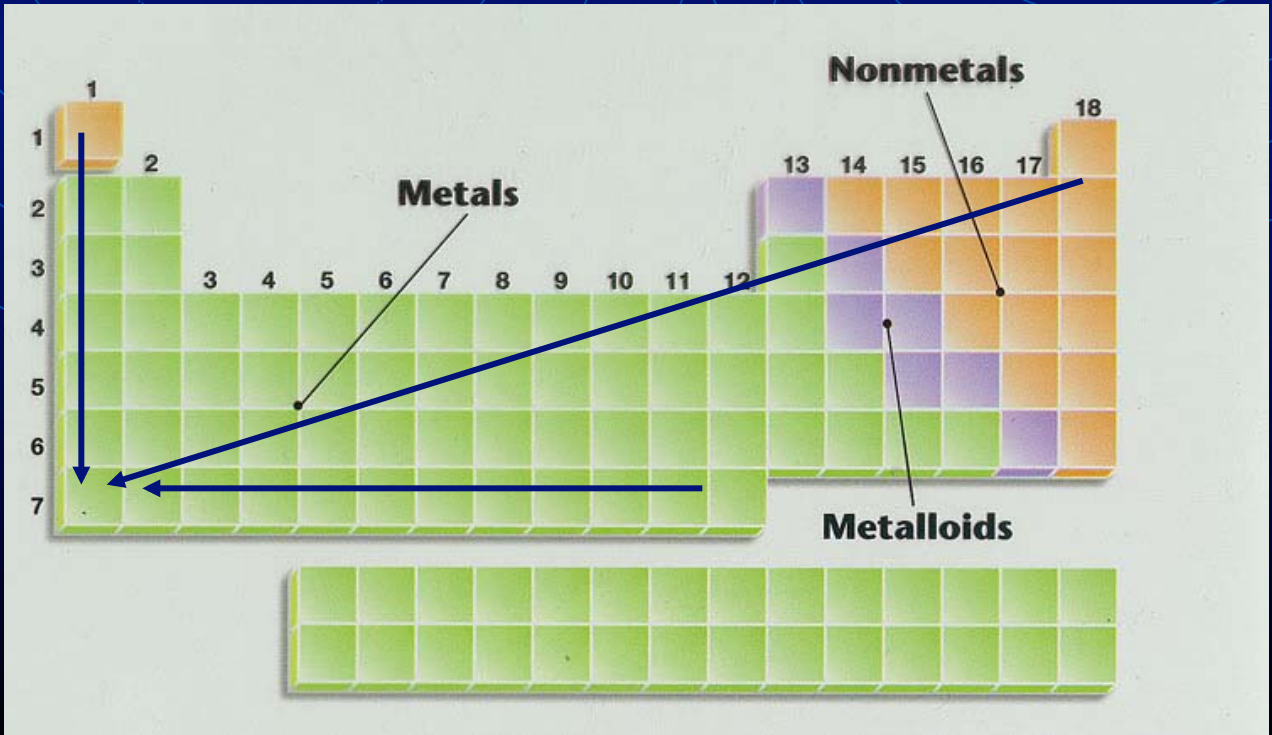
Atomic Radius

- The overall trend in atomic radius looks like this.



Atomic Radius

- Here is an animation to explain the trend.
- On your help sheet, draw arrows like this:



The Octet Rule

- The "goal" of most atoms (except H, Li and Be) is to have an octet or group of 8 electrons in their valence energy level.
- They may accomplish this by either giving electrons away or taking them.
- Metals generally give electrons, nonmetals take them from other atoms.
- Atoms that have gained or lost electrons are called ions.

Ions

- When an atom gains an electron, it becomes negatively charged (more electrons than protons) and is called an **anion.**
- In the same way that nonmetal atoms can gain electrons, metal atoms can lose electrons.
- They become positively charged **cations**.

Ions

- Here is a simple way to remember which is the cation and which the anion:

This is Ann Ion.

She's unhappy and negative.

This is a cat-ion.

He's a "plussy" cat!

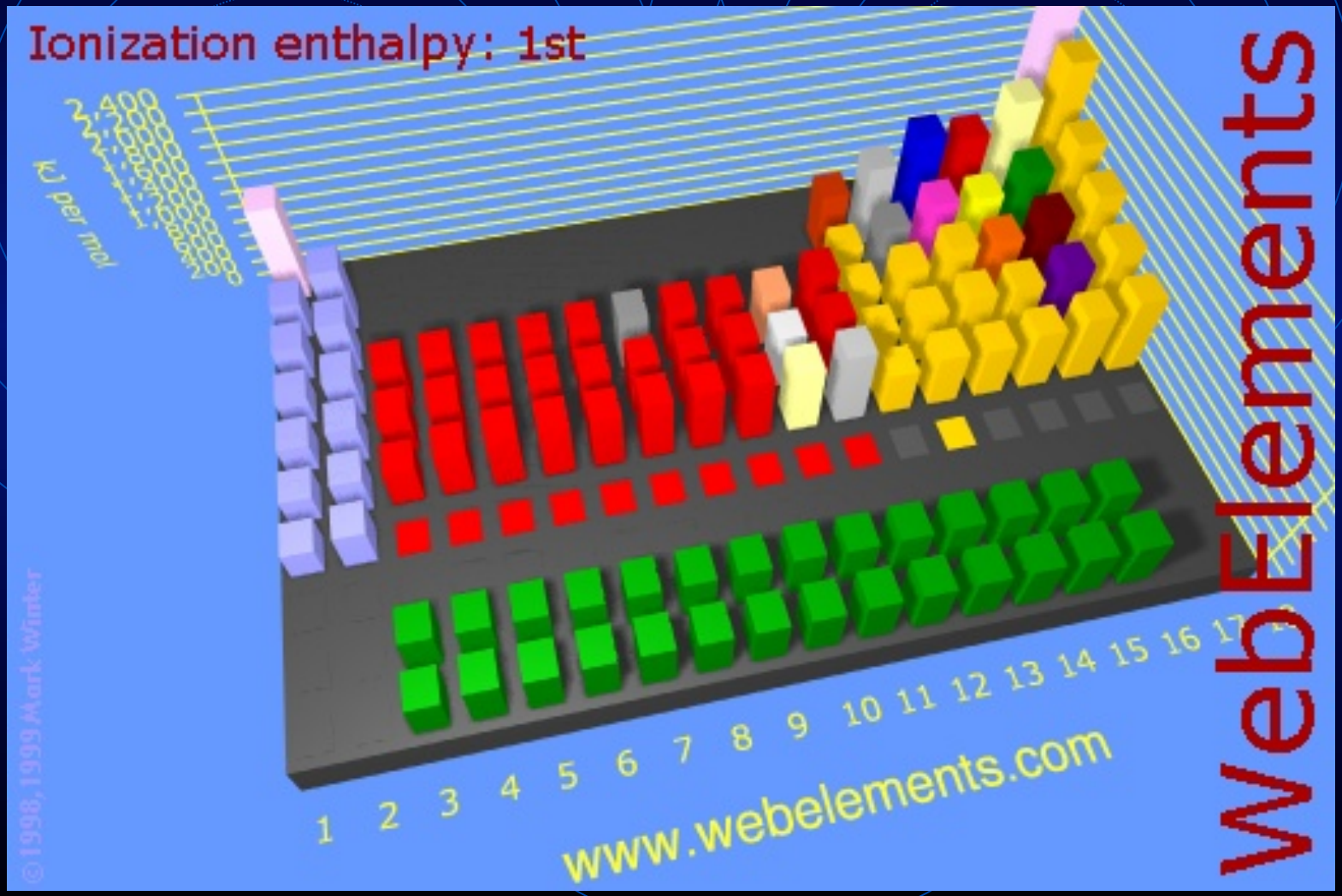
Ionization Energy

- This is the second important periodic trend.
- If an electron is given enough energy (in the form of a photon) to overcome the effective nuclear charge holding the electron in the cloud, it can leave the atom completely.
- The atom has been "ionized" or charged.
- The number of protons and electrons is no longer equal.

Ionization Energy

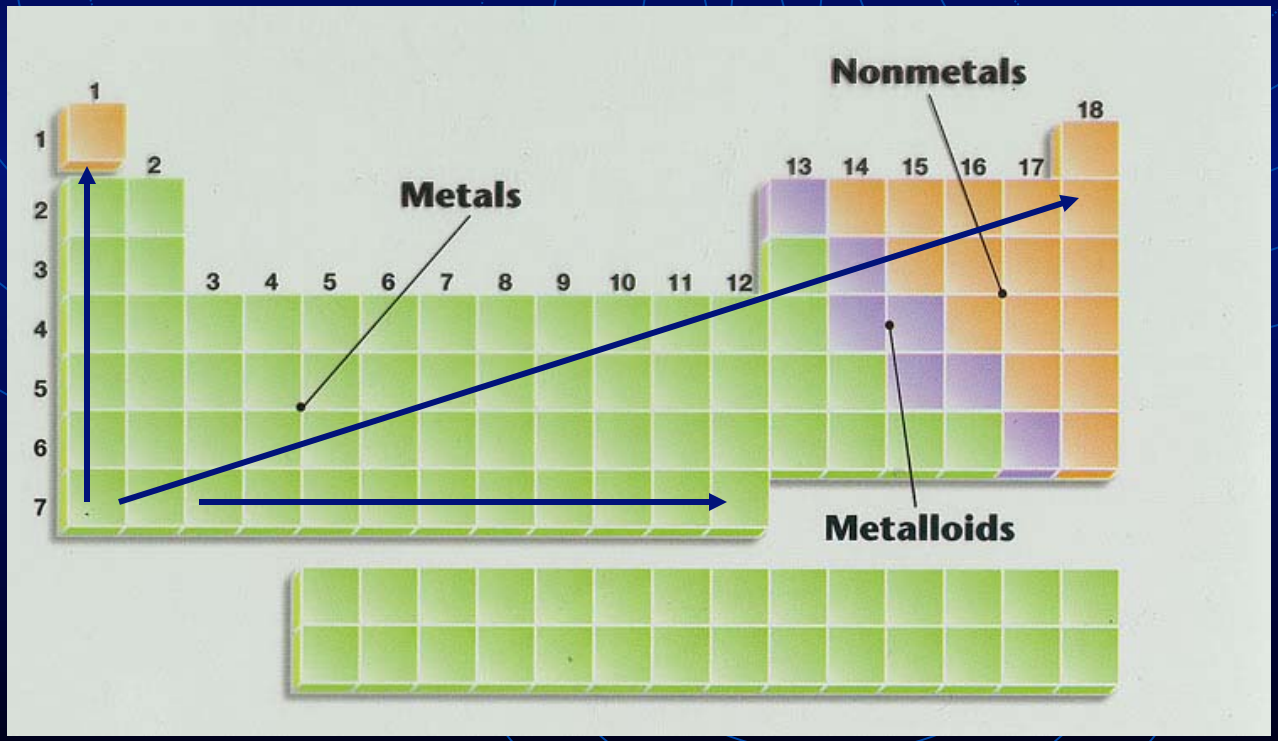
- The energy required to remove an electron from an atom is ionization energy. (measured in kilojoules, kJ)
- The larger the atom is, the easier its electrons are to remove.
- **Ionization energy and atomic radius are inversely proportional.**
- Ionization energy is always endothermic, that is energy is added to the atom to remove the electron.

Ionization Energy



Ionization Energy (Potential)

- Draw arrows on your help sheet like this:



Electron Affinity

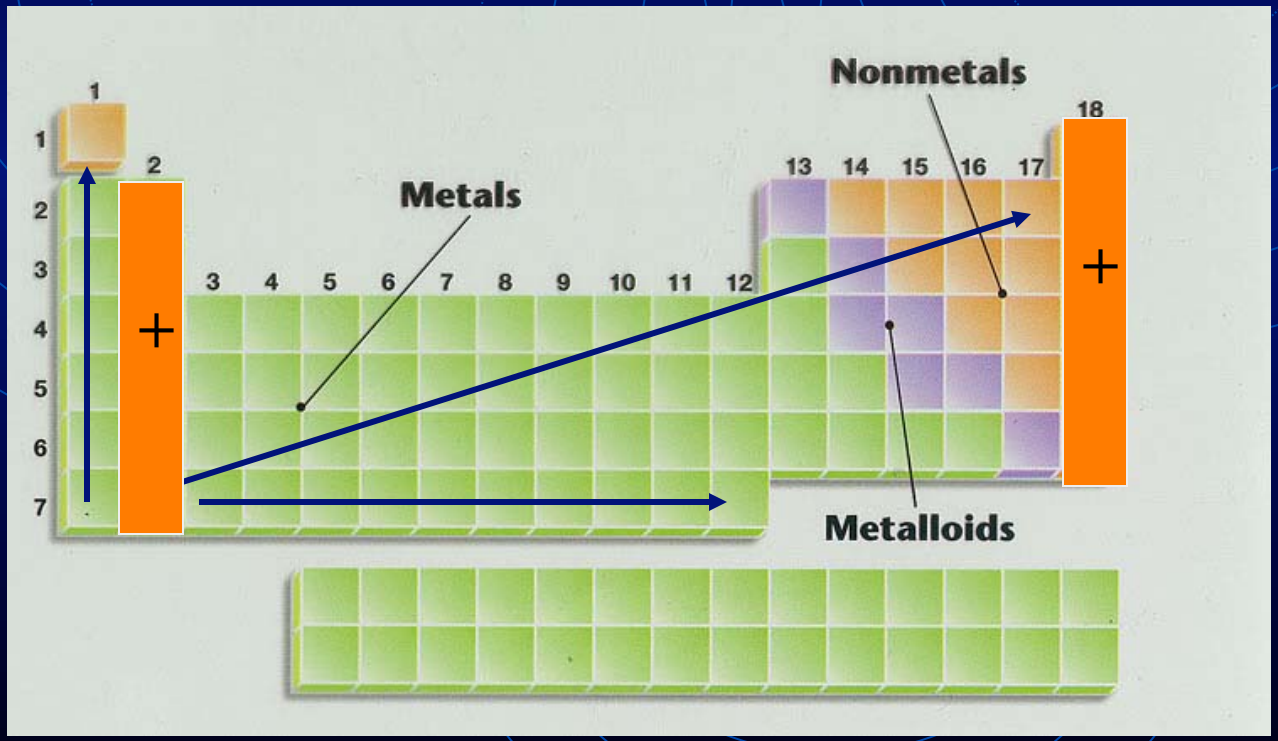
- What does the word ‘affinity’ mean?
- Electron affinity is the energy **change** that occurs when an atom **gains an electron** (also measured in kJ).
- Where ionization energy is always endothermic, electron affinity is usually exothermic, but not always.

Electron Affinity

- Electron affinity is exothermic if there is an empty or partially empty orbital for an electron to occupy.
- If there are no empty spaces, a new orbital or PEL must be created, making the process endothermic.
- This is true for the alkaline earth metals and the noble gases.

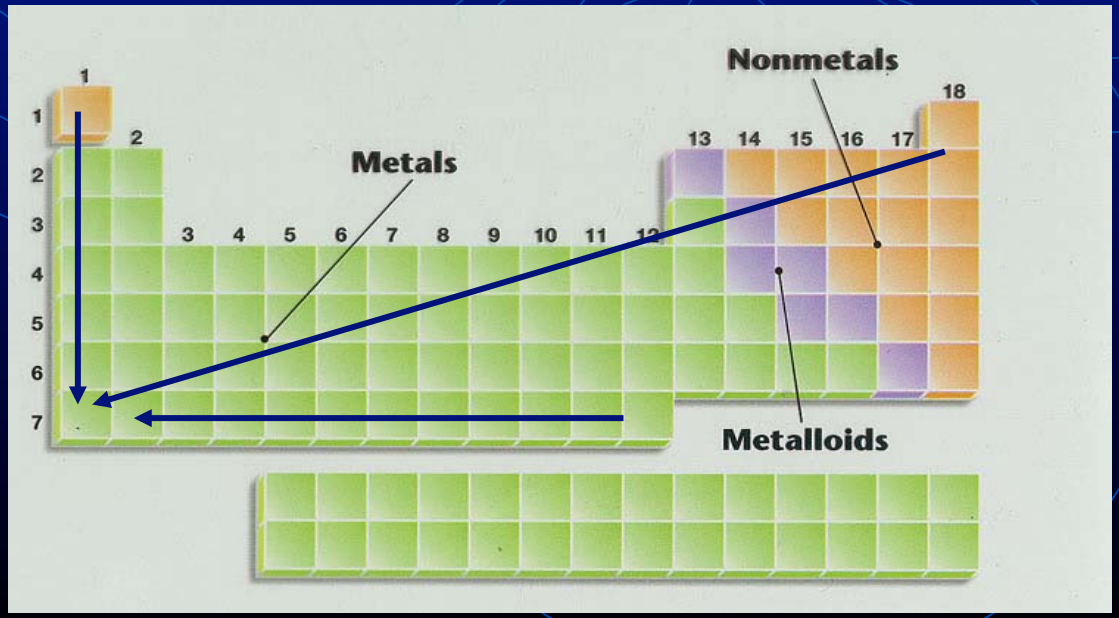
Electron Affinity

- Your help sheet should look like this:



Metallic Character

- This is simple a relative measure of how easily atoms lose or give up electrons.
- Your help sheet should look like this:

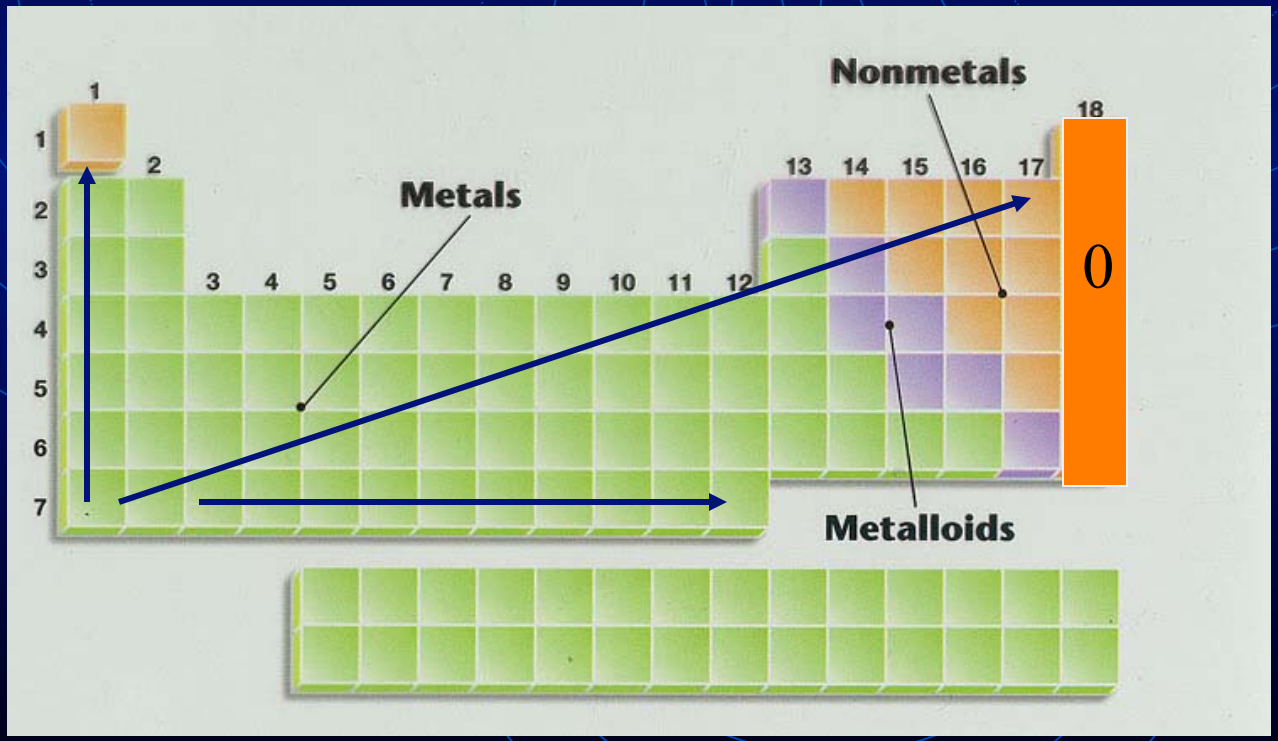


Electronegativity

- Electronegativity is a measure of an atom's attraction for another atom's electrons.
- It is an arbitrary scale that ranges from 0 to 4.
- The units of electronegativity are Paulings.
- Generally, metals are electron givers and have low electronegativities.
- Nonmetals are are electron takers and have high electronegativities.
- What about the noble gases?

Electronegativity

- Your help sheet should look like this:

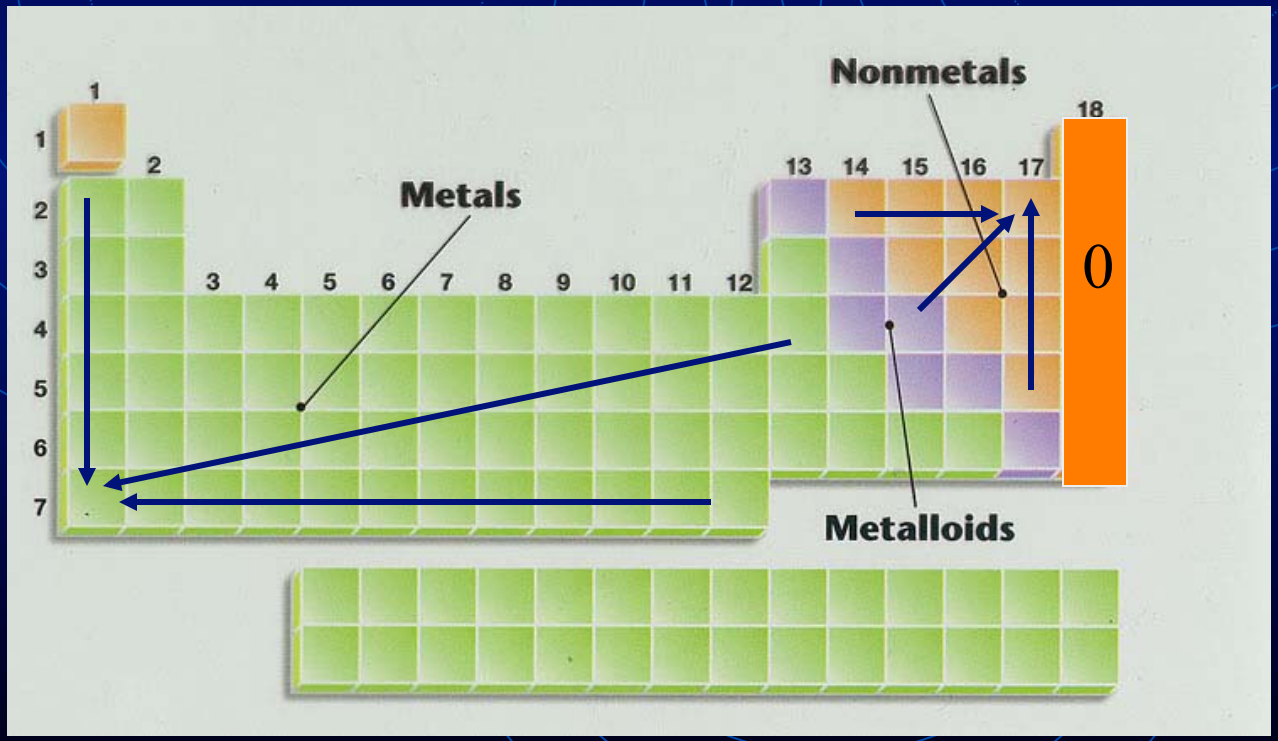


Overall Reactivity

- This ties all the previous trends together in one package.
- However, we must treat metals and nonmetals separately.
- The most reactive metals are the largest since they are the best electron givers.
- The most reactive nonmetals are the smallest ones, the best electron takers.

Overall Reactivity

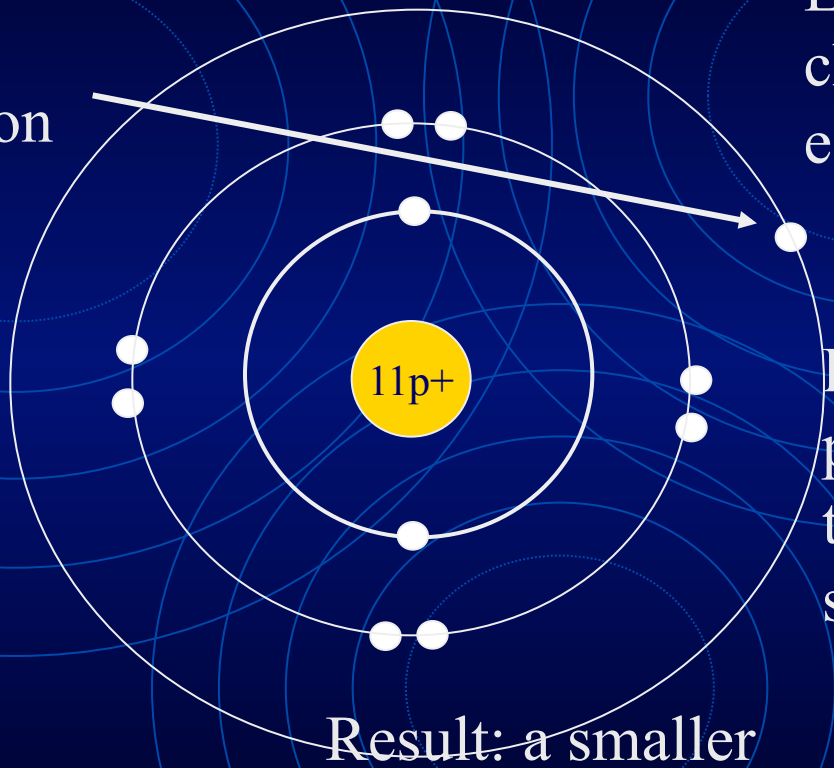
- Your help sheet will look like this:



Cation Formation

Na atom

1 valence electron



Effective nuclear charge on remaining electrons increases.

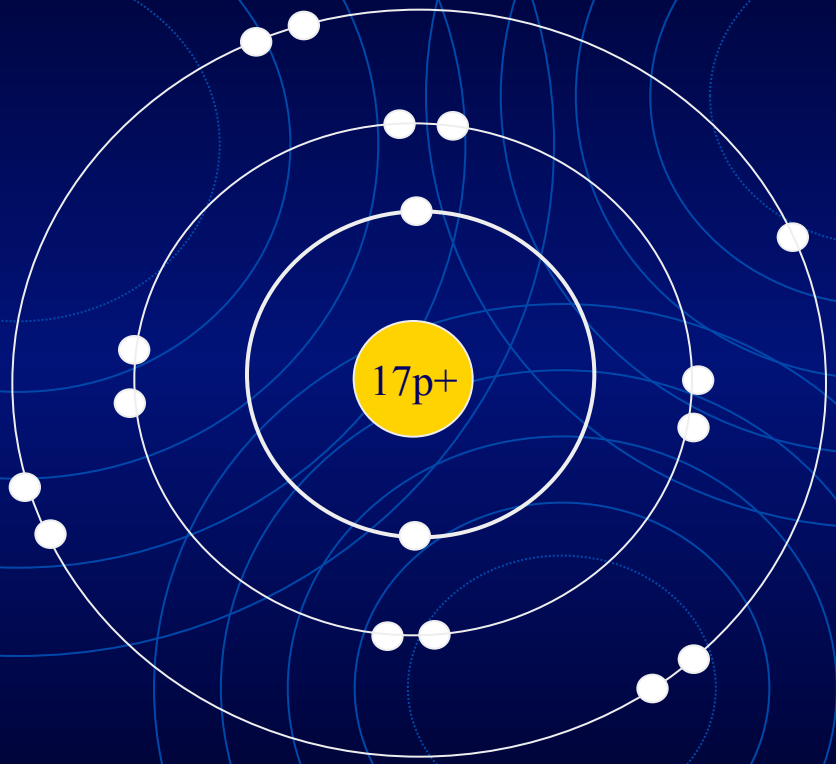
Remaining e- are pulled in closer to the nucleus. Ionic size decreases.

Valence e- lost in ion formation

Result: a smaller sodium cation, Na^+

Anion Formation

Chlorine atom with 7 valence e-



A chloride ion is produced. It is larger than the original atom.

One e- is added to the outer shell.

Effective nuclear charge is reduced and the e- cloud expands.