






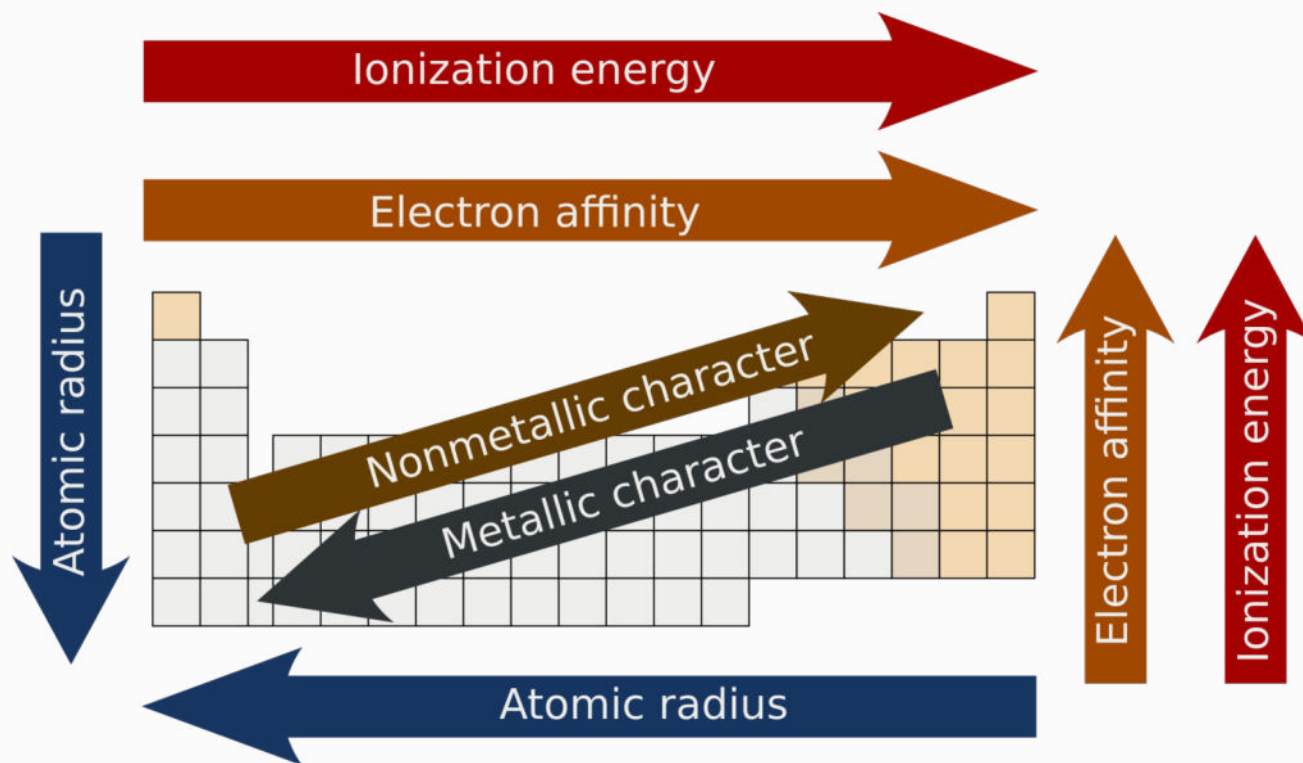
# Periodic Trends

# AIMES Trends

		Direction of Increase	Left to Right Across Period	Down Group
A	Atomic Radii		decreases	increases
I	Ionization Energy		increases	decreases
M	Metallic Properties		decreases	increases
E	Electronegativity		increases	decreases
S	Shielding		stays same	increases

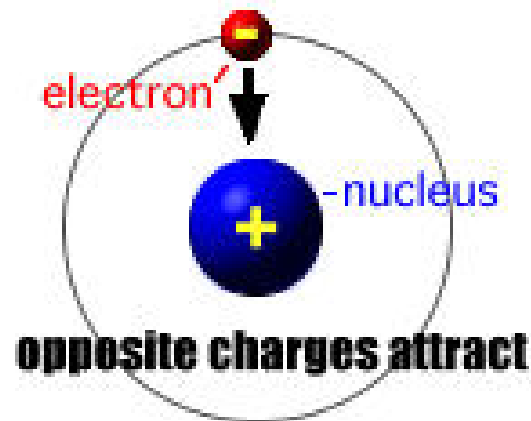


# Direction of Increasing Trend



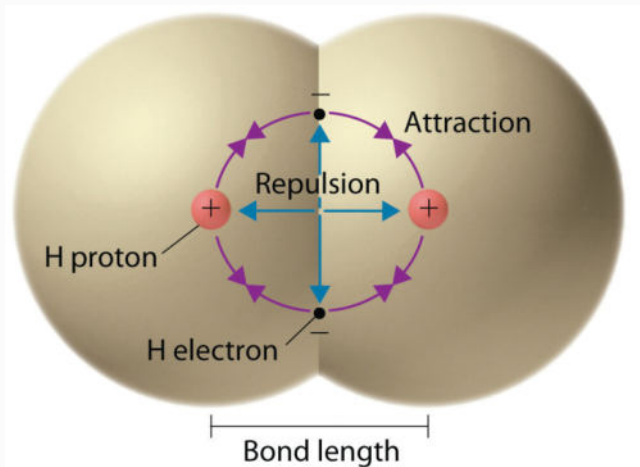
# Force Determining Trends

- **Nuclear Force:** the positive protons inside the nucleus pull the negative electrons outside the nucleus in toward the center because of the magnetic rule that “opposite attract”; this is stronger than electron-electron repulsion



# Force Determining Trends

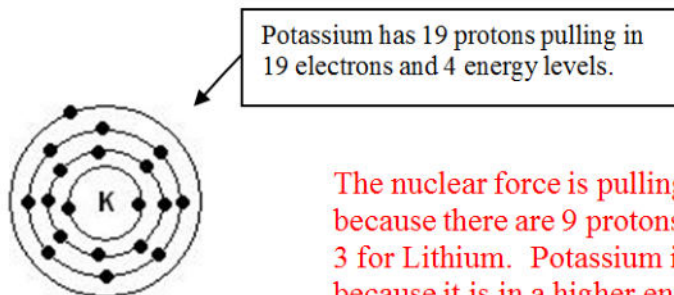
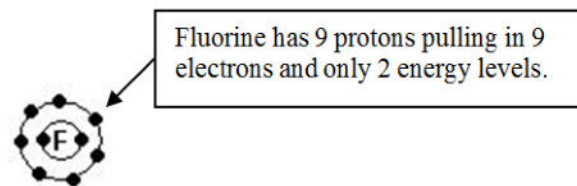
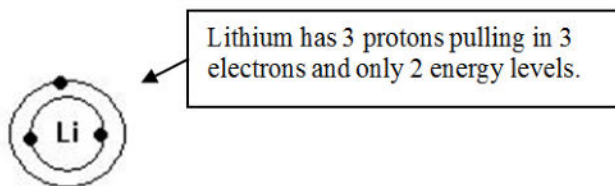
- **Electron-Electron Repulsion:** the electrons in the valence shell will repel each other and try to spread out because of the magnetic rule that says “likes repel”; this is weaker than the nuclear force





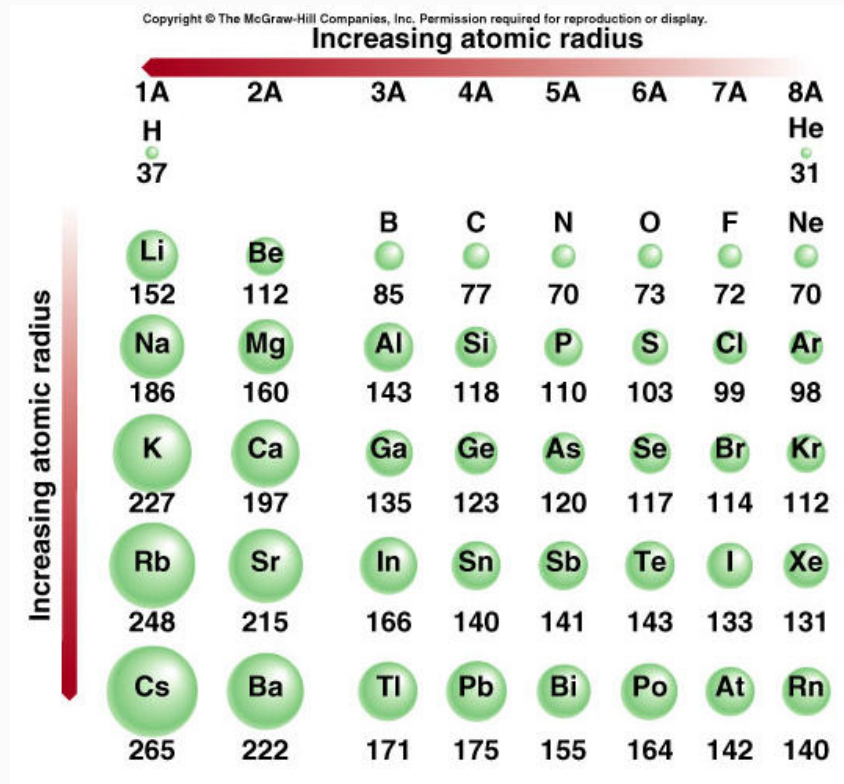
# Atomic Radii

**Atomic Radii** – involves the size of the nucleus and electron cloud around the atom where the number of protons inside the atom equals the number of electrons outside the atom



The nuclear force is pulling Fluorine's electrons in closer because there are 9 protons in the nucleus compared with only 3 for Lithium. Potassium is bigger than Lithium and Fluorine because it is in a higher energy level and has more orbitals.

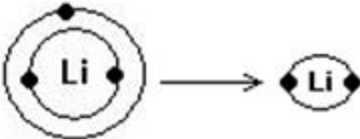
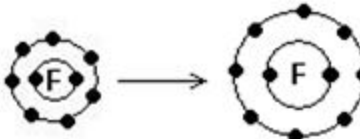
# Atomic Radii Trend





# Ionic Radii

**Ionic Radii** - the size of the nucleus and electron cloud around the atom where the number of protons inside the atom DOES NOT equal the number of electrons outside the atom; the size pattern for Group A1 – A8 is Large, Medium, Small, Equal, Large, Medium, Small, N/A

<u>Cation</u>	<u>Anion</u>
<p>Positive ion; electron is removed</p>  <p><math>\text{Li} \rightarrow \text{Li}^+</math></p> <p>Lithium atom has 3 electrons and 3 protons; Lithium ion has 2 electrons and 3 protons</p> <p>Cations get smaller because there are more protons pulling inward on fewer electrons.</p> <p>The nuclear force is constant and the electron-electron repulsion force is decreased</p>	<p>Negative ion; electron is gained</p>  <p><math>\text{F} \rightarrow \text{F}^-</math></p> <p>Fluorine atom has 9 electrons and 9 protons; Fluorine ion has 10 electrons and 9 protons</p> <p>Anions get larger because there are less protons pulling inward on more electrons.</p> <p>The nuclear force is constant and the electron-electron repulsion force is increased</p>



# Ionic Radii Trend

Sizes of atoms and their ions in pm

Group 1		Group 2		Group 13		Group 16		Group 17	
$\text{Li}^+$	Li	$\text{Be}^{2+}$	Be	$\text{B}^{3+}$	B	O	$\text{O}^{2-}$	F	$\text{F}^-$
90	134	59	90	41	82	73	126	71	119
$\text{Na}^+$	Na	$\text{Mg}^{2+}$	Mg	$\text{Al}^{3+}$	Al	S	$\text{S}^{2-}$	Cl	$\text{Cl}^-$
116	154	86	130	68	118	102	170	99	167
$\text{K}^+$	K	$\text{Ca}^{2+}$	Ca	$\text{Ga}^{3+}$	Ga	Se	$\text{Se}^{2-}$	Br	$\text{Br}^-$
152	196	114	174	76	126	116	184	114	182
$\text{Rb}^+$	Rb	$\text{Sr}^{2+}$	Sr	$\text{In}^{3+}$	In	Te	$\text{Te}^{2-}$	I	$\text{I}^-$
166	211	132	192	94	144	135	207	133	206

# Ionization Energy

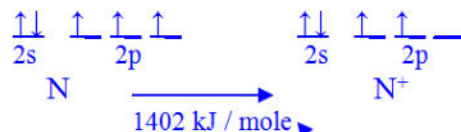
**Ionization Energy** – the energy required to *remove* an electron from an atom in the gas phase; because energy is required to ionize an atom, the process will always be endothermic (+); also removing an electron always makes the atom positive forming a *cation*



Li<sup>+</sup> has a noble gas configuration, which is more stable. Therefore, not much energy is required to remove the 2s<sup>1</sup> electron.



Remember Be is a Group 2 element, so it wants to have a charge of 2+. So when only 1 electron is removed, the ion is not stable and requires a lot more energy.



Notice Nitrogen forms a N<sup>+</sup> cation, not a N<sup>-3</sup> anion. The configuration for N<sup>+</sup> is becoming more unstable so the energy required is higher.



The electron configuration for O<sup>+</sup> is actually more stable than for N<sup>+</sup> because all orbitals have at least one electron; therefore, the energy is slightly less.



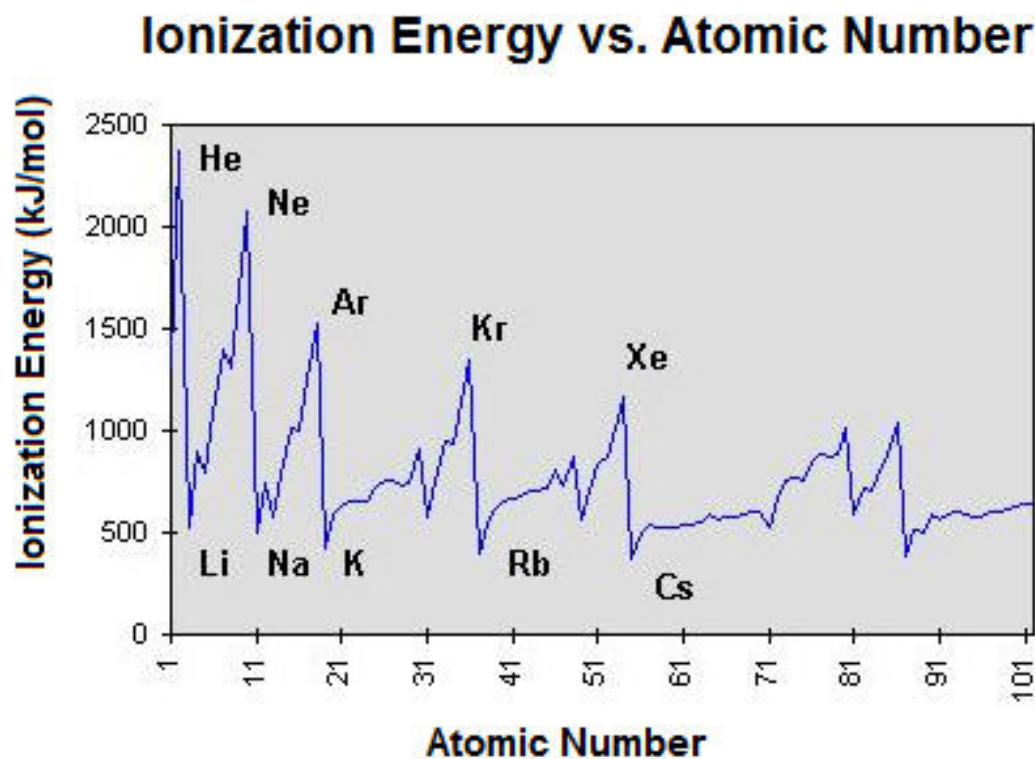
# Ionization Energy

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8
n = 2	Li+ 520 kJ/mol	Be+ 899 kJ/mol	B+ 801 kJ/mol	C+ 1086 kJ/mol	N+ 1402 kJ/mol	O+ 1314 kJ/mol	F+ 1681 kJ/mol	Ne+ 2081 kJ/mol
n = 3	Na+ 496 kJ/mol							
n = 4	K+ 419 kJ/mol							
n = 5	Rb+ 403 kJ/mol							
n = 6	Cs+ 377 kJ/mol							

For Group 3 and Group 6 elements, more stable electron configurations are formed upon ionization; therefore, a slight dip in energy is seen in the upward trend.

For periods n = 4 and higher, the energy difference within each group is noticed less and less. This is because the inner orbitals shield the outer valence level causing the nuclear force to be less intense. Therefore, it is easier and easier to remove an electron from the valence orbital as you go down a group.

# Ionization Energy Trend





# Metallic Groups

s <sup>1</sup>												s <sup>2</sup>	
		Number of Protons Increases Atomic Radius Decreases Ionization Energy Increases Electronegativity Increases											
</													

# Metallic Properties

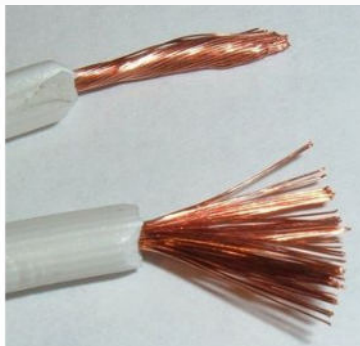
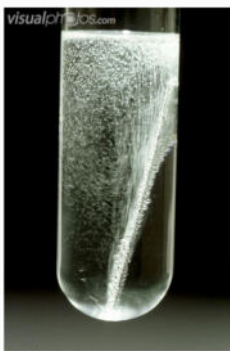
Shiny Luster

Malleable & Ductile

Good electric conductor

Good thermal conductor

Reacts with acids



Thermal conductivity is dependent on phase, temperature, density, and molecular bonding



Which pan is a better conductor, one made from copper or one made from cast iron?

	Thermal Conductivity (k) $W \cdot K^{-1} \cdot m^{-1}$	
Copper	385.00	
Cast Iron	80.40	
Steel	50.40	
Concrete	0.80	
Glass	0.80	
Brick	0.60	
Wood	0.12-0.04	
Styrofoam	0.01	

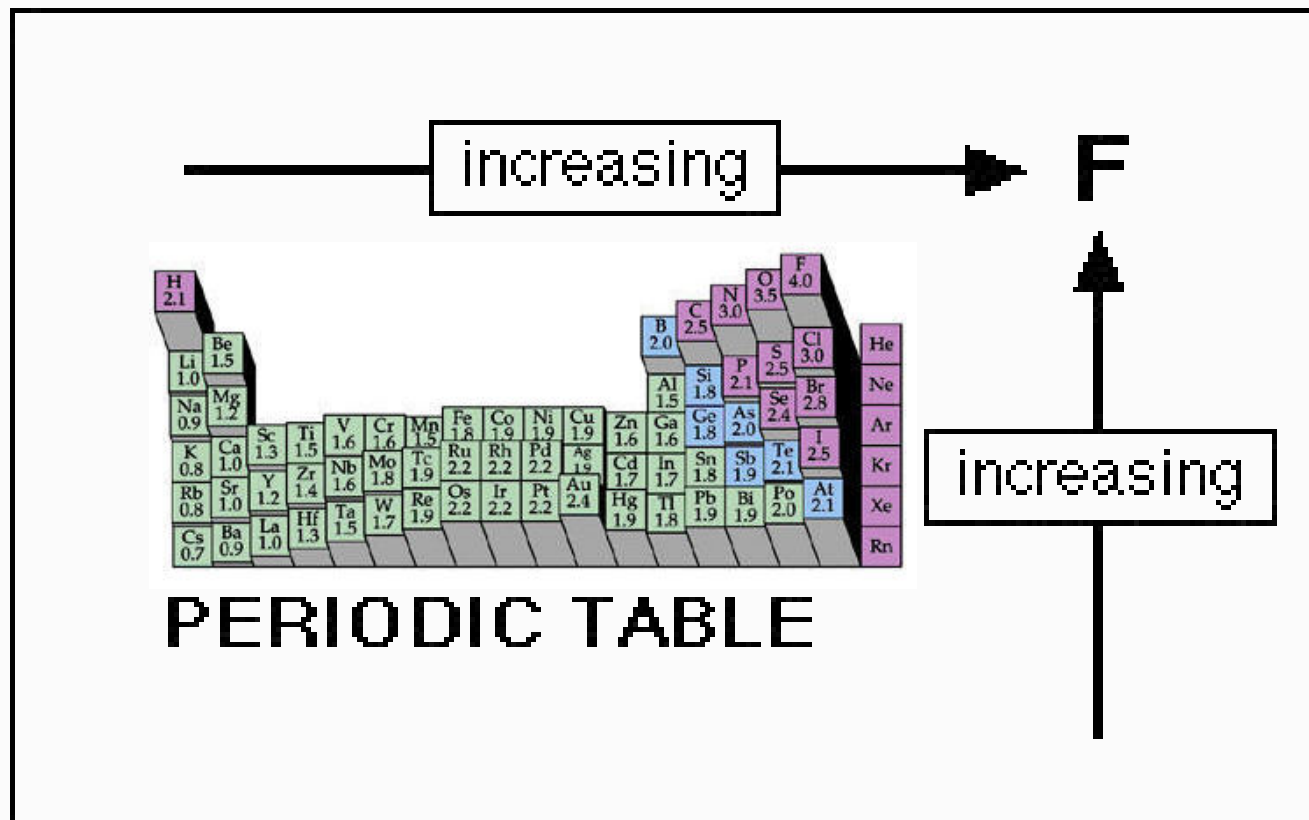


# Electronegativity

**Electronegativity** – a measure of the tendency of an atom to attract a bonding pair of electrons

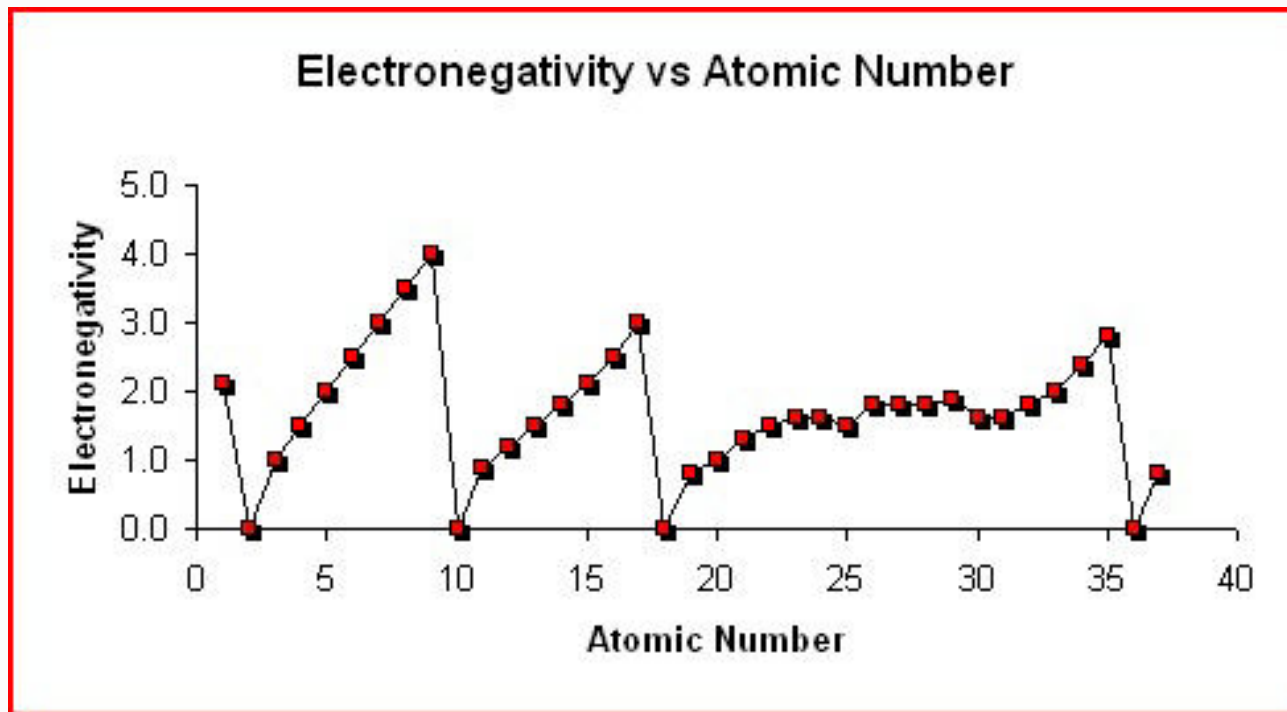
- o Gaining an electron always forms an anion
- o According to the Pauling scale, Fluorine (the most electronegative element) is assigned a value of 4.0, and values range down to cesium and francium which are the least electronegative at 0.7
- o If two atoms bond together, the difference in their electronegativity determines the type of bond
  - Non-polar covalent  $< 0.4$
  - Polar covalent 0.5 to 1.6
  - Ionic  $> 1.6$

# Electronegativity Trend





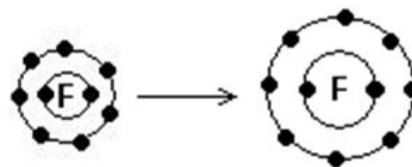
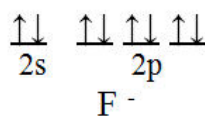
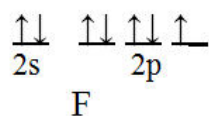
# Electronegativity Trend



# Flourine

◊ **Fluorine** is the most electronegative atom because:

- Its configuration becomes a complete **octet** when the electron is obtained
- It has the least amount of shielding between the nucleus and outer valence orbital.





# Electron Affinity

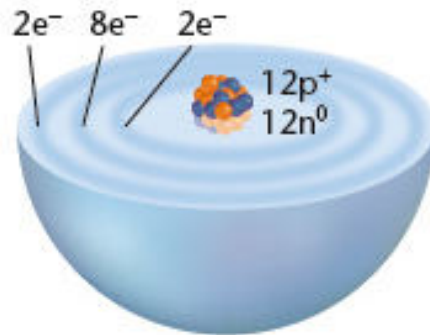
- o **Electron Affinity** – the energy required for the electronegativity process in which the electron is assigned to the lowest energy unoccupied valence orbital of a gaseous atom.
- o When a stable anion is formed, energy is released. The reaction is exothermic. ( $-\Delta H$ )
- o When an atom has no affinity for an electron (the configuration is already complete), an unstable anion is formed causing energy to be absorbed. The reaction is endothermic. ( $+\Delta H$ ).
- o **Electron Affinity is positive for Groups 2 and 18.**

# Shielding Effect

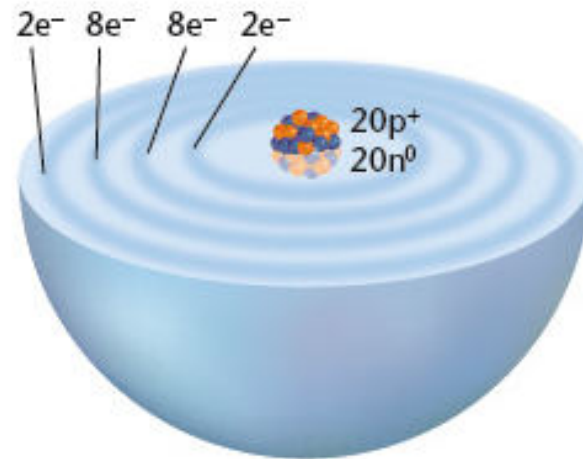
- o **Shielding** refers to the number of orbitals between the nucleus and the valence orbital.
- o The more inner core orbitals, the greater the shielding effect.
- o The **shielding effect** interferes with the protons in the nucleus being attracted to the valence electrons in the outer orbital.
- o Shielding directly effects both the nuclear force and the electron-electron repulsion force and therefore affects all the previously mentioned trends



# Shielding

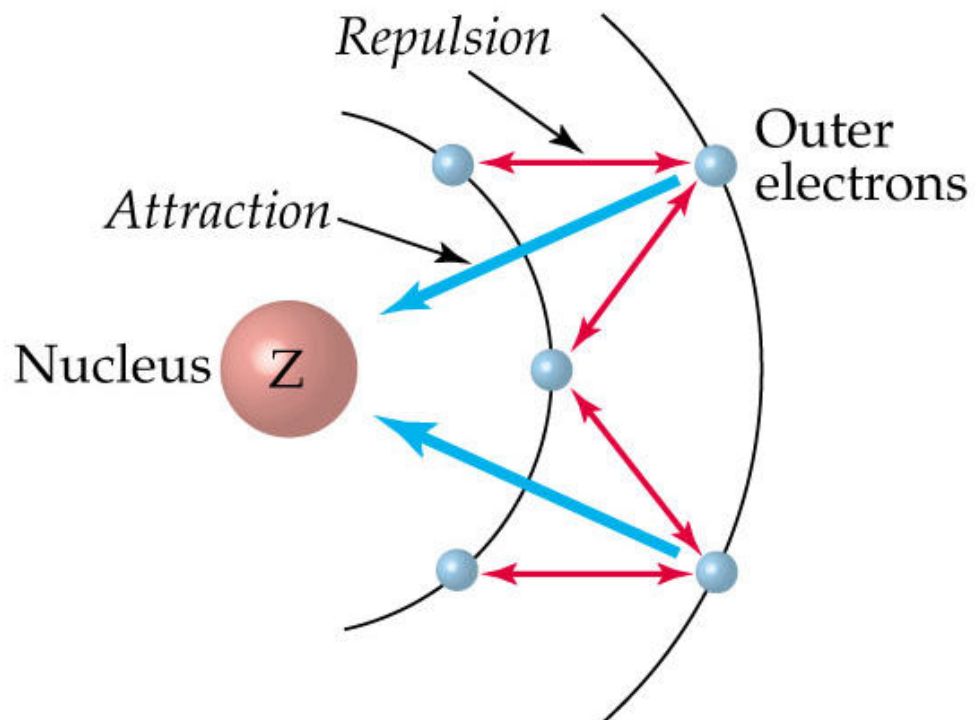


Magnesium atom



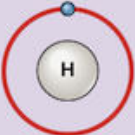
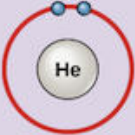
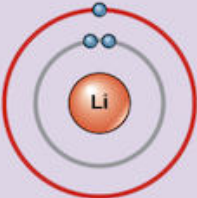
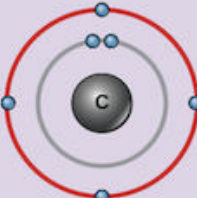
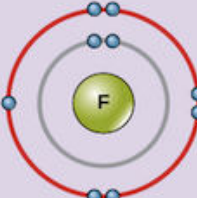
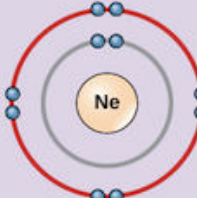
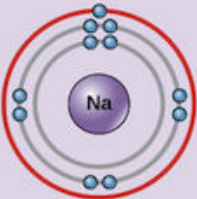
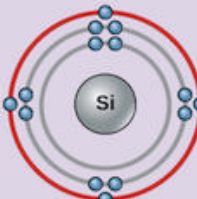
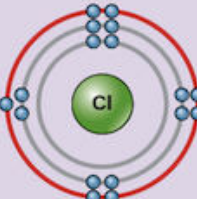
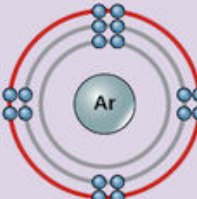
Calcium atom

# Shielding





# Valence Electrons

	Group 1	Group 14	Group 17	Group 18
Period 1 (1n is filling)				
Period 2 (2n is filling)				
Period 3 (3n is filling)				

# Chemical Properties

- Elements in the same group have similar chemical properties because they have the same number of valence electrons.

**Periodic Table**  
**Main Group Elements 1 - 26**

Hydrogen 1 H							Helium 2 He
Lithium 3 Li	Beryllium 4 Be	Boron 5 B	Carbon 6 C	Nitrogen 7 N	Oxygen 8 O	Fluorine 9 F	Neon 10 Ne
Sodium 11 Na	Magnesium 12 Mg	Aluminum 13 Al	Silicon 14 Si	Phosphorus 15 P	Sulfur 16 S	Chlorine 17 Cl	Argon 18 Ar
Potassium 19 K	Calcium 20 Ca	Gallium 31 Ga	Germanium 32 Ge	Arsenic 33 As	Selenium 34 Se	Bromine 35 Br	Krypton 36 Kr



# Periodic Groups

IA 1	alkali metals																noble gases					VIIA 18
H	IIA 2	alkaline earths										post-transition metals										He
Li	Be	transition metals										III A 13					IV A 14	V A 15	VIA 16	VII A 17	Ne	
Na	Mg	3	4	5	6	7	8	9	10	11	12	B	C	N	O	F	Ar					
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr					
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe					
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn					
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	semimetals (metalloids)								halogens				
lanthanides																						
actinides																						

Ce

Pr

Nd

Pm

Sm

Eu

Gd

Tb

Dy

Ho

Er

Tm

Yb

Lu

Th

Pa

U

Np

Pu

Am

Cm

Bk

Cf

Es

Fm

Md

No

Lr

S.K. Lower

# Periodic Table Scientists

**Dmitri Mendeleev**

(arranged by atomic mass)



**Henry Moseley**

(arranged by atomic #)

