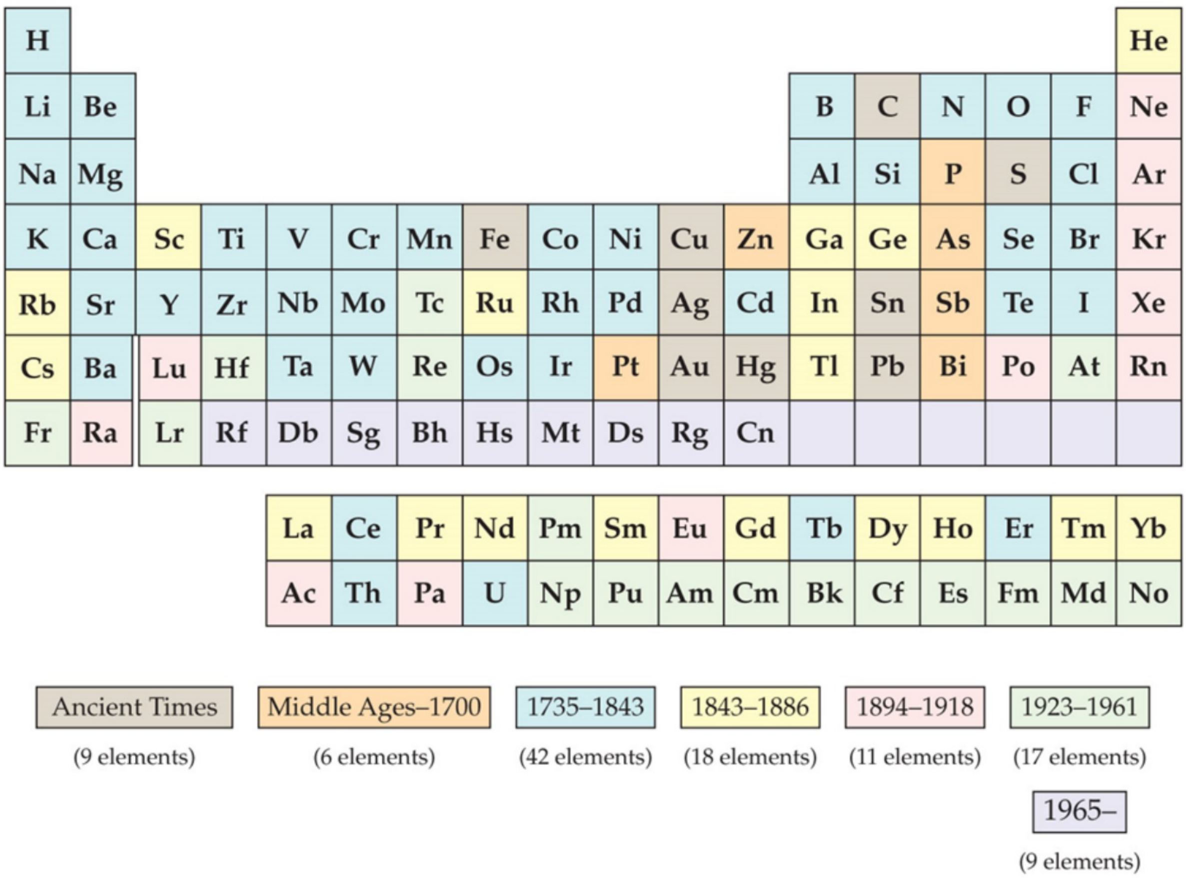
Lesson Overview
Development of the Modern Periodic Table

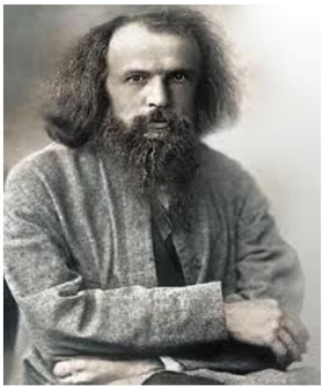
Objective: The student will be able to (1) identify and describe the experiments which lead to the current Periodic Table, (2) define the effective nuclear charge for an element, and (3) evaluate the effective nuclear charge in relationship to basic periodic trends.

Lesson Outline:
I. Origins of the Periodic Table
II. Effective Nuclear Charge (& Coloumb's Law)
III. Basic Periodic Trends (4)

The Development of the Periodic Table



Dueling Scientists: Origins of the Periodic Table

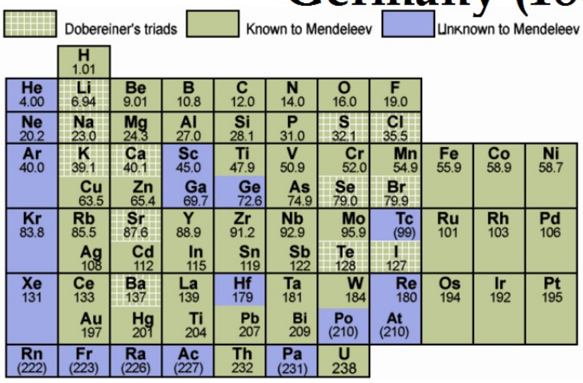


Dmitri Mendeleev
Russia (1869)

Proposed the first arrangement of elements (arranged by atomic mass)

Lothar Meyer
Germany (1869)

Mendeleev noticed gaps and was able to predict that there were undiscovered elements.

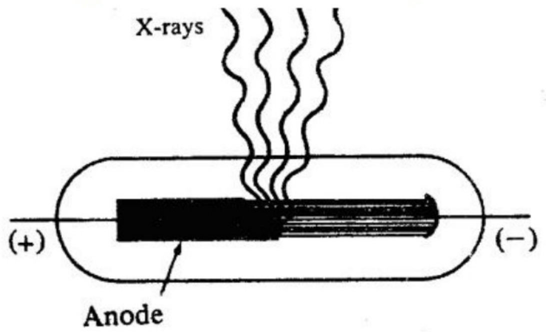


Eka-silicon ("under" silicon)

Property	Mendeleev's Predictions for Eka-Silicon (made in 1871)	Observed Properties of Germanium (discovered in 1886)
Atomic weight	72	72.59
Density (g/cm^3)	5.5	5.35
Specific heat (J/g-K)	0.305	0.309
Melting point (°C)	High	947
Color	Dark gray	Grayish white
Formula of oxide	XO_2	GeO_2
Density of oxide (g/cm^3)	4.7	4.70
Formula of chloride	XCl_4	$GeCl_4$
Boiling point of chloride (°C)	A little under 100	84

Henry Moseley
England, 1913

Bombarded different elements with high energy electrons. These produced X-rays of unique frequencies.



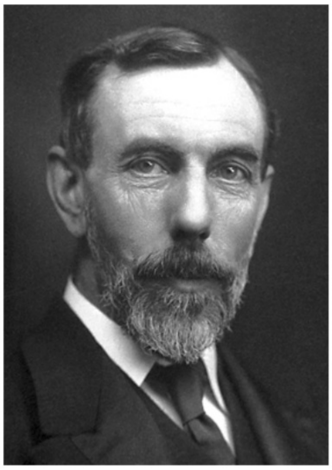
He assigned these frequencies a unique whole number, called the atomic number, and then correctly identified this as the number of protons in the atom.

Relation to Rutherford?

Notable Achievements

1770s -- Anton Lavoisier (discovery of the role of oxygen. He named it too!)

1890-1900 -- Sir William Ramsey discovered all inert (noble) gases.



Periodic Trends

Periodic: repeating pattern

Periodic Law: "Physical and chemical properties of elements are periodic functions of their atomic numbers.

Five Primary Trends:

(1) Effective Nuclear Charge
(2) Atomic and Ionic Radii
(3) Ionization energy
(4) Electron Affinity
(5) Electronegativity

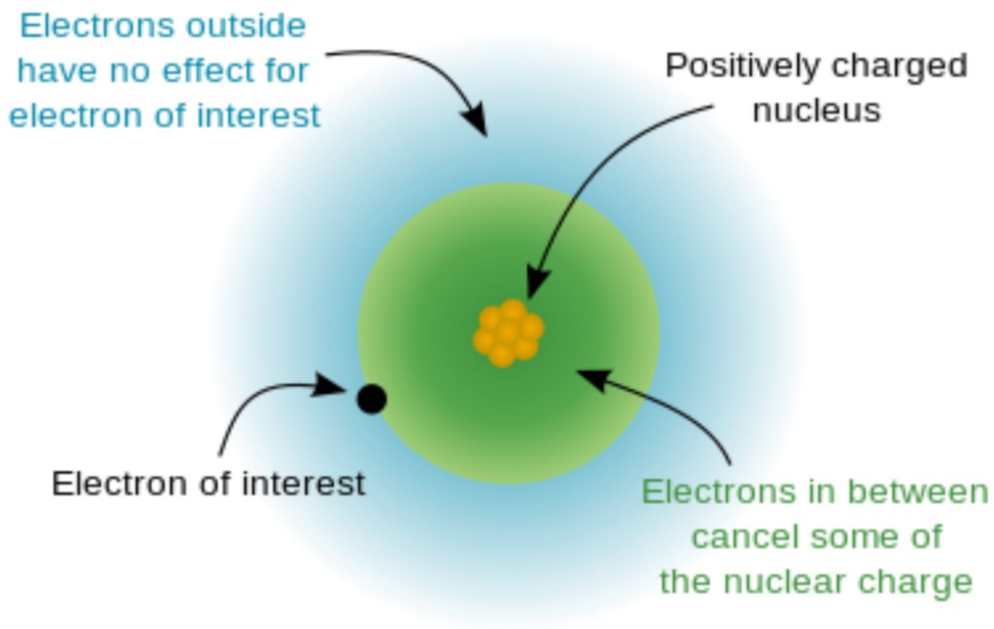
Coulomb's Law

$$E = \frac{kQ_1Q_2}{r}$$

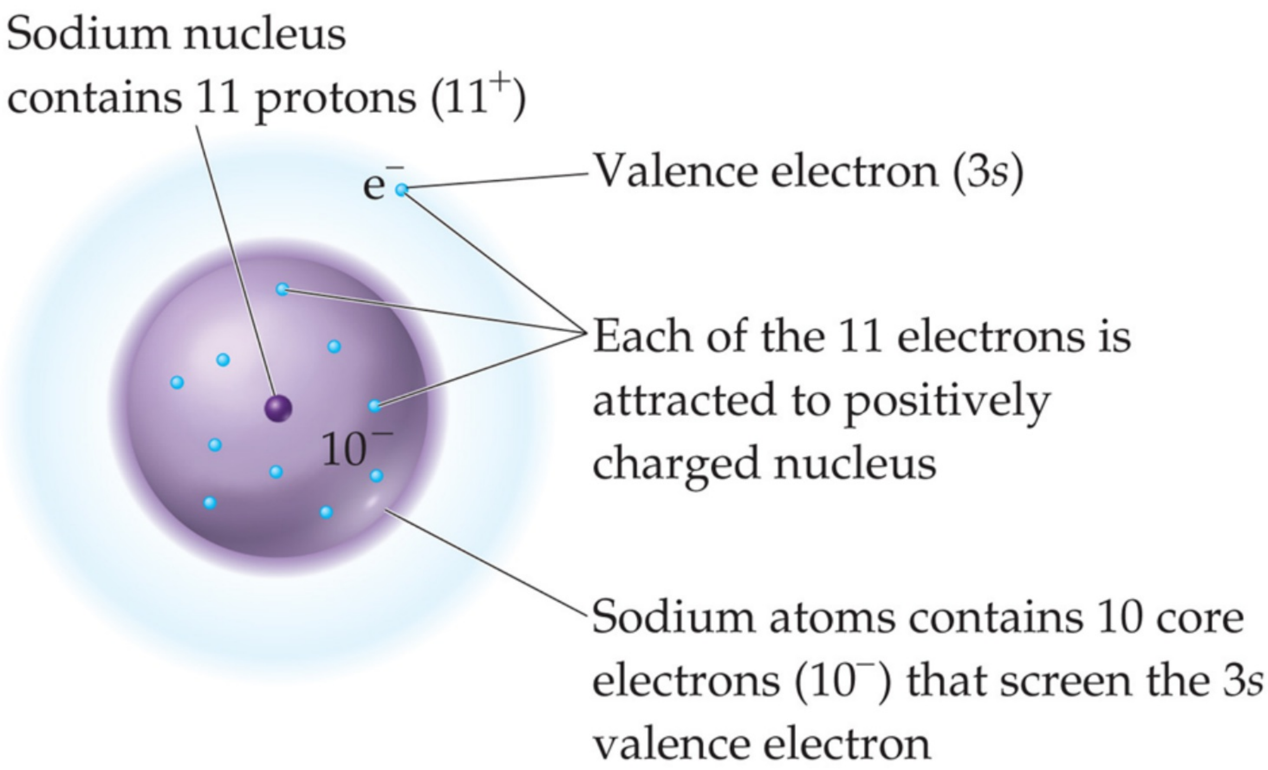
$$F = \frac{k|Q_1||Q_2|}{r^2}$$

$k = 9.0\text{x}10^9\ N \cdot m^2 \cdot C^{-2}$

The strength of the interaction between two electrical charges depends on the magnitudes of the charges (Q) and the distance between them (r).


Electrons outside
have no effect for
electron of interest
Positively charged
nucleus
Electron of interest
Electrons in between
cancel some of
the nuclear charge

Effective Nuclear Charge (Z_{eff})



The attractive force between an electron and the nucleus depends on the charges of both and the distance between them.

Determining Z_{eff}

To calculate using Coulomb's Law would be incredibly difficult. We cannot know it exactly!

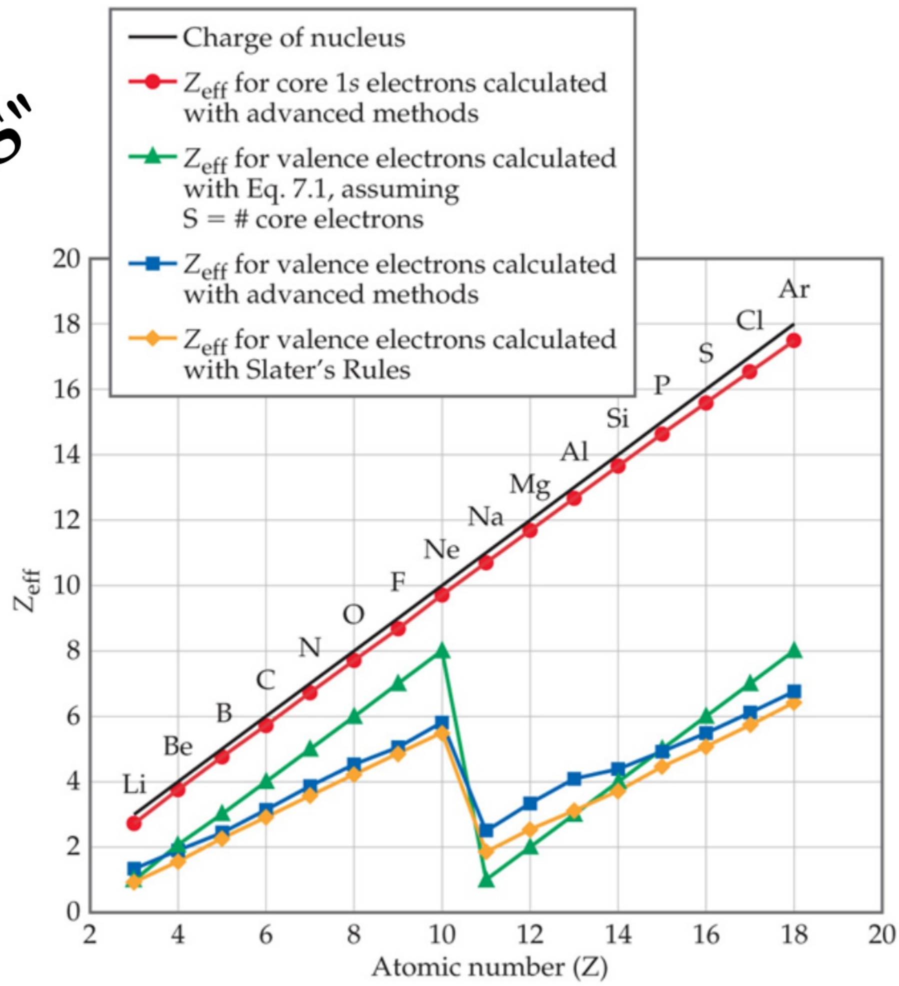
We can estimate it though:

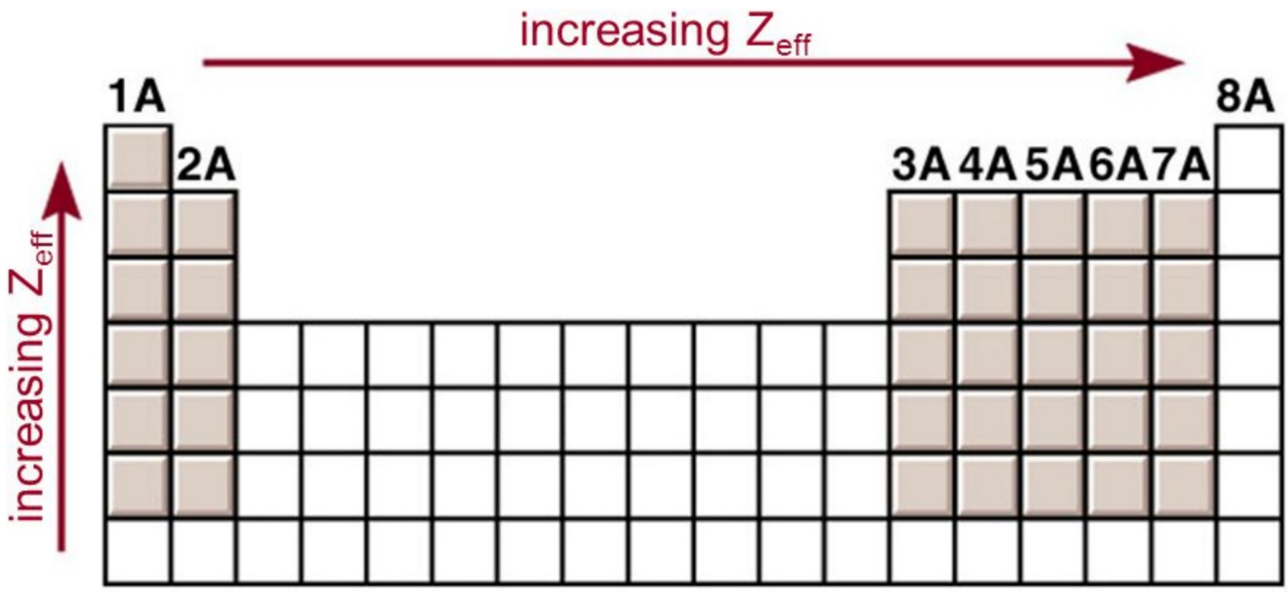
$$Z_{eff} = Z - S \qquad \textbf{[Eqn 7.1]}$$

where S is the screening constant.

The methods for determining S differ slightly (Eqn 7.1, advanced methods, Slater's Rules). In this course, we will assume that S is equal to the # of core electrons.

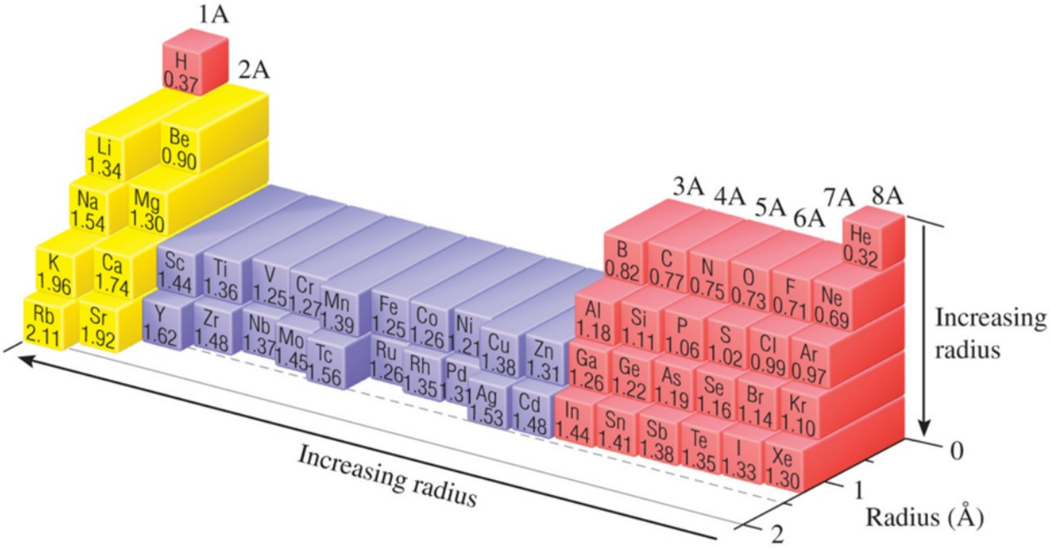
Methods to determine "S"



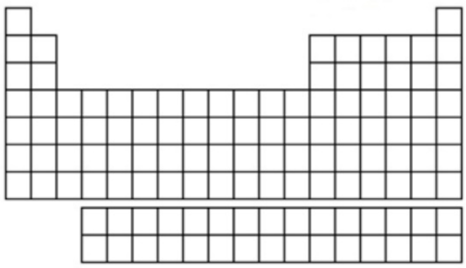


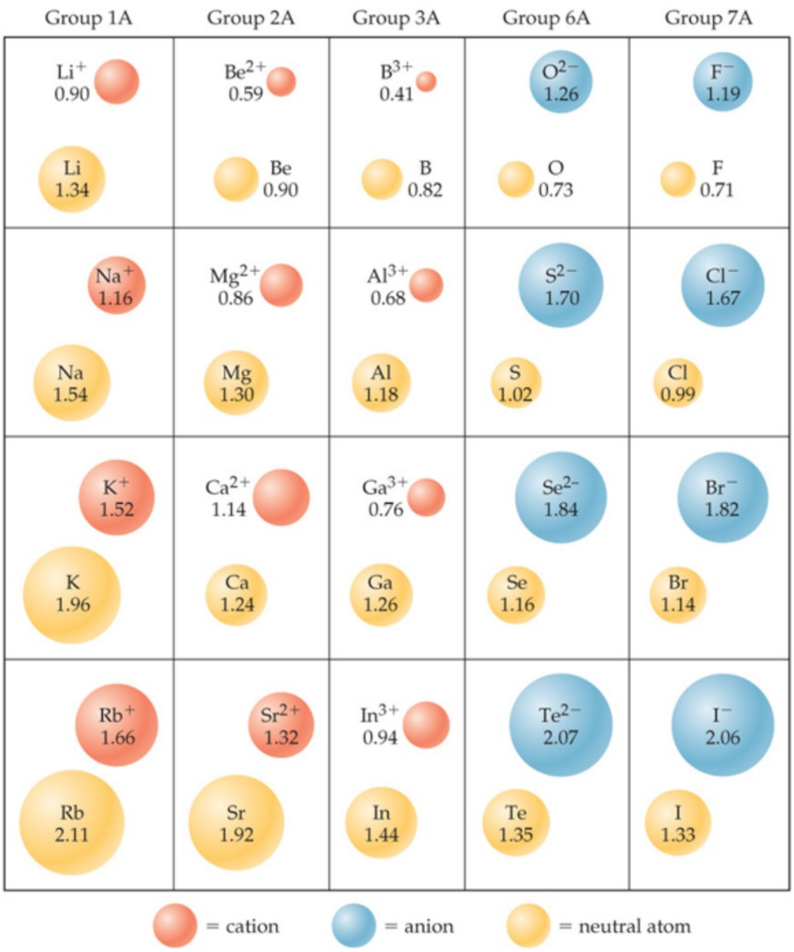
increasing Z_{eff}
1A
2A
3A 4A 5A 6A 7A
8A
increasing Z_{eff}

Sizes of Atoms and Ions



Derived from the attraction of nucleus and the outermost electron.





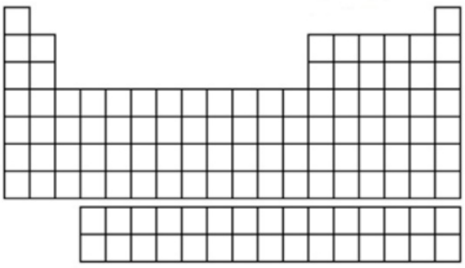
Group 1A
Group 2A
Group 3A
Group 6A
Group 7A
Li+ 0.90
Be2+ 0.59
B3+ 0.41
O2− 1.26
F− 1.19
Li 1.34
Be 0.90
B 0.82
O 0.73
F 0.71
Na+ 1.16
Mg2+ 0.86
Al3+ 0.68
S2− 1.70
Cl− 1.67
Na 1.54
Mg 1.30
Al 1.18
S 1.02
Cl 0.99
K+ 1.52
Ca2+ 1.14
Ga3+ 0.76
Se2− 1.84
Br− 1.82
K 1.96
Ca 1.24
Ga 1.26
Se 1.16
Br 1.14
Rb+ 1.66
Sr2+ 1.32
In3+ 0.94
Te2− 2.07
I− 2.06
Rb 2.11
Sr 1.92
In 1.44
Te 1.35
I 1.33
= cation
= anion
= neutral atom

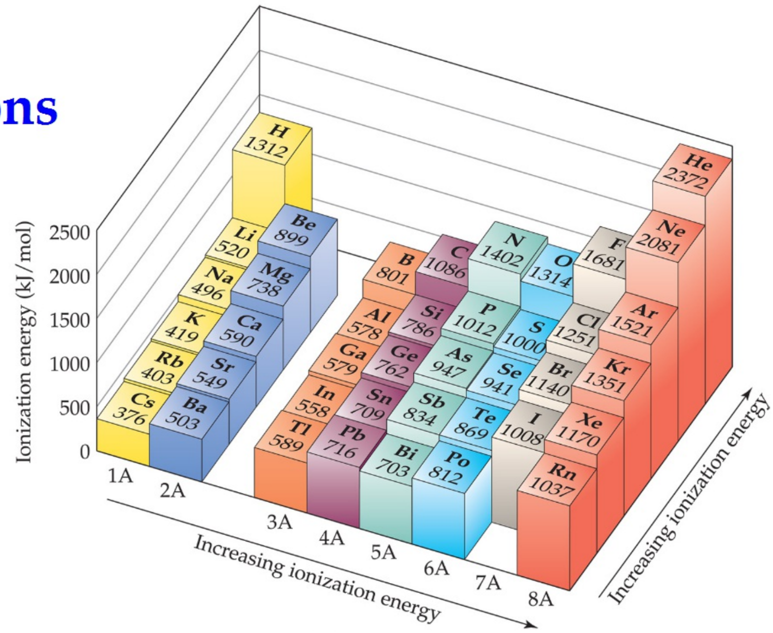
Ionization Energy (IE)

Ionization Energy (IE): The energy required to remove one valence electron from an atom.

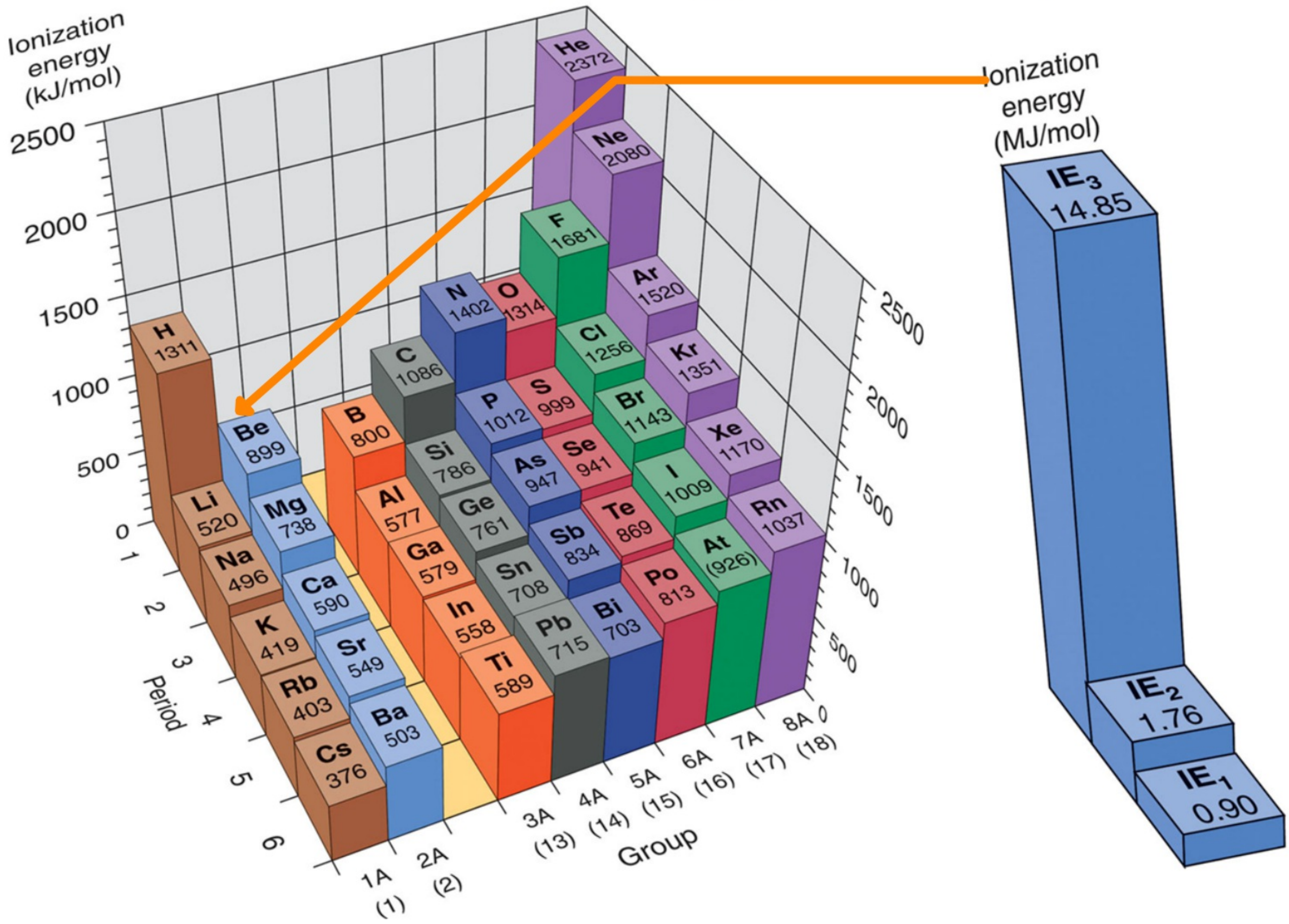
Think of this as the energy needed to make an atom an ion.

Energy must always be added to remove electrons



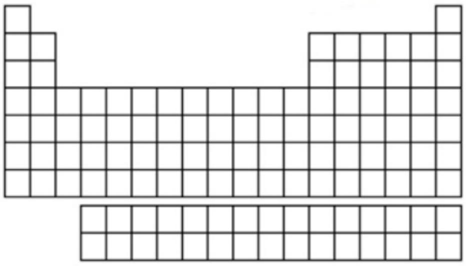


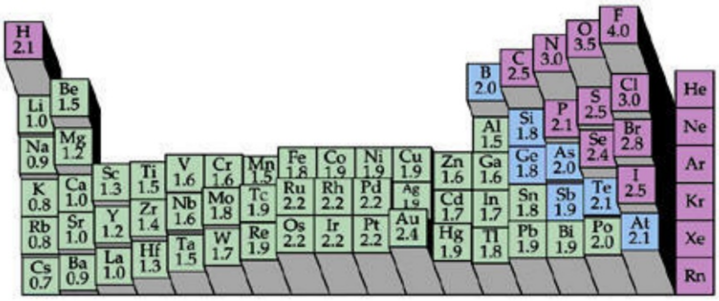
Ionization Energy (Continued)



Electron Affinity

A measure of the "affinity" that an atom has for an electron



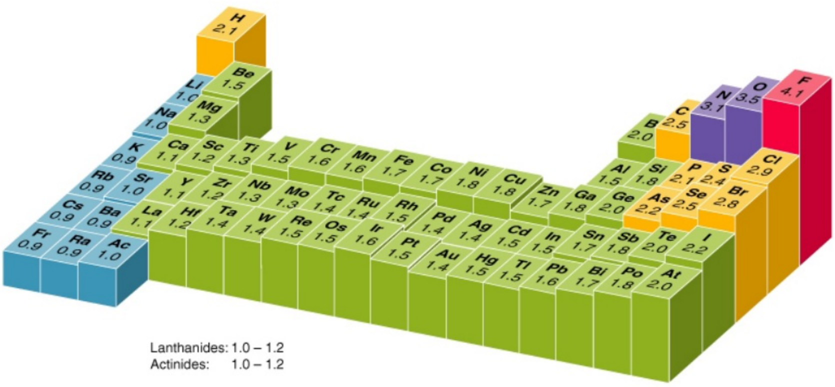


Values may be positive, negative or zero.

What is the difference between Electron Affinity and Electronegativity?

Electronegativity

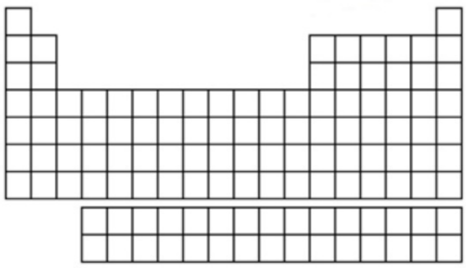
Electronegativity: how much of a "hold" a nucleus has on its electrons



value of EN can be calculated

(we use Pauling electronegativity values)

Not a property of an atom but more a property of the atom when bonded in a molecule



Summary of Main Periodic Trends