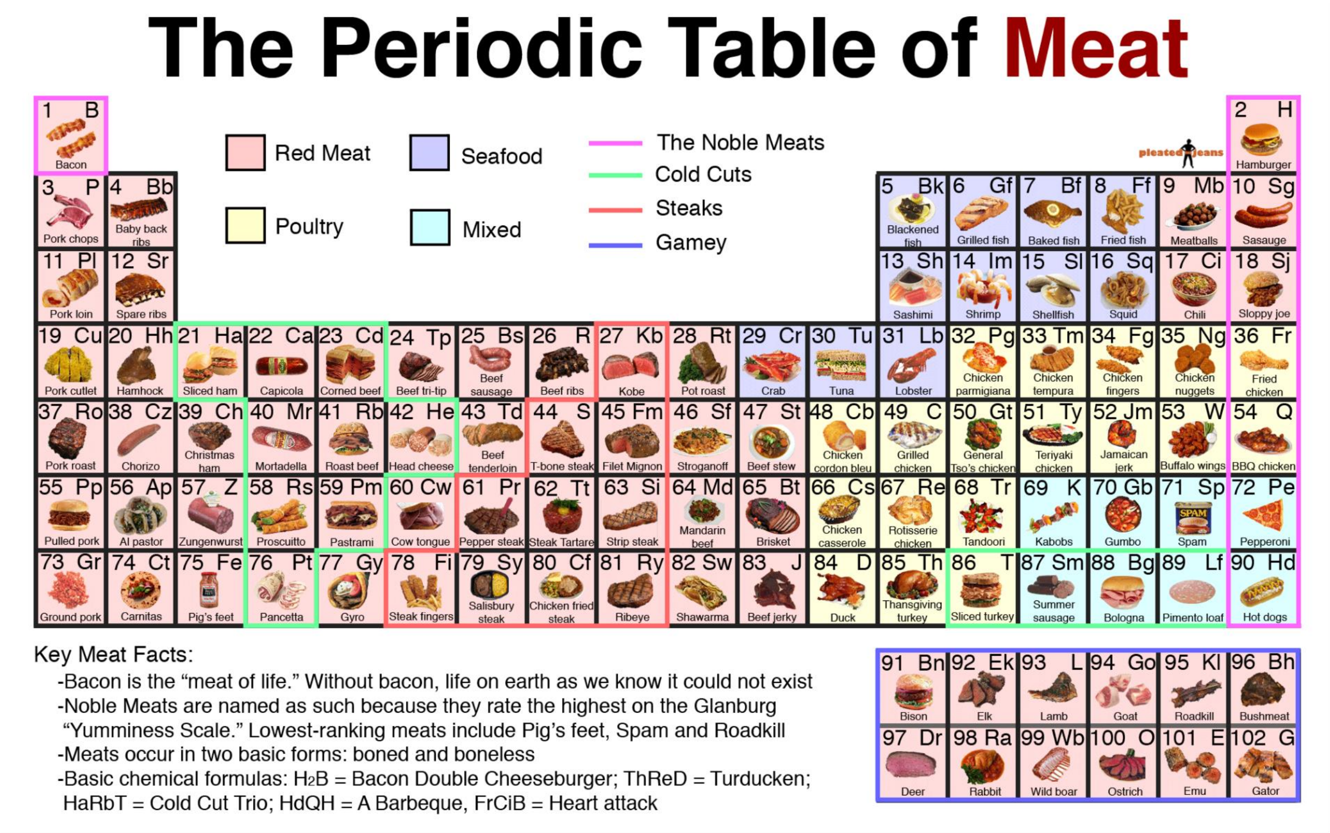
1.2 The Periodic Table

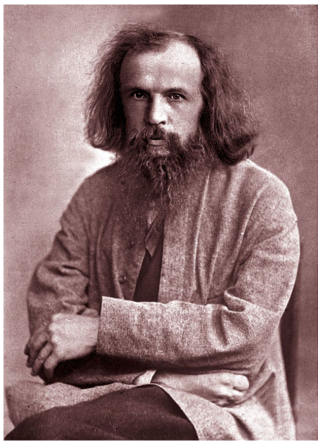


The Periodic Table

The periodic table is an incredibly helpful tool in Chemistry as it organizes all of the elements on earth (natural and synthetic) into groups/families that share characteristics. This allows scientists to observe a great number of things from only a quick glance at the table including, but not limited to,

-atomic number
-atomic mass
-valence electrons (chemical reactivity)
*relates to the **shell model**
-various physical properties including standard state

Dmitri Mendeleev is the scientist credited with the original periodic table (1869) and the discovery of the periodic law.



http://www.biography.com/people/dmitri-mendeleyev-9405465#youth-and-education

Periodic Trends

Periodic trends are specific patterns that are present in the periodic table that illustrate characteristics of a certain element. Major periodic trends include:

-electronegativity
-ionization energy
-atomic radius
-melting point
-metallic character

Electronegativity

Electronegativity is a chemical property describing an atom's ability to attract and bind with electrons (the measure of an atom's tendency to attract and form bonds with electrons).

-This property exists due to the octet rule (referring to the number of electrons in an atom's valence shell)

-The Pauling scale (named after Linus Pauling) shows us unit-less values that quantify the electronegativity of each atom

-Trends:

1. From left to right across a period of elements, electronegativity increases.
   - If the valence shell of an atom is less than half full, it requires less energy to lose an electron than to gain one. Conversely, if the valence shell is more than half full, it is easier to pull an electron into the valence shell than to donate one.
2. From top to bottom down a group, electronegativity decreases.
   - This is because atomic number increases down a group, and thus there is an increased distance between the valence electrons and nucleus, or a greater atomic radius.

*Important exceptions of the above rules include the noble gases, lanthanides, and actinides. The noble gases possess a complete valence shell and do not usually attract electrons. The lanthanides and actinides possess more complicated chemistry that does not generally follow any trends. Therefore, noble gases, lanthanides, and actinides do not have electronegativity values.

**As for the transition metals, although they have electronegativity values, there is little variance among them across the period and up and down a group. This is because their metallic properties affect their ability to attract electrons as easily as the other elements.

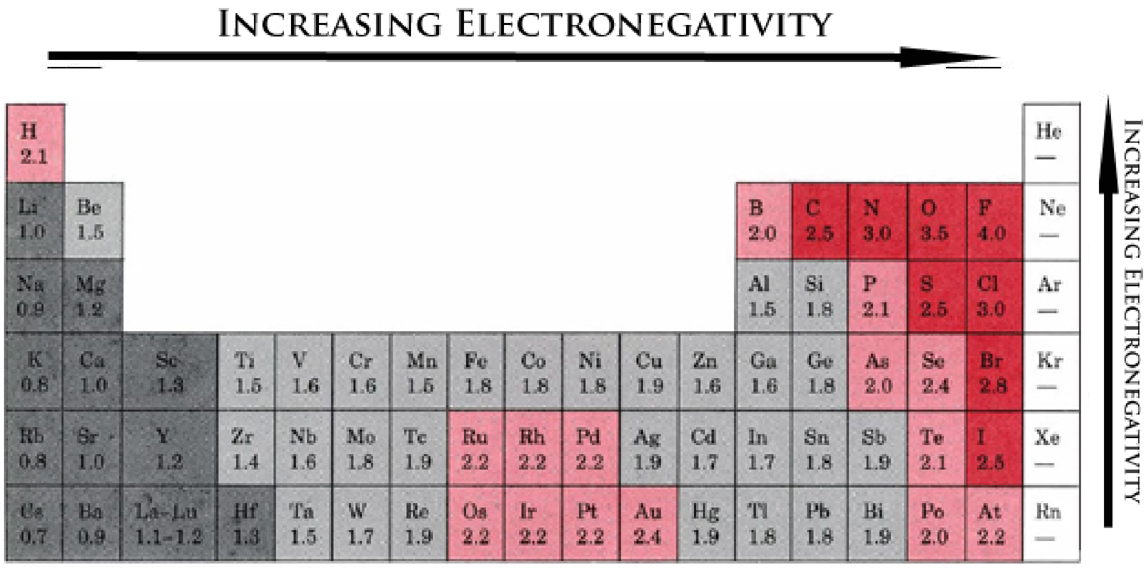


Figure 1. Periodic Table of Electronegativity values

Ionization Energy Trend

Ionization energy is the energy required to remove an electron from a neutral atom in it's gaseous phase (essentially, it is the opposite of electronegativity). **The lower the energy is, the easier the atom becomes a cation**

Trends:
1. The ionization energy of the elements within a period generally increases from left to right. This is due to valence shell stability.

2. The ionization energy of the elements within a group generally decreases from top to bottom. This is due to electron shielding.

3. The noble gases possess very high ionization energies because of their full valence shells as indicated in the graph. Note that helium has the highest ionization energy of all the elements.

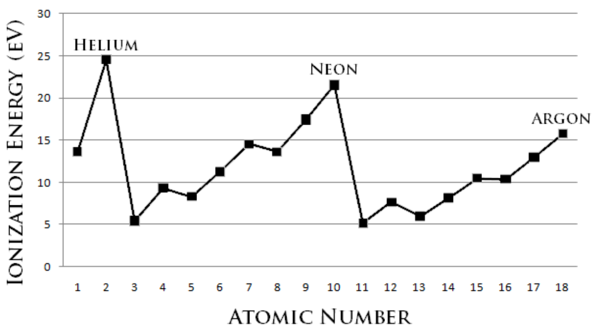
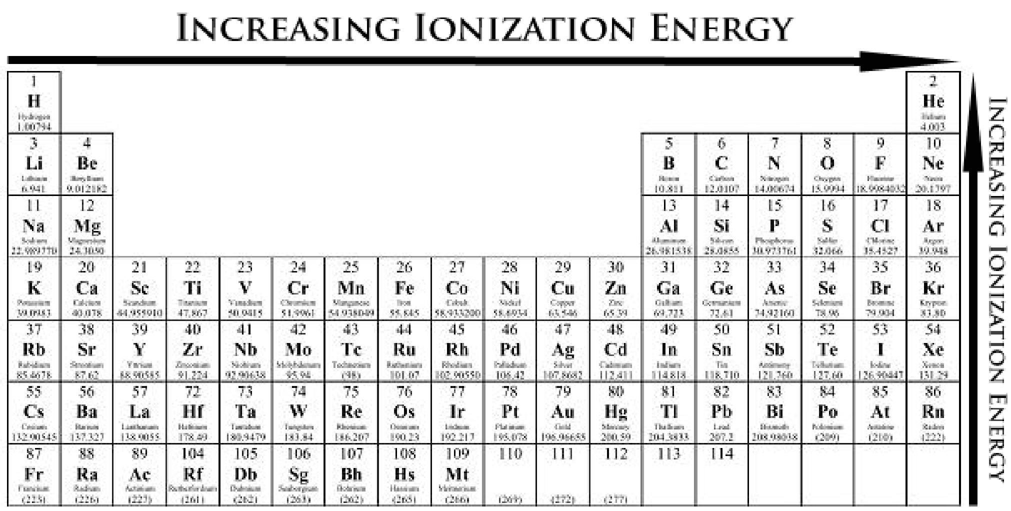


Figure 3. Graph showing the Ionization Energy of the Elements from Hydrogen to Argon



Atomic Radii

The atomic radius is one-half the distance between nuclei of two atoms (just like the radius of a circle) when covalently bonded together.

Trends:
1. Atomic radius decreases from left to right within a period. This is caused by the increase in the number of protons and electrons across a period. One proton has a greater effect than one electron; thus, electrons are pulled towards the nucleus, resulting in a smaller radius.

2. Atomic radius increases from top to bottom within a group. This is caused by electron shielding.

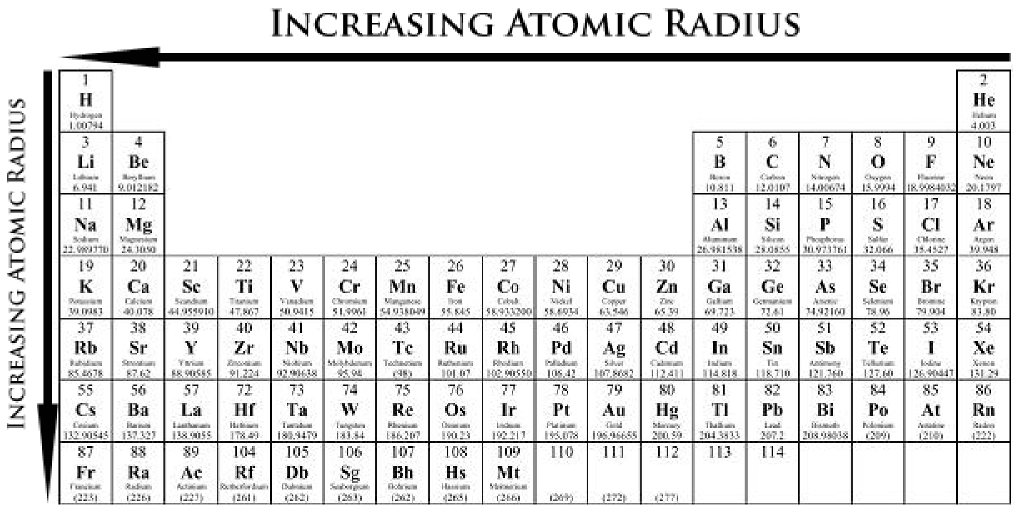


Figure 6. Periodic Table showing Atomic Radius Trend

Melting Point

Melting point is the amount of energy required to break a bond(s) to change the solid phase of a substance to a liquid. Generally, the stronger the bond between the atoms of an element, the higher the energy requirement in breaking that bond.

Trends:
1. Metals generally possess a high melting point.

2. Most non-metals possess low melting points.

3. The non-metal carbon possesses the highest boiling point of all the elements. The semi-metal boron also possesses a high melting point.

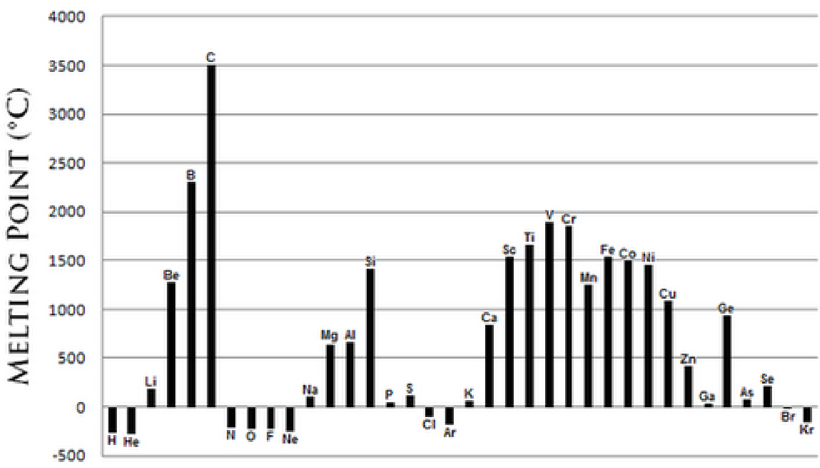


Figure 7. Chart of Melting Points of Various Elements

Metallic Character

The metallic character of an element can be defined as how readily an atom can lose an electron and form a positive cation (thereby making it act like a metal). Remember this trend when we talk about metallic bonding in unit 2.

Trends:
1. Metallic characteristics decrease from left to right across a period. This is caused by the decrease in radius of the atom which allows the outer electrons to ionize more readily.

2. Metallic characteristics increase down a group. Electron shielding causes the atomic radius to increase thus the outer electrons ionizes more readily than electrons in smaller atoms.

3. Metallic character relates to the ability to lose electrons, and nonmetallic character relates to the ability to gain electrons.
**Another easier way to remember the trend of metallic character is:
-Move left across period and down the group: increase metallic character (heading towards alkali and alkaline metals)
-Move right across period and up the group: decrease metallic character (heading towards nonmetals like noble gases)

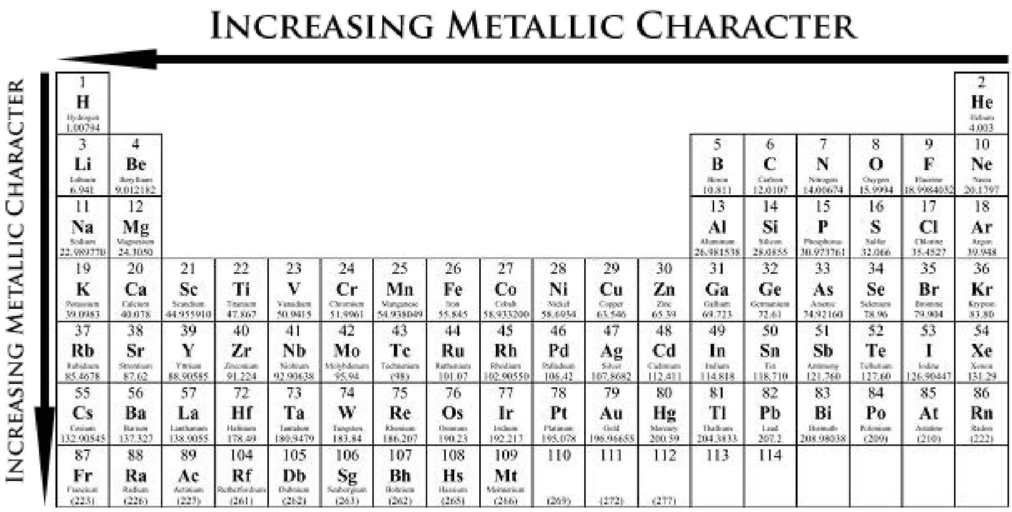


Figure 8. Periodic Table of Metallic Character Trend

Assignment

Use the information in this section to answer the following questions. When done, check your answers using the key provided.

1. a. Explain how an atoms number of valence electrons can help a young scientist predict the chemical reactivity of that atom.

b. Based on their position on the periodic table, predict the relative reactivities of the following elements:
a) Cs vs. Ba
b) C vs. F
c) Na vs Ar
d) Mg vs Si

2. Why is it more difficult for fluorine to lose an electron than for sulfur to do so?

3. It is relatively easy to pull one electron away from a potassium atom, but very difficult to remove a second one. Explain why.

4. Which should have a higher ionization energy: an atom of indium (atomic number 49) or an atom of aluminum (atomic number 13)? Why?

5. Scientists are trying to synthesize element 119. Based on your knowledge of the trends in the periodic table, predict 2 physical properties and 1 chemical property for element 119.

Challenge! Since atoms are mostly empty space, why don't objects pass through one another?
a. The nucleus of one atom repels that nucleus of another atom when it gets close
b. The electrons of the atoms repel one another when they get too close
c. the electrons of one atom attract the nucleus of a neighboring atom to form a barrier
d. atoms actually do pass through one another, but only in the gaseous phase