Worksheet 12 - Periodic Trends

A number of physical and chemical properties of elements can be predicted from their position in the **Periodic Table**. Among these properties are **Ionization Energy**, **Electron Affinity** and **Atomic/ Ionic Radii**.

These properties all involve the **outer shell** (valence) **electrons** as well as the **inner shell** (shielding) **electrons**. Electrons are held in the atom by their electrostatic attraction to the positively charged protons, the nuclear charge, Z. However, not all electrons in an atom experience the same nuclear charge. Those closest to the nucleus experience the full nuclear charge and are held most strongly. As the number of electrons between the nucleus and the valence electrons increases, the apparent nuclear charge decreases, due to the "screening" of these inner shell electrons. The charge felt by the valence electrons is called the **effective nuclear charge**, $\mathbf{Z_{eff}}$.

Going **down** a **group** increases the value of **n**, and increases the number of inner shell electrons. This leads to better shielding and a weaker attraction between the nucleus and the outer shell electrons.

Going **across** a **period** leads to a **larger nuclear charge**, as the number of protons increases. There is also an increase in the number of valence electrons, but electrons in the same shell are poor at shielding each other. Going across a row generally leads to a **stronger** interaction between the nucleus and the valence electrons.

The **type of orbital** holding the shielding electrons is also important. The ***s*** orbitals are said to be **penetrating** - they have electron density close to the nucleus. The best shielding comes from ***s*** orbitals, followed by ***p***, ***d*** and ***f***.

Ionization Energy

Ionization energy is the energy required to remove an electron from a gaseous atom in its ground state. This is related to how "tightly" the electron is held by the nucleus. The higher the ionization energy, the more difficult it is to remove the electron. For a many-electron atom, the energy required for the reaction:

$$\text{energy} + X\,(g) \rightarrow X^{+}\,(g) + e^{-}$$

is called the **first ionization energy** (I_1). Since this requires an input of energy, it is an **endothermic reaction**, with a positive energy value. The energy required for the reactions

$$\text{energy} + X^{+}\,(g) \rightarrow X^{2+}\,(g) + e^{-}$$
$$\text{energy} + X^{2+}\,(g) \rightarrow X^{3+}\,(g) + e^{-}$$

are the second (I_2) and third (I_3) ionization energies.