

It's All Electrostatics . . . (almost)

- Discuss within your group why the negative charge of an electron orbiting around a positively charged nucleus doesn't cause it to be pulled into the nucleus and collapse the atom.

If the only force was that from the electrostatic attraction of the electron for the positively charged nucleus, the atom wouldn't be stable. There is an outward force due to the circular orbit of the electron, its wave behavior, that exactly balances the attractive force directed towards the nucleus. Since the electrostatic force is a potential energy (P. E.) while the motion of the electron provide a kinetic energy(K.E.), one can write this balancing of forces as: $P. E. + K.E. = 0$

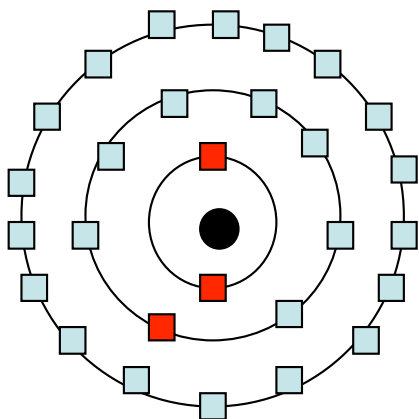
- Define for each other the terms "ionization energy" and "electronegativity".

Ionization energy (I.E.) is the energy added to remove one electron from an atom (or ion), such as written for Na:

$$Na \rightarrow Na^+ + e^- \quad DE = I.E.$$

Electronegativity is a measure of the affinity of an atom (or ion) for an electron. Within a bond, the electronegative atom will have a majority of the electron density near it (and consequently the other atom will have the minority). It cannot be directly measured, but is best thought about as a relative effect.

- Use the template of an atom to explain the trend in ionization energies for atoms of Li vs B vs F vs Na

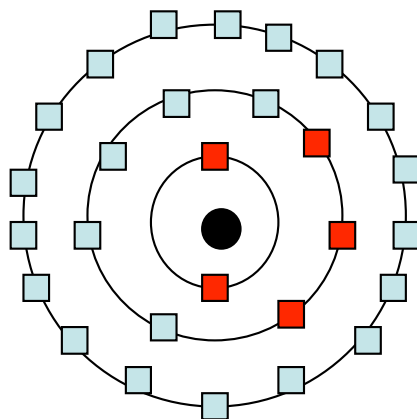


Li: $Z = 3+$

The 2 electron in the $n=1$ offset about $2+$ units of Z . The electron in $n=2$ feels

$\sim 1+$ charge and so is least

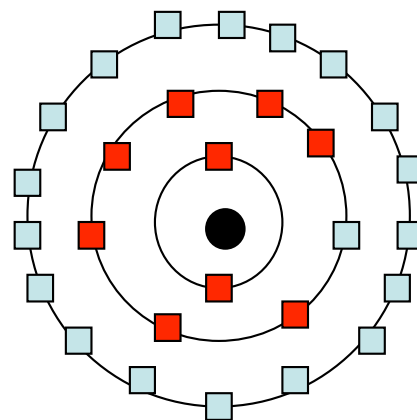
tightly held and easy to remove.



B: $Z = 5+$

The 2 electron in the $n=1$ offset about $2+$ units of Z .

The electron in $n=2$ feels $\sim 3+$



F: $Z = 9+$

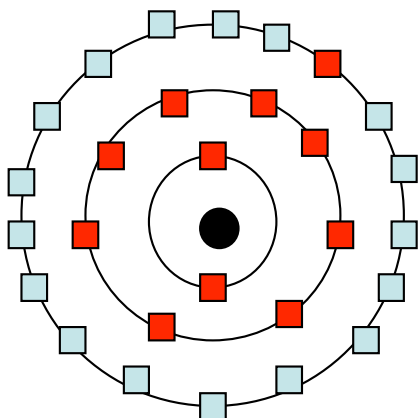
The 2 electron in the $n=1$ offset about $2+$ units of Z .

An electron in $n=2$

$\sim 7+$ charge and difficult

remove.

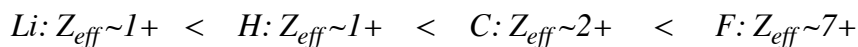
Na has $Z = 11+$. The 2 electrons in $n=1$ level and 8 electrons in $n=2$ level compensate for $\sim 10+$ units of nuclear charge. So the valence electron in $n=3$ level is easy to ionize off, especially since it is also farther away.



Therefore, the degree to which inner electrons “shield” the outer electrons from nuclear charge explains the trend in ionization energies: $Na < Li < B < F$.

- Use the template of an atom to explain the trend in electronegativity (on page 22) for atoms of H vs Li vs C vs F and for the series Be vs. Mg vs Ca.

Using the same approach as in 3., the “effective nuclear charge” correlates with electronegativity:



Also keeping in mind that $n=2$ electrons of Li and C are further away than the one electron in H.

Be, Mg and Ca would feel similar nuclear charges, but the valence electron going down the group is further and further away, hence, has less attraction to the nucleus. And the electron negativity decreases down the group.

- Use the template of an atom to explain the trend in atomic radii across the second row of elements and then down a column of a group, Be vs. Mg vs Ca vs Sr.

The nuclear charge felt by valence electrons will increase going across a row, as Z increase but electrons are put into the same $n=2$ shell. A larger Z will attract more strongly, and hence bring to a closer distance, the valence electrons which are those electrons that may be considered to determine the size of an atom.

As in the second part of 4, Z decrease down a column, so the electrons are held more weakly and at greater distance. The apparent radii increases.

What else is misleading about these atom templates?

Two things are misleading in the templates: a) as electrons fill up a shell, such as $n=2$, all the electrons are considered to be the same and b) it doesn't take into account the pairing of 2 electrons with opposite spins, $+1/2$ and $-1/2$

Describe a better picture of electron orbitals within each shell. What does a “quantum number “ refer to?

A better picture distinguishes that electrons can fill an s-type spherical orbital or a p-type “dumbbell” orbital within any quantum level, n . A quantum number refers to the number of the shell, n .