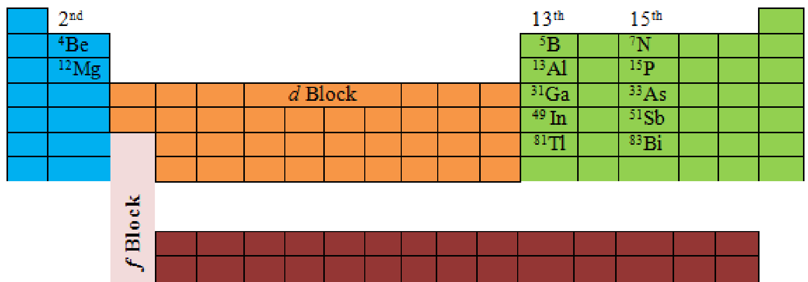
PERIODIC PROPERTY: DEVIATIONS IN THE TREND OF IONIZATION ENERGY

We discussed about ionization energy in the last post. In this post, we will discuss the factors affecting IE and will try to find out the reasons behind the unexpected behavior of a few elements. There are a few deviations in the usual trend of IE, like



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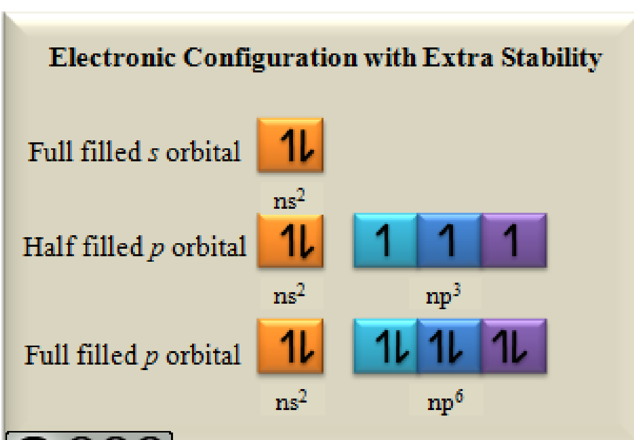
- ^{4}Be has higher IE than ^{5}B.
- ^{12}Mg has higher IE than ^{13}Al
- Group 13 shows irregular trend of IE
- Elements of group 15 have higher IE than expected.

Let’s find out the reasons behind their remarkable behaviour. I hope you have understood the process and concept of ionization. So think about the factors that decide the amount of ionization energy. These factors are:

- Size of the atom: In a smaller atom electrons are packed tightly as compared to a larger one.
- Nucleus charge: Large nuclear charge holds electrons tightly.

- How effectively the inner sub-shells shield the outer electrons (shielding effect *s* > *p* > *d* > *f*). Strong shielding defends outer electrons from the nuclear attraction and makes the exit of outer electron easier, while weak shielding enables nucleus to attract outer electrons more powefully and to hold them tightly, consequently hindering the exit of electron.
- The type of sub-shell or electron is involved (*s*, *p*, *d* or *f*): *s* sub-shell placed closer to the nucleus than *p* and hold electrons tightly than *p*, similarly *p* is closer than *d*, and *d* is closer than *f* . That's why the order of IE : *s* > *p* > *d* > *f*. Energy required for the removal of an electron belonging to s sub-shell is the highest and for the removal of an electron belonging to f sub-shell is the lowest.
- Electronic configuration: Half filled and fulfilled sub-shells have extra stability. That's why extra energy is needed to break such configurations.

All these factors are interrelated. Let's write down the electronic configuration of ^{4}Be and ^{5}B.



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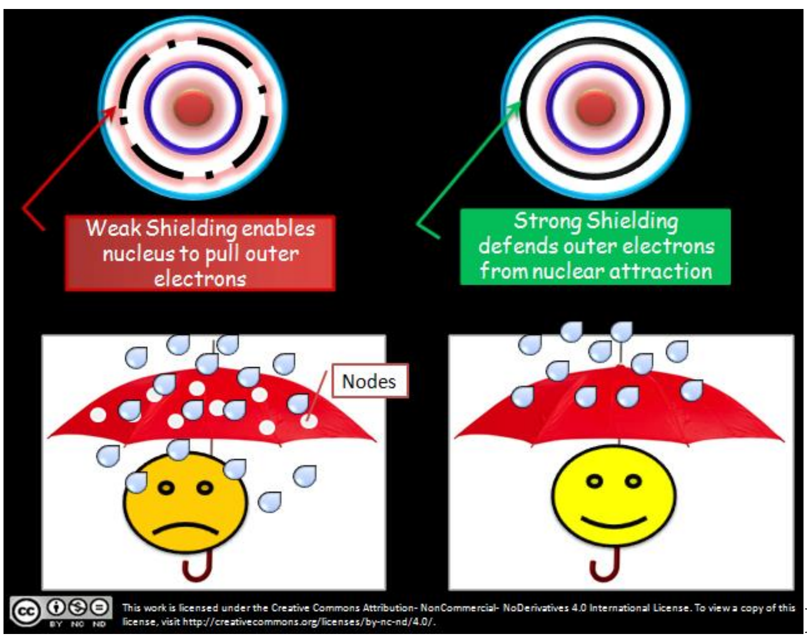
^{4}Be : $1s^2$, $2s^2$

^{5}B : $1s^2$, $2s^2$, $2p^1$

In ^{4}Be outer most electron belongs to the *s* sub-shell which is placed closer to the nucleus and holds the electron tightly. And *s* sub-shell is in its completely filled state, which is the most stable state, so it makes the exit of the outer most electron even more difficult. On the other hand, in^{5}B, the outer most electron belongs to the *p* sub-shell which is placed farther than the *s* sub-shell, and the electron is placed singly in an orbital, which is comparatively easier to remove.

And for the similar reason ^{12}Mg has higher IE than ^{13}Al. You may check it yourself.

Let's check the group 13 now. What is different here? It is placed just after the *d* block. Elements of this group show unexpected behaviour once in case of ^{31}Ga which has higher IE than ^{13}Al and secondly in case of ^{81}Tl which has higher IE than ^{49}In.



If you notice the place of ^{31}Ga in periodic table and write the electronic configuration, you will find that it has a completely filled *d* sub-shell which shields its outer most single electron of *p* sub-shell quite weakly, as a result of which the nucleus binds this electron more tightly and more energy is required to remove it.

Similarly ^{81}Tl also has a completely filled *d* and *f* sub-shells. Its single outer most electron of *p* sub-shell is even more weakly shielded by these *d* and *f* sub-shells, hence bound tightly by the nucleus. This makes its exit more difficult.

Now see the elements of group 15. Write the configuration and focus on the outer most electron. You will find that it is the third electron of *p* sub-shell. All orbitals of *p* sub-shell are singly occupied. This state of a sub-shell is called the half-filled state. It is the next stable state to the fully filled one. That's why group 15 elements require more energy to remove their outer most electron from the half-filled *p* sub-shell.

The trend of second and third ionization energies are quite irregular. The reason behind this is the change in electronic configuration and effective nuclear charge resulting from the removal of the first electron from the atom. This in turn changes major factors affecting the ionization energies.

Source : http://chemistrynotmystery.blogspot.in/2014/07/periodic-property-deviations-in-trend_15.html