4.16: Periodic Trends - Ionization Energy

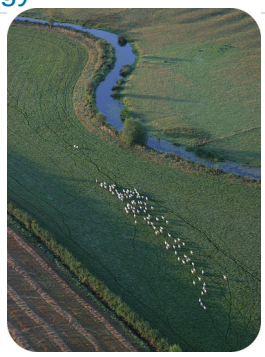


Figure 4.16.1 (Credit: Paul Englefield; Source: http://commons.wikimedia.org/wiki/File:Sheep_herd.jpg(opens in new window); License: CC by 2.0(opens in new window))

Why do sheep travel in herds?

Like many other animals, sheep travel in herds. The tendency is for each individual sheep to stay with the herd. However, a sheep may sometimes wander off, depending on how strong the attraction is for a particular food or water supply. At other times, a sheep may become frightened and run off. Whether a sheep chooses to stay with the herd or go its own way depends on the balance between attraction to the herd and attraction to the outside influence.

There is an on-going tension between the electrons and protons in an atom. Reactivity of the atom depends in part on how easily the electrons can be removed from the atom. We can measure this quantity and use it to make predictions about the behaviors of atoms.

Ionization Energy

Ionization energy is the energy required to remove an electron from a specific atom. It is measured in kJ/mol, which is an energy unit, much like calories. The ionization energies associated with some elements are described in table below. For any given atom, the outermost valence electrons will have lower ionization energies than the inner-shell kernel electrons. As more electrons are added around a nucleus, the outer electrons become shielded from the nucleus by the inner shell electrons. This is called **electron shielding**.

Table $PageIndex1$: Ionization Energies (kJ/mol) of the First 18 Elements

Element	IE_1	IE_2	IE_3	IE_4	IE_5	IE_6
H	1312					
He	2373	5251				
Li	520	7300	11,815			
Be	899	1757	14,850	21,005		
B	801	2430	3660	25,000	32,820	
C	1086	2350	4620	6220	38,000	47,261
N	1400	2860	4580	7500	9400	53,000
O	1314	3390	5300	7470	11,000	13,000

If we plot the first ionization energies vs. atomic number for the main group elements, we would have the following trend

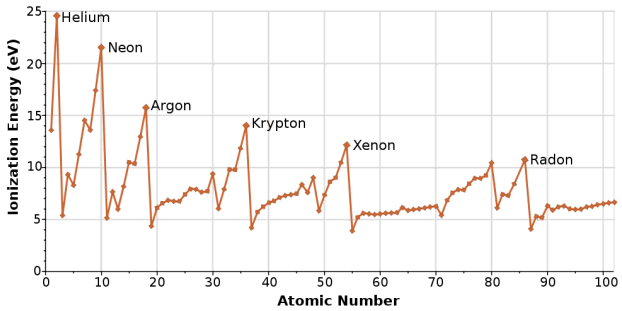


Figure 4.16.2: Ionization energy and atomic number. (Credit: User:RJHall/Wikimedia Commons; Source: http://commons.wikimedia.org/wiki/File:Ionization_energies.svg(opens in new window); License: Public Domain)

Moving from left to right across the periodic table, the ionization energy for an atom increases. We can explain this by considering the nuclear charge of the atom. The more protons in the nucleus, the stronger the attraction of the nucleus to electrons. This stronger attraction makes it more difficult to remove electrons.

Within a group, the ionization energy decreases as the size of the atom gets larger. On the graph, we see that the ionization energy increases as we go up the group to smaller atoms. In this situation, the first electron removed is farther from the nucleus as the atomic number (number of protons) increases. Being farther away from the positive attraction makes it easier for that electron to be pulled off.

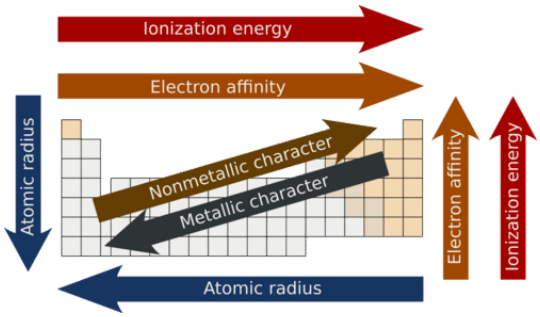
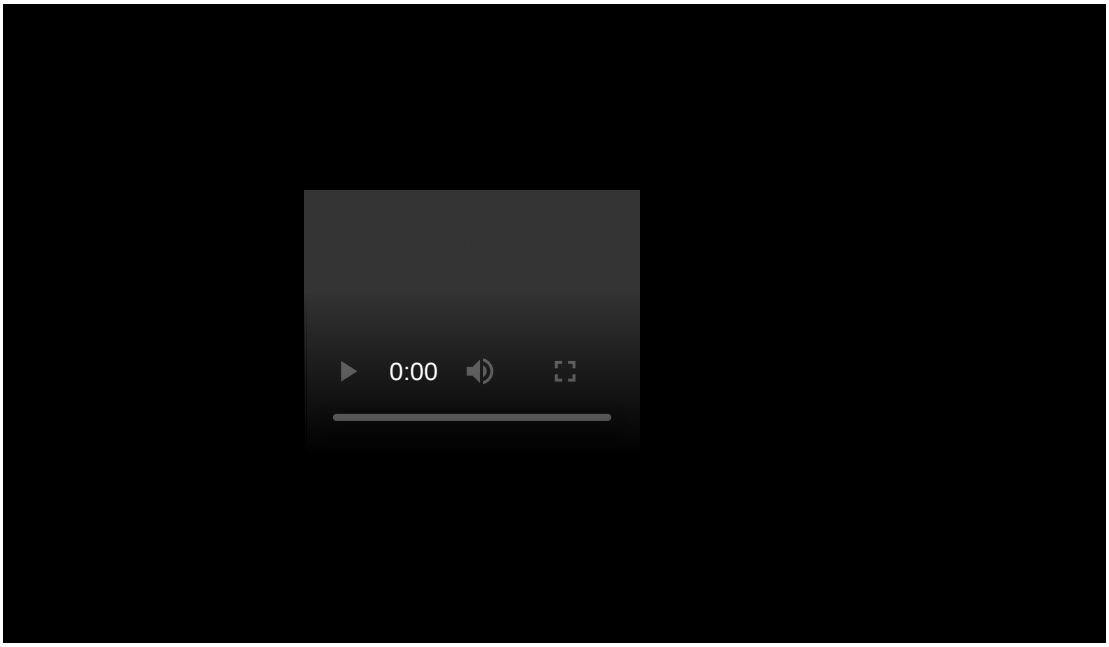


Figure 4.16.3 (Credit: User:Mirek2/Wikimedia Commons; Source: http://commons.wikimedia.org/wiki/File:Periodic_trends.svg(opens in new window); License: Public Domain)



Summary

- Ionization energy refers to the amount of energy needed to remove an electron from an atom.
- Ionization energy decreases as we go down a group.
- Ionization energy increases from left to right across the periodic table.

Review

1. Define “ionization energy.”
2. Do valence electrons have larger or smaller ionization energies that the inner-shell kernel electrons?
3. What is electron shielding?
4. Describe the trends in ionization energy from left to right across the periodic table.
5. Describe the trends in ionization energy from top to bottom of a group in the periodic table.
6. Why is the second ionization energy for lithium so much larger than the first ionization energy?