

**Ionization Energy**

1. What is ionization energy?

It is the energy needed to remove an electron from an atom in the gas phase. The process is denoted by:  

$$\text{Ionization Energy} + X \rightarrow X^+ + e^-$$

2. If the **ionization energy is high**, then it is relatively (**easy, hard**) to remove an electron from the atom.

3. As the atomic radius increases (down a column/family), the ionization energy gets (**lower, higher**).

**Explain** this trend in terms of distance between the valence electrons and the nucleus, and amount of shielding by core electrons.

Moving down a column, the outer electrons are in higher energy levels that are farther from the nucleus and more shielded by core electrons, so the attraction of the electrons to the nucleus decreases, making it easier to remove an electron.

4. Moving left to right in a period/row, the ionization energy gets (**lower, higher**). **Explain** this trend in terms of effective nuclear charge ( $Z_{\text{eff}}$ ) and atomic radius.

Moving right in a period,  $Z_{\text{eff}}$  increases, pulling the electrons closer to the nucleus, making them more attracted to the nucleus and harder to remove.

5. In general, do metals or non-metals have higher ionization energy? Why?

Non-metals have higher IE because they have higher  $Z_{\text{eff}}$  and are smaller, so their electrons are more strongly attracted to the nucleus.

6. Which element has higher ionization energy: C or O? Why?

O has higher IE. It is farther to the right, so it is smaller with higher  $Z_{\text{eff}}$  and has a higher attraction between the nucleus and electrons.

7. Which element has higher ionization energy: Na or Rb? Why?

Na has higher IE. It is higher in its family, so it is smaller with its outer electrons closer to the nucleus and more attracted.

**Electronegativity**

8. What is electronegativity?

Electronegativity is the relative tendency of an atom to attract electrons from another atom in a bond.

9. If the **electronegativity is high**, then it attracts electrons (**weakly, strongly**).

10. As the atomic radius increases (down a column/family), the electronegativity gets **(lower, higher)**. **Explain** this trend in terms of distance between the valence electrons and the nucleus, and amount of shielding by core electrons.

Coming down a column, the valence electrons are farther from the nucleus and more shielded, so an added electron would not be strongly attracted to the nucleus.

11. Moving left to right in a period/row, the electronegativity gets **(lower, higher)**. **Explain** this trend in terms of effective nuclear charge ( $Z_{\text{eff}}$ ) and atomic radius.

Moving left to right,  $Z_{\text{eff}}$  increases and atomic radius decreases, so an added electron would be close to the nucleus and more strongly attracted to it.

12. In general, do metals or non-metals have higher electronegativity? Why?

Non-metals have higher EN since they are smaller with higher  $Z_{\text{eff}}$ , increasing the attraction of electrons to their nucleus.

13. Which family of elements is an exception to that generalization? Why?

The Noble Gases have no EN (except Kr and Xe, which can form compounds when bonded with atoms like F or O with very high EN) since their valence shells are full and they have no tendency to gain electrons.

14. If **Na and Cl** bonded together to form NaCl, which atom would attract the electrons more strongly? Why?

Cl would attract the electrons more strongly since it has a higher EN.

15. If **Mg and O** bonded together to form MgO, which atom would attract the electrons more strongly? Why?

O would attract the electrons more strongly since it has a higher EN.

### Summary

16. For each of the following properties, indicate whether fluorine or bromine has a larger value

- |                                      |                                      |
|--------------------------------------|--------------------------------------|
| a. electronegativity <b>fluorine</b> | c. atomic radius <b>bromine</b>      |
| b. ionic radius <b>bromine</b>       | d. ionization energy <b>fluorine</b> |

17. Sketch a simplified periodic table and use arrows and labels to indicate period and group trends in atomic and ionic radii, ionization energies, electronegativities, and metallic and nonmetallic character.

