

# Periodic Trends in Electron Affinity

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## CONCEPT

## 1

# Periodic Trends in Electron Affinity

## Lesson Objectives

The student will:

- define electron affinity.
- describe the trends for electron affinity in the periodic table.

## Vocabulary

**electron affinity**

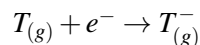
the energy released when an electron is added to a gaseous atom or ion

## Introduction

We have talked about atomic structure, electronic configurations, size of atoms and ions, ionization energy, and electronegativity. The final periodic trend that we will examine is how atoms gain electrons.

## Electron Affinity Defined

Atoms can gain or lose electrons. When an atom gains an electron, energy is given off and is known as the electron affinity. **Electron affinity** is defined as the energy released when an electron is added to a gaseous atom or ion.



For most elements, the addition of an electron to a gaseous atom releases potential energy.



## Group and Period Trends in Electron Affinity

Let's look at the electron configurations of a few elements and the trend that develops within groups and periods. **Table 1.1** shows the electron affinities for the halogen family.

**TABLE 1.1: Electron Affinities for Group 7A**

Element	Electron Configuration	Electron Affinity, kJ/mol
Fluorine, F	[He]2s <sup>2</sup> 2p <sup>5</sup>	-328
Chlorine, Cl	[Ne]3s <sup>2</sup> 3p <sup>5</sup>	-349
Bromine, Br	[Ar]4s <sup>2</sup> 4p <sup>5</sup>	-325
Iodine, I	[Kr]5s <sup>2</sup> 5p <sup>5</sup>	-295

Going down a group, the electron affinity generally decreases because of the increase in size of the atoms. Remember that within a family, atoms located lower on the periodic table are larger because there are more filled energy levels. When an electron is added to a large atom, less energy is released because the electron cannot move as close to the nucleus as it can in a smaller atom. Therefore, as the atoms in a family get larger, the electron affinity gets smaller.

There are exceptions to this trend, especially when comparing the electron affinity of smaller atoms. In **Table 1.1**, the electron affinity for fluorine is less than that for chlorine. This phenomenon is observed in other families as well. The electron affinity of all the elements in the second period is less than the the electron affinity of the elements in the third period. For instance, the electron affinity for oxygen is less than the electron affinity for sulfur. This is most likely due to the fact that the elements in the second period have such small electron clouds ( $n = 2$ ) that electron repulsion of these elements is greater than that of the rest of the family.

Overall, each row in the periodic table shows a general trend similar to the one below.

Electron Affinities for Period 4 Main Group Elements		
Element	Electron Configuration	Electron Affinity
Potassium (K)	[Ar] 4s <sup>1</sup>	-48 kJ/mol
Calcium (Ca)	[Ar] 4s <sup>2</sup>	-2.4 kJ/mol
Gallium (Ga)	[Ar] 4s <sup>2</sup> 4p <sup>1</sup>	-29 kJ/mol
Germanium (Ge)	[Ar] 4s <sup>2</sup> 4p <sup>2</sup>	-118 kJ/mol
Arsenic (As)	[Ar] 4s <sup>2</sup> 4p <sup>3</sup>	-77 kJ/mol
Selenium (Se)	[Ar] 4s <sup>2</sup> 4p <sup>4</sup>	-195 kJ/mol
Bromine (Br)	[Ar] 4s <sup>2</sup> 4p <sup>5</sup>	-325 kJ/mol
Krypton (Kr)	[Ar] 4s <sup>2</sup> 4p <sup>6</sup>	0 kJ/mol

The general trend in the electron affinity for atoms is almost the same as the trend for ionization energy. This is because both electron affinity and ionization energy are highly related to atomic size. Large atoms have low ionization energy and low electron affinity. Therefore, they tend to lose electrons. In general, the opposite is true for small atoms. Since they are small, they have high ionization energies and high electron affinities. Therefore, the small atoms tend to gain electrons. The major exception to this rule is the noble gases. Noble gases follow the general trend for ionization energies, but do not follow the general trend for electron affinities. Even though the noble gases are small atoms, their outer energy levels are completely filled with electrons. Any added electron cannot enter their outer most energy level and would have to be the first electron in a new (larger) energy level. This causes the noble gases to have essentially zero electron affinity.

When atoms become ions, the process involves either releasing energy (through electron affinity) or absorbing energy (ionization energy). Therefore, the atoms that require a large amount of energy to release an electron will most likely be the atoms that give off the most energy while accepting an electron. In other words, nonmetals will gain electrons

most easily since they have large electron affinities and large ionization energies. Metals will lose electrons since they have the low ionization energies and low electron affinities.

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## Lesson Summary

- Electron affinity is the energy released when an electron is added to a gaseous atom or ion.
- Electron affinity generally decreases going down a group and increases left to right across a period.
- Nonmetals tend to have the highest electron affinities.

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## Further Reading / Supplemental Links

This video shows the relationships between atomic size, ionization energy, and electron affinity.

- <http://www.youtube.com/watch?v=iCwYjpl8eeY&feature=channel>

This pdf document reviews the causes and relationships of the trends in atomic size, ionization energy, electronegativity, and electron affinity.

- <http://www.oakland.k12.mi.us/Portals/0/Learning/PeriodicTable.pdf>

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## Review Questions

1. Define electron affinity and write an example equation.
2. Choose the element in each pair that has the lower electron affinity.
  - a. Li or N
  - b. Cl or Na
  - c. Ca or K
  - d. Mg or F
3. Why is the electron affinity for calcium higher than that of potassium?
4. Which of the following will have the largest electron affinity?
  - a. Se
  - b. F
  - c. Ne
  - d. Br
5. Which of the following will have the smallest electron affinity?
  - a. Na
  - b. Ne
  - c. Al
  - d. Rb
6. Place the following elements in order of increasing electron affinity: Tl, Br, S, K, Al.
7. Describe the general trend for electron affinities in period 2.
8. Why does sulfur have a greater electron affinity than phosphorus does?

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