

Unit 7: Periodicity (Periodic Properties)

Electronegativity, Ionization Energy, and Electron Affinity

This worksheet will cover the different trends in the periodic table. These are electronegativity, ionization energy, and electron affinity. Elements behave differently because they each have a unique number of electrons. We can numericalize an atom's ability to attract an electron, the amount of energy required to remove an electron from an atom, and the stability of a negative ion. The number of electrons affects these values as elements want to complete an octet or a valence shell of 8 electrons. Atoms will take the path of least resistance either by losing or gaining electrons. Generally, if an atom has 4 or fewer valence electrons it will lose electrons, and if it has 4 or more valence electrons it will gain electrons.

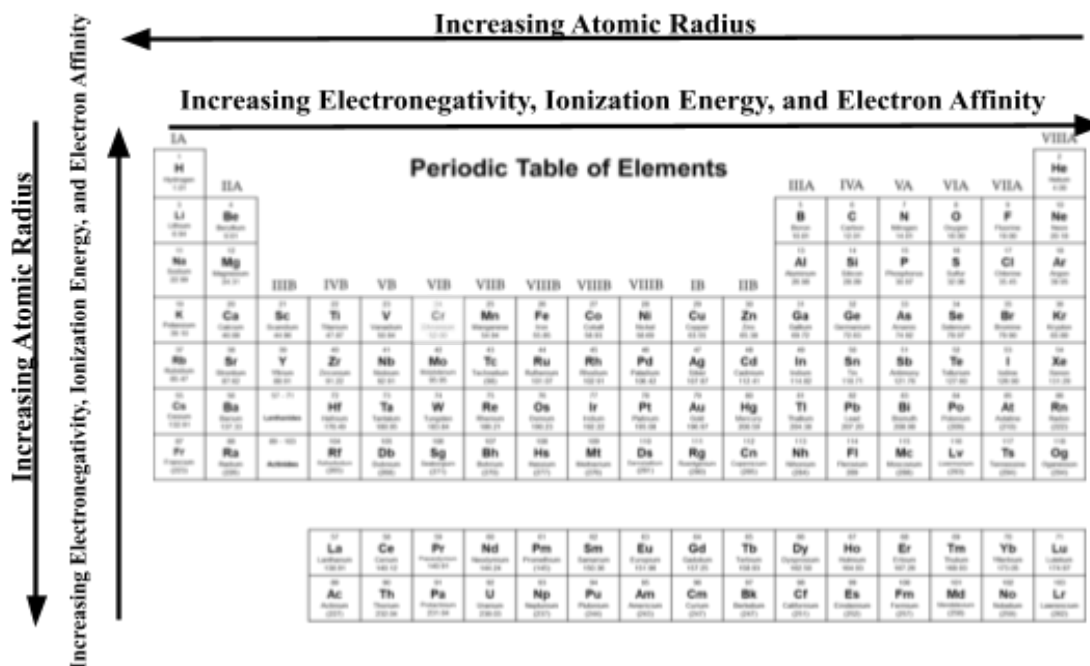
Electronegativity: An atom's ability to attract a bonding electron pair

First Ionization Energy: The energy required to remove the first electron

Electron Affinity: Energy lost when an electron is added to an atom in a gaseous state

Atomic Radius: The radius of the atom

Shown Below are the Period trends of Electronegativity, Ionization Energy, and Electron Affinity.



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Recap:

<u>Periodic Trends</u>	<u>Definition</u>	<u>Trends</u>
Electronegativity		As it goes across a period it: _____. As it goes down a group it: _____.
First Ionization Energy		As it goes across a period it: _____. As it goes down a group it: _____.
Electron affinity		As it goes across a period it: _____. As it goes down a group it: _____.
Atomic Radius		As it goes across a period it: _____. As it goes down a group it: _____.

1. Which of the following elements has the highest electronegativity? Explain. Tc, Cl, Ne, Mg

2. Which of the following elements has the smallest electronegativity? Explain. F, K, Li, Al

3. Which of the following elements has the smallest ionization energy? Explain. Li, F, Na, H

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4. Which of the following elements has the largest ionization energy? Explain. Ta, Ir, K, Se

5. Which of the following elements has the smallest electron affinity? Explain. Xe, Ba, Cr, Cs

6. Fill in the blank.

Ionization energy _____, and atomic radius _____ down a group of the periodic table.

7. Challenge Question: A chlorine atom gains an electron and becomes a chlorine ion with a -1 charge. A scientist measures the ionization energy of the electron just added. How does the magnitude of the ionization energy of chloride compare to the electron affinity of a neutral chlorine atom? (Magnitude means to disregard the sign of the value)

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ANSWER KEY

Recap:

<u>Periodic Trends</u>	<u>Definition</u>	<u>Trends</u>
Electronegativity	An atom's ability to attract a bonded electron pair.	As it goes across a period it: increases . As it goes down a group it: decreases .
First Ionization Energy	The energy required to remove the first valence electron from an atom's neutral state.	As it goes across a period it: increases . As it goes down a group it: decreases .
Electron affinity	Energy that is lost when an electron is added to an atom in a gaseous state.	As it goes across a period it: increases . As it goes down a group it: decreases .
Atomic Radius	The radius or size of an atom.	As it goes across a period it: decreases . As it goes down a group it: increases .

1. Which of the following elements has the largest electronegativity? Explain. Tc, Cl, Ne, Mg

Cl or chlorine because it has the highest effective nuclear charge or (Z_{eff}) compared to Mg and it has the least amount of electron shells. Effective nuclear charge is determined by the equation:
 $Z_{\text{eff}} = Z - S$
 Where Z is the number of total electrons and S is the number of electrons not in the valence shell.
 Chlorine has an effective nuclear charge of 7 and Mg has an effective nuclear charge of 2. Tc has too many electron shells. This results in the valence shell being very far from the nucleus. The protons will have trouble exerting a large force to attract electrons from a further distance. Ne is a noble gas. Noble gasses are known for their inert characteristic tendency to not interact with electrons as they already have a full electron shell and have little desire to attract

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electrons.

2. Which of the following elements has the smallest electronegativity? Explain F, K, Li, Al

K or potassium has the smallest electronegativity because it has the greatest amount of electron shells. Its distance from the nucleus is the greatest compared to the other atoms in the list. According to Coulomb's law the greater the distance the weaker the attraction.

3. Which of the following elements has the smallest ionization energy? Explain. Li, F, Na, H

Na or sodium because it only has 1 valence electron, meaning it only needs to lose 1 electron to have a complete valence shell. Atoms have a strong desire to have a complete valence shell and will do so by losing or gaining electrons. If we look at the periodic table, we can see that Na is under Li and to the left of both F and H, (**Li has more valence shells, and moving left on the same period on the periodic table results in a smaller atomic radius**) making it the element that requires the least amount of energy to remove an electron.

4. Which of the following elements has the largest ionization energy? Explain. Ta, Ir, K, Se

Se or selenium because it wants to gain 2 electrons to complete its valence shell compared to the other elements (Ta, Ir, and K) that want to get rid of electrons because it requires less energy to remove 1 or 2 electrons than to remove 6. Removing 6 from Se means each resulting electron removed will have to deal with the increasing nuclear attraction due to the absence of an electron to balance out the attraction of the protons. It would require the greatest amount of energy to remove an electron from Se than the other elements.

5. Which of the following elements has the smallest electron affinity? Explain. Ca, Ba, Cr, Cs

Cs, or cesium has the lowest electron affinity, as its position on the periodic table is the lowest and is in group 1. In addition, cesium will release very little energy when it takes in electrons as it wants to lose electrons instead. Ca, Ba, and Cr valence shells' are closer to their nucleus, so the attraction between the electrons and protons will require more energy to break, therefore when they are made they release more energy. Cesium's alkali nature makes it so it wants to lose its single electron to have an octet.

6. Fill in the Blank.

Ionization energy _____, and atomic radius _____ down a group of the periodic table.



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Ionization energy **decreases** and atomic radius **increases** down a group of the periodic table. This concept is depicted in the graphic shown above. As you go down a group on the periodic table, the number of valence shells increases. This means the atom gets bigger and the valence shell gets further away from the nucleus. Columbus law states that the greater the distance the weaker the force. The weaker force means it requires less energy to remove the electrons, and thus the energy required to remove an electron decreases.

7. Challenge Question: A chlorine atom gains an electron and becomes a chlorine ion with a -1 charge. A scientist measures the ionization energy of the electron just added. How does the magnitude of the ionization energy of chloride compare to the electron affinity of a neutral chlorine atom? (Magnitude means to disregard the sign of the value)

The values are equal. The ionization energy of the electron that is attached to the chlorine ion is the same magnitude as the energy required to remove it. All forces have an equal and opposite pair. Recall that electron affinity is the energy released when an electron is added to a neutral atom to form a negative ion. The energy required to remove the electron on the chlorine ion is the same magnitude as the electron affinity of a neutral chlorine atom.