Periodic trends: Electronegativity answers.

Name ____

1. What is the electronegativity of an element?

   It is the tendency of a bonded atom to accept or to donate an electron.

2. Is the "electronegativity" the same thing as the "electron affinity"?

   No, the electronegativity relates to bonded atoms and their tendency to attract electrons. Electron affinity has to do with an unbonded atom in the gaseous phase becoming an anion.

3. Do you think that the electron affinity might have any impact on the electronegativity?

   Yes, if an element has a higher electron affinity, it is reasonable to assume it will have a higher electronegativity. Energy is released when you add an electron to elements with a high electron affinity. They should be more apt to attract electrons from a less electronegative element.

4. Robert Mulliken developed the following equation to quantify electronegativity based on atomic properties: $EN = (IE + EA)/2$, where EN = electronegativity, IE = ionization energy, and EA = electron affinity. Does this equation make sense based on what you know about ionization energy and electron affinity? Explain.

   A higher IE means that it is more difficult to get an electron away from an atom. A higher EA means that it is easier to put an extra electron onto an atom. If you add a high IE to a large EA, then you end up with a high electronegativity.

   Both a high EA and IE indicate an atom that strongly attracts electrons, which is consistent with an electronegative element.

5. Make a prediction about the trend you expect to see in electronegativity:

   a. As you move from left to right across a period? Why?

      It will increase. The elements to the right have a larger positive charge within the nucleus, which means they will pull on electrons more strongly.

   b. As you move down a group? Why?

      It will decrease. The pull on the electrons goes down due to shielding of outer electrons by inner electrons and the greater distance from the *nucleus to the outer electrons, since atoms get larger as you move down in a group.*

Go to the Periodic Table Live! at *www.chemeddl.org/resources/ptl*. Click on the "Graph/Table" button in the upper right corner. Use this graphing feature to answer the questions below.

Start by clicking the "Deselect All" button above the miniature periodic table. You want to be able to choose which *elements, groups,* and *periods* will be graphed to answer this worksheet.

On the graph to the right of your screen, go to the drop-down menus below *x* and *y* (this is where you can choose the value for your *x*- and *y*-axis). You should graph atomic number (under atomic properties) and the electron affinity (also under atomic properties).

6. Do you notice a *general trend* (don't worry about a few outliers—look for the overall trend) in the electronegativity across the period you chose? Try a couple of other periods, is the trend consistent? Describe the trend. Is it consistent with your predictions?

   It's fairly consistent, and there is a general upward trend. Elements are more electronegative to the right side of the periodic table.

7. Can you explain why you see this trend as you move across a period?

   It is consistent with the trend we see with IE and EA; we know that they are related to EN based on Mulliken's equation. Both of them relate to the pull of the nucleus on the electrons, as the atomic number (and number of protons in the nucleus) goes up, the pull also goes up.

8. Deselect all and choose any one group in the periodic table, with the same *x*- and *y*-axes that you used above. Look at a few more groups, but avoid the transition metals (i.e., groups 3–12). Do you see a trend in the electronegativity down a group? Is it consistent between groups? Is it consistent with your predictions?

   It generally decreases.

9. Can you explain why you see this trend?

   It relates to the IE and EA (see 5b, above). *When electrons are farther away from the nucleus (in shells that are farther away), there is less attraction for the nucleus, and the inner electrons shield the outer electrons, also decreasing the attraction. There is also some contribution from electron configuration.*

10. Water is a molecule composed of one oxygen and two hydrogen atoms (H_2O). Using the chart-and-sort feature, determine the electronegativity of hydrogen and

oxygen (you can choose these elements only). After you have graphed them, use the mouse to hover over each point and determine the electronegativity of each. What is the electronegativity of each element?

H = 2.2
O = 3.44

11. Which one is more electronegative? What effect does one element being more electronegative have on the bond between them?

    Oxygen is more electronegative. This means that oxygen will have a tendency to have more of the electron density from bonding electrons around it, and hydrogen will have less, giving the oxygen end of the bond a partial negative charge.

12. Draw a Lewis structure for water. Using what you know about the electronegativity of each element, show where there will be a slight negative charge (δ-) and where there will be a slight positive charge (δ+).

    There should be a δ- near the oxygen and a δ+ near the hydrogens.

13. Direct your browser to Models 360 at *www.chemeddl.org/resources/models360/index.php.* Choose water from the list of molecules. Under the display menu, check "Bond Dipole" and "Partial Charge." Is the answer consistent with your prediction above?

    Yes.

For a more thorough exploration of electronegativity, download the following articles:

Jensen, W.B. 1996. Electronegativity from Avogadro to Pauling: Part I: Origins of the electronegativity concept. *Journal of Chemical Education* 73 (1)11–20.

Jensen, W.B. 2003. Electronegativity from Avogadro to Pauling: Part II. Late nineteenth- and early twentieth-century developments. *Journal of Chemical Education* 80 (3): 279–287.

Spencer, J.M. and R.S. Moog. 1996. Part III: Ionization energies, electronegativity polar bonds and partial charges. *Journal of Chemical Education* 73 (7): 627–631.