HyperChem Lite: Periodic Table Trends

PA State Standards:
3.7.10.C Apply basic computer operations and concepts.
3.4.10.A Explain concepts about the structure and property of matter.
2.7.8.B Present the results of an experiment using visual representations.
1.2.11.A Read and understand the central content of informational texts and documents in all academic areas.

Background:

The Periodic Table is an arrangement of the elements in order of their atomic numbers so that elements with similar properties fall in the same column. The elements are grouped in the Periodic Table according to their physical and chemical properties and their electron configurations.

The electron cloud surrounding the nucleus of the atom determines the size of the atom. Since this distance is somewhat fuzzy, the **atomic radius** of an atom is defined as one-half the distance between the nuclei of identical atoms bonded together. A chemical bond is a link between atoms resulting from the mutual attraction of their nuclei for electrons. A **chemical bond** or **bond length** is the distance from the nucleus of one atom to the nucleus of the other bonded atom and is usually measured in Angstroms. One **Angstrom unit**, **Å**, is **10^{-10} m or 10^{-8}cm.**

When bonded together, different atoms have a different amount of pulling power, called **electronegativity.** An atom with a higher electronegativity will pull the electrons closer to it and farther from the atom with a lower electronegativity. Another measurable property of an atom is **ionization energy,** which is the amount of energy required to remove an electron from at atom in the gas phase.

In this activity, the trends in atomic radius, bond length, electronegativity, and ionization energy will be studied. The trend in electron affinity will be predicted. Data will be examined to determine if these properties increase or decrease across the periodic table from left to right and from top to bottom. The trends are general; there are exceptions. Elements for which not all data is available will be marked with an asterisk (*).

Guiding Questions:

Please answer the following questions before completing the activity.

1. Do atoms on the left or right of the periodic table have a stronger nuclear charge?

2. Are the valence electrons of atoms at the top or bottom of the periodic table more shielded from the nucleus?

Vocabulary

1. **Angstrom (Å):** 10^{-10} m or 10^{-8}cm
2. **Atomic radius:** one-half the distance between the nuclei of identical atoms bonded together
3. **Bond length:** the distance from the nucleus of one atom to the nucleus of another bonded atom
4. **Electron affinity:** energy released when an electron is added to an atom in the gas phase.
5. **Electronegativity:** electron pulling power of an atom when part of a bond
6. **Group:** column of the periodic table
7. **Ionization energy:** energy required to remove an electron from at atom in the gas phase
8. **Period:** row of the periodic table

Equipment/Materials:

Computer with HyperChem Lite software program installed
Mouse
Mousepad

Procedure:

1. Left (L)-double click on the Draw Icon at the top of the screen (Figure 1). The Element Table dialog box will appear. Left (L)-click on lithium on the periodic table. L-click on Properties.


Figure 1: Draw Icon

2. Record the atomic radius, electronegativity, and ionization energy (1st Ionization Potential) of lithium on Data Table I.

3. L-click OK to close the Element Properties screen.

4. Drag the Element Table dialog box to the lower right corner of the workspace.

5. L-click in the workspace to place a lithium atom.

6. L-click on display, and then L-click on Rendering. Choose Balls and Cylinders, and then L-click OK.

7. L-click on the Zoom Tool (Figure 2). L-click in the workspace and drag straight up to shrink the lithium atom until it is smaller than a penny.


Figure 2: Zoom Tool

8. L-click on the XY Translation Tool (Figure 3). L-click and drag in the workspace to move the lithium atom to the left of the workspace near the top.


Figure 3: XY Translation Tool

9. In the Element Table dialog box, L-click on beryllium, and then L-click on Properties.

10. Record the atomic radius, electronegativity, and ionization energy of beryllium on the Data Table I.

11. L-click in the workspace to place a beryllium atom to the right of the lithium atom. Be sure to leave room for the other six atoms in Data Table I.

12. Repeat steps 9 – 11 for the other elements in Data Table I.

13. Once all 8 elements are displayed in order across the screen, L-click on Build, and then L-click on Add H & Model Build. The software will display the appropriate number of bonded hydrogen atoms that each molecule should have. The Element Table dialog box may be dragged out of the way if necessary, or closed.

Figure 4: Selection Tool

14. L-click on the Select Tool (Figure 4). L-click on the bond between Li and H; the bond and the attached atoms should now be green indicating that they have been selected.

15. The bond distance from atom 1 to atom 2 will be displayed underneath the workspace. Record the value in Data Table I.

16. Right-click on the bond between Li and H to de-select it.

17. L-click on one of the bonds between Be and H and record the bond length in Data Table I. De-select the bond.

18. Repeat step 17 for the remaining elements in Data Table I.

19. There are a couple of ways to clear the workspace.
    a. L-click on File, and then L-click on New. (Instead, the New icon may be clicked.) When asked to save, L-click No.
    b. L-click in workspace outside of the molecules; they will all turn green. L-click Edit, L-click clear, and then answer Yes.

20. Use the above procedures to complete Data Table II.

Data:

Data Table I: Periodic Table from Left to Right

Element	Atomic Radius (Å)	Bond Length (Å)	Electronegativity	Ionization Energy (V)
Li				
Be				
B				
C				
N				
O				
F				
Ne*				

Data Table II: Periodic Table from Top to Bottom

Element	Atomic Radius (Å)	Bond Length (Å)	Electronegativity	Ionization Energy (V)
Li				
Na				
K				
Rb				
Cs				
Fr*				

Questions:

1. What is the trend in atomic radius across a period of the periodic table from left to right? Why does this trend occur?

2. What is the trend in atomic radius down a group of the periodic table from top to bottom? Why does this trend occur?

3. What is the trend in bond length across a period of the periodic table from left to right? Why does this trend occur?

4. What is the trend in bond length down a group of the periodic table from top to bottom? Why does this trend occur?

5. What is the trend in electronegativity across a period of the periodic table from left to right? Why does this trend occur?

6. What is the trend in electronegativity down a group of the periodic table from top to bottom? Why does this trend occur?

7. What is the trend in ionization energy across a period of the periodic table from left to right? Why does this trend occur?

8. What is the trend in ionization energy down a group of the periodic table from top to bottom? Why does this trend occur?

9. An atom with a high electron affinity will release a large amount of energy when an electron is added to it in the gas phase; these atoms tend to form negative ions, as they will easily accommodate an extra electron. An atom with a low electron affinity (many have a negative value) will require energy to be added in order to accommodate an extra electron; these atoms tend to form positive ions.
    a. Predict the trend in electron affinity across the periodic table from left to right. Explain your reasoning.

    b. Predict the trend in electron affinity down the periodic table from top to bottom. Explain your reasoning.

Optional Questions:

1. Why are no values listed for bond length and electronegativity for neon?

2. Why are no values listed for atomic radius and ionization energy for francium?

References:

(Harsh, Science in Motion, Gannon University)