*Ionization Energy and the Electron Configuration*

Ionization energy (IE) is the quantity of energy needed to remove an electron from a gaseous atom or ion. If it is the first electron removed from an atom, it is called the first ionization energy; the second electron is the second ionization energy and so forth. Below is a table of the first eight IE for elements of the third row.

Table one: *Successive Ionization Energies in Kilojoules per Mole for the Elements in Period 3*

| ***Element*** | ***$IE_1$*** | ***$IE_2$*** | ***$IE_3$*** | ***$IE_4$*** | ***$IE_5$*** | ***$IE_6$*** | ***$IE_7$*** | ***$IE_8$*** |
|---|---|---|---|---|---|---|---|---|
| Na | 490 | 4560 | 6913 | 9543 | 13355 | 16606 | 20108 | 25491 |
| Mg | 735 | 1445 | 7730 | 10540 | 13623 | 17995 | 21698 | 25665 |
| Al | 580 | 1815 | 2740 | 11600 | 15033 | 18372 | 23292 | 27455 |
| Si | 780 | 1575 | 3220 | 4350 | 16083 | 19790 | 23773 | 29246 |
| P | 1060 | 1890 | 2905 | 4950 | 6270 | 21267 | 25405 | 29840 |
| S | 1005 | 2260 | 3375 | 4565 | 6950 | 8494 | 28079 | 31723 |
| Cl | 1255 | 2295 | 3850 | 5160 | 6560 | 9360 | 11025 | predict |
| Ar | 1525 | 2665 | 3945 | 5770 | 7230 | 8780 | 12000 | predict |

1. Valence electrons are available to be lost, gained, or shared in the formation of chemical compounds. On the backside of this paper, write the valence electron configurations (highest s and p orbitals) for each element in the third row.

2. Examine the ionization energies the Al row. Notice that the IE increases for removal of each additional electron. Enter your calculator list L1 the ionization energy number (1,2...8) and the corresponding ionization energy to remove a single electron for the element AL. Plot this data.

3. Would you describe this data as continuous (one function) or discontinuous (multiple functions or a piece-wise function)? What might cause discontinuity?

4. For each row draw a vertical that separates unusually large jumps in the IE such as observed for aluminum. After completing this task, connect the vertical lines with horizontal lines making a staircase appearance.

5. On the left of the staircase are _____ electrons and on the right are the electrons belonging to the noble gas _____.

6. Run the calculator program entitled "IONIZE" by clearing the screen, selecting PGRM, IONIZE, Enter, and Enter. This program enters the above data for ionization energies 1-3 into the calculator lists L2, L3, and L4 respectively.

7. You must enter the atomic numbers for the elements in table one above into calculator list L1.

8. Construct the three following connected line plots (xyplot) of ionization energy vs. atomic number. *Be sure to use differing markers for each plot.*

   - Plot one: first ionization energy vs. atomic number
   - Plot two: second ionization energy vs. atomic number
   - Plot three: third ionization number vs. atomic number

9. Explain the peaks on each of the graphs.

10. How can you tell the number of valence electrons in an element from simply studying the data in the above table? How does correlate to the graphs?

11. Explain the trend of IE in the third row. Why does Mg have a greater first IE than Al and why does P have a greater first E than does S?

12. Write a summary on today's activity.

**IONIZE Calculator Program**

Download http://dwb.unl.edu/calculators/programs/IONIZE.83p.hqx

To enter this program, select PRGM, NEW

The commands are found under their respective menus on the TI calculator. For example, the "Float" command is found by pressing MODE, maneuvering to "Float" and selecting ENTER.

This program can also be constructed on a computer (Windows or Macintosh) with the Graph Link software from Texas Instruments (free download) and downloaded to the calculator with a graph-link cable (~$45.00 from TI).

Name = IONIZE

```
ClrHome
ClrList L1,L2,L3,L4,L5,L6
SetUpEditor
{490,735,580,780,1060,1005,1255,1525}->L2
{4560,1445,1815,1575,1890,2260,2295,2665}->L3
{6913,7730,2740,3220,2905,3375,3850,3945}->L4
Output(2,2,"L2 Is IE1")
Output(3,2,"L3 Is IE2")
Output(4,2,"L4 Is IE3")
Output(8,5,"[ENTER]")
Pause
ClrHome
Stop
```