**Keeping Up With the Trends - In-class assignment – Periodic trends – Worksheet**

When Mendeleev proposed the Periodic Table of the Elements, he based the positions of different elements primarily on shared chemical properties. Mendeleev’s arrangement led to what is called periodic law.

Modern atomic theory has since provided a framework for explaining periodic trends in:

* Atomic size
* Ionic size
* Ionization energy
* Electron affinity

In this exercise, you will write arguments to correctly explain observed periodic trends drawing upon your knowledge of electron configurations, electron-nuclear attractions and electron-electron repulsions/electron shielding. To help you in your task, you must choose from a number of cards (provided) statements that will support your explanation. When you have constructed an argument, call your teacher over to see if you got it right.

1. Complete the following table to help you explain the trend that atomic size increases down a group.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Element** | **Atomic radius (pm)** | **Ionization energy** | **Electron configuration. Write the last orbitals representing the largest shell in a different colour** | **# protons** | **# electrons** | **# core electrons** | **# valence electrons** |
| H | 37 | 1312.0 |  |  |  |  |  |
| Li | 152 | 520.2 |  |  |  |  |  |
| Na | 186 | 495.8 |  |  |  |  |  |
| K | 231 | 418.8 |  |  |  |  |  |

Use the cards provided to fill in the blanks below and help you construct an explanation for the trend in **increasing atomic size**:

*The size of an atom is roughly based on the location of the electrons furthest way from the nucleus. According to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, atoms of elements with the electrons located in larger shells (i.e. those \_\_\_\_\_\_\_\_\_\_\_from the nucleus) will be the largest. Since K has its last electron in an orbital with the largest shell size (4s), it is the largest atom and H the smallest.*

2. Complete the sentence provided in italics below to help you explain the trend that atomic size decreases across a period. Use the cards to help you fill in the blanks.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Element** | **Atomic radius (pm)** | **Ionization energy (kJ/mol)** | **Electron configuration. Write the last orbitals representing the largest shell in a different colour** | **# protons** | **# electrons** | **# core electrons** | **# valence electrons** |
| Li | 152 | 520.2 |  |  |  |  |  |
| Be | 111 | 899.5 |  |  |  |  |  |
| B | 88 | 800.6 |  |  |  |  |  |
| C | 77 | 1086.5 |  |  |  |  |  |

*The size of an atom is roughly based on the location of the electrons furthest way from the nucleus. According to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, atoms with their last electron in the \_\_\_\_\_\_\_\_\_ shell will be roughly the same size. However as you go across the period, these electrons experience a \_\_\_\_\_\_\_\_\_\_ attraction to the nucleus because the elements increase in the number of protons. As the proton number increases, and the \_\_\_\_\_\_ electron shielding is experienced from core electrons, the outermost electrons feel \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_nucleus. This causes a slight shrinking in the size of the atom across the period.*

3. Refer back to the table in Q1. Use relevant cards to develop a statement that explains the periodic trend of ionization energy decreasing down a group (HINT: think of what orbital the electron is being removed from).

4. Refer back to the table in Q2. Use the cards to develop a statement that explains the periodic trend of ionization energy increasing across a period.

5. When atoms turn into ions, they gain a charge but they also change in size. Fill out the 1st four rows of the following table then use the information therein to explain why *cations are smaller than the neutral, parent atoms but anions are larger than parent atoms.*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Atom and element** | **Radius (pm)** | **Electron configuration. Write the last orbitals representing the largest shell in a different colour** | **# protons** | **# electrons** | **# core electrons** | **# valence electrons** |
| Li | 152 |  |  |  |  |  |
| Li+ | 60 |  |  |  |  |  |
| F | 57 |  |  |  |  |  |
| F- | 133 |  |  |  |  |  |
| Na+ | 102 |  |  |  |  |  |
| Be2+ | 45 |  |  |  |  |  |

6. Complete the 5th row of the table in Q5 and compare it to Li+. Explain why the sodium ion is larger than the lithium ion. Use the cards to help you construct an argument.

7. Complete the 6th row of the table in Q5 and compare it to Li+. Explain why the beryllium ion is smaller than the lithium ion. Use the cards to help you construct an argument.

8. Periodic properties can also be used to infer other phenomenon, for example, the preferred charge states of different elements. Consider the ionization energies associated with aluminum:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Species and change in radius | Al 🡪 Al+  118 pm 🡪 98 pm | Al+ 🡪 Al2+  98 pm 🡪 80 pm | Al2+ 🡪 Al3+  80 pm 🡪 50 pm | Al3+ 🡪 Al4+  50 pm 🡪 slightly smaller |
| Ionization energy (kJ/mol) | 1st  577 | 2nd  1817 | 3rd  2745 | 4th  11577 |

Create your own table, similar to what is in Q5, then use the cards to help you develop an argument for a) what is the preferred charge state of Al and b) why on the basis of electron-nuclear interactions.

9. Design your own table using the elements N, O and F to explain the following trend: electron affinity becomes more exothermic across a period.

10. Design your own table using the elements H, Li and Na to explain the following trend: electron affinity becomes less exothermic down a group.

**Activity Cards**

|  |  |  |
| --- | --- | --- |
| **Coulomb’s law,** | **Lower energy levels** | **Higher energy levels** |
| **Increased electron shielding** | **Same electron shielding** | **Less electron shielding** |
| **Greater attraction to nucleus** | **Same attraction to nucleus** | **Less attraction to nucleus** |
| **Less valence electrons** | **Same # valence electrons** | **Increasing # of valence electrons** |
| **Larger shell** | **Smaller shell** | **Same size shell** |
| **Electrons further from nucleus** | **Electrons closer to nucleus** | **Electrons the same distance from nucleus** |
| **Zeff = Z – shielding from core electrons** | **Isoelectronic** |  |