Name _____ Honors Chemistry __/__/__

Ions: Electron Configuration and Sizes

- In virtually every case, the atoms in **a stable compound have a noble gas arrangement of electrons**.
- When **two nonmetals** react to form a **covalent bond**, they **share electrons** in a way that completes the valence electron configurations of both atoms. Both nonmetals attain noble gas electron configurations.
- When a **nonmetal and a metal** react to form a binary **ionic compound**, the ions form so that the valence electron configuration of the **nonmetal achieves the electron configuration of the next noble gas atom** and **the valence orbitals of the metal are emptied**.
- **Metals lose valence electrons first**. After the metal loses valence electrons, additional d orbital electrons can be removed if necessary.
- For example: Write the electron configurations for the following ions.
    - Mn^{4+}
    - Fe^{3+}
- There are some important exceptions to the rules above.
    - Sn forms Sn^{2+} and Sn^{4+}
    - Pb forms Pb^{2+} and Pb^{4+}
    - Bi forms Bi^{3+} and Bi^{5+}
    - Tl forms Tl^{+} and Tl^{3+}
- The reasons Sn^{2+}, Pb^{2+}, Bi^{3+} and Tl^{+} can all form are that all atoms are large and there is a great deal of shielding of the nucleus. In addition, the s orbitals further shield the nucleus making the p orbital electrons to be easily removed.
- Write the electron configurations for the following exception.
    - Sn^{2+}
- Since a positive ion is formed by removing one or more electrons from a neutral atom, the resulting **cation is smaller than its parent atom**. The opposite is true for negative ions; the addition of electrons to a neutral atom produces an **anion significantly larger than its parent atom**. In determining whether an atom or its ion are larger (or smaller) compare the proton to electron ratio.
- In each of following identify the larger species:
    - O vs. O^{2-}
    - Al^{3+} vs. Al
- **Ion radius increases going down a group (**just like atomic radius**)**. Horizontally, the trend is complicated because metals on the left side of the periodic table form cations, and nonmetals on the right side of the periodic table form anions. For example In the second period, C^{4-} has the largest ionic radius and C^{4+} has the smallest ionic radius.
- One trend worth noting involves relative sizes of an isoelectric set. **An isoelectric set is a group of atoms or ions with the same number of electrons**.
- Consider the ions O^{2-}, F^{-}, Na^{+}, Mg^{2+} and Al^{3+}.
    - Since all species have the same number of electrons, it can be assumed that as the number of protons increases, the attraction between protons and electrons will increase and make the ionic radius smaller.
    - For the set listed above O^{2-} has the fewest protons and as a result is the largest ionic radius. Al^{3+} has the most protons and is the smallest ionic radius.

- Put the following isoelectric set in order from smallest to largest:
  - H^{1-}, Be^{2+}, C^{4+}, Li^{1+}, He

Homework:

Part 1: Write electron configurations for the following ions.

1. Cu^{1+}
2. Cu^{2+}
3. Mn^{6+}
4. Cr^{3+}
5. Bi^{3+}

Part 2: Pick the ion or atom that is largest in each of the following pairs.

1. N or N^{3-}
2. Ca or Ca^{2+}
3. Fe^{2+} or Fe^{3+}
4. Sb^{3+} or Sb^{3-}
5. S^{2-} or S

Part 3: Put the following species in an isoelectric set in order from smallest to largest.

1. S^{2-}, Ar, P^{3-}, Sc^{3+}, Cl^{1-}, K^{1+}
2. Y^{3+}, As^{3-}, Kr, Mo^{6+}, Sr^{2+}, Br^{1-}
3. Ce^{4+}, Sb^{3-}, I^{1-}, La^{3+}, Cs^{1+}, Te^{2-}

Part 4: Answer the following questions regarding ionic trends.

1. Which of the following ions is most stable? Explain.
   Mn^{2+}, Mn^{3+}, Mn^{4+}, Mn^{6+}, Mn^{7+}
2. Which of the following has the highest ionization energy? Explain.
   Mn^{2+}, Mn^{3+}, Mn^{4+}, Mn^{6+}, Mn^{7+}