Problem Set 7.1: The Periodic Table-Trends

The vertical columns in the periodic table are referred to as **families or groups**. Elements in a periodic table family, much like siblings in families, have some things in common. The similarities of chemical reactivity and chemical behaviour are almost entirely due to the way in which electrons are arranged around the atoms of the elements in a chemical family.

Some of the families have particular significance, both historically as well as due to their chemical reactivity (or lack thereof). These have been given special names. Group 1 elements are the **Alkali metals**, group 2 are the **Alkaline Earth metals**, groups 3-12 are labeled the **Transition metals**, group 17 the **Halogens** and group 18 the **Noble gases**.

1.1 Which group do the following elements belong to?

a) Rubidium b) W c) Chlorine

d) Argon e) Gold f) Be

1.2 For each of group 1, 2, 17 and 18, do some research to show a significant chemical reaction they undergo which demonstrates something about their reactivity.

1.3 A certain unknown element, X, was heated and mixed with a number of other elements and compounds. It was found that it reacted violently with bromine to form an ionic compound with formula XBr2. What formula do you expect for a reaction of the element directly below X, which we will call Y, with Cl? Explain your response. What families do X and Y most likely belong to?

We have seen that elements in a family often react in a similar way. This means that the oxides of one family, for example, will have similar chemical formulae. The oxide of lithium is Li2O, the oxide of sodium is Na2O, the oxide of potassium is K2O, etc... Answer the following to explore the reactivities of families of elements.

1.4 You know that the formula for water is H2O. List the formulas for the compounds of hydrogen with the rest of the elements in the same family as oxygen. (family 16). Assume that all of the elements in the family will react in the same way that oxygen does.

1.5 The formula for rust (iron oxide) is Fe2O3. What do you suspect the formula is for osmium sulfide?

1.6 The formula for boron trichloride is BCl3. What do you suspect the formula is for the compound that forms between aluminum and Iodine?

1.7 What is the formula for the compound that forms between germanium and oxygen?

1.8 What is the formula for the compound that forms between sodium and arsenic?

1.9 Explain why you think that ClO either does or does not exist.

We have now seen the trend that as we proceed down a family, the number of valence electrons on an element stays the same. We will now begin to explore other trends in the periodic table, and begin to unravel is complexity while also acknowledging its orderliness. There are exceptions to trends at times.

To help you to focus on the trends, try to look first from peak to peak or from valley to valley. If the charts on the following pages were roller coaster rides, which elements are found at each of the highest points? Is there a relationship between these elements on the periodic table?

Refer to the charts below in order to answer the following questions.

The first trend we can see is that of the size of atoms. Refer to the chart below as you answer the questions that follow:

1.10 Which of the elements (excluding H) has the atom with the smallest radius? Which has the largest?

1.11 What happens to the size of the atom as you move down a family on the periodic table? Try looking at group 1, the alkali metals first, then try other families as well.

1.12 What happens to the size of the atom as you move across a period on the periodic table? Try looking at the series of elements from lithium to fluorine first, then try other periods as well.

1.13 Make a general statement about the trend of changing atomic size as you move across the table from left to right and top to bottom. In addition, explain why as you move from left to right the atom gets smaller and why when you move down a family the atom gets bigger.

1.14\* It is important to note here that the size of the noble gasses is anomalous. Research various sources to help you explain why.

The second trend we see is the size of the **ion**. You will recall that an ion is an atom that has either gained or lost electrons and as a result carries a charge. Use the following chart to answer the questions that follow:

1.15 From the elements 1 to 89 which has the largest ion? Which has the smallest?

1.16 Generally, which family tends to have the largest ions? Which has the smallest?

1.17 Make a general statement about the trend of changing ionic size as you move across the table from left to right and top to bottom.

1.18 Explain why the carbon 4+ ion is smaller than the lithium 1+ ion.

1.19 The ions shown are the most common ions. So, for example, the carbon ion is 4+, but the Nitrogen ion is 3-. How does this explain why the N-3 ion is bigger than the C4+?

The third trend we see is **ionization energy**. This is the amount of energy required to remove one electron from the atom of an element.

1.20 Which element has the highest ionization energy? Which has the lowest?

1.21 Which family has elements with the highest ionization energy? Explain why this is so.

1.22 Make a general statement about the trend of changing ionization energy as you move across the table from left to right and top to bottom.

1.23 Explain what you would expect for the energy required to remove a **second** electron from the alkali metals.

1.24 The energy required to remove an electron from helium (e- configuration 1s2) is 2 372 KJ/mol. The energy required to remove an electron from a Li 1+ ion (e- configuration 1s2) is 7 285 KJ/mol. Explain why these are so different.

The fourth trend is one that in many ways explains some of the other trends. It is **electronegativity**. Electronegativity (sometimes given the Greek character, ) is a measure of the ability of an atom in a molecule to attract electrons to itself. Electronegativity will be further discussed during the chemical bonding unit later in the course.

1.25 Which element has the greatest electronegativity? Which has the lowest (not including the noble gases)?

1.26 Using the definition of electronegativity, why are the noble gases assigned a value of 0?

1.27 Since the noble gases are assigned zero, which family has the lowest electronegativities that are not assigned?

1.28 Make a general statement about the trend of changing electronegativity as you move across the table from left to right and top to bottom.

1.29 Comment on the statement that electronegativity trends can explain other trends. How is electronegativity related to the size of an element? How is it related to the ionization energy?

1.30 Electronegativity is sometimes equated with degree metallic character. Comment on this statement.

The last trend to look at is melting and boiling point. Although the trends are less obvious for these two properties, some generalities can be seen.

1.31 Which family tends to have the highest melting points? Which has the lowest?

1.32 Which family tends to have the highest boiling points? Which has the lowest?

1.33 Try to make some kind of general statement about the trend of melting point as you move across the table from left to right and top to bottom. Again, look for trends as opposed to the exceptions.