Periodic Trends

We will be discussing 4 trends found in the periodic table. We will first define them.

1. **Atomic radius** (size) – ½ the distance from center to center of two like atoms.

2. **Ionization energy** – the amount of energy needed to remove an electron from a specific atom or ion in its ground state
   a. \( A + \text{energy} \rightarrow A^+ + e^- \)
   b. The amount of energy absorbed is equal to the ionization energy. It is an ENDOThERMIC process, therefore, the number will always be positive.
   c. 1\(^{st}\) I.E. – energy it takes to remove the 1\(^{st}\) electron
      2\(^{nd}\) I.E. – energy it takes to remove the 2\(^{nd}\) electron
      3\(^{rd}\) I.E. - energy it takes to remove the 3\(^{rd}\) electron

3. **Electronegativity** – the ability of an atom to attract electrons or electron pairs from another atom. A high electronegativity value means a strong attraction for electrons.
**Periodic Trends**

1. **Atomic radius**
   - Increases as you move down a family
   Why??? As you move down any family, another principle energy level is added.
   - Decreases as you move from left to right within a period.
   Why??? As the number of protons increase within the nucleus, the positive charge of the nucleus increases. As a result, the nucleus exerts a greater pull on all the electrons in the atom. Hence, pulling the electrons closer to the nucleus and decreasing the atomic size.

2. **Ionization energy**
   - Decreases as you move down a family.
   Why??? The electrons that are removed from atoms of each succeeding element in a group are in a higher energy level. Therefore, since they are farther from the nucleus they receive less pull and are easily removed.
   - Increases as you move from left to right within a period.
   Why??? The nuclei of succeeding elements in a period exert more pull on their electrons because of the increase of positive charge. The stronger pull means more energy is required to remove an electron. The harder the hold, the harder it is to remove.

3. **Reactivity**
   - Increases down a group of metals but decrease down a group of nonmetals.
   From the middle of the d block going outward, the reactivity increases across a period. In other words, across a period reactivity will decrease until the middle of the d block where it will then start increasing.

4. **Electronegativity**
   - Going down a group, the electronegativity value decreases.
   - Going across a period, the electronegativity value increases.
   - Electronegativity values are arbitrary scales of numbers. They range from 0.7 to 4.0.

**Using Electronegativity Values in Bonding:**

Subtracting the values of each element in a compound can indicate what type of bond exists between the elements.

As bond strength increases, the electronegativity value increases.

Polarity -- the formation of partially charged atoms in a molecule

If the difference in electronegativity is:

- 0 – 0.5 the bond is non-polar covalent
0.5 – 1.6 the bond is polar covalent

1.6 or higher the bond is ionic

Example: CsF

What is the e-neg value of Cs? From the chart above, I see it is 0.7

This is the smallest e-neg value there is. This means the atom has very little ability to gain an electron. Instead, the atom loses an electron to obtain a 1⁺ charge.

What is the e-neg value of F? From the chart above I see it is 4.0

This is the highest value. It means the atom attracts electrons very strongly. It will gain one electron to form a 1⁻ ion.

The difference is 4.0-0.7=3.3. Therefore, the bond is ionic. This is a very strong bond.

Example: PH₃

The e-neg value for P is 2.1.

The e-neg value for H is 2.1

Both have equal e-neg values and attracting abilities. The difference is 2.1-2.1=0. Therefore, neither element can take electrons away from the other. Therefore, they share the electrons equally. This is called a non-polar covalent bond.

Example: H₂O

E-neg value for H: 2.1

E-neg value for O: 3.5

Difference: 3.5-2.1 = 1.4 (NOTE: always subtract the smaller FROM the larger so you don’t get a negative answer)
When the difference is 0.5 – 1.6, a polar covalent bond is formed. This means the sharing of the electrons is not equal and the bonding electrons are more strongly attracted by one of the atoms. The uneven sharing causes the more electronegative atom to have a partial negative charge. The other atom will have a partial positive charge.

**For questions 1-20 (Days 1 and 2), if no highlighter, use one ring around for the highest/largest, and double ring for lowest/smallest)**

**Day 1:**

1. Highlight the element with the largest atomic radius in RED and highlight in YELLOW around the element with the smallest atomic radius:
   Cu  K  Ni  Br
   Explain why you made these choices.

2. Highlight the element with the highest ionization energy in RED and highlight in YELLOW around the element with the lowest ionization energy:
   Cu  K  Ni  Br
   Explain why you made these choices.

3. Highlight the element with the highest electron affinity in RED and highlight in YELLOW around the element with the lowest electron affinity:
   Cu  K  Ni  Br
   Explain why you made these choices.

4. Highlight the element with the highest electronegativity in RED and highlight in YELLOW around the element with the lowest electronegativity:
   Cu  K  Ni  Br
   Explain why you made these choices.

5. Highlight the element with the largest atomic radius in RED and highlight in YELLOW around the element with the smallest atomic radius:
   O  C  Be  Ne
   Explain why you made these choices.

6. Highlight the element with the highest ionization energy in RED and highlight in YELLOW around the element with the lowest ionization energy:
   O  C  Be  Ne
   Explain why you made these choices.

7. Highlight the element with the highest electron affinity in RED and highlight in YELLOW around the element with the lowest electron affinity:
   O  C  Be  Ne
   Explain why you made these choices.

8. Highlight the element with the highest electronegativity in RED and highlight in YELLOW around the element with the lowest electronegativity:
   O  C  Be  Ne
   Explain why you made these choices.
9. Highlight the element with the largest atomic radius in RED and highlight in YELLOW around the element with the smallest atomic radius:
   Na  Rb  Fr  H
   Explain why you made these choices.

10. Highlight the element with the highest ionization energy in RED and highlight in YELLOW around the element with the lowest ionization energy:
    Na  Rb  Fr  H
    Explain why you made these choices.

Day 2:

11. Highlight the element with the highest electron affinity in RED and highlight in YELLOW around the element with the lowest electron affinity:
    Na  Rb  Fr  H
    Explain why you made these choices.

12. Highlight the element with the highest electronegativity in RED and highlight in YELLOW around the element with the lowest electronegativity:
    Na  Rb  Fr  H
    Explain why you made these choices.

13. Highlight the element with the largest atomic radius in RED and highlight in YELLOW around the element with the smallest atomic radius:
    Pb  C  Sn  Si
    Explain why you made these choices.

14. Highlight the element with the highest ionization energy in RED and highlight in YELLOW around the element with the lowest ionization energy:
    Pb  C  Sn  Si
    Explain why you made these choices.

15. Highlight the element with the highest electron affinity in RED and highlight in YELLOW around the element with the lowest electron affinity:
    Pb  C  Sn  Si
    Explain why you made these choices.

16. Highlight the element with the highest electronegativity in RED and highlight in YELLOW around the element with the lowest electronegativity:
    Pb  C  Sn  Si
    Explain why you made these choices.

17. Highlight the element with the largest atomic radius in RED and highlight in YELLOW around the element with the smallest atomic radius:
    Au  W  S  Fr  Ne  Zn
    Explain why you made these choices.

18. Highlight the element with the highest ionization energy in RED and highlight in YELLOW around the element with the lowest ionization energy:
    Au  W  S  Fr  Ne  Zn
Explain why you made these choices.

19. Highlight the element with the highest electron affinity in RED and highlight in YELLOW around the element with the lowest electron affinity:
   Au  W  S  Fr  Ne  Zn
   Explain why you made these choices.

20. Highlight the element with the highest electronegativity in RED and highlight in YELLOW around the element with the lowest electronegativity:
   Au  W  S  Fr  Ne  Zn
   Explain why you made these choices.

Day 3:

21. Rank the following elements by increasing atomic radius: Carbon, aluminum, oxygen, potassium.

22. Rank the following elements by increasing electronegativity: sulfur, oxygen, neon, aluminum.

23. Why does Fluorine have a higher ionization energy than iodine?

24. Why do elements in the same family generally have similar properties?

For problems 25-28, find the differences in the electronegativities of the two elements involved, and predict what type of bond holds the compound together. Show your work:

25. NaCl

26. H₂S

27. CO₂

28. CaBr₂