Honors Chemistry: Coulomb's Law and periodic trends

Question: How are electrons "arranged" in an atom?

$$F = k\frac{Q_1 Q_2}{r^2}$$

Coulomb's Law equation:

1. A) Define what each of the following variables in the equation represents.

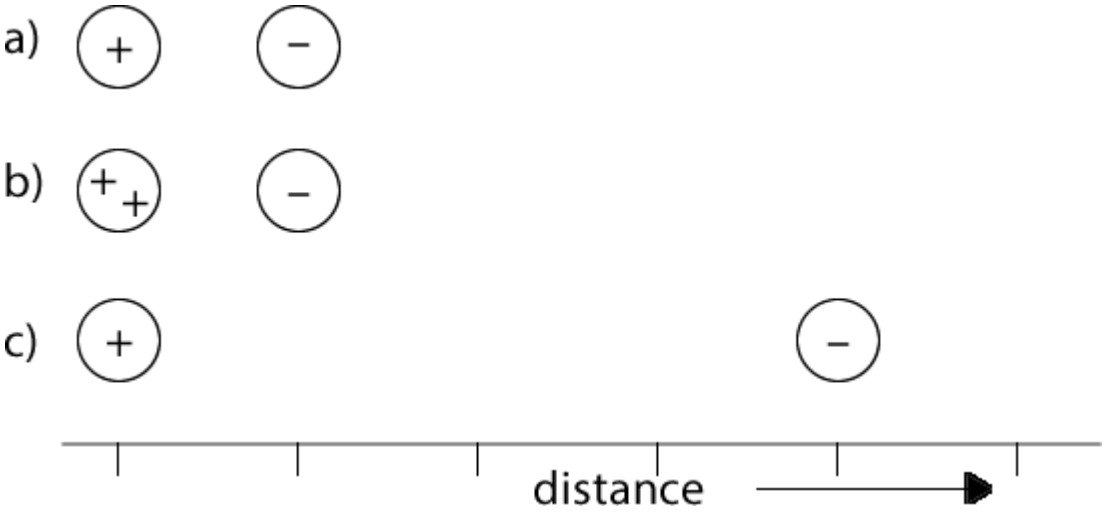
    a. F

    b. Q1, Q2

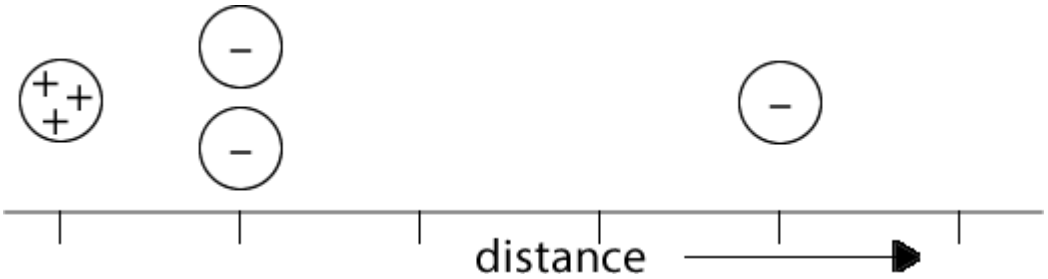
    c. r

    d. Describe the nature of the interaction between protons and electrons in an atom. Consider using some or all of the following terms in your description: attraction, repulsion, neutral, positive, negative, charge, distance, nucleus, force, energy, Coulomb's Law.

2. Compare the relative energy necessary to separate positive and negative electrical charges in the following situations. Compare a and b, then compare a and c.



3. Consider the following diagram:



a. How many electrons do you see in the picture? _____ How many protons? _____

b. Which of these electrons is the easiest to remove? (i.e., which requires the least amount of energy to ionize?)

c. Explain your response in b.

d. How does the energy required to remove the outermost electron in 3 compare to 2a? to 2c?

The first ionization energy is defined as the minimum energy that must be added to a neutral atom, in the gas phase, to remove an electron from that atom. This definition can be represented in the following chemical equation: **energy + A(g) $\rightarrow$ A^+(g) + $1e^-$**

3. In the ionization equation above, which is at lower energy? A(g) or A^+(g) and $1e^-$?

   Which is at higher energy? A(g) or A^+(g) and $1e^-$?

   Explain.

4. Explain why energy is required to remove the electron in a neutral atom.

5. The values for the first ionization energy for a hydrogen and helium atom are provided in the table below.

Atom	**H**	**He**	**Li**
Ionization energy (kJ/mol)	1312	2373	

Based on comparisons you made in Question 2, how would you explain the difference in the values for the first ionization energy for hydrogen and helium? How does your explanation account for the relative charge on hydrogen and helium and the distance of the electron(s) from the nucleus?

6. In the energy diagram below draw a horizontal line to represent the first ionization energy for hydrogen and the first ionization energy for helium. Assume the product of the ionization ($\mathbf{H^+(g) + 1e^-}$ or $\mathbf{He^+(g) + 1e^-}$) have an energy = 0 kJ/mol.

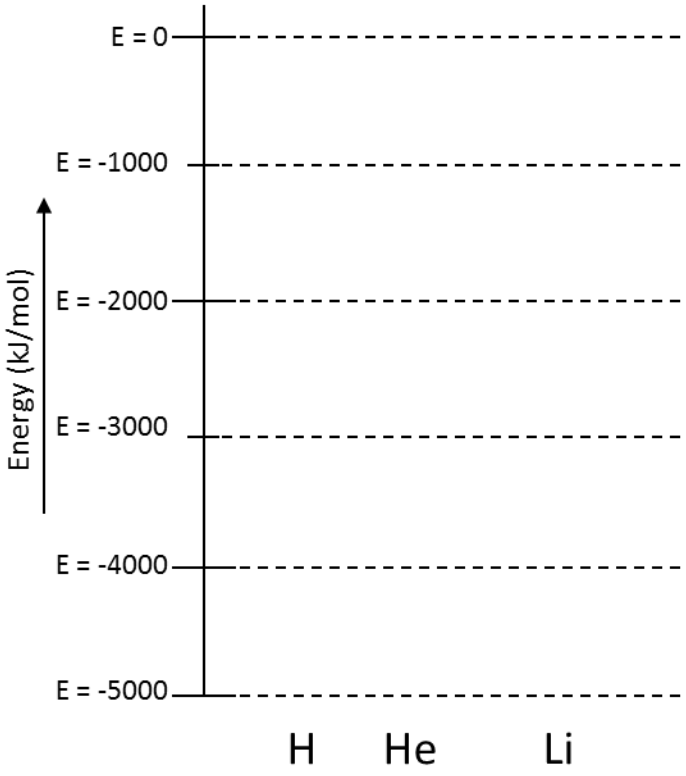


Figure 2

7. How does your diagram illustrate the relative ease with which an electron can be removed from hydrogen and from helium? Which one is easier to remove?

8. Predict an approximate value for the first ionization energy for lithium. Do not add your prediction to Figure 2 just yet. Justify your prediction based on Question 2.

9. The value of the first ionization energy of lithium is 520 kJ/mol. Add this value for lithium to Figure 2 above. Based on comparisons you made in Question 2, how would you explain the ionization energy for lithium compared to the ionization energy for helium? Compared to hydrogen?

10. Predict the relative value of the energy necessary to remove a second electron (called the second ionization energy) from lithium. Support your prediction with an explanation.

11. Based on the first ionization energies for hydrogen, helium, and lithium that you represented in Figure 2, what can you say about the distance of the electrons from their respective nuclei in these three atoms?

12. The first ionization energies for selected elements from the second period of the periodic table follow:

Atom	$_{3}$**Li**	$_{4}$**Be**	$_{6}$**C**	$_{7}$**N**	$_{9}$**F**	$_{10}$**Ne**
Ionization Energy (kJ/mol)	520	899	1086	1302	1681	2081

Explain the trend in ionization energies in terms of the relative location of the electrons and the charge of the nucleus.

13. The first ionization energy for the element sodium is given in the following table. Predict the other values for the first ionization energy for the selected third period elements:

Atom	$_{11}$**Na**	$_{12}$**Mg**	$_{14}$**Si**	$_{15}$**P**	$_{17}$**Cl**	$_{18}$**Ar**
Ionization Energy (kJ/mol)	495					

How did you arrive at your predictions?