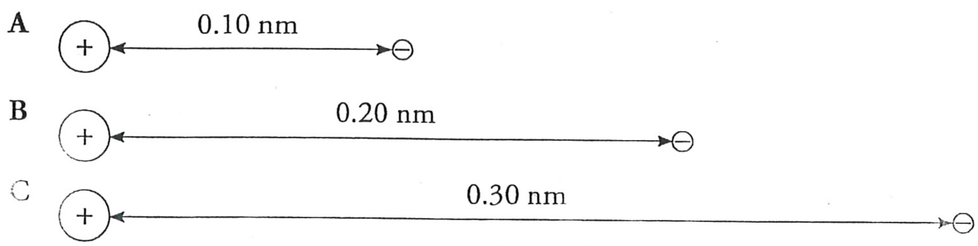
Coulombic Attraction and Periodic Trends

Coulombic attraction is the attraction between oppositely charged particles. For example, the protons in the nucleus of an atom have attraction for the electrons surrounding the nucleus. This is because the protons are positive and the electrons are negative. The attractive force can be weak or strong. In this activity, you will explore the strength of attraction between protons and electrons in various atomic structures and then relate that to periodic trends like atomic size, ionization energy and electron affinity.

Model 1: Distance and Attractive Force



Force of Attraction (Newtons)

A: 2.30×10^{-8}

B: 0.58×10^{-8}

C: 0.26×10^{-8}

1. What do the symbols (+) and (-) represent?

   proton — electron

2. What relationship is shown in Model 1? Be as specific as possible.

   as ↑ distance ↓ force of attraction

3. If the distance between a proton and electron is 0.50 nm, would you expect the force of attraction to be greater than or less than 0.26×10^{-8} N? Why?

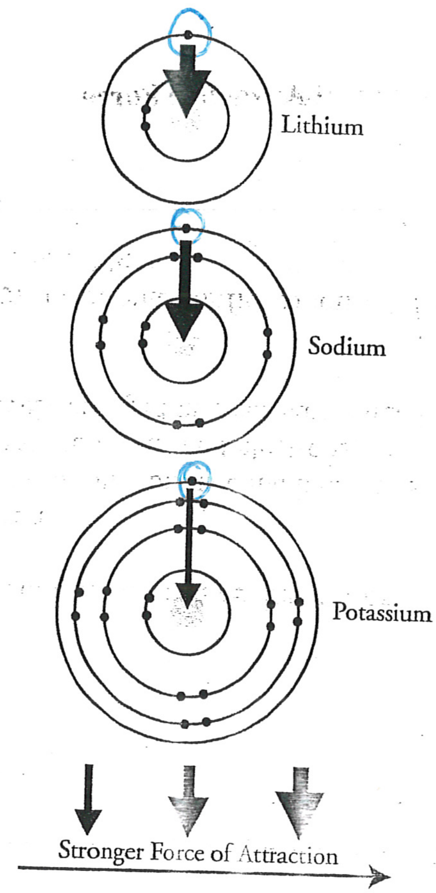
   less than (see #2) ∴ inversely prop.

4. If two protons are 0.10 nm away from one electron, would you expect the force of attraction to be greater than or less than 2.30×10^{-8} N? Why?

   p, p —0.1nm— e-

   might be slighty greater b/c more (+) charge "pulling" e-

Model 2: The Alkali Metals



1. Consider the diagrams in Model 2, what do the arrows, and the thickness of the arrows represent?

length = distance Thickness = strength of attraction

2. Are the atoms in the same group or same period?

3. What trend exists for size?

as ↓ group ↑ size (↑ n)

4. Circle the outermost electron in each of the atoms in Model 2. see above.
   a. As you move from the smallest atom to the largest atom in Model 2, how does the distance between the outermost electron and the nucleus change?

   ~~incr~~ increases

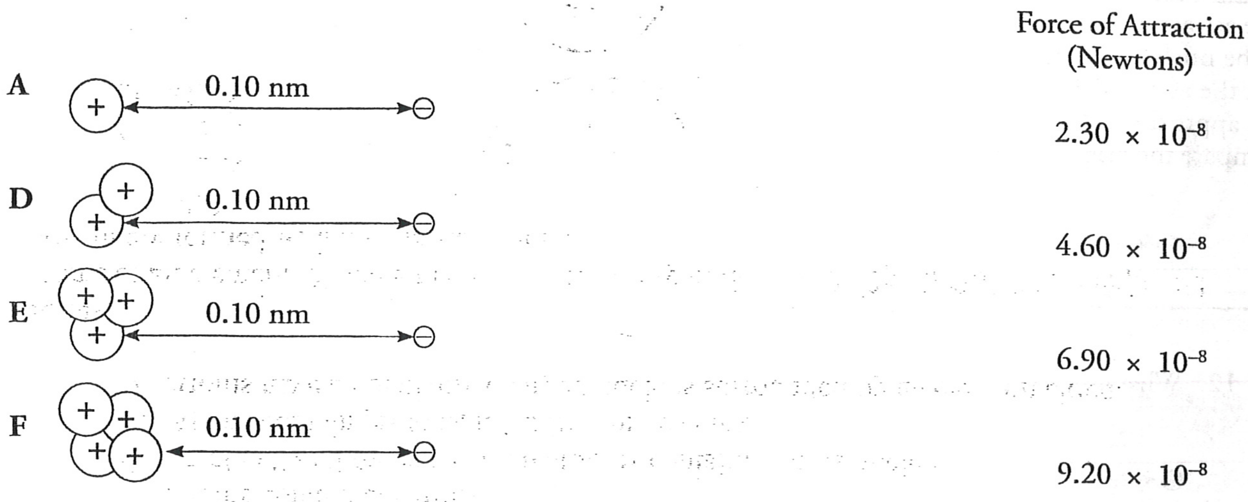
   b. As you move from the smallest atom to the largest atom in Model 2, how does the attractive force between the outermost electron and the nucleus change?

   decreases.

   c. Are your answers to parts a and b consistent with the information from Model 1? What is the trend for size as related to the force of attraction and distance?

↑ size, ↑ distance from nucleus, ↓ force of attraction

Model 3: Number of Protons and Attractive Force



1. Consider the data in Model 3, write a statement that describes the relationship shown.

if d same, but ↑ # ⊕ (protons), ↑ force of attraction

2. What would be the attractive force on a single electron if 5 protons were in the nucleus of an atom? Show mathematical work to support your answer. if 0.1 nm...

(5+) . . . . e⁻

1p: 2.30×10^{-8} 2p: 4.60×10^{-8} → doubled so (×5)

3. Image that a second electron was placed to the left of a nucleus containing 2 protons. Predict the force of attraction on both the original electron and the second electron. Explain your prediction.

(2p+) ——— e⁻

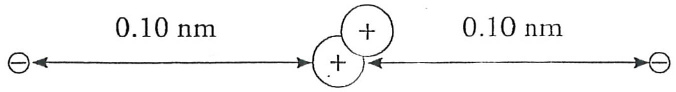
not sure what they are asking?

4. Circle your answer:

As protons are added to the nucleus, nuclear charge (increases/decreases) and, therefore, the force of attraction (increases/decreases). If force of attraction is large, size will most likely be (large/small).

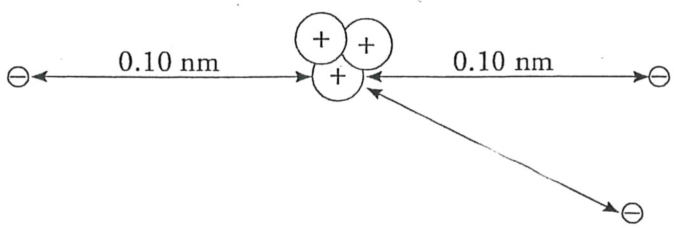
Read This!

The attractive and repulsive forces in an atom are rather complex. An electron is attracted to the protons in the nucleus, but it is also repelled by the other electrons in the atom. It is important to note however that the attractive force of the nucleus is NOT divided up among the electrons in the atom. Each electron gets approximately the full attractive force of the nucleus (minus the repulsive effects of other electrons). Compare the diagram below to set D in Model 3. Notice the similarity in attractive force.



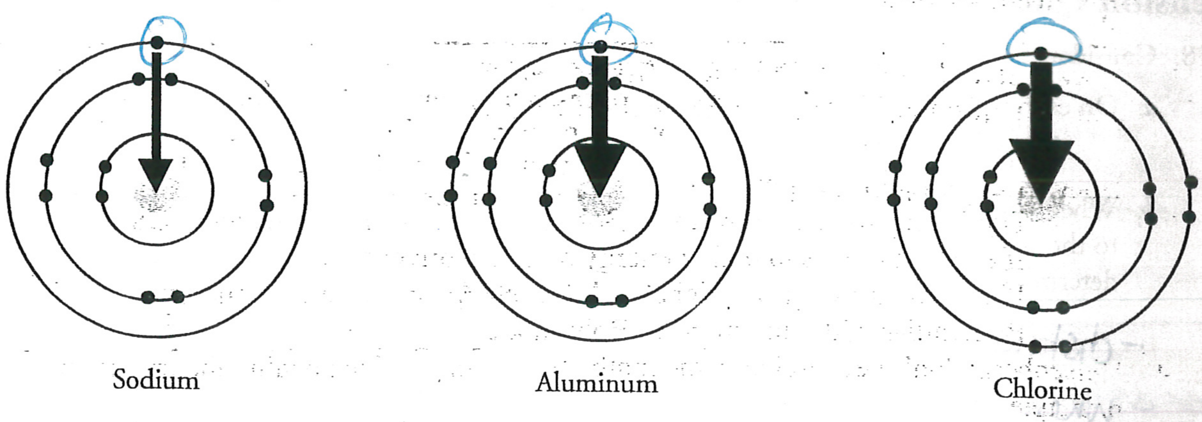
approx. 4.60×10^{-8}
(on each electron)

12. What is the approximate attractive force on each electron below?



6.90×10^{-8} N

Model 4 – Period 3 Elements



13. Using the periodic table, locate the elements whose atoms are diagrammed in Model 4. Are the elements in the same group or the same period? What is the trend for size w/in group?

↓group, ↑size ; across per ↓size. w/in period

14. Circle the outermost electron(s) in each of the atoms in Model 4.

b/c of n (principle q.n.) b/c of Z (effective) nuclear charge

15. Which of the three atoms diagrammed in Model 4 has the strongest attraction for its outermost electron(s)?

Cl (smallest) bk most p in nucleus (largest Z)

16. Consider the information in Model 4.

a. As you move from the smallest atom to the largest atom, does the distance between the outermost electron(s) and the nucleus change significantly?

no b/c n same

b. Can the differences in the attractive force shown by the arrows be explained by a change in the distance between the electron(s) and the nucleus?

no; its Z (#p)

c. On the diagrams in Model 4, write the number of protons located in the nucleus of each atom.

Na = 11 Al = 13 Cl = 17

d. Can the differences in attractive forces shown by the arrows in Model 4 be explained by a change in the number of protons in the nucleus? If yes, explain the relationship in Model 4.

↑Z ↑ attractive forces

17. For each set of elements below, circle the element whose atoms will have a stronger attractive force between their outermost electron(s) and the nucleus. Why did you pick the one you picked?

a. Ba and Ca *b.* Cr and Cu *c.* Ar and Xe

larger smaller
Coulomb
↑d ↓F

smaller bk of Z (greater nuclear charge, same n)

size | Coulomb

Extension Questions

18. Consider the atom diagrams in Model 2.

    a. On each diagram write the number of protons in the nucleus of the atom.

    Li = 3   Na = 11   K = 19

    b. When comparing elements in the same column of the periodic table, which factor—distance to the nucleus or number of protons in the nucleus—seems to be the dominant factor for determining the attractive force between the outermost electron(s) and the nucleus? Explain.

    - distance (Coulomb)
    - when do math $Z_{eff} = Z - S$ fairly constant down a group

19. Consider the data presented in Models 1 and 3.

    a. Describe the mathematical relationship between the distance (*d*) and the attractive force (*F*) between protons and electrons.

    as ↑d ↓F (Coulomb)

    b. Describe the mathematical relationship between the number of protons in the nucleus (*Z*) and the attractive force (*F*) between the nucleus and electrons.

    as ↑Z ↑F (greater inward pull if n same)

20. How does force of attraction influence

    a. ionization Energy (E to remove e-)

    as ↑F, harder to remove e- (E_{ion} = endo so E_{ion} get more ⊕)

    b. electron affinity (E to add e-)

    as ↑F, easier to add e-
    (e⁻ aff = ⊖/exo. as ↑F, get more ⊖/easier to add)