

1. Given the distance between the proton and the electron, estimate the probability of finding the electron in a small volume =  $0.8 \text{ pm}^3$  for a ground state H atom
- The volume is centered at a distance of  $10 \text{ pm}$  from the nucleus in the  $+y$  direction.
  - If you move the volume further from the nucleus, to  $25 \text{ pm}$  in the  $+y$  direction, how does the probability of finding the electron change, does it increase or decrease? Please carefully explain your answer.

a).

$$\vec{r} = \langle 0, 10, 0 \rangle$$

$$\|\vec{r}\| = 10 \times 10^{-12} \text{ m}$$

$$\psi_{1s} = 2 \left( \frac{z}{a_0} \right)^{3/2} e^{-\sigma} \sqrt{\frac{1}{4\pi}}$$

$$z = 1$$

$$\sigma = \frac{zr}{a_0} = \frac{10 \times 10^{-12}}{a_0}$$

$$a_0 = 0.529 \times 10^{-10} \text{ m}$$

$$\text{Probability} = |\psi_{1s}|^2 \cdot \text{Volume} = 4 \left( \frac{1}{a_0} \right)^3 e^{-\frac{20 \times 10^{-12}}{a_0}} \left( \frac{1}{4\pi} \right) \cdot 0.8 \times 10^{-36} = 1.179 \times 10^{-6}$$

- b. The probability would decrease because as  $r$  increases, the ~~probability~~ probability found of finding the electron decreases. The electrons are more likely to be ~~found~~ close to the nucleus, rather than far away. Mathematically, increasing  $r$  also decreases the probability

$$\text{when } r = 25 \times 10^{-12} \text{ m}$$

$$\text{Probability} = |\psi_{1s}|^2 \cdot \text{Volume} = 4 \left( \frac{1}{a_0} \right)^3 e^{-\frac{50 \times 10^{-12}}{a_0}} \left( \frac{1}{4\pi} \right) \cdot 0.8 \times 10^{-36} = 6.685 \times 10^{-7}$$

$$\text{Probability @ } r = 25 \times 10^{-12} \text{ m} = 6.685 \times 10^{-7} < \text{Probability @ } r = 10 \times 10^{-12} \text{ m} = 1.179 \times 10^{-6}$$

It's more likely to find the electron with volume centered at

$\langle 0, 10, 0 \rangle$  than at  $\langle 0, 25, 0 \rangle$

+100

2. Predict the larger ion in each of the following pairs. Please carefully explain your answers?

- a.  $F^-$  or  $Cl^-$
- b.  $Li^+$  or  $Be^{2+}$
- c.  $K^+$  or  $Sr^{2+}$
- d.  $Ca^{2+}$  or  $Sr^{2+}$

a.  $Cl^-$  will be larger because it has an extra ~~valence~~ electron shell.

b.  $Li^+$  would be larger because it would have a smaller positive charge in the nucleus, and thus not exert as strong of a pull on the electrons as a  $Be^{2+}$  ion. Lithium has 3 protons while Be has 4 protons so Be would pull the electrons closer, creating a smaller ion. ~~Also, the~~ ~~both lose their valence shell~~ Also, they have the same number of electron shells, so only the nucleus charge needs to be taken into account.

c.  $Sr^{2+}$  would be larger because it has an extra electron shell.

d.  $Sr^{2+}$  would be larger because it has an extra electron shell.