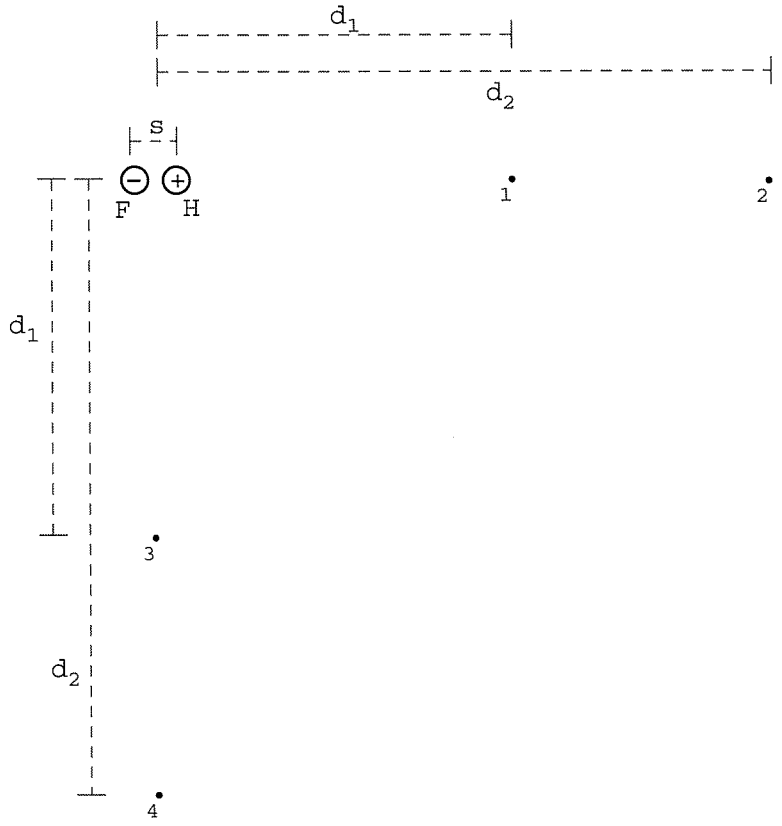
Physics 2212 Spring 2015 Lab Quiz #3

Name: Key Section: _____

Show all work clearly and in order, and box your final answers.

An HF molecule in the gas phase has an internuclear separation s. We can consider the molecule to be composed of two point charges, H^+ and F^-, with charges $+e$ and $-e$ respectively.



1. (*25 points*) Calculate the potential difference $V_2 - V_1$, where locations 1 and 2 are shown on the diagram above. The distances d_1 and d_2 are much larger than the internuclear separation s. Make sure the sign of your answer is correct. Show all of your work.

$|E_{\text{dipole axis}}| \approx \frac{1}{4\pi\epsilon_0}\frac{2qs}{r^3}$

$\Delta V = -\int_i^f \vec{E}\cdot d\vec{l}$ $\qquad \vec{E}\cdot d\vec{l} = E\,dl$

$= -\int_{d_1}^{d_2} \frac{1}{4\pi\epsilon_0}\frac{2qs}{r^3}\,dr$

$= \frac{1}{4\pi\epsilon_0}\frac{qs}{r^2}\Big|_{d_1}^{d_2}$

$= \frac{es}{4\pi\epsilon_0}\frac{[d_1^2 - d_2^2]}{d_1^2 d_2^2}$ $\qquad < 0$ as it should be!

$q = e.$

2. (*25 points*) What is the potential difference $V_2 - V_\infty$? Where V_∞ is located at $x = \infty$ Briefly explain your reasoning.

$$\Delta V = -\int_i^f \vec{E}\cdot d\vec{l} \qquad \vec{E}\cdot d\vec{l} = E\,dl$$

$$= -\int_\infty^{d_2} \frac{1}{4\pi\epsilon_0}\frac{2qs}{r^3}\,dr$$

$$= \frac{qs}{4\pi\epsilon_0 d_2^2}$$

$$= \frac{es}{4\pi\epsilon_0 d_2^2} > 0 \quad \text{as it should be!}$$

Note: @ ∞ the potential is defined to be zero.

3. (*25 points*) What is the potential difference $V_3 - V_4$? Locations 3 and 4 are on a line extending throught he midpoint of the molecule. Explain your reasoning.

$$\Delta V = -\int_i^f \vec{E}\cdot d\vec{l} \qquad |E_{\text{dipole}}| \approx \frac{1}{4\pi\epsilon_0}\frac{qs}{r^3}$$

$\perp$

But $\vec{E}\cdot d\vec{l} = 0$ (the electric field is $\perp$ to the path taken)

i.e. $\vec{E}\cdot d\vec{l} = 0$

Therefore, $\Delta V = 0$.

4. (*25 points*) What is the potential difference $V_4 - V_\infty$? Where V_∞ is located at $y = -\infty$ Briefly explain your reasoning.

Again, $\Delta V = 0$ because $\vec{E}\cdot d\vec{l} = 0$.

Same reason as #3.