Name____

Physics 121 Quiz #2, January 15, 2016

Please show all work, thoughts and/or reasoning in order to receive partial credit. The quiz is worth 10 points total.

I affirm that I have carried out my academic endeavors with full academic honesty.

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Suppose that a Fe^{+3} (iron +3e ion) is located at a point P located at $\langle 0,400,0 \rangle nm$ in space and that a HF molecule is located at the origin with the H^+ ion located on the negative x-axis and the F^- ion located on the positive x-axis. The magnitude of the dipole moment of HF is $|\vec{p}| = 6.36\times10^{-30}\,Cm$.

a. What is the electric force on the Fe^{+3} due to the electric dipole HF at the origin?

$$\vec{E} = \left\langle \frac{kqs}{r^3},0,0 \right\rangle = \left\langle \frac{kp}{r^3},0,0 \right\rangle = \left\langle \frac{9\times10^9 \frac{Nm^2}{C^2}\times 6.36\times10^{-30}\,Cm}{\left(400\times10^{-9}\,m\right)^3},0,0 \right\rangle$$

$$\vec{E} = \langle 0.89,0,0 \rangle \tfrac{N}{C}$$

$$\vec{F} = q\vec{E} = (3e)\vec{E} = \left(3\times1.6\times10^{-19}\,C\right)\langle 0.89,0,0 \rangle \tfrac{N}{C}$$

$$\vec{F} = \left\langle 4.29\times10^{-19},0,0 \right\rangle N$$

b. What is the polarizability of HF ?

$$p = qs = \alpha E \rightarrow \alpha = \frac{p}{E} = \frac{6.36\times10^{-30}\,Cm}{0.89\,\frac{N}{C}} = 7.15\times10^{-30}\,\frac{Cm}{N/C}$$

From the literature: https://www.princeton.edu/~fhs/paper97/paper97.pdf, the polarizability of HF is $\alpha = 8.20\times10^{-31}\,\frac{Cm}{N/C}$.

c. Suppose that the Fe^{+3} were replaced by a Cu^{+2} ion located the same point P in space. The net force on the Cu^{+2} ion due to the HF molecule located at the origin would be

1. the same magnitude as the force on the Fe^{+3} ion but in the opposite direction.
2. the same force as on the Fe^{+3}.
3. greater for the Cu^{+2} ion than for the Fe^{+3} ion.
4. lower for the Cu^{+2} ion than for the Fe^{+3} ion.

Physics 121 Equation Sheet

Electric Forces, Fields and Potentials

$$\vec{F} = k\frac{Q_1Q_2}{r^2}\hat{r}; \quad \hat{r} = \frac{\vec{r}_o - \vec{r}_s}{|\vec{r}_o - \vec{r}_s|}$$

$$\vec{E} = \frac{\vec{F}}{q}$$

$$\vec{E}_Q = k\frac{Q}{r^2}\hat{r}$$

$$\vec{p} = q\vec{s} = \alpha\vec{E}$$

$$\left|\vec{E}_{\parallel}\right| = \frac{2kqs}{r^3}; \text{ dipole } r >> s$$

$$\left|\vec{E}_{\perp}\right| = \frac{kqs}{r^3}; \text{ dipole } r >> s$$

Constants

$$g = 9.8\,\tfrac{m}{s^2}$$

$$1e = 1.6\times10^{-19}\,C$$

$$k = \frac{1}{4\pi\varepsilon_o} = 9\times10^{9}\,\tfrac{Nm^2}{C^2}$$

$$\varepsilon_o = 8.85\times10^{-12}\,\tfrac{C^2}{Nm^2}$$

$$1eV = 1.6\times10^{-19}\,J$$

$$\mu_o = 4\pi\times10^{-7}\,\tfrac{Tm}{A}$$

$$c = 3\times10^{8}\,\tfrac{m}{s}$$

$$h = 6.63\times10^{-34}\,Js$$

$$m_e = 9.11\times10^{-31}\,kg = \frac{0.511 MeV}{c^2}$$

$$m_p = 1.67\times10^{-27}\,kg = \frac{937.1 MeV}{c^2}$$

$$m_n = 1.69\times10^{-27}\,kg = \frac{948.3 MeV}{c^2}$$

$$1amu = 1.66\times10^{-27}\,kg = \frac{931.5 MeV}{c^2}$$

$$N_A = 6.02\times10^{23}$$

$$Ax^2 + Bx + C = 0 \rightarrow x = \frac{-B\pm\sqrt{B^2-4AC}}{2A}$$