CEM 882, Problem Set 3 – Due Tuesday, February 25 – Please email a pdf to weliky@chemistry.msu.edu

Please show all units in each step of every calculation.

1.

a. (15 points) Consider the Bohr Hydrogen atom with counterclockwise electron orbit in the $\boldsymbol{x}$-$\boldsymbol{y}$ plane with initial position $\boldsymbol{r}(0) = -a_0\boldsymbol{y}$. The angular frequency of the orbit is ω. Derive an expression for the position of the electron at some later time t, $\boldsymbol{r}(t)$, in terms of a_0, ω, t, $\boldsymbol{x}$, and $\boldsymbol{y}$.

b. (20 points) Consider radiation described by an electric field $\boldsymbol{E}(t) = E_0\cos(\omega t)\,\boldsymbol{x}$. Consider the energy of the electron as U with $\mathrm{d}U(t) = -\boldsymbol{F}(t) \cdot \mathrm{d}\boldsymbol{r}(t)$. Derive an expression for $\mathrm{d}U(t)$ for the electron in the radiative electric field in terms of e, a_0, ω, E_0, and $\mathrm{d}t$.

c. (10 points) Derive an expression for the average $\langle \mathrm{d}U \rangle$ for one period of the electron orbit in terms of e, a_0, ω, E_0, and $\mathrm{d}t$.

d. (15 points) Calculate ω in units of s^{-1} to two significant figures for the Bohr Hydrogen atom in the $n_e = 1$ state.

e. (10 points) Use your **c** and **d** results to numerically calculate $\langle \mathrm{d}U/\mathrm{d}t \rangle$ for one period of the electron orbit for one Hydrogen atom in units of J/s and to two significant figures. You should consider that $E_0 = 10^5$ V/m and you should use the $n_e = 1$ state.

f. (15 points) Use your **e** result to calculate the time in units of s to two significant figures for sufficient radiative energy to be absorbed so that the hydrogen atom could change from the $n_e = 1$ to the $n_e = 2$ states.

g. (10 points) Is your **f** result qualitatively reasonable or is it not qualitatively reasonable? Provide a reasoned explanation for your choice.