BCHM485 Graded HW#3 (20 points) Due date/time: April 9, 2025 by 11:59pm

Consider an excited state of hydrogen atom with electron in the 3p orbital with m_l=1. Answer the following questions. You don't need to provide fully numerical answers – they can be expressed via a combination of numerical factors and physical constants, like e, $\hbar$, ε_o, a_o, etc

A. Write the expression for the probability density to find the electron at a given point (r,θ,ϕ) in the 3D space. (You may leave the numerical factors as they are: no need to reduce or calculate them.)

B. In which point(s) in the 3D space within the atom you are unlikely to find the electron?

C. At what distance from the nucleus you are most likely to find the electron? (If you have problems finding the answer analytically through derivative, you can try to answer this question by graphing the corresponding probability)

D. Calculate the average potential energy of the electron in this orbital and compare it with the total energy in this state. Does the relationship ($<V> = 2E$) we derived in class for the 1s orbital still hold?

E. What is the smallest quantum of energy required for this electron to leave the atom?

The following table integral could be useful for some calculations: $\int_0^\infty x^m e^{-ax} dx = \frac{m!}{a^{m+1}}$