Problem Set 6

Problems

1. Calculate the ratio of the electrical and gravitational forces between a proton and an electron. Is the neglect of gravitational force justified when dealing with the Hydrogen atom problem?

2. From the handout provided in class, determine the associated Laguerre Polynomial when \( n = 4 \) and \( l = 3 \).

3. The Laguerre polynomials are defined as:
\[
L_n(z) = e^z \frac{d^n}{dz^n} (e^{-z} z^n)
\]
with the Associated Laguerre polynomial being given by:
\[
L_n^l(z) = \frac{d^l}{dz^l} L_n(z)
\]
Use these definitions to determine \( L_2 \) and \( L_2^1 \).

4. What is the value of the azimuthal quantum number \( l \) for an \( m \) orbital?

5. How many nodes exist in a \( 5p \) orbital? How many occur in the Radial Wave function?

6. Find \( \langle r \rangle \) for the \( 2p_0 \) state of a Hydrogen atom. Express your answer in units of \( a_o \).

7. For the \( n = 4 \) state of Hydrogen, what is the total degeneracy?

8. Calculate the Ionization Potential for \( B^{5+} \).

9. Calculate the adsorption frequencies for the transition from the \( 1s \) to the \( 2p \) states for \( H \) and \( \text{He}^{+} \).

10. The first Balmer Line of the Hydrogen discharge spectrum (\( \lambda = 656.47 \) nm) has a very faint satellite line that occurs at \( \lambda = 656.29 \) nm. What is the origin of this line? Verify your prediction quantitatively.