MSE228 Engineering Quantum Mechanics
Quiz 3 Duration: 30 minutes Open Book Quiz

1. The shortest wavelength of the hydrogen Lyman series is 91.13 nm. Find the three longest wavelengths in this series. (Hint: The shortest wavelength is the series limit)

Lynman Series $\frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{n^2}\right)$

Shorthest wavelength $\Rightarrow$ series limit $\Rightarrow n \to \infty$ $\frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{\infty^2}\right)$

$\frac{1}{\lambda} = R$, $\lambda_{shorthest} = \frac{1}{R} = \frac{1}{1.097373 \times 10^7 m^{-1}} = 91.127 \, nm$

other wavelengths; $\frac{1}{\lambda} = R\left(\frac{n^2-1}{n^2}\right) \to \lambda = \frac{1}{R}\left(\frac{n^2}{n^2-1}\right) = (91.127 nm)\frac{n^2}{n^2-1}$

1st longest wavelength; $n=2$ $\lambda = (91.127 nm)\frac{2^2}{2^2-1} = 121.5 \, nm$

2nd longest wavelength; $n=3$ $\lambda = (91.127 nm)\frac{3^2}{3^2-1} = 102.5 \, nm$

3rd longest wavelength; $n=4$ $\lambda = (91.127 nm)\frac{4^2}{4^2-1} = 97.2 \, nm$

2. In the n = 3 state of hydrogen (for Bohr model), find the electron's radius, velocity, kinetic energy, and potential energy.

kinetic energy, and potential energy.

$R_n = n^2\left(\frac{h^2 \varepsilon_0}{\pi m e^2}\right) = n^2 a_0 = n^2 (0.53 \times 10^{-10} m)$; $v_n = \sqrt{\frac{1}{4\pi\varepsilon_0} \frac{e^2}{m R_n}}$

$KE_n = \frac{1}{2} m v_n^2 = \frac{1}{2} m \frac{1}{4\pi\varepsilon_0} \frac{e^2}{m R_n}$; $PE_n = -\frac{1}{4\pi\varepsilon_0} \frac{e^2}{R_n}$

$\Rightarrow R_{n=3} = 9 a_0 = 9(0.53 \times 10^{-10} m) = 0.477 \, nm$

$v_{n=3} = \sqrt{\frac{1}{4\pi (8.85 \times 10^{-12} C^2/Nm^2)} \frac{(1.602 \times 10^{-19} C)^2}{(9.1 \times 10^{-31} kg)(0.477 \times 10^{-10} m)}} = 7.29 \times 10^5 m/s$

$KE_{n=3} = \frac{1}{8\pi (8.85 \times 10^{-12} C^2/Nm^2)} \frac{(1.602 \times 10^{-19} C)^2}{0.477 \times 10^{-10} m} = 2.42 \times 10^{-19} J = 1.51 \, eV$

$PE_{n=3} = -\frac{1}{4\pi (8.85 \times 10^{-12} C^2/Nm^2)} \frac{(1.602 \times 10^{-19} C)^2}{0.477 \times 10^{-10} m} = -4.84 \times 10^{-19} J = -3.02 \, eV$