Quiz 8.1 – Hydrogenic Atoms

Name: Key

Hydrogen Atomic Emission

Below are the four visible light hydrogen atomic emission line wavelengths. Convert them into energy units of wavenumbers (cm^{-1}), and identify each transition's starting and ending states

$E = \frac{1}{\lambda}$

Wavelength (nm)	656	486	434	410
Energy (cm^{-1})	15,244	20,576	23,041	24,390
States	$2 \leftarrow 3$	$2 \leftarrow 4$	$2 \leftarrow 5$	$2 \leftarrow 6$

Consider the same transitions in a hydrogenic C ion (C^{5+}). Give the transition energies and wavelengths for the same transitions in this ion.

Energy (cm^{-1})	549,000	741,000	829,000	878,000
Wavelength (nm)	18.2	13.5	12.1	11.4

$E_{C,n} = \frac{-hc \cdot 36 \cdot \tilde{R}}{n^2}$

$E_{C,n} = 36 \cdot E_{H,n}$

Atomic Orbitals

Give the number of angular and radial nodes for each of the following atomic orbitals:

$3s$	$3d$	$4p$	$6f$	$6s$	$3p$
A: Ø R: 2	A: 2 R: Ø	A: 1 R: 2	A: 3 R: 2	A = Ø R = 5	A = 1 R = 1

$A = \ell$

$R = n - \ell - 1$

The radial node of a $2s$ wavefunction splits the orbital into two parts, like an onion with only two layers.

For a hydrogen atom, the $2s$ atomic orbital is: $\Psi = N_{2s}\left(2 - \frac{r}{a_0}\right)e^{-r/2a_0}$

Give the radial distance to the first radial node (you may express your answer in terms of the Bohr radius)

$\Psi = \emptyset$ @ $r = 2a_0$

Suppose you wanted to compare the probabilities of finding a $2s$ electron inside or outside of the radial node. Give the integrals you would evaluate to find those probabilities (you don't have to solve them, but if your curiosity grips you it shouldn't be too difficult to do so)

$P_{inner} = N_{2s}^2 \int_0^{\pi} d\phi \int_0^{2\pi} \sin\theta\, d\theta \int_0^{2a_0} \left[\left(2 - \frac{r}{a_0}\right)e^{-r/2a_0}\right]^2 r^2 dr$

$\hookrightarrow$ 5.26%

$P_{outer} = N_{2s}^2 \int_0^{\pi} d\phi \int_0^{2\pi} \sin\theta\, d\theta \int_{2a_0}^{\infty} \left(2 - \frac{r}{a_0}\right)^2 e^{-r/a_0} r^2 dr$

$\hookrightarrow$ 94.74%