

Laboratory Exercise: The Electronic Structures of the Hydrogen Atom, Part 3 and Helium

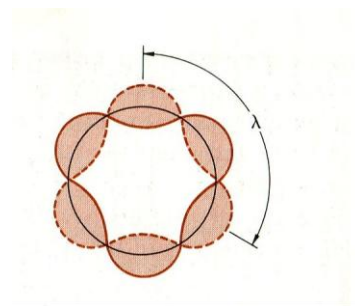
In this exercise we will examine the wave model of the Hydrogen and Helium atoms. In this model, the electron is treated as a wave "orbiting" the nucleus. In order to avoid destructive interference, the "orbiting" electron's wave must form a standing wave. The standing waves possible give rise to *s*, *p*, *d*, *f*, etc. orbitals that provide us with the probable position of the electron within the atom.

In the case of the Hydrogen atom, we can envision a one dimensional electron wave orbiting the nucleus at radii corresponding to the Bohr orbits. As previously noted, Neils Bohr was able to determine the radii of the electron's discrete orbits as:

$$r \text{ [nm]} = 0.052917 n^2 \quad n = 1, 2, 3, \dots$$

In order to establish a standing wave, the circumference of the electron's orbit must be such that it is an integral multiple of the electron's wavelength.

$$n \lambda = 2\pi r \quad n = 1, 2, 3, \dots$$



Physics, Paul A. Tipler

So, if we know the electron's orbit, we can determine its wavelength. Applying the prescription of Louis de Broglie, we can then determine the velocity (*v*) of the electron where the electron is now treated as a particle.

$$\lambda = h / mv$$

$m = 9.1095 \times 10^{-31}$ kg is the mass of the electron and h is Planck's constant 6.626×10^{-34} J sec.

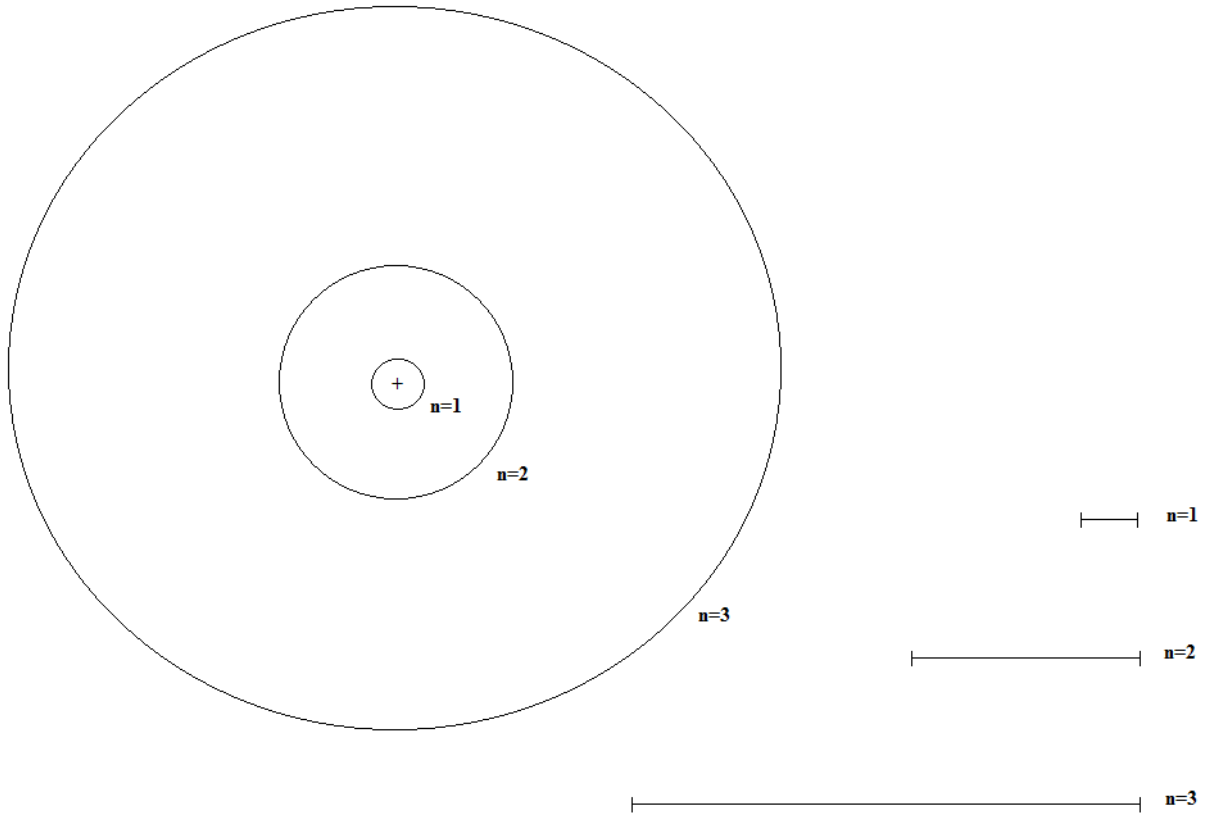
Data Analysis

One Dimensional Wave Model of the Hydrogen Atom

Use your previously determined Bohr orbit radii for the Hydrogen atom to calculate:

- i) the electron's wavelength.
- ii) the electron's velocity.

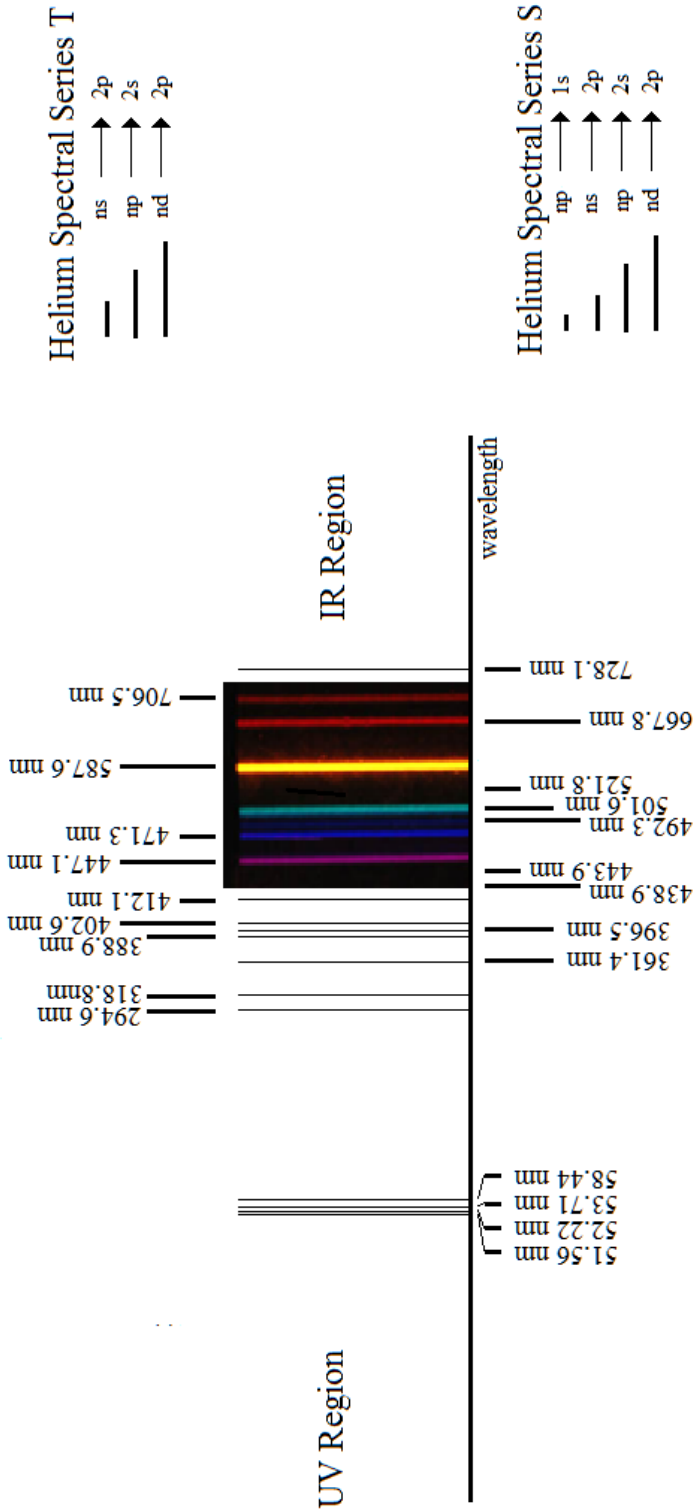
Additionally, sketch the one dimensional standing wave pattern for the electron for each orbit.



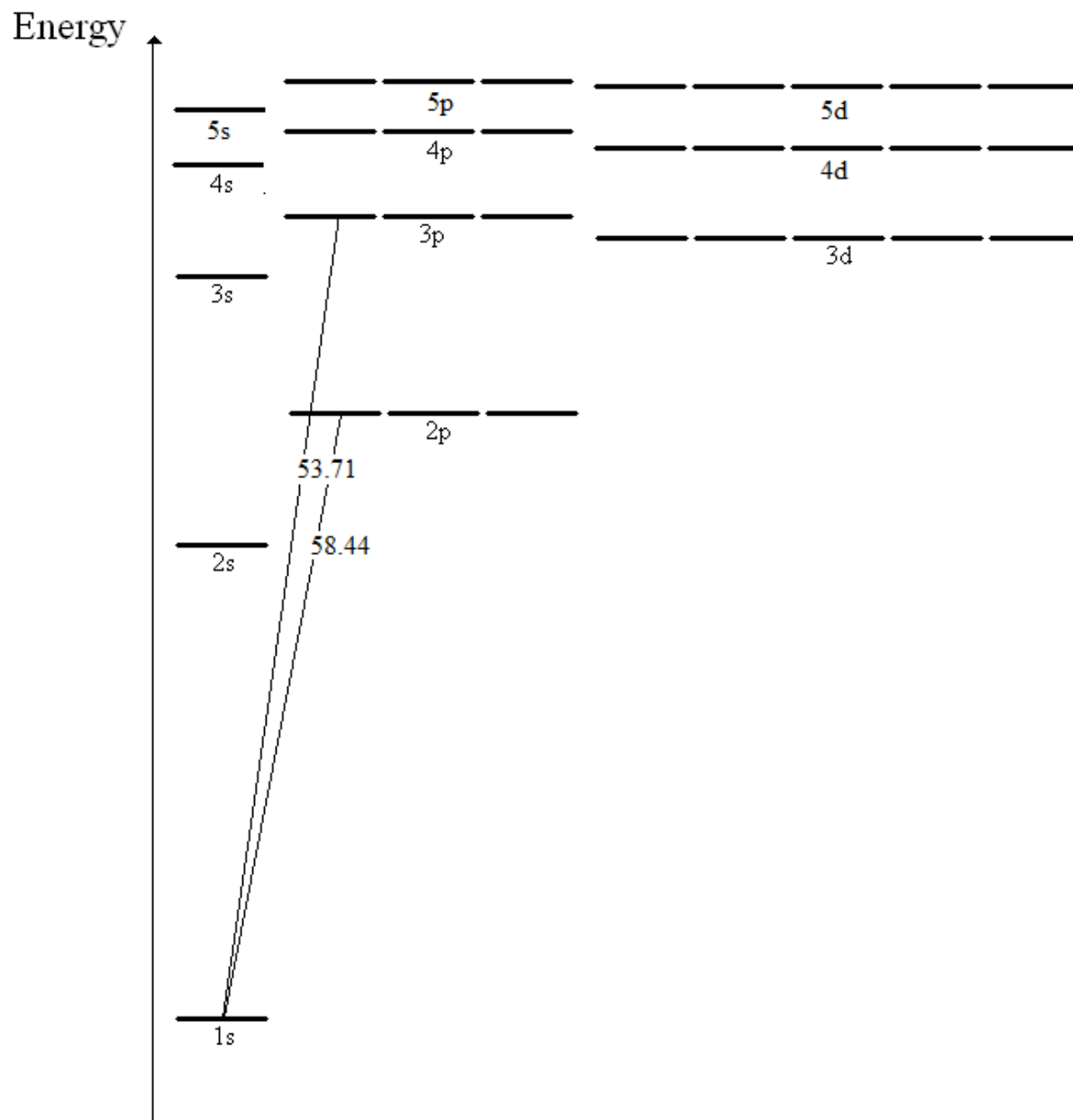
n	λ [m]	v [m/s]

Wave Model of the Helium Atom

Consider the Partial Spectrum of Helium.



Identify all the spectral transitions on the energy diagram below. (I've started this process for the 58.44 nm and 53.71 nm spectral lines.)



Now, assume the energy of the Ground State of the Helium atom is zero. Use the appropriate spectral lines to determine the indicated energies. (Again, I have started this process for you.)

