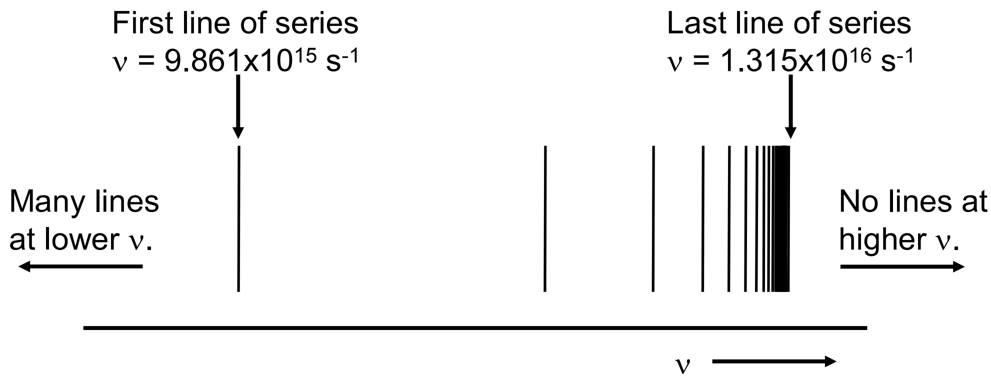
Quiz 10
CHEM 325
Spring 2009

Name: ____

1. (8 Points) A portion of the He^+ emission spectrum is shown below. Determine the value of R_H in joules.



Since there are no other series at higher *n*, the last line of the series must correspond to the highest energy transition that the electron can make, namely the $n = \infty$ to $n = 1$. We can write this energy difference as the difference in two terms, one with $n = \infty$ and the other with $n = 1$, as follows.

$$\Delta E = E_1 - E_\infty = \left(-\frac{R_H Z^2}{1^2}\right) - \left(-\frac{R_H Z^2}{\infty^2}\right) = -R_H Z^2 = -4R_H$$

The negative sign is irrelevant because it simply shows that the atom is losing energy (i. e., this is an emission). Applying the Bohr frequency condition yields $h\nu = \Delta E = 4R_H$ **and** $R_H = \frac{h\nu}{4}$**.**

Substituting gives

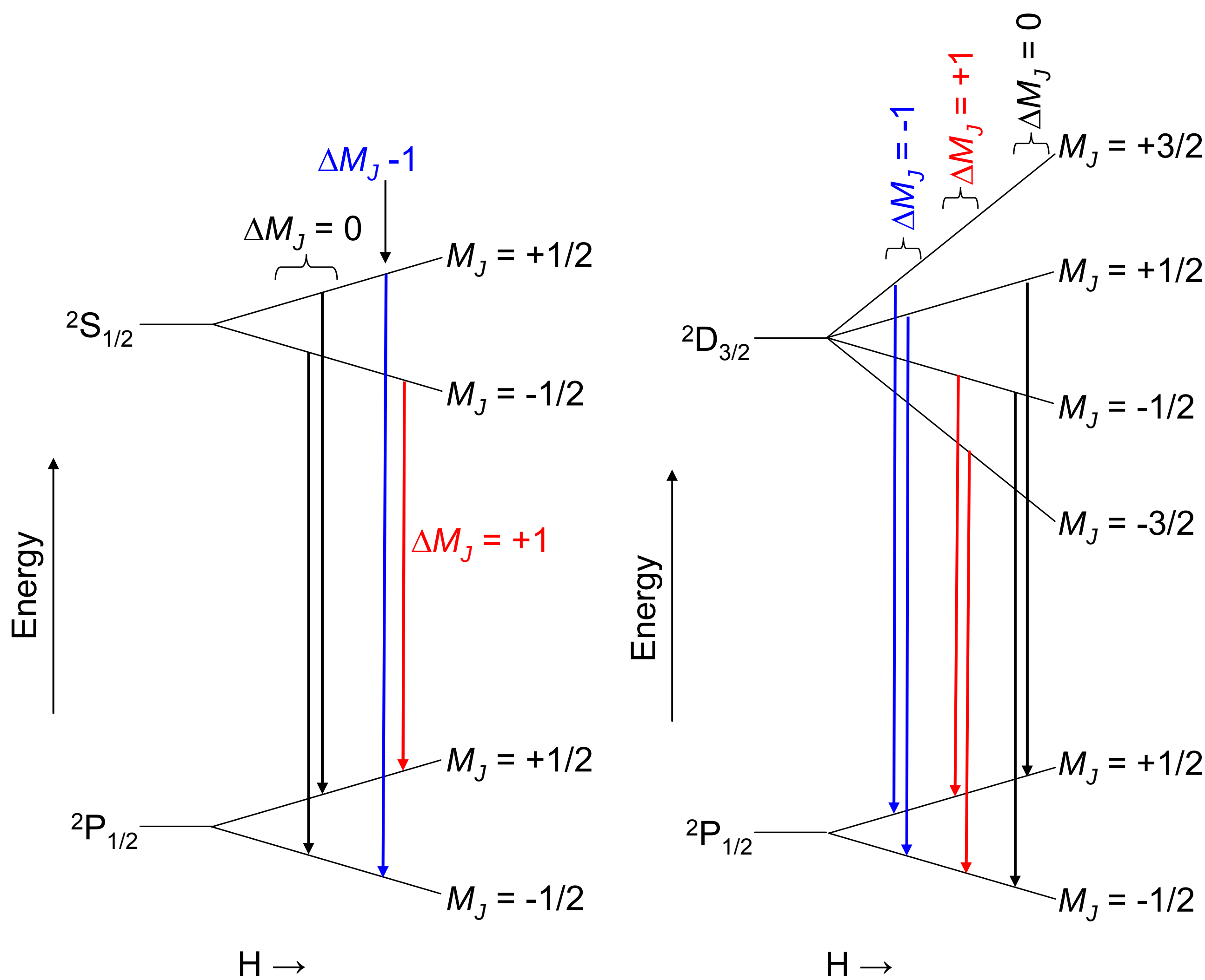
$$R_H = \frac{h\nu}{4} = \frac{(6.62608x10^{-34}\ \text{J·s})(1.315x10^{16}\ \text{s}^{-1})}{4} = 2.178x10^{-18}\ \text{J}$$

Thus R_H equals $2.178x10^{-18}$ J.

2a. (3 Points) Two intense transitions have been observed in the emission spectrum of gaseous B which have been assigned as the $^2P_{1/2} \leftarrow {}^2S_{1/2}$ and the $^2P_{1/2} \leftarrow {}^2D_{3/2}$ transitions. Explain how the intensity of the peaks alone did not give enough information to definitively assign these transitions.

The $^2P_{1/2} \leftarrow {}^2S_{1/2}$ has $\Delta S = 0$, $\Delta L = +1$ and $\Delta J = 0$, while the $^2P_{1/2} \leftarrow {}^2D_{3/2}$ transition has $\Delta S = 0$, $\Delta L = -1$ and $\Delta J = 0$. Both transitions are fully allowed and are expected to be very intense. Unless very precise intensity measurements and very accurate theoretical calculations were made, it is unlikely that we would be able to distinguish any difference between the intensity of these transitions.

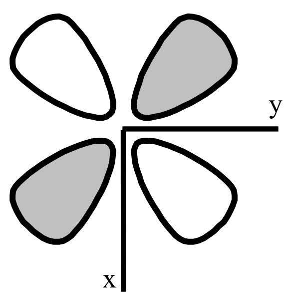
b. (7 Points) Using the templates given below, draw what happens to each of the terms with increasing magnetic field. Indicate the Zeeman-allowed transitions.

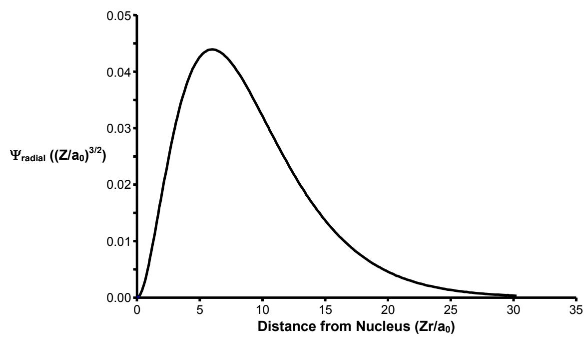


c. (3 Points) Explain how the Zeeman effect will allow you to distinguish between the $^2P_{1/2} \leftarrow {}^2S_{1/2}$ and the $^2P_{1/2} \leftarrow {}^2D_{3/2}$ transitions in gaseous B.

> **In a magnetic field the $^2P_{1/2} \leftarrow {}^2S_{1/2}$ transition will split into as many as four lines (depending on the *g* values in the ground and excited states it may be possible for there to be some overlap of lines, and thus fewer lines then we expect), while the $^2P_{1/2} \leftarrow {}^2D_{3/2}$ transition will split into as many as six lines (again, depending on the *g* values for the ground and excited states). It is simply a matter of getting the magnetic field strong enough and a spectrometer with sufficient resolution to resolve the splitting to assign which line goes with which transition based on the number of lines it splits into in a magnetic field.**

3. (7 Points) Fill in the blanks for the wavefunction shown below. Note that for the angular part of the wavefunction you are looking at it from above (the z axis is coming out of the page at you).





a. Number of angular nodes = **2**

b. Number radial nodes = **0**

c. For this orbital $\boldsymbol{\ell}$ = **2**, and possible m_ℓ for this $\boldsymbol{\ell}$ are **±2, ±1, 0**.

d. This orbital's complete name is $\mathbf{3d_{xy}}$.

e. What term symbol would result if this were the only orbital occupied in the H atom? $\mathbf{^2D_{5/2}}$ *or* $\mathbf{^2D_{3/2}}$

Since there is only one electron, the orbital part of the term is the same as the occupied orbital (in this case, D) and because there is only one electron $m_S = M_S = S = 1/2$, so the multiplicity is 2. The possible values of J range from $L + S, L + S - 1, \ldots, |L - S|$, which when $L = 2$ and $S = 1/2$ are 5/2 and 3/2 ($|L - S| = L + S - 1 = 3/2$). Thus, we have two possibilities either $^2D_{5/2}$ or $^2D_{3/2}$, but they are degenerate in the hydrogen atom because there are no electron-electron interactions.