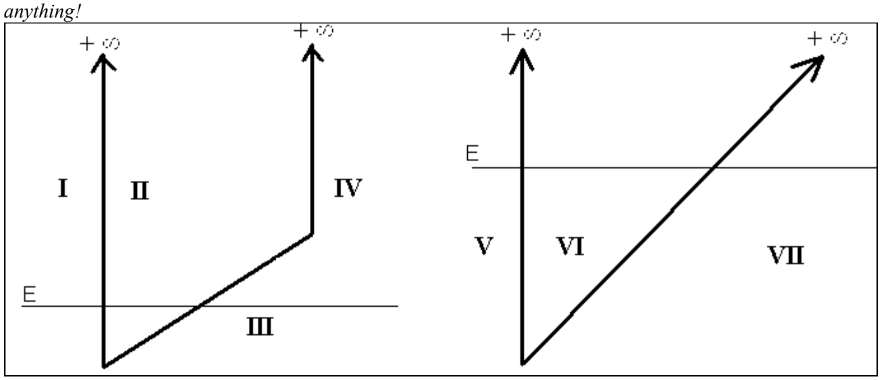
PHYS-309(2) (Kaldon-21722) **Name** ____
WMU - Winter 2000
Exam 3 - 100,000 points

3/30/2000•Rev.4

State Any Assumptions You Need To Make – Show All Work – Circle Any Final Answers
Use Your Time Wisely – Work on What You Can – Be Sure to Write Down Equations
Feel Free to Ask Any Questions

Going to the Well Once Too Often (50,000 points)

1.) Sketches of two angled well potentials and what a wavefunction ψ might look like are shown below. For each of the Regions I, II, III, IV, V, VI, VII, *briefly* indicate what is going on and why. *Do not attempt to solve anything!*



I.

II.

III.

IV.

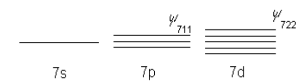
V.

VI.

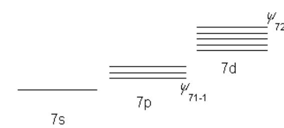
VII.

Bohring Atoms (50,000 points)

2.) (a) In the Bohr atom, there is only one quantum number n. Therefore one cannot talk about transitions inside the $n = 7$ state, only between states n and n'. In the Q.M. hydrogen solution, we can have 7s, 7p, 7d, 7f, 7g, 7h or 7i electrons, but they all have the same energy and we still cannot make a transition inside the $n = 7$ state. However – if we apply a magnetic field (Zeeman effect), we can split the orbits to show each of the m_L. What are the allowed transitions from the 7d electron ψ_{722} to any 7p state?



(b) Same problem as (a), but for the general Q.M. model.



(c) In the *Sample Exam Problems*, Dr. Phil gave a list of seven (7) allowed transitions between 5s and 1s for the general Q.M. model. Turns out that there are more than seven. Find these other transition paths.
Hint: The order of the states from lowest energy to highest is 1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p, 5s.

1.) 5s → 4p → 4s → 3p → 3s → 2p → 1s
2.) 5s → 4p → 4s → 3p → 1s
3.) 5s → 4p → 4s → 2p → 1s
4.) 5s → 4p → 3s → 2p → 1s
5.) 5s → 4p → 1s
6.) 5s → 3p → 3s → 2p → 1s
7.) 5s → 3p → 1s

Below are the functional forms of the Q.M. hydrogenic atom solutions through $n = 3$.

n	l	m_l	Eigenfunction
1	0	0	$A_{100}e^{-Zr/a_0}$
2	0	0	$A_{200}\left(2-\frac{Zr}{a_0}\right)e^{-Zr/2a_0}$
2	1	0	$A_{210}\left(\frac{Zr}{a_0}\right)e^{-Zr/2a_0}\cos\theta$
2	1	±1	$A_{21\pm1}\left(\frac{Zr}{a_0}\right)e^{-Zr/2a_0}\sin\theta e^{\pm i\varphi}$
3	0	0	$A_{300}\left(27-18\frac{Zr}{a_0}+2\frac{Z^2r^2}{a_0^2}\right)e^{-Zr/3a_0}$
3	1	0	$A_{310}\left(6-\frac{Zr}{a_0}\right)\frac{Zr}{a_0}e^{-Zr/3a_0}\cos\theta$
3	1	±1	$A_{31\pm1}\left(6-\frac{Zr}{a_0}\right)\frac{Zr}{a_0}e^{-Zr/3a_0}\sin\theta e^{\pm i\varphi}$
3	2	0	$A_{320}\frac{Z^2r^2}{a_0^2}e^{-Zr/3a_0}(3\cos^2\theta-1)$
3	2	±1	$A_{32\pm1}\frac{Z^2r^2}{a_0^2}e^{-Zr/3a_0}\sin\theta\cos\theta e^{\pm i\varphi}$
3	2	±2	$A_{32\pm2}\frac{Z^2r^2}{a_0^2}e^{-Zr/3a_0}\sin^2\theta e^{\pm 2i\varphi}$

Source: Quantum Physics of Atoms, Molecules, Nuclei and Particles / Robert Eisberg and Robert Resnick. New York: John Wiley & Sons, 1974. *aka* "The Silver Bullet".

(d) Write down (but do not solve) the complete integral to find the expectation value of $\langle r \rangle$ for ψ_{322}.
$dV = r^2 \sin\varphi\, dr\, d\theta\, d\varphi$. If you don't remember how to find $\langle r \rangle$, write down the integral to normalize ψ_{322} instead (and take a 3000 point deduction).

(e) Using the results from the Bohr atom, what might be the expectation value of $\langle r \rangle$ for ψ_{322}?

A Blank Worksheet for your convenience…