Physical Chemistry II
Problem Set 3
Due Friday, March 7, 2008 (at 4 p.m.)
Total Number of Points = 65

Notes: (1) The answers to most of these problems are in the back of the book. However, you must justify your answers to receive credit. (2) You are free to check your symbolic integration and differentiation using a program like Mathematica, but you must justify your work on the paper you turn in.

1. (12 points) Atkins and de Paula Problem 8.14. (postponed from Problem Set 1)
   - Do only part (a) (the normalization) and treat only wavefunction (ii)
   - Use the hint in Problem 8.13. (You should not need this hint at this point in the semester!)
   - Anticipate the need to invoke a fundamental trigonometric identity and using a trigonometric substitution to perform an integral. Alternatively, you can look up the integral in a CRC Handbook (but it is better if you know how to do the trig substitution).
   - Final answer: $N = \sqrt{\frac{1}{32\pi a_o^5}}$
2. (4 points) Atkins and de Paula Exercise 9.17b. Report actual numerical values for the angular momenta (in J s) to four significant figures. (One of the answers in the back of the book is slightly wrong.)

3. (16 points) Atkins and de Paula Problem 9.23 (a) and (c) (we did part (b) in class).

4. (12 points) Atkins and de Paula Problem 9.24. Since the spherical harmonics do not depend on *r*, you should not integrate over *r*. Show any trig substitution required to do the integral.

5. (5 points) Atkins and de Paula Exercise 10.8b. Briefly justify your answers. Report the orbital angular momenta in units of $\hbar$. Note that some of the answers in the back of the book are wrong (or at least incorrectly formatted).

6. (16 points) Predict whether the electron in a hydrogen atom is closer to the nucleus on average when the electron occupies a 2*s* or a 2*p* orbital. Assume that $a = a_o$ (the Bohr radius). Since the radial wavefunctions do not depend on θ or ϕ, do not integrate over these angles.