

**Physical Chemistry II**  
**Problem Set 2—due Friday, February 22, 2008 (at 4 p.m.)**  
Total Number of Points = 65

Notes: (1) Write all numbers with the correct number of significant figures and units. Avoid rounding errors by writing intermediate results with additional subscripted non-significant figures. (2) Assume all zeroes to the left of the decimal place are significant (unless told otherwise). For example, 100 V has three significant figures (and should therefore have been written by Atkins and de Paula as 100. V or  $1.00 \times 10^2$  V). (3) The answers to most of these problems are in the back of the book. However, you must justify your answers to receive credit.

1. (26 points) Atkins and de Paula Problem 8.7.
  - This problem is based on the precise definitions of uncertainties in  $x$  and  $p$  (equation 8.36b in the textbook), which we (should have) discussed in class on Monday, February 11.
  - This problem is long, but far from impossible. Just be careful in your algebra.
  - You will need to look up definite integrals in the CRC Handbook. Again, be careful in applying the formulas in the Handbook to your particular integrals.
  - If an integral is zero by symmetry, just say so (and briefly explain your reasoning)—you are not required to work the integral out!
  - Answer:  $\langle x \rangle \langle p \rangle = \frac{\hbar}{2}$ . That is, a Gaussian wavefunction represents the minimum possible mutual uncertainties in  $x$  and  $p$  in quantum mechanics.
2. (9 points) Atkins and de Paula Problem 8.18. Be sure to justify your answers completely. Answers: (a)  $\cos^2 \chi$ ; (b)  $\sin^2 \chi$ ; (c)  $\psi = 0.95e^{ikx} \pm 0.32e^{-ikx}$
3. (6 points) Atkins and de Paula Exercise 9.5b. You should use a little calculus to solve this problem.
4. (3 points) Atkins and de Paula Exercise 9.8b.
5. (4 points) Atkins and de Paula Exercise 9.16a. Even if you don't have the International Edition of Atkins and de Paula, you should be able to find the normalization constant in the body of Chapter 9.
6. (6 points) Atkins and de Paula Exercise 9.16b.

Problem Set 2 continues on the back.

7. (11 points) Atkins and de Paula Problem 9.12.

- Start by confirming that the given function is a solution of the Schrodinger equation for a harmonic oscillator in general. Then confirm that it specifically describes the ground state of a harmonic oscillator.
- Answer:  $g = \frac{\sqrt{km}}{2\hbar}$