

CHEM 482, sec 0102. Homework #4-5

Due date: Mon, May 3, 2004, 10am

A printed or hand-written homework (no electronic versions please) is due no later than 10am Mon, Apr 12, 2004. It can be handed in during the class (after the lecture). If you are unable to come to the class, please bring it to my office at any other time before the deadline.

Problem 1. (20 points)

The state of a system is given by the (unnormalized) wavefunction $\Psi = e^{ia\phi - bx^2}$. The available space covers the range from $-\infty$ to ∞ in x and from 0 to 2π in ϕ .

(a) Normalize the wavefunction.

(b) Find the expectation values for the following operators.

$$\hat{x}^2$$

\hat{p}_x^2 (x-component of the linear momentum operator)

\hat{l}_z (z-component of the angular momentum operator)

Problem 2. (20 points)

Consider rotational states of a diatomic molecule, e.g. H_2 . The energy difference between the energy levels with $l = 1$ and $l = 2$ of the molecule is $E(2) - E(1) = 243.3 \text{ cm}^{-1}$.

(a) From these data determine the bond length in H_2 .

(b) What will be the energy difference between the same rotational levels for a half-deuterated (HD) and fully deuterated (D_2) molecule. Assume that the bond length does not change upon deuteration.