

## Modern Physics : PHYS 5811

### Midterm I

NAME:\_\_\_\_\_

1) Compute the leading order relativistic correction to the 1-d harmonic oscillator spectrum. Use the formula for relativistic energy  $E = \sqrt{p^2c^2 + m^2c^4} \sim mc^2 + p^2/2m - p^4/(8m^3c^2) + \dots$  and ignore the constant  $mc^2$ .

You may recall that  $\hat{p} = i\beta(a^\dagger - a)$  where  $\beta = \sqrt{m\hbar\omega/2}$ .

- a.) Compute  $\langle n|H^{(1)}|n \rangle$  and use it to determine the first-order energy shift in the spectrum of  $H$ .
- b.) Compute  $\langle n + 1|H^{(1)}|n \rangle$

2) A Hückel theory model of a binary covalent bond between  $A$  and  $B$  (one electron each) has the following data. (1) The binding energy of the electron to an isolated  $A$  is 6eV and the binding energy of the electron to the isolated  $B$  is 3eV. (2) When they form a molecule, the hopping term in the Hückel Hamiltonian has a magnitude of 2eV.

Use these data to compute the heat of formation per molecule  $AB$ .

3) (BRIEF Answer)

- a) What is the physical cause of the fine structure splitting?
- b) What is the nuclear size shift...tell me also what states it shifts and what states it doesn't.
- c) A deuteron (deuterium nucleus) is spin 1. Describe the hyperfine structure of deuteron spectrum.