Physics 449 **HOMEWORK SET 4** **Spring 2009**

Due Wednesday February 18

15) Calculate the exchange energy, $\Delta E_{\rm EX} = \langle \phi_{1s}(1)\phi_{2s}(2)|v_{ee}|\phi_{2s}(1)\phi_{1s}(2)\rangle$, for the $(1s)^1(2s)^1$ configuration of helium. This calculation can be done using the same procedure we used in class to find $\Delta E_{\rm DIR}$ for the helium ground state. [Hint: The correct answer is $\Delta E_{\rm EX} = \frac{2^4}{3^6}\frac{Z}{a_0}\frac{e^2}{4\pi\epsilon_0}$.]

16) The direct energy contribution for the $(1s)^1(2s)^1$ configuration of helium is given by $\Delta E_{\rm DIR} = \frac{17}{81}\frac{Z}{a_0}\frac{e^2}{4\pi\epsilon_0}$. Using this result together with your result from problem 15 above, predict the energies of the "singlet" ($S = 0$) and "triplet" ($S = 1$) $(1s)^1(2s)^1$ states of helium. The measured energies are -57.37 eV for the singlet and -59.17 eV for the triplet.

17) Use the variational method to obtain an upper bound on the energy of the ground state of a particle in a potential well $V(x) = C\,x$ for $x \geq 0$ and $V(x) = \infty$ for $x \leq 0$. Use a trial wave function $\psi(x) = Nxe^{-\alpha x}$ for $x \geq 0$ and $\psi(x) = 0$ for $x \leq 0$, where α is the variational parameter.

18) Gasiorowicz Problem 14-9.

19) Gasiorowicz Problem 14-11.