PHYSICS 4E QUIZ 4 SPRING QUARTER 2017
PROF. HIRSCH JUNE 5

Show all steps in your calculations. Justify all answers. Write clearly.
Suggestion: do the problems you find easiest first

Some constants: $hc = 12,400 eVA,\ \ k_B = 1/11,600 eV/K,\ \ m_e c^2 = 511,000 eV$

$\hbar c = 1973 eV\Lambda \quad ; \quad ke^2 = 14.4 eV\Lambda \quad ; \quad 1\Lambda = 10^{-10} m \quad ; \quad m_{neutron} c^2 = 939.6 MeV$

$\hbar^2/m_e = 7.62 eVA^2 \qquad \mu_B = 5.79 \times 10^{-5} eV/T$

Problem 1 (10 pts)
There are 7 electrons in a two-dimensional square box of side length L. Electrons have spin 1/2 and obey the Pauli principle, for this problem we assume that they don't interact with each other and that there is no spin-orbit coupling. When light of wavelengths in the range 1,000A<λ<10,000A is incident on this box, the longest wavelength photon that is absorbed has wavelength 4122A.
(a) What is the length L, in A?
(b) What is the second longest wavelength photon that can be absorbed by this system?

Problem 2 (10 pts)
An electron in a hydrogen-like ion is described by the wavefunction
$\psi(r,\theta,\phi) = Cr^2 e^{-r/a_0} \sin\theta\cos\theta e^{-i\phi}$
(a) Give the values of the quantum numbers n, ℓ, m_ℓ and of the ionic charge Z. Justify your answers.
(b) Find the most probable value of r for this electron and compare with the Bohr atom result.
(c) Taking spin-orbit coupling into account, what are the possible values of the total angular quantum number j for this electron? What are the possible values of m_j?

Problem 3 (10 pts)
The ground state energy of a one-dimensional harmonic oscillator is 0.01 eV.
(a) At what temperature is the average energy of this system 0.02 eV?
(b) At the temperature found in (a), what is the average energy of this system predicted by the equipartition theorem? Is it higher or lower than what was found in (a)? Why?
(c) For a 3-dimensional solid where the atomic vibrations are modeled by such harmonic oscillators, by how much does the molar heat capacity differ from the Doulong-Petit value C_V=3R at the temperature found in (a)? Give your answer in percent. Is it higher or lower than the Doulong-Petit value?