Physics 390 Fall 2004: Exam #1 Practice

These are a few problems comparable to those you will see on the exam. They were picked from previous exams. I will provide a sheet with useful constants and equations for the exam.

1: The energy reaching the Earth from the Sun at the top of the atmosphere is described by the ‘Solar Constant’: 1360 W/m^2. The radius of the Earth is 6.4x10^6m. Assume that the Earth radiates like a blackbody at a uniform temperature.

a) What value would you estimate for the equilibrium temperature of the Earth?
b) What would be the peak wavelength for thermal emission from the Earth?

2: An electron is trapped in an infinitely deep one-dimensional potential well. The width of the well is 10^{-9}m.

a) Write an expression for the solutions to the Schrodinger equation for this potential. Your solutions need not be normalized, but they should meet the boundary conditions appropriate for this potential well.
b) Draw the wave function for the n=5 state.
c) What is the difference in energy between the n=4 and the n=5 state?

3: In a repeat of the Davisson and Germer electron diffraction experiment a beam of electrons with kinetic energy of 54 eV are fired at a clean surface of Nickel.

a) What is the wavelength of these electrons?
b) If the Ni atoms are arranged in a regular cubic lattice with a spacing of 0.45 nm, what is the largest angle at which a strong signal of scattered electrons will be seen?

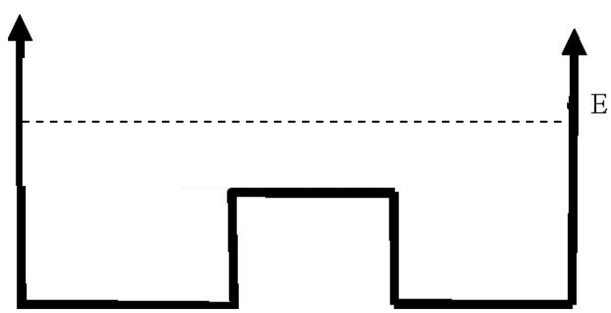
4: X-rays tubes used in dentist's offices often have an accelerating voltage of 80 kV.

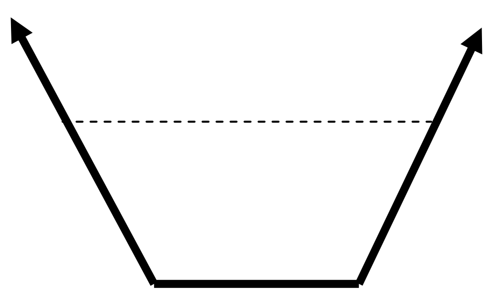
a) What is the minimum wavelength such an x-ray tube can produce?

b) What is the maximum wavelength such an x-ray can have after Compton scattering off an electron inside your tooth?

c) Estimate the maximum wavelength such an x-ray can have after scattering off a calcium nucleus in your tooth. A calcium nucleus contains 20 protons and 20 neutrons.

5: Draw qualitative wavefunctions which represent solutions to the Schroedinger equation for particles with the energies shown confined by the following potentials. Please note with words any particular features you wish to stress.





6: One solution for a particle in a one dimensional infinite square well of width L which extends from x=0 to x=L is:

$\psi 2(x) = [\sqrt{(2/L)}]\sin(2\pi x/L)$ This is a properly normalized wave function. That is $\int \psi 2^{*} \psi 2 dx = 1$. The operator for the momentum is $Op = (\hbar/i)\partial/\partial x$.

a) Calculate the expectation value for the momentum <p>

b) Calculate the expectation value for the momentum squared $<p^2>$

c) What is the uncertainty in the momentum Δp for this state?

d) Show that this is roughly the value you would expect from the Heisenberg uncertainty principle.

In answering these you may find the following relation useful:

$\sin A \cos B = ½[\sin(A+B) + \sin(A-B)]$