Physics 8D/Harpell

Quiz 2

Show all your work! If you do not completely understand a question, write down your assumptions and then answer what you believe is being asked! Partial credit will be given. Read over the entire quiz before beginning. The quiz is due by 5 pm on Friday either in building 100 or under my office door.

1. **Black body spectra (12 pts**)

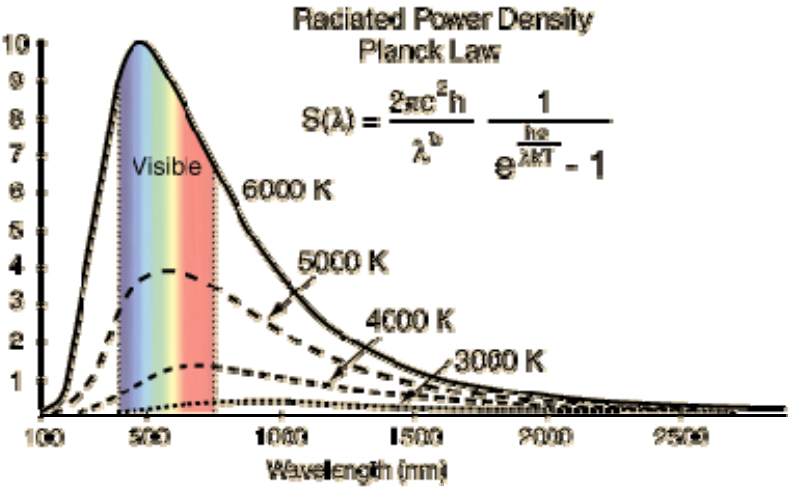
a) What are the peak wavelengths of a black body at 6000, and 4000 K respectively? 3 pts

b) How much more energy per do an objects of the same size radiate at 6000 K compared with an object at 5000 Kelvin. Note this is the total energy at all wavelengths. Hint: once again, the easy way has already been figured out! 3 pts

c) The graph of a blackbody spectrum u(λ, T) for various perfect "black bodies" are shown below. Note that in words, u(λ, T) is equal to the energy per unit volume, per unit wavelength at Temperature T. Based on the sketch below, how would the **visible** energy output of a typical incandescent light bulb at 4000 K compared with one at 6000 K. 2 pts

d) The **fraction** of energy per unit volume emitted by an object at 6000 Kelvin between 400 and 700 nm is 0.37. In other words, the amount of energy emitted in the visible portion of the spectrum is 37% of the total energy emitted. Write down a relation that would demonstrate this if solved (See extra credit at end of exam if you are dying to solve this) 2 pts

u(λ,T)=
4S(λ)/c



e) (*warning: the following problem is somewhat **challenging**—don't' get stuck yet!*)

Assuming the number of normal modes per unit volume are the same ($\frac{8\pi f^2}{c^2}$) what would be the new value of S(λ) be if Plank had decided that the energy for an oscillator was $E = nhf^2$ instead of nhf, where n is an integer and f is the frequency of the oscillator? *Your notes will be useful here!* 2 pts.

2. **The semi-classical atom** ***12 pts***

A photon is emitted from a hydrogen atom that makes an electronic transition from n= 4 to n = 2. :

a) Calculate the energy and wavelength of the photon emitted 5 pts

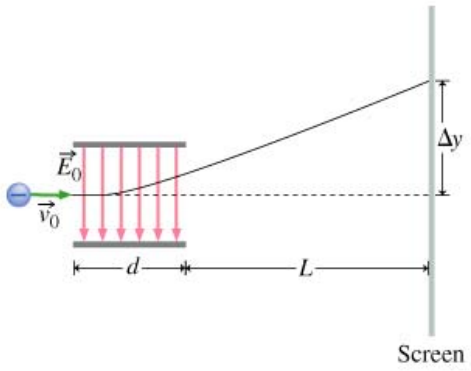
b) Calculate the recoil speed of the nucleus 5 pts

3. **A scattering of short questions**: 11 pts

a) A proton accelerated through a potential difference V and comes with a distance d = 0.1872 nm of the center of nucleus of Iron (Z = 26) before stopping. What is the potential difference V? 4 pts

b) In a Compton scattering experiment, photons of wavelength 0.1 angstroms are incident on free electrons. What wavelengths do the photons have if they are reflected directly back to the source? 3 pts

c) an electron with charge e and mass m_e is fired across a pair of parallel electrodes with Electric field E_o as shown below. Show that $\Delta y = \frac{LdeE_o}{m_e v_o^2}$. Assume that d is reasonably small compared with the distance L. 4 pts



4. Photoelectric effect 3 pts each.

When violet light with a wavelength 420 nm of falls on a certain metal surface, the maximum kinetic energy of the emitted photoelectrons is 2.1 eV.

a) What stopping potential would be required to stop all of the electrons ejected?
b) What is the longest wavelength of light that will still eject electrons when the surface is illuminated?

5. **The history of modernism**: Explain each in three sentences or less, using equations and diagrams where appropriate. 3 pts each

a) in what way did Einstein correct Planck in explaining blackbody radiation?
b) How did Bohr "correct" the classical model of the atom to explain the observed (Rydberg) spectrum?
c) How did De Broglie explain discreet or "quantized" atomic orbits?

Extra Credit up to five points possible.

a) Derive the Compton Relationship: $\lambda - \lambda' = \frac{h}{m_e c}(1 - \cos\theta)$

Where λ and λ' are the original and scattered wavelengths of a photon scattered off of stationary electrons, and θ is the angle that the photon is scattered.

b) Verify, by integration, the claim from Question 1, part (d) that 37% of the energy emitted by a black body at temperature 6000 Kelvin is in the visible part of the spectrum. Note that you may need to perform analytical and numerical integration. (Thus an integral table will be helpful!)