PY 451: Quantum Physics I   Problem Set 1

Due date: Friday, January 23, 2009, by 4:00pm

1. (Text 1-2) Given (1-6) in the text, calculate the energy density in a wavelength interval $\Delta\lambda$. Use your expression to calculate the value of $\lambda = \lambda_{\text{max}}$ for which this density is maximal. Show that λ_{max} is of the form b/T, calculate b and use 6000K as an estimate of the sun's surface temperature to calculate λ_{max} for solar radiation. [*Hint:* In calculating b you will need the solution for x in the equation $(5 - x) = 5\,e^{-x}$.]

2. Assume that the Sun is a black-body radiator with surface temperature 6000°K. Further assume that the Earth is also a black-body radiator that absorbs all the energy that it receives from the Sun and then re-radiates this energy at a temperature T_E to maintain a steady temperature. Using these facts, and basic astronomical data about the Earth and the Sun, determine the surface temperature of the earth, T_E. Comment on the reasonableness of your answer.

3. (Text 1-3) Ultraviolet light of wavelength $3500\AA$ falls on a potassium surface. The maximum energy of the photo-electrons is $1.6\,eV$. What is the work function of potassium?

4. Show that the ratio between the kinetic energy K of the recoil electron and the energy E of the incident photon in the Compton effect, when expressed in terms of the incoming photon frequency ν and outgoing photon scattered angle θ, is

$$\frac{K}{E} = \frac{\left(\frac{2h\nu}{m_e c^2}\right)\,\sin^2\frac{\theta}{2}}{1 + \left(\frac{2h\nu}{m_e c^2}\right)\,\sin^2\frac{\theta}{2}}\ .$$

5. (Text 1-8) A beam of X-rays is scattered by electrons at rest. What is the energy of the X-rays if the wavelength of the X-rays scattered at 60° to the beam axis is $0.035\AA$?

6. (Text 1-14) Use the Bohr quantization rules to calculate the energy states for a harmonic oscillator, for which the energy is $p^2/2m + m\omega^2 r^2/2$; that is, the force is $m\omega^2 r$. Restrict yourself to circular orbits. What is the analog of the Rydberg formula? Show that the correspondence principle is satisfied for all values of the quantum number n used in quantizing the angular momentum.