Problem Set 3: various and sundry

Instructions:

1. Answer all questions below. Show your work for full credit.
2. All problems are due Tues 12 February 2013 by the end of the day.
3. You may collaborate, but everyone must turn in their own work.

1. In an experiment to find the value of h, light at wavelengths 218 and 431 nm were shone on a clean sodium surface. The potentials that stopped the fastest photoelectrons were 5.69 and 0.59 V, respectively. What values of h and W, the sodium work function, are deduced?

2. A 0.3 MeV X-ray photon makes a "head on" collision with an electron initially at rest. Using conservation of energy and momentum, find the recoil velocity of the electron. Check your result with the Compton formula.

3. A cavity is maintained at a temperature of 1650 K. At what rate does energy escape from the interior of the cavity through a hole in its wall of diameter 1.00 mm?

4. Radio waves have a frequency of the order of 1 to 100 MHz. **(a)** What is the range of energies of these photons? **(b)** Our bodies are continuously bombarded by these photons. Why are they not dangerous to us?

5. An atom absorbs a photon of wavelength 375 nm and immediately emits another photon of wavelength 580 nm. What is the net energy absorbed by the atom in this process?

6. The Compton shift in wavelength $\Delta\lambda$ is independent of the incident photon energy $E_i = hf_i$. However, the Compton shift in *energy*, $\Delta E = E_f - E_i$ is strongly dependent on E_i. Find the expression for ΔE. Compute the fractional shift in energy for a 10 keV photon and a 10 MeV photon, assuming a scattering angle of 90°.

7. Assume the sun radiates like a black body at 5500 K. Assume the moon absorbs all the radiation it receives from the sun and reradiates an equal amount of energy like a black body at temperature T. The angular diameter of the sun seen from the moon is about 0.01 rad. What is the equilibrium temperature T of the moon's surface? (Note: you do not need any other data than what is contained in the statement above.

8. Presume the surface temperature of the sun to be 5500 K, and that it radiates approximately as a blackbody. What fraction of the sun's energy is radiated in the visible range of $\lambda = 400 - 700$ nm? One valid solution is to plot the energy density on graph paper and find the result numerically.

9. Show that it is impossible for a photon striking a free electron to be absorbed and not scattered.