CHEM 101: PROBLEM SET #2

Due: ***Wednesday, September 12, 2007 by 11 AM*.**

Turn in to the Chem 101 box at the beginning of lecture or if you want to turn it in early, the box will be in Kathy Kennedy's office, the Chemistry Department secretary (Chem 303).

> **Please show your work in detail.** Remember to include units on all numbers, and express your answers to the correct number of significant figures. If you have questions about significant figures, see pages 23-26 in Whitten. If you still have questions, see Maggie, Arwyn, Arthur, Randy, Wendy, or the Q Center tutors (DoJo). Unit conversion factors and values of physical constants are on the inside back cover of your book.

1. The human eye is a complex sensing device for visible light. The optic nerve needs a minimum of 2.0×10^{-17} J of energy to trigger a series of impulses that eventually reaches the brain.

   (a) How many photons of red light (700. nm) are needed?

   (b) How many photons of blue light (475 nm)?

2. The threshold energy required to remove an electron from a solid material is called the work function, ϕ. Work function values are given in Figure 1-10 of the Star Module for elements that are solids at room temperature. The units are electron volts (eV), where 1 eV = 1.6022×10^{-19} J.

   (a) What general trends do you observe in ϕ as a function of the location of the element in the periodic table? (Look down a column or across a row.)

   (b) If the energy of incoming radiation is *greater* than the work function, electrons will be emitted from a material. Which element(s) will emit electrons in response to blue light if the wavelength of blue light is 450 nm?

3. Rubidium (Rb) metal has a work function equal to 2.16 eV. (a) Assuming a 1 photon-1 electron interaction, how many photoelectrons, in principle, will be produced when Rb metal is illuminated with light having a wavelength of 475 nm and delivering a *total* energy of 8.386×10^{-16} J? (b) How much kinetic energy does any one photoelectron in this instance carry away? (c) What is the velocity (in m/s) of the photoelectron? *Hint:* To see how the units come out, remember that 1 J = 1 kg m^2 s^{-2}.

4. Use Wien's Law to determine λ_{max} (in nm) for the following stars. (a) Class K Star, Arcturus, T = 4500 K; (b) Class B Star, Regulus, T = 12,000 K; (c) Class O Star, Zeta Orionis, T = 30,000 K.

5. (a) Rank these stars in order from coolest to hottest. The stars appear: orange, red, white, yellow, blue. (b) Which color stars emit the highest energy radiation? Briefly explain your answers.

6. In 1896, E. C. Pickering found a series of unidentifiable lines in the spectrum of a class O star (T ~ 30,000 K). The pattern of lines looked similar to that of the hydrogen Balmer series. Bohr identified these lines as belonging to He^+ (Z = 2) and showed that his equation could predict the wavelengths of these electronic transitions. *Note*: He^+ is also a one-electron species like H.

   (a) Calculate the wavelengths of He^+ emission lines with $n_{final} = 2$ and $n_{initial} = 3$ and 4. Consult the conference activity from Exploration 3D of the *Star Module* if you are not sure how to do these calculations.

   (b) What type of electromagnetic radiation is this?

   (c) How do these wavelengths compare to transitions between corresponding levels in hydrogen?