North Carolina State University   Physical Chemistry 331   Quiz #8
Name ___________________________ Section ______   Tu/Th Nov. 2/4, 2004

1. A group of scientists wants to generate 20 eV electrons (electrons that have 20 eV of kinetic energy). The decide to do this by allowing radiation to strike the surface of an alloy that has a work function of 5 eV. What is the wavelength of the radiation that must be used to generate the electrons?

   Solution:
   The kinetic energy of an electron that is photoejected from a metal is:
   $1/2\ mv^2 = h\nu - \Phi$ or Electron energy = Photon energy - Work function.
   Therefore, Photon energy = Electron energy + Work function
   = 20 eV + 5 eV = 25 eV.

   Energy of radiation (5 points) = ______________25 eV_________________.

   The energy of a photon is $E = h\nu = hc/\lambda$, therefore $\lambda = hc/E$. First we need to convert energy into Joules using the conversion factor 1.602×10^{-19} J/eV.
   $E = 25\ eV(1.602 \times 10^{-19}\ J/eV) = 4.00 \times 10^{-18}\ J$
   $\lambda = hc/E = 6.626 \times 10^{-34}\ Js(2.99 \times 10^{8}\ m/s)/\ 4.00 \times 10^{-18}\ J = 4.95 \times 10^{-8}\ m = 49.5\ nm.$

   Wavelength of radiation (5 points) = __________49.5 nm________________.

2. What is the surface temperature of a star that emits radiation peaked at 420 nm?

   Solution:
   $\lambda_{max}T = 2.88 \times 10^{6}$ nm-K.

   $T = 2.88 \times 10^{6}\ nm\text{-}K/\lambda_{max} = 2.88 \times 10^{6}\ nm\text{-}K/420\ nm = 6.86 \times 10^{3}\ K.$

   Temperature (10 points) = ________6860 K______________________________.

3. Estimate the electron transition energy and wavelength of decene using the particle-in-a-box model. Assume that decene is a box of length 13.5 Å that contains 10 electrons.

   Solution: The particle-in-a-box model for a polyene assumes that electrons are paired in each quantum level. Thus, 10 electrons will fill the first 5 levels and the first transition will be from level 5 → 6. The ground state quantum number will be $n_g = 5$ and the excited state quantum number will be $n_e = 6$.
   $\Delta E = h^2/8ma^2(n_e^2 - n_g^2) = (6.626 \times 10\text{-}34\ Js)^2/8/9.1 \times 10^{-31}\ kg/(13.5 \times 10^{-10}\ m)^2\ (6^2 - 5^2) = 3.64 \times 10^{-19}\ J = 2.27\ eV = 18325\ cm^{-1}$.
   The wavelength can be obtained from $\Delta E = hc/\lambda$ or $\lambda = hc/\Delta E = (6.626 \times 10^{-34}\ Js)(2.99 \times 10^{8}\ m)/(\ 3.64 \times 10^{-19}\ J) = 5.44 \times 10^{-7}\ m = 544\ nm.$

Transition energy (15 points) = 3.64×10^{-19} J = 2.27 eV = 18325 cm^{-1}.
Transition wavelength (5 points) = 5.44×10^{-7} m = 544 nm.