Quiz #8 Recitation 3-22-04
Chem. 132

1a) The photoelectric effect could not be explained using classical physics. It was not possible to understand why intense red light with $\nu < \nu_{threshold}$ would not cause ejection of e^- from a metal while weak light with $\nu > \nu_{threshold}$ was able to do so. Classically, the stronger electric field should accelerate the electrons more.

b) $\lambda = \frac{h}{mv} = \frac{6.63 \times 10^{-34} \text{ J-sec}}{(9.1 \times 10^{-31} \text{ kg})(0.1 \times 3 \times 10^{8} \text{ m/sec})} = 2.4 \times 10^{-11} \text{ m}$
(0.24 Å)

When the DeBroglie wavelength of the electron is comparable to the system size or larger, we must think of it as a wave and expect phenomena like diffraction and interference. Since 0.24 Å is close to the size of atoms, electrons behave like waves and we must use the Schrödinger wave equation to describe them in atomic and molecular systems. If instead this electron were traveling alone in a TV set towards the phosphor, you could just use Newton's Law ($F = ma$) where the force is eE to describe its motion as a particle.

e ↑ charge of the e^-
E ↑ electric field in the CRT (cathode ray tube)

2) $E_n = \frac{-Z^2}{n^2}\left(\frac{me^4}{8\epsilon_0^2 h^2}\right) = -2.178\times10^{-18}\left(\frac{Z^2}{n^2}\right)$ J

For hydrogen, $Z=1$.
To remove an atom means going from $n=3 \rightarrow n=\infty$

$$E_{photon} = E_{final} - E_{initial} = E_\infty - E_3$$

$$E_{photon} = -2.178\times10^{-18}\left(\frac{1}{\infty} - \frac{1}{3^2}\right) = \underline{\underline{2.42\times10^{-19}\text{ J}}}$$

$$\lambda_{photon} = \frac{hc}{E} = \frac{(6.63\times10^{-34}\text{ J-sec})(3\times10^8\text{ m/sec})}{2.42\times10^{-19}\text{ J}} = 8.22\times10^{-7}\text{ m} = \underline{\underline{822\text{ nm}}}$$

If I go to Na^0 atoms, there are now $Z=11$ protons pulling to keep the electron in, ~~However~~ This would obviously raise the energy of photon I need. However, there are also 10 other electrons pushing the electron in question away (hiding the nucleus). Because the electron in question can sometimes sneak closer to the nucleus, it can feel that huge pull without feeling all the repulsion. Thus, I will need high energy (shorter wavelength) to ionize Na than to remove a 3s electron from hydrogen. We will revisit this idea more in the next few weeks.