Chem 1410 Spring 2001 HW #1

1. A star has a blackbody spectrum with $\lambda_{max} = 245$ nm. What temperature is its surface?

$$\lambda_{max} T = 2.90 \times 10^{-3} \text{ mK}$$

$$T = \frac{2.90 \times 10^{-3} \text{ mK}}{245 \times 10^{-9} \text{ m}} = 1.18 \times 10^{4} \text{ K}$$

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2. Problem 1-18 from text.

A silver surface is irradiated with light with $\lambda = 230$ nm. The KE of the ejected electrons is 0.805 eV. Calculate the workfunction and the threshold frequency of silver.

$$E = h\nu = \frac{hc}{\lambda} = \frac{(6.63 \times 10^{-34} \text{ J}\cdot\text{s})(3.00 \times 10^{8} \text{ m/s})}{230 \times 10^{-9} \text{ m}}$$

$$E = 8.64 \times 10^{-19} \text{ J}$$

$$\frac{8.64 \times 10^{-19} \text{ J}}{1.602 \times 10^{-19} \text{ J/eV}} = 5.39 \text{ eV}$$

work function $\phi = 5.39 - .80 = 4.59$ eV

threshold freq $\nu = \frac{E}{h} = \frac{(4.59 \text{ eV})(1.602 \times 10^{-19} \frac{\text{J}}{\text{eV}})}{6.63 \times 10^{-34} \text{ J}\cdot\text{s}}$

$$= 1.15 \times 10^{15} \text{ Hz}.$$

3. What is the speed of an electron in the first Bohr orbit of the H atom? How does this compare with the speed of light?

$mvr = n\hbar$

$$v = \frac{n\hbar}{mr} = \frac{1(1.054 \times 10^{-34}\ J\cdot s)}{(9.11 \times 10^{-31}\ kg)(0.529 \times 10^{-10}\ m)}$$

$= 2.18 \times 10^{6}\ m/s$

$c = 3.00 \times 10^{8}\ m/s$.

So the electron is moving at a little less than 1% of the speed of light.

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4. Problem 1-27 from text.

Through what potential must a proton initially at rest fall so that its de Broglie wavelength is 1.0×10^{-10}?

$$p = \frac{h}{\lambda} = \frac{6.63 \times 10^{-34}\ J\cdot s}{1 \times 10^{-10}\ m} = 6.63 \times 10^{-24}\ kg\cdot m/s$$

$$E = \frac{1}{2}mv^2 = \frac{p^2}{2m} = \frac{(6.63 \times 10^{-24})^2}{2(1.672 \times 10^{-27})} = 13.1 \times 10^{-21}\ J$$

$$\frac{13.1 \times 10^{-21}\ J}{1.602 \times 10^{-19}\ J/eV} = 0.082\ eV$$

5. Consider an electron to be constrained between $-a_0$ and a_0 (i.e., $-a_0 \leq x \leq a_0$). What is the uncertainty in p_x?

$$\Delta x \, \Delta p_x \geq \frac{\hbar}{2}$$ (This is using the correct expression)

$$\Delta p_x \geq \frac{\hbar}{2 \Delta x} = \frac{1.05 \times 10^{-34}}{2(1.058 \times 10^{-10})} = 0.496 \times 10^{-24} \frac{kg \cdot m}{s}$$

Note that this implies an uncertainty in the kinetic energy.

$$\Delta E = \frac{\Delta p^2}{2m} = \frac{(4.96 \times 10^{-25})^2}{2(9.11 \times 10^{-31})} = 1.35 \times 10^{-19} J$$

$$\frac{1.35 \times 10^{-19} J}{1.602 \times 10^{-19} J/eV} = 0.84 eV.$$