Physics 100 HW 12 (Due 4/18/07; **Wednesday**) Name________________________

1. What characteristic property of light was discovered by Einstein when he considered the experimental features of the photoelectric effect?

He discovered that light is comprised of particle-like quanta of energy called "photons." The photon energy depends on frequency: $E_{photon} = hf$

2. You are radiating black-body radiation with a peak wavelength of $<\lambda> = 2.9 \times 10^{-3} m/T$, where $T = 310^0$K is your normal body temperature in Kelvin degrees. What is the typical energy of the photons that you are radiating?

$E = hf = \frac{hc}{\lambda}$; $\lambda = \frac{2.9 \times 10^{-3} m}{310^\circ K} = 9.4 \times 10^{-6} m$

$E = \frac{6.6 \times 10^{-34} Js \times 3 \times 10^8 m/s}{9.4 \times 10^{-6} m} = 2.1 \times 10^{-22} J$

3. The FM radio station KHPR broadcasts at a frequency of 88.1MHz (i.e. 88.1×10^6Hz). What is the energy of photons that this station emits?

$E_{photon} = hf = 6.6 \times 10^{-34} Js \cdot 88.1 \times 10^6 Hz = 5.8 \times 10^{-26} J$

4. Suppose that you want to make a diffraction pattern using electrons ($m_e = 9.1 \times 10^{-31} kg$) with speeds of $2 \times 10^6 m/s$. Estimate the width of the slit that you would have to use. Compare this to the diameter of an atom (about $10^{-10}m$).

About the same dimension as the wavelength $\lambda = \frac{h}{p} = \frac{h}{mv}$

$\lambda = \frac{6.6 \times 10^{-34} Js}{9.1 \times 10^{-31} kg \times 2 \times 10^6 m/s} = 3.7 \times 10^{-10} m$

↖ about the size of an atom.

5. Suppose that you want to make a diffraction pattern using protons ($m_p = 1.7 \times 10^{-27} kg$) with speeds of $2 \times 10^6 m/s$. Estimate the width of the slit that you would have to use. Compare this to the diameter of an atomic nucleus (about $10^{-14}m$).

About the same dimension as the wavelength

$\lambda = \frac{h}{mv} = \frac{6.6 \times 10^{-34} Js}{1.7 \times 10^{-27} kg \cdot 2 \times 10^6 m/s} = 1.9 \times 10^{-13} m$

about 20× the size of an atomic nucleus

6. Rutherford discovered the atomic nucleus by looking at how α-particles, which have a mass $M_\alpha = 6.6 \times 10^{-27} kg$ and a speed of $v = 0.03c$, scattered from a gold foil. What is their deBroglie wavelength? Compare this to the diameter of a gold nucleus ($d_{gold} \simeq 10^{-14} m$).

$$\lambda = \frac{h}{mv} = \frac{h}{m \times 0.03 \times c} = \frac{6.6 \times 10^{-34}\ Js}{6.6 \times 10^{-27}\ kg \times 0.03 \times 3 \times 10^{8}\ m/s}$$

$$= 1.1 \times 10^{-14}\ m$$ ⇐ about the same as the size of a Gold nucleus

7. A beam of electrons with DeBroglie wavelength $\lambda = 2.0 \times 10^{-10} m$ impinges on the single slit with width $w = 2.0 \times 10^{-10} m$ shown in the top figure below. Sketch the intensity pattern of electrons hitting the screen. Show how this intensity pattern changes when the same beam of electrons impinges on two slits of the same dimension (bottom figure).