MSE228 Engineering Quantum Mechanics
Quiz 1 Duration: 30 minutes Open Book Quiz

1. (40 pts) X-rays of wavelength λ=0.200 nm are aimed at a block of carbon. The scattered x-rays are observed at an angle of 45.0° to the incident beam. Calculate the increased wavelength of the scattered x-rays at this angle.

this angle.

$$\lambda' - \lambda = \frac{h}{m_e c}(1 - \cos\theta) = \frac{(6.626\times10^{-34}\ J.s)}{(9.1\times10^{-31} kg)(3\times10^{8} m/s)}(1 - \cos 45)$$

$$= 7.11\times10^{-13}\ m = 0.000711\ nm$$

$$\rightarrow \lambda = 0.200\ nm$$

$$\Rightarrow \lambda' = 0.200\ nm + 0.000711\ nm = \underline{0.200711\ nm}$$

2. (60) Suppose that light of total intensity 1.0 μW/cm^2 falls on a clean iron sample 2.0 cm^2 in area. Assume that the iron sample reflects 92% of the light and that only 6.0% of the absorbed energy lies in the violet region of the spectrum above the threshold frequency.
   i. What intensity is actually available for the photoelectric effect?
   ii. Assuming that all the photons in the violet region have an effective wavelength of 250 nm, how many electrons will be emitted per second? (Hint: For an efficiency of 100%, one photon of energy, hv, will produce one electron)
   iii. Calculate the current in the phototube in amperes.
   iv. If the cutoff frequency is v_0 = 1.1x10^{15} Hz, find the work function, φ, for iron.
   v. Find the stopping voltage for iron if photoelectrons are produced by light with λ = 250 nm.

$I_0 = 1.0\ \mu W/c^2$, only 8.0% of the incident energy is absorbed & only 6.0% of that absorbed energy is able to produce photoelectrons $\rightarrow I = (0.08 I_0)\,0.06 = \underline{4.8\ nW/cm^2}$

$$\left.\frac{\#\ of\ e^-s}{second}\right|_{at\ 1cm^2} = \frac{4.8\times10^{-9}\ W}{h\nu} = \frac{4.8\times10^{-9}\ J/s}{7.95\times10^{-19}\ J} = \underline{6.04\times10^{9}}\ e^-s/second$$

$h\nu \rightsquigarrow$ energy of one photon $\rightsquigarrow h\nu = \frac{hc}{\lambda} = \frac{(6.626\times10^{-34}\ J.s)(3\times10^{8} m/s)}{250\times10^{-9} m}$

$$i = \frac{q}{t} = \frac{(\#\ of\ e^-s)*(Charge\ of\ e^-)}{1\ second} = 6.04\times10^{9}\times1.602\times10^{-19}\ C = \underline{9.7\times10^{-10} A}$$

$$\phi = h\nu_0 = (6.626\times10^{-34} J.s)(1.1\times10^{15}\ 1/s) = 7.3\times10^{-19} J = \frac{7.3\times10^{-19} J}{1.602\times10^{-19} J/eV} = \underline{4.5\ eV}$$

KE_{max} of photoelectrons ≡ Stopping Potential $= h\nu - \phi$

$$= \frac{7.95\times10^{-19}\ J}{1.602\times10^{-19}\ J/eV} - 4.5eV = \underline{0.46eV}$$