Name_____

Physics 111 Quiz #7, March 12, 2021

Please show all work, thoughts and/or reasoning in order to receive partial credit. The quiz is worth 10 points total.

I affirm that I have carried out my academic endeavors with full academic honesty.

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1. Suppose that you perform a photoelectric effect experiment with gold as the emitter. What is the work function of gold (in eV) if the minimum frequency of incident light needed to eject electrons from the gold surface is $f_{min} = 1.32 \times 10^{15} s^{-1}$?

$$K = hf - \phi \rightarrow 0 = hf_{min} - \phi \rightarrow \phi = hf_{min} = \left(6.63 \times 10^{-34} Js \times \frac{1eV}{1.6\times10^{-19}J}\right) \times 1.32 \times 10^{15} s^{-1}$$

$$\phi = 5.47eV$$

2. Suppose that you use the same gold emitter, but this time you shine a different color of light onto the metal surface and this particular color causes electrons to be emitted from the gold surface. To stop these electrons from striking the collector, we need to apply a stopping potential difference of $7.70V$. What was the wavelength of the light that was used?

$$K = eV_{stop} = hf - \phi = \frac{hc}{\lambda} - \phi \rightarrow \lambda = \frac{hc}{eV_{stop} + \phi} = \frac{\left(6.63 \times 10^{-34} Js \times \frac{1eV}{1.6\times10^{-19}J}\right) \times 3 \times 10^{8}\frac{m}{s}}{7.70eV + 5.47eV}$$

$$\lambda = 9.4 \times 10^{-8} m = 94nm$$

3. Tungsten x-rays ($E = 67.2443keV$) are used in a Compton effect experiment and are observed to scatter from stationary electrons in a block of carbon at an angle of $\phi = 125^0$ with respect to the direction of the incident beam. What is the energy of the scattered x-rays?

$$\lambda' = \lambda + \frac{h}{mc}(1 - \cos\phi) \rightarrow \frac{\lambda'}{hc} = \frac{\lambda}{hc} + \frac{h}{hmc^2}(1 - \cos\phi) \rightarrow \frac{1}{E'} = \frac{1}{E} + \frac{(1 - \cos\phi)}{E_{rest}}$$

$$\frac{1}{E'} = \frac{1}{E} + \frac{(1 - \cos\phi)}{mc^2} = \frac{1}{67.2443keV} + \frac{(1 - \cos 125)}{\left(511\frac{keV}{c^2}\right)c^2} \rightarrow E' = 55.7103keV$$

4. What is the speed of the recoiling electron expressed as a fraction of the speed of light?

$$E = E' + K_e \rightarrow K_e = E - E' = 67.2443keV - 55.7103keV = 11.534keV$$

$$K = (\gamma - 1)mc^2 \rightarrow \gamma = 1 + \frac{K_e}{mc^2} = 1 + \frac{11.534keV}{\left(511\frac{keV}{c^2}\right)c^2} = 1.0226$$

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \rightarrow v = \sqrt{1 - \frac{1}{\gamma^2}}c = \sqrt{1 - \frac{1}{(1.0226)^2}}c = 0.209c$$

Physics 111 Equation Sheet

Electric Forces, Fields and Potentials

$$\vec{F} = k\frac{Q_1Q_2}{r^2}\hat{r}$$

$$\vec{E} = \frac{\vec{F}}{q}$$

$$\vec{E}_Q = k\frac{Q}{r^2}\hat{r}$$

$$PE = k\frac{Q_1Q_2}{r}$$

$$V(r) = k\frac{Q}{r}$$

$$E_x = -\frac{\Delta V}{\Delta x}$$

$$W = -q\Delta V_{f,i}$$

Magnetic Forces and Fields

$$F = qvB\sin\theta$$

$$F = IlB\sin\theta$$

$$\tau = NIAB\sin\theta = \mu B\sin\theta$$

$$PE = -\mu B\cos\theta$$

$$B = \frac{\mu_0 I}{2\pi r}$$

$$\varepsilon_{induced} = -N\frac{\Delta\phi_B}{\Delta t} = -N\frac{\Delta(BA\cos\theta)}{\Delta t}$$

Constants

$g = 9.8\,\frac{m}{s^2}$

$1e = 1.6\times10^{-19}C$

$k = \frac{1}{4\pi\varepsilon_o} = 9\times10^9\ \frac{Nm^2}{C^2}$

$\varepsilon_o = 8.85\times10^{-12}\ \frac{C^2}{Nm^2}$

$1eV = 1.6\times10^{-19}J$

$\mu_o = 4\pi\times10^{-7}\ \frac{Tm}{A}$

$c = 3\times10^8\ \frac{m}{s}$

$h = 6.63\times10^{-34}Js$

$m_e = 9.11\times10^{-31}kg = \frac{0.511MeV}{c^2}$

$m_p = 1.67\times10^{-27}kg = \frac{937.1MeV}{c^2}$

$m_n = 1.69\times10^{-27}kg = \frac{948.3MeV}{c^2}$

$1amu = 1.66\times10^{-27}kg = \frac{931.5MeV}{c^2}$

$N_A = 6.02\times10^{23}$

$Ax^2 + Bx + C = 0 \rightarrow x = \frac{-B\pm\sqrt{B^2-4AC}}{2A}$

Electric Circuits

$$I = \frac{\Delta Q}{\Delta t}$$

$$V = IR = I\left(\frac{\rho L}{A}\right)$$

$$R_{series} = \sum_{i=1}^{N} R_i$$

$$\frac{1}{R_{parallel}} = \sum_{i=1}^{N}\frac{1}{R_i}$$

$$P = IV = I^2R = \frac{V^2}{R}$$

$$Q = CV = \left(\frac{\kappa\varepsilon_0 A}{d}\right)V = (\kappa C_0)V$$

$$PE = \tfrac{1}{2}QV = \tfrac{1}{2}CV^2 = \frac{Q^2}{2C}$$

$$Q_{charge}(t) = Q_{max}\left(1-e^{-\frac{t}{RC}}\right)$$

$$Q_{discharge}(t) = Q_{max}e^{-\frac{t}{RC}}$$

$$C_{parallel} = \sum_{i=1}^{N} C_i$$

$$\frac{1}{C_{series}} = \sum_{i=1}^{N}\frac{1}{C_i}$$

Light as a Particle & Relativity

$$E = hf = \frac{hc}{\lambda} = pc$$

$$KE_{max} = hf - \phi = eV_{stop}$$

$$\Delta\lambda = \frac{h}{m_e c}(1-\cos\phi)$$

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$p = \gamma mv$$

$$E_{total} = KE + E_{rest} = \gamma mc^2$$

$$E_{total}^2 = p^2c^2 + m^2c^4$$

$$E_{rest} = mc^2$$

$$KE = (\gamma - 1)mc^2$$

Geometry

$Circles\ C = 2\pi r = \pi D \qquad A = \pi r^2$

$Triangles\ A = \tfrac{1}{2}bh$

$Spheres\ A = 4\pi r^2 \qquad V = \tfrac{4}{3}\pi r^3$

Light as a Wave

$$c = f\lambda = \frac{1}{\sqrt{\varepsilon_o\mu_o}}$$

$$S(t) = \frac{energy}{time\ \times\ area} = c\varepsilon_o E^2(t) = c\frac{B^2(t)}{\mu_o}$$

$$I = S_{avg} = \tfrac{1}{2}c\varepsilon_o E_{max}^2 = c\frac{B_{max}^2}{2\mu_o}$$

$$P = \frac{S}{c} = \frac{Force}{Area} \qquad P = \frac{2S}{c}$$

$$S = S_o\cos^2\theta$$

$$v = \frac{1}{\sqrt{\varepsilon\mu}} = \frac{c}{n}$$

$$\theta_{inc} = \theta_{refl}$$

$$n_1\sin\theta_1 = n_2\sin\theta_2$$

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

$$M = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$$

$$M_{total} = \prod_{i=1}^{N} M_i$$

$$S_{out} = S_{in}e^{-\sum_i \mu x_i}$$

$$HU = \frac{\mu_w - \mu_m}{\mu_w}$$

Nuclear Physics

$$E_{binding} = (Zm_p + Nm_n - m_{rest})c^2$$

$$\frac{\Delta N}{\Delta t} = -\lambda N_o \rightarrow N(t) = N_o e^{-\lambda t}$$

$$A(t) = A_o e^{-\lambda t}$$

$$m(t) = m_o e^{-\lambda t}$$

$$t_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$$

Misc. Physics 110 Formulae

$$\vec{F} = \frac{\Delta\vec{p}}{\Delta t} = \frac{\Delta(m\vec{v})}{\Delta t} = m\vec{a}$$

$$\vec{F} = -k\vec{y}$$

$$\vec{F}_C = m\frac{v^2}{R}\hat{r}$$

$$W = \Delta KE = \tfrac{1}{2}m\left(v_f^2 - v_i^2\right) = -\Delta PE$$

$$PE_{gravity} = mgy$$

$$PE_{spring} = \tfrac{1}{2}ky^2$$

$$|\vec{A}| = \sqrt{A_x^2 + A_y^2}$$

$$\phi = \tan^{-1}\left(\frac{A_y}{A_x}\right)$$

$$\vec{v}_f = \vec{v}_i + \vec{a}t$$

$$v_f^2 = v_i^2 + 2a\Delta x$$

$$\vec{x}_f = \vec{x}_i + \vec{v}_i t + \tfrac{1}{2}\vec{a}t^2$$